DEPARTMENT OF THE INTERIOR

CANADA

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

Volume III

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CONTENTS OF VOL. III

DEPARTMENT OF THE INTERIOR

CANADA

Hon. W. J. Roche, *Minister*. W. W. Cory, C.M.G., *Deputy Minister*.

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

W. F. King, C.M.G., LL.D., *Director*.

Vol. III, No. 1

Earthquake of February 10, 1914

BY

OTTO KLOTZ, LL.D., F.R.A.S.

OTTAWA
Government Printing Bureau
1915

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EARTHQUAKE OF FEBRUARY 10, 1914.

BY OTTO KLOTZ, LL.D., F.R.A.S.

About half-past one in the afternoon of February 10, 1914, a pretty severe earthquake shock was felt in Ottawa, though not by everyone. Persons travelling in the street cars and many engaged in factories were unaware of the disturbance. The whole observatory staff felt the shock or shocks (two) distinctly; it created some excitement. Occurring during our luncheon hour, I was reading at the time, facing the north in my room. When the first impulse arrived, I looked up at the electric clock—it stood at $1^h\ 31^m$—and from the first sound or noise I thought that some of the desks in the large room overhead were being rolled across the floor. But presently the noise grew louder and stronger, and I noticed a trembling of my book-cases, showing that the disturbance was due to an earthquake. The photographic sheet containing the record of the two horizontal seismographs was taken off and developed, and the vertical component was well shown on the smoked paper. Naturally, immediately following the shock the Observatory was deluged with telephone calls, not only from the city, but also from neighbouring places, and from the Press in Montreal. They continued for fully three hours. Perhaps the scientist should consider it a compliment that when a phenomenon takes place, such as an earthquake, that the next moment the public calls upon him, clamours for an answer to: Where did it happen? Why did it happen? How deep down was it? Did you know it was coming? Can you foretell earthquakes? Such were some of the questions that poured into the Observatory. Before the paper was dry after developing, we were able to answer as to the distance of the epicentre from Ottawa, and its probable direction.

We felt safe in saying that the distance was 120 km., or about 75 miles, and the direction northeasterly from Ottawa in the Laurentian hills. As to the depth, that required a little more time for consideration and possible determination. The evening papers and those of the following morning from many places showed that the quake had been felt over a very wide area. In consequence, many of our blank earthquake-forms were sent out to postmasters from Rimouski to Philadelphia, and from Sault Ste. Marie to New York for reply to the various printed questions. These replies, together with newspaper reports were compiled, sifted, and alphabetically arranged as seen in the subjoined table. As usual, gross exaggerations were encountered, not as bad as those of the great quake of 1663, yet bad enough. As an example, we quote the following from a Buffalo paper: " In parliament building at Ottawa, pictures were shaken from the walls, tables and desks were overturned, and the buildings rocked on their foundations. Telephone poles were shaken down on the outskirts of the city and telephone communication to some extent was interrupted. Residents of the outskirts were panic-stricken and fled from their homes into the open fields. Members of parliament left their desks and ran bareheaded into the streets." There was practically not a word of truth in this statement, but it no doubt made interesting reading for the public at the time, and the public craves for things exciting. Imagine an earthquake overturning a desk resting on its base or four legs; why, the motion necessary to do that would raze every building in the city.

The places where the earthquake was felt, as tabulated hereunder, were entered on a map in order to give a bird's-eye view of the area disturbed, which was found to cover nearly 200,000 square miles (fully 500,000 sq. km.), an area about eight times as large as that affected by the local quake of April 28, 1913, of which a monograph was issued, as Publication No. 5, Vol. 1, of the Dominion Observatory. The most westerly point in the Ontario peninsula at which the quake was felt was at St. Thomas, corresponding to Ashtabula, nearly due south, on the south shore of lake Erie, which marked the westerly limit on the lake. Philadelphia was the most southerly place, and Chicoutimi the most easterly, as well as the most northerly place, to feel the shock. To the northwest we have reports both from North Bay and from White River, but in each case the informant is not certain of the cause of what was felt at approximately the time of the quake, as some blasting was going on at the time there.

Comparing the distribution of the places where the quake was felt with the geologic map accompanying the " Index to the Stratigraphy of North America," by Bailey Willis, there is no very apparent relation between the surface geology and such distribution. We find formations affected from his 15, the Devonian, to 24, Pre-Cambrian Intrusives. It may be noted that the extremes to the north and south are respectively Chicoutimi and Philadelphia, and each is shown as on or near the edge of 24, Pre-Cambrian Intrusives, so are St. Jérôme and Saranac Lake within that designation. The general observation might probably with justice be made that relatively more places reported from areas classified as "Laurentian" or "Pre-Cambrian" than from sedimentary formations. As the hypocentre or hearth of the quake was pretty deep below the surface, as we shall show later, it is to be expected that the vibrations would be more readily and effectively transmitted through the archæan and intrusive rocks than through various sedimentary formations overlying one another. The intensity of the shock as described at different places was not sufficiently definite or accurate that isoseists could be drawn. The intensity does not appear to have been directly related to or a function of the distance from the epicentre. Believing the determination of the distance to the epicentre from the Ottawa seismograms to be correct within narrow limits, say 10 or 15 kilometres, and the direction also, one is at a loss to explain satisfactorily why the effect of the quake was not greater in and about the epicentre, and why, again, the effect if weak in the epicentre was so widespread. This anomaly has been noted elsewhere. In the article "Zur Erklärung der geographischen Verteilung von Grossbeben," by Rudolph and Szirtes in the March number of Petermann's Mitteilungen, we read, p. 130, that it has been found that a large number of the destructive earthquakes are not even registered or recorded at any considerable distance from the epicentre. As an instance, the destructive quake of July 8, 1911, in Hungary is quoted, which was scarcely recognizable on seismograms 200 km. distant. Again, in the case of the quake of November 16, 1911, in southern Germany, the area in which it was instrumentally recorded is not much larger than the area in which it was felt. On the other hand, for a similarly large number of quakes, the epicentral disturbance may be comparatively small, yet the quake may be registered over the whole or greater part of the globe. This latter statement is somewhat in line with the further phenomenon referred to by Quervain in his "Die Erdbeben der Schweiz im Jahre, 1912," p. 2, wherein he points out, referring to the local Swiss quake of March 31, 1912, that the area within which the earthquake was actually felt was extraordinarily large, considering the intensity at the supposed epicentre.

This last is thoroughly in keeping with our experience of the local quake of February 10 last. As a plausible explanation of these phenomena, the depth of the hypocentre may be considered.

Obviously the greater the depth of the hearth, the greater relatively will be the extent of country shaken, the quake has got in that case a good grip on the earth, and the differences of intensity on the surface will be less than for more shallow quakes, that is, the gradients of the isoseists will be longer in the former than in the latter case. Furthermore, the nature of the rupture, whether vertical or horizontal, or in an oblique direction to the surface, would be manifested in the dimensions of the disturbed area. The available instrumental records of the quake are so very few that the latter consideration cannot be examined for a definite answer, and we are practically confined to the consideration of our own record.

In line with our experience we may refer to the Californian quake of April 24, 1914, where the instrumental record at Berkeley pointed to a quake of considerable intensity, but no place so reported. E. F. Davies, in "University of California Publications," p. 168, says of it: "The wide area over which this earthquake was felt, together with the fact that no very high degree of intensity was reported at any point, seems to indicate that it was an earthquake whose depth of origin was greater than is usual for the ordinary earthquakes of this region."

The following are the records of Ottawa and Harvard:—

Ottawa.						Harvard.			
Component.	Phase.	Time.	Period.	Amplitude.	Distance.	Phase.	Time.	Period.	Distance.
		h. m. s.	s.	μ	km.		h. m. s.	s.	km.
N	*P*	18 30 59·5	0·5	20	120	eP_N	18 32 03	0·4	435
E	*P*	18 30 59·5	0·5	15		eP_E	18 32 04	0·4	
N	*MP*	18 31 03·8		38		SL_N	18 32 51	16·0	
E	*MP*	18 31 03·8		28			18 33 07	6·0	
N	*S*	18 31 11·8				SL_E	18 32 51	8·0	
E	*S*	18 31 13·0					18 33 07		
	F	18 40				*F*	18 40		
V	*P*	18 31 00·0	0·5	20					
V	*S*	18 31 12·3	1·0						
V	*M*	18 31 13·7	1·0	110					
	F	18 38							

From the Ottawa record, on which for the three components the *P* and *S* phases can be read with accuracy, it is believed that the distance, 120 km., is correct within narrow limits. The reading of amplitudes on the seismogram, and applying the proper magnification is not so easy or reliable as reading the time-scale. On the former depend the azimuth and the depth, while on the latter depends the distance. From the amplitudes 20 and 15 respectively for the north and east components, we obtain from the simple trigonometrical relation, the azimuth N 37° E, to the nearest degree. The epicentre is therefore in latitude 46° 15′ N, and longitude 74° 46′ W.

The depth of the hearth or hypocentre is next to be considered. Difficulties, theoretical and instrumental, have so far been of such a nature and magnitude, that the problem still awaits a satisfactory solution. The question has occupied a number of able investigators; various formulæ have been devised—some simple, others more involved—all made under certain assumptions, none of which has stood the test of actual conditions, so that at the moment the uncertainty of a determination of the depth of the hearth is a large fraction of the depth itself. From the two horizontal components and the vertical one we obtain the direction of the emerged seismic ray, that is, of the tangent to the circular path of the ray which passes through the hypocentre and station. For our quake we find the angle of emergence to have been 38° 40′. We may attack the problem in the following manner, using as argument the above angle of emergence. There are various tables giving the theoretical angle of emergence for seismic rays covering arcual distances with 500 km. intervals. Among them we may refer to the one in Galitzin's "Seismometrie," p. 118. Interpolating from this table for emergence angle 38° 40′, we find the corresponding distance, Δ, to be 2,100 km. As our quake gives an angle of emergence of 38° 40′, we reason that the hypocentre must lie somewhere on the path of a seismic ray of 2,100 km. arcual distance. On this assumption we have the following data for computing the depth of the hearth or hypocentre:—

Distance of epicentre from Ottawa 120 km., arc 1° 04′·8; angle of emergence 38° 40′; its complement 51° 20′; above distance, Δ, 2,100 km.; chord 2,090 km.; arc 18° 54′; angle of chord with horizon 9° 27′; deduced radius of seismic ray 2,140 km.; and deduced distance from centre of earth to centre of seismic ray 8,152 km. From the above data we readily compute the length of the radius vector at the hypocentre and find it to be 6,285 km., the radius of the earth having been taken at 6,370. Hence we have for the depth of the hypocentre, the difference of the two quantities, or 85 km.

In the distance, 120 km., of the epicentre from Ottawa there can be but a very small margin of error; though the direction may be in error a few degrees, the immediate epicentral area is fairly confined within narrow limits. The depth, 85 km., of the hypocentre at first sight seems great. However, the writer believes, with considerable confidence, that it was not less than this. The earth movement as described by residents at Labelle and Nominingue, small hamlets situated near the determined epicentre, was not much more severe than at Ottawa. This affords an indication that the depth was a large fraction of the distance, 147 km., of the hypocentre from Ottawa.

We find that the epicentre as determined falls in the vast area marked 23, Laurentian, of the above geologic map; in an area beneath which there are no sedimentary formations, and we cannot speak here of newer formations settling and adjusting themselves as the cause of the quake; nor is there any evidence of any fault line in the vicinity along which the adjustment of the stresses took place, as is so common in earthquakes. The great St. Lawrence-Champlain fault line is not marked by any pronounced movement, as would be the case if along that line of weakness the adjustment had taken place. An earthquake is a manifestation of adjustment towards equilibrium of the stresses prevailing in that area or part of the earth's crust. In our local quake of the preceding year, the epicentre fell within an area of the Cambro-Silurian period, in which the Calciferous and Trenton predominate, affording us a more plausible explanation of the quake than we are able to offer in the present case. Also in the quake of 1913 we had very pronounced differences of effect, due to varying proximity to the epicentre, which shows that this quake was far shallower than that of February 10 last, which moreover at the computed depth of 85 km. was far below any recognized geological formation, and at two-thirds or more of the theoretical depth of isostatic compensation.

It is gratifying that the number of earthquake stations with recording instruments on this continent is steadily increasing, so that local quakes, such as the one of February last, will have less chance of escaping analysis.

The accompanying table has already been referred to. The copy of the record of the vertical seismograph and the map covering the area affected by the quake are self-explanatory.

RECORD OF PLACES WHERE EARTHQUAKE WAS FELT.

Station.	Duration.	Number of Shocks.	Nature of Shock.	Effect.	Sound.	Ground.
Actonvale, Que.	Few secs.	1	....	Windows rattled.	....	No rock.
Albany, N.Y.	20 secs.	2	Jerks.	Desks, tables, and electric lighting fixtures moved.	No noise.	Clay and loam.
Ashtabula, Ohio.	3 mins.	1	Tremble.	....	Rumbling.	....
Auburn, N.Y.	About 15 s.	1 small, 1 heavy.	....	....	....	....
Batiscan, Que.	1 min.	1	Wave.	Articles on shelves shook.	No noise.	Sandy loam.
Bédard, Que.	1 to 2 mins.	1	Wave.	....	Like freight train.	Rock
Belleville, Ont.	About 1 m.	1	Wave.	Hand-bag hanging on post had swinging motion.	No noise.	Clay soil.
Berlin, Ont.	15 secs.	1	Wave.	....	....	Sand, no rock exposure.
Berthier en haut, Que.	14 or 15 secs.	2	Wave.	....	No noise.	No rock.
Binghamton, N.Y.	Few secs.	1	Slight vibrat'ns.	No effects, save vibrations.	Not noticed.	River valley rock bed.
Brantford, Ont.	5 secs.	1	Lateral movement.	Draughting desk shook	No noise.	Gravel, no rock exposure.
Brockville, Ont.	About 1 m.	1	Wave.	Everything in house shook, plaster on S. side cracked.	....	Rocky surface.
Buckingham, Que.	20 secs.	1	....	Windows rattled.	No noise.	Rocky.
Buffalo, N.Y.	....	....	....	Slight shock.	....	....
Burlington, Vt.	30 secs.	2	Jerks.	Dishes and windows rattled, chandeliers and curtains moved.	....	Rocky foundation.
Cambridge, Mass.	....	....	....	Collection case doors swing open.	....	....
Canton, N.Y.	10 secs.	1	Wave.	A slight rattling.	Rumbling.	Gneiss.
Carleton Place, Ont.	10 secs.	1	Wave.	Windows rattled a little.	Like rumble of passing train	Rock exposed in some places.
Castleton, Vermont.	30 secs.	....	....	Felt mostly in north end of town.	....	....
Catskill, N.Y.	2 secs.	1	Wave.	Windows rattled.	No noise.	Clay hills.
Chalk River, Ont.	Several secs	....	....	....	....	Sandy loam.
Chelsea, Que.	30 secs.	1	A shaking motion.	Crockery rattled in sideboard.	As if high wind had started to blow.	Clay.

RECORD OF PLACES WHERE EARTHQUAKE WAS FELT—*Continued.*

Station.	Duration.	Number of Shocks.	Nature of Shock.	Effect.	Sound.	Ground.
Chicoutimi, Que	About 30 s.			Light shock only		
Cohoes, N.Y		2		Shock distinctly felt		
Cooperstown, N.Y	About 1 m.			Buildings shaken		
Cornwall, Ont	About 45 s.		Like an explosion.	Windows rattled, plaster fell.	Like an explosion.	Clay, sandy foundation.
Drummondville, Que.	40 secs.	2 1 small.	Wave	Windows and doors rattled.	Rumbling	Rock.
Danville, Que				Shock distinctly felt		
Duhamel, Que	1 min.		Wave-motion.	Shock passed from N. to S., house cracked on N. side.	Rumbling	Rocky.
East Hereford, Que	15 to 20 s.	1	Wave		No noise	Mountainous.
Eganville, Ont	2 mins.			Windows rattled		Loam and stony.
Elmira, N.Y				Very perceptible tremors felt.		
Farrellton, Que	2 mins.			Everything shook, nothing fell.	Sounded like a train coming.	Mountainous.
Fort Edward, N.Y	About 30 s.			Shock distinctly felt		
Fort Plain, N.Y				Very perceptible tremors felt.		
Fredonia, N.Y				Houses were observed to shake.		
Galt, Ont				Slight disturbance noticed by patients in hospital.		
Gananoque, Ont	Sev'l secs.			Shock more severe in stone buildings. Clock started that was formerly stop'd.	Like something heavy rolling on roof.	
Glens Falls, N.Y	2½ mins.	1		Windows rattled	Like ice sliding off the roof.	
Gloversville, N.Y				Pictures hanging on walls began to swing.		
Gracefield, Que	1 min.	1	Wave	Windows rattled	Rumbling	Clay.
Grand Mère, Que	30 secs.	1	Wave			Rocks.
Guelph, Ont				Very slight shock felt?		
Hamilton, Ont				Distinct lateral shock felt.		
Hartford, Conn				Dishes rattled, doors slammed.		
Hudson Falls, N.Y	About 30 s.			Shock distinctly felt		
Ithaca, N.Y	40 secs.			Keys hanging on board rattled.		Rock.
Jamestown, N.Y		2		Shaking disturbed pendulum of clock from its course.		
Joe Lake (Algonquin Park), Ont.	10 mins.?			Stove rattled	Like a train in motion.	Sand and rock.

RECORD OF PLACES WHERE EARTHQUAKE WAS FELT—*Continued.*

Station.	Duration.	Number of Shocks.	Nature of Shock.	Effect.	Sound.	Ground.
Joliette, Que.	30 secs.	1	Wave	Windows rattled	Like noise of waggon over frozen road.	Rocky.
Kemptville, Ont.	1 min.	1	Wave	Windows rattled, bell rang which was hanging on line.	Slight	Gravel and clay.
Kingston, N.Y.				Slight tremor felt		
Kingston, Ont.	About 20 s.	2	Distinct vibration.	Rattling in chimney	Like rumbling of heavily loaded waggon.	Clay and rock.
Labelle, Que.	About 30 s.	1	From jerk to wave.			Rocks.
Lake George, N.Y.	About 30 s.			County buildings shook.		
Lanark, Ont.	20 secs.	1	Wave	Cooking utensils on wall rattled.	Like heavy truck passing.	Rock foundation.
Limoilou, near Quebec city.				Slight tremors felt		
Lindsay, Ont.	2 mins.	2	Steady trembling.	Furniture shook	Rumbling.	No rock.
Longueuil, Que.	10 secs.	1	Wave	Windows rattled		
Loudonville, near Albany, N.Y.				Shock quite noticeable	Like heavy motor truck passing.	
Louiseville, Que.	1 min.	1	Wave		Like a gust of wind.	No rock.
Malone, N.Y.				Distinct tremors felt		
Maniwaki, Que.	15 to 30 s.	1	Wave	House and furniture shook.	Sounded like a loaded waggon passing.	Mountainous
Meaford, Ont.	2 to 3 mins.			Pictures hanging on walls, and foliage noticeably affected.		
Millbrook, Ont.				Slight tremor felt		
Montebello, Que.	25 to 30 s.	1	Wave		Like train passing near the house.	Rocky.
Montreal, Que.	2 mins.	1	Jerky	Windows rattled		Rocky.
Morrisburg, Ont.	30 secs.	1	Wave			No rock.
Mount Royal Tunnel, (Montreal), Que.				People living in vicinity of tunnel thought tunnel had collapsed		
Napierville, Que.	1 min.	1	Wave		Slight noise	No rock.
New Haven, Conn.				Tremors quite perceptible.		
New York, N.Y.	15 to 30 s.	1				
Nominingue, Que.	37 secs.	3	Wave and jerk.	Windows rattled	Like thunder	Rocks.
North Bay, Ont.			Jerk	Steam water pipes rattled.		Rock.
Northfield, Vermont	1 min. 15 secs.	2	Wave	Doors of office cabinet rattled.	No noise	Glacial sand, probably on bed rock.

RECORD OF PLACES WHERE EARTHQUAKE WAS FELT—*Continued.*

Station.	Duration.	Number of Shocks.	Nature of Shock.	Effect.	Sound.	Ground.
Norwood, Ont.	About 1 m.	Several shocks.		Dishes rattled and pictures shook.	A deep rumbling.	
Ogdensburg, N.Y.				Slight shock felt.		
Ormstown, Que.	Over 1 min.	1		Violent shaking, crockery rattled.	No noise.	Clay, no rock.
Oswego, N.Y.	30 secs.	1	Wave-motion.	Windows rattled.	No noise.	Sandy loam.
Ottawa, Ont.	2 secs.		Jerk.	Windows rattled.	No noise.	
Owen Sound, Ont.	40 secs.	1	Jerk.	Electric fixtures and flowers in room shook.		
Parry Sound, Ont.	10 to 20 s.	1	A steady vibration.	No damage, shock felt all over house.		Rock surface.
Pembroke, Ont.		1	Trembling motion.	Bottles shook.	Heavy rumbling	Clay surface, rock foundation.
Peterboro, Ont.	8 to 10 s.		Wave-motion.	Plaster cracked on all four sides of building.	As though some heavy object were being rolled on floor	Rock foundation.
Philadelphia, Pa.				Distinct shock felt.		
Plainfield, N.J.				Tremor plainly felt.		
Port Hope, Ont.				Quite a distinct shock felt,no damage done.		
Potsdam, N.Y.	1 min.	2 1 small.	Continued irregular shaking.	Statue which was cracked broke into pieces.	Rumbling rolling.	
Prescott, Ont.	40 secs.	1 distinct 5 light.	1 jerk and several waves.	Windows rattled.	Low rumbling	Rock.
Quyon, Que.	About 30 s.	1	Jerky.	Windows rattled.	Rumbling.	Rock.
Renfrew, Ont.	2 mins.	1	Wave.	Dishes rattled.	No noise.	Clay.
Rigaud, Que.	15 secs.	1	Wave.	Electric lamp moved.		Clay.
Rochester, N.Y.	Very few secs.	1	Wave-motion.			Rock.
Rome, N.Y.				No damage done, shock distinctly felt.		
Saranac Lake, N.Y.	3 or 4 secs.	1 strong, 2 small.	Fundamental rocking.	Windows rattled, pictures rocked against walls.	Noise of house vibrations.	Rock.
Saratoga, N.Y.	7 or 8 secs.			No damage done.		
Schenectady, N.Y.				Shock distinctly felt.		
Scranton, Pa.				Shock felt slightly.		
Sharbot Lake, Ont.	About 15 s.	1	Wave-motion.	Rattling.		Rock.
Skaneateles, N.Y.				Shock disturbed type in print-shop.		
Slingerlands, near Albany, N.Y.				Shock very slight.		
Sorel, Que.	30 secs. at least.	2	Jerky.	Two lids of the stove were thrown out of place, and shaken back into their original position.	Rumbling noise.	No rock.

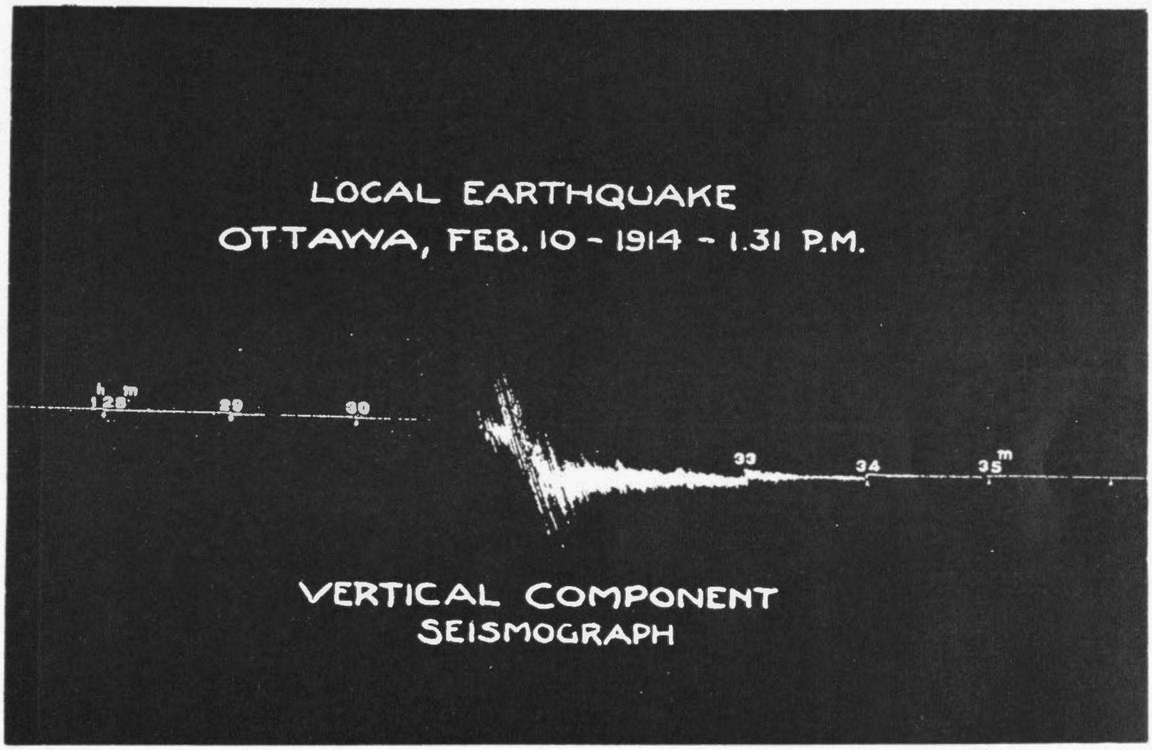
RECORD OF PLACES WHERE EARTHQUAKE WAS FELT—*Concluded.*

Station.	Duration.	Number of Shocks.	Nature of Shock.	Effect.	Sound.	Ground.
Springfield, Mass.				Distinct shock felt. Buildings rocked from E. to W.		
Ste. Agathe des Monts, Que.	1 min. 30 secs.		Wave		Rumbling	Mountainous
Ste. Madeleine, Que				Distinct shock felt	Dull rumbling noise.	
Ste. Therèse, Que	25 to 30 s.		Wave		Like the rolling of a waggon.	No rocks.
St. Catharines, Ont				Billiard balls rolled around tables.		
St. Charles, Que				Severe shock felt		
St. Jean, Que	About 5 s.	1	Jerk	Dishes rattled		No rock.
St. Jérôme, Que.	1 min.	1	Succession of jerks.	Windows rattled	Loud rumblings	Rock.
Stratford, Ont	1 sec.	1	Wave-motion.	Vibration of house		Gravel bottom.
St. Thomas, Ont				Only slight shock felt.		
Syracuse, N.Y	1 sec.	1	Wave	Swaying of chandelier.	Dull jar, like some heavy object falling.	Glacial tills, overlying Silurian shales.
Three Rivers, Que	20 to 30 s.	2	Wave-motion.		No noise	No rock.
Toronto, Ont		2	Wave	Windows rattled	Like the tearing of paper.	
Troy, N.Y	10 secs.	2		Seemed to come from N. to S.		
Tunkhannock, Pa				Distinct shock felt		
Utica, N.Y	15 secs.	1	Wave-motion.	Windows rattled	Like heavy waggon passing.	Rock.
Vankleek Hill, Ont				Quite a severe shock felt.		
Verdun, near Montreal, Que.				People ran out of their houses.	Like passing of heavy motor truck.	
Voorheesville, near Albany, N.Y.				Shock very slight		
Wakefield, Que.	1 to 2 mins.	1		No damage done	Loud rumbling noise.	Clay loam.
Watertown, N.Y.	20 secs.	1 slight, then 1 heavy	Wave-motion.	Windows rattled	Low rumbling .	Hilly, rock exposures.
Westmount, adjoining Montreal, Que.				Felt as though someone on the floor above were jumping up and down, shaking the building.		
White River, Ont	1 or 2 secs.			Slight shock felt		
Woodstock, Ont.				Clock stopped, bookcase shook.	As though verandah were being torn loose from house.	No rock.
Worcester, Mass				Distinct shock felt		

These places were heard from, but no shock was noticed at them:—

Arthabaska, Que.; Cartier, Ont.; Chatham, Ont.; Cleveland, Ohio; Collingwood, Ont.; Erie, Pa.; Father Point, Que.; Goderich, Ont.; Granby, Que.; Harrisburg, Pa.; Kincardine, Ont.; Levis, Que.; L'Islet, Que.; London, Ont.; Montmagny, Que.; Mount Forest, Ont.; Olean, N.Y.; Oshawa, Ont.; Pittsburg, Pa.; Port Rowan, Ont.; Preston, Ont.; Quebec, Que.; Richmond, Que.; Roberval, Que.; Sarnia, Ont.; Sault Ste. Marie, Ont.; Scotia Jct., Ont.; St. Frederic, Que.; St. Marys, Ont.; White River Jct., Vt.; Windsor, Ont.

Dominion Observatory,
Ottawa,
July, 1914.


LOCAL EARTHQUAKE
OTTAWA, FEB. 10 - 1914 - 1.31 P.M.
1h 28m
29
30
33
34
35m
VERTICAL COMPONENT
SEISMOGRAPH

82241—p. 14.

DEPARTMENT OF THE INTERIOR

CANADA

HON. W. J. ROCHE, *Minister*. W. W. CORY, C.M.G., *Deputy Minister*.

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

W. F. KING, C.M.G., LL.D., *Director*.

Vol. III, No. 2

Seismological Tables

BY

OTTO KLOTZ, D.Sc., F.R.A.S.

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CONTENTS.

SEISMOLOGICAL TABLES.

BY OTTO KLOTZ, D.Sc., F.R.A.S.

FOREWORD.

There has been a general desire for a compilation or collection of seismological tables useful to the working seismologist. To meet such want the following symbols, tables and data are issued.

SYMBOLS.

The symbols are those of Göttingen, adopted by the International Seismological Association with the addition of O, suggested by Professor J. B. Woodworth, as indicating the time of the earthquake at the epicentre; and of γ and γ_μ suggested by the writer for gal, unit acceleration of one centimetre per second per second, and for milligal the one thousandth of a gal, or ten microns per second per second.

P = Longitudinal waves, and time of arrival.
PR_1 = " " once reflected, and time of arrival.
PR_2 = " " twice reflected, " "
etc.
S = Transverse waves, and time of arrival.
SR_1 = " " once reflected, and time of arrival.
SR_2 = " " twice reflected " "
etc.
PS = Alternating waves (Wechselwellen), and time of arrival, $= PR_1S = SR_1P$.
L = Long or surface waves, and time of arrival.
M = Maximum of long waves, and time of arrival.
$M_1\, M_2\, M_3 \ldots$ = When more than one maximum of long waves.
L_{rep_1} = Long waves reaching the station from the anti-epicentre; path $40000 - \Delta$.

L_{rep_2} = Long waves again reaching the station from the anti-epicentre; path $40000+\Delta$.

F = End of record on seismogram.

e = emersio,—emergence of phase not sharply defined.

i = impetus,—a sharply defined impulse, especially used with P and S.

A_N = Amplitude or half range of movement of earth particle—not of the instrument, or measurement from the zero line for the $N-S$ component, expressed in microns.

A_E = Amplitude similarly for the $E-W$ component.

A_Z = " " vertical "

μ = Microns or 1/1000 of a millimetre.

γ = Gal, or unit acceleration, one centimetre per second per second.

γ_μ = Milligal, or 1/1000 of a gal, or acceleration of 10 microns per second per second.

O = Time of earthquake at epicentre.

φ = Latitude.

λ = Longitude from Greenwich.

Δ = Distance, epicentre to station.

ca. = Approximately.

T = Period, complete time of oscillation; for simple pendulum = $2\pi\sqrt{\frac{l}{g}}$

T_o = Period of undamped pendulum (seismograph).

T_e = Period of earth particle.

h, m, s = Time, Greenwich Mean Time, midnight to midnight.

$\mathcal{M}$ = Theoretical magnification of seismograph.

$\mathcal{M}_a$ = Actual magnification, for damping ratio and periods of earth particle and undamped pendulum.

V_P, V_S, V_L = Velocity of P, S and L waves respectively.

* = Epicentre.

EXPLANATION OF TABLES, THEIR SOURCE AND USE.

Table 1. This table gives the time interval $P-O$ or I_P between the arrival of the P, longitudinal waves, and the time O, of the earthquake at the epicentre. The symbol O, suggested by

Professor J. B. Woodworth, is a very useful one, for *O*, deduced from various stations should be the same for any particular earthquake. This table is due to Dr. Mohorovičić of Agram.

Table 2. This table gives the time interval between the arrival of the *P* waves and of the PR_1 waves, the latter having been once reflected, hence the time of arrival of the latter will be twice the time a *P* wave requires to travel the half distance or $\frac{\Delta}{2}$. This table, as well as the next one, table 3, has been directly computed from the preceding one.

Table 3. This table gives the time interval between the arrival of the *P* waves and of the PR_2 waves, the latter having been twice reflected.

Table 4. This table gives the time interval between the arrival of the *P* waves and of the *PS* waves, the path of the latter being one part *P* waves, the other part *S* waves, and which may be written too as PR_1S or SR_1P waves.

Table 5. This is the well-known table of Zeissig, based on Wiechert and Zöppritz's values, so useful in determining the distance, Δ, of an earthquake, its epicentre, from the seismological station. It expresses the time-interval between the arrival of the *P* and *S* or transverse waves.

Table 6. This table has been compiled from tables 1 and 5, being the sum of the two, but expressed in a smoothed series of whole seconds. For distant earthquakes the horizontal component is weak, often wanting; hence *O* may be obtained from $S-O$, written too I_S, provided we obtain the distance, Δ, from $L-S$. Knowing *O*, even approximately, we can now look for *P*, and frequently identify it then. Applying now $P-O=I_P$, the value of *O* can be corrected.

Table 7. This table gives the time interval between the arrival of the *S* waves and of the SR_1 waves, the latter having been once reflected. The derivation is from table 6, and computed similarly to table 2.

Table 8. This table corresponds to table 3, and is for transverse waves.

Table 9. This table gives the time interval between the arrival of the P waves and of the L or surface waves. It is less accurate than any of the preceding, due to the uncertainty of the velocity of propagation of the L waves. This uncertainty is partly due to the difficulty of reading the appearance of the L waves on the seismogram, necessary for deducing the rate of propagation. In an isotropic medium the velocity is constant, but not in the medium of the crust of the earth. From an examination here of 234 earthquake records of Pulkovo and Ottawa in each of which P, S and L are given, the mean velocity of 228 km. per minute, or 3·8 km. per second, has been adopted.

Plotting the velocities for the respective distances, the variation in velocity is found—as was expected—to be quite independent of the distance. Leaving out of account the uncertainty of reading eL, observations show that the velocity of L waves is not constant for different earthquakes and traversing different paths from the epicentre to the station, involving probably too, different depths of hearths. The velocities were examined too with reference to the paths over land and water; for it was believed that the paths under the ocean would dampen or reduce the velocity. This was found not to be the case. However, from a larger number of earthquakes and a careful analysis, this *a priori* conclusion may be ratified.

Hitherto the generally accepted value has been 3·5 km. per second, or 210 km. per minute, but this is decidedly too low for an average velocity. The identification of the first L waves, on which P and S waves are superimposed, is not easy. The long period, often 40 seconds, of the first L waves helps to identify them.

Table 10. This table is a counterpart of the immediately preceding table, and is based on table 6, and the time interval for L waves, $L-O$ or I_L, from the epicentre, given in the next following table.

Table 11. This table gives the time interval, $L-O$ or I_L, between the arrival of the L or surface waves and the time O of the earthquake at the epicentre; in short, it gives the transmission time of L waves for the various distances of the table from 2,000 km. onwards for intervals of 100 km. The table is based on a uniform velocity of 228 km. per minute as explained under table 9.

Table 12. This table was originally published by Zöppritz & Geiger, and gives the angle of emergence of the seismic ray of the longitudinal waves. The other angle ϵ is the angle made by the chord, epicentre to station, with the tangent to the earth at the station, and it is equal to half the angle subtended by the chord at the centre of the earth.

Table 13. This table gives the value of the chord and its middle ordinate in kilometres for the corresponding arc of the earth; computed with mean radius of the earth 6,370 km.

Table 14. This table gives the values of d and r for the principal seismological stations, for plotting by means of the stereographic projection method (described by the writer in 1910) the position—in latitude and longitude—of an epicentre. It is an extension of the one issued in 1913 as Vol. I, No. 1, of the "Publications of the Dominion Observatory."

Magnification Curves.—These curves are for converting the measurement of the amplitude on the seismogram to the actual amplitude of the earth particle by applying the particular ratio of $\mathcal{M}_a$ to $\mathcal{M}$ that obtains. The curves were drawn from Wiechert's adopted formula:—

$$\mathcal{M}_a = \frac{\mathcal{M}}{\sqrt{\left\{1-\left(\frac{T_e}{T_o}\right)^2\right\}^2 + 4\,\frac{\cdot 537(\log\epsilon)^2}{1+\cdot 537\,(\log\epsilon)^2}\,\left(\frac{T_e}{T_o}\right)^2}}$$

where $\mathcal{M}_a$ is the actual magnification, $\mathcal{M}$ the theoretical magnification, T_e and T_o respectively the period of the earth particle and of the undamped pendulum, and ϵ the damping ratio. $\mathcal{M}$ is a constant, $\mathcal{M}_a$ is not.

Velocity Curves.—These have been plotted on a large scale from the preceding tables and then reduced by photography one-half. The plotting was all done from the zero base line of time. The velocity curves will be found useful for co-ordinating the various phases read on the seismogram. One plots on a strip of paper the times of the various phases read, on a time-scale equal to that of the velocity curves; then sliding the strip along the Δ ordinates until co-incidence with two or more of the phases is found. This gives a preliminary value for Δ. Accordance or large discrepancy will then lead to confirmation of the Δ or to a further examination of the seismogram and interpretation of the phases. With regard to the latter it may be pointed out that for distant earthquakes P is frequently missing, and PR_1 or PR_2 read therefor, due to the fact that the horizontal component of P is weak, more so than of PR_1 and PR_2, although these last suffer more from absorption than does P. The application of the curves to readings of the seismogram will prevent incompatible or impossible interpretation of phases, for within narrow limits the various phases, if properly read, will fall simultaneously on the curves for a given distance. It is suggested that this diagram be taken out and mounted on stiff card-board, so as not to warp, it will then be more available for measurement.

TABLE 1.

$P-O$ or I_P

Δ 100 km.	00	Diff. for 20 km.	20	Diff. for 20 km.	40	Diff. for 20 km.	60	Diff. for 20 km.	80	Diff. for 20 km.	Δ 100 km.
	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	
2	0 30·6	2·5	0 33·1	2·5	0 35·6	2·6	0 38·2	2·5	0 40·7	2·5	2
3	0 43·2	2·5	0 45·7	2·6	0 48·3	2·5	0 50·8	2·5	0 53·3	2·5	3
4	0 55·8	2·6	0 58·4	2·5	1 00·9	2·5	1 03·4	2·6	1 06·0	2·5	4
5	1 08·5	2·6	1 11·1	2·5	1 13·6	2·5	1 16·1	2·6	1 18·7	2·5	5
6	1 21·2	2·6	1 23·8	2·5	1 26·3	2·6	1 28·9	2·6	1 31·5	2·5	6
7	1 34·0	2·6	1 36·6	2·5	1 39·1	2·5	1 41·6	2·6	1 44·2	2·5	7
8	1 46·7	2·5	1 49·2	2·6	1 51·8	2·5	1 54·3	2·5	1 56·8	2·5	8
9	1 59·3	2·5	2 01·8	2·6	2 04·4	2·5	2 06·9	2·5	2 09·4	2·5	9
10	2 11·9	2·5	2 14·4	2·5	2 16·9	2·5	2 19·4	2·5	2 21·9	2·5	10
11	2 24·4	2·5	2 26·9	2·5	2 29·4	2·5	2 31·9	2·5	2 34·4	2·5	11
12	2 36·9	2·5	2 39·4	2·5	2 41·9	2·4	2 44·3	2·5	2 46·8	2·5	12
13	2 49·3	2·4	2 51·7	2·5	2 54·2	2·5	2 56·7	2·4	2 59·1	2·5	13
14	3 01·6	2·4	3 04·0	2·5	3 06·5	2·4	3 08·9	2·4	3 11·3	2·4	14
15	3 13·7	2·4	3 16·1	2·3	3 18·4	2·4	3 20·8	2·4	2 23·2	2·4	15
16	3 25·6	2·4	3 28·0	2·3	3 30·3	2·4	3 32·7	2·4	3 35·1	2·4	16
17	3 37·5	2·3	3 39·8	2·4	3 42·2	2·4	3 44·6	2·3	3 46·9	2·4	17
18	3 49·3	2·3	3 51·6	2·4	3 54·0	2·3	3 56·3	2·3	3 58·6	2·3	18
19	4 00·9	2·3	4 03·2	2·3	4 05·6	2·2	4 07·8	2·3	4 10·1	2·3	19
20	4 12·4	2·3	4 14·7	2·3	4 17·0	2·2	4 19·2	2·3	4 21·5	2·2	20
21	4 23·7	2·2	4 25·9	2·3	4 28·2	2·2	4 30·4	2·2	4 32·6	2·2	21
22	4 34·8	2·2	4 37·0	2·2	4 39·2	2·2	4 41·4	2·2	4 43·6	2·2	22
23	4 45·8	2·1	4 47·9	2·2	4 50·1	2·2	4 52·3	2·1	4 54·4	2·2	23
24	4 56·6	2·1	4 58·7	2·2	5 00·9	2·1	5 03·0	2·1	5 05·1	2·1	24
25	5 07·2	2·1	5 09·3	2·0	5 11·3	2·1	5 13·4	2·1	5 15·5	2·0	25
26	5 17·5	2·0	5 19·5	2·0	5 21·5	2·1	5 23·6	2·0	5 25·6	2·0	26
27	5 27·6	2·0	5 29·6	2·0	5 31·6	1·9	5 33·5	2·0	5 35·5	2·0	27
28	5 37·5	2·0	5 39·5	1·9	5 41·4	1·9	5 43·3	2·0	5 45·3	1·9	28
29	5 47·2	1·9	5 49·1	1·9	5 51·0	1·9	5 52·9	1·9	5 54·8	1·9	29
30	5 56·7	1·9	5 58·6	1·8	6 00·4	1·9	6 02·3	1·8	6 04·1	1·9	30
31	6 06·0	1·8	6 07·8	1·8	6 09·6	1·9	6 11·5	1·8	6 13·3	1·8	31
32	6 15·1	1·8	6 16·9	1·8	6 18·7	1·8	6 20·5	1·8	6 22·3	1·8	32
33	6 24·1	1·7	6 25·8	1·7	6 27·5	1·7	6 29·1	1·6	6 30·7	1·6	33
34	6 32·3	1·6	6 33·9	1·6	6 35·5	1·6	6 37·1	1·6	6 38·7	1·6	34
35	6 40·3	1·6	6 41·9	1·6	6 43·5	1·6	6 45·1	1·5	6 46·6	1·5	35
36	6 48·1	1·6	6 49·7	1·5	6 51·2	1·5	6 52·7	1·5	6 54·2	1·5	36
37	6 55·7	1·5	6 57·2	1·5	6 58·7	1·5	7 00·2	1·5	7 01·7	1·5	37
38	7 03·2	1·5	7 04·7	1·5	7 06·2	1·5	7 07·7	1·5	7 09·2	1·5	38
39	7 10·7	1·5	7 12·2	1·5	7 13·7	1·5	7 15·2	1·5	7 16·7	1·4	39
40	7 18·1	1·5	7 19·6	1·5	7 21·1	1·4	7 22·5	1·5	7 24·0	1·4	40

TABLE 1—*Continued.*

P—O or *Ip*

Δ 100 km.	00	Diff. for 20 km.	20	Diff. for 20 km.	40	Diff. for 20 km.	60	Diff. for 20 km.	80	Diff. for 20 km.	Δ 100 km.
	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	
41	7 25·4	1·5	7 26·9	1·5	7 28·4	1·4	7 29·8	1·5	7 31·3	1·4	41
42	7 32·7	1·4	7 34·1	1·5	7 35·6	1·4	7 37·0	1·4	7 38·4	1·5	42
43	7 39·9	1·4	7 41·3	1·4	7 42·7	1·5	7 44·2	1·4	7 45·6	1·4	43
44	7 47·0	1·4	7 48·4	1·4	7 49·8	1·4	7 51·2	1·4	7 52·6	1·4	44
45	7 54·0	1·4	7 55·4	1·4	7 56·8	1·4	7 58·2	1·4	7 59·6	1·4	45
46	8 01·0	1·4	8 02·4	1·4	8 03·8	1·3	8 05·1	1·4	8 06·5	1·4	46
47	8 07·9	1·3	8 09·2	1·4	8 10·6	1·4	8 12·0	1·3	8 13·3	1·4	47
48	8 14·7	1·4	8 16·1	1·4	8 17·5	1·3	8 18·8	1·3	8 20·1	1·3	48
49	8 21·4	1·4	8 22·8	1·3	8 24·1	1·3	8 25·4	1·3	8 26·7	1·3	49
50	8 28·0	1·3	8 29·3	1·3	8 30·6	1·3	8 31·9	1·3	8 33·2	1·3	50
51	8 34·5	1·3	8 35·8	1·3	8 37·1	1·3	8 38·4	1·3	8 39·7	1·3	51
52	8 41·0	1·3	8 42·3	1·3	8 43·6	1·2	8 44·8	1·3	8 46·1	1·3	52
53	8 47·4	1·3	8 48·7	1·2	8 49·9	1·3	8 51·2	1·3	8 52·5	1·2	53
54	8 53·7	1·3	8 55·0	1·3	8 56·3	1·2	8 57·5	1·3	8 58·8	1·3	54
55	9 00·0	1·2	9 01·3	1·3	9 02·6	1·2	9 03·8	1·3	9 05·1	1·2	55
56	9 06·3	1·3	9 07·6	1·3	9 08·9	1·2	9 10·1	1·3	9 11·4	1·2	56
57	9 12·6	1·2	9 13·8	1·3	9 15·1	1·2	9 16·3	1·3	9 17·6	1·2	57
58	9 18·8	1·2	9 20·0	1·2	9 21·2	1·2	9 22·4	1·2	9 23·6	1·2	58
59	9 24·8	1·2	9 26·0	1·2	9 27·2	1·1	9 28·3	1·2	9 29·5	1·2	59
60	9 30·7	1·2	9 31·9	1·2	9 33·1	1·1	9 34·2	1·2	9 35·4	1·2	60
61	9 36·6	1·2	9 37·8	1·1	9 38·9	1·2	9 40·1	1·2	9 41·3	1·1	61
62	9 42·4	1·2	9 43·6	1·1	9 44·7	1·2	9 45·9	1·2	9 47·1	1·1	62
63	9 48·2	1·2	9 49·4	1·2	9 50·6	1·1	9 51·7	1·2	9 52·9	1·1	63
64	9 54·0	1·1	9 55·1	1·2	9 56·3	1·1	9 57·4	1·1	9 58·5	1·2	64
65	9 59·7	1·1	10 00·8	1·2	10 02·0	1·1	10 03·1	1·1	10 04·2	1·2	65
66	10 05·4	1·1	10 06·5	1·1	10 07·6	1·2	10 08·8	1·1	10 09·9	1·1	66
67	10 11·0	1·1	10 12·1	1·1	10 13·2	1·2	10 14·4	1·1	10 15·5	1·1	67
68	10 16·6	1·1	10 17·7	1·1	10 18·8	1·1	10 19·9	1·1	10 21·0	1·1	68
69	10 22·1	1·1	10 23·2	1·1	10 24·3	1·1	10 25·4	1·1	10 26·5	1·1	69
70	10 27·6	1·1	10 28·7	1·1	10 29·8	1·1	10 30·9	1·1	10 32·0	1·1	70
71	10 33·1	1·1	10 34·2	1·1	10 35·3	1·0	10 36·3	1·1	10 37·4	1·1	71
72	10 38·5	1·1	10 39·6	1·1	10 40·7	1·0	10 41·7	1·1	10 42·8	1·1	72
73	10 43·9	1·1	10 45·0	1·1	10 46·1	1·0	10 47·1	1·1	10·48·2	1·1	73
74	10 49·3	1·1	10 50·4	1·0	10 51·4	1·1	10 52·5	1·1	10 53·6	1·0	74
75	10 54·6	1·1	10 55·7	1·1	10 56·8	1·0	10 57·8	1·1	10 58·9	1·0	75
76	10 59·9	1·1	11 01·0	1·0	11 02·0	1·1	11 03·1	1·1	11 04·2	1·0	76
77	11 05·2	1·1	11 06·3	1·1	11 07·4	1·0	11 08·4	1·1	11 09·5	1·0	77
78	11 10·5	1·1	11 11·6	1·0	11 12·6	1·1	11 13·7	1·1	11 14·8	1·0	78
79	11 15·8	1·1	11 16·9	1·1	11 18·0	1·0	11 19·0	1·1	11 20·1	1·0	79
80	11 21·1	1·0	11 22·1	1·1	11 23·2	1·0	11 24·2	1·0	11 25·2	1·1	80

TABLE 1—*Concluded.*

P—O or *IP*

Δ 100 km.	00	Diff. for 20 km.	20	Diff. for 20 km.	40	Diff. for 20 km.	60	Diff. for 20 km.	80	Diff. for 20 km.	Δ 100 km.
	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	m. s.	s.	
81	11 26·3	1·0	11 27·3	1·0	11 28·3	1·1	11 29·4	1·0	11 30·4	1·1	81
82	11 31·5	1·0	11 32·5	1·1	11 33·6	1·0	11 34·6	1·0	11 35·6	1·1	82
83	11 36·7	1·0	11 37·7	1·0	11 38·7	1·1	11 39·8	1·0	11 40·8	1·1	83
84	11 41·9	1·0	11 42·9	1·1	11 44·0	1·0	11 45·0	1·0	11 46·0	1·1	84
85	11 47·1	1·0	11 48·1	1·0	11 49·1	1·1	11 50·2	1·0	11 51·2	1·0	85
86	11 52·2	1·0	11 53·2	1·0	11 54·2	1·1	11 55·3	1·0	11 56·3	1·0	86
87	11 57·3	1·0	11 58·3	1·0	11 59·3	1·1	12 00·4	1·0	12 01·4	1·0	87
88	12 02·4	1·0	12 03·4	1·0	12 04·4	1·1	12 05·5	1·0	12 06·5	1·0	88
89	12·07·5	1·0	12 08·5	1·0	12 09·5	1·1	12 10·6	1·0	12 11·6	1·0	89
90	12 12·6	1·0	12 13·6	1·0	12 14·6	1·0	12 15·6	1·0	12 16·6	1·0	90
91	12 17·6	1·0	12 18·6	1·0	12 19·6	1·0	12 20·6	1·0	12 21·6	1·0	91
92	12 22·6	1·0	12 23·6	1·0	12 24·6	1·0	12 25·6	1·0	12 26·6	1·0	92
93	12 27·6	1·0	12 28·6	1·0	12 29·6	1·0	12 30·6	1·0	12 31·6	1·0	93
94	12 32·6	1·0	12 33·6	1·0	12 34·6	1·0	12 35·6	1·0	12 36·6	1·0	94
95	12 37·6	1·0	12 38·6	1·0	12 39·6	0·9	12 40·5	1·0	12 41·5	1·0	95
96	12 42·5	1·0	12 43·5	1·0	12 44·5	0·9	12 45·4	1·0	12 46·4	1·0	96
97	12 47·4	1·0	12 48·4	1·0	12 49·4	0·9	12 50·3	1·0	12 51·3	1·0	97
98	12 52·3	1·0	12 53·3	1·0	12 54·3	0·9	12 55·2	1·0	12 56·2	1·0	98
99	12 57·2	1·0	12 58·2	1·0	12 59·2	0·9	13 00·1	1·0	13 01·1	1·0	99
100	13 02·1	1·0	13 03·1	1·0	13 04·1	0·9	13 05·0	1·0	13 06·0	0·9	100
101	13 06·9	1·0	13 07·9	0·9	13 08·8	1·0	13 09·8	1·0	13 10·8	0·9	101
102	13 11·7	1·0	13 12·7	1·0	13 13·7	0·9	13 14·6	1·0	13 15·6	0·9	102
103	13 16·5	1·0	13 17·5	0·9	13 18·4	1·0	13 19·4	1·0	13 20·4	0·9	103
104	13 21·3	1·0	13 22·3	1·0	13 23·3	0·9	13 24·2	1·0	13 25·2	0·9	104
105	13 26·1	0·9	13 27·0	1·0	13 28·0	0·9	13 28·9	0·9	13 29·8	1·0	105
106	13 30·8	0·9	13 31·7	0·9	13 32·6	1·0	13 33·6	0·9	13 34·5	1·0	106
107	13 35·4	0·9	13 36·3	1·0	13 37·3	0·9	13 38·2	0·9	13 39·1	1·0	107
108	13 40·1	0·9	13 41·0	0·9	13 41·9	1·0	13 42·9	0·9	13 43·8	1·0	108
109	13 44·8	0·9	13 45·7	1·0	13 46·7	0·9	13 47·6	0·9	13 48·5	1·0	109
110	13 49·5	0·9	13 50·4	0·9	13 51·3	1·0	13 52·3	0·9	13 53·2	0·9	110
111	13 54·1	0·9	13 55·0	0·9	13 55·9	1·0	13 56·9	0·9	13 57·8	0·9	111
112	13 58·7	0·9	13 59·6	0·9	14 00·5	1·0	14 01·5	0·9	14 02·4	0·9	112
113	14 03·3	0·9	14 04·2	0·9	14 05·1	1·0	14 06·1	0·9	14 07·0	0·9	113
114	14 07·9	0·9	14 08·8	0·9	14 09·7	1·0	14 10·7	0·9	14 11·7	0·9	114
115	14 12·5	0·9	14 13·4	0·9	14 14·3	1·0	14 15·3	0·9	14 16·2	0·9	115
116	14 17·1	0·9	14 18·0	0·9	14 18·9	1·0	14 19·9	0·9	14 20·8	0·9	116
117	14 21·7	0·9	14 22·6	0·9	14 23·5	0·9	14 24·4	0·9	14 25·3	0·9	117
118	14 26·3	0·9	14 27·1	0·9	14 28·0	0·9	14 28·9	0·9	14 29·8	0·9	118
119	14 30·7	0·9	14 31·6	0·9	14 32·5	0·9	14 33·4	0·9	14 34·3	0·9	119
120	14 35·2	0·9	14 36·1	0·9	14 37·0	0·9	14 37·9	0·9	14 38·8	0·9	120

TABLE 2.

PR₁—P

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	11	13	14	16	17	19	21	23	26	28
3	31	33	36	39	43	47	51	55	59	63
4	67	71	75	79	83	87	91	95	99	103
5	106	110	114	118	122	125	129	132	136	139
6	143	146	150	153	156	160	163	166	168	171
7	173	176	178	180	182	184	187	189	191	193
8	195	197	199	202	204	206	208	210	212	214
9	215	217	219	221	223	225	227	229	231	232
10	234	236	237	239	241	242	244	246	247	249
11	250	252	254	256	257	259	261	262	263	265
12	266	268								

TABLE 3.

PR₂—P

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	17	18	20	22	24	26	28	30	33	36
3	39	42	45	49	53	58	63	68	72	77
4	82	87	92	97	102	107	112	117	122	127
5	133	138	143	149	154	160	165	170	176	181
6	187	192	198	203	208	214	219	224	230	235
7	241	246	251	257	262	267	272	277	282	287
8	292	297	301	306	311	315	320	324	329	333
9	338	342	346	350	354	359	363	367	371	375
10	379	382	385	388	392	395	398	401	404	407
11	410	413	416	419	422	425	428	430	433	436
12	439	442								

TABLE 4.

PS—P

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
2	2 00	2 05	2 11	2 18	2 25	2 32	2 39	2 46	2 53	3 01
3	3 08	3 15	3 23	3 31	3 39	3 47	3 55	4 04	4 13	4 21
4	4 30	4 39	4 47	4 55	5 03	5 11	5 19	5 27	5 36	5 44
5	5 52	6 00	6 07	6 15	6 22	6 30	6 38	6 45	6 52	6 59
6	7 06	7 13	7 20	7 27	7 34	7 40	7 46	7 53	7 59	8 04
7	8 10	8 15	8 21	8 26	8 32	8 37	8 42	8 47	8 52	8 57
8	9 02	9 07	9 12	9 17	9 22	9 27	9 32	9 37	9 42	9 47
9	9 51	9 55	9 59	10 04	10·09	10 13	10 18	10 23	10 28	10 32
10	10 36	10 40	10 44	10 49	10 54	10 58	11 02	11 07	11 11	11 15
11	11 19	11 24	11 28	11 33	11 37	11 42	11 46	11 50	11 55	11 59
12	12 03	12 07								

TABLE 5.

S—P

		1000 km.	2000 km.	3000 km.	4000 km.	5000 km.	6000 km.	7000 km.	8000 km.	9000 km.	10000 km.	11000 km.	12000 km.
km.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
0	**0** 0	**1** 48	**3** 23	**4** 43	**5** 47	**6** 42	**7** 36	**8** 29	**9** 20	**10** 10	**10** 58	**11** 41	**12** 21
10	1	49	24	44	48	43	37	30	20	11	59	41	21
20	2	50	25	44	48	43	37	30	21	12	59	42	22
30	3	51	26	45	49	44	38	31	21	12	59	42	22
40	4	52	28	46	49	44	38	31	22	13	**11** 0	43	22
50	6	53	28	47	50	45	39	32	22	13	0	43	23
60	7	54	28	47	51	45	39	32	23	14	1	43	23
70	8	55	29	48	51	46	40	33	23	14	1	44	24
80	9	56	30	49	52	47	40	33	24	15	2	44	24
90	10	57	31	50	52	47	41	34	24	15	2	45	24
100	11	58	32	50	53	48	41	34	25	16	2	45	25
10	12	59	33	51	53	48	42	35	25	16	3	45	25
20	13	**2** 0	34	52	54	49	43	35	26	17	3	46	25
30	15	1	35	52	55	49	43	36	26	17	4	46	26
40	16	2	35	53	55	50	44	36	27	18	4	47	26
50	17	3	36	54	56	50	44	37	27	18	5	47	26
60	18	4	37	54	56	51	45	37	28	19	5	47	27
70	19	5	38	55	57	51	45	38	28	19	6	48	27
80	20	6	39	56	57	52	46	38	29	20	6	48	28
90	21	7	39	57	58	53	46	39	29	20	7	49	28
200	22	8	40	58	58	53	47	39	30	20	7	49	28
10	23	9	41	58	59	54	47	40	30	21	7	50	29
20	24	10	42	58	**6** 0	54	48	40	31	21	8	50	29
30	26	11	43	59	0	55	48	41	31	22	8	50	30
40	27	12	44	0	1	55	49	41	32	23	9	51	30
50	28	13	44	1	1	56	50	42	32	23	9	51	30
60	29	14	45	1	2	56	50	42	33	23	10	51	31
70	30	15	46	2	2	57	51	43	33	23	10	52	31
80	31	16	47	3	3	57	51	43	34	24	11	52	31
90	32	17	48	4	4	58	52	44	34	25	11	53	32
300	33	18	49	5	4	58	52	44	35	25	11	53	32
10	34	19	49	5	5	59	53	45	35	26	12	53	32
20	36	20	50	5	5	**7** 0	53	45	36	26	12	54	33
30	37	21	51	6	6	0	54	46	36	27	13	54	33
40	38	22	52	7	6	1	54	46	37	27	13	55	34
50	39	23	53	7	7	1	55	47	37	28	14	55	34
60	40	24	54	8	7	2	55	47	38	28	14	55	34
70	41	25	55	9	8	2	56	48	38	29	15	56	35
80	42	25	55	9	9	3	57	48	39	29	15	56	35
90	43	26	56	10	10	3	57	49	40	30	15	57	35
400	44	27	57	10	10	4	58	50	40	30	16	57	36
10	45	28	58	11	10	4	58	50	40	31	16	57	36
20	46	29	59	12	11	5	59	51	41	31	17	58	36
30	47	30	59	13	11	5	59	51	42	32	17	58	37
40	49	31	**4** 0	13	12	6	**8** 0	52	42	32	18	59	37
50	50	32	1	14	12	7	0	52	43	33	18	59	37
60	51	33	2	14	13	7	1	53	43	33	18	**12** 0	38
70	52	34	3	15	13	8	1	53	44	34	19	0	38
80	53	35	4	16	14	8	2	54	44	34	19	0	38
90	54	36	4	16	15	9	2	54	45	35	20	1	39

TABLE 5—*Concluded.*

S—P

		1000 km.	2000 km.	3000 km.	4000 km.	5000 km.	6000 km.	7000 km.	8000 km.	9000 km.	10000 km.	11000 km.	12000 km.
km.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
500	0 55	2 37	4 5	5 17	6 15	7 9	8 3	8 55	9 45	10 35	11 20	12 1	12 39
10	56	38	6	18	15	10	3	55	46	36	20	1	39
20	57	39	7	18	16	10	4	55	46	36	21	2	40
30	58	40	7	19	16	11	5	56	46	37	21	2	40
40	59	41	8	20	17	12	5	57	47	37	22	3	40
50	1 1	42	9	20	17	12	6	57	48	37	22	3	41
60	2	43	10	21	18	13	6	58	48	38	23	3	41
70	3	44	11	21	19	13	7	58	49	38	23	4	42
80	4	45	11	22	19	14	7	59	49	39	24	4	42
90	5	45	12	23	20	14	8	59	50	39	24	5	42
600	6	46	13	24	20	15	8	9 0	50	40	24	5	43
10	7	47	14	24	21	15	9	0	51	40	25	5	43
20	8	48	15	25	21	16	9	1	51	41	25	6	43
30	9	49	15	26	22	16	10	1	52	41	26	6	44
40	10	50	16	26	23	17	10	2	52	42	26	7	44
50	11	51	17	26	23	17	11	2	53	42	27	7	44
60	12	52	18	27	24	18	11	3	53	43	27	7	45
70	13	53	18	28	24	18	12	3	54	43	27	8	45
80	15	54	19	28	25	19	12	4	54	44	28	8	45
90	16	55	20	29	25	20	13	4	55	44	28	9	46
700	16	56	21	30	26	20	13	5	55	45	29	9	46
10	18	57	21	30	26	21	14	5	56	45	29	10	46
20	19	58	22	31	27	21	15	6	56	45	30	10	47
30	20	59	23	31	28	22	15	6	57	46	30	10	47
40	21	3 0	24	32	28	22	15	7	57	46	30	11	47
50	22	0	24	33	29	23	16	7	58	47	31	11	48
60	23	1	25	33	29	23	17	8	58	47	31	12	48
70	24	2	26	34	30	24	17	8	59	48	32	12	48
80	25	3	27	34	30	24	18	9	59	48	32	12	49
90	26	4	28	35	31	25	18	9	10 0	49	32	13	49
800	27	5	28	35	31	25	19	10	0	49	33	13	49
10	28	6	29	36	32	26	19	10	0	49	33	14	50
20	29	7	30	37	32	26	20	11	1	50	34	14	50
30	30	8	30	37	33	27	20	11	2	50	34	14	50
40	31	9	31	38	34	27	21	12	2	51	34	15	51
50	32	10	32	39	34	28	21	12	3	51	35	15	51
60	33	11	33	39	35	28	22	13	3	52	35	15	51
70	34	12	34	40	35	29	22	13	4	52	36	16	52
80	36	12	34	40	36	30	23	14	4	53	36	16	52
90	37	13	35	41	36	30	23	14	5	53	36	17	53
900	38	14	36	41	37	31	24	15	5	54	37	17	53
10	39	15	36	42	37	31	24	15	6	54	37	17	53
20	40	16	37	43	38	32	25	16	6	54	38	18	54
30	41	17	38	43	38	32	25	16	7	55	38	18	54
40	42	18	39	44	39	33	26	17	7	55	38	19	54
50	43	19	39	44	39	33	26	17	8	56	39	19	55
60	44	19	40	45	40	34	27	18	8	56	39	19	55
70	45	20	41	45	41	34	27	18	9	57	40	20	55
80	46	21	42	46	41	35	28	19	9	57	40	20	55
90	47	22	42	47	42	35	28	19	10	58	41	21	56
1000	48	23	43	47	42	36	29	20	10	58	41	21	56

TABLE 6.

S−O or *Is*

Δ in 100 km.	00	20	40	60	80	Δ in 100 km.
	m. s.	m. s.	m. s.	m. s.	m. s.	
2	52	57	1 02	1 07	1 12	2
3	1 16	1 21	1 26	1 31	1 35	3
4	1 40	1 44	1 49	1 54	1 59	4
5	2 03	2 08	2 13	2 18	2 23	5
6	2 27	2 32	2 36	2 41	2 46	6
7	2 50	2 55	3 00	3 05	3 09	7
8	3 14	3 18	3 23	3 27	3 32	8
9	3 37	3 42	3 46	3 51	3 55	9
10	4 00	4 04	4 09	4 13	4 18	10
11	4 22	4 27	4 31	4 36	4 40	11
12	4 45	4 49	4 54	4 58	5 03	12
13	5 07	5 12	5 16	5 21	5 25	13
14	5 29	5 33	5 38	5 42	5 46	14
15	5 51	5 55	5 59	6 04	6 08	15
16	6 12	6 16	6 20	6 25	6 29	16
17	6 34	6 38	6 42	6 46	6 50	17
18	6 54	6 59	7 03	7 07	7 11	18
19	7 15	7 19	7 23	7 27	7 31	19
20	7 35	7 40	7 44	7 48	7 52	20
21	7 56	8 00	8 04	8 07	8 11	21
22	8 15	8 19	8 23	8 27	8 31	22
23	8 35	8 38	8 42	8 46	8 50	23
24	8 54	8 58	9 01	9 05	9 09	24
25	9 13	9 16	9 19	9 23	9 27	25
26	9 31	9 35	9 38	9 42	9 45	26
27	9 49	9 52	9 56	9 59	10 03	27
28	10 06	10 10	10 13	10 16	10 19	28
29	10 23	10 26	10 30	10 33	10 37	29
30	10 40	10 43	10 46	10 49	10 53	30
31	10 56	11 00	11 03	11 06	11 09	31
32	11 13	11 16	11 19	11 22	11 25	32
33	11 28	11 31	11 34	11 37	11 40	33
34	11 42	11 45	11 48	11 51	11 54	34
35	11 57	12 00	12 03	12 06	12 09	35
36	12 12	12 15	12 17	12 19	12 22	36
37	12 25	12 28	12 31	12 33	12 36	37
38	12 38	12 41	12 44	12 47	12 49	38
39	12 52	12 55	12 58	13 00	13 03	39
40	13 05	13 08	13 10	13 13	13 16	40

TABLE 6—*Continued.*

S–O or *Is*

Δ in 100 km.	00	20	40	60	80	Δ in 100 km.
	m. s.	m. s.	m. s.	m. s.	m. s.	
41	13 18	13 21	13 23	13 26	13 28	41
42	13 31	13 34	13 37	13 39	13 41	42
43	13 44	13 46	13 49	13 51	13 54	43
44	13 57	13 59	14 02	14 04	14 07	44
45	14 09	14 11	14 14	14 16	14 19	45
46	14 21	14 23	14 26	14 29	14 31	46
47	14 34	14 36	14 39	14 41	14 43	47
48	14 46	14 48	14 51	14 54	14 56	48
49	14 58	15 01	15 03	15 05	15 08	49
50	15 10	15 12	15 15	15 17	15 20	50
51	15 22	15 25	15 27	15 29	15 32	51
52	15 34	15 36	15 39	15 41	15 43	52
53	15 45	15 48	15 51	15 53	15 55	53
54	15 58	16 00	16 02	16 04	16 07	54
55	16 09	16 11	16 14	16 17	16 19	55
56	16 21	16 24	16 26	16 28	16 30	56
57	16 33	16 35	16 37	16 39	16 42	57
58	16 44	16 46	16 48	16 50	16 53	58
59	16 56	16 58	17 00	17 02	17 04	59
60	17 07	17 09	17 11	17 13	17 15	60
61	17 18	17 21	17 23	17 25	17 27	61
62	17 29	17 32	17 34	17 36	17 38	62
63	17 40	17 42	17 45	17 47	17 50	63
64	17 52	17 54	17 56	17 58	18 00	64
65	18 03	18 05	18 07	18 09	18 11	65
66	18 13	18 15	18 18	18 20	18 22	66
67	18 24	18 26	18 28	18 31	18 33	67
68	18 36	18 38	18 40	18 42	18 44	68
69	18 46	18 48	18 50	18 52	18 54	69
70	18 57	18 59	19 01	19 03	19 05	70
71	19 07	19 09	19 11	19 13	19 15	71
72	19 17	19 20	19 22	19 24	19 26	72
73	19 28	19 30	19 32	19 34	19 36	73
74	19 39	19 41	19 43	19 45	19 48	74
75	19 50	19 52	19 54	19 56	19 58	75
76	20 00	20 02	20 04	20 06	20 08	76
77	20 10	20 12	20 14	20 16	20 18	77
78	20 20	20 23	20 25	20 27	20 29	78
79	20 31	20 33	20 35	20 37	20 39	79
80	20 41	20 43	20 45	20 47	20 49	80

TABLE 6—*Concluded.*

S—O or *Is*

Δ in 100 km.	00	20	40	60	80	Δ in 100 km.
	m. s.	m. s.	m. s.	m. s.	m. s.	
81	20 51	20 53	20 55	20 57	20 59	81
82	21 01	21 03	21 06	21 08	21 10	82
83	21 12	21 14	21 16	21 18	21 20	83
84	21 22	21 24	21 26	21 28	21 30	84
85	21 32	21 34	21 36	21 38	21 40	85
86	21 42	21 44	21 46	21 48	21 50	86
87	21 52	21 54	21 56	21 58	22 00	87
88	22 02	22 04	22 06	22 08	22 10	88
89	22 12	22 14	22 16	22 19	22 21	89
90	22 23	22 26	22 28	22 30	22 32	90
91	22 34	22 36	22 38	22 40	22 42	91
92	22 43	22 45	22 47	22 49	22 51	92
93	22 53	22 55	22 57	22 59	23 01	93
94	23 03	23 05	23 07	23 09	23 11	94
95	23 13	23 15	23 17	23 18	23 20	95
96	23 22	23 24	23 26	23 28	23 30	96
97	23 32	23 34	23 35	23 37	23 39	97
98	23 41	23 43	23 45	23 47	23 49	98
99	23 51	23 53	23 54	23 56	23 58	99
100	24 00	24 02	24 04	24 06	24 08	100
101	24 09	24 11	24 13	24 15	24 17	101
102	24 19	24 21	24 23	24 25	24 27	102
103	24 28	24 30	24 31	24 33	24 35	103
104	24 37	24 39	24 41	24 43	24 44	104
105	24 46	24 48	24 50	24 52	24 54	105
106	24 55	24 57	24 59	25 01	25 03	106
107	25 04	25 06	25 08	25 10	25 11	107
108	25 13	25 15	25 16	25 18	25 20	108
109	25 22	25 24	25 25	25 27	25 29	109
110	25 31	25 32	25 34	25 36	25 37	110
111	25 39	25 41	25 43	25 44	25 46	111
112	25 48	25 50	25 52	25 53	25 54	112
113	25 56	25 58	26 00	26 01	26 03	113
114	26 05	26 07	26 09	26 11	26 12	114
115	26 14	26 15	26 17	26 19	26 20	115
116	26 22	26 24	26 26	26 27	26 29	116
117	26 31	26 33	26 35	26 36	26 38	117
118	26 39	26 41	26 43	26 44	26 46	118
119	26 48	26 50	26 52	26 53	26 54	119
120	26 56	26 58	26 59	27 01	27 03	120

TABLE 7.

$SR_1 - S$

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	24	27	30	33	36	40	44	48	52	57
3	62	67	72	78	84	90	97	105	112	119
4	126	134	141	147	154	161	168	175	182	188
5	194	200	206	212	219	225	231	237	242	247
6	253	258	263	268	273	278	283	287	291	295
7	299	303	307	310	313	316	319	322	325	327
8	329	332	335	338	340	343	346	348	351	354
9	356	358	360	363	366	368	370	373	376	378
10	380	383	386	389	391	394	397	400	403	406
11	409	412	415	418	420	423	426	429	432	435
12	437	440								

TABLE 8.

$SR_2 - S$

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
2	32	36	40	44	48	52	57	62	68	74
3	80	86	92	99	107	115	123	131	140	149
4	159	168	177	185	194	203	213	222	230	239
5	249	258	268	277	286	295	304	312	321	329
6	338	348	358	367	376	384	392	400	409	418
7	426	435	443	452	460	467	475	483	491	499
8	507	515	522	529	536	543	550	557	564	570
9	576	582	589	595	602	608	614	621	627	633
10	639	644	649	654	659	665	671	677	682	687
11	692	697	702	706	710	715	720	725	730	735
12	739	743								

TABLE 9.

L−P

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
2	4 34	4 49	5 04	5 19	5 34	5 50	6 06	6 22	6 39	6 56
3	7 12	7 29	7 47	8 04	8 22	8 41	8 59	9 17	9 36	9 55
4	10 15	10 34	10 53	11 12	11 31	11 51	12 10	12 29	12 49	13 09
5	13 28	13 48	14 08	14 28	14 47	15 08	15 28	15 48	16 08	16 28
6	16 48	17 08	17 29	17 50	18 10	18 31	18 52	19 12	19 33	19 54
7	20 14	20 35	20 56	21 17	21 38	21 59	22 20	22 41	23 02	23 23
8	23 44	24 05	24 26	24 47	25 08	25 30	25 51	26 12	26 34	26 55
9	27 16	27 37	27 58	28 19	28 40	29 02	29 23	29 45	30 07	30 28
10	30 50	31 11	31 33	31 55	32 16	32 38	32 59	33 21	33 43	34 04
11	34 26	34 47	35 09	35 31	35 52	36 14	36 36	36 57	37 19	37 41
12	38 03	38 24								

TABLE 10.

L−S

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
2	1 11	1 17	1 24	1 30	1 37	1 45	1 53	2 02	2 11	2 20
3	2 29	2 39	2 49	3 00	3 12	3 24	3 36	3 48	4 01	4 14
4	4 28	4 41	4 55	5 08	5 22	5 36	5 50	6 04	6 18	6 32
5	6 46	7 00	7 15	7 30	7 44	7 59	8 13	8 27	8 42	8 57
6	9 12	9 27	9 43	9 58	10 13	10 28	10 44	10 59	11 14	11 30
7	11 45	12 01	12 17	12 33	12 49	13 04	13 20	13 36	13 52	14 08
8	14 24	14 40	14 56	15 12	15 28	15 45	16 01	16 17	16 34	16 50
9	17 06	17 22	17 38	17 54	18 10	18 27	18 44	19 00	19 17	19 34
10	19 52	20 09	20 26	20 43	21 00	21 18	21 35	21 52	22 10	22 27
11	22 44	23 02	23 20	23 38	23 55	24 13	24 31	24 48	25 06	25 24
12	25 42	25 59								

TABLE 11.

$L-O$ or I_L

Δ in 1000 km.	0	1	2	3	4	5	6	7	8	9
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
2...............	8 46	9 12	9 39	10 05	10 31	10 58	11 24	11 50	12 17	12 43
3...............	13 09	13 35	14 02	14 28	14 54	15 21	15 47	16 13	16 40	17 06
4...............	17 33	17 59	18 26	18 52	19 18	19 45	20 11	20 37	21 04	21 30
5...............	21 56	22 22	22 49	23 15	23 41	24 08	24 34	25 00	25 27	25 53
6...............	26 19	26 45	27 12	27 38	28 04	28 31	28 57	29 23	29 50	30 16
7...............	30 42	31 08	31 35	32 01	32 27	32 54	33 20	33 46	34 13	34 39
8...............	35 05	35 31	35 58	36 24	36 50	37 17	37 43	38 09	38 36	39 02
9...............	39 28	39 54	40 21	40 47	41 13	41 40	42 06	42 32	42 59	43 25
10...............	43 52	44 18	44 45	45 11	45 37	46 04	46 30	46 56	47 23	47 49
11...............	48 15	48 41	49 08	49 34	50 00	50 27	50 53	51 19	51 46	52 12
12...............	52 38	53 04								

TABLE 12.

ANGLE OF EMERGENCE.

Δ in 100 km.	e_0	ϵ	$e_0-\epsilon$	Δ in 100 km.	e_0	ϵ	$e_0-\epsilon$
	° ′	° ′	° ′		° ′	° ′	° ′
0............	0 00	0 00	0 00	65.........	64 59	29 14	35 45
5............	10 40	2 15	8 25	70.........	65 18	31 29	33 49
10............	20 40	4 30	16 12	75.........	65 42	33 43	31 59
15............	29 37	6 45	22 52	80.........	66 11	35 58	30 13
20............	37 15	9 00	28 15	85.........	66 45	38 13	28 32
25............	43 40	11 14	32 26	90.........	67 22	40 28	26 54
30............	49 03	13 29	35 34	95.........	68 03	42 43	25 20
35............	53 16	15 44	37 32	100.........	68 48	44 58	23 50
40............	56 47	17 59	38 48	105.........	69 34	47 13	22 21
45............	60 01	20 14	39 47	110.........	70 23	49 28	20 55
50............	62 48	22 29	40 19	115.........	71 17	51 43	19 34
55............	64 42	24 44	39 58	120.........	72 13	53 58	18 15
60............	64 47	26 59	37 48	125.........	73 11	56 12	16 59

TABLE 13.

CHORD AND MIDDLE ORDINATE.

Arc.		Chord.	Middle Ordinate.	Arc.		Chord.	Middle Ordinate.
1000 km.	Angle.			1000 km.	Angle.		
	° ′				° ′		
·25	2 15	250	2	10·25	92 15	9,183	1,955
·5	4 30	500	5	10·5	94 30	9,355	2,046
·75	6 45	750	11	10·75	96 45	9,524	2,138
1	9 00	1,000	20	11	99 00	9,688	2,233
1·25	11 15	1,249	31	11·25	101 15	9,849	2,329
1·5	13 30	1,497	44	11·5	103 30	10,005	2,426
1·75	15 45	1,745	60	11·75	105 45	10,158	2,525
2	18 00	1,993	78	12	108 00	10,307	2,626
2·25	20 15	2,240	99	12·25	110 15	10,452	2,728
2·5	22 30	2,486	122	12·5	112 30	10,593	2,831
2·75	24 45	2,730	148	12·75	114 45	10,730	2,936
3	27 00	2,974	176	13	117 00	10,863	3,042
3·25	29 15	3,217	207	13·25	119 15	10,991	3,149
3·5	31 30	3,458	239	13·5	121 30	11,116	3,257
3·75	33 45	3,698	274	13·75	123 45	11,236	3,367
4	36 00	3,937	312	14	126 00	11,351	3,478
4·25	38 15	4,175	352	14·25	128 15	11,463	3,590
4·5	40 30	4,410	394	14·5	130 30	11,570	3,703
4·75	42 45	4,644	438	14·75	132 45	11,672	3,817
5	45 00	4,876	485	15	135 00	11,770	3,932
5·25	47 15	5,106	534	15·25	137 15	11,864	4,048
5·5	49 30	5,334	585	15·5	139 30	11,953	4,165
5·75	51 45	5,560	639	15·75	141 45	12,037	4,283
6	54 00	5,784	694	16	144 00	12,117	4,402
6·25	56 15	6,006	752	16·25	146 15	12,191	4,521
6·5	58 30	6,225	812	16·5	148 30	12,262	4,641
6·75	60 45	6,442	875	16·75	150 45	12,327	4,762
7	63 00	6,657	939	17	153 00	12,388	4,883
7·25	65 15	6,869	1,005	17·25	155 15	12,445	5,005
7·5	67 30	7,078	1,073	17·5	157 30	12,495	5,127
7·75	69 45	7,285	1,144	17·75	159 45	12,541	5,250
8	72 00	7,489	1,217	18	162 00	12,583	5,374
8·25	74 15	7,690	1,291	18·25	164 15	12,620	5,497
8·5	76 30	7,887	1,367	18·5	166 30	12,652	5,622
8·75	78 45	8,082	1,446	18·75	168 45	12,679	5,746
9	81 00	8,274	1,526	19	171 00	12,701	5,870
9·25	83 15	8,463	1,608	19·25	173 15	12,718	5,995
9·5	85 30	8,648	1,692	19·5	175 30	12,730	6,120
9·75	87 45	8,830	1,778	19·75	177 45	12,737	6,245
10	90 00	9,008	1,866	20	180 00	12,740	6,370

TABLE 14.

STEREOGRAPHIC PROJECTION TABLES.

The following tables are for facilitating the plotting of epicentres, that is, determining their geographical position, by means of the stereographic projection. The distance, Δ, from any station to the epicentre is obtained from the seismogram, from the difference of time of arrival of the first and second preliminary tremors.

In the tables $d = \dfrac{\cos \varphi}{\sin \varphi + \cos \Delta}$ $\quad r = \dfrac{\sin \Delta}{\sin \varphi + \cos \Delta}$

φ = latitude, Δ = distance expressed in arc, 10,000 km. = 90°. The modus operandi is very simple. A circle is described with a radius, say of 10 cm. A radius is taken as the meridian of Greenwich, to which all longitudes are referred. Other radii, generally three, are drawn representing the meridians of the stations utilized for locating the epicentre. Along each is then laid off its respective d from the centre, and from the point so found an arc is described with radius r for that station. The intersection of the arcs gives the position of the epicentre. The longitude of the latter is obtained directly by reading the angle between the radius running through it, and the Greenwich meridian; while the latitude is found by measuring the distance from the centre of the primary circle to the epicentre, and this distance is equal to $\tan\,(45° - \tfrac{1}{2}\varphi_0)$, where φ_0 is the latitude of the epicentre.

It may be stated that the numbers given for d and r in the table are in units of the radius, taken at 1000 units, of the primary circle.

Distance.	Aachen $\varphi=50° 46'$ $\lambda=6° 05'$ E.		Agram $\varphi=45° 49'$ $\lambda=15° 59'$ E.		Albany $\varphi=42° 39'$ $\lambda=73° 45'$ W.		Ann Arbor $\varphi=42° 17'$ $\lambda=83° 44'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	359	89	409	92	442	94	446	94
1,250	360	111	411	115	444	118	447	118
1,500	362	134	413	138	446	141	450	142
1,750	364	156	415	162	448	165	452	166
2,000	367	179	418	185	452	190	456	190
2,250	369	202	421	209	455	214	459	215
2,500	372	225	425	233	459	239	463	240
2,750	376	249	429	258	464	264	468	265
3,000	380	273	433	282	469	289	473	290
3,250	384	297	438	307	475	315	479	316
3,500	389	321	444	333	481	341	485	343
3,750	394	346	450	359	487	368	492	369
4,000	399	371	457	385	495	395	499	397
4,250	405	397	464	412	503	423	507	425
4,500	412	423	472	440	512	452	516	453
4,750	419	450	480	468	521	481	526	482
5,000	426	477	489	496	531	511	536	512
5,250	435	505	499	526	542	541	547	543
5,500	444	534	510	556	554	573	560	575
5,750	454	563	522	588	567	606	573	608
6,000	464	594	534	620	581	639	587	642
6,250	475	625	548	653	596	674	602	677
6,500	488	657	562	688	613	710	619	713
6,750	501	691	578	724	631	748	637	751
7,000	515	725	595	761	650	787	657	791
7,250	530	761	614	800	671	828	678	832
7,500	546	798	634	840	694	871	701	875
7,750	564	837	656	882	719	917	726	921
8,000	584	878	679	927	746	964	754	969
8,250	605	920	705	974	775	1,014	784	1,019
8,500	627	965	733	1,023	807	1,067	816	1,073
8,750	652	1,011	764	1,075	843	1,124	852	1,130
9,000	679	1,061	798	1,131	882	1,184	892	1,191
9,250	709	1,113	835	1,190	925	1,249	936	1,257
9,500	741	1,169	876	1,253	973	1,319	985	1,327
9,750	777	1,228	921	1,321	1,026	1,394	1,039	1,403
10,000	817	1,291	972	1,395	1,086	1,476	1,100	1,486
10,250	860	1,359	1,028	1,474	1,152	1,566	1,168	1,577
10,500	909	1,433	1,091	1,561	1,228	1,664	1,245	1,677
10,750	963	1,511	1,162	1,656	1,313	1,773	1,332	1,788
11,000	1,023	1,598	1,243	1,762	1,411	1,895	1,433	1,913
11,250	1,091	1,692	1,335	1,879	1,525	2,033	1,549	2,053
11,500	1,169	1,797	1,441	2,010	1,656	2,190	1,684	2,213
11,750	1,257	1,913	1,564	2,160	1,811	2,370	1,843	2,398
12,000	1,358	2,043	1,708	2,331	1,996	2,581	2,034	2,614
12,250	1,476	2,189	1,879	2,529	2,219	2,831	2,264	2,872
12,500	1,614	2,357	2,084	2,763	2,495	3,134	2,550	3,185
12,750	1,777	2,552	2,336	3,043	2,842	3,509	2,911	3,574
13,000	1,973	2,779	2,649	3,387	3,291	3,987	3,381	4,072

Distance.	Athens $\varphi=37° 58'$ $\lambda=23° 43'$ E.		Baku $\varphi=40° 23'$ $\lambda=49° 54'$ E.		Balboa Heights $\varphi=8° 58'$ $\lambda=79° 33'$ W.		Barcelona $\varphi=41° 25'$ $\lambda=2° 08'$ E.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	492	98	466	96	864	137	454	95
1,250	494	122	468	120	869	172	456	119
1,500	497	147	470	144	876	207	459	143
1,750	500	172	473	169	883	243	462	167
2,000	503	197	476	193	892	279	465	192
2,250	508	223	480	218	903	316	469	216
2,500	512	249	485	243	915	354	473	241
2,750	518	275	490	269	928	393	478	267
3,000	523	301	495	295	944	434	483	292
3,250	530	328	501	321	961	475	489	318
3,500	537	356	508	348	979	518	495	345
3,750	545	384	515	376	1,001	563	502	372
4,000	554	413	523	403	1,024	609	510	399
4,250	563	442	531	432	1,050	658	518	428
4,500	573	472	541	461	1,078	709	527	456
4,750	584	503	551	491	1,110	763	537	486
5,000	596	535	562	522	1,145	819	548	516
5,250	609	567	574	553	1,183	880	559	547
5,500	623	601	587	586	1,227	944	572	580
5,750	639	636	601	620	1,275	1,013	585	613
6,000	655	672	616	655	1,328	1,088	601	647
6,250	673	710	633	691	1,388	1,169	616	683
6,500	693	749	650	728	1,456	1,257	633	720
6,750	714	790	670	768	1,533	1,354	652	758
7,000	737	833	691	809	1,620	1,461	672	798
7,250	763	878	714	851	1,719	1,581	694	840
7,500	790	926	739	896	1,834	1,716	718	884
7,750	820	976	766	944	1,968	1,869	744	930
8,000	853	1,029	796	994	2,125	2,046	773	979
8,250	889	1,086	829	1,047	2,312	2,252	804	1,032
8,500	929	1,146	864	1,103	2,537	2,498	838	1,087
8,750	973	1,210	904	1,163	2,815	2,795	875	1,145
9,000	1,022	1,280	947	1,228	3,163	3,163	916	1,207
9,250	1,076	1,355	995	1,297	3,613	3,632	962	1,275
9,500	1,137	1,437	1,049	1,372	4,216	4,255	1,013	1,347
9,750	1,205	1,527	1,109	1,454	5,062	5,121	1,069	1,425
10,000	1,282	1,625	1,176	1,543	6,338	6,416	1,133	1,511
10,250	1,369	1,735	1,252	1,642	....	....	1,204	1,605
10,500	1,469	1,857	1,338	1,751	....	....	1,286	1,709
10,750	1,584	1,995	1,436	1,872	....	....	1,377	1,825
11,000	1,718	2,153	1,550	2,010	....	....	1,484	1,955
11,250	1,877	2,335	1,682	2,166	....	....	1,606	2,102
11,500	2,065	2,547	1,838	2,346	....	....	1,750	2,271
11,750	2,293	2,800	2,023	2,557	....	....	1,920	2,467
12,000	2,575	3,106	2,248	2,806	....	....	2,128	2,698
12,250	2,930	3,486	2,524	3,109	....	....	2,377	2,975
12,500	3,391	3,974	2,872	3,483	....	....	2,688	3,312
12,750	4,012	4,621	3,323	3,962	....	....	3,090	3,740
13,000	4,891	5,527	3,920	4,595	....	....	3,630	4,293

Distance.	Basel $\varphi=47° 34'$ $\lambda=7° 35'$ E.		Batavia $\varphi=6° 11'$ S. $\lambda=106° 50'$ E.		Belgrade $\varphi=44° 49'$ $\lambda=20° 27'$ E.		Berkeley $\varphi=37° 52'$ $\lambda=122° 16'$ W.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	391	91	1,130	178	419	92	493	98
1,250	393	114	1,139	223	421	116	495	122
1,500	394	136	1,150	270	423	139	498	147
1,750	397	160	1,163	318	425	163	501	172
2,000	399	183	1,179	366	428	187	504	197
2,250	402	206	1,197	417	432	211	509	223
2,500	406	230	1,218	469	436	235	513	249
2,750	410	254	1,242	523	440	260	519	275
3,000	414	279	1,269	580	445	284	525	302
3,250	419	303	1,300	639	450	310	531	329
3,500	424	328	1,335	701	455	335	538	356
3,750	430	354	1,374	768	462	362	546	384
4,000	436	380	1,418	838	469	388	555	413
4,250	443	406	1,467	914	476	415	564	442
4,500	450	433	1,523	995	484	443	574	473
4,750	458	461	1,587	1,083	493	472	586	504
5,000	467	489	1,659	1,180	502	501	598	535
5,250	476	518	1,741	1,286	513	531	611	568
5,500	486	548	1,835	1,404	524	561	625	602
5,750	497	579	1,944	1,536	536	593	640	637
6,000	509	610	2,071	1,685	549	626	657	673
6,250	522	643	2,220	1,857	563	660	675	711
6,500	535	676	2,397	2,055	578	695	695	750
6,750	550	711	2,610	2,291	594	731	716	791
7,000	566	747	2,871	2,573	612	769	739	834
7,250	583	785	3,197	2,920	631	808	765	880
7,500	602	824	3,616	3,360	652	850	792	927
7,750	622	865	4,170	3,935	675	893	822	977
8,000	644	908	4,939	4,725	700	938	855	1,031
8,250	668	953	....	....	727	986	892	1,087
8,500	694	1,001	....	....	756	1,036	932	1,148
8,750	723	1,051	....	....	788	1,090	976	1,213
9,000	754	1,104	....	....	824	1,147	1,025	1,282
9,250	789	1,161	....	....	863	1,208	1,079	1,358
9,500	826	1,221	....	....	906	1,273	1,140	1,440
9,750	868	1,285	....	....	953	1,343	1,209	1,530
10,000	914	1,355	....	....	1,006	1,419	1,286	1,629
10,250	966	1,430	....	....	1,066	1,501	1,374	1,739
10,500	1,023	1,511	....	....	1,133	1,592	1,475	1,862
10,750	1,087	1,600	....	....	1,208	1,691	1,591	2,001
11,000	1,160	1,698	....	....	1,294	1,801	1,726	2,159
11,250	1,243	1,806	....	....	1,392	1,924	1,885	2,342
11,500	1,337	1,927	....	....	1,505	2,063	2,075	2,556
11,750	1,446	2,062	....	....	1,637	2,221	2,305	2,811
12,000	1,572	2,216	....	....	1,792	2,403	2,590	3,120
12,250	1,721	2,393	....	....	1,978	2,616	2,949	3,505
12,500	1,898	2,600	....	....	2,202	2,868	3,416	3,998
12,750	2,112	2,843	....	....	2,479	3,174	4,046	4,655
13,000	2,375	3,136	....	....	2,828	3,553	4,940	5,576

Distance.	de Bilt $\varphi=52°\ 06'$ $\lambda=5°\ 11'$ E.		Budapest $\varphi=47°\ 29'$ $\lambda=19°\ 04'$ E.		Capetown $\varphi=33°\ 56'$ S $\lambda=18°\ 29'$ E.		Cartuja $\varphi=37°\ 11'$ $\lambda=3°\ 36'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	346	88	392	91	1,932	364	500	98
1,250	347	110	393	114	1,963	462	503	123
1,500	349	133	395	137	2,003	563	505	148
1,750	351	155	398	160	2,052	671	508	173
2,000	353	178	400	183	2,112	786	512	199
2,250	356	200	403	207	2,183	911	516	224
2,500	359	223	407	230	2,269	1,046	521	250
2,750	362	247	411	254	2,371	1,197	527	277
3,000	366	270	415	279	2,493	1,364	533	304
3,250	370	294	420	304	2,640	1,555	539	331
3,500	374	318	425	329	2,818	1,775	547	359
3,750	379	343	431	354	3,036	2,033	555	387
4,000	384	368	437	380	3,308	2,344	564	416
4,250	390	393	444	407	3,653	2,726	573	445
4,500	396	419	451	434	4,103	3,212	584	476
4,750	403	446	459	461	....	....	595	507
5,000	411	473	468	490	....	....	607	539
5,250	418	500	477	519	....	....	621	572
5,500	427	529	487	548	....	....	635	606
5,750	436	558	498	579	....	....	651	642
6,000	446	588	510	611	....	....	668	679
6,250	457	618	523	643	....	....	687	717
6,500	468	650	537	677	....	....	707	757
6,750	481	683	551	712	....	....	729	798
7,000	494	717	567	748	....	....	753	842
7,250	509	752	585	786	....	....	779	888
7,500	524	788	604	825	....	....	807	936
7,750	541	826	624	866	....	....	838	987
8,000	559	866	646	909	....	....	872	1,041
8,250	579	908	670	954	....	....	909	1,098
8,500	601	951	696	1,002	....	....	951	1,161
8,750	624	997	725	1,052	....	....	996	1,227
9,000	650	1,045	756	1,105	....	....	1,047	1,298
9,250	678	1,095	791	1,162	....	....	1,104	1,376
9,500	708	1,149	829	1,222	....	....	1,167	1,460
9,750	742	1,206	870	1,287	....	....	1,238	1,552
10,000	778	1,267	917	1,357	....	....	1,318	1,654
10,250	819	1,333	971	1,432	....	....	1,410	1,768
10,500	864	1,403	1,026	1,514	....	....	1,515	1,896
10,750	915	1,479	1,091	1,603	....	....	1,636	2,040
11,000	971	1,561	1,164	1,701	....	....	1,778	2,205
11,250	1,034	1,651	1,247	1,810	....	....	1,946	2,396
11,500	1,105	1,750	1,342	1,931	....	....	2,147	2,621
11,750	1,187	1,859	1,451	2,067	....	....	2,392	2,890
12,000	1,280	1,981	1,579	2,222	....	....	2,697	3,220
12,250	1,387	2,118	1,728	2,391	....	....	3,084	3,632
12,500	1,512	2,273	1,907	2,607	....	....	3,594	4,167
12,750	1,658	2,452	2,122	2,852	....	....	4,290	4,890
13,000	1,833	2,659	2,387	3,147	....	....	5,297	5,924

Distance.	Cleveland $\varphi=41° 29'$ $\lambda=81° 42'$ W.		Czernowitz $\varphi=48° 18'$ $\lambda=25° 56'$ E.		Denver $\varphi=39° 41'$ $\lambda=104° 57'$ W.		Disko $\varphi=69° 15'$ $\lambda=53° 23'$ W.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	454	95	384	90	473	96	184	81
1,250	456	119	385	113	476	120	185	102
1,500	458	143	387	136	478	145	186	122
1,750	461	167	389	159	481	169	187	143
2.000	464	192	392	182	484	194	188	164
2,250	468	216	395	205	488	219	189	185
2,500	472	241	398	229	493	245	191	206
2,750	477	267	402	253	498	271	192	227
3,000	482	292	406	277	503	297	194	249
3,250	488	318	411	302	509	323	196	270
3,500	494	345	416	327	516	350	198	292
3,750	501	372	422	352	524	378	201	315
4,000	509	399	428	378	532	406	203	337
4,250	517	428	434	404	540	435	206	360
4,500	526	456	441	431	550	464	209	383
4,750	536	486	449	458	561	494	212	407
5,000	547	516	458	486	572	525	216	431
5,250	558	547	467	515	584	557	220	455
5,500	571	580	477	545	598	590	224	480
5,750	585	613	487	575	612	624	228	505
6,000	599	647	499	606	628	660	233	531
6,250	615	683	511	639	645	696	238	558
6,500	632	720	524	672	663	734	243	585
6,750	651	758	539	706	683	774	249	613
7,000	671	798	554	742	704	816	255	641
7,250	693	840	571	779	728	859	262	671
7,500	717	884	589	818	754	905	269	701
7,750	743	930	609	859	782	953	277	732
8,000	771	979	630	901	812	1,004	285	764
8,250	801	1,030	653	945	846	1,058	294	798
8,500	836	1,086	679	992	883	1,115	303	832
8,750	874	1,144	706	1,042	923	1,176	313	868
9,000	915	1,206	737	1,094	968	1,242	325	905
9,250	961	1,273	770	1,149	1,018	1,313	337	943
9,500	1,011	1,346	806	1,208	1,073	1,390	350	984
9,750	1,068	1,424	846	1,271	1,135	1,474	364	1,025
10,000	1,131	1,510	891	1,340	1,205	1,566	379	1,069
10,250	1,202	1,604	940	1,413	1,284	1,667	396	1,115
10,500	1,283	1,707	996	1,492	1,374	1,780	414	1,164
10,750	1,375	1,822	1,057	1,579	1,477	1,906	433	1,215
11,000	1,480	1,952	1,127	1,674	1,596	2,049	455	1,268
11,250	1,603	2,099	1,206	1,778	1,735	2,212	479	1,325
11,500	1,746	2,267	1,296	1,894	1,900	2,400	505	1,386
11,750	1,916	2,462	1,400	2,026	2,096	2,622	534	1,450
12,000	2,120	2,691	1,520	2,173	2,335	2,886	566	1,519
12,250	2,368	2,966	1,661	2,343	2,632	3,208	602	1,593
12,500	2,678	3,303	1,828	2,539	3,008	3,611	641	1,673
12,750	3,074	3,726	2,029	2,769	3,502	4,130	686	1,759
13,000	3,595	4,275	2,281	3,045	4,170	4,828	736	1,852

Distance.	Durlach $\varphi=49°\ 00'$ $\lambda=8°\ 29'$ E.		Ekaterinburg $\varphi=56°\ 49'$ $\lambda=60°\ 38'$ E.		Eskdalemuir $\varphi=55°\ 19'$ $\lambda=3°\ 12'$ W.		Firenze $\varphi=43°\ 47'$ $\lambda=11°\ 15'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	377	90	300	86	314	86	430	93
1,250	378	112	301	107	315	108	432	117
1,500	380	135	302	129	317	130	434	140
1,750	382	158	304	151	319	152	436	164
2,000	385	181	306	173	321	174	439	188
2,250	388	204	308	195	323	197	443	212
2,500	391	228	311	217	326	219	447	237
2,750	395	252	314	240	329	242	451	262
3,000	399	276	317	263	332	265	456	287
3,250	403	300	320	286	336	289	462	312
3,500	408	325	324	309	340	312	467	338
3,750	414	350	328	333	344	336	474	365
4,000	420	376	333	357	348	360	481	392
4,250	426	402	337	382	353	385	489	419
4,500	433	429	343	407	359	410	497	447
4,750	441	456	348	432	365	436	506	476
5,000	449	484	354	458	371	462	516	505
5,250	458	512	361	484	378	489	527	536
5,500	467	542	368	512	386	517	538	567
5,750	478	572	376	539	394	545	551	599
6,000	489	603	384	568	402	574	564	632
6,250	501	635	393	597	412	603	579	667
6,500	514	668	403	627	422	634	595	702
6,750	528	702	413	658	433	665	612	739
7,000	543	737	424	690	445	698	630	778
7,250	559	774	436	723	458	731	650	818
7,500	577	812	449	758	472	766	672	860
7,750	596	852	463	793	487	802	696	904
8,000	617	894	478	830	503	840	721	950
8,250	639	938	494	868	520	880	750	999
8,500	664	984	511	909	539	922	780	1,051
8,750	691	1,033	530	950	559	965	814	1,106
9,000	720	1,084	551	994	582	1,010	851	1,164
9,250	752	1,139	573	1,041	606	1,056	892	1,227
9,500	787	1,196	598	1,089	632	1,105	937	1,294
9,750	826	1,258	625	1,140	661	1,159	987	1,367
10,000	869	1,325	654	1,195	692	1,217	1,044	1,445
10,250	917	1,397	686	1,253	727	1,276	1,106	1,531
10,500	970	1,474	722	1,314	765	1,339	1,177	1,625
10,750	1,030	1,559	761	1,380	807	1,407	1,257	1,729
11,000	1,097	1,651	804	1,451	855	1,483	1,348	1,844
11,250	1,172	1,753	853	1,528	908	1,563	1,453	1,974
11,500	1,259	1,865	907	1,611	966	1,650	1,575	2,121
11,750	1,358	1,992	969	1,702	1,032	1,746	1,717	2,289
12,000	1,472	2,134	1,037	1,801	1,109	1,853	1,886	2,484
12,250	1,606	2,296	1,115	1,912	1,195	1,969	2,088	2,713
12,500	1,764	2,484	1,204	2,034	1,294	2,100	2,335	2,988
12,750	1,953	2,703	1,309	2,173	1,410	2,250	2,643	3,324
13,000	2,182	2,963	1,434	2,334	1,545	2,419	3,035	3,745

Distance.	Göttingen $\varphi=51°\ 33'$ $\lambda=9°\ 58'$ E.		Graz $\varphi=47°\ 05'$ $\lambda=15°\ 27'$ E.		Guildford $\varphi=51°\ 15'$ $\lambda=0°\ 36'$ W.		Halifax $\varphi=44°\ 38'$ $\lambda=63°\ 36'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	351	88	396	91	354	89	421	93
1,250	352	111	397	114	355	111	423	116
1,500	354	133	399	137	357	133	425	139
1,750	356	155	402	160	359	156	427	163
2,000	359	178	404	184	362	178	430	187
2,250	361	201	408	207	364	201	434	211
2,500	364	224	411	231	367	224	438	235
2,750	368	248	415	255	370	248	442	260
3,000	371	271	419	280	374	272	447	285
3,250	376	295	424	304	378	296	452	310
3,500	380	319	430	330	383	320	458	336
3,750	385	344	435	355	388	345	464	362
4,000	391	369	442	381	394	370	471	389
4,250	396	395	449	408	400	396	478	416
4,500	403	421	456	435	406	422	486	444
4,750	410	447	464	463	413	449	495	473
5,000	417	474	473	491	421	476	505	502
5,250	425	502	483	520	429	504	515	532
5,500	434	531	493	550	438	532	526	563
5,750	443	560	504	581	447	561	538	595
6,000	453	590	516	613	457	591	551	627
6,250	464	621	529	646	468	622	565	661
6,500	476	653	543	679	480	654	581	696
6,750	489	686	558	715	493	688	598	732
7,000	503	720	574	751	507	722	615	770
7,250	517	756	592	789	522	758	635	810
7,500	533	792	611	829	538	794	656	852
7,750	551	831	631	870	555	833	679	895
8,000	569	871	654	913	574	874	703	940
8,250	590	913	678	959	595	916	731	988
8,500	612	956	705	1,007	618	960	760	1,039
8,750	636	1,003	734	1,058	642	1,005	793	1,093
9,000	662	1,051	766	1,111	669	1,054	828	1,150
9,250	690	1,103	801	1,169	698	1,105	868	1,211
9,500	722	1,157	840	1,230	729	1,160	911	1,277
9,750	756	1,215	882	1,295	764	1,218	959	1,347
10,000	794	1,277	930	1,366	803	1,281	1,013	1,423
10,250	836	1,343	983	1,442	845	1,348	1,073	1,506
10,500	882	1,415	1,041	1,525	892	1,419	1,140	1,597
10,750	934	1,492	1,108	1,615	945	1,498	1,216	1,698
11,000	992	1,576	1,182	1,715	1,003	1,581	1,303	1,809
11,250	1,057	1,668	1,267	1,826	1,069	1,676	1,402	1,933
11,500	1,131	1,769	1,365	1,949	1,144	1,778	1,517	2,073
11,750	1,215	1,881	1,477	2,088	1,230	1,891	1,651	2,232
12,000	1,311	2,006	1,609	2,247	1,328	2,020	1,808	2,417
12,250	1,423	2,146	1,763	2,429	1,443	2,162	1,996	2,632
12,500	1,553	2,307	1,948	2,643	1,574	2,325	2,225	2,888
12,750	1,706	2,491	2,171	2,896	1,734	2,512	2,506	3,198
13,000	1,889	2,707	2,447	3,202	1,920	2,734	2,863	3,584

Distance.	Hamburg $\varphi=53°\ 34'$ $\lambda=9°\ 59'$ E.		Harvard $\varphi=42°\ 23'$ $\lambda=71°\ 07'$ W.		Helwan $\varphi=29°\ 52'$ $\lambda=31°\ 21'$ E.		Hohenheim $\varphi=48°\ 43'$ $\lambda=9°\ 14'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	331	87	445	94	584	105	379	90
1,250	333	109	446	118	586	132	381	113
1,500	334	131	449	142	590	159	383	135
1,750	336	154	451	166	594	186	385	158
2,000	338	176	455	190	598	213	388	181
2,250	341	199	458	215	604	241	390	205
2,500	344	221	462	239	610	269	394	228
2,750	347	244	467	265	617	298	398	252
3,000	350	268	472	290	624	327	402	276
3,250	354	291	478	316	633	357	406	301
3,500	358	315	484	342	642	387	411	326
3,750	363	340	491	369	652	418	417	351
4,000	368	364	498	396	664	450	423	377
4,250	374	389	506	424	676	482	429	403
4,500	380	415	515	453	689	516	436	430
4,750	386	441	524	482	704	551	444	457
5,000	393	468	535	512	720	587	452	485
5,250	400	495	546	543	737	624	461	513
5,500	408	523	558	574	756	663	471	543
5,750	417	552	571	607	776	703	481	573
6,000	427	581	585	641	799	745	493	604
6,250	437	611	601	676	823	789	505	636
6,500	448	643	617	713	850	835	518	669
6,750	459	675	635	750	879	884	532	704
7,000	472	708	655	790	911	936	547	739
7,250	486	742	676	831	946	991	564	776
7,500	500	778	699	874	985	1,049	582	815
7,750	516	815	724	920	1,027	1,111	601	855
8,000	533	854	751	967	1,075	1,179	622	897
8,250	551	894	781	1,018	1,127	1,251	645	941
8,500	572	937	815	1,073	1,186	1,330	670	987
8,750	594	981	850	1,128	1,251	1,415	697	1,036
9,000	618	1,028	889	1,189	1,325	1,509	727	1,088
9,250	644	1,077	933	1,255	1,409	1,613	759	1,143
9,500	673	1,129	982	1,325	1,504	1,729	795	1,201
9,750	704	1,184	1,035	1,401	1,614	1,860	834	1,264
10,000	738	1,243	1,096	1,483	1,741	2,008	878	1,331
10,250	776	1,306	1,164	1,574	1,891	2,178	926	1,403
10,500	818	1,373	1,240	1,674	2,067	2,377	980	1,481
10,750	864	1,445	1,327	1,784	2,279	2,610	1,041	1,566
11,000	916	1,524	1,427	1,908	2,539	2,891	1,109	1,660
11,250	975	1,609	1,542	2,048	2,863	3,238	1,186	1,763
11,500	1,040	1,703	1,676	2,206	3,277	3,675	1,273	1,877
11,750	1,114	1,805	1,834	2,390	3,827	4,248	1,374	2,005
12,000	1,199	1,919	2,023	2,605	4,588	5,032	1,491	2,149
12,250	1,296	2,047	2,252	2,860	....	....	1,628	2,314
12,500	1,408	2,190	2,535	3,171	....	....	1,789	2,505
12,750	1,539	2,354	2,892	3,556	....	....	1,983	2,729
13,000	1,694	2,542	3,356	4,048	....	....	2,218	2,995

Distance.	Honolulu $\varphi = 21° 19'$ $\lambda = 158° 04'$ W.		Innsbruck $\varphi = 47° 16'$ $\lambda = 11° 24'$ E.		Irkutsk $\varphi = 52° 16'$ $\lambda = 104° 19'$ E.		Ithaca $\varphi = 42° 27'$ $\lambda = 76° 29'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	689	116	394	91	344	88	444	94
1,250	693	145	396	114	345	110	446	118
1,500	697	175	398	137	347	133	448	142
1,750	703	205	400	160	349	155	450	166
2,000	709	235	403	183	351	177	453	190
2,250	716	266	406	207	354	200	457	215
2,500	724	297	409	231	357	223	461	239
2,750	733	329	413	255	360	246	466	264
3,000	743	362	417	279	364	270	471	290
3,250	754	395	422	304	368	294	477	316
3,500	766	430	428	329	372	318	483	342
3,750	780	465	433	355	377	342	489	369
4,000	795	501	440	381	383	367	497	396
4,250	811	539	447	407	388	393	505	424
4,500	829	578	454	434	395	419	514	453
4,750	849	618	462	462	401	445	523	482
5,000	870	660	471	491	409	472	533	511
5,250	894	704	480	520	416	500	543	540
5,500	920	751	490	549	425	528	556	574
5,750	948	799	501	580	434	557	570	607
6,000	979	850	513	612	444	587	584	641
6,250	1,014	905	526	645	455	617	599	675
6,500	1,051	962	540	678	466	649	616	711
6,750	1,093	1,024	555	713	478	682	634	750
7,000	1,140	1,090	571	750	491	715	653	788
7,250	1,191	1,161	588	787	506	751	674	830
7,500	1,248	1,238	607	827	521	787	696	874
7,750	1,313	1,322	628	868	538	825	720	919
8,000	1,385	1,414	650	911	556	865	748	967
8,250	1,467	1,516	675	957	576	906	778	1,017
8,500	1,561	1,629	701	1,005	597	949	810	1,070
8,750	1,668	1,756	730	1,055	621	995	845	1,128
9,000	1,792	1,900	762	1,109	646	1,043	885	1,187
9,250	1,937	2,065	796	1,166	674	1,093	930	1,253
9,500	2,108	2,255	835	1,226	704	1,147	980	1,323
9,750	2,313	2,481	877	1,291	737	1,204	1,033	1,399
10,000	2,563	2,751	924	1,361	774	1,264	1,092	1,482
10,250	2,874	3,082	976	1,437	814	1,329	1,160	1,572
10,500	3,269	3,498	1,034	1,520	859	1,399	1,236	1,672
10,750	3,787	4,037	1,100	1,610	909	1,475	1,323	1,782
11,000	4,498	4,769	1,174	1,709	965	1,557	1,421	1,905
11,250	....	....	1,258	1,818	1,027	1,646	1,538	2,044
11,500	....	....	1,354	1,941	1,098	1,744	1,671	2,203
11,750	....	....	1,465	2,078	1,178	1,853	1,827	2,386
12,000	....	....	1,595	2,235	1,270	1,974	2,016	2,599
12,250	....	....	1,747	2,416	1,376	2,109	2,243	2,847
12,500	....	....	1,929	2,626	1,499	2,263	2,525	3,162
12,750	....	....	2,148	2,876	1,644	2,440	2,880	3,544
13,000	....	....	2,419	3,176	1,817	2,645	3,340	4,034

Distance.	Jugenheim $\varphi=49° 46'$ $\lambda=8° 39'$ E.		Jurjew $\varphi=58° 23'$ $\lambda=26° 43'$ E.		Königsberg $\varphi=54° 43'$ $\lambda=20° 30'$ E.		Königstuhl $\varphi=49° 25'$ $\lambda=8° 42'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	369	89	285	85	320	87	372	90
1,250	370	112	286	106	321	109	374	112
1,500	372	134	287	128	323	130	376	135
1,750	374	157	289	150	325	153	377	158
2,000	377	180	291	171	327	175	380	181
2,250	380	203	293	193	329	197	383	204
2,500	383	227	295	216	332	220	386	227
2,750	386	250	298	238	335	243	390	251
3,000	390	274	301	261	338	266	394	275
3,250	395	299	304	283	342	289	399	299
3,500	400	323	308	307	346	313	404	324
3,750	405	348	311	330	351	337	409	349
4,000	411	374	316	354	355	362	415	375
4,250	417	400	320	378	361	387	421	401
4,500	424	426	325	403	366	412	428	427
4,750	431	453	331	428	373	438	436	454
5,000	439	481	336	454	379	464	443	482
5,250	448	509	343	480	386	491	452	511
5,500	457	538	349	507	394	519	462	540
5,750	467	568	356	534	402	547	472	570
6,000	478	599	364	562	411	576	483	600
6,250	490	630	373	591	421	606	495	632
6,500	502	663	381	620	431	637	507	665
6,750	516	697	391	651	443	669	521	699
7,000	531	732	402	682	455	701	536	734
7,250	546	768	413	715	468	735	552	771
7,500	564	806	425	749	482	771	569	809
7,750	582	846	438	783	497	807	588	849
8,000	602	887	452	819	513	845	609	890
8,250	624	930	467	857	531	885	631	934
8,500	648	975	483	896	550	926	655	979
8,750	674	1,023	501	937	571	970	682	1,027
9,000	702	1,074	520	980	594	1,015	710	1,078
9,250	733	1,127	541	1,025	619	1,064	742	1,132
9,500	767	1,184	564	1,072	646	1,114	776	1,190
9,750	805	1,245	588	1,122	675	1,168	814	1,251
10,000	846	1,309	616	1,174	708	1,225	857	1,317
10,250	892	1,380	645	1,230	743	1,286	903	1,387
10,500	943	1,455	678	1,289	783	1,351	955	1,464
10,750	1,000	1,538	714	1,353	827	1,421	1,013	1,547
11,000	1,064	1,627	754	1,421	875	1,497	1,079	1,638
11,250	1,137	1,726	798	1,494	930	1,579	1,153	1,738
11,500	1,219	1,835	848	1,573	991	1,668	1,236	1,848
11,750	1,313	1,956	903	1,659	1,060	1,766	1,333	1,972
12,000	1,421	2,093	966	1,753	1,139	1,875	1,444	2,111
12,250	1,548	2,248	1,037	1,856	1,228	1,995	1,574	2,269
12,500	1,697	2,427	1,118	1,970	1,332	2,131	1,727	2,452
12,750	1,874	2,634	1,211	2,098	1,453	2,284	1,909	2,665
13,000	2,088	2,880	1,318	2,241	1,594	2,459	2,130	2,917

Distance.	Krakau φ=50° 04′ λ=19° 58′ E.		Ksara φ=33° 49′ λ=35° 52′ E.		Laibach φ=46° 03′ λ=14° 31′ E.		La Paz φ=16° 30′ S. λ=68° 09′ W.	
Δ in km.	d	r	d	r	d	r	d	r
1,000	366	89	538	101	406	92	1,363	222
1,250	367	112	540	127	408	115	1,376	280
1,500	369	134	543	153	410	138	1,393	339
1,750	371	157	547	179	413	161	1,413	400
2,000	374	180	551	205	415	185	1,437	463
2,250	376	203	556	232	419	209	1,466	529
2,500	380	226	561	259	422	233	1,498	598
2,750	383	250	567	286	426	257	1,536	671
3,000	387	274	574	314	431	282	1,579	748
3,250	392	298	581	342	436	307	1,629	830
3,500	396	323	590	371	441	332	1,686	919
3,750	402	348	599	400	447	358	1,751	1,015
4,000	407	373	608	430	454	384	1,826	1,119
4,250	414	399	619	461	461	411	1,912	1,235
4,500	420	425	631	493	469	439	2,012	1,363
4,750	428	452	644	526	477	467	2,129	1,507
5,000	436	480	657	560	486	496	2,266	1,672
5,250	444	508	673	594	496	525	2,428	1,860
5,500	453	537	689	631	507	555	2,623	2,081
5,750	463	567	707	668	518	586	2,861	2,343
6,000	474	597	726	707	531	619	3,156	2,663
6,250	485	629	747	748	544	652	3,530	3,061
6,500	498	661	770	790	559	686	4,020	3,575
6,750	511	695	795	835	574	722	4,686	4,265
7,000	526	730	822	882	591	759	5,640	5,242
7,250	541	766	852	931	609	798		
7,500	558	804	885	984	629	838		
7,750	577	843	920	1,039	651	880		
8,000	597	884	960	1,099	674	924		
8,250	618	927	1,004	1,163	700	971		
8,500	642	972	1,052	1,231	728	1,020		
8,750	667	1,020	1,105	1,305	758	1,072		
9,000	695	1,070	1,165	1,385	792	1,127		
9,250	726	1,123	1,233	1,473	829	1,186		
9,500	759	1,179	1,308	1,570	869	1,249		
9,750	796	1,240	1,394	1,677	914	1,316		
10,000	837	1,304	1,493	1,797	964	1,389		
10,250	882	1,373	1,606	1,932	1,020	1,468		
10,500	933	1,448	1,738	2,086	1,082	1,554		
10,750	989	1,529	1,892	2,262	1,152	1,649		
11,000	1,052	1,618	2,076	2,469	1,231	1,753		
11,250	1,123	1,716	2,299	2,714	1,322	1,869		
11,500	1,203	1,823	2,571	3,010	1,427	1,999		
11,750	1,296	1,943	2,914	3,376	1,547	2,146		
12,000	1,402	2,078	3,357	3,843	1,688	2,315		
12,250	1,526	2,230	....	....	1,857	2,510		
12,500	1,671	2,405	....	....	2,058	2,740		
12,750	1,844	2,609	....	....	2,304	3,015		
13,000	2,052	2,848	....	....	2,610	3,351		

Distance.	Lemberg $\varphi=49° 50'$ $\lambda=24° 01'$ E.		Madras $\varphi=10° 14'$ $\lambda=77° 28'$ E.		Makejevka $\varphi=48° 02'$ $\lambda=37° 59'$ E.		Manila $\varphi=14° 35'$ $\lambda=120° 59'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	368	89	844	134	386	90	781	126
1,250	370	112	849	168	388	113	785	158
1,500	371	134	856	203	390	136	791	191
1,750	374	157	863	238	392	159	797	224
2,000	376	180	872	274	395	182	805	257
2,250	379	203	882	310	398	205	813	291
2,500	382	227	893	347	401	229	823	326
2,750	386	250	906	386	405	253	834	361
3,000	390	274	921	425	409	277	847	397
3,250	394	299	937	465	414	302	861	435
3,500	399	323	955	507	419	327	876	473
3,750	404	348	975	551	425	352	893	513
4,000	410	374	997	596	431	378	912	554
4,250	416	400	1,022	643	438	405	933	597
4,500	423	426	1,049	692	445	432	956	642
4,750	430	453	1,079	744	453	459	981	688
5,000	438	481	1,112	799	461	487	1,009	737
5,250	447	509	1,149	857	470	516	1,040	789
5,500	456	538	1,190	919	480	545	1,074	844
5,750	466	568	1,235	986	491	576	1,111	902
6,000	477	598	1,286	1,057	502	608	1,153	964
6,250	489	630	1,342	1,134	515	640	1,199	1,030
6,500	501	663	1,405	1,218	528	674	1,250	1,101
6,750	515	696	1,477	1,309	543	708	1,307	1,178
7,000	529	731	1,558	1,410	559	744	1,371	1,262
7,250	545	768	1,650	1,523	576	781	1,443	1,354
7,500	562	806	1,756	1,649	594	820	1,525	1,456
7,750	581	845	1,879	1,791	614	861	1,619	1,569
8,000	601	886	2,022	1,954	636	904	1,726	1,696
8,250	623	929	2,191	2,143	659	948	1,850	1,840
8,500	647	975	2,394	2,365	684	995	1,995	2,004
8,750	672	1,022	2,640	2,631	712	1,045	2,166	2,195
9,000	701	1,073	2,946	2,956	742	1,097	2,371	2,420
9,250	732	1,126	3,334	3,364	777	1,153	2,621	2,689
9,500	765	1,183	3,841	3,891	814	1,213	2,930	3,018
9,750	803	1,244	4,535	4,605	855	1,276	3,325	3,432
10,000	844	1,309	....	....	899	1,345	3,844	3,971
10,250	890	1,378	....	....	949	1,419		
10,500	941	1,454	....	....	1,005	1,499		
10,750	997	1,536	....	....	1,067	1,586		
11,000	1,061	1,625	....	....	1,138	1,682		
11,250	1,133	1,723	....	....	1,219	1,788		
11,500	1,215	1,832	....	....	1,311	1,906		
11,750	1,309	1,953	....	....	1,417	2,039		
12,000	1,417	2,089	....	....	1,539	2,189		
12,250	1,543	2,244	....	....	1,683	2,361		
12,500	1,691	2,422	....	....	1,853	2,560		
12,750	1,867	2,628	....	....	2,058	2,795		
13,000	2,079	2,872	....	....	2,310	3,077		

Distance.	Messina $\varphi=38° 12'$ $\lambda=15° 33'$ E.		München $\varphi=48° 09'$ $\lambda=11° 37'$ E.		Osaka $\varphi=34° 39'$ $\lambda=135° 26'$ E.		Ottawa $\varphi=45° 24'$ $\lambda=75° 43'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	489	97	385	90	528	100	413	92
1,250	491	122	387	113	531	125	415	115
1,500	494	147	389	136	534	151	417	139
1,750	497	172	391	159	537	177	419	162
2,000	501	197	393	182	541	203	422	186
2,250	505	222	396	206	546	230	426	210
2,500	510	248	400	229	551	257	429	234
2,750	515	274	404	253	557	284	433	258
3,000	521	301	408	278	564	311	438	283
3,250	527	328	412	302	570	339	443	308
3,500	534	355	418	327	578	368	449	334
3,750	542	383	423	352	587	397	455	360
4,000	551	412	429	378	597	427	462	386
4,250	560	441	436	405	608	457	469	413
4,500	570	471	443	431	619	489	477	441
4,750	581	502	451	459	631	521	486	469
5,000	593	533	459	487	645	554	495	498
5,250	606	566	468	516	660	589	505	528
5,500	620	600	478	545	676	624	516	559
5,750	635	635	489	576	694	661	528	590
6,000	652	671	501	607	712	699	540	622
6,250	669	708	513	639	732	740	554	656
6,500	689	747	526	673	754	781	569	691
6,750	710	788	541	707	777	825	585	727
7,000	733	831	556	743	804	871	602	764
7,250	758	876	573	780	833	920	621	803
7,500	785	923	592	819	865	971	641	844
7,750	815	973	612	860	900	1,026	664	887
8,000	847	1,026	633	902	937	1,084	688	932
8,250	883	1,082	657	947	980	1,146	714	979
8,500	923	1,142	682	994	1,025	1,212	743	1,029
8,750	966	1,206	710	1,043	1,076	1,284	774	1,081
9,000	1,014	1,275	740	1,096	1,134	1,362	809	1,137
9,250	1,068	1,350	774	1,152	1,198	1,448	847	1,197
9,500	1,128	1,430	810	1,211	1,270	1,541	888	1,261
9,750	1,195	1,519	851	1,274	1,354	1,644	935	1,330
10,000	1,271	1,617	896	1,342	1,445	1,759	986	1,404
10,250	1,357	1,725	946	1,416	1,554	1,888	1,044	1,485
10,500	1,456	1,846	1,001	1,496	1,675	2,034	1,108	1,574
10,750	1,569	1,983	1,063	1,583	1,824	2,202	1,181	1,670
11,000	1,701	2,138	1,134	1,678	1,994	2,396	1,264	1,778
11,250	1,857	2,317	1,214	1,784	2,202	2,626	1,358	1,897
11,500	2,041	2,526	1,304	1,901	2,454	2,901	1,467	2,032
11,750	2,265	2,774	1,409	2,033	2,768	3,239	1,594	2,185
12,000	2,540	3,074	1,531	2,182	3,169	3,664	1,742	2,360
12,250	2,886	3,445	1,673	2,353	3,698	4,217	1,919	2,564
12,500	3,334	3,920	1,842	2,551	4,425	4,969	2,132	2,806
12,750	3,935	4,547	2,045	2,784	5,488	6,058	2,394	3,096
13,000	4,780	5,420	2,294	3,063	7,178	7,777	2,722	3,453

Distance.	Parc Saint-Maur $\varphi=48°\ 49'$ $\lambda=2°\ 29'$ E.		Pola $\varphi=44°\ 52'$ $\lambda=13°\ 51'$ E.		Pompeii $\varphi=40°\ 44'$ $\lambda=14°\ 30'$ E.		Potsdam $\varphi=52°\ 23'$ $\lambda=13°\ 04'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	378	90	419	92	462	96	343	88
1,250	380	113	420	116	464	120	344	110
1,500	382	135	422	139	466	144	346	132
1,750	384	158	425	163	469	168	348	155
2,000	387	181	428	187	473	193	350	177
2,250	389	205	431	211	476	218	353	200
2,500	393	228	435	235	480	243	356	223
2,750	397	252	439	259	485	268	359	246
3,000	401	276	444	284	490	294	363	270
3,250	405	301	449	310	496	320	367	294
3,500	410	326	455	335	503	347	371	318
3,750	416	351	461	361	510	374	376	342
4,000	422	376	468	388	518	402	381	367
4,250	428	403	475	415	527	431	387	392
4,500	435	429	484	443	536	460	393	418
4,750	443	457	492	471	546	490	400	445
5,000	451	484	502	501	557	520	407	472
5,250	460	513	512	530	569	552	415	499
5,500	470	542	523	561	582	584	423	528
5,750	480	573	535	593	596	617	433	556
6,000	491	604	548	626	610	652	442	586
6,250	503	636	562	659	627	688	453	617
6,500	516	669	577	694	645	725	464	649
6,750	531	703	594	731	664	764	477	681
7,000	546	738	611	768	684	805	490	715
7,250	562	775	630	808	707	848	504	750
7,500	580	814	651	849	732	892	520	786
7,750	599	854	674	892	758	940	536	824
8,000	620	896	699	938	788	989	554	864
8,250	643	940	726	985	820	1,041	574	905
8,500	668	986	755	1,036	855	1,097	595	948
8,750	695	1,035	787	1,089	894	1,157	618	994
9,000	724	1,087	822	1,146	936	1,221	644	1,041
9,250	757	1,141	861	1,207	983	1,290	671	1,092
9,500	792	1,199	904	1,272	1,036	1,364	701	1,145
9,750	832	1,262	952	1,342	1,095	1,445	734	1,202
10,000	875	1,329	1,005	1,417	1,161	1,533	771	1,262
10,250	923	1,401	1,064	1,500	1,235	1,629	811	1,327
10,500	977	1,479	1,130	1,590	1,319	1,736	855	1,397
10,750	1,037	1,564	1,205	1,689	1,415	1,856	905	1,472
11,000	1,104	1,657	1,291	1,799	1,526	1,991	960	1,554
11,250	1,181	1,759	1,389	1,922	1,655	2,144	1,022	1,643
11,500	1,268	1,873	1,501	2,060	1,807	2,320	1,093	1,740
11,750	1,368	2,000	1,633	2,217	1,988	2,525	1,172	1,848
12,000	1,484	2,144	1,788	2,399	2,204	2,770	1,264	1,969
12,250	1,620	2,308	1,972	2,610	2,470	3,059	1,369	2,104
12,500	1,780	2,498	2,196	2,862	2,805	3,421	1,491	2,257
12,750	1,972	2,720	2,471	3,166	3,236	3,880	1,635	2,432
13,000	2,205	2,984	2,818	3,543	3,811	4,482	1,805	2,635

Distance.	Pulkovo $\varphi=59° 46'$ $\lambda=30° 20'$ E.		Reykjavik $\varphi=64° 09'$ $\lambda=21° 57'$ W.		Rocca di Papa $\varphi=41° 46'$ $\lambda=12° 43'$ E.		Samoa (Apia) $\varphi=13° 48'$ S. $\lambda=171° 45'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	272	84	231	83	451	95	1,296	209
1,250	273	106	232	104	453	118	1,308	263
1,500	274	127	233	125	455	142	1,323	318
1,750	276	149	234	146	458	167	1,341	375
2,000	277	170	236	167	461	191	1,363	434
2,250	279	192	237	188	465	216	1,388	495
2,500	282	214	239	210	469	241	1,417	558
2,750	284	236	241	232	474	266	1,450	625
3,000	287	259	243	254	479	292	1,488	696
3,250	290	281	246	276	485	318	1,532	771
3,500	293	304	249	298	491	344	1,581	851
3,750	297	328	252	321	498	371	1,638	937
4,000	301	351	255	344	506	398	1,702	1,030
4,250	305	375	259	367	514	427	1,776	1,132
4,500	310	400	263	391	523	455	1,861	1,244
4,750	315	425	267	415	533	485	1,959	1,369
5,000	320	450	271	440	543	515	2,072	1,509
5,250	326	476	276	465	555	546	2,206	1,668
5,500	333	502	281	491	567	578	2,363	1,850
5,750	340	529	287	517	580	611	2,552	2,063
6,000	347	557	293	544	595	645	2,781	2,316
6,250	355	586	300	571	611	681	3,063	2,622
6,500	363	615	307	599	628	717	3,420	3,002
6,750	372	645	314	628	646	756	3,884	3,489
7,000	382	676	322	658	666	795	4,507	4,135
7,250	393	708	331	689	688	837		
7,500	404	741	340	720	711	881		
7,750	416	775	350	753	737	927		
8,000	429	811	361	787	765	975		
8,250	443	848	372	822	796	1,027		
8,500	459	886	385	858	829	1,081		
8,750	475	926	398	896	866	1,139		
9,000	493	968	413	935	907	1,201		
9,250	513	1,012	429	976	952	1,267		
9,500	534	1,058	446	1,019	1,002	1,339		
9,750	557	1,106	464	1,064	1,057	1,417		
10,000	583	1,157	484	1,111	1,120	1,501		
10,250	611	1,212	507	1,161	1,190	1,594		
10,500	641	1,269	531	1,214	1,269	1,697		
10,750	674	1,330	557	1,269	1,360	1,810		
11,000	712	1,396	586	1,328	1,463	1,938		
11,250	753	1,466	619	1,392	1,584	2,082		
11,500	798	1,542	654	1,459	1,724	2,247		
11,750	850	1,624	694	1,531	1,890	2,439		
12,000	907	1,714	738	1,610	2,089	2,663		
12,250	972	1,812	787	1,694	2,331	2,932		
12,500	1,046	1,920	843	1,786	2,632	3,260		
12,750	1,131	2,039	906	1,887	3,015	3,671		
13,000	1,228	2,173	978	1,998	3,517	4,201		

Distance.	Santa Clara $\varphi=37° 26'$ $\lambda=121° 57'$ W.		Saskatoon $\varphi=52° 08'$ $\lambda=106° 38'$ W.		Seattle $\varphi=47° 39'$ $\lambda=122° 18'$ W.		Simla $\varphi=31° 06'$ $\lambda=77° 12'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	498	98	345	88	390	91	569	104
1,250	500	122	346	110	392	113	572	130
1,500	503	147	348	133	394	136	575	157
1,750	506	173	350	155	396	160	579	184
2,000	509	198	352	177	399	183	583	211
2,250	513	224	355	200	402	206	589	238
2,500	518	250	358	223	405	230	594	266
2,750	524	276	361	247	409	254	601	294
3,000	530	303	365	270	413	279	608	323
3,250	536	330	369	294	418	303	616	352
3,500	543	358	374	318	423	328	625	382
3,750	551	386	379	343	428	354	635	412
4,000	560	415	384	368	435	380	646	443
4,250	570	444	390	393	442	406	658	476
4,500	580	474	396	419	449	433	671	509
4,750	592	506	402	446	457	461	685	543
5,000	604	538	409	473	466	489	700	578
5,250	617	571	418	500	475	519	716	614
5,500	631	605	427	528	485	548	734	652
5,750	647	640	436	557	496	578	754	692
6,000	664	677	445	587	508	610	775	733
6,250	682	715	456	618	520	642	799	776
6,500	702	754	468	650	534	676	824	821
6,750	724	795	480	683	549	711	852	868
7,000	748	839	493	717	565	747	882	918
7,250	774	884	508	752	582	784	916	971
7,500	802	932	523	788	601	824	952	1,027
7,750	833	984	540	826	621	865	993	1,088
8,000	867	1,037	559	866	643	908	1,037	1,152
8,250	903	1,094	579	907	667	953	1,087	1,222
8,500	944	1,155	600	950	693	1,000	1,142	1,297
8,750	990	1,221	624	996	721	1,050	1,203	1,378
9,000	1,038	1,291	649	1,044	752	1,103	1,273	1,468
9,250	1,094	1,368	677	1,094	787	1,159	1,351	1,566
9,500	1,155	1,450	707	1,148	824	1,219	1,439	1,675
9,750	1,226	1,543	740	1,205	865	1,284	1,541	1,798
10,000	1,306	1,645	777	1,266	912	1,353	1,658	1,936
10,250	1,396	1,756	818	1,331	963	1,428	1,794	2,094
10,500	1,500	1,880	863	1,402	1,019	1,509	1,955	2,276
10,750	1,618	2,028	913	1,478	1,084	1,598	2,146	2,489
11,000	1,760	2,189	969	1,560	1,156	1,695	2,378	2,743
11,250	1,924	2,377	1,033	1,650	1,239	1,803	2,664	3,052
11,500	2,121	2,597	1,104	1,749	1,332	1,923	3,025	3,435
11,750	2,361	2,861	1,185	1,858	1,441	2,058	3,494	3,927
12,000	2,658	3,183	1,278	1,980	1,567	2,212	4,127	4,584
12,250	3,034	3,586	1,385	2,116	1,715	2,388		
12,500	3,528	4,104	1,509	2,271	1,891	2,593		
12,750	4,199	4,802	1,656	2,449	2,103	2,835		
13,000	5,163	5,793	1,830	2,656	2,364	3,126		

Distance.	Sofia $\varphi=42° 42'$ $\lambda=23° 20'$ E.		Spring Hill $\varphi=30° 42'$ $\lambda=88° 09'$ W.		St. Boniface $\varphi=49° 54'$ $\lambda=97° 07'$ W.		St. Louis $\varphi=38° 38'$ $\lambda=90° 14'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	441	94	574	104	368	89	485	97
1,250	443	118	577	131	369	112	487	122
1,500	445	141	580	157	371	134	489	146
1,750	448	165	584	184	373	157	492	171
2,000	451	190	588	211	375	180	496	196
2,250	455	214	594	239	378	203	500	222
2,500	459	239	599	267	381	227	505	247
2,750	463	264	606	295	385	250	510	273
3,000	468	289	614	324	389	274	516	300
3,250	474	315	622	353	393	298	522	326
3,500	480	341	631	383	398	323	529	354
3,750	487	368	641	414	403	348	537	382
4,000	494	395	652	445	409	373	545	410
4,250	502	423	664	478	415	399	554	439
4,500	511	451	677	511	422	426	564	469
4,750	520	481	691	545	430	453	575	500
5,000	530	510	706	581	438	480	587	531
5,250	542	541	723	617	446	509	599	563
5,500	554	573	741	656	455	538	613	597
5,750	566	605	761	695	465	567	628	632
6,000	580	639	783	737	476	598	645	667
6,250	596	674	807	780	488	630	662	705
6,500	612	710	832	825	500	662	681	743
6,750	630	748	861	873	514	696	702	784
7,000	649	787	892	924	528	731	724	826
7,250	670	828	925	977	544	767	749	871
7,500	693	871	963	1,034	561	805	776	917
7,750	717	916	1,004	1,095	580	844	805	967
8,000	744	963	1,049	1,161	600	886	837	1,019
8,250	774	1,014	1,100	1,231	622	929	871	1,073
8,500	806	1,067	1,156	1,307	645	974	911	1,134
8,750	842	1,123	1,219	1,390	671	1,022	953	1,197
9,000	881	1,183	1,289	1,481	699	1,072	1,001	1,265
9,250	924	1,248	1,369	1,581	730	1,125	1,053	1,339
9,500	971	1,317	1,460	1,693	764	1,182	1,112	1,418
9,750	1,024	1,393	1,564	1,817	801	1,242	1,177	1,506
10,000	1,084	1,474	1,684	1,959	842	1,307	1,251	1,602
10,250	1,150	1,564	1,825	2,121	888	1,377	1,335	1,708
10,500	1,225	1,662	1,991	2,308	938	1,452	1,431	1,826
10,750	1,311	1,771	2,188	2,527	995	1,534	1,541	1,959
11,000	1,408	1,893	2,428	2,789	1,059	1,623	1,670	2,111
11,250	1,521	2,030	2,726	3,110	1,130	1,721	1,820	2,285
11,500	1,652	2,186	3,103	3,509	1,212	1,830	1,998	2,488
11,750	1,807	2,366	3,596	4,026	1,305	1,950	2,214	2,727
12,000	1,991	2,576	4,267	4,720	1,413	2,086	2,478	3,016
12,250	2,213	2,825	....	....	1,538	2,240	2,808	3,372
12,500	2,487	3,127	....	....	1,685	2,417	3,233	3,824
12,750	2,832	3,499	....	....	1,860	2,623	3,800	4,417
13,000	3,278	3,974	....	....	2,072	2,866	4,587	5,232

Distance.	Strassburg $\varphi=48°\ 35'$ $\lambda=7°\ 46'$ E.		Sydney $\varphi=33°\ 50'$ S. $\lambda=151°\ 10'$ E.		Tacubaya $\varphi=19°\ 24'$ $\lambda=99°\ 12'$ W.		Tashkent $\varphi=41°\ 20'$ $\lambda=69°\ 18'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	381	90	1,928	363	715	118	456	95
1,250	382	113	1,959	460	718	149	458	119
1,500	384	136	1,999	562	723	179	460	143
1,750	386	158	2,048	669	729	210	463	167
2,000	389	182	2,107	784	735	241	466	192
2,250	392	205	2,178	907	742	272	470	217
2,500	395	229	2,263	1,042	751	305	474	242
2,750	399	253	2,365	1,192	760	338	479	267
3,000	403	277	2,486	1,359	771	371	484	293
3,250	408	301	2,631	1,548	783	406	490	319
3,500	413	326	2,808	1,766	796	441	496	345
3,750	418	351	3,024	2,023	811	477	503	372
4,000	424	377	3,294	2,331	826	515	511	400
4,250	431	403	3,635	2,709	844	554	519	428
4,500	438	430	4,081	3,190	863	594	529	457
4,750	446	457	......	......	884	636	538	487
5,000	454	485	......	......	908	680	549	517
5,250	463	514	......	......	933	726	561	548
5,500	473	543	......	......	961	775	573	581
5,750	483	574	......	......	991	826	587	614
6,000	495	605	......	......	1,025	879	602	648
6,250	507	637	......	......	1,062	937	618	684
6,500	520	670	......	......	1,104	998	635	721
6,750	534	704	......	......	1,149	1,063	654	759
7,000	549	740	......	......	1,200	1,133	674	800
7,250	566	777	......	......	1,256	1,209	696	842
7,500	584	816	......	......	1,319	1,292	720	886
7,750	604	856	......	......	1,391	1,383	746	932
8,000	625	898	......	......	1,471	1,483	775	981
8,250	648	942	......	......	1,563	1,595	805	1,032
8,500	673	989	......	......	1,668	1,719	840	1,088
8,750	700	1,038	......	......	1,789	1,860	878	1,146
9,000	730	1,090	......	......	1,930	2,021	919	1,209
9,250	763	1,145	......	......	2,097	2,208	965	1,277
9,500	799	1,203	......	......	2,297	2,427	1,016	1,349
9,750	838	1,266	......	......	2,539	2,690	1,073	1,428
10,000	882	1,333	......	......	2,839	3,010	1,137	1,514
10,250	931	1,406	......	......	3,220	3,411	1,209	1,609
10,500	985	1,485	......	......	3,718	3,929	1,290	1,713
10,750	1,046	1,570	......	......	......	......	1,383	1,829
11,000	1,115	1,664	......	......	......	......	1,490	1,960
11,250	1,192	1,768	......	......	......	......	1,614	2,108
11,500	1,281	1,883	......	......	......	......	1,759	2,277
11,750	1,382	2,011	......	......	......	......	1,930	2,474
12,000	1,500	2,157	......	......	......	......	2,137	2,707
12,250	1,638	2,323	......	......	......	......	2,389	2,985
12,500	1,801	2,516	......	......	......	......	2,704	3,327
12,750	1,997	2,742	......	......	......	......	3,107	3,757
13,000	2,236	3,011	......	......	......	......	3,638	4,317

Distance.	Tiflis $\varphi=41° 43'$ $\lambda=44° 48'$ E.		Tokyo $\varphi=35° 42'$ $\lambda=139° 46'$ E.		Toronto $\varphi=43° 40'$ $\lambda=79° 24'$ W.		Trieste $\varphi=45° 38'$ $\lambda=13° 46'$ E.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	452	95	517	100	431	93	411	92
1,250	453	119	519	125	433	117	412	115
1,500	456	143	522	150	435	140	414	138
1,750	459	167	525	176	438	164	417	162
2,000	462	191	529	201	441	188	420	186
2,250	465	216	534	227	444	213	423	209
2,500	470	241	539	254	448	237	427	234
2,750	474	266	544	281	453	262	431	258
3,000	480	292	551	308	457	287	435	283
3,250	485	318	558	336	463	313	440	308
3,500	492	344	565	364	469	339	446	333
3,750	499	371	574	393	475	365	452	359
4,000	506	399	583	422	482	392	459	386
4,250	514	427	593	452	490	420	466	413
4,500	523	456	604	483	499	448	474	440
4,750	533	485	616	515	508	476	483	468
5,000	544	515	629	548	518	506	492	497
5,250	555	546	643	582	528	536	502	527
5,500	568	578	659	617	540	568	512	557
5,750	581	611	675	653	552	600	524	589
6,000	596	646	693	691	566	633	537	621
6,250	611	681	713	730	581	667	550	654
6,500	628	718	734	771	596	703	565	689
6,750	647	756	757	814	614	740	581	725
7,000	667	796	783	859	632	779	598	762
7,250	688	838	810	906	652	819	617	801
7,500	712	881	841	956	674	861	637	842
7,750	738	928	874	1,009	698	905	659	884
8,000	766	976	910	1,066	724	952	683	929
8,250	796	1,026	950	1,126	752	1,001	709	976
8,500	830	1,082	994	1,190	783	1,052	737	1,025
8,750	867	1,140	1,043	1,260	817	1,107	768	1,078
9,000	908	1,202	1,098	1,335	854	1,166	803	1,134
9,250	953	1,268	1,158	1,417	895	1,229	840	1,193
9,500	1,003	1,340	1,227	1,506	941	1,296	881	1,256
9,750	1,059	1,418	1,304	1,604	991	1,369	927	1,325
10,000	1,122	1,503	1,392	1,714	1,048	1,448	978	1,399
10,250	1,192	1,596	1,492	1,836	1,111	1,534	1,035	1,479
10,500	1,272	1,699	1,608	1,974	1,182	1,629	1,099	1,566
10,750	1,362	1,813	1,743	2,131	1,262	1,733	1,170	1,662
11,000	1,466	1,940	1,901	2,313	1,354	1,849	1,252	1,768
11,250	1,587	2,085	2,091	2,525	1,460	1,980	1,345	1,887
11,500	1,728	2,251	2,320	2,777	1,583	2,127	1,453	2,020
11,750	1,894	2,443	2,602	3,084	1,726	2,297	1,577	2,170
12,000	2,094	2,669	2,958	3,465	1,896	2,493	1,723	2,343
12,250	2,338	2,938	3,421	3,952	2,100	2,724	1,896	2,544
12,500	2,640	3,268	4,044	4,601	2,350	3,002	2,105	2,781
12,750	3,026	3,681	4,928	5,510	2,662	3,341	2,361	3,066
13,000	3,531	4,215	6,271	6,880	3,059	3,767	2,680	3,415

Distance.	Uccle $\varphi=50° 48'$ $\lambda=4° 22'$ E.		Vladivostok $\varphi=43° 07'$ $\lambda=131° 55'$ E.		Victoria $\varphi=48° 24'$ $\lambda=123° 19'$ W.		Vieques $\varphi=18° 09'$ $\lambda=65° 26'$ W.	
Δ in km.	*d*	*r*	*d*	*r*	*d*	*r*	*d*	*r*
1,000	359	89	436	94	382	90	731	120
1,250	360	111	438	117	384	113	735	151
1,500	362	134	441	141	386	136	740	182
1,750	364	156	444	165	388	159	746	213
2,000	366	179	447	189	391	182	753	245
2,250	369	202	450	213	394	205	760	277
2,500	372	225	454	238	397	229	769	310
2,750	376	249	458	263	401	253	779	343
3,000	379	273	463	288	405	277	790	378
3,250	384	297	469	314	410	302	803	413
3,500	388	321	475	340	415	326	816	449
3,750	393	346	482	366	420	352	831	486
4,000	399	371	489	393	426	378	848	525
4,250	405	397	497	421	433	404	866	564
4,500	412	423	505	450	440	431	886	606
4,750	419	450	514	479	448	458	909	649
5,000	426	477	524	508	456	486	933	694
5,250	435	505	536	539	465	515	960	741
5,500	444	534	548	571	475	544	989	791
5,750	453	563	560	603	485	574	1,021	844
6,000	464	594	574	636	497	606	1,057	900
6,250	475	625	589	671	509	638	1,096	959
6,500	487	657	605	707	522	671	1,139	1,022
6,750	500	691	623	745	537	706	1,188	1,090
7,000	514	725	642	784	552	741	1,241	1,164
7,250	529	761	662	824	569	778	1,301	1,244
7,500	546	798	685	867	587	817	1,369	1,331
7,750	564	837	709	911	607	858	1,445	1,427
8,000	583	877	736	958	628	900	1,531	1,533
8,250	604	920	764	1,008	651	944	1,630	1,651
8,500	627	964	796	1,060	676	991	1,744	1,785
8,750	652	1,011	831	1,116	704	1,040	1,876	1,936
9,000	679	1,061	869	1,176	734	1,092	2,031	2,111
9,250	708	1,113	911	1,240	767	1,147	2,215	2,315
9,500	741	1,168	958	1,308	803	1,206	2,436	2,556
9,750	776	1,227	1,010	1,383	843	1,269	2,709	2,848
10,000	816	1,290	1,068	1,463	887	1,337	3,050	3,210
10,250	859	1,358	1,133	1,551	931	1,410	3,491	3,671
10,500	908	1,432	1,207	1,648	991	1,489	4,078	4,279
10,750	961	1,511	1,290	1,755	1,053	1,575		
11,000	1,022	1,597	1,385	1,874	1,122	1,670		
11,250	1,090	1,692	1,495	2,008	1,200	1,774		
11,500	1,167	1,796	1,622	2,161	1,290	1,890		
11,750	1,255	1,912	1,772	2,336	1,393	2,020		
12,000	1,357	2,041	1,949	2,540	1,512	2,167		
12,250	1,474	2,188	2,164	2,781	1,651	2,334		
12,500	1,611	2,356	2,427	3,071	1,817	2,529		
12,750	1,774	2,549	2,756	3,429	2,015	2,758		
13,000	1,969	2,777	3,181	3,882	2,257	3,031		

Distance.	Washington $\varphi=38° 54'$ $\lambda=77° 03'$ W.		Wien $\varphi=48° 15'$ $\lambda=16° 22'$ E.		Zi-ka-wei $\varphi=31° 12'$ $\lambda=121° 26'$ E.	
Δ in km.	d	r	d	r	d	r
1,000	482	97	384	90	568	104
1,250	484	121	386	113	571	130
1,500	486	146	388	136	574	157
1,750	489	171	390	159	578	184
2,000	493	196	392	182	582	210
2,250	497	221	395	205	587	237
2,500	501	247	399	229	593	265
2,750	506	273	403	253	600	294
3,000	512	299	407	277	607	322
3,250	519	326	411	302	615	351
3,500	526	353	417	327	624	381
3,750	533	381	422	352	634	412
4,000	542	409	428	378	645	443
4,250	551	438	435	404	656	475
4,500	560	468	442	431	669	508
4,750	571	498	450	459	683	542
5,000	583	530	458	487	698	577
5,250	595	562	467	515	715	614
5,500	609	595	477	545	733	651
5,750	624	630	488	575	752	691
6,000	640	665	499	606	774	732
6,250	657	703	512	639	797	774
6,500	676	741	525	672	822	819
6,750	697	781	539	707	850	867
7,000	719	823	555	742	880	917
7,250	743	868	572	780	913	969
7,500	770	914	590	818	950	1,026
7,750	799	963	610	859	990	1,086
8,000	831	1,015	631	901	1,034	1,150
8,250	865	1,070	654	946	1,084	1,219
8,500	903	1,129	680	993	1,137	1,294
8,750	945	1,192	708	1,042	1,200	1,375
9,000	992	1,259	738	1,094	1,268	1,465
9,250	1,044	1,332	771	1,150	1,346	1,563
9,500	1,101	1,411	808	1,209	1,434	1,671
9,750	1,166	1,497	848	1,272	1,535	1,793
10,000	1,239	1,592	893	1,340	1,651	1,930
10,250	1,322	1,697	942	1,414	1,787	2,087
10,500	1,416	1,814	997	1,493	1,946	2,268
10,750	1,524	1,945	1,059	1,580	2,136	2,480
11,000	1,650	2,094	1,129	1,675	2,365	2,732
11,250	1,798	2,266	1,209	1,780	2,649	3,037
11,500	1,973	2,464	1,299	1,897	3,006	3,416
11,750	2,182	2,699	1,403	2,028	3,469	3,903
12,000	2,439	2,982	1,523	2,176	4,093	4,551
12,250	2,762	3,328	1,665	2,346		
12,500	3,172	3,766	1,832	2,542		
12,750	3,718	4,339	2,034	2,774		
13,000	4,472	5,121	2,280	3,050		

FORMULAE.

Velocity of longitudinal waves in an isotropic medium $= V_P = \sqrt{\dfrac{\lambda + 2\mu}{\rho}}$

" transverse " " $= V_S = \sqrt{\dfrac{\mu}{\rho}}$

" surface " " $= V_L = \cdot 9194\sqrt{\dfrac{\mu}{\rho}}$ (Galitzin)

E = Young's modulus, or the longitudinal elasticity of a body which is perfectly free to expand or contract laterally,

$$= \frac{\mu\,(3\lambda + 2\mu)}{\lambda + \mu} = \frac{9k\mu}{3k+\mu}$$

μ = Modulus of rigidity or resistance to shearing, $= \dfrac{E}{2(1 + \sigma)}$

k = Modulus of cubical compression, $= \lambda + \frac{2}{3}\mu = \dfrac{E}{3\,(1-2\sigma)}$.

$$\lambda = k - \tfrac{2}{3}\mu$$

σ = Poisson's ratio, or ratio of transverse contraction to longitudinal expansion, $= \cdot 25$ very nearly for rocks.

ρ = density.

Assuming $\sigma = \cdot 25$ for the above formulae we get the continued relation

$$V_P = \sqrt{\frac{6}{5}\cdot\frac{E}{\rho}} = \sqrt{3}\;V_S = 1\cdot 732\;V_S = \frac{\sqrt{3}\;V_L}{\cdot 9194} = 1\cdot 884\;V_L$$

To give a concrete example of known data of μ and ρ at the surface of the earth for deducing V_L, we have for granite, $\mu = 2\cdot 373 \times 10^{11}$ in absolute C. G. S. units, and $\rho = 2\cdot 8$,

hence $V_L = \cdot 9194\sqrt{\dfrac{\mu}{\rho}} = 2\cdot 68 \times 10^5$ cm., or $2\cdot 68$ km. per second.

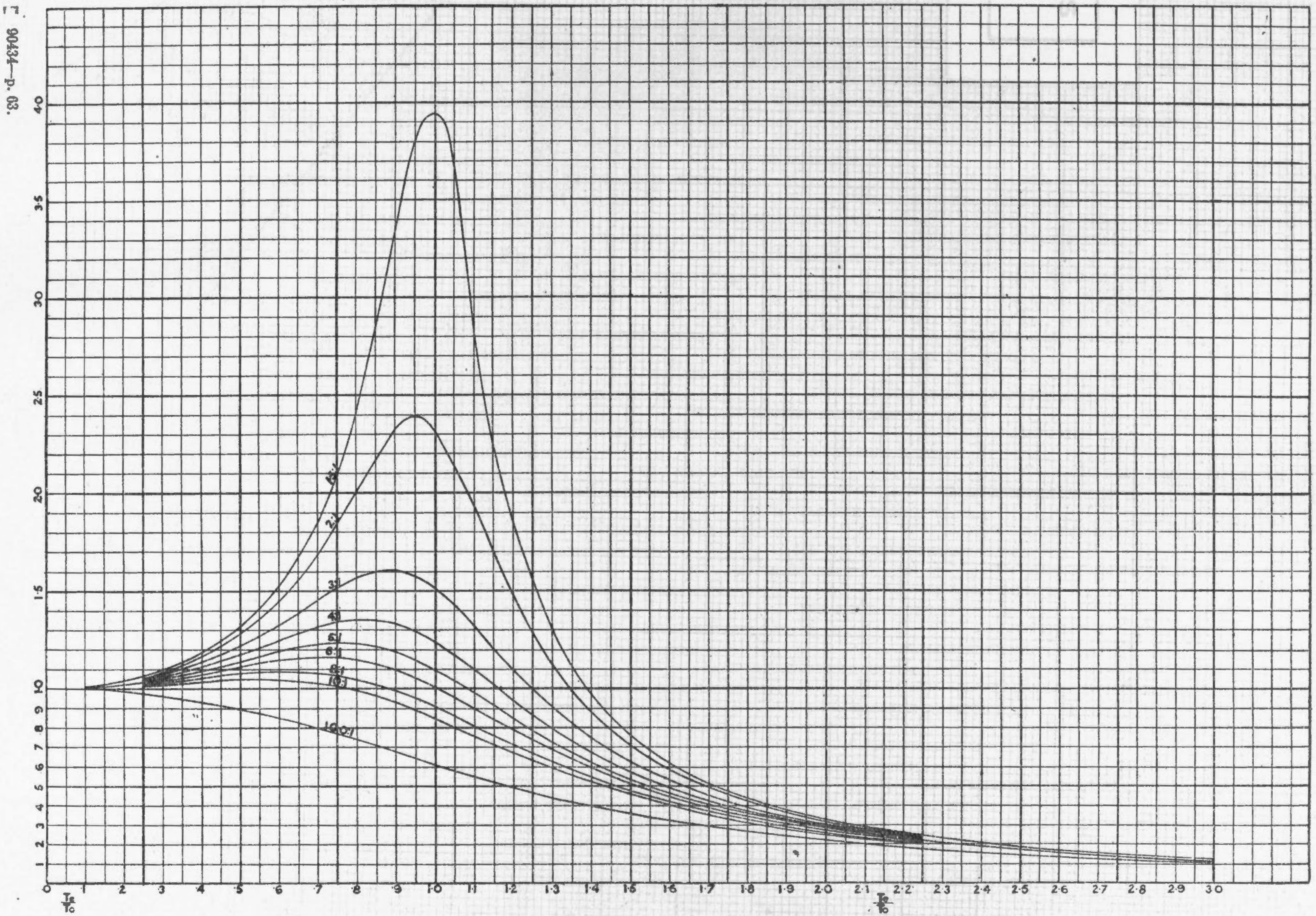
This is less than observed values, but it must be remembered that our data are for the surface conditions, while the conditions at a considerable depth must be taken into account, but which can not be directly measured. However, the ratio between μ and ρ, or E and ρ can be found from observed velocities. As the velocity increases with depth, it is obvious that both μ and E must increase faster than does ρ, the density. Galitzin gives a numerical example* for the velocity of the longitudinal waves in steel, for which he takes $E=21 \cdot 6 \times 10^{11}$ and $\rho=7 \cdot 8$,

$$\text{hence } V_P = \sqrt{\frac{6}{5} \cdot \frac{216 \times 10^{10}}{7 \cdot 8}} = 5 \cdot 77 \text{ km. per second.}$$

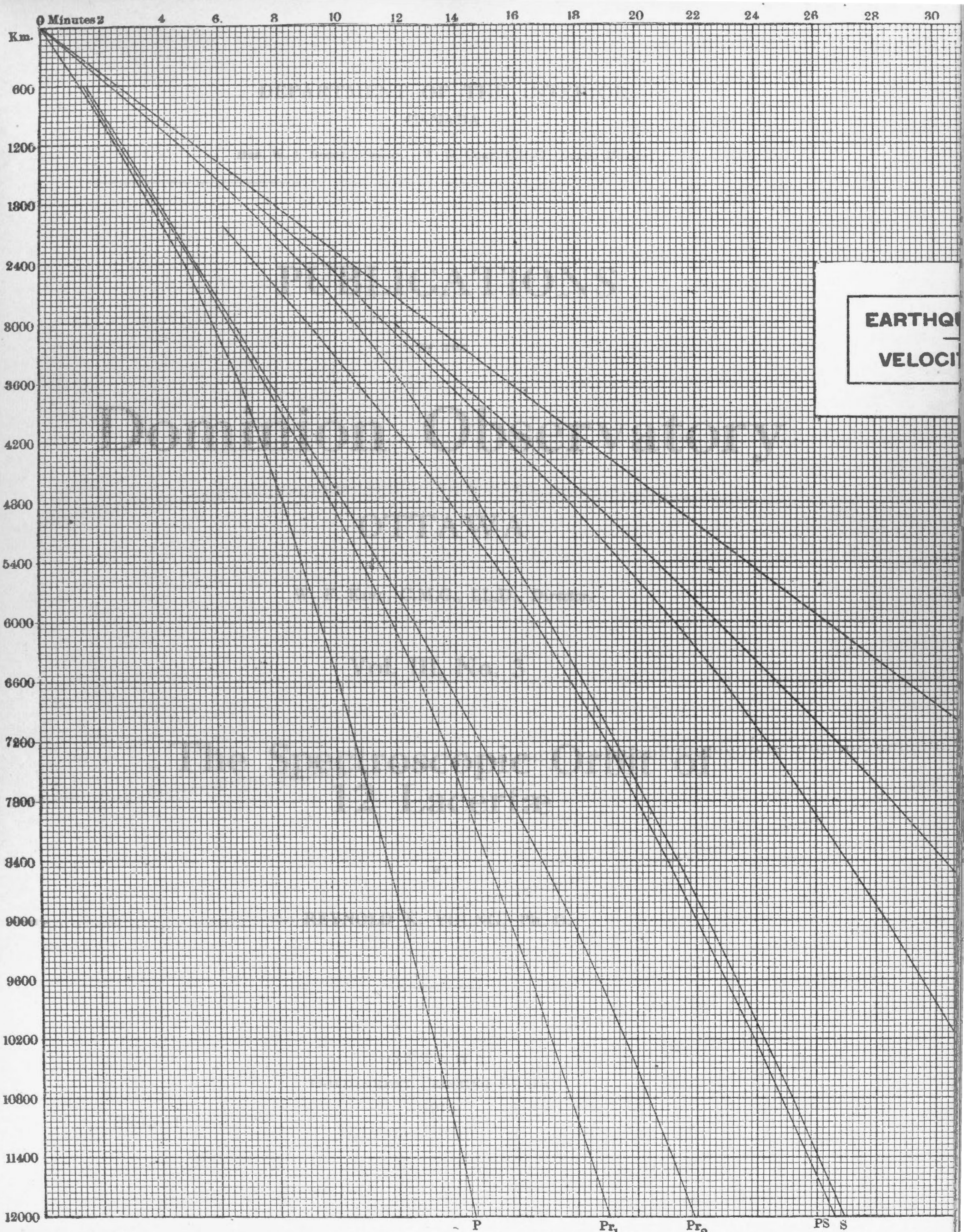
This value too is less than the initial value of the velocity of the P waves. Theoretically the velocity of the L waves is constant, while for P and S waves the velocity increases with the depth of the path, that is, with the distance. But this increase does not continue up to 180° or for the path along a diameter. The constitution of the interior of the earth and its separation into various concentric shells is not as yet sufficiently well known to assign definite limits to abrupt changes in the velocities of P and S waves.

*Seismometrie, p. 61

Dominion Observatory,
Ottawa,
December, 1915.



Magnification Curves.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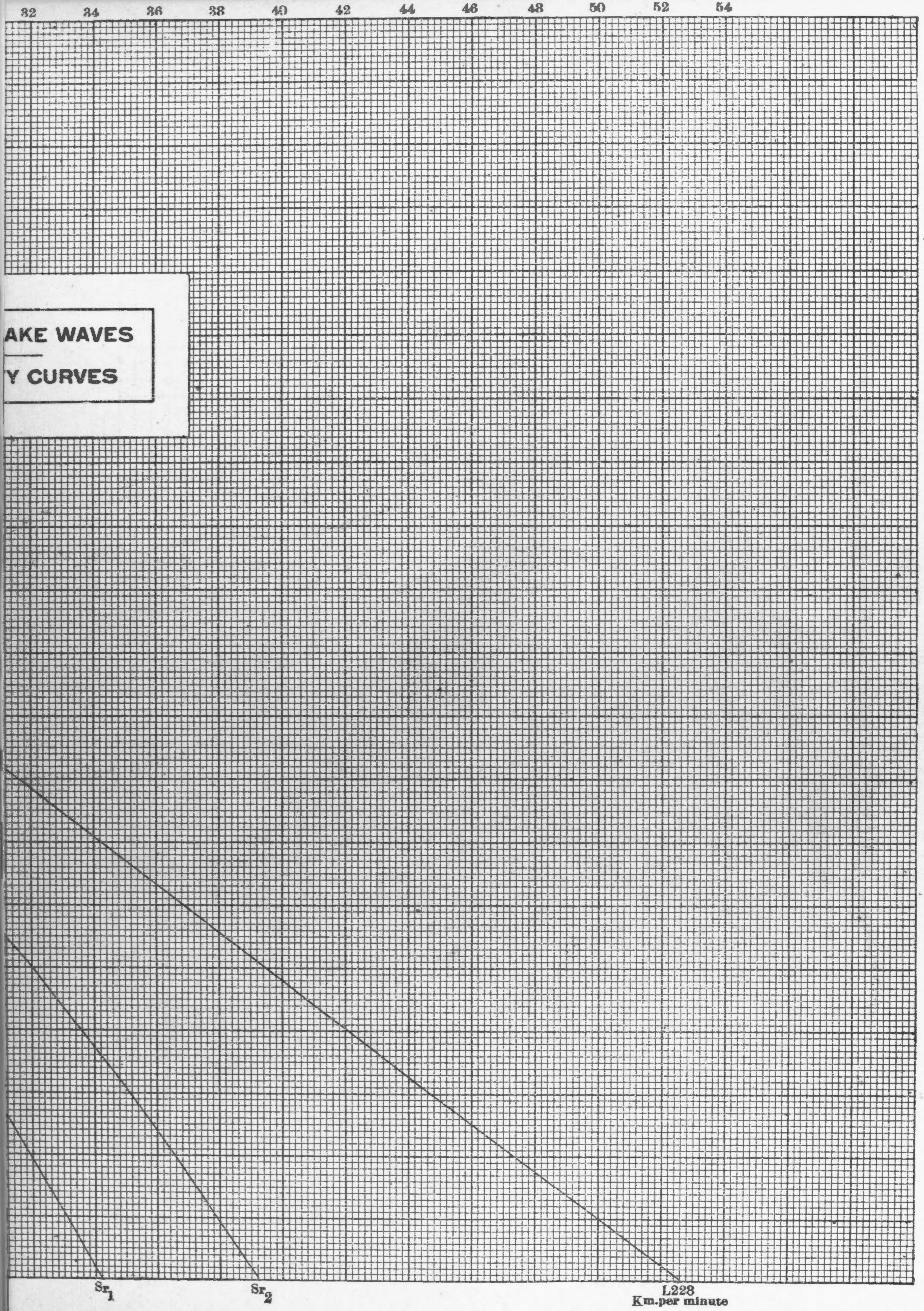
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Km.per minute

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PUBLICATIONS

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The Spectroscopic Orbit of 12 Lacertæ

BY

REYNOLD K. YOUNG, Ph. D.

OTTAWA
GOVERNMENT PRINTING BUREAU
1915

88612—1

THE SPECTROSCOPIC ORBIT OF 12 LACERTÆ.

BY REYNOLD K. YOUNG, Ph.D.

The binary character of 12 Lacertæ ($\alpha = 22^{h}\ 37^{m}\cdot 6$, $\delta = +39°\ 46'$, mag. 5·3, type B2) was announced by Adams in the Astrophysical Journal in 1912. The character of the spectrum may be judged from Table I, which gives the wave-lengths of the lines used. In addition to the wave-lengths there given, helium lines at λ 3963·875, λ 4009·417, the lines λ 4046, λ 4064, λ 4072 are also present. None of these latter lines were included in the final reductions.

TABLE I.

Wave-Length.	Element.	Wave-Length.	Element.
3933·727	*Ca*	4340·634	*H*
3964·875	*He*	4388·100	*He*
4026·352	*He*	4471·676	*He*
4101·890	*H*	4481·400	*Mg*
4143·928	*He*	4552·750	*Si*
4267·301	*C*	4567·950	*Si*

The observations, numbering 117, are given in Table III. When the writer began work on 12 Lacertæ in 1914, over fifty spectrograms had already been obtained and as this number usually suffices to determine the orbit of a binary, the star was removed from the observing programme until such time as those plates already on hand should be reduced. When this work was completed it was too late in the season to get more plates and while the 1913 and 1914 velocities indicated a short period, all efforts to harmonize the results failed, so that it was not until the fall of 1915 that a run of exposures made during the course of one night showed the true period. The individual observations do not fit any curve well. This and also the fact that the period is very short make the determination of the number of cycles performed between successive seasons difficult and a little uncertain. Between the first and last plate the star has travelled nearly eight thousand revolutions, so that if no mistake has been made in the whole number of cycles, the period should be accurate to within a second of time. Observations secured at other observatories, covering the same or part of the same epoch as those obtained here, would probably eliminate any uncertainty in this regard.

88612—1½

TABLE II.

MOUNT WILSON OBSERVATIONS OF 12 LACERTÆ.

Date.	Julian Day.	Velocity.	Phase.
1911			
Aug. 16	2,419,265·958	+ 3	·046
Sept. 8	288·909	+ 6	·020
Sept. 16	296·794	− 8	·181
Oct. 11	321·815	−43	·100

TABLE III.

OTTAWA OBSERVATIONS OF 12 LACERTÆ.

Plate.	Observer*	Date.	Julian Day.	Velocity.	Weight.	Phase.	O–C.	Remarks.
		1913						
5623	P^1	July 14	2,419,963·831	−23·7	3	·095	+ 6·4	
5630	C	July 21	970·830	−10·6	2	·143	+ 4·5	
5634	P^1	July 25	974·785	− 5·1	2	·043	+ 3·4	
5642	P^1	July 30	979·792	+ 1·8	2	·030	+ 4·0	
5647	P^1	Aug. 7	987·813	− 9·3	2	·134	+ 9·0	
5664	P^1	Sept. 5	20,016·705	−28·2	1	·063	− 8·8	Exposed 110 min.
5665	P^1	Sept. 8	019·827	−42·1	2	·096	−11·7	
5670	P^1	Sept. 15	026·679	+ 9·3	2	·189	+ 7·0	
5680	C	Sept. 19	030·672	−16·3	1	·127	+ 8·0	Exposed 105 min.
5685	P^1	Sept. 22	033·660	+ 3·5	1	·026	+ 4·2	Exposed 115 min.
5692	Y	Sept. 24	035·686	−35·1	2	·121	− 7·8	
5704	P^1	Sept. 26	037·748	−11·5	2	·059	+ 6·5	
5711	P^1	Sept. 29	040·748	− 1·2	3	·163	+ 5·4	
5720	Y	Sept. 30	041·609	−19·8	3	·059	− 1·6	
5728	P	Oct. 1	042·635	− 8·4	1	·119	+19·4	Very weak.
5735	C	Oct. 3	044·644	+21·6	2	·004	+18·3	
5750	P^1	Oct. 6	047·608	−15·7	2	·072	+ 8·0	
5765	P	Oct. 8	049·587	−22·0	2	·119	+ 5·8	
5768	Y	Oct. 9	050·580	−22·4	2	·048	−10·8	
5775	C	Oct. 13	054·602	−25·2	3	·115	+ 3·9	
5787	C	Oct. 31	072·610	+ 4·4	2	·165	+10·5	
5792	G	Nov. 5	077·564	−31·6	2	·099	− 0·8	Exposed 105 min.
5800	Y	Nov. 6	078·500	−19·0	2	·070	+ 3·8	
5837	P^1	Dec. 22						Prism under strain
		1914						
6139	H	June 30	314·834	− 1·1	2	·063	+20·0	
6164	P^1	July 8	322·785	−13·9	2	·097	+16·5	
6169	H–Y	July 9	323·725	−19·5	2	·072	+ 4·0	
6183	Y–H	July 14	328·748	−48·4	2	·074	−24·0	
6187	G–P^1	July 15	329·736					Temp. changed 3 degrees.

TABLE III.

OTTAWA OBSERVATIONS OF 12 LACERTÆ.—*Continued.*

Plate.	Observer*	Date.	Julian Day.	Velocity.	Weight.	Phase.	O–C.	Remarks.
		1914						
6198	P^1	July 17......	2,420,331·810	−14·6	3	·047	− 3·3	
6216	H	July 21......	335·774	− 3·1	1	·149	−10·5	
6220	H	July 23......	337·675	−30·9	2	·129	−12·0	
6223	P^1	July 24......	338·788	−25·2	2	·074	− 1·0	
6223	P^1	July 24......	338·788	−25·3	....	·074	....	Remeasure.
6228	C	July 27......	341·828	....	....	....	....	Exposed 135 min.
6233	P^1	July 29......	343·849	−20·3	2	·114	+ 9·0	
6236	H	July 30......	344·634	−20·2	3	·127	+ 4·8	
6244	P^1–C	Aug. 3......	348·738	+ 0·8	3	·176	+ 1·8	
6262	H	Aug. 4......	349·862	−31·8	3	·142	−14·0	
6266	P^1–C	Aug. 5......	350·727	−20·1	2	·041	−12·5	
6270	H	Aug. 11......	356·762	−21·7	2	·090	+ 7·8	
6276	P^1	Aug. 14......	359·788	− 5·3	2	·027	− 4·5	
6281	Y–H	Aug. 18......	363·736	−27·0	2	·113	+ 2·5	
6286	C	Aug. 19......	364·757	−19·6	2	·169	−15·0	Epoch earlier?
6291	C	Aug. 21......	366·654	−32·7	1	·134	−10·5	
6308	H	Aug. 25......	370·722	−14·0	3	·148	0·0	
6314	G–C	Aug. 26......	371·743	− 6·3	2	·011	− 9·5	
6318	H	Aug. 27......	372·612	−21·1	0	·106	+ 9·5	Exposed 144 min.
6328	C	Aug. 31......	376·767	− 7·3	2	·014	−10·0	
6335	H	Sept. 4......	380·665	−19·8	2	·050	− 6·8	
6342	H	Sept. 8......	384·555	−21·9	2	·079	+ 4·3	
6349	P	Sept. 9......	385·669	+12·6	2	·034	+18·0	
6349	P	Sept. 9......	385·669	+ 9·2	....	·034	+14·8	Remeasure.
6356	P–H	Sept. 11......	387·714	−15·7	3	·148	− 1·0	
6369	P^1	Sept. 14......	390·656	− 1·3	3	·000	− 4·2	
6409	Y	Sept. 20......	396·637	− 7·1	2	·189	− 9·0	
6409	Y	Sept. 20......	396·637	− 5·5	....	·189	− 7·4	Remeasure.
6426	P^1	Sept. 25......	401·655	+ 1·6	2	·187	0·0	
6439	P^1	Sept. 28......	404·655	−25·8	1	·097	+ 4·8	
6454	H	Oct. 1......	407·598	+ 4·0	2	·144	+20·0	
6479	Y	Oct. 4......	410·632	−30·1	3	·089	− 1·0	
6479	Y	Oct. 4......	419·604	−33·1	3	·089	− 4·0	Remeasure.
6497	Y	Oct. 13......	419·604	+ 3·3	3	·178	+ 3·7	
6504	P^1	Oct. 14......	420·613	+ 7·0	3	·029	+ 9·0	
6512	C	Oct. 21......	427·609	−30·4	3	·074	− 6·0	
6521	H	Oct. 22......	428·695	+ 1·4	3	·001	− 1·8	
6531	G	Oct. 24......	430·498	−19·9	3	·104	+11·0	
6542	P^1	Nov. 2......	439·620	−24·3	3	·113	− 5·5	
6557	P^1	Nov. 16......	453·608	+12·7	3	·006	+ 9·5	
6559	Y	Nov. 17......	454·591	+ 4·2	2	·023	+ 4·0	
		1915						
6992	Y	May 13......	631·858	−10·7	2	·035	− 5·5	
6998	C	May 14......	632·852	−13·9	2	·063	+ 1·0	
7001	Y	May 15......	633·847	−27·9	3	·093	+ 2·0	
7020	Y	May 27......	645·849	−23·8	3	·123	+ 2·5	
7023	P	May 28......	646·846	+ 1·3	3	·155	+12·0	
7026	P^{11}	May 29......	647·839	−11·8	2	·182	−12·8	

TABLE III.

OTTAWA OBSERVATIONS OF 12 LACERTÆ—*Concluded.*

Plate.	Observer*	Date.	Julian Day.	Velocity.	Weight.	Phase.	O–C.	Remarks.
		1915						
7033	H	May 30......	2,420,648·846	+ 8·6	3	·031	+11·0	
7043	H	June 1......	650·812	−14·5	2	·066	− 3·5	
7046	P¹¹	June 2......	651·835	−23·6	2	·123	+ 2·7	
7172	Y	Aug. 26......	736·753	−49·9	3	·082	−22·5	
7176	Y	Aug. 26......	736·890	− 3·6	1	·026	− 3·0	
7177	Y	Aug. 27......	737·538	−35·2	3	·095	− 5·0	
7178	Y	Aug. 27......	737·582	−14·6	3	·141	+ 3·8	
7180	Y	Aug. 27......	737·677	− 7·7	3	·041	0·0	
7181	Y	Aug. 27......	737·722	−23·8	3	·086	+ 5·0	
7182	Y	Aug. 27......	737·832	+ 2·3	3	·003	− 1·0	
7183	Y	Aug. 27......	737·875	− 5·6	3	·045	+ 4·4	
7184	Y	Aug. 28......	738·534	−32·9	3	·125	− 6·0	
7185	H	Aug. 28......	738·666	− 1·0	2	·064	−19·0	
7200	P¹¹	Sept. 3......	744·545	....	....	....	....	Slit set very wide.
7201	P¹¹	Sept. 3......	744·593	+ 3·5	1	·006	0·0	" "
7202	P¹¹	Sept. 3......	744·642	−23·8	1	·054	− 9·0	" "
7203	P¹¹	Sept. 3......	744·674	−18·7	1	·087	+10·0	" "
7204	Y	Sept. 3......	744·747	− 0·8	3	·160	+ 7·0	
7207	Y	Sept. 3......	744·842	−16·3	3	·061	+ 2·5	
7208	Y	Sept. 3......	744·889	−32·3	3	·108	− 1·7	
7209	Y	Sept. 4......	745·528	−10·5	3	·168	− 6·0	
7210	H	Sept. 4......	745·700	−15·6	3	·147	0·0	
7211	Y	Sept. 4......	745·751	+11·3	3	·005	+ 8·0	
7214	Y	Sept. 4......	745·846	−38·3	3	·100	− 7·4	
7215	Y	Sept. 4......	745·889	−29·4	3	·143	−12·0	
7229	Y	Sept. 10......	751·569	− 2·9	3	·030	− 0·5	
7231	Y	Sept. 10......	751·658	−30·9	3	·121	− 3·7	
7239	Y	Sept. 14......	755·545	−19·1	3	·145	− 3·0	
7240	Y	Sept. 14......	755·587	+18·1	3	·187	+16·0	
7241	Y	Sept. 14......	755·628	− 8·2	3	·034	− 4·0	
7242	Y	Sept. 14......	755·672	−34·6	3	·078	− 8·0	
7243	Y	Sept. 14......	755·712	−44·1	3	·118	−16·0	
7244	H	Sept. 14......	755·750	−21·1	3	·157	−11·0	
7249	P	Sept. 15......	756·599	− 5·2	2	·000	− 8·2	
7250	P	Sept. 15......	756·642	−30·3	3	·043	−21·0	
7251	P	Sept. 15......	756·690	−37·5	3	·083	−10·0	
7252	C	Sept. 15......	756·750	− 7·6	1	·131	+15·0	Epoch very uncertain.
7256	H	Sept. 16......	757·641	−41·0	3	·117	−12·0	
7266	Y	Sept. 19......	760·516	−24·2	3	·095	+ 6·0	
7268	Y	Sept. 19......	760·611	− 3·8	3	·190	− 6·0	
7270	Y	Sept. 19......	760·713	−26·5	3	·099	+ 4·2	
7293	Y	Sept. 28......	769·599	−24·3	3	·103	+ 6·8	
7296	Y	Sept. 28......	769·699	− 2·9	3	·010	− 6·0	
7300	Y	Sept. 29......	770·556	−18·5	3	·095	+12·0	
7302	Y	Sept. 29......	770·667	− 7·5	3	·013	−10·0	
7303	C	Sept. 29......	770·757	−26·5	3	·103	+ 4·5	
7310	H	Sept. 30......	771·621	+ 8·2	3	·002	+ 5·0	
7313	Y–H	Sept. 30......	771·721	−42·0	3	·102	−11·8	

*P=Plaskett; C=Cannon; H=Harper; P¹=Parker; Y=Young; G=Gibson; P¹¹=H. H. Plaskett.

MEASURES OF 12 LACERTÆ.

λ	5623		5630		5634		5642		5647		5664		5665	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−35·7	½	−27·4	½	...	...	−19·1	½	...	...	...	...	...	...
4026·352	−34·6	½	−40·0	½	−23·4	¼	...	...	−28·1	½	...	...	...	...
4101·890	−36·6	½	−30·8	½	...	...	...	...	...	...	...	...	...	...
4143·928	−55·3	¼	−15·8	½	...	...	− 7·0	¼	−13·8	½	−26·7	½	...	...
4267·301	...	...	−27·4	½	...	...	−17·2	½	−24·1	½	−51·5	½	...	...
4340·634	−54·3	¼	−35·8	½	...	...	...	...	−20·8	½	−23·6	¼	−46·6	½
4388·100	−41·8	½	−33·5	½	−29·9	½	− 4·8	¼	−31·1	½	−27·5	½	...	...
4471·676	−54·4	½	−15·2	½	−22·8	½	−16·5	½	−27·9	½	−40·5	½	−50·6	½
4552·750	...	...	−33·3	½	...	...	...	...	−21·3	½	−28·0	½	−42·6	½
4567·950	...	...	...	...	− 7·0	¼	...	...	...	...	...	...	...	...
Weighted mean	−42·97		−28·80		−22·63		−14·68		−23·87		−33·82		−46·60	
V_a	+19·54		+18·48		+17·78		+16·76		+14·89		+ 5·91		+ 5·00	
V_d	0·00		0·00		+ 0·03		+ 0·01		− 0·07		− 0·05		− 0·18	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	−23·7		−10·6		− 5·1		+ 1·8		− 9·3		−28·2		−42·1	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	5670		5680		5685		5692		5704		5711		5720	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	− 5·0	¼	−14·1	½	...	...	...	...	...	...	+ 2·9	½	−11·1	½
3964·875	...	...	...	...	...	...	...	...	...	...	+ 5·1	¼	...	...
4026·352	...	...	−25·2	½	...	...	−40·6	½	...	...	+ 7·6	½	− 8·1	½
4101·890	...	...	...	...	...	...	...	...	...	...	...	...	− 5·8	½
4143·928	...	...	− 5·9	¼	...	...	−36·8	½	...	...	+ 6·0	¼	−26·9	½
4267·301	...	...	...	...	...	...	−24·2	½	− 8·8	½	−18·6	¼	−20·8	½
4340·634	+ 4·6	¼	−17·3	½	...	...	−21·9	½	− 4·6	½	+ 5·8	½	− 9·2	½
4388·100	...	...	−16·7	½	−14·3	½	−39·4	½	−16·1	½	+ 7·2	½	...	...
4471·676	+21·5	¼	−17·7	½	+25·8	¼	−41·7	½	− 8·8	½	−26·6	½	−34·2	½
4552·750	...	...	...	...	...	...	−33·4	½	...	...	+16·0	½	...	...
Weighted mean	+ 7·03		−17·07		+ 3·83		−34·00		− 9·57		+ 1·63		−16·60	
V_a	+ 2·56		+ 1·12		+ 0·02		− 0·72		− 1·48		− 2·54		− 2·89	
V_d	− 0·03		− 0·05		− 0·03		− 0·07		− 0·17		− 0·02		+ 0·03	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	+ 9·3		−16·3		+ 3·5		−35·1		−11·5		− 1·2		−19·8	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	5728		5735		5750		5765		5768		5775		5787	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	+ 0·9	½	+ 3·4	½									+14·1	½
3964·875							− 8·5	½					+11·0	½
4026·352	− 3·6	½	+27·1	½	+ 3·6	½			−11·7	½	−19·8	½	+10·8	½
4101·890	− 2·4	¼							−23·1	½	− 9·6	½	+24·0	½
4143·928			+28·9	½	− 6·0	½	−10·9	½	− 5·0	½	−22·8	½	+23·8	½
4267·301	− 4·9	¼	+32·8	½			−14·2	½	−11·0	½	−12·0	½		
4340·634			+19·7	½	− 3·4	½	−15·0	½	−12·7	½	−27·8	½	+13·9	1
4388·100	−17·9	½	+26·3	½	−34·7	½	−16·7	½	−35·9	½	−15·5	½	+16·7	½
4471·676	0·0	½	+32·9	½	−11·3	½	−27·8	½	−11·4	½	−13·9	½	+35·4	½
4552·750			+36·0	½			−18·7	½	−17·2	½				
Weighted mean	− 4·84		+ 25·90		− 10·36		− 15·95		− 16·00		− 17·34		+ 18·18	
V_a	− 3·27		− 3·99		− 5·07		− 5·77		− 6·12		− 7·55		− 13·41	
V_d	+ 0·02		− 0·03		0·00		+ 0·03		+ 0·03		− 0·02		− 0·10	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 8·4		+ 21·6		− 15·7		− 22·0		− 22·4		− 25·2		+ 4·4	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	5792		5800		6139		6164		6169		6183		6198	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	− 7·5	½	+ 3·3	½									−21·1	½
3964·875	−14·4	½	− 9·3	½										
4026·352	−25·2	½	+ 3·6	½							−78·0	½	−21·7	½
4101·890											−60·3	½	−47·2	½
4143·928	−21·8	½	+ 1·0	½			−34·6	½			−78·9	¼		
4267·301			+ 1·1	½			−33·0	½			−56·6	½		
4340·634	−19·7	½			−14·8	¼	−31·5	½	−45·0	½	−65·3	½	−45·0	½
4388·100	−19·1	½	− 8·3	½	−20·6	¼	−42·0	½	−31·5	½	−65·5	½	−31·5	½
4471·676	−11·4	½	−16·4	½	−30·0	¼	−28·5	½	−55·7	¼	−82·9	½	−34·7	½
4552·750									−34·0	½	−55·0	½		
4567·950											−74·0	½		
Weighted mean	− 16·44		− 3·57		− 21·80		− 34·00		− 39·53		− 67·88		− 33·50	
V_a	− 14·83		− 15·09		+ 20·86		+ 20·25		+ 20·14		+ 19·59		+ 19·16	
V_d	− 0·06		+ 0·04		+ 0·07		+ 0·11		+ 0·18		+ 0·13		+ 0·03	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 31·6		− 19·0		− 1·1		− 13·9		− 19·5		− 48·4		− 14·6	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	6216		6220		6223		6223*		6233		6236		6244	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727													−17·9	½
4026·352	−23·4	½			−33·8	½	−34·7	½	−13·9	½	−36·4	½		
4143·928					−27·9	¼					−23·1	½	−14·4	½
4267·301									−34·0	½			−24·5	¼
4340·634	−23·6	½			−49·0	1	−41·6	1	−46·1	¼	−45·0	1	+ 1·1	¼
4388·100	−26·8	½	−49·0	½	−51·3	1	−57·1	1	−66·4	½	−37·3	1	−12·8	½
4471·676					−37·0	1	−34·6	1	−23·5	½	−35·9	1	−17·3	½
4552·750	−12·0	½												
Weighted mean	− 21·45		− 49·00		− 42·90		− 43·06		− 36·97		− 36·98		− 14·88	
V_a	+ 18·53		+ 18·20		+ 18·00		+ 18·00		+ 17·01		+ 16·84		+ 15·93	
V_d	+ 0·07		+ 0·19		+ 0·03		+ 0·03		− 0·08		+ 0·20		+ 0·07	
Curv.	− 0·28		− 0·28		+ 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 3·1		− 30·9		− 25·2		− 25·3		− 20·3		− 20·2		+ 0·8	

*Remeasure.

MEASURES OF 12 LACERTÆ—*Continued.*

λ	6262		6266		6270		6276		6281		6286		6291	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−29·9	½	...	...	−27·5	½	−18·7	½	−37·0	¼	...	...	−24·3	½
3964·875	−43·4	½	...	...	...	...	...	...	...	...	...	...	−58·1	¼
4026·352	−61·6	¼	...	...	...	...	−12·1	¼	−26·0	½	...	...	−53·8	½
4143·928	−34·6	½	...	...	...	...	...	...	−48·1	½	−30·2	½	...	...
4267·301	...	...	...	...	...	...	−13·8	¼	...	...	−41·2	½	...	...
4340·634	−48·4	½	−23·6	½	...	...	...	...	−51·7	¼	...	...	−41·7	½
4388·100	−64·1	½	−42·8	½	−48·9	½	−21·0	½	−35·0	½	−26·8	½	−52·8	½
4471·676	−54·5	½	−39·7	½	−29·7	½	−18·6	½	−51·9	¼	−27·2	1	−38·4	½
4481·400	...	...	...	...	...	...	...	...	...	...	−32·4	1	...	...
Weighted mean	− 47·05		− 35·36		− 35·37		− 17·82		−. 38·75		− 30·90		− 43·67	
V_a	+ 15·66		+ 15·46		+ 13·92		+ 13·10		+ 11·96		+ 11·65		+ 11·17	
V_d	− 0·12		− 0·07		0·00		− 0·06		+ 0·01		− 0·02		+ 0·12	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 31·8		− 20·1		− 21·7		− 5·3		− 27·0		− 19·6		− 32·7	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	6308		6314		6318		6328		6335		6342		6349	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−26·1	1	−26·5	½	.....	.....	−18·7	½	−12·4	½	−18·3	½	.....	.....
3964·875	−25·4	½	− 9·0	½	.....	.....	.....	.....	.....	.....	−38·5	½	.....	.....
4026·352	.....	.....	+ 6·1	½	.....	.....	−12·1	½	−37·3	½	−22·6	½	.....	.....
4101·890	.....	.....	.....	.....	−39·9	½	.....	.....	.....	.....	.....	.....	+17·3	½
4143·928	.....	.....	−10·5	½	−13·5	½	−11·5	½	−20·2	½	−19·2	½	+12·0	½
4267·301	.....	.....	−22·3	½	−31·9	½	.....	.....	.....	.....	−35·0	½	.....	.....
4340·634	−19·1	¼	−16·9	½	−22·5	¼	.....	.....	−25·9	½	−28·2	1	+13·5	½
4388·100	−15·1	½	−17·5	½	−26·8	½	−16·3	½	.....	.....	−31·5	½	− 1·2	½
4471·676	−27·3	½	−27·2	½	−42·1	½	−16·1	½	−34·7	½	−21·0	½	− 1·2	½
Weighted mean	− 23·56		− 15·48		− 30·10		− 14·76		− 26·10		− 26·94		+ 8·08	
V_a	+ 9·83		+ 9·50		+ 9·17		+ 7·86		+ 6·53		+ 5·18		+ 4·80	
V_d	0·00		− 0·03		+ 0·15		− 0·08		+ 0·05		+ 0·18		+ 0·03	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 14·0		− 6·3		− 21·1		− 7·3		− 19·8		− 21·9		+ 12·6	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	6349*		6356		6369		6409		6409*		6426		6439	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−11·6	½	− 8·4	½	+ 1·2	½	− 9·2	½	−24·3	½	− 1·3	½		
3964·875											+13·9	¼		
4026·352	0·0	½	−27·7	½	+ 0·9	½	− 9·5	¼	− 4·3	½	− 3·5	¼	−23·4	½
4101·890	+11·1	¼	−19·5	½										
4143·928	+17·3	½	−13·5	½	− 1·9	¼	− 5·8	½	− 2·0	½	+10·6	½	−17·7	½
4267·301							− 8·5	¼	− 9·6	¼				
4340·634	+12·4	½			0·0	½	−10·1	1	− 5·6	½			−28·1	1
4388·100	− 4·6	½	−32·7	½	−17·5	½	− 5·8	½	− 4·6	½	+ 7·3	½		
4471·676	+ 2·5	¼	−14·8	½	− 6·1	½	− 3·7	½	+ 6·1	½	−12·4	½	−19·8	½
4552·750	+20·0	¼												
Weighted mean	+ 4·65		− 19·43		− 4·09		− 7·67		− 6·07		+ 2·92		− 23·42	
V_a	+ 4·80		+ 4·07		+ 3·01		+ 0·85		+ 0·85		− 0·99		− 2·08	
V_d	+ 0·03		− 0·06		+ 0·02		+ 0·02		+ 0·02		− 0·02		− 0·03	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	+ 9·2		− 15·7		− 1·3		− 7·1		− 5·5		+ 1·6		− 25·8	

*Remeasure.

MEASURES OF 12 LACERTÆ—*Continued.*

λ	6454		6479		6479*		6497		6504		6512		6521	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	+ 2·0	½					+ 8·7	¼	+12·3	½			+25·0	½
3964·875			−26·2	½	−27·0	½								
4026·352	+13·0	½					+20·8	½	+ 7·8	½	−16·5	½	+ 4·3	½
4101·890									+29·7	¼			+ 3·8	½
4143·928	+ 1·9	½					+ 2·9	½	+22·1	¼	−21·2	½	+10·5	½
4267·301	+ 9·5	½					+16·0	¼	+11·7	¼				
4340·634	+ 7·8	½	−19·1	½	−23·6	½	+ 7·9	½	+13·5	½	−10·1	½	+16·9	1
4388·100	+16·2	½	−26·8	½	−29·1	½	0·0	½	+13·3	½	−25·6	½	+ 7·0	½
4471·676	+ 1·2	½	−34·7	½	−34·6	½	+ 9·8	1	+19·9	½	−26·0	½	+14·8	½
4552·750							+25·3	½						
Weighted mean	+ 7·37		− 25·50		− 28·58		+ 11·09		+ 15·16		− 19·88		+ 12·40	
V_a	− 3·16		− 4·36		− 4·26		− 7·46		− 7·81		− 10·19		− 10·55	
V_d	+ 0·04		− 0·02		− 0·02		− 0·02		− 0·03		− 0·07		− 0·18	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	+ 4·0		− 30·1		− 33·1		+ 3·3		+ 7·0		− 30·4		+ 1·4	

*Remeasure.

MEASURES OF 12 LACERTÆ—*Continued.*

λ	6531		6542		6557		6559		6992		6998		7001	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	− 2·4	½	−14·4	½	+31·1	½	....	....	−29·1	½	−26·7	¼	−30·0	¼
3964·875	....	....	....	....	+19·8	½	....	....	....	....	....	....	....	....
4026·352	− 7·8	½	−25·2	½	+26·1	½	+34·9	¼	−16·0	¼	−18·7	¼	−56·3	¼
4101·890	....	....	0·0	½	....	....	....	....	....	....	....	....	....	....
4143·928	− 7·7	½	....	....	+39·7	½	+ 5·8	¼	....	....	....	....	....	....
4267·301	....	....	−25·5	½	+28·9	¼	+35·3	¼	....	....	....	....	....	....
4340·634	−11·3	½	0·0	½	+21·5	¼	....	....	−21·4	¼	−29·3	½	−36·0	½
4388·100	−16·3	½	+ 8·1	½	+39·8	½	+12·9	¼	−14·0	½	−39·6	½	−46·6	¼
4471·676	− 5·6	½	−14·9	½	+28·6	½	+38·6	¼	−37·9	½	−30·3	¼	−54·4	½
4481·400	....	....	....	....	....	....	....	....	−44·3	¼	....	....	....	....
4552·750	....	....	....	....	+35·0	½	+ 6·5	¼	....	....	....	....	....	....
Weighted mean	− 8·50		− 10·27		+ 30·67		+ 22·33		− 27·08		− 30·54		− 44·82	
V_a	− 11·14		− 13·63		− 17·53		− 17·73		+ 16·50		+ 16·73		+ 16·95	
V_d	....		− 0·13		− 0·15		− 0·12		+ 0·19		+ 0·20		+ 0·20	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 19·9		− 24·3		+ 12·7		+ 4·2		− 10·7		− 13·9		− 27·9	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	7020		7023		7026		7033		7043		7046		7172	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−29·1	½	−25·9	¼	−33·0	½	−20·2	¼	−22·3	½	...	...	...	...
3964·875	−50·8	½	−16·6	½	...	...	− 8·2	¼	...	...	...	...	...	...
4026·352	−62·3	½	−13·0	½	−33·0	½	− 3·4	¼	...	...	...	...	−69·4	½
4101·890	−30·6	¼	−14·8	¼	−47·3	¼	− 3·7	¼	...	...	...	...	...	...
4143·928	−30·3	½	−17·8	½	−30·8	½	−23·0	¼	−31·2	½	−43·3	½	−35·8	¼
4267·301	−47·9	½	− 1·6	¼	−44·1	¼	...	...	...	...	...	...	...	...
4340·634	−37·1	½	−28·1	½	−27·0	¼	− 9·0	½	−30·4	½	−38·3	½	−52·9	½
4388·100	−37·3	½	− 7·0	¼	−12·8	¼	+ 6·9	¼	−45·5	½	...	...	−60·6	½
4471·676	−50·1	½	−24·8	½	−30·3	1	−19·2	½	−41·5	½	−48·9	½	−74·9	¼
4481·400	−58·5	¼	...	...	...	...	...	...	...	...	...	...	...	...
4552·750	...	...	...	...	−21·0	¼	...	...	...	...	...	...	−53·7	½
Weighted mean	− 43·27		− 17·84		− 31·13		− 10·80		− 34·18		− 43·50		− 59·01	
V_a	+ 19·47		+ 19·25		+ 19·40		+ 19·53		+ 19·78		+ 19·92		+ 9·57	
V_d	+ 0·18		+ 0·18		+ 0·18		+ 0·18		+ 0·20		+ 0·12		− 0·21	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 23·8		+ 1·3		− 11·8		+ 8·6		− 14·5		− 23·6		− 49·9	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	7176		7177		7178		7180		7181		7182		7183	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−26·1	½	−22·0	½	−23·5	½	...		...		− 5·2	½	− 4·4	½
3964·875	...		...		...		...		...		−12·2	¼	−19·7	½
4026·352	−22·5	¼	−39·0	½	−30·3	½	− 6·1	½	−42·5	¼	− 2·6	¼	−22·5	½
4101·890	−31·5	¼	−40·8	½	−27·8	½	− 7·4	¼	−36·2	½	...		− 6·5	½
4143·928	− 5·8	¼	−38·0	¼	−24·5	½	−24·0	½	−35·6	½	− 4·8	½	−26·0	½
4267·301	...		...		−30·8	½	− 7·4	½	−28·7	¼	− 6·4	¼	−30·8	¼
4340·634	{−86·0, +37·0}		−64·2	½	−14·6	½	−12·4	½	−25·9	½	− 5·6	½	−23·6	½
4388·100	+ 4·6	½	−51·3	½	−19·8	½	−25·6	¼	−53·6	½	−11·7	½	− 1·2	½
4471·676	0·0	¼	−54·5	½	−30·3	½	−24·1	½	−14·9	½	− 4·0	½	−10·5	1
4481·400	...		−45·5	½	...		−28·6	¼	−23·1	¼	...		...	
4552·750	...		−39·2	¼	−13·1	½	...		...		...		− 1·3	¼
4567·950	...		...		...		...		...		...		−18·5	¼
Weighted mean	− 12·85		− 44·49		− 23·84		− 16·83		− 32·83		− 6·45		− 14·30	
V_a	+ 9·53		+ 9·32		+ 9·30		+ 9·28		+ 9·26		+ 9·22		+ 9·21	
V_d	− 0·03		+ 0·22		+ 0·21		+ 0·07		0·00		− 0·15		− 0·20	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 3·6		− 35·2		− 14·6		− 7·7		− 23·8		+ 2·3		− 5·6	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	7184		7185		7201		7202		7203		7204		7207	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	...	...	...	...	−15·5	½	...	...	...	...	...	...	...	...
3964·875	...	...	...	...	− 0·8	¼	...	...	...	...	...	...	...	...
4026·352	...	...	...	...	− 5·2	½	−33·8	¼	−26·9	½	...	...	−31·2	½
4101·890	...	...	...	...	+12·1	½	−26·9	¼	−30·6	¼	− 5·5	½	...	...
4143·928	−41·8	½	...	...	−12·5	½	−36·1	½	−37·0	½	+ 2·4	½	−15·9	½
4267·301	−55·3	½	...	...	...	...	...	...	−37·2	¼	...	...	...	...
4340·634	−41·7	¼	−12·4	½	−10·1	½	−23·6	½	−20·3	½	−19·0	½	−11·3	½
4388·100	−33·8	½	− 7·0	½	+ 2·3	½	−30·3	½	−12·8	½	− 3·5	½	−29·2	½
4471·676	−35·3	½	...	...	+ 4·3	¼	−32·8	½	−17·3	¼	− 9·3	½	−26·0	½
4552·750	−44·6	¼	...	...	...	...	...	...	...	...	− 9·2	½	...	...
Weighted mean	− 41·86		− 9·70		− 3·33		− 30·59		− 25·37		− 7·35		− 22·72	
V_a	+ 8·98		+ 8·95		+ 6·98		+ 6·96		+ 6·95		+ 6·93		+ 6·90	
V_d	+ 0·21		+ 0·04		+ 0·15		+ 0·10		+ 0·03		− 0·07		− 0·19	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 32·9		− 1·0		+ 3·5		− 23·8		− 18·7		− 0·8		− 16·3	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	7208		7209		7210		7211		7214		7215		7229	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	...	...	...	...	−6·0	½	−4·8	½	−27·5	½	...	...	−11·6	½
3964·875	...	...	...	...	−9·0	½	+2·5	½	...	...	...	...	...	...
4026·352	−20·8	½	−17·3	¼	−13·0	½	+4·3	¼	−32·1	½	...	...	−3·4	½
4101·890	...	...	−24·1	¼	−28·7	½	−1·9	½	−47·3	¼	...	...	−9·3	½
4143·928	−36·1	¼	−11·5	½	−25·0	½	−1·4	1	−44·7	½	−45·7	½	−7·2	½
4267·301	−33·0	¼	−6·4	¼	−30·3	½	+10·6	½	−39·4	¼	...	...	...	...
4340·634	...	...	−4·5	¼	−29·3	½	+16·9	1	−25·9	½	−23·6	½	−10·1	½
4388·100	−38·5	1	−23·3	½	−35·0	½	−17·5	½	−59·5	1	−21·0	½	−5·8	½
4471·676	−34·0	¼	−30·9	½	−18·6	½	+15·5	1	−53·8	1	−40·8	1	−3·7	½
4481·400	−24·3	¼	...	...	...	...	−2·5	¼	...	...	...	...	...	...
4552·750	...	...	−3·9	¼	−25·6	¼	+19·0	½	−47·0	½	−44·6	½	−7·9	½
4567·950	...	...	...	...	−23·8	¼	−6·0	¼	−37·1	¼	−33·1	¼	...	...
Weighted mean	−32·30		−17·06		−21·96		+5·02		−44·35		−35·85		−7·37	
V_a	+6·88		+6·67		+6·61		+6·60		+6·56		+6·54		+4·56	
V_d	−0·22		+0·21		0·00		−0·08		−0·19		−0·22		+0·15	
Curv.	−0·28		−0·28		−0·28		−0·28		−0·28		−0·28		−0·28	
Radial Velocity	−25·9		−10·5		−15·6		+11·3		−38·3		−29·4		−2·9	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	7231		7239		7240		7241		7242		7243		7244	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	....	....	....	....	....	....	....	....	....	....	−41·8	¼	−28·2	¼
4026·352	....	....	−26·0	¼	+ 1·7	¼	....	....	....	....	−41·6	½	....	....
4143·928	−20·7	½	−22·6	½	+22·0	½	−13·0	¼	....	....	−46·7	1	....	....
4267·301	....	....	....	....	+ 5·3	½	−20·3	¼	....	....	....	....	....	....
4340·634	....	....	−19·1	1	+10·1	½	−16·9	½	−21·2	½	−49·5	1	....	....
4388·100	−38·5	½	−23·3	½	+25·5	½	− 1·2	¼	−40·8	½	−53·6	½	−30·3	¼
4471·676	−36·5	½	−28·5	½	+15·5	½	−19·2	½	−50·0	½	−43·9	½	−23·5	¼
4552·750	....	....	....	....	....	....	+ 1·3	¼	....	....	....	....	−13·1	¼
4567·950	....	....	....	....	....	....	+ 5·2	¼	....	....	....	....	....	....
Weighted mean	− 35·20		− 22·18		+ 15·10		− 11·13		− 37·35		− 46·99		− 23·80	
V_a	+ 4·54		+ 3·14		+ 3·13		+ 3·11		+ 3·09		+ 3·08		+ 3·06	
V_d	+ 0·05		+ 0·18		+ 0·12		+ 0·07		0·00		− 0·07		− 0·12	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 30·9		− 19·1		+ 18·1		− 8·2		− 34·6		− 44·1		− 21·1	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	7249		7250		7251		7252		7256		7266		7268	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−10·0	¼	......	......	−29·9	½	......	......	......	......	−18·7	½	− 0·8	½
4026·352	+12·1	¼	......	......	−20·0	¼	−13·0	½	......	......	−21·7	½	−11·3	¼
4143·928	−17·8	¼	−29·3	½	−37·0	1	− 2·4	½	−40·4	½	−20·7	½	− 1·4	½
4267·301	......	......	−30·0	¼	−46·8	¼	......	......	......	......	−25·5	½	− 9·0	¼
4340·634	− 6·7	½	−36·0	½	−42·8	½	− 5·8	½	−51·7	¼	−33·8	½	− 7·9	½
4388·100	−15·8	½	−44·3	½	−57·1	1	−18·6	½	−41·4	½	−31·5	½	− 4·7	½
4471·676	−14·2	½	−22·3	½	−39·0	1	......	......	......	......	−24·1	½	− 5·6	½
4481·400	......	......	......	......	−43·0	½	......	......	......	......	−27·6	½	− 3·3	¼
4552·750	......	......	......	......	−43·8	½	......	......	......	......	......	......	......	......
4567·950	......	......	......	......	−18·5	½	......	......	......	......	......	......	......	......
Weighted mean	− 7·70		− 32·65		− 39·80		− 9·95		− 43·00		− 25·42		− 4·94	
V_a	+ 2·62		+ 2·61		+ 2·60		+ 2·58		+ 2·20		+ 1·33		+ 1·31	
V_d	+ 0·11		+ 0·04		− 0·03		......		......		+ 0·19		+ 0·08	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 5·2		− 30·3		− 37·5		− 7·6		− 41·0		− 24·2		− 3·8	

MEASURES OF 12 LACERTÆ—*Continued.*

λ	7270		7293		7296		7300		7302		7303		7310	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−12·4	½	−24·3	½	...	...	− 6·1	½	− 7·2	½	...	...	− 5·6	½
3964·875	...	...	...	...	...	...	...	...	...	...	...	...	+ 9·0	¼
4026·352	−36·4	½	−25·1	½	− 5·6	¼	−33·0	¼	−13·9	½	...	...	+ 7·8	½
4101·890	...	...	...	...	...	...	...	...	−17·6	¼	...	...	+18·6	¼
4143·928	−23·1	½	−18·7	½	− 7·7	½	−32·0	¼	− 2·4	½	−11·1	½	+10·1	½
4267·301	−40·4	¼	−27·1	½	...	...	− 8·5	¼	+15·8	½	−12·8	¼	+12·7	¼
4340·634	−21·4	¼	−22·5	½	+ 1·1	½	− 2·3	½	− 1·7	½	−31·5	1	+16·9	½
4388·100	−23·3	¼	−14·0	¼	...	...	−18·7	½	−13·6	½	−29·2	1	+28·0	½
4471·676	−37·1	1	−38·3	½	− 4·9	½	−19·2	1	...	...	−26·6	1	+14·2	½
4552·750	−17·1	½	−15·8	¼	+12·6	½	−18·3	½	...	...	−22·3	¼	− 4·5	¼
4567·950	...	...	+ 2·6	¼	− 1·3	½	...	...	− 2·0	¼	+ 3·9	¼	...	...
Weighted mean	− 27·43		− 22·09		− 0·55		− 16·06		− 4·79		− 23·68		+ 11·16	
V_a	+ 1·29		− 1·96		− 1·95		− 2·32		− 2·36		− 2·40		− 2·72	
V_d	− 0·08		+ 0·06		− 0·12		+ 0·12		− 0·06		− 0·18		+ 0·01	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 26·5		− 24·3		− 2·9		− 18·5		− 7·5		− 26·5		+ 8·2	

MEASURES OF 12 LACERTÆ—*Concluded.*

λ	7313													
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·727	−10·4	¼												
4026·352	−55·5	½												
4101·890	−36·2	¼												
4143·928	−26·5	¼												
4340·634	−34·9	½												
4388·100	−33·9	½												
4471·676	−52·6	½												
Weighted mean	− 38·80													
V_a	− 2·75													
V_d	− 0·13													
Curv.	− 0·28													
Radial Velocity	− 42·0													

The observations were grouped into normal places on the assumption of a period ·193089 day, the initial epoch being taken at Julian Day 2,420,761·0. Each normal place covers one-twelfth the period.

NORMAL PLACES.

	Julian Day.	Phase from T.	Observed Velocity.	Computed Velocity Preliminary.	Computed Velocity Final.	O–C Preliminary.	O–C Final.
1............	2,420,761·0056	·0487	+ 2·5	+ 4·0	+ 3·2	−1·5	−0·7
2............	·0283	·0714	+ 2·3	− 0·6	− 1·8	+2·9	+4·1
3............	·0407	·0838	−10·8	− 6·1	− 7·5	−4·7	−3·3
4............	·0580	·1011	−16·5	−15·5	−16·9	−1·0	−0·4
5............	·0726	·1157	−23·9	−22·9	−24·1	−1·0	+0·2
6............	·0902	·1333	−29·6	−28·8	−29·7	−0·8	+0·1
7............	·1014	·1445	−29·7	−30·0	−30·7	+0·3	+1·0
8............	·1195	·1626	−28·0	−27·2	−27·4	−0·8	−0·4
9............	·1385	·1816	−21·7	−19·2	−19·3	−2·5	−2·4
10............	·1494	·1925	−11·8	−13·3	−13·4	+1·5	+1·6
11............	·1647	·0147	− 5·2	− 5·2	− 5·4	−0·0	+0·2
12............	·1844	·0344	+ 2·0	+ 2·3	+ 1·8	−0·3	+0·2

The following preliminary elements were estimated to be sufficiently close to serve as a basis for correction.

$$
\begin{aligned}
P &= 0{\cdot}193089 \text{ day}\\
e &= 0{\cdot}0\\
T &= \text{Julian Day } 2{,}420{,}761{\cdot}150\\
K &= 17{\cdot}00 \text{ km.}\\
\gamma &= -13{\cdot}00 \text{ km.}
\end{aligned}
$$

T is taken as the point where the radial velocity curve cuts the axis of velocity of the system while changing from negative to positive, *i.e.*, at the instant the primary member of the system is nearest the sun. This instant may conveniently be designated *perihelion*.

The observation equations resulting from these initial elements are:—

	x	y	z	$-n$
1	1	+1·000	+ ·014	+1·5
2	1	+ ·730	+ ·684	−2·9
3	1	+ ·403	+ ·915	+4·7
4	1	− ·148	+ ·989	+1·0
5	1	− ·583	+ ·812	+1·0
6	1	− ·931	+ ·366	+0·8
7	1	−1·000	+ ·010	−0·3
8	1	− ·837	− ·546	+0·8
9	1	− ·365	− ·931	+2·5
10	1	− ·019	−1·000	−1·5
11	1	+ ·460	− ·888	0·0
12	1	+ ·900	− ·436	+0·3

Where $x = d\gamma$
$y = dK$
$z = K\mu dT$

These give normal equations,

$$\begin{aligned} 9\cdot300x \quad -0\cdot890y \quad +0\cdot119z \quad +6\cdot989 &= 0 \\ +5\cdot141y \quad +0\cdot166z \quad -0\cdot162 &= 0 \\ +4\cdot157z \quad +2\cdot733 &= 0 \end{aligned}$$

$$\begin{aligned} x &= -0\cdot750 \\ y &= -0\cdot078 \\ z &= -0\cdot633 \end{aligned}$$

$$\begin{aligned} \text{or } d\gamma &= -0\cdot75 \text{ km.} \\ dK &= -0\cdot08 \text{ km.} \\ dT &= -0\cdot0012 \text{ day} \end{aligned}$$

The final elements become,

$$\begin{aligned} P &= 0\cdot193089 \text{ day} \\ e &= 0\cdot0 \\ T &= \text{Julian Day } 2{,}420{,}761\cdot1488 \quad \pm \cdot001 \\ K &= 16\cdot92 \text{ km.} \quad \pm 0\cdot50 \\ \gamma &= -13\cdot75 \text{ km.} \quad \pm 0\cdot37 \\ a \sin i &= 45{,}000 \text{ km.} \\ \frac{m_1^3 \sin^3 i}{(m+m_1)^2} &= \cdot0001 \odot \end{aligned}$$

No attempt was made to determine eccentricity. The residuals which the individual observations give when represented by these elements are tabulated in Table III. They were obtained graphically and though given to a tenth of a kilometre are not in general so accurately determined. The probable error of a single observation is 5·8 km.

It seems to the writer that this is larger than the character of the spectrum would lead one to expect. Part of it may be due to the length of the exposure time, which in 1913 was often one-third and sometimes one-half the period. The 1915 plates on the average were exposed less than one-fourth the period but, even so, the epoch becomes uncertain. The phases were not reduced to the sun which would alter the residuals a little though not much.

There seems to be a peculiar feature indicated by the measures so far made, which may go a long way toward explaining the large probable error. If a high velocity is obtained at positive maximum, the velocity at the following minimum is very low, and *vice versa*; that is the amplitude varies from cycle to cycle.

In figure 1 are plotted the results of some individual nights' observations. The velocities obtained on one night are designated alike, and there seems to be a distinct tendency for the residuals at maximum and minimum to have opposite signs. It would be interesting to take series of plates with an instrument which would permit of a shorter exposure, so that more plates could be obtained covering one revolution.

Dominion Observatory,
Ottawa,
October, 1915.

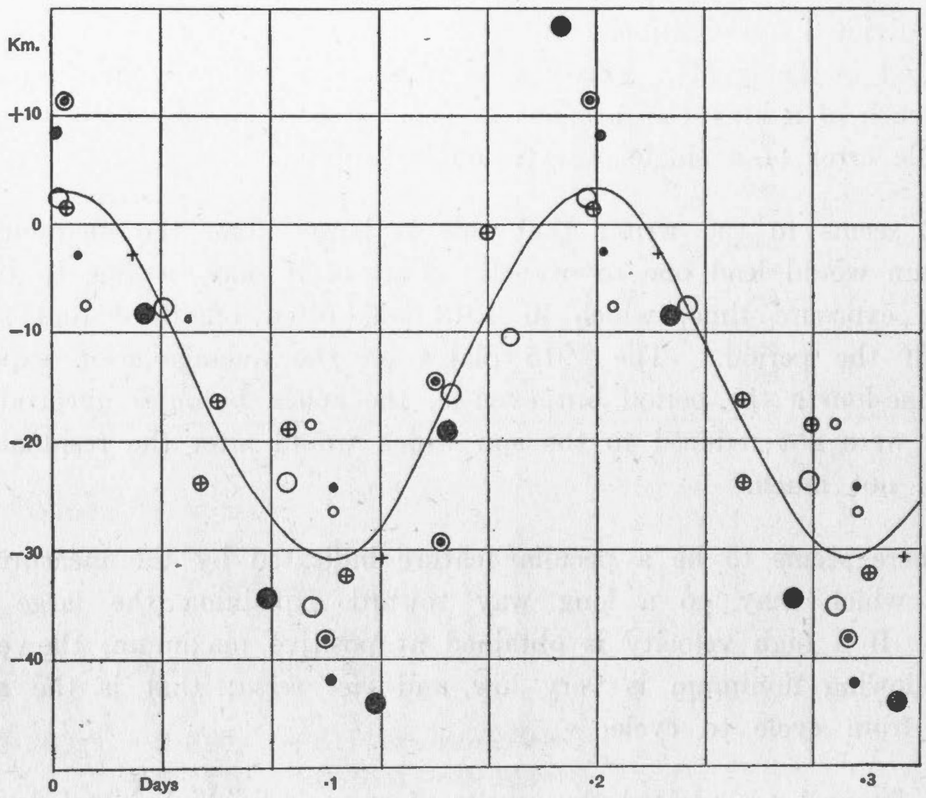
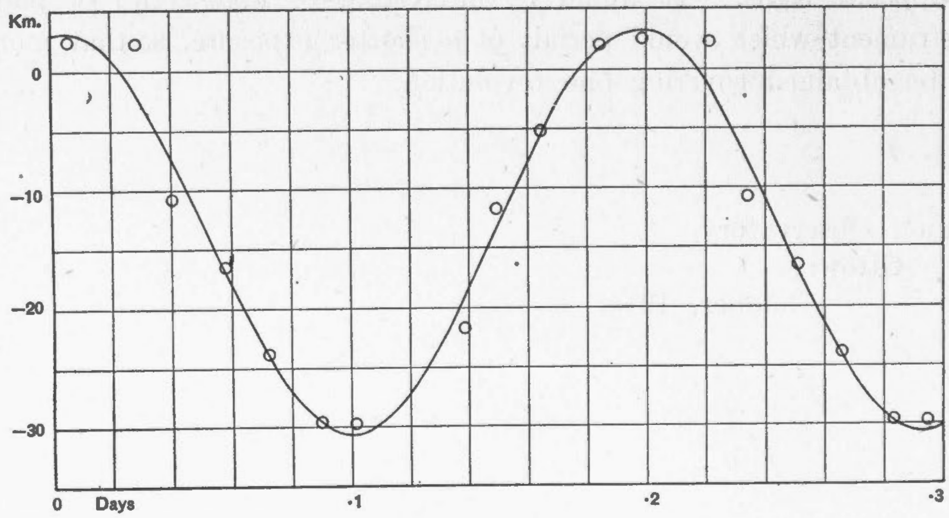
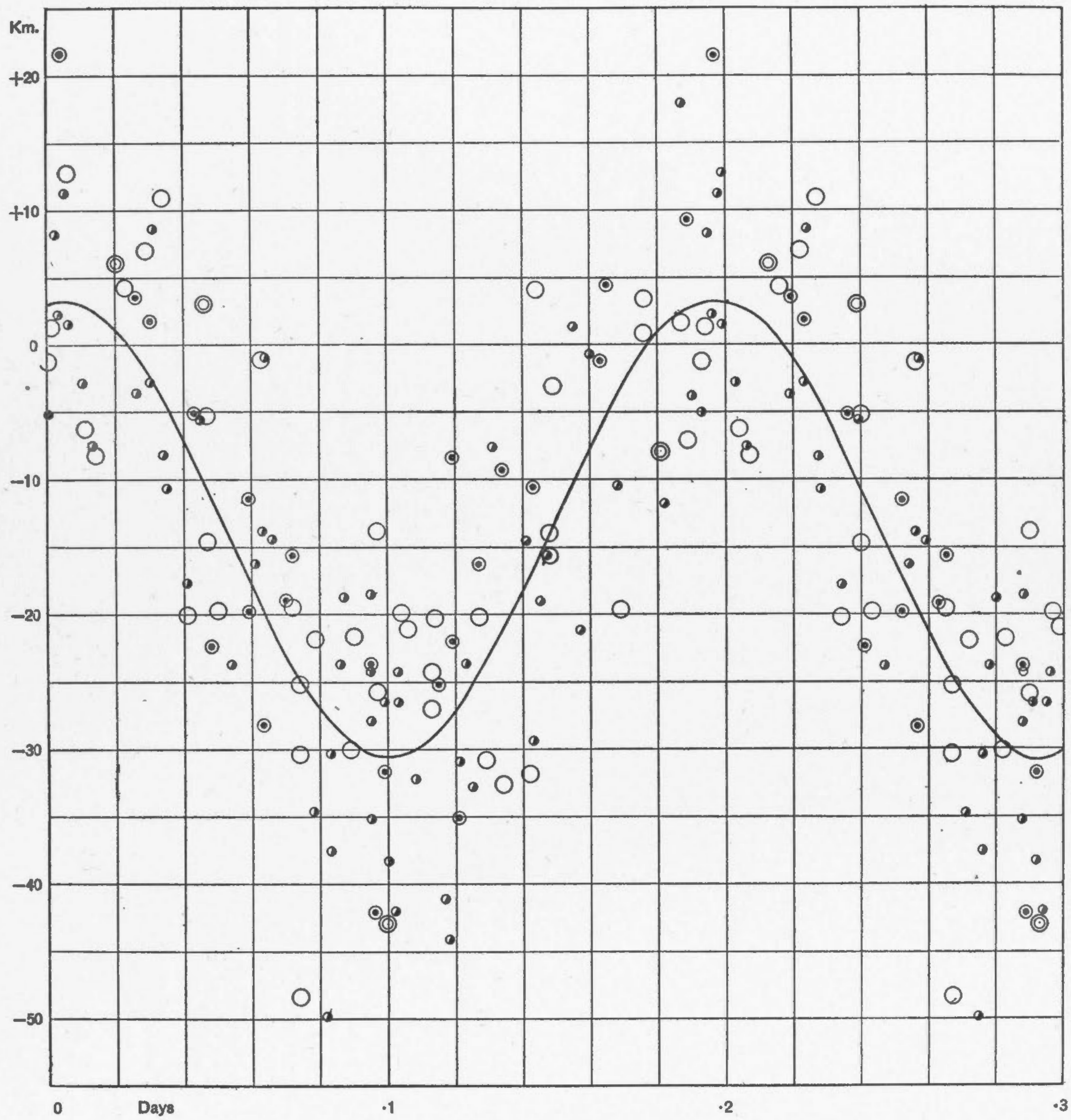


FIGURE I.



VELOCITY CURVE OF 12 LACERTÆ.



OBSERVATIONS OF 12 LACERTÆ.

Mount Wilson observations are represented by two concentric circles.
Ottawa, 1913, " " " two circles, the centre one filled.
Ottawa, 1914, " " " one open circle.
Ottawa, 1915, " " " one half filled circle.

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Orbit of the Spectroscopic Binary A Boötis

BY

REYNOLD K. YOUNG, Ph. D.

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ORBIT OF THE SPECTROSCOPIC BINARY A BOÖTIS.

BY REYNOLD K. YOUNG, Ph.D.

The binary character of A Boötis ($\alpha = 14^h\ 14^m$, $\delta = +35°54'$, type G5, mag. 4·8) was announced by Moore in Lick Observatory Bulletin 123. Forty-two spectrograms secured at this observatory with a one-prism spectrograph have been used in determining an orbit. In this, as in many other cases, the Lick Observatory results have been useful in defining the period. The details of their observations were very kindly communicated by mail.

In general an orbit of a late type star determined with a one-prism instrument does not compare favourably with an orbit of the same star based on three-prism results. The accuracy is so much greater in the latter case that the practice has been generally followed of leaving the late types for high dispersion. However, the range of the present binary permits of a fairly accurate determination of the orbit with a one-prism instrument. On this account and also because at the time the number of available binaries was rather limited, the star was placed on the observing programme here.

Table I gives the wave-lengths of the lines used in reducing the measures. The corrections in the third column are computed to make the sum of the weighted residuals of column four vanish. The residuals were taken in the sense, observed minus the mean of the plate. If we compute from Rowland's Preliminary Table of Solar Wave-Lengths the lines which would in one-prism dispersion lie near these, we find that the wave-lengths given in the table are about 0·03 Ångström units larger. The method of combining the various lines in a high dispersion table is arbitrary and the resulting position of the blend uncertain. About all we may say of the wave-lengths given, is that they are homogeneous and that the scale is not very different from Rowland's. It is doubtful if they would suit another star unless it were exactly the same type. The results from several late type stars, whose orbits have been computed at this observatory, seem to show that the apparent wave-lengths of blends, as measured on low dispersion plates, vary markedly with a slight variation in the spectral type.

The usual method of first finding approximate elements and then correcting these differentially was followed. One correction was found sufficient. The successive steps in the solution and the results are given below. In the radial velocity curve the initial date is Julian Day 2,420,500.

TABLE I

Element.	Wave-Length.	Correction.	Algebraic Residual.	Arithmetic Residual.	Number of times Measured.
Fe	4005·426	−·037	− 2·8	4·4	24
Fe	4045·975	+·011	+ 0·8	1·8	4
Fe	4063·756	+·114	+ 8·4	8·4	4
Fe	4071·939	−·004	− 0·3	2·7	10
Fe+	4092·737	−·023	− 1·7	4·1	36
V	4116·643	+·041	+ 3·0	5·9	16
Fe−Ti	4123·748	+·033	+ 2·4	4·7	13
Fe	4127·992	−·029	− 2·1	4·1	27
Fe+	4132·361	+·021	+ 1·5	3·3	22
Fe	4191·697	+·011	+ 0·8	3·3	20
Fe	4202·294	−·032	− 2·3	5·2	33
Fe	4236·057	+·013	+ 0·9	4·3	17
Fe	4250·616	−·013	− 0·9	3·3	29
Fe	4258·605	−·010	− 0·7	1·5	6
Fe	4271·829	+·006	+ 0·4	3·1	40
	4275·119	−·003	− 0·2	3·3	18
Fe−Ti	4282·722	+·027	+ 1·9	4·2	36
Cr	4289·766	+·003	+ 0·2	3·0	34
Ti	4314·866	−·010	− 0·7	4·0	30
	4323·612	+·073	+ 4·8	7·1	15
Fe	4325·792	−·003	− 0·2	4·8	12
Fe	4404·890	−·004	− 0·3	4·0	37
Fe	4415·225	+·007	+ 0·5	3·9	40
Fe	4430·469	−·023	− 1·6	3·7	35
Fe−Mn	4462·037	−·029	− 2·0	4·6	27
Fe−Ti	4549·766	+·015	+ 1·0	4·4	33
Cr−Ti	4571·891	−·009	− 0·6	4·3	39

LICK AND POTSDAM OBSERVATIONS.

Observatory.	Julian Day.	Phase from J. D. 2,420,500	Velocity.	O–C.
Lick	2,417,362·820	254·02	−39·8	+4·9
Lick	7,617·998	85·30	−11·7	+5·8
Lick	7,664·976	132·28	−10·1	+5·8
Lick	7,687·924	155·23	−12·3	+5·8
Lick	7,725·799	193·10	−18·6	+4·9
Potsdam	8,818·46	14·06	−23·3	+8·1
Potsdam	8,839·39	34·99	−32·7	+7·3
Potsdam	9,572·38	132·13	−12·5	+3·4

OTTAWA OBSERVATIONS.

Plate.	Observer.*	Date.	Julian Day.	Velocity.	O–C.
		1915			
6792	C	Feb. 17	2,420,546·821	−40·0	+ 8·0
6825	H	Mar. 1	558·876	−46·5	+ 2·1
6849	H	Mar. 8	565·724	−30·8	+ 7·2
6866	Y	Mar. 14	571·710	−32·3	− 3·8
6882	Y	Mar. 19	576·713	−20·9	+ 1·6
6889	Y	Mar. 23	580·713	−21·8	− 2·3
6895	H	Mar. 29	586·705	−14·0	+ 3·0
6904	Y	April 4	592·691	−28·5	−13·0
6908	Y	April 7	595·724	−11·4	− 3·8
6917	P[1]	April 12	600·785	−23·1	− 8·3
6922	Y	April 13	601·705	−16·7	− 1·9
6937	P[1]	April 20	608·861	−12·2	+ 2·4
6958	Y	April 28	616·676	−12·5	+ 2·3
6969	H–Y	May 6	624·715	−15·3	0·0
6988	H	May 13	631·697	−12·2	+ 3·4
7008	Y	May 23	641·708	−21·9	− 5·2
7018	Y	May 27	645·756	−19·5	− 2·4
7029	Y	May 30	648·665	−13·0	+ 4·4
7049	Y	June 6	655·599	−26·6	− 8·4
7059	P	June 16	665·613	−12·9	+ 6·5
7068	Y	June 20	669·649	−17·4	+ 2·6
7076	Y	June 27	676·642	−24·6	− 3·6
7088	H	July 8	687·643	−22·5	+ 0·1
7111	Y	July 20	699·580	−28·4	− 3·7
7126	Y	July 27	706·580	−22·6	+ 3·6
7139	H	Aug. 5	715·576	−27·4	+ 0·8
7146	Y	Aug. 10	720·561	−34·0	− 4·8
7158	Y	Aug. 17	727·562	−34·9	− 3·1
7168	Y	Aug. 26	736·544	−38·3	− 3·1
7193	H	Sept. 2	743·546	−41·3	− 3·0
7228	Y	Sept. 10	751·500	−43·2	− 0·2
7257	C	Sept. 17	758·524	−43·1	+ 4·6
7271	Y	Sept. 21	762·512	−48·7	+ 1·0
7281	H	Sept. 22	763·508	−51·9	− 0·8
7288	H	Sept. 27	768·508	−48·7	+ 1·4
7291	Y	Sept. 28	769·493	−54·3	− 4·6
7317	Y	Oct. 3	774·486	−47·4	− 3·4
7321	Y	Oct. 8	779·469	−34·7	− 0·2
7326	Y	Oct. 10	781·474	−28·6	+ 2·9
7340	Y	Oct. 15	786·470	−27·9	− 3·4
7355	Y	Oct. 21	792·462	−17·0	+ 2·5
7359	H	Oct. 23	794·458	−18·2	+ 0·3

*P=Plaskett; H=Harper; P[1]=Parker; C=Cannon; Y=Young.

MEASURES OF A BOÖTIS.

λ	6792		6825		6849		6866		6882		6889		6895	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	−52·3	½	…	…	−34·4	1	−38·6	½	−27·5	½	−30·1	½	…	…
4045·975	…	…	…	…	−42·6	½	…	…	…	…	…	…	…	…
4071·939	…	…	…	…	−36·3	½	…	…	−24·5	½	…	…	−20·0	½
4092·748	−60·7	½	−54·2	1	−42·2	1	−40·8	1	−26·9	1	−21·4	1	−10·7	½
4116·643	−59·1	½	−66·2	½	−40·7	½	−28·5	½	−25·6	½	−28·4	½	…	…
4123·754	−59·9	½	…	…	−30·4	½	−45·1	½	…	…	…	…	…	…
4127·990	−64·8	½	−57·2	1	…	…	−32·9	½	−31·0	1	−26·7	½	−12·9	½
4132·336	−48·8	½	−61·7	½	−48·8	½	−32·1	½	−23·9	½	−26·3	1	−14·3	½
4191·806	−53·0	½	−60·0	½	−46·5	½	…	…	−26·3	½	−22·8	½	−15·8	½
4202·294	−54·2	½	−66·3	½	−44·8	½	−40·0	1	−28·6	½	−21·7	½	−19·6	½
4236·072	…	…	−63·1	½	…	…	−44·8	½	−22·4	½	−27·6	½	…	…
4250·616	−61·2	½	−54·9	½	−35·9	½	−42·2	½	−24·8	½	−20·0	½	−17·4	1
4258·614	−53·1	½	−60·0	½	−43·6	½	−39·8	½	−28·7	½	−25·5	½	…	…
4271·829	−47·2	1	−56·3	1½	−42·4	1	−39·1	1	−29·5	½	−25·7	½	−15·5	1
4275·131	−50·5	½	−60·3	½	−39·9	½	−45·2	1	−24·3	½	−28·6	½	…	…
4282·722	…	…	…	…	−39·0	½	−37·9	½	…	…	−27·0	½	−20·6	½
4289·766	−55·4	1	−60·3	½	−48·4	½	−42·9	½	−26·0	½	−21·1	1	…	…
4314·866	…	…	…	…	…	…	−39·3	½	−24·9	½	−31·0	½	−17·4	½
4317·426	−51·7	½	…	…	−41·1	½	…	…	−21·0	½	…	…	…	…
4325·792	−58·7	1	…	…	−41·2	½	…	…	−25·6	½	…	…	…	…
4404·890	−55·0	1½	−55·6	1	−40·2	1½	−40·2	1½	−27·5	1½	−36·6	½	−17·1	1
4415·228	−45·8	1	−57·1	1	−39·2	1	−42·8	½	−26·1	1½	−29·7	1	−12·9	1
4430·503	−51·9	½	−68·8	½	−35·0	½	−45·9	½	−26·6	½	−31·4	1	…	…
4462·092	…	…	−51·3	½	−39·5	½	−43·2	½	−30·9	½	…	…	…	…
4549·766	−51·2	½	…	…	−42·0	½	−30·2	½	…	…	−23·6	½	−19·7	½
4571·891	−58·5	½	−50·5	½	−42·5	½	−43·9	½	−35·9	½	−25·2	½	−17·2	½
Weighted mean	− 55·14		− 58·28		− 40·53		− 40·03		− 26·92		− 26·41		− 16·33	
V_a	+ 15·35		+ 11·99		+ 9·85		+ 7·87		+ 6·17		+ 4·79		+ 2·53	
V_d	+ 0·12		+ 0·07		+ 0·18		+ 0·16		+ 0·13		+ 0·13		+ 0·13	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 39·95		− 46·50		− 30·78		−32·28		− 20·90		− 21·77		− 13·95	

MEASURES OF A BOÖTIS—*Continued.*

λ	6904		6908		6917		6922		6937		6958		6969	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	....		−16·4	½	−16·4	½	−17·3	1	....		− 6·0	½	− 3·6	½
4045·975	....		....		....		−13·3	½	....		....		....	
4063·756	....		....		....		− 4·5	½	....		+ 6·8	½	....	
4071·939	....		−13·7	½	−16·4	½	−16·4	1	....		− 4·5	½	....	
4092·748	−35·2	½	−14·9	1	−22·8	1	−11·2	1	−16·7	½	− 8·2	1	− 6·5	1
4116·643	....		− 2·9	½	−20·0	½	−20·0	½	....		− 0·7	½	....	
4123·754	−18·0	½	....		....		−10·9	½	....		....		− 7·1	½
4127·990	−24·3	½	−11·4	½	−21·4	½	−15·3	½	....		−13·3	½	− 1·9	½
4132·336	....		− 9·6	½	−21·5	½	−12·9	½	+ 2·9	½	− 1·9	½	+ 1·0	½
4191·806	....		−15·8	½	−15·8	½	−13·3	½	− 0·7	½	− 6·7	1	− 6·7	½
4202·294	−29·6	½	−10·5	½	−21·7	½	−11·5	1	+ 4·2	½	−11·5	½	−12·0	½
4236·072	....		....		....		−15·1	½	+ 1·0	½	....		+ 2·1	½
4250·616	−35·3	½	− 5·3	½	−13·2	½	−13·7	½	− 8·4	½	− 8·4	½	− 4·2	½
4271·829	−29·4	½	− 8·0	½	−17·2	1	−15·0	1	+ 1·6	½	− 4·8	1	− 6·4	1
4275·131	....		− 5·4	½	−17·8	½	−15·7	½	+ 4·2	½	− 4·3	½	....	
4282·722	−22·1	½	−11·3	1	−26·0	½	− 5·4	½	−13·0	½	− 3·7	1	− 7·0	½
4289·766	−29·9	½	− 2·1	½	−25·6	½	−12·0	1	− 5·9	½	− 2·6	½	− 3·1	½
4314·866	−27·1	½	− 7·7	½	−17·7	½	−19·3	½	− 7·1	½	....		− 6·5	½
4317·426	....		....		....		−18·8	½	....		....		....	
4325·792	....		....		−16·6	½	−17·9	½	....		+ 3·5	½	+ 5·7	½
4404·890	−28·9	1	− 4·0	1	−26·0	1	−12·9	1	−14·0	½	− 3·4	1	− 2·2	1
4415·228	−30·8	1	−24·3	½	−23·7	1	−14·1	1	− 7·0	½	− 4·6	1	− 8·7	1
4430·503	....		....		....		−24·8	½	−12·7	½	....		− 7·8	½
4462·092	....		....		....		−13·6	½	−15·4	½	− 6·1	½	....	
4549·766	−21·0	½	−17·0	½	....		−30·2	½	....		− 7·2	½	....	
4571·891	−38·7	½	− 9·9	½	−17·2	½	− 9·9	½	−17·2	½	+ 2·8	½	....	
Weighted mean	− 28·67		− 10·50		− 20·31		− 13·71		− 6·51		− 4·47		− 4·70	
V_a	+ 0·39		− 0·71		− 2·47		− 2·80		− 5·27		− 7·76		− 10·28	
V_d	+ 0·10		+ 0·07		− 0·07		+ 0·07		− 0·19		+ 0·04		− 0·05	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 28·46		− 11·42		− 23·13		− 16·72		− 12·25		− 12·47		− 15·31	

MEASURES OF A BOÖTIS—*Continued.*

λ	6988		7008		7018		7029		7049		7059		7068	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	...	...	...	...	...	...	+ 1·1	1	−11·3	½	...	...	+ 2·0	½
4045·975	...	...	...	...	...	...	+ 7·9	½	− 7·5	½	...	...	...	...
4063·756	...	...	...	...	...	...	+10·8	½	− 2·2	½	...	...	...	...
4071·939	...	...	...	...	...	...	+ 6·2	½	−12·3	½	...	...	...	...
4092·748	− 5·2	½	+11·4	½	− 0·1	½	+ 0·8	1	− 7·0	1	− 0·1	½	+ 3·1	1
4116·643	...	...	...	...	+ 6·4	½	+ 8·2	½	+ 3·1	½	+12·0	½	+13·0	½
4123·754	...	...	...	...	− 2·4	½	+ 7·6	½	− 9·0	½	...	...	+ 1·9	½
4127·990	...	...	...	...	...	...	+ 3·8	½	−13·7	½	...	...	− 2·8	½
4132·336	...	...	− 7·1	½	− 1·4	½	− 1·9	½	− 6·2	½	+ 4·4	½	+ 4·3	½
4191·806	− 3·7	½	...	...	...	...	+ 3·8	1	− 4·7	½	+ 0·3	½	− 1·7	½
4202·294	+ 5·1	½	−13·0	½	−11·5	½	− 3·5	1	−16·6	½	...	...	− 3·4	½
4236·072	...	...	...	...	− 5·2	½	+ 5·2	½	...	...	...	...	+ 6·2	½
4250·616	+ 4·2	½	...	...	−10·0	½	+ 2·6	½	− 8·4	½	+ 2·1	½	− 4·2	½
4271·829	+ 8·0	½	− 1·6	½	− 4·8	½	+ 4·8	½	− 3·7	1	+10·0	½	− 3·7	½
4275·131	...	...	...	...	−11·8	½	+ 4·2	½	− 8·0	½	...	...	+ 5·3	½
4282·722	+ 5·4	1	− 6·4	½	− 4·3	½	+ 6·4	½	− 3·7	½	...	...	+ 2·8	½
4289·766	+ 0·1	1	− 8·5	½	− 1·6	½	+ 9·3	1	− 5·3	½	+ 7·7	½	+ 1·8	½
4314·866	− 4·8	½	− 8·7	½	− 6·9	½	+ 5·7	½	−10·9	½	...	...	...	...
4317·426	+ 4·6	½	+ 2·4	½	...	...	+10·2	½	...	...	...	...	...	...
4325·792	...	...	...	...	...	...	...	...	− 1·5	½	...	...	− 0·9	½
4404·890	+ 3·1	½	−15·8	½	− 4·6	1	+ 4·9	1	−13·4	1	+ 9·5	½	+ 4·9	1
4415·228	− 9·3	1	−13·4	½	− 3·4	½	+ 0·8	½	−16·4	1	+17·5	½	+ 5·6	1
4430·503	− 7·2	½	−16·8	½	− 2·4	½	− 1·8	½	− 6·6	½	+ 4·2	½	+ 5·4	½
4462·092	...	...	−11·1	½	+ 7·4	½	− 4·3	½	−14·1	½	...	...	+ 1·8	½
4549·766	+ 6·5	½	− 5·2	½	...	...	+ 0·6	½	− 3·3	½	+ 3·2	½	...	...
4571·891	+ 4·8	½	+ 0·8	½	+ 3·5	½	+ 6·2	½	− 6·5	½	+ 8·2	½	+ 4·8	½
Weighted mean	+ 0·46		− 6·64		− 3·21		+ 3·74		− 8·21		+ 6·58		+ 2·60	
V_a	− 12·31		− 14·88		− 15·80		− 16·42		− 18·08		− 19·17		− 19·61	
V_d	− 0·07		− 0·12		− 0·19		− 0·08		0·00		− 0·07		− 0·13	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 12·20		− 21·92		− 19·48		− 13·04		− 26·57		− 12·94		− 17·42	

MEASURES OF A BOÖTIS—*Continued.*

λ	7076		7088		7111		7126		7139		7146		7158	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4005·426	− 3·2	½	− 9·0	½	−10·3	½	−14·1	½			−20·1	½		
4071·939											−15·9	½		
4092·748	− 7·4	1	− 6·5	½	− 8·8	½	− 6·5	½	−10·7	½	−17·1	½	−14·9	½
4123·754			+ 4·2	½			0·0	½						
4127·990	− 2·9	½			− 7·6	½	− 1·9	½	−10·4	½	−17·1	½		
4132·336			0·0	½			+ 1·4	½						
4191·806	+ 4·8	½	+ 1·3	½	− 4·0	½								
4202·294	−13·0	½	− 7·5	½	−14·5	½	− 8·5	½			−18·6	½	−15·6	½
4236·072	− 6·2	½							− 3·1	½				
4250·616	− 6·8	½	0·0	½	− 7·8	½					−15·7	½		
4271·829	− 3·2	1	− 0·6	½	−11·8	½	− 4·8	½	− 9·0	½	−18·7	½	−30·5	½
4275·131	− 5·4	½					− 3·8	½	− 8·6	½				
4282·722	− 3·7	½	+ 1·6	½	− 2·7	½	+ 4·8	½	− 5·4	½	− 8·6	½	−17·8	½
4289·766	− 6·9	½	− 1·6	½	− 3·6	½			−19·3	½	−18·8	½		
4314·866	− 8·1	½					+ 5·7	½					−15·8	½
4317·426	− 6·5	½			−17·6	½	+ 0·2	½						
4325·792	− 8·7	½												
4404·890	− 9·3	1	− 4·0	1	− 3·4	1	− 3·4	1	− 4·5	½	−16·4	½	−21·1	½
4415·228	+ 0·8	1	− 1·5	1	− 6·3	½	+ 0·2	1	−14·0	½	−11·2	½	−13·6	½
4430·503	− 4·2	½	− 3·6	1	−13·2	½			− 7·2	½	−16·8	½	−27·1	½
4462·092	− 6·8	½	+ 5·5	½	− 9·0	½			− 6·8	½	−21·5	½		
4549·766	+ 1·3	½	− 0·7	½	− 6·5	½	− 9·1	½	− 7·2	½	−13·1	½	−11·0	½
4571·891	− 2·5	½	+ 2·8	½	− 6·9	½	− 4·9	½					−19·8	½
Weighted mean	− 4·87		− 1·51		− 8·08		− 2·83		− 8·85		− 16·40		− 18·72	
V_a	− 19·24		− 20·66		− 19·93		− 19·27		− 18·03		− 17·16		− 15·66	
V_d	− 0·16		− 0·19		− 0·15		− 0·19		− 0·20		− 0·20		− 0·22	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 24·55		− 22·54		− 28·44		− 22·57		− 27·36		− 34·04		− 34·88	

MEASURES OF A BOÖTIS—*Continued.*

λ	7168		7193		7228		7257		7271		7281		7288	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4092·748	−30·0	½			−37·8	½			−51·7	½	−61·3	½		
4123·754	−14·7	½												
4127·990	−23·7	½			−28·5	½					−65·5	½		
4132·336									−36·2	½				
4202·294	−22·6	½							−51·4	½	−51·9	½		
4236·072					−29·1	½			−46·7	½				
4250·616	−26·8	½			−35·7	½								
4271·829	−31·5	½	−30·0	½	−36·8	½			−39·0	½	−43·2	½	−43·9	½
4282·722	−27·5	½					−29·6	½	−33·4	½	−47·8	½	−36·6	½
4289·766	−28·6	½					−32·4	½	−39·4	½	−42·1	½		
4314·866	−32·9	½			−25·2	½	−32·4	½	−45·1	½	−35·1	½	−53·9	½
4317·426											−32·0	½		
4404·890					−36·5	½			−36·4	½	−51·8	½	−43·0	½
4415·228	−20·2	½			−25·9	½	−37·2	½	−43·2	½	−35·4	½	−43·4	½
4430·503	−15·6	½	−31·3	1	−36·1	½	−33·1	½	−46·9	½	−46·3	½	−44·7	½
4462·092	−28·3	½	−22·8	½			−36·9	½			−40·0	½	−45·7	½
4549·766	−19·6	½			−36·6	½	−36·6	½			−51·6	½	−45·7	½
4571·891	−17·1	½	−30·3	½	−38·9	½	−43·6	½	−40·9	½	−40·9	½	−44·3	½
Weighted mean	− 24·22		− 29·14		− 33·37		− 35·22		− 42·52		− 46·06		− 44·58	
V_a	− 13·57		− 11·66		− 9·27		− 7·35		− 5·67		− 5·34		− 3·60	
V_d	− 0·22		− 0·23		− 0·23		− 0·25		− 0·25		− 0·25		− 0·25	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 38·29		− 41·31		− 43·15		− 43·10		− 48·72		− 51·93		− 48·71	

MEASURES OF A BOÖTIS—*Concluded.*

λ	7291		7317		7321		7326		7340		7355		7359	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4092·746	−57·6	½	−55·8	½			−32·3	½	−27·3	½				
4127·990	−57·9	½			−45·7	½	−30·4	½	−35·0	½				
4202·294					−19·6	½	−19·6	½	−43·7	½	−22·6	½		
4236·072					−38·4	½					−25·9	½	−13·0	½
4250·616			−48·8	½	−39·9	½	−33·1	½						
4271·829	−47·5	½	−51·5	½			−29·4	½	−19·2	½	−22·4	½	−31·9	½
4275·131									−36·5	½				
4282·722	−35·5	½	−40·9	½	−42·5	½	−39·5	½	−30·1	½	−15·1	½	−23·7	½
4289·766	−56·1	½					−28·0	½	−28·0	½	−25·3	½	−24·8	½
4314·866	−51·2	½	−46·2	½	−30·8	½	−28·0	½	−42·9	½	−26·4	½		
4317·426			−36·5	½			−15·4	½	−18·7	½			−13·2	½
4325·792							−32·1	½					−31·0	½
4404·890	−43·5	½	−35·3	½	−27·0	½	−24·7	½	−34·2	1				
4415·228	−46·2	½	−43·2	½	−30·1	½	−31·3	½	−23·6	1			−19·9	½
4430·503	−48·3	½	−43·3	½			−29·5	½	−27·0	1	−16·2	½	−24·1	½
4462·092	−61·7	½			−28·3	½	−28·3	½			−19·1	½	−36·1	½
4549·766	−47·2	½	−45·8	½	−35·9	½	−24·8	½	−27·4	½	−18·3	½	− 9·9	½
4571·891	−53·8	½	−51·6	½	−40·9	½	−38·9	½	−33·3	½	−22·4	½	−28·4	½
Weighted mean	− 50·54		− 45·35		− 34·46		− 29·08		− 30·10		− 21·37		− 23·27	
V_a	− 3·26		− 1·49		+ 0·29		+ 1·00		+ 2·78		+ 4·91		+ 5·61	
V_d	− 0·25		− 0·25		− 0·25		− 0·26		− 0·27		− 0·27		− 0·28	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 54·33		− 47·37		− 34·70		− 28·62		− 27·87		− 17·01		− 18·22	

NORMAL PLACES.

	Julian Day.	Phase from J.D. 2,420,500	Velocity.	Weight.	O–C Preliminary.	O–C Final.
1.	2,420,728·22	16·27	−35·7	1·0	−2·9	−3·6
2.	753·09	41·14	−41·9	1·3	+2·8	+2·1
3.	763·01	51·06	−50·3	0·7	−0·7	−0·3
4.	769·00	57·05	−51·5	0·7	−2·3	−1·5
5.	772·66	60·71	−47·0	0·7	−0·7	−0·5
6.	780·57	68·62	−31·6	1·3	+2·9	+1·1
7.	790·94	78·99	−21·2	1·7	+0·7	−0·5
8.	596·22	96·22	−16·3	1·3	−1·4	−1·1
9.	620·48	120·48	−13·0	1·3	+1·3	+2·1
10.	645·38	145·38	−18·3	1·0	−1·9	−1·2
11.	674·86	174·86	−19·4	1·3	+0·9	+1·3
12.	707·23	207·23	−26·1	1·0	+0·5	+0·3

PRELIMINARY ELEMENTS.

T = Julian Day 2,420,562·00
K = 18·0 km.
ω = 225°
e = 0·50
γ = −25·64 km.
P = 211·95 days
μ = 1°·6985.

OBSERVATION EQUATIONS.

	x	y	z	p	q	$-n$	Weight.
1..................	1	−0·398	+0·926	−0·645	+0·438	+2·91	1·0
2..................	1	−1·057	+1·189	−0·358	+0·708	−2·75	1·3
3..................	1	−1·327	−0·166	+0·124	+0·344	+0·72	0·7
4..................	1	−1·312	−1·149	+0·641	−0·595	+2·26	0·7
5..................	1	−1·148	−0·973	+0·962	−1·361	+0·71	0·7
6..................	1	−0·491	+1·205	+1·345	−1·936	−2·87	1·3
7..................	1	+0·210	+1·558	+1·180	−0·985	−0·65	1·7
8..................	1	+0·598	−0·062	+0·661	−0·183	+1·44	1·3
9..................	1	+0·630	−0·923	+0·174	+0·062	−1·29	1·3
10..................	1	+0·513	−0·970	−0·144	+0·133	+1·91	1·0
11..................	1	+0·295	−0·587	−0·407	+0·192	−0·92	1·3
12..................	1	−0·054	+0·208	−0·600	+0·296	−0·50	1·0

where
$$
\begin{aligned}
x &= d\gamma \\
y &= dK \\
p &= Kde \\
z &= Kd\omega \\
q &= \frac{K\mu}{(1-e^2)^{\frac{3}{2}}}dT
\end{aligned}
$$

NORMAL EQUATIONS.

$$
\begin{array}{rrrrrr}
13\cdot300x & -2\cdot265y & +\ 2\cdot262z & +3\cdot665p & -3\cdot439q & -2\cdot509=0 \\
 & +6\cdot719y & -\ 1\cdot763z & -0\cdot705p & +1\cdot091q & +1\cdot620=0 \\
 & & +12\cdot864z & +2\cdot972p & -3\cdot051q & -9\cdot987=0 \\
 & & & +7\cdot427p & -7\cdot567q & -3\cdot906=0 \\
 & & & & +9\cdot196q & +5\cdot042=0
\end{array}
$$

whence
$$
\begin{aligned}
d\gamma &= +0\cdot02 \text{ km.} \\
dK &= +0\cdot02 \text{ km.} \\
de &= +0\cdot04 \\
d\omega &= -1^\circ\cdot58 \\
dT &= -0\cdot82 \text{ day.}
\end{aligned}
$$

When these corrections were added to the approximate elements and the normal places represented, Σpv^2 was lowered from 44 to 34. The individual observations were represented graphically and the residuals are given in the tables of the observations under the heading O–C. The Lick and Potsdam observations are very consistently positive. Part of this difference may be due to the scale of wave-lengths used, but some other factor must be operative also.

The final elements are

$$
\begin{aligned}
T &= \text{J. D. } 2{,}420{,}561{\cdot}18 && \pm 0{\cdot}90 \\
K &= 18{\cdot}02 \text{ km.} && \pm 0{\cdot}59 \\
\omega &= 223^\circ{\cdot}42 && \pm 2^\circ{\cdot}60 \\
e &= 0{\cdot}54 && \pm 0{\cdot}024 \\
\gamma &= 25{\cdot}62 \text{ km.} && \pm 0{\cdot}45 \\
P &= 211{\cdot}95 \text{ days} && \\
\mu &= 1^\circ{\cdot}6985 && \\
a \sin i &= 44{,}000{,}000 \text{ km.} && \\
\frac{m_1^3 \sin^3 i}{(m + m_1)^2} &= 0{\cdot}076 \odot &&
\end{aligned}
$$

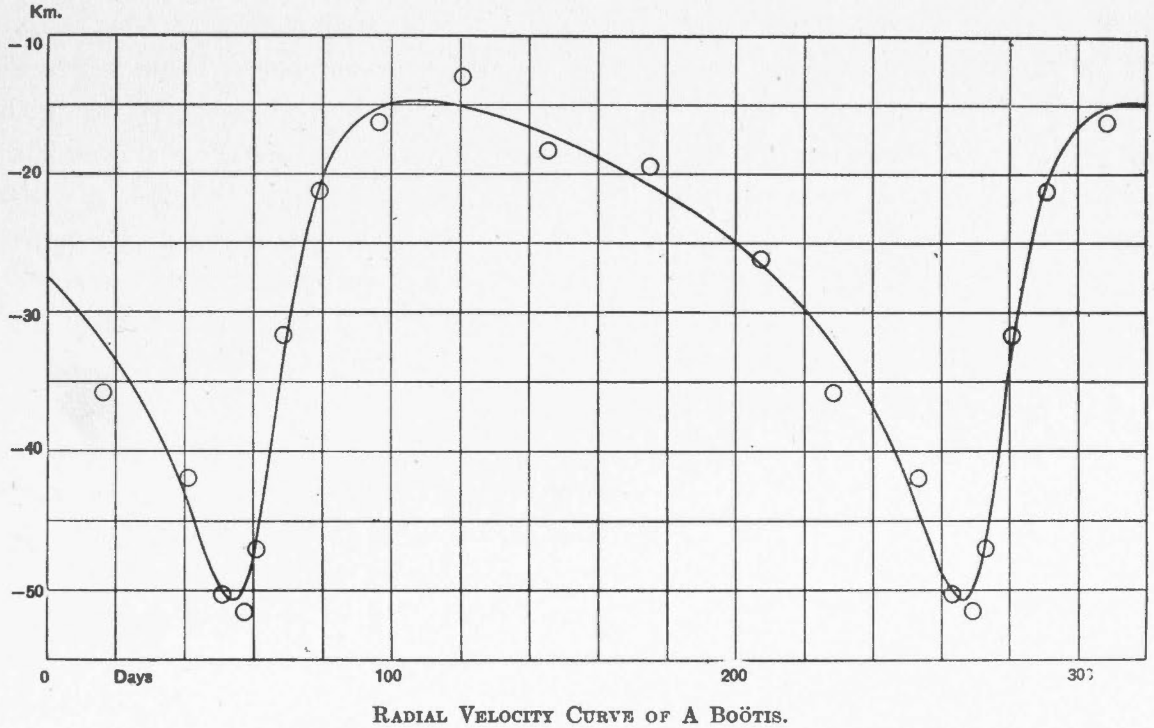
The residuals from our own measures are often very large, in one case thirteen kilometres. The agreement of the individual lines would lead one to expect a probable error for a single plate between one-half and one kilometre, whereas it actually came out 2·8. The measures were so discordant, that an investigation was undertaken to try and locate some reason for the erratic manner in which the velocities behaved.

Part of the trouble may lie in the star itself, the conditions there changing irregularly so as to alter the apparent wave-lengths of the lines. The effect of such changes are small, provided they do not arise from a third body, for the higher the dispersion employed and the more perfect the method of observation the smaller do the variations in velocity become. This is practically conclusive evidence, so far as one-prism work is concerned, that the anomalies in velocities, for good line stars at least, arise within the spectrograph.

Flexure, temperature change, poor focus, irregular guiding, nonuniform illumination of the collimator, each of these plays its part in the final result. The first three causes have been well met, and the modern spectrograph is almost mechanically perfect and free from these defects. With good focus the danger from nonuniform illumination of the collimator vanishes.

The effect of guiding was tested by taking plates of Arcturus, placing the stellar image first on one side of the slit and then on the other. The results of these experiments were published in the Astronomical Society of the Pacific Publications, August, 1915. They showed that velocities, as much as thirteen kilometres from the truth, could be obtained by guiding with the star not perfectly central on the slit. When one remembers that the guiding is done by blue-green light, while the plate registers the blue and violet and that the images of the star in these colours do not coincide, one can readily see that error could be introduced in this way. There are other considerations which lend plausibility to the suspicion that this source of error is very important. It would be larger in one-prism than in three-prism instruments. It would be larger the smaller the telescope; for with a small objective the guiding image is fainter, the power is lower and, consequently, it is more difficult to bisect the star with the slit of the spectroscope. It would be larger in short-focus than in long-focus telescopes, because the latter require more frequent attention in guiding and the image is shifted often from place to place, so that in the mean the whole slit is better covered. Moreover, the effective image (the tremor disk) is larger for long-focus instruments, so that a slight displacement of the star probably affects the centre of intensity of the image less than the same displacement in a telescope of shorter focus. These latter factors I believe to be very important. With the short-focus instrument used at this observatory and a clock which runs very uniformly, a star will often stay in position for fifteen minutes. This fact often coupled with that of a temperature in the dome in winter as low as minus 20° Fahrenheit, when to place the eye to the guiding telescope is to receive the sensation of an electric shock, does not contribute to constant attention to the position of the star image on the slit. One might have a personal equation in bisecting the star image, so that a run of plates would all be consistently too high or too low. Part of the difference between the Lick Observatory and Potsdam and the Ottawa observations might be accounted for in this way. Experiment to ascertain the best method of guiding to secure consistent results would probably be worth while. Thus it might be found that slight illumination of the slit, so that it could be seen without the aid of the star's light would add to the accuracy. Personally, I find guiding easier in the twilight than on a dark night. In the case of A Boötis, the majority of the latter half of the plates were taken under these conditions and in general they give smaller residuals than the early plates, but the evidence is not sufficient to show whether this is to be ascribed to the twilight or not.

Dominion Observatory,
Ottawa,
November, 1915.



RADIAL VELOCITY CURVE OF A BOÖTIS.

DEPARTMENT OF THE INTERIOR
CANADA
HON. W. J. ROCHE, *Minister*. W. W. CORY, C.M.G., *Deputy Minister*.

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Orbit of the Spectroscopic Binary *a* Trianguli

BY

W. E. HARPER, M.A.

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ORBIT OF THE SPECTROSCOPIC BINARY α TRIANGULI.

BY W. E. HARPER, M.A.

This star ($\alpha = 1^h\ 47^m$, $\delta = +29°\ 06'$) was announced as a spectroscopic binary in *Lick Observatory Bulletin 199* from the measures of six plates, the data of which may be seen in Table II.

The star was placed on our observing list in January, 1913, and twenty spectrograms had been secured in 1913 and 1914 before an investigation of its orbit was undertaken by the writer. The spectrum is of type F5; the lines are diffuse and ill-defined and consequently the measured velocities may be considerably in error. When the twenty plates had been reduced without any greater range in velocity being found than that announced on discovery, it was felt that if the period was to be obtained, then results upon which more dependence could be placed than that furnished by a single plate would have to be secured. Consequently it was decided to make at least two plates each time the star was spectrographed and this procedure has been carried out the present autumn. The star is of photographic magnitude 4·1, and 30 minutes or less with the single-prism is sufficient to get a measurable plate.

In all eighty-five plates on Seed 27 emulsion have been secured and upon these the determination of the orbit is based. Owing to the uncertain character of the lines, the wave-lengths have not been corrected in the customary manner of equating the residuals to zero, but all the data regarding the lines are given in Table I. The residuals are given in the sense, mean minus measured. Were the corresponding corrections made, the agreement of some of the observations with the curve would be slightly improved, but on the whole no material difference in the elements would be produced.

TABLE I.

LINES USED IN α TRIANGULI.

Wave-Length.	Times Measured.	Total Weight.	Mean Numerical Residual.	Mean Algebraic Residual.	Wave-Length.	Times Measured.	Total Weight.	Mean Numerical Residual.	Mean Algebraic Residual.
4572·156	13	5	12·0	+5·4	4236·107	11	5	12·1	+6·9
4549·766	43	19	9·4	+3·3	4233·328	38	17	7·9	−2·4
4481·400	21	10	10·2	−3·8	4226·860	69	32	6·5	−1·7
4404·927	7	4	7·5	+2·4	4215·668	25	12	13·7	−11·4
4395·286	16	8	10·8	−2·0	4203·161	9	5	6·1	+0·6
4352·006	62	29	7·6	+2·6	4198·658	40	17	9·1	−0·9
4340·634	84	54	5·5	−1·3	4143·658	57	27	9·5	+1·1
4325·638	55	24	11·0	−7·0	4101·890	73	38	7·0	+3·1
4299·735	34	13	8·0	+0·2	4071·733	32	13	10·1	−1·0
4290·195	10	4	10·1	+1·7	4063·756	37	15	10·3	+6·9
4271·760	6	3	7·1	−2·4	4045·851	77	36	7·4	+2·0
4260·640	5	2	5·0	+3·4	4005·485	24	10	10·5	−5·7
4250·616	8	4	8·6	−1·6					

The first ten plates were made with the single-prism spectrograph I, whose dispersion at $H\gamma$ is 33·4 Å per millimetre; the next two with the single-prism Ia, dispersion at $H\gamma$, 54·5 Å per millimetre ; and the remainder with the single-prism I′ at present in use, whose dispersion at the same region is 32·8 Å per millimetre.

The period is found from the September and October, 1915, observations to be about 1·74 days. Our 1913 and 1914 observations change this to 1·7365 days. To bring the Lick observations into the best agreement—allowance being made for the equation of light—this value was further changed to 1·73652 days which seems to be the only permissible value. As about 3600 revolutions have taken place in the interval between the dates of the first and last plates, the fifth decimal place in the period should be significant. The Lick observations are more positive than our own by about 5 km. In quite a number of stars of late, we find our own observations from 3 to 5 km. more negative than those of the Lick observatory. There is a possibility in this case that the difference represents a real change in the velocity of the system, as our 1913 observations have likewise systematically positive residuals. The evidence, however, does not seem to be sufficient to state definitely that such is the case.

A summary of the observations will now be given. The phases are reckoned from the periastron finally determined, J. D. 2,414,552·768, using the true period 1·73652 days. A correction is applied to each for the light equation due to the velocity of the system. That due to the earth's orbit is negligible. In assigning weights to the plates not only was the number of lines measured and their weights taken into account, but the instrument employed and other conditions as well. The residuals are scaled from the curve and are approximately correct to 0·1 km. While the first decimal place in the velocities has been retained throughout, it would have been sufficient to have rounded them off to the nearest km. as greater dependence cannot be placed upon them.

TABLE II.

LICK OBSERVATIONS OF α TRIANGULI.

Date.	Julian Date.	Phase.	Velocities		Mean.	Systematic Difference −5 km.	O–C.
1898 Sept. 19	2,414,552·791	1·449	−10·0	− 6·4	− 8·2	−13·2	−2·7
1903 Oct. 19	6,407·954	·401	−29·6	−17·8	−23·7	−28·7	−6·4
Oct. 25	6,413·914	1·151	+ 6·6	+ 0·3	+ 3·4	− 1·6	0·0
1904 Sept. 12	6,736·996	1·254	+ 1·0	+ 6·1	+ 4·3	− 0·7	+1·4
1906 July 30	7,422·996	1·358	+ 5·0	+ 0·7	+ 2·8	− 2·2	+1·8
1910 Nov. 14	8,990·718	1·068	....	+ 7·2	+ 7·2	+ 2·2	+4·2

TABLE III.

OTTAWA OBSERVATIONS OF α TRIANGULI.

Plate.	Observer*	Date.	Julian Day G.M.T.	Phase.	Velocity.	Weight.	O–C.
		1913					
5317	P	Jan. 22	2,419,790·538	·387	−16·2	5	+ 5·5
5328	H	Jan. 28	2,419,796·554	1·193	+ 3·4	5	+ 5·2
5661	Y	Sept. 3	2,420,014·852	·699	− 9·3	4	+ 1·0
5674	C	Sept. 15	026·854	·546	− 4·2	3	+11·5
5695	G	Sept. 24	035·837	·847	− 4·3	3	+ 1·4
5716	C	Sept. 29	040·864	·667	− 4·9	5	+ 6·5
5745	P	Oct. 4	045·747	·338	−17·6	4	+ 5·7
5755	C	Oct. 6	047·823	·678	− 7·7	5	+ 3·3
5770	Y	Oct. 9	050·653	·034	−33·0	5	− 9·7
5778	C–P1	Oct. 13	054·729	·638	− 5·4	5	+ 7·1
5808	C	Dec. 8	110·572	·914	− 3·1	3	+ 1·0
5843	P1	Dec. 22	124·642	1·092	+ 0·3	3	+ 2·1
5861	P	Dec. 31	133·578	1·345	− 6·3	6	− 1·8
		1914					
5867	Y	Jan. 1	134·497	·529	−28·9	4	−12·6
5878	P1	Jan. 5	138·614	1·174	+ 2·7	5	+ 4·4
5884	P1	Jan. 12	145·633	1·247	+ 2·2	4	+ 4·5
5919	P1	Feb. 9	173·554	1·384	− 1·6	4	+ 2·5
5929	H	Feb. 12	176·514	·872	− 5·4	5	− 0·3
6340	P1	Sept. 4	380·911	·367	−25·2	3	− 3·0
6351	G	Sept. 9	385·783	·029	−26·9	5	− 3·6
		1915					
7150	H	Aug. 10	720·781	1·630	−15·0	5	+ 2·4
7151	H	Aug. 10	720·802	1·651	−15·2	4	+ 3·3
7166	C	Aug. 23	733·818	·776	− 2·8	3	+ 4·6
7167	C	Aug. 23	733·850	·807	−11·4	3	− 4·7
7173	Y	Aug. 26	736·784	·269	−26·7	4	− 2·0
7174	Y	Aug. 26	736·799	·284	−33·3	5	− 8·9
7190	H	Sept. 1	742·816	1·091	+ 2·9	5	+ 4·7
7191	H	Sept. 1	742·850	1·125	+ 1·2	5	+ 2·8
7196	Y	Sept. 2	743·764	·303	−27·6	4	− 3·6
7197	Y	Sept. 2	743·785	·324	−18·4	5	+ 5·0
7205	Y	Sept. 3	744·782	1·321	− 9·8	5	− 5·8
7206	Y	Sept. 3	744·802	1·341	− 2·9	6	+ 1·6
7212	Y	Sept. 4	745·789	·592	−11·8	6	+ 2·1
7213	Y	Sept. 4	745·810	·613	−13·6	3	− 0·6
7217	H	Sept. 8	749·765	1·094	−12·9	5	−11·1
7218	H	Sept. 8	749·800	1·129	− 2·3	5	− 0·8
7223	Y	Sept. 9	750·747	·340	−23·1	6	0·0
7224	Y	Sept. 9	750·767	·360	−23·0	7	− 0·7
7232	P11	Sept. 10	751·734	1·327	+ 3·8	4	+ 8·8
7233	P11	Sept. 10	751·760	1·353	+ 0·9	5	+ 5·7
7235	P	Sept. 11	752·686	·543	−35·2	4	−19·4
7236	P	Sept. 11	752·710	·567	−22·3	4	− 6·7
7245	H	Sept. 14	755·805	·189	−21·7	4	+ 4·0
7246	H	Sept. 14	755·826	·210	−21·8	5	+ 3·8
7253	C	Sept. 15	756·802	1·186	− 3·9	6	− 2·1

TABLE III.

OTTAWA OBSERVATIONS OF α TRIANGULI—*Concluded.*

Plate.	Observer*	Date.	Julian Day G.M.T.	Phase.	Velocity.	Weight.	O–C.
		1915					
7254	C	Sept. 15	2,420,756·825	1·209	−10·6	5	− 8·7
7260	C	Sept. 17	758·672	1·319	− 6·2	4	− 2·3
7261	C	Sept. 17	758·697	1·344	+ 1·5	3	+ 6·3
7265	P[11]	Sept. 17	758·917	1·564	−17·8	2	− 3·9
7273	Y	Sept. 21	762·596	·034	−23·2	4	+ 0·4
7274	Y	Sept. 21	762·616	·054	−33·6	2	− 9·4
7278	H	Sept. 21	762·800	·238	−21·5	4	+ 3·8
7283	H	Sept. 22	763·586	1·024	+ 1·1	3	+ 3·3
7284	H	Sept. 22	763·608	1·046	− 5·5	4	− 3·4
7294	Y	Sept. 28	769·633	·126	−28·7	4	− 2·9
7295	Y	Sept. 28	769·657	·150	−22·7	4	+ 3·1
7304	C	Sept. 29	770·792	1·284	− 3·2	5	− 0·2
7305	C	Sept. 29	770·812	1·304	− 3·6	4	− 0·1
7311	H	Sept. 30	771·659	·415	−22·7	4	− 2·3
7312	H	Sept. 30	771·683	·439	−16·0	4	+ 3·5
7319	Y	Oct. 3	774·615	1·634	−12·6	3	+ 5·0
7320	Y	Oct. 3	774·635	1·654	−12·4	3	+ 6·2
7348	H	Oct. 16	787·535	·660	−15·8	4	− 4·6
7349	H	Oct. 16	787·673	·800	−10·3	4	− 3·5
7350	H	Oct. 16	787·695	·820	− 6·7	4	− 0·5
7353	C	Oct. 20	791·750	1·402	−11·8	2	− 5·4
7354	C	Oct. 20	791·771	1·423	− 9·8	2	− 2·3
7357	Y	Oct. 21	792·600	·516	−14·2	2	+ 2·4
7358	Y	Oct. 21	792·622	·538	−17·3	3	− 4·4
7362	Y	Oct. 24	795·784	·227	−20·4	3	+ 5·0
7365	Y	Oct. 26	797·554	·261	−21·6	4	+ 3·2
7366	Y	Oct. 26	797·577	·284	−20·6	3	+ 4·0
7368	H	Oct. 28	799·656	·626	−17·3	5	− 4·8
7369	H	Oct. 28	799·695	·665	−11·6	5	− 0·4
7377	C	Nov. 5	807·628	1·651	−22·0	1	− 3·3
7380	H	Nov. 6	808·656	·943	+ 0·6	3	+ 3·9
7386	H	Nov. 7	809·451	·002	−23·1	3	− 0·6
7387	H	Nov. 7	809·480	·031	−28·3	5	− 4·8
7388	H	Nov. 7	809·509	·060	−20·8	4	+ 3·7
7392	H	Nov. 10	812·556	1·370	−12·0	3	− 6·5
7393	H	Nov. 12	814·431	1·508	−16·4	6	− 5·2
7394	H	Nov. 12	814·452	1·529	−11·8	6	+ 0·5
7398	C	Nov. 12	814·646	1·723	−22·8	6	− 0·8
7399	C	Nov. 12	814·668	·009	−14·3	4	+ 8·5
7400	C	Nov. 12	814·697	·038	−20·5	4	+ 3·2

* C = Cannon; G = Gibson; H = Harper; P = Plaskett; P[1] = Parker; P[11] = H. H. Plaskett; Y = Young.

The detailed measures of the plates are now given.

MEASURES OF α TRIANGULI.

λ	5317		5328		5661		5674		5695		5716		5745	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156	......	...	......	...	......	...	......	...	−10·8	½	......	...	......	...
4549·766	+16·0	½	+28·0	½	......	...	......	...	−33·3	½	−29·7	½	......	...
4481·400	+35·3	¾	+27·8	¾	......	...	......	...	−21·6	½	− 1·0	½	......	...
4352·006	......	...	+30·1	½	−26·2	½	−14·4	½	......	...	−28·4	½	−53·6	¼
4340·634	+10·2	1	+33·5	1	−26·7	1	− 26·6	½	− 2·8	½	−15·2	¾	−24·0	¾
4325·638	+ 5·1	½	+19·6	½	− 8·0	½	−18·3	½	− 8·4	½	−26·2	¼	−23·3	½
4299·735	+11·6	½	......	...	......	...	......	...	......	...	......	...	......	...
4271·760	+22·4	½	+43·3	½	−34·2	¾	......	...	−22·6	½	−26·5	½	......	...
4233·328	......	...	+50·5	½	......	...	......	...	......	...	− 7·0	½	−31·0	½
4226·860	+ 4·2	¾	+39·0	½	−30·8	½	......	...	......	...	− 4·2	½	−30·2	½
4198·658	+17·5	1	+30·2	¾	−47·6	½	......	...	−27·3	½	− 6·7	¼	......	...
4143·658	+14·9	½	+18·9	½	−44·6	½	−15·7	½	......	...	−22·5	½	......	...
4101·890	+ 1·1	¾	+40·4	1	−40·0	¾	......	...	......	...	−18·2	½	−27·4	¾
4071·733	......	...	......	...	......	...	......	...	......	...	−22·4	½	−23·8	½
4063·756	......	...	......	...	......	...	......	...	......	...	......	...	−39·2	¼
4045·851	+ 6·9	¾	+26·1	½	−27·7	½	−29·8	½	−27·7	½	−23·1	½	−21·0	½
4005·485	......	...	......	...	......	...	−31·7	½	......	...	......	...	−33·4	½
Weighted mean	+ 13·05		+ 32·73		− 31·75		− 22·97		− 19·31		− 17·89		− 28·58	
V_s	− 28·89		− 28·90		+ 22·75		+ 18·92		+ 15·50		+ 13·42		+ 11·27	
V_d	− ·13		− ·18		− ·02		+ ·09		− ·18		− ·16		± ·00	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 16·2		+ 3·4		− 9·3		− 4·2		− 4·3		− 4·9		− 17·6	

MEASURES OF α TRIANGULI—*Continued.*

λ	5755		5770		5778		5808		5843		5861		5867	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156											−7·0	½		
4549·766			−46·6	½	−8·5	½					+3·2	½		
4481·400	−22·8	½	−41·7	½	−15·6	¾					+30·2	½		
4404·927			−47·3	1							+13·6	¾	+15·3	½
4395·286											+16·5	½	−19·2	½
4352·006			−46·6	¾	−11·6	½	−4·2	½	+19·0	¾	+24·8	½	−7·4	½
4340·634	−14·0	1	−47·1	1	+2·6	¾	+10·8	¾	+6·7	¾	+20·0	¾	−11·6	¾
4325·638	−13·7	½	−54·1	¾	−20·9	½					+16·6	½	+15·8	½
4299·735	−23·0	½									+36·8	½		
4271·760			−31·0	½			+8·6	½			+24·6	½	−19·7	½
4260·640							+7·2	½						
4233·328	−11·3	½	−32·6	½										
4226·860											+18·5	¾	± 0·0	½
4198·658			−31·7	½	−24·1	½					+37·7	½		
4143·658	−23·5	½	−30·9	¾			+40·0	½	+43·7	¾	+18·9	½	+15·3	½
4101·890	−16·1	½			−13·0	½	+26·3	¾	+16·4	¾	+29·1	½	+18·4	½
4071·733					−7·6	½								
4063·756	−13·1	½					+0·6	½	+1·2	½				
4045·851	−15·3	½	−55·0	½	−27·2	½	+24·5	¾	+16·6	¾	+23·2	½	−18·1	¾
4005·485	−27·8	½	−24·1	½	−1·9	½	+25·9	½	+43·9	¾				
Weighted mean	− 17·69		− 41·82		− 12·25		+ 16·23		+ 24·54		+ 20·14		− 2·37	
V_a	+ 10·35		+ 8·97		+ 7·12		− 19·04		− 23·80		− 26·09		− 26·26	
V_d	− ·12		+ ·12		− ·01		± ·00		− ·17		− ·11		+ ·02	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 7·7		− 33·0		− 5·4		− 3·1		+ 0·3		− 6·3		− 28·9	

MEASURES OF α TRIANGULI—*Continued.*

λ	5878		5884		5919		5929		6340		6351		7150	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	+31·9	3/4	+53·6	1/2	+34·1	1/2	+17·1	1/2	...	...	−65·6	1/4	...	...
4481·400	+54·6	1/2	+43·8	1/2	...	...	+35·8	1/2	...	...	−72·8	1/4	...	...
4404·927	...	...	+28·0	3/4	...	...	+14·4	1/2	...	...	...	...	...	...
4395·286	...	...	+24·4	1/2	...	...	...	...	−33·0	1/2	...	...	...	...
4352·006	+ 7·6	1/2	+34·6	1/2	...	...	...	...	...	...	−36·1	3/4	−57·2	1/2
4340·634	+29·3	3/4	+36·2	1/2	+22·1	3/4	+35·2	3/4	−43·6	1/2	−58·3	3/4	−50·2	1/2
4325·638	...	...	...	...	...	...	+12·9	1/2	−42·5	1/2	−26·9	1/4	−36·1	1/2
4299·735	...	...	...	...	...	...	+10·1	1/2	−42·7	1/2	−36·6	1/4	−52·7	1/2
4271·760	+18·1	1/2	+17·1	1/2	+28·5	1/4	+30·2	1/2	...	...	−53·5	3/4	−44·6	1/2
4236·107	+36·4	1/2	...	...	+16·4	1/2	...	...	...	...	...	...	...	...
4233·328	+28·4	1/2	...	...	+23·4	1/2	...	...	...	...	...	...	−37·0	1
4226·860	+31·2	1/2	+13·5	1/2	+30·4	1/2	+20·7	1/2	−62·6	1/2	−39·9	1/2	−41·9	1/2
4198·658	...	...	...	...	+34·6	1/2	+25·9	1/2	...	...	...	...	...	...
4143·658	+44·9	1/2	...	...	...	...	+19·9	1/2	...	...	−54·2	1/2	−39·6	1/2
4101·890	+29·1	1/2	...	...	+27·4	1/2	+22·5	1/2	−59·8	1/2	−47·6	1/2	−41·2	1/2
4071·733	...	...	...	...	...	...	...	...	−52·8	1/2	...	...	...	...
4063·756	+18·6	1/2	...	...	...	...	+18·0	1/2	...	...	−38·2	3/4	...	...
4045·851	+31·9	3/4	+31·7	1/2	+28·4	1/2	+24·8	3/4	−41·6	1/2	−51·1	1/2	−41·4	1/2
4005·485	...	...	...	...	...	...	...	...	...	...	...	...	−28·9	1/2
Weighted mean	+ 30·30		+ 31·24		+ 26·91		+ 22·68		− 47·31		− 47·70		− 42·30	
V_a	− 27·10		− 28·57		− 27·99		− 27·57		+ 22·52		+ 21·06		+ 27·45	
V_d	− ·18		− ·20		− ·19		− ·18		− ·14		+ ·06		+ ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 2·7		+ 2·2		− 1·6		− 5·4		− 25·2		− 26·9		− 15·0	

MEASURES OF α TRIANGULI—*Continued.*

λ	7151		7166		7167		7173		7174		7190		7191	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156	...		−29·5	½	−38·0	½	...		...		...		...	
4549·766	−46·8	½	−25·3	½	−48·8	½	...		−68·4	¼	...		−33·4	½
4481·400	...		...		...		...		−69·0	¼	...		...	
4395·286	...		−49·0	½	...		...		...		...		...	
4352·006	−44·6	½	−15·8	½	−13·7	½	−44·3	½	−65·9	¼	−20·1	½	...	
4340·634	−39·2	½	−25·9	½	−39·6	½	−52·0	¾	−53·7	½	−30·4	½	−20·2	½
4325·638	...		...		...		−39·7	½	−34·7	¾	− 4·6	½	...	
4299·735	...		...		−35·8	½	−55·8	¼	...		...		−25·3	¼
4271·760	−49·1	½	−40·1	½	−50·0	½	...		−60·6	½	...		−34·0	½
4233·328	−49·7	½	...		...		...		−70·6	½	−12·5	½	− 1·7	½
4226·860	−53·0	½	...		−37·0	½	−50·2	½	−67·4	½	−22·1	½	−24·2	¼
4215·668	−44·5	½	−12·0	½	...		...		−59·4	½	−30·8	¾	− 3·4	½
4198·658	−29·4	½	...		...		−44·9	½	−63·2	½	−18·3	½	...	
4143·658	...		...		−45·2	½	−66·0	½	...		− 9·6	½	−30·0	½
4101·890	−41·0	½	...		...		−47·5	½	−59·5	½	−24·4	½	−24·8	½
4071·733	...		...		...		...		...		−24·0	½	−15·9	¼
4063·756	...		...		...		−60·3	½	−52·2	½	−34·2	¼	−33·1	¼
4045·851	−27·6	½	−27·3	½	−33·1	½	−55·2	½	−56·9	½	...		−19·0	½
4005·485	...		...		...		...		...		−13·8	½	−29·9	¼
Weighted mean	− 42·49		− 28·11		− 36·60		− 51·40		− 58·07		− 20·23		− 21·96	
V_a	+ 27·45		+ 25·51		+ 25·51		+ 24·89		+ 24·89		+ 23·40		+ 23·40	
V_d	+ ·17		+ ·07		+ ·02		+ ·12		+ ·11		+ ·04		± 0·00	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 15·2		− 2·8		− 11·4		− 26·7		− 33·3		+ 2·9		+ 1·2	

MEASURES OF α TRIANGULI—*Continued.*

λ	7196		7197		7205		7206		7212		7213		7217	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156	−27·8	¼	−23·0	¼	−33·1	¼	−60·2	¼			−51·8	¼		
4549·766	−37·9	½	−46·3	½	−41·5	½	−38·2	½	−29·3	½	−49·1	¼		
4395·286			−40·0	½									−21·2	½
4352·006			−37·1	½	−47·7	¼	−35·3	½	−37·8	½	−46·3	¼	−45·0	¾
4340·634	−53·0	¾	−40·1	¾	−30·9	½	−22·6	½	−43·2	¾	−16·2	¼	−49·1	¾
4325·638					−25·3	½	−21·4	¼	−31·0	½	−19·9	¼		
4299·735	−36·2	¼	−37·3	½	−35·8	¼			−52·1	¼	−31·6	¼		
4271·760	−26·4	½	−33·7	¾	−45·9	¼	−16·9	½	−32·2	½	−43·6	¼		
4260·640							−21·0	½	−40·0	½				
4236·107	−45·6	½												
4233·328					−40·7	¼							−40·8	½
4226·860	−39·4	½	−30·3	¾	−38·3	½	−16·2	½	−42·0	½	−22·2	¼	−21·1	½
4215·668							− 6·0	½	−31·4	¼			− 4·3	½
4198·658									−20·9	¼			−18·0	½
4143·658			−53·5	½	−26·2	½	−29·4	½	−34·3	½	−29·6	¼	−28·8	¾
4101·890	−72·9	¾	−46·9	¾	−31·7	½	−32·4	½	−31·3	¾	−47·1	¼	−32·5	¾
4071·733			−24·0	¼			− 6·7	½	−29·4	½			−54·6	½
4063·756	−68·5	½	−53·2	½	−33·6	¼	−38·0	½						
4045·851	−67·5	½	−55·7	¾	−21·2	½	−32·2	½	−26·7	¾	−38·3	¼	−51·3	½
4005·485					−17·0	¼	−22·6	½						
Weighted mean	− 50·56		− 41·41		− 32·51		− 25·56		− 34·26		− 35·97		− 34·19	
V_a	+ 23·15		+ 23·15		+ 22·90		+ 22·90		+ 22·65		+ 22·65		+ 21·44	
V_d	+ ·11		+ ·09		+ ·10		+ ·05		+ ·07		+ ·04		+ ·10	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 27·6		− 18·4		− 9·8		− 2·9		− 11·8		− 13·6		− 12·9	

MEASURES OF α TRIANGULI—*Continued.*

λ	7218		7223		7224		7232		7233		7235		7236	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766			−63·0	¾					−29·2	½				
4534·139									+10·4	½				
4501·448									−14·7	½				
4395·286	+12·5	¾					−12·4	¼	− 7·7	½	−52·0	¼		
4352·006			−44·6	¾	−45·4	¾	−29·7	½	−37·9	½	−68·5	½	−49·5	½
4340·634	−22·1	¾	−43·6	½	−48·8	¾	−28·1	½	−17·2	¾	−48·4	1	−27·2	½
4325·638	− 3·0	½							− 5·6	½	−44·7	¾		
4299·735					−31·1	½							−47·8	½
4271·760	−38·9	¾	−33·5	1	−56·7	¾	+ 6·4	½	−40·1	½	−55·0	½	−64·8	½
4250·616					−31·5	¾								
4236·107					−62·4	¾								
4233·328	−27·2	½	−43·2	¾	−41·8	¾	−13·5	¼	−22·3	½	−58·8	½	−19·3	¼
4226·860	−21·6	¼	−48·9	½	−37·7	¾	− 9·7	½	−20·9	½	−43·0	½	−55·9	¼
4215·668			−39·1	¾	−14·2	¾	+ 1·0	½						
4198·658			−32·5	½	−59·0	½							−53·0	¼
4143·658			−48·0	½	−43·8	¾	−22·7	¾			−73·6	½	−36·4	½
4101·890	−36·4	½	−42·3	¾	−42·9	¾	−21·9	½	−26·1	¾	−53·2	½	−40·4	¼
4071·733	−45·2	½	−28·3	½					−14·8	½	−65·6	½		
4063·756	−46·9	½	−55·3	½	−64·2	½								
4045·851	−21·8	½	−41·4	½	−48·2	½	−25·8	¾	−29·2	½	−62·1	¾	−37·1	½
4005·485	−18·2	½									−44·8	¼	−32·5	¼
Weighted mean	− 23·52		− 44·04		− 43·97		− 16·82		− 19·76		− 55·62		− 42·71	
V_a	+ 21·44		+ 21·14		+ 21·14		+ 20·81		+ 20·81		+ 20·51		+ 20·51	
V_d	+ ·04		+ ·12		+ ·10		− ·14		+ ·10		+ ·19		+ ·16	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 2·3		− 23·1		− 23·0		+ 3·8		+ 0·9		− 35·2		− 22·3	

MEASURES OF α TRIANGULI—*Continued.*

λ	7245		7246		7253		7254		7260		7261		7265	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156					−25·8	½								
4549·766	−29·7	½			−15·2	½							−39·0	½
4395·286			−45·2	½	−20·2	½	−25·5	½	−25·5	½			−29·3	¼
4352·006	−51·2	½	−44·6	½	−15·4	½	−28·5	½	−23·9	¼				
4340·634	−33·1	½	−43·8	1	−22·8	1	−28·8	1	−20·5	1	−11·9	¾	−37·2	¾
4325·638	−29·4	½	−30·3	½	− 9·0	1	−32·2	¾			± 0·0	¼		
4299·735			−28·0	½	−41·0	¼							−43·4	½
4271·760	−35·6	½			−41·4	¾	−30·7	½	−34·8	½	−23·2	¼		
4250·616			−55·4	½										
4236·107			−59·9	¼	−31·9	¼								
4233·328							−38·0	½	−45·4	½				
4226·860	−37·7	½	−48·2	½	−18·2	½	−14·7	½	−22·1	¼	−23·3	½	−21·6	½
4198·658			−28·5	1	−24·7	¾	−29·0	½	−16·2	½				
4143·658			−35·3	½					−25·9	½	−35·6	¼		
4101·890	−47·6	½	−49·0	¾	−32·9	½	−40·2	½	−20·8	½	−29·0	¼	−36·1	½
4071·733	−50·5	½			− 3·2	½			− 4·1	¼				
4063·756							−29·0	¾	−13·4	¼	− 5·3	¼		
4045·851	−53·4	½	−39·2	1	−34·2	½	−26·5	½	−33·0	¼	−10·0	¼	−40·3	½
Weighted mean	− 40·87		− 40·90		− 22·75		− 29·39		− 24·55		− 16·84		− 35·80	
V_a	+ 19·45		+ 19·45		+ 19·10		+ 19·10		+ 18·44		+ 18·44		+ 18·44	
V_d	± ·00		− ·04		± ·00		− ·04		+ ·19		+ ·15		− ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 21·7		− 21·8		− 3·9		− 10·6		− 6·2		+ 1·5		− 17·8	

MEASURES OF α TRIANGULI—*Continued.*

λ	7273		7274		7278		7283		7284		7294		7295	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	−19·5	¼									−36·1	½	−27·9	¼
4352·006			−56·1	½			−11·4	¾	−19·5	½				
4340·634	−44·7	¾	−46·0	¾	−37·4	¾	−19·0	½	−28·3	¾	−36·9	¾	−31·5	½
4325·638	−29·4	½	−25·7	¼			−29·3	½	−20·2	½			−47·5	¼
4271·760	−38·2	¾	−66·8	¾					−14·6	½	−62·6	½	−45·2	¾
4233·328	−28·7	¼					− 9·1	½			−56·7	½		
4226·860	−43·7	½	−35·5	¾	−27·0	¾	−13·6	½			−29·5	½	−36·7	½
4215·668	−24·6	½									−31·2	½		
4198·658					−35·5	½	− 7·4	¾	−28·4	½	−41·4	½	−23·4	½
4143·658	−52·2	½			−44·1	½			−32·7	½	−31·1	¼	−39·2	½
4101·890	−55·2	½			−34·4	½	−24·6	½	− 6·8	½	−43·3	¼	−40·6	¾
4071·733									−32·6	¼	−40·2	½	−33·9	¼
4063·756					−49·4	¾			−15·2	½	−63·6	¼	−40·6	¼
4045·851	−47·9	½	−74·4	¼	−40·6	¾			−26·9	¼	−54·7	½	−33·6	½
4005·485					−39·4	½								
Weighted mean	− 40·16		− 50·52		− 38·44		− 15·45		− 22·06		− 42·75		− 36·76	
V_a	+ 16·98		+ 16·98		+ 17·08		+ 16·58		+ 16·58		+ 14·13		+ 14·13	
V_d	+ ·25		+ ·23		+ ·12		+ ·26		+ ·24		+ ·20		+ ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 23·2		− 33·6		− 21·5		+ 1·1		− 5·5		− 28·7		− 22·7	

MEASURES OF α TRIANGULI—*Continued.*

λ	7304		7305		7311		7312		7319		7320		7348	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	−28·7	¼	−20·1	½					−35·8	¼				
4481·400									−31·1	¼				
4395·286			−30·9	½										
4352·006	−13·8	½	−23·1	¼					−37·2	¼	−21·0	¼		
4340·634	−21·2	½	− 9·7	¾	−41·9	¾	−22·2	¾	−20·5	¼	−23·6	½	−24·4	½
4325·638	−18·9	½							+ 4·6	¼	−13·6	¼	− 2·5	¼
4299·735													−12·5	¼
4271·760	−14·5	¾			−24·8	½			−38·6	¼	−16·8	½		
4260·640	−18·9	½												
4250·616									−25·7	½				
4233·328	− 9·2	½					−26·7	¼	−28·0	½			−18·6	¼
4226·860	−15·3	½	−31·9	¼	−22·3	½	−23·7	¼	−21·0	½	−27·4	¼		
4215·668	−13·9	½					−25·8	¼					+ 0·6	¼
4198·658	− 5·0	½	−16·0	¼							−42·0	¼	−41·8	½
4143·658			−10·4	½	−45·8	½	−30·9	½			−35·3	¼	−19·8	½
4101·890	−29·8	½	−20·9	½	−43·4	½	−36·4	½			−20·2	½	−14·2	½
4071·733	− 7·7	½	− 2·3	½	− 9·0	½	−39·9	¼					−13·1	¼
4063·756	−20·7	¼			−60·1	½	−40·4	½	−14·0	¼	−31·0	¼	−29·5	¼
4045·851	−20·6	½	−17·9	¾	−34·8	¾	−20·2	½			−24·5	½	−16·6	¼
4005·485													−38·8	½
Weighted mean	− 16·57		− 16·93		− 35·92		− 29·20		− 24·58		− 24·28		− 21·78	
V_a	+ 13·72		+ 13·72		+ 13·31		+ 13·31		+ 12·00		+ 12·00		+ 6·00	
V_d	− ·05		− ·07		+ ·16		+ ·12		+ ·21		+ ·18		+ ·24	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 3·2		− 3·6		− 22·7		− 16·0		− 12·6		− 12·4		− 15·8	

MEASURES OF α TRIANGULI—*Continued.*

λ	7349		7350		7353		7354		7357		7358		7362	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4352·006	...	...	−11·3	½	− 1·2	¼	−48·1	¼	−31·0	¼	−34·0	½	−19·8	¼
4340·634	− 2·8	¾	+ 3·5	½	−12·6	½	−15·5	¼	−16·8	¾	−11·0	½	−26·3	½
4325·638	−12·8	¼	−18·0	½	...	...	...	...	...	...	+ 4·4	½	−17·6	½
4299·735	− 1·6	½	−30·5	¼	...	...	...	...	...	...	−22·5	½	−33·9	¼
4290·195	−35·3	¼	...	...	− 6·2	½	...	...	...	...	−27·0	¼	...	...
4271·760	− 5·5	¼	...	...	−27·8	¼	...	...	−23·4	¼	...	...	...	...
4236·107	...	...	...	...	+ 3·8	¼	...	...	...	...	...	...	...	...
4233·328	...	...	...	...	−10·2	¼	−36·4	¼	− 5·8	¼	...	...	...	...
4226·860	−21·1	¼	− 8·2	½	−23·2	¼	...	...	...	...	...	...	−20·4	½
4215·668	...	...	+ 6·2	½	−25·2	¼	...	...	...	...	−26·5	¼	...	...
4198·658	− 9·0	¼	−12·4	½	...	...	−17·5	¼	...	...	...	...	...	...
4143·658	−40·2	¼	+ 8·0	¼	−24·1	¼	−22·5	¼	...	...	−28·2	¼	−18·5	¼
4101·890	−24·0	½	−33·6	½	−16·5	½	−20·0	¼	−31·7	½	−30·3	¼	−15·4	¼
4071·733	−23·4	¼	...	...	...	...	−28·5	¼	...	...	...	...	...	...
4063·756	...	...	−21·4	¼	−34·8	½	−51·5	¼	...	...	...	...	...	...
4045·851	−24·0	¼	−17·6	½	− 8·6	½	−30·0	¼	−19·0	¼	−27·8	½	−25·3	½
4005·485	−25·8	¼	...	...	−17·0	¼	+ 4·2	½	...	...	...	...	...	...
Weighted mean	− 16·05		− 12·48		− 15·66		− 13·66		− 17·68		− 20·69		− 22·10	
V_a	+ 6·00		+ 6·00		+ 4·05		+ 4·05		+ 3·54		+ 3·54		+ 2·08	
V_d	+ ·07		+ ·04		+ ·07		+ ·11		+ ·15		+ ·12		− ·13	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 10·3		− 6·7		− 11·8		− 9·8		− 14·2		− 17·3		− 20·4	

MEASURES OF α TRIANGULI—*Continued.*

λ	7365		7366		7368		7369		7377		7380		7386	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt
4572·156									−20·6	¼			−12·3	¼
4549·766					−33·1	¼			−19·6	¼			−35·7	¼
4481·400					−13·6	½			−21·6	¼				
4352·006	−30·5	½	−13·8	¼	−20·6	¼	− 6·4	¼			+21·4	½	−45·4	¼
4340·634	−22·6	¾	−20·5	½	− 4·2	½	−17·2	½			+11·8	¾	+16·7	¼
4325·638	−24·5	½			− 4·4	¼	+ 9·8	¼	− 8·0	¼			+ 9·7	¼
4299·735					−27·8	¼	−14·3	¼			− 5·4	¼		
4290·195	− 8·0	½			−23·2	½	− 8·0	¼			− 6·0	¼		
4271·760			− 6·4	¼	−21·4	¼	− 9·4	¼			+ 1·8	¼		
4260·640									−19·7	¼				
4250·616											+ 2·8	¼		
4236·107											−25·2	¼		
4233·328					−14·7	¼							−25·1	¼
4226·860	−12·4	¼	−27·0	½			− 8·2	¼			+ 7·2	¼		
4215·668					+ 4·2	½	+ 6·3	½			+17·5	¼		
4198·658	−19·4	¼			−20·4	½	−23·0	¼			+13·6	½	−30·0	¼
4143·658	−10·9	½					−21·1	½					−16·5	¼
4101·890	−39·0	¾	−17·0	½			−21·6	½			− 3·4	½		
4071·733	−35·3	¼	−44·8	¼										
4063·756			−16·8	¼			−24·0	¼						
4045·851	−22·5	½	−28·4	½	−27·3	¾	−22·5	½						
4005·485	− 8·0	¼	−12·8	¼	− 9·8	¼	+ 3·6	½						
Weighted mean	− 22·58		− 21·60		− 17·22		− 11·40		− 17·90		+ 5·68		− 17·33	
V_a	+ 1·11		+ 1·11		+ ·14		+ ·14		− 3·91		− 4·84		− 5·78	
V_d	+ ·20		+ ·17		+ ·06		− ·02		+ ·13		± ·00		+ ·26	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 21·6		− 20·6		− 17·3		− 11·6		− 22·0		+ 0·6		− 23·1	

MEASURES OF α TRIANGULI—*Continued.*

λ	7387		7388		7392		7393		7394		7398		7399	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156	−46·4	½	...	...	...	...	...	...	...	...	...	...	...	...
4549·766	−35·7	¼	...	...	− 6·5	¼	−21·4	½	+11·4	½	...	...	−26·6	¼
4481·400	...	...	...	...	− 9·8	¼	−20·1	½	−14·4	¼	...	...	+ 7·8	½
4404·927	−35·4	½	...	...	...	...	...	...	...	...	...	...	...	...
4352·006	−28·4	½	−19·1	¼	...	...	−10·3	½	− 8·6	½	−26·5	½	− 0·4	½
4340·634	−18·2	¼	− 7·9	½	+ 1·0	¼	− 9·2	¾	− 1·9	¾	−20·5	¾	− 3·0	½
4325·638	...	...	− 2·8	¼	+ 4·8	¼	+ 6·0	¼	+ 8·0	½	−15·7	½	+11·8	½
4299·735	− 6·1	¼	−14·7	¼	...	...	−13·1	½	...	...	−14·9	½	−16·5	¼
4290·195	−40·3	¼	...	...	...	...	...	...	...	...	− 9·8	½	−17·8	½
4271·760	− 4·4	¼	−10·8	¾	+ 4·6	½	−24·6	½	− 2·4	½	−15·4	½	−12·7	¾
4250·616	−37·4	¼	...	...	+15·1	¼	...	...	− 0·9	½	−14·0	½	...	...
4236·107	+12·1	¼	...	...	...	...	−19·7	½	...	...	−29·0	½	...	...
4233·328	...	...	...	...	...	...	...	...	− 2·1	½	− 0·4	½	...	...
4226·860	−29·9	½	−23·7	¼	...	...	−13·2	½	− 6·2	½	−15·9	½	− 8·7	¼
4215·668	...	...	...	...	...	...	...	...	...	...	...	...	− 7·1	¼
4202·161	...	...	...	...	...	...	− 4·8	¾	...	...	−12·2	½	...	...
4198·658	− 3·0	½	−12·8	¾	−23·4	¼	−12·0	½	−11·8	½	− 7·4	½	+ 5·3	¼
4143·658	...	...	−24·3	½	−37·4	¼	+ 8·4	½	...	...	−23·8	½	+ 0·2	¾
4101·890	−19·0	¼	...	...	...	...	− 1·6	½	−16·2	½	−18·2	½	−15·9	¼
4071·733	−13·6	½	−21·1	½	...	...	+ 0·4	½	− 7·9	½	...	...	...	...
4063·756	...	...	...	...	...	...	−11·9	½	− 7·4	½	...	...	− 7·2	¼
4045·851	−16·8	¼	−15·4	½	− 7·6	¼	+ 1·8	¾	− 7·0	½	− 6·6	¾	−23·8	½
Weighted mean	− 22·50		− 14·91		− 5·56		− 9·12		− 4·53		− 15·24		− 6·62	
V_a	− 5·78		− 5·78		− 6·33		− 7·24		− 7·24		− 7·30		− 7·30	
V_d	+ ·25		+ ·22		+ ·15		+ ·26		+ ·26		± ·00		− ·05	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 28·3		− 20·8		− 12·0		− 16·4		− 11·8		− 22·8		− 14·3	

MEASURES OF α TRIANGULI—*Concluded.*

λ	7400													
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	−16·6	$\frac{3}{4}$												
4481·400	− 7·2	$\frac{1}{4}$												
4352·006	−12·6	$\frac{1}{4}$												
4340·634	± 0·0	$\frac{3}{4}$												
4299·735	−12·6	$\frac{1}{2}$												
4271·760	−29·2	$\frac{1}{4}$												
4236·107	− 9·4	$\frac{1}{2}$												
4233·328	− 2·4	$\frac{1}{4}$												
4226·860	− 4·6	$\frac{1}{4}$												
4215·668	+20·2	$\frac{1}{4}$												
4198·658	+ 5·2	$\frac{1}{4}$												
4143·658	−47·4	$\frac{1}{2}$												
4101·890	−21·4	$\frac{3}{4}$												
Weighted mean	− 12·86													
V_a	− 7·30													
V_d	− ·09													
Curv.	− ·28													
Radial Velocity	− 20·5													

The Ottawa observations were grouped according to phase into 12 normal places and preliminary elements obtained by the usual graphical method. These elements are the following:—

$$
\begin{aligned}
P &= 1\cdot73652 \text{ days} \\
e &= \cdot10 \\
\omega &= 105^\circ \\
K &= 12 \text{ km.} \\
\text{Max.} &= -1\cdot5 \text{ km.} \\
\text{Min.} &= -25\cdot5 \text{ km.} \\
T &= \text{J. D. } 2{,}414{,}552\cdot948 \\
\gamma &= -13\cdot19 \text{ km.}
\end{aligned}
$$

NORMAL PLACES.

	Phase Preliminary.	Phase Final.	Velocity.	Weight.	O–C Preliminary.	O–C Final.
1.	·975	·835	− 6·8	·5	+0·3	−0·9
2.	1·207	1·067	− 2·1	·6	−0·2	−0·3
3.	1·327	1·187	− 1·6	·6	0·0	+0·2
4.	1·466	1·326	− 3·2	·8	+1·0	+0·8
5.	1·531	1·391	− 7·8	·3	−1·3	−1·7
6.	1·707	1·567	−14·6	·6	+1·6	−0·6
7.	·158	·018	−24·4	·7	−1·1	−1·4
8.	·279	·139	−24·0	·5	+1·4	−1·7
9.	·407	·267	−25·3	·5	−0·7	−0·5
10.	·523	·383	−21·8	·8	+0·5	−0·2
11.	·668	·528	−17·0	·4	−0·4	−0·6
12.	·798	·658	−10·3	·7	+2·7	+1·2

OBSERVATION EQUATIONS FOR α TRIANGULI.

	Weight.	x	y	z	u	v	$-n$
1.	·5	1·000	+ ·282	− ·752	+ ·744	− ·688	− ·3=0
2.	·6	1·000	+ ·707	− ·698	+ ·160	− ·232	+ ·2=0
3.	·6	1·000	+ ·731	+ ·020	− ·237	+ ·136	·0=0
4.	·8	1·000	+ ·521	+ ·922	− ·723	+ ·677	−1·0=0
5.	·3	1·000	+ ·330	+1·051	− ·905	+ ·913	+1·3=0
6.	·6	1·000	− ·487	− ·193	−1·076	+1·178	−1·6=0
7.	·7	1·000	−1·082	−1·035	− ·665	+ ·657	+1·1=0
8.	·5	1·000	−1·254	− ·456	− ·199	+ ·110	−1·4=0
9.	·5	1·000	−1·191	+ ·467	+ ·266	− ·355	+ ·7=0
10.	·8	1·000	− ·994	+ ·682	+ ·581	− ·617	− ·5=0
11.	·4	1·000	− ·518	+ ·674	+ ·869	− ·806	+ ·4=0
12.	·7	1·000	− ·219	+ ·162	+ ·902	− ·813	−2·7=0

Where $x = \delta\gamma$

$y = \delta K$

$z = K.\delta e$

$u = K.\delta\omega$

$$v = \frac{K}{(1-e^2)^{\frac{3}{2}}} \cdot \mu \cdot \delta T = [1\cdot64427]\delta T.$$

NORMAL EQUATIONS.

$$\begin{aligned}
7\cdot000x - 1\cdot906y + \cdot364z - \cdot157u + \cdot075v - 3\cdot110 &= 0 \\
4\cdot301y + \cdot237z - \cdot319u + \cdot322v + \cdot578 &= 0 \\
3\cdot140z + \cdot197u - \cdot220v - \cdot899 &= 0 \\
3\cdot189u - 3\cdot138v - \cdot908 &= 0 \\
3\cdot127v + \cdot714 &= 0
\end{aligned}$$

Whence $\delta\gamma = +\cdot54$ km.

$\delta K = +\cdot10$ km.

$\delta e = +\cdot021$

$\delta\omega = +30^\circ\cdot56$

$\delta T = +\cdot1405$ day

The value of Σpvv for the normal places was reduced from $11\cdot1$ to $6\cdot2$. One solution was sufficient, as the residuals obtained by substitution in the observation equations and by computing directly from the corrected elements agreed within $0\cdot2$ km. The probable error of a plate computed from the last two columns in the table of observations, using the formula

$$r = \pm\cdot6745\sqrt{\frac{\Sigma pvv}{n-1} \cdot \frac{n}{\Sigma p}},$$

is $\pm3\cdot5$ km. per sec. No plates have been omitted, even though some of them were somewhat underexposed; one in fact having only three or four minutes exposure. If four of the largest residuals were omitted, the probable error would become $\pm2\cdot9$. However, the probable error of $3\cdot5$ is very satisfactory considering the character of the spectrum for measurement.

A plot of the observations is given in Fig. 1, the circles with dark centres representing the Lick observations when $-5\cdot0$ km. has been added to each of them. The grouped velocities are shown with the curve from the final elements in Fig. 2.

The final values of the elements, then, with their probable errors are the following.

$$
\begin{aligned}
P &= 1\cdot73652 \text{ days} \\
e &= \cdot121 \quad \pm\cdot041 \\
\omega &= 135^\circ\cdot56 \quad \pm23^\circ\cdot35 \\
K &= 12\cdot10 \text{ km.} \quad \pm \cdot46 \text{ km.} \\
\gamma &= -12\cdot65 \text{ km.} \quad \pm \cdot36 \text{ km.} \\
A &= 11\cdot05 \text{ km.} \\
B &= 13\cdot15 \text{ km.} \\
T &= \text{J. D. } 2{,}420{,}793\cdot821 \quad \pm \cdot105 \\
a \sin i &= 286{,}800 \text{ km.}
\end{aligned}
$$

Dominion Observatory,
Ottawa,
November, 1915.

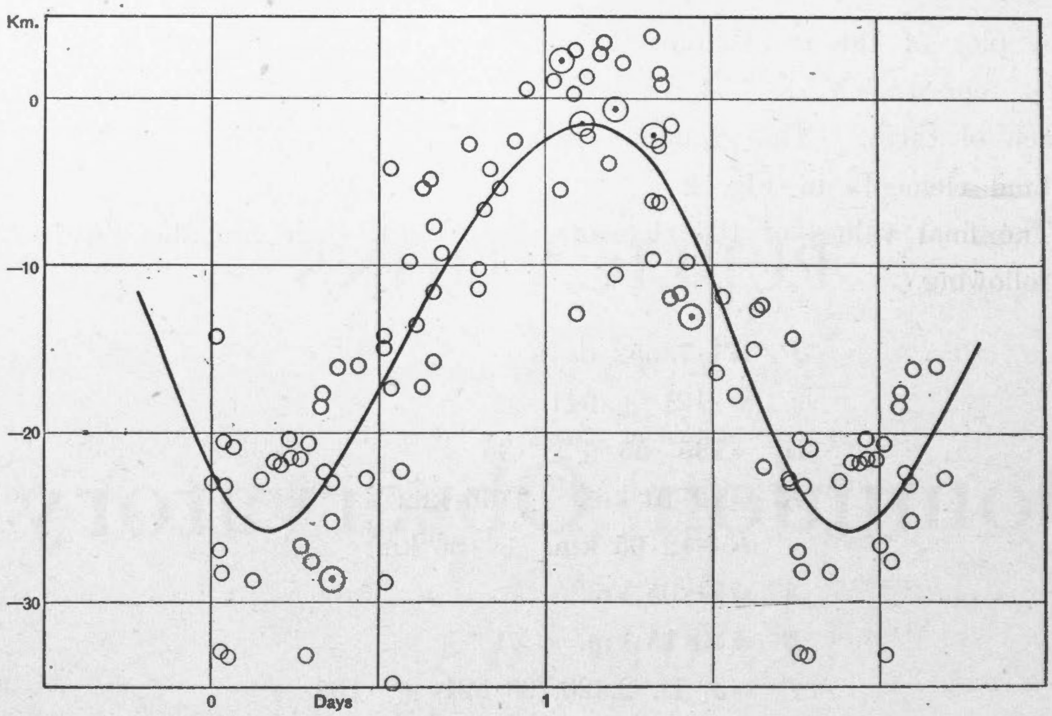

FIG. 1—Observations of α Trianguli.

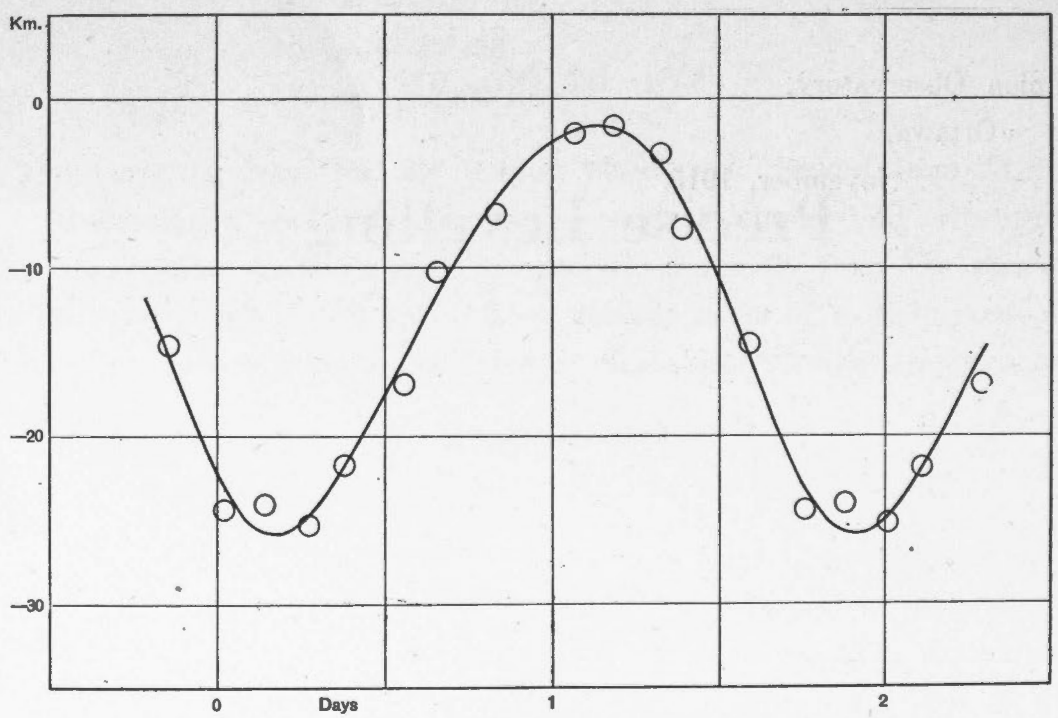

FIG. 2—Velocity Curve of α Trianguli

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PUBLICATIONS

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OTTAWA

W. F. KING, C.M.G., LL.D., *Director*.

Vol. III, No. 6

Precise Levelling

BY

F. B. REID, B.A.Sc., D.L.S.

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PRECISE LEVELLING.

BY F. B. REID, B.A.Sc., D.L.S.

Supervisor of Levelling.

CONTENTS.

PRECISE LEVELLING.

This publication is the sixth one on the subject of precise levelling by the Geodetic Survey of Canada, the ones previously issued being as follows:

Appendix to Chief Astronomer's report issued in 1910.			
Vol. I, No. 2,	issued in	1913*	
Vol. I, No. 3,	"	1913	
Vol. I, No. 8,	"	1914	
Vol. II, No. 1,	"	1915	

The present publication is arranged in the same general form as the previous ones, with the results of the levelling set forth in three tables. The index and map included herein are complete for all the work previously published, as well as that in the present publication; the index indicates in which publication descriptions and elevations of bench-marks published before this may be found.

Table I indicates the routes followed between terminal points and gives complete descriptions of all bench-marks established along these routes.

Table II shows in the first two columns the numbers of the bench-marks; in the third and fourth columns the approximate distance (in miles) between bench-marks, and from the initial bench-mark of the line; the fifth and sixth columns (headed "Discrepancy") give the difference (in feet) between the forward levelling and the backward levelling for each section between bench-marks and the accumulated difference from the initial bench-mark. The seventh column gives the elevations of the bench-marks shown in the second column; for convenience, these bench-marks are repeated (in the eighth column) in order that the number of any bench-mark and its elevation may be in adjoining columns. In this table are shown also the elevations determined by the Geodetic Survey for certain bench-marks established by other surveys and connected with our levelling.

*Levelling in Yukon territory only.

Table III shows the elevations at railway stations and at crossings of intersecting railways; also on the bridges over rivers and lakes and the more important streams. Rail elevations were in all cases taken on top of the rail, in front of the telegraph office at telegraph stations and opposite the shelter or platform at flag-stations.

The results are given for the following lines:—

1. Halifax, N.S., to Moncton, N.B.
2. Bridgewater, N.S., to Windsor, N.S.
3. St. Leonard, N.B., to Campbellton, N.B.
4. McGivney Junction, N.B., to Chatham, N.B.
5. St. Anselme, Que., to Levis, Que.
6. Cookshire, Que., to Beecher Falls, Vt.
7. Sudbury, Ont., to Sault Ste. Marie, Mich.
8. Fort Frances, Ont., to Port Arthur, Ont.
9. Stanley, Ont., to North Lake, Ont.
10. Wainwright, Alta., to Edmonton, Alta.
11. Calgary, Alta., to Tofield, Alta.
12. Calgary, Alta., to Field, B.C.
13. Vancouver, B.C., to Blaine, Wash.
14. Colebrook, B.C., to Huntingdon, B.C.

Line 1—run by G. F. Dalton, 1914 and 1915—was started at a bench-mark (a chiselled groove marked with a broad arrow) on No. 3 storehouse in the Naval Yard, Halifax. The elevation of this has been fixed by the Tidal and Current Survey, Department of the Naval Service, as 12·59 feet above mean sea level at Halifax, determined from the hourly ordinates of the tide, day and night, during nine complete years. Our elevations along line 1 are based upon the above-mentioned figures and the line is terminated at Moncton upon bench-mark 132–B, the original elevation of which was carried from St. Stephen, N.B., (refer to 1910 and 1913 publications). It should be noted that the two determinations for this bench-mark—namely, from St. Stephen and from Halifax—differ by only 0·20 feet. The levelling along line 1 has been connected with a large number of bench-marks established by the Public Works Department of Canada; these bench-marks are designated by Roman numerals. For their descriptions the reader is referred to that department. Table II in the present publication gives their elevations as determined by the Geodetic Survey. Bench-mark 135–B at Oxford Junction, the initial bench-mark of the line to Mulgrave (1913 publication), has also been connected; its elevation—89·824 feet—is 0·152 feet higher than that previously assigned to it; hence to reduce all bench-marks between Oxford Junction and Mulgrave to the present Halifax datum, the above-mentioned amount should be added to the figures given in the former publication.

Line 2 (G. F. Dalton, 1914) was started from the Halifax-Yarmouth line, which when published last year was based upon the same datum as the Halifax-Moncton line now published. At Windsor the closing error is 0·058 feet, the length of the circuit—Halifax–Bridgewater-Middleton-Windsor—being 234 miles. Line 3 (H. P. Moulton, 1914) was started from the St. Stephen–Rivière-du-Loup line (1910 publication) and closed at Campbellton upon bench-marks of the Public Works Department. Line 4 (H. P. Moulton, 1914, and G. F. Dalton, 1915) was started from the Grand Falls-Moncton line (1914 publication) and connected at Derby Junction and again at Chatham with bench-marks of the Public Works Department. Line 5 (T. C. Dennis, 1911, and J. E. Ratz, 1913) was started from the Megantic–Levis line (1913 publication) and closed upon the same line at Levis, the closing error of the circuit of 54 miles being 0·024 feet. Line 6 (G. F. Dalton, 1915) was started from the Lennoxville–Megantic line (1913 publication) and terminated at the international boundary at Beecher Falls, Vermont.

Line 7 (A. J. Rainboth, 1914 and 1915) was started from the Bala–Sudbury line (1914 publication) and terminated at Sault Ste. Marie, Mich., connection being made at that place with two bench-marks of the United States Lake Survey, on the Poe lock and the Weitzel lock respectively. Line 8 (D. McMillan and N. H. Smith, 1913) is a continuation of the

Emerson–Fort Frances line (1914 publication); at Port Arthur it is connected with a benck-mark of the Hydrographic Survey, Department of the Naval Service; the elevation of this, derived by water transfers between the years 1907 and 1914 from Marquette, Mich., is 616·154; the elevation obtained by us by our line of levels from Stephen, Minn.—refer to introduction to 1913 publication—is 615·274. Line 9 (N. H. Smith, 1913) is a branch from line 8. Line 10 (N. H. Smith, 1914) is a continuation of the Saskatoon–Wainwright line (1915 publication). Line 11 (N. H. Smith, 1915) was started from the Lethbridge–Calgary line (1915 publication) and closed at Tofield upon line 10, thus completing a circuit of the Geodetic Survey's levelling embracing Regina, Lethbridge, Calgary, Tofield and Saskatoon; the closing error of this circuit—as represented by the two elevations obtained for the junction bench-mark at Tofield—is 1·285 feet; while this is larger than the closing errors obtained on other sections of the work, it should be noted that the length of the circuit in question is almost 1,200 miles. Line 12 (G. S. Raley, 1915) commences at the same bench-mark as line 11.

Line 13 (D. McMillan, 1914) was started from the reference bench-mark of the Tidal and Current Survey, Department of the Naval Service, on the stone sill of the Welton Block, Vancouver. The following statement as to the original levels at Vancouver is furnished by the Tidal and Current Survey:—

	Above C.P.R. Datum.
Original bench-mark on old station building of Canadian Pacific railway (now demolished).................	108·35
Reference bench-mark on stone sill of the Welton Block, established by the Tidal Survey in 1912 to preserve the original levels.........................	111·22
Level of "Ordinary high water" by which the C. P. R. datum is defined......................................	100·00
Low water at spring tides or "Chart datum" for Vancouver harbour; defined on the charts since 1891 as 23 feet 7 inches below the bench-mark on the old C. P. R. station building....................	84·77

	Above C.P.R. Datum.
Mean sea level, as determined by the Tidal Survey from the hourly ordinates of the tide during seven complete years of observation, between 1902 and 1912..	92·804
This is the average of these seven years and is 8·034 feet above the "Chart datum" which has been adopted since 1901 as the Zero level for the tide tables.	

From the above statement it will be seen that the elevation of the reference bench-mark is 18·416 feet above mean sea level. The elevation of our bench-mark 2–J, in Vancouver post-office has been determined by precise levelling as 35·268 feet above the reference bench-mark or 53·684 feet above mean sea level. All the elevations along line 13 are based upon the above result for bench-mark 2–J, as are also the elevations along line 14, which is a branch from line 13, run during the same season by the same leveller.

All elevations given are instrumental and have had no adjustments applied to them, consequently changes may be made in the future; it should be noted, however, that in almost all cases where circuits have been closed, the closing errors are quite small.

The standard bench-mark adopted consists of a copper bolt, three-quarters of an inch in diameter and four inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench-mark). The bolt is sunk horizontally in rock or masonry so that only the circular end is visible; the number of the bench-mark is stamped on this end as well as the letters mentioned above, and a horizontal chisel line is cut, upon which the elevation is taken. At certain points concrete bench-mark piers have been built; these project from six inches to one foot above the ground and extend below the frost line; the copper bolt upon which the elevation is taken is placed horizontally as in other cases, and is about nine inches below the top of the pier.

TABLE I.

BENCH-MARKS BETWEEN HALIFAX, N.S., AND MONCTON, N.B., VIA INTERCOLONIAL RAILWAY TO WINDSOR JUNCTION, DOMINION ATLANTIC RAILWAY TO TRURO AND INTERCOLONIAL RAILWAY TO MONCTON.

Note.—These descriptions are written with the assumption that the railway runs in a northerly direction from Halifax to Windsor Junction, thence northwesterly to Windsor and thence northeasterly to Truro; between Truro and Moncton the direction has been determined (approximately) at each bench-mark.

386–B In east face of stone footing of pilaster at southeast corner of Intercolonial station-house, corner of North and Lockman streets, Halifax.

387–B In fourth course of stonework below water-table course, in west end of north wall of clock tower of custom-house, Halifax.

388–B In north face of seat-stone of northerly girder—on east abutment—of subway by which main road from Halifax to Truro passes under Halifax and Southwestern railway at Fairview, 3 miles from Halifax.

506–B In concrete bench-mark pier, 4 feet east of west line of Intercolonial railway right-of-way, 560 feet north of north end of bridge over Sackville river at Bedford and 507 feet south of mile-post 9 from Halifax.

507–B In first course of stonework below bridge-seat, in northeast face of southeast abutment of small plate-girder bridge on Dominion Atlantic railway, 1 mile northwest of Beaverbank.

508–B In exposed rock surface, 10 feet southwest of Dominion Atlantic railway track—at southeast end of a rocky knoll about 70 feet long and 10 feet high—situated at eighth telegraph pole southeast of mile-post 7 from Windsor Junction.

509–B In first course of stonework below bridge-seat, in southwest face of west retaining wall of three-span bridge on Dominion Atlantic railway, ½ mile northwest of South Uniacke.

510–B In exposed rock surface, 10 feet northeast of Dominion Atlantic railway track, 1 mile northwest of Mount Uniacke and near the centre of a rocky point of land—the second such point northwest of the station—projecting into Uniacke lake. There is a rock cut immediately southeast of here.

511–B In northeast side of shallow rock cut on Dominion Atlantic railway—80 feet from northwest end of cut—between two long deep fills, 4 miles northwest of Mount Uniacke and at twelfth telegraph pole southeast of mile-post 17 from Windsor Junction.

512–B In southwest side of curved rock cut on Dominion Atlantic railway, 600 feet northwest of mile-post 20 from Windsor Junction; this is the first rock cut northwest of Stillwater flag-station and is 3 miles southeast of Ellershouse.

513–B In second course of stonework below coping, in northwest end of northeast face of north retaining wall of long plate-girder bridge on Dominion Atlantic railway, 1¼ miles southeast of Ellershouse.

514–B In second course of stonework below coping, in southeast end of northeast face of east retaining wall of Dominion Atlantic railway bridge over St. Croix river, immediately northwest of Hartville flag-station.

515–B In fourth course of stonework below top, in southwest face of south retaining wall of small plate-girder bridge on Dominion Atlantic railway, ¾ mile southeast of Threemile Plains.

505–B In Dominion Atlantic station, Windsor—see line from Bridgewater to Windsor.

516–B In first course of stonework above bridge-seat, in northwest face of retaining wall behind southwest abutment of Dominion Atlantic railway bridge over St. Croix river, 3¾ miles northeast of Windsor.

517–B In second course of stonework below top, in northwest face of small square culvert under Dominion Atlantic railway, 650 feet southeast of Scotch Village.

518–B In fourth course of stonework below top, in northeast end of southeast face of east retaining wall of plate-girder bridge on Dominion Atlantic railway, 0·9 mile northeast of Mosherville and at mile-post 13 from Windsor.

519–B In southwest end of southeast face of concrete culvert under Dominion Atlantic railway, 3 miles southwest of Clarksville and ¼ mile southwest of mile-post 16 from Windsor.

520–B In concrete bench-mark pier, 4 feet southeast of northwest line of Dominion Atlantic railway right-of-way, 315 feet northeast of bridge over Mile brook, ¾ mile southwest of Clarksville and 130 feet southwest of mile-post 18 from Windsor.

521–B In northeast end of northwest face of stone and concrete culvert under Dominion Atlantic railway, 500 feet northeast of Clarksville station.

522–B In second course of stonework below bridge-seat, in southeast face of south retaining wall of Dominion Atlantic railway bridge over Kennetcook river, 1¾ miles northeast of Clarksville.

523–B In southwest end of southeast face of stone and concrete culvert under Dominion Atlantic railway, 0·6 mile southwest of Kennetcook and 950 feet southwest of mile-post 26 from Windsor.

524–B In southeast face of concrete culvert under Dominion Atlantic railway, 550 feet southwest of Kennetcook station.

525–B In second course of stonework above bridge-seat, in southeast end of southwest face of retaining wall behind northeast abutment of Dominion Atlantic railway bridge over Kennetcook river, 2 miles northeast of Kennetcook.

526–B In third course of stonework below timber-seat, in northwest face of southwest abutment of open culvert under Dominion Atlantic railway, 200 feet northeast of Patterson.

527–B In southwest end of southeast face of stone and concrete culvert under Dominion Atlantic railway, ¾ mile northeast of Burton and at fifth telegraph pole southwest of mile-post 36 from Windsor.

528–B In second course of stonework above bridge-seat, in northwest end of northeast face of retaining wall behind southwest abutment of Dominion Atlantic railway bridge over Fivemile river, 1 mile southwest of South Maitland.

529–B In southeast end of southwest face of concrete retaining wall behind northeast abutment—2 feet above bridge-seat—of Dominion Atlantic railway bridge over Shubenacadie river, 1 mile northeast of South Maitland.

530–B In fourth course of stonework below top, in southeast face of small square culvert under Dominion Atlantic railway, 2½ miles northeast of Princeport Road and 800 feet southwest of mile-post 48 from Windsor.

531–B In northeast end of northwest face of stone and concrete culvert under Dominion Atlantic railway, 540 feet southwest of Clifton.

532–B In concrete bench-mark pier, 4 feet northwest of southeast line of Dominion Atlantic railway right-of-way, 104 feet southwest of the intersection of a highway fence with the southeast line of the right-of-way, 2¼ miles southwest of Truro station and 1,815 feet southwest of mile-post 56 from Windsor.

533–B In first course of stonework below bridge-seat, in southeast face of south abutment of plate-girder bridge on Dominion Atlantic railway, 1¼ miles southwest of Truro station and ¼ mile southwest of mile-post 57 from Windsor.

534–B In fourth course of stonework below water-table course, in west wall of Truro civic building—midway between first and second basement windows from northwest corner.

535–B In second course of stonework below water-table course, in south wall of Truro post-office, 10 feet east of the letter-drop.

536–B In north stone foundation wall of Bank of Nova Scotia—corner of Inglis and Prince streets—Truro. The bench-mark is 1 foot above sidewalk and 12 feet from northwest corner of building.

537–B In water-table course of stonework, in rear (or north) wall of Intercolonial station-house at Truro, 6 feet from northwest corner.

538–B In first course of stonework below bridge-seat, in east end of south face of north abutment of plate-girder bridge on Intercolonial railway, 1½ miles south of Folleigh.

539–B In concrete bench-mark pier, 4 feet east of west line of Intercolonial railway right-of-way, 2,860 feet south of Folleigh station and 405 feet south of south switch of passing-track.

540–B In fourth course of stonework below top, in north face of northeast retaining wall of large stone arch culvert under Intercolonial railway, ½ mile east of Thompson.

135–B In first course of stonework below cap-stone, in east face of southeast retaining wall of Intercolonial railway bridge over River Philip, 1,800 feet west of Oxford Junction.

541–B In concrete bench-mark pier, 4 feet north of south line of Intercolonial railway right-of-way, 26 feet west of a private crossing, 280 feet west of a small stone culvert and 1½ miles west of Oxford Junction.

542–B In north face of north face-wall of small concrete culvert under Intercolonial railway, 1,550 feet west of River Philip station.

543–B In second course of stonework below top, in north face of small square stone culvert under Intercolonial railway, 2 miles west of Springhill Junction.

544–B In concrete bench-mark pier, 4 feet west of east line of Intercolonial railway right-of-way, 1,170 feet south of a private crossing and 2 miles south of Amherst.

545–B In water-table course of stonework, in east end of north wall of Intercolonial station-house at Amherst.

546–B In fourth course of stonework below water-table course, in front (or south) wall of Amherst post-office, 6 feet west of easterly doorway.

547–B In first course of stonework below water-table course, in front (or south) wall of Amherst court-house, between the two basement windows to the west of main entrance.

548–B In water-table course of stonework, in south wall of Amherst town-hall and fire-station—5 feet from southwest corner of building.

549–B In north end of west face-wall of concrete tile culvert under Intercolonial railway, ¾ mile north of Memramcook.

550–B In concrete bench-mark pier, 4 feet south of north line of Intercolonial railway right-of-way, 2½ miles east of Painsec—on a section of straight track—and at tenth telegraph pole west of west end of a sharp curve.

132–B In stone water-table course, at south end of east wall of Intercolonial station-house at Moncton.

BENCH-MARKS BETWEEN BRIDGEWATER AND WINDSOR, N.S., VIA HALIFAX AND SOUTHWESTERN RAILWAY TO MIDDLETON AND DOMINION ATLANTIC RAILWAY TO WINDSOR.

Note.—These descriptions are written with the assumption that the railway runs in a northwesterly direction from Bridgewater to Middleton, thence easterly to Avonport and thence southeasterly to Windsor.

466–B In fourth course of stonework below top, in southwest face of west retaining wall of open culvert under Halifax and Southwestern railway, 650 feet southeast of mile-post 2 from Bridgewater Junction.

467–B In fifth course of stonework below top, in northeast face of east retaining wall of open culvert under Halifax and Southwestern railway—at a diagonal highway crossing—0·6 mile northwest of Mossman and ½ mile northwest of mile-post 5 from Bridgewater Junction.

468–B In third course of stonework below bridge-seat, in northeast face of east retaining wall of Halifax and Southwestern railway bridge over Lahave river, 1,200 feet southeast of Riversdale.

469–B In second course of stonework below timber-seat, in northeast end of southeast face of northwest abutment of open culvert under Halifax and Southwestern railway, 2¼ miles northwest of Riversdale and 800 feet northwest of mile-post 12 from Bridgewater Junction.

469–B–2 In south end of east face of west concrete abutment—about 11 feet below bridge-seat—of steel highway bridge over Lahave river in the village of New Germany.

470–B In first course of stonework below bridge-seat, in southwest face of southeast abutment of bridge on Halifax and Southwestern railway—at a water-tank—2½ miles northwest of New Germany.

471–B In northeast side of shallow rock cut on Halifax and Southwestern railway—near centre of cut—1 mile northwest of Cherryfield and 220 feet southeast of mile-post 23 from Bridgewater Junction.

472–B In northwest concrete foundation wall of I. W. Roop's general store at Springfield—about 300 feet southwest of the station. The bench-mark is 4 feet below woodwork and 4 feet 8 inches northeast of basement doorway.

473–B In first course of stonework below timber-seat, in northeast face of southeast abutment of open culvert under Halifax and Southwestern railway, ½ mile northwest of mile-post 29 from Bridgewater Junction.

474–B In northeast side of shallow rock cut on Halifax and Southwestern railway, 540 feet northwest of mile-post 34 from Bridgewater Junction.

475–B In second course of stonework below bridge-seat, in north face of east retaining wall of Halifax and Southwestern railway bridge over Waterloo river, 1 mile southeast of Squirreltown.

476–B In northeast end of southeast face of northwest abutment of open culvert under Halifax and Southwestern railway, 600 feet northwest of mile-post 40 from Bridgewater Junction.

476–B–2 In concrete bench-mark pier, 4 feet northeast of southwest line of Halifax and Southwestern railway right-of-way, ¾ mile southeast of Albany and 52 feet northwest of mile-post 41 from Bridgewater Junction—at a private crossing.

477–B In second course of stonework below timber-seat, in northeast end of southeast face of northwest abutment of open culvert under Halifax and Southwestern railway, 600 feet northwest of Albany.

478-B In northeast side of long deep rock cut, on a sharp curve on Halifax and Southwestern railway—1,680 feet southeast of mile-post 46 from Bridgewater Junction; the bench-mark is in the most prominent vertical rock face—near the middle of the cut.

479-B In fourth course of stonework below timber-seat, in northeast end of southeast face of northwest abutment of open culvert under Halifax and Southwestern railway, 0·6 mile southeast of Nictaux and 540 feet northwest of mile-post 49 from Bridgewater Junction.

480-B In rear (or northeasterly) stone foundation wall of Halifax and Southwestern station-house at Nictaux, 3 feet 6 inches below sill of most southerly window.

481-B In sixth course of stonework below bridge-seat, in south face of northwest retaining wall of Halifax and Southwestern railway bridge over Annapolis river, 1½ miles south of Middleton.

482-B In north face of square granite block supporting wooden pillar at northerly side of main entrance to the Armory at Middleton—immediately south of Dominion Atlantic railway.

483-B In north stone foundation wall—2 feet 2 inches below brickwork and 3 feet from northwest corner—of Royal Bank at Middleton.

484-B In west face of coping on south end of concrete arch culvert under Dominion Atlantic railway, 2 miles east of Middleton and 1,800 feet east of mile-post 100 from Halifax.

485-B In west face—11 inches below top—of north face-wall of square concrete culvert under Dominion Atlantic railway, ¾ mile east of Wilmot and 750 feet west of mile-post 97 from Halifax.

486-B In east concrete foundation wall—10 inches below woodwork and 40 inches from northeast corner—of apple storehouse (Markland Fruit Co.), 1,200 feet west of Kingston station.

487-B In south face of west abutment—6 feet 2 inches below coping of bridge-floor—of concrete highway bridge over a stream, immediately north of Dominion Atlantic railway and 1,700 feet west of Auburn station.

488-B In west stone foundation wall—11 inches below woodwork and 11 feet from northwest corner—of apple storehouse (Pleasant Valley Fruit Co.), immediately east of Berwick station.

489-B In south face-wall of concrete tile culvert under Dominion Atlantic railway, 650 feet east of Waterville station.

490-B In north end of west face of concrete retaining wall behind east abutment of bridge on Dominion Atlantic railway, 400 feet east of Cambridge station.

491-B In second course of stonework below timber-seat, in north end of east face of west abutment of open culvert under Dominion Atlantic railway, 0·4 mile east of Coldbrook and at mile-post 75 from Halifax.

492-B In east stone foundation wall of Kentville post-office, 15 inches above sidewalk and 8 feet north of the letter-drop.

493-B In west stone foundation wall of Kentville court-house, 2 feet 3 inches below brickwork and 7 feet north of stairway at main entrance.

494-B In fourth course of stonework below bridge-seat, in south face of southeast retaining wall of plate-girder bridge on Dominion Atlantic railway, ½ mile east of Kentville.

494-B-2 In concrete bench-mark pier, 6 feet north of south line of Dominion Atlantic railway right-of-way, 85 feet west of a private crossing, 1¼ miles west of Wolfville and at fourth telegraph pole west of mile-post 65 from Halifax.

495-B In west end of south face of coping on south end of concrete arch culvert under Dominion Atlantic railway, ½ mile west of Wolfville.

496–B In sandstone water-table course—centre of east foundation wall—of Dominion Atlantic station-house at Wolfville.

497–B In first course of stonework below water-table course, in west wall of Wolfville post-office, 1 foot north of first basement window from rear of building.

498–B In west concrete foundation wall—16 inches below woodwork and 30 inches from northwest corner—of office at west end of apple storehouse (Grand Pré Fruit and Packing Co.), immediately east of Grand Pré station.

499–B In north face-wall of concrete tile culvert under Dominion Atlantic railway, 1 mile east of Avonport and 200 feet east of mile-post 57 from Halifax.

500–B In southwest face-wall—immediately above west wing-wall—of large stone and concrete culvert under Dominion Atlantic railway, ½ mile northwest of Hantsport.

501–B In southwest face-wall—immediately above west wing-wall—of square concrete culvert under Dominion Atlantic railway, 600 feet southeast of Mount Denison.

502–B In southwest face—1 foot below top—of concrete retaining wall behind southeast abutment of Dominion Atlantic railway bridge over Avon river, between Falmouth and Windsor.

503–B In west stone foundation wall of Windsor post-office, 3 feet below brickwork and 10 feet south of the letter-drop.

504–B In first course of stonework below water-table course, in west foundation wall of Windsor civic building, 15 feet 6 inches north of large door of fire-hall.

505–B In first course of stonework below water-table course, in east wall—3 feet from northeast corner—of Dominion Atlantic station-house at Windsor.

BENCH-MARKS BETWEEN ST. LEONARD AND CAMPBELLTON, N.B., VIA INTERCOLONIAL RAILWAY.

Note.—These descriptions are written with the assumption that the railway runs in a northeasterly direction from St. Leonard to Campbellton.

1–G In southeast face—10 inches below top—of northeast concrete abutment of plate-girder bridge on Intercolonial railway, about 5 miles northeast of St. Leonard and at mileage 106·7 from Campbellton.

2–G In concrete bench-mark pier, 43 feet northwest of Intercolonial railway track, 200 feet southwest of a timber culvert—opposite a log cabin—and between tenth and eleventh telegraph poles northeast of mile-post 100 from Campbellton.

3–G In southeast face—19 inches below top—of southwest concrete abutment of plate-girder bridge on Intercolonial railway, at southwesterly end of Grand River siding and at mile-post 96 from Campbellton.

4–G In southeast face—23 inches below top—of southwest concrete abutment of plate-girder bridge on Intercolonial railway, at northeasterly end of Grand River siding and at mileage 95·8 from Campbellton.

5–G In southeast face—16 inches below top—of northeast concrete abutment of plate-girder bridge on Intercolonial railway, at mileage 91·5 from Campbellton.

6–G In southeast face—15 inches below top—of northeast concrete abutment of Intercolonial railway bridge over Grand river at mileage 85·4 from Campbellton.

7–G In concrete bench-mark pier, 30 feet northwest of Intercolonial railway track, 2·4 miles southwest of Jardine Brook station and 120 feet northeast of mile-post 80 from Campbellton — on top of a small knoll immediately southwest of Hammond siding.

8–G In southeast face—20 inches below top—of southwest concrete abutment of Intercolonial railway bridge over Jardine brook, 2·4 miles northeast of Jardine Brook station.

9–G In south face of exposed rock surface, 16 feet southeast of Intercolonial railway track, ½ mile southwest of Hazen and at fifth telegraph pole southwest of mile-post 72 from Campbellton.

10–G In southeast face—19 inches below top—of southwest concrete abutment of plate-girder bridge on Intercolonial railway, 3 miles northeast of Anderson and at mileage 66·6 from Campbellton.

11–G In southeast side of rock cut on Intercolonial railway—near centre of cut—550 feet southwest of a small wooden culvert in a deep fill, 5¼ miles northeast of Anderson and at mileage 64·3 from Campbellton.

12–G In concrete bench-mark pier, 34 feet southeast of Intercolonial railway track, 515 feet northeast of mile-post 56 from Campbellton and 70 feet northeast of easterly switch of the Y, about 1¾ miles southwest of Kedgwick.

13–G In south face of boulder, 25 feet northwest of Intercolonial railway track, 2½ miles northeast of Kedgwick and 50 feet northeast of mile-post 52 from Campbellton.

14–G In southeast face—19 inches below top—of northeast concrete abutment of small bridge on Intercolonial railway, 4½ miles northeast of Kedgwick and at mileage 49·6 from Campbellton.

15–G In concrete bench-mark pier, 38 feet northwest of Intercolonial railway track, 12½ miles northeast of Kedgwick and 157 feet northeast of mile-post 42 from Campbellton.

16–G In southeast face—16 inches below top—of southwest concrete abutment of plate-girder bridge over Grog brook, at mileage 34·8 from Campbellton.

17–G In southeast face—17 inches below top—of southwest concrete abutment of plate-girder bridge over Grog brook, at mileage 31·8 from Campbellton.

18–G In southeast face—16 inches below top—of southwest concrete abutment of plate-girder bridge over Grog brook, at second telegraph pole southwest of mile-post 29 from Campbellton.

19–G In southeast face—18 inches below top—of southwest concrete abutment of plate-girder bridge over Grog brook, at mile-post 27 from Campbellton.

20–G In south face of exposed rock surface, 33 feet northwest of Intercolonial railway track and 150 feet southwest of mile-post 24 from Campbellton. This is about the centre of a high rocky bank facing the track at a point where Grog brook runs close beside the track.

21–G In northwest end of southwest face of concrete retaining wall behind northeast abutment—3 feet 6 inches above bridge-seat—of Intercolonial railway bridge over Upsalquitch river, immediately northeast of Upsalquitch.

22–G In concrete bench-mark pier, 33 feet northwest of Intercolonial railway track, 950 feet northeast of a small timber culvert and 190 feet northeast of mile-post 11 from Campbellton.

23–G In northwest face of concrete retaining wall behind southwest abutment—9 inches above bridge-seat—of plate-girder bridge over Christopher brook, at mileage 7·2 from Campbellton.

24–G In east face of east concrete wall of northerly (or smaller) gate chamber of Intercolonial railway reservoir, 2 miles from Campbellton—on the line to St. Leonard. The bench-mark is 8 inches below top of concrete, 9 feet south (or in rear) of crest of weir and 11 feet 6 inches north of northerly wall of main gate chamber.

25–G In water-table course of stonework, in front (or north) wall of Intercolonial station-house at Campbellton, 16 feet from northwest corner.

26–G In north stone foundation wall of Campbellton post-office, 3 feet below brickwork and 5 feet to the right of the letter-drop.

BENCH-MARKS BETWEEN McGIVNEY JUNCTION AND CHATHAM, N.B., VIA INTERCOLONIAL RAILWAY.

Note.—These descriptions are written with the assumption that the railway runs in a northeasterly direction from McGivney Junction to Chatham.

31–G In southeast end of southwest face of concrete retaining wall behind northeast abutment—21 inches above bridge-seat—of plate-girder bridge on Intercolonial railway, 4½ miles northeast of McGivney Junction and at mileage 70·7 from Derby Junction.

32–G In northwest side—1 foot below rail level—of rock cut on Intercolonial railway, 30 feet southwest of a railway bench-mark, painted white (on opposite side of cut), 1·6 miles southwest of Boiestown and 510 feet southwest of mile-post 64 from Derby Junction.

33–G In southeast face—16 inches below top and 34 inches back from southwest face—of concrete retaining wall behind northeast abutment of long plate-girder bridge on Intercolonial railway, 2,100 feet northeast of Boiestown.

34–G In concrete bench-mark pier, 8 feet southeast of northwest line of Intercolonial railway right-of-way, 120 feet southwest of a private crossing and 770 feet northeast of mile-post 56 from Derby Junction.

35–G In southeast face-wall of concrete tile culvert under Intercolonial railway, 540 feet northeast of Carroll flag-station.

36–G In northwest face of exposed rock surface, 11 feet southeast of centre line of Intercolonial railway track—25 inches below rail level—2·6 miles southwest of Doaktown and 78 feet southwest of mile-post 49 from Derby Junction.

37–G In southeast end of southwest face of stone and concrete retaining wall behind northeast abutment—30 inches above bridge-seat—of Intercolonial railway bridge over Southwest Miramichi river, ¾ mile northeast of Doaktown.

38–G In centre of northwest face of cap-stone on northwest end of small square culvert under Intercolonial railway, ¾ mile northeast of Blissfield flag-station and 3,000 feet northeast of mile-post 42 from Derby Junction.

39–G In northwest face-wall of concrete tile culvert under Intercolonial railway, 2,250 feet southwest of mile-post 39 from Derby Junction.

40–G In concrete bench-mark pier, 7 feet southeast of northwest line of Intercolonial railway right-of-way, ¼ mile southwest of Upper Blackville and 90 feet southwest of mile-post 32 from Derby Junction.

41–G In southeast face-wall of concrete tile culvert under Intercolonial railway, 3¾ miles southwest of Blackville and 400 feet northeast of mile-post 26 from Derby Junction.

42–G In southwest face of coping on southeast end of concrete arch culvert under Intercolonial railway, 1¾ miles southwest of Blackville and 120 feet northeast of mile-post 24 from Derby Junction.

43–G In southeast end of northeast face of concrete retaining wall behind southwest abutment of plate-girder bridge on Intercolonial railway, 1¼ miles northeast of Blackville and 400 feet northeast of mile-post 21 from Derby Junction.

44–G In southeast face of southeast face-wall of concrete tile culvert under Intercolonial railway, 230 feet northeast of a diagonal highway crossing and 2,500 feet southwest of mile-post 16 from Derby Junction.

45–G In west face of concrete retaining wall behind north abutment—30 inches above bridge-seat—of steel highway bridge over Southwest Miramichi river at Quarryville.

46–G In first course of stonework above timber-seat, in northwest face of southwest abutment of open culvert under Intercolonial railway, 550 feet southwest of mile-post 8 from Derby Junction.

47–G In first course of stonework below timber-seat, in northwest face of northeast abutment of open culvert under Intercolonial railway, at a private crossing, ½ mile northeast of Millerton and 170 feet southwest of mile-post 4 from Derby Junction.

47–G–2 In concrete bench-mark pier at Nelson Junction, 3 feet east of west line of right-of-way of Intercolonial railway (main line), 43 feet south of a farm crossing and 1,420 feet south of south end of bridge over Southwest Miramichi river.

48–G In northwest face of small square concrete culvert under Intercolonial railway, 1½ miles northeast of Nelson and 2,200 feet northeast of mile-post 4 from Nelson Junction.

49–G In water-table course of stonework, in rear (or south) wall of Intercolonial station-house at Chatham, in third stone from southwest corner of building.

BENCH-MARKS BETWEEN ST. ANSELME AND LEVIS, QUE., VIA NATIONAL TRANSCONTINENTAL RAILWAY.

Note.—These levels were carried along the National Transcontinental railway to the overhead crossing of the Intercolonial railway, about 1½ miles northeast of Chaudiere Junction and thence along the Intercolonial railway to Levis, closing on bench-mark 222-B.

250–B In south face of coping on south end of concrete tile culvert under National Transcontinental railway—at the west side of a highway crossing—1¾ miles west of St. Anselme and at mileage 81·1 from Monk.

251–B In west end of south face of concrete coping on south end of concrete arch culvert under National Transcontinental railway, 1 mile east of St. Isidore and at mileage 84·4 from Monk.

252–B In east end of north face of concrete coping on north end of iron pipe culvert under National Transcontinental railway, 1¾ miles west of St. Isidore and at mileage 87·2 from Monk.

253–B In north end of east face of concrete coping on east end of iron pipe culvert under National Transcontinental railway, at mileage 89·5 from Monk and midway between two private crossings 100 yards apart.

254–B In west sloping face—8 inches below top—of concrete retaining wall behind north abutment of plate-girder bridge on National Transcontinental railway, ½ mile north of Beaudet and at mileage 91·9 from Monk.

255–B In west face of flat boulder projecting slightly above ground, 20 feet west of National Transcontinental railway track, 70 feet north of a private crossing and between sixth and seventh telegraph poles south of mile-post 94 from Monk.

256–B In west face of concrete coping on north end of concrete arch culvert under National Transcontinental railway, 3 miles east of Diamond Junction and at mile-post 98 from Monk.

257–B In north end of east concrete foundation wall of signal tower at Diamond Junction—the crossing of National Transcontinental railway and Intercolonial railway cut-off.

258–B Destroyed.

259–B In east end of north face of concrete retaining wall behind north abutment of subway by which main road to Levis passes under National Transcontinental railway, 600 feet south of south abutment of Quebec bridge.

222–B In stone water-table course of south foundation wall—3 feet 6 inches west of main doorway—of power station of Dussault and Powers, on St. Laurent street, Levis.

BENCH-MARKS BETWEEN COOKSHIRE, QUE., AND BEECHER FALLS, VERMONT, VIA MAINE CENTRAL RAILROAD.

551–B In second course of stonework below top, in east face of south abutment of open culvert under Maine Central railroad, 3¾ miles south of Cookshire and 1,340 feet south of mile-post 21 from Lime Ridge.

552–B In east concrete foundation wall—2 feet below sheeting and 3 feet from southeast corner—of Mohawk Dairy company's building at Sawyerville.

553–B In first course of stonework below bridge-seat, in west face of south abutment of plate-girder bridge on Maine Central railroad, 2¼ miles south of Sawyerville and 1,700 feet north of mile-post 27 from Lime Ridge.

554–B In east face of large boulder, 20 feet east of Maine Central railroad track, 160 feet south of a wooden culvert, 2 miles south of St. Isidore and 780 feet south of mile-post 33 from Lime Ridge.

555–B In concrete bench-mark pier, 4 feet west of east line of Maine Central railroad right-of-way, ½ mile south of St. Malo and 720 feet north of mile-post 36 from Lime Ridge.

556–B In second course of stonework above bridge-seat, in east end of south face of retaining wall behind north abutment of Maine Central railroad bridge over east branch of Hall stream, 3 miles south of Malvina.

557–B In west face—2 feet 6 inches below top—of rock exposure lying along east right-of-way fence of Maine Central railroad, 615 feet south of a wooden culvert, ½ mile south of Paquette and 2,130 feet north of mile-post 46 from Lime Ridge.

558–B In first course of stonework above bridge-seat, in east face of northeast retaining wall of Maine Central railroad bridge over middle branch of Hall stream, 1 mile north of East Hereford and 130 feet north of mile-post 48 from Lime Ridge.

559–B In west end of south face of stone retaining wall behind north abutment of Maine Central railroad bridge over west branch of Hall stream, 1,000 feet north of East Hereford station.

560–B In second course below top, in west face of square stone culvert under Maine Central railroad, 1 mile north of Comin Mills station and 660 feet north of mile-post 52 from Lime Ridge.

561–B In south face of large mass of rock which just fills the space between the track and the west right-of-way fence of Maine Central railroad, ½ mile north of Comin Mills station and immediately south of Frank Rowell's residence. The bench-mark is about 1 foot above ground surface and near centre of southerly face of rock.

562–B In east side of stone boundary monument No. 519–A, situated in the door-yard of Chouinard's "line house" at the international boundary—immediately west of Maine Central railroad and ½ mile south of Comin Mills station.

BENCH-MARKS BETWEEN SUDBURY, ONT., AND SAULT STE. MARIE, MICH., VIA CANADIAN PACIFIC RAILWAY.

567-A In third course of stonework above concrete sidewalk, in south face of Durham street entrance to Sudbury post-office, 21 feet from southwest corner of building.

568 In north face of small square concrete culvert under Canadian Pacific railway, at mileage 1·9 from Sudbury.

569 In south face of exposed rock surface, 6 feet north of Canadian Pacific railway track and at eleventh telegraph pole west of mile-post 6 from Sudbury.

570 In second course of stonework below top, in southeast face of southeast wing-wall of large stone arch culvert under Canadian Pacific railway, 2 miles east of Naughton and at mileage 9·3 from Sudbury.

571 In south side of short deep rock cut on Canadian Pacific railway—50 feet from west end of cut—1⅓ miles west of Naughton and at thirteenth telegraph pole east of mile-post 13 from Sudbury.

572 In south face of central supporting wall of double concrete culvert under Canadian Pacific railway, 2¾ miles west of Naughton and at mile-post 14 from Sudbury.

573 In north face—16 inches below top—of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over Vermilion river, 2¼ miles east of Whitefish.

574 In south end of west face of concrete retaining wall behind east abutment—3 feet above bridge-seat—of plate-girder bridge on Canadian Pacific railway, 1¼ miles east of Whitefish and at mileage 17·14 from Sudbury.

575 In north end of west face of concrete retaining wall behind east abutment—2 feet above bridge-seat—of plate-girder bridge on Canadian Pacific railway, 1¾ miles west of Whitefish and at mileage 20·13 from Sudbury.

576 In west end of north face of concrete arch culvert under Canadian Pacific railway, 1½ miles west of Victoria Mine and at mileage 23·4 from Sudbury.

577 In east face of north face-wall of square concrete culvert under Canadian Pacific railway, 1 mile west of Worthington and at mileage 26·2 from Sudbury.

578 In north face—10 inches below top—of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 2¾ miles east of Nairn and at mileage 29·8 from Sudbury.

579 In east face of northeast sloping retaining wall—22 inches below top of north face-wall—of stone and concrete culvert under Canadian Pacific railway, ¼ mile east of Nairn.

580 In north end of west face of concrete retaining wall behind east abutment—27 inches above bridge-seat—of bridge by which Canadian Pacific railway passes over Algoma Eastern railway, ¾ mile west of Nairn.

581 In second course of stonework above bridge-seat, in south face—22 inches from west end—of southeast retaining wall of Canadian Pacific railway bridge over Spanish river, 5 miles west of Nairn.

582 In north face of concrete footing of highway bridge over Canadian Pacific railway at mileage 38·8 from Sudbury, 150 feet east of east switch of Lorne passing-track. The footing referred to is the first one south of the track and is at the west side of the bridge.

583 In south face—1 foot above rail level—of large mass of rock, 10 feet north of Canadian Pacific railway track and 1 mile west of Espanola.

584 In concrete bench-mark pier, 6 feet south of north line of Canadian Pacific railway right-of-way, 3¼ miles east of Webbwood and exactly opposite a whistle-post between third and fourth telegraph poles east of mile-post 45 from Sudbury.

585 In south concrete foundation wall (facing main line track) of Canadian Pacific roundhouse at Webbwood, 1 foot below brickwork and in first pilaster from southeast corner.

586 In second course of stonework above bridge-seat, in south end of west face of retaining wall behind east abutment of Canadian Pacific railway bridge over Birch brook, 1 mile west of Webbwood.

587 In north face of concrete footing of highway bridge over Canadian Pacific railway, 2 miles west of Webbwood. The footing referred to is the first one south of the track and is at the west side of the bridge.

588 In second course of stonework below top, in southeast face of southeast wing-wall of stone arch culvert under Canadian Pacific railway, 200 feet east of east switch of Hallam passing-track and at mileage 4·8 from Webbwood.

589 In north face-wall—immediately above northeast wing-wall—of concrete arch culvert under Canadian Pacific railway, 1¾ miles east of Massey and at mileage 8·53 from Webbwood.

590 In third course of stonework above bridge-seat, in north end of west face of retaining wall behind east abutment of Canadian Pacific railway bridge over River aux Sables, immediately east of Massey.

591 In east end of north face of square concrete culvert under Canadian Pacific railway, 1¾ miles west of Massey and at mile-post 12 from Webbwood.

592 In north end of west face of concrete retaining wall behind east abutment—3 feet above bridge-seat—of plate-girder bridge on Canadian Pacific railway, 2¾ miles east of Walford and at mileage 15·46 from Webbwood.

593 In centre of north face of square concrete culvert under Canadian Pacific railway, 1¼ miles east of Walford and at mileage 16·83 from Webbwood.

594 In north face-wall—immediately above northeast wing-wall—of square concrete culvert under Canadian Pacific railway, 1¾ miles east of Spanish and at mileage 21·6 from Webbwood.

595 In south face-wall—immediately above southwest wing-wall—of square concrete culvert under Canadian Pacific railway, ½ mile west of Spanish.

596 In north face of exposed rock surface, 15 feet south of Canadian Pacific railway track and at sixth telegraph pole east of mile-post 27 from Webbwood. The bench-mark is near the centre of the rock exposure and directly below an outcrop of quartz.

597 In south face-wall—immediately above southwest wing-wall—of square concrete culvert under Canadian Pacific railway, 1½ miles west of Cutler and at mileage 30·8 from Webbwood.

598 In west face of concrete retaining wall behind east abutment—3 feet above bridge-seat and 4 feet from north end of retaining wall—of Canadian Pacific railway bridge over Serpent river, at mileage 34·7 from Webbwood.

599 In second course of stonework below top, in west end of south face of southwest retaining wall of large square culvert under Canadian Pacific railway, 2¾ miles east of Spragge, 200 feet east of a private crossing and at mileage 36·4 from Webbwood.

600 In south end of east face of concrete retaining wall behind west abutment—2 feet above bridge-seat—of bridge on Canadian Pacific railway, 800 feet west of Spragge station.

601 In concrete bench-mark pier, 6 feet south of north line of Canadian Pacific railway right-of-way, at seventeenth telegraph pole west of mile-post 41 from Webbwood and 120 feet west of McFerson east mileboard.

602 In south face—10 inches below top—of concrete retaining wall behind west abutment of Canadian Pacific railway bridge over Lauzon river, immediately east of Algoma.

603 In south face of large boulder, 10 feet south of north line of Canadian Pacific railway right-of-way and 75 feet west of mile-post 51 from Webbwood.

604 In first course of stonework above bridge-seat, in south end of west face of retaining wall behind east abutment of Canadian Pacific railway bridge over Blind river, immediately west of Blind River station.

605 In second course of stonework below brickwork, in north wall of Blind River town-hall, 7 feet 3 inches from northwest corner.

606 In north end of west face of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 2 miles west of Blind River station and at mileage 56·3 from Webbwood.

607 In first course of stonework above plate-girder seat, in north end of east face of stone pier at east end of steel truss span in Canadian Pacific railway bridge over Mississagi river, 4 miles west of Blind River station.

608 In north face-wall—immediately above northeast wing-wall—of square concrete culvert under Canadian Pacific railway, 2½ miles east of Dean Lake station and at mile-post 62 from Webbwood.

609 In south side of rock cut on Canadian Pacific railway—near east end of cut—at mile-post 65 from Webbwood. This is the first rock cut west of Dean Lake station.

610 In north end of west face of east abutment wall of square concrete culvert under Canadian Pacific railway, 3½ miles west of Dean Lake station and at mileage 67·9 from Webbwood.

611 In south side—50 feet from west end—of rock-cut on Canadian Pacific railway at mileage 71·5 from Webbwood.

612 In north side of rock cut on Canadian Pacific railway, 600 feet west of westerly switch at Dayton and 90 feet from mile-post 74 from Webbwood.

613 In south face of exposed rock surface, 70 feet north of Canadian Pacific railway track and north of north line of right-of-way—opposite mile-post 77 from Webbwood.

614 In east face of north face-wall of concrete arch culvert under Canadian Pacific railway at mileage 79·8 from Webbwood.

615 In east face of coping on north end of concrete arch culvert under Canadian Pacific railway, 1½ miles west of Thessalon and at fifth telegraph pole west of mile-post 84 from Webbwood.

616 In west face of concrete retaining wall behind east abutment (at south side of southerly girder) of Canadian Pacific railway bridge over Thessalon river, 2½ miles west of Thessalon and immediately west of westerly switch of Sherwood passing-track.

616–A In west face of coping on north end of concrete arch culvert under Canadian Pacific railway, between third and fourth telegraph poles east of mile-post 89 from Webbwood.

617 In east end of north face of concrete coping on north end of concrete arch culvert under Canadian Pacific railway, at mileage 91·3 from Webbwood.

618 In concrete bench-mark pier, 4 feet south of north line of Canadian Pacific railway right-of-way, 1¾ miles east of Bruce and at sixth telegraph pole west of mile-post 93 from Webbwood.

619 In east end of north face of square concrete culvert under Canadian Pacific railway about 700 feet east of Bruce station.

620 In north face of square concrete culvert under Canadian Pacific railway, at eleventh telegraph pole east of mile-post 100 from Webbwood.

621 In north face of concrete retaining wall behind east abutment—immediately above northeast wing-wall—of plate-girder bridge on Canadian Pacific railway, 1¾ miles east of Desbarats.

622 In north face of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over Walker river, immediately east of Desbarats.

623 In north side of rock cut on Canadian Pacific railway—near west end of cut—at fifteenth telegraph pole east of mile-post 107 from Webbwood.

624 In north face of granite boulder, 80 feet north of Canadian Pacific railway track and directly opposite second telegraph pole west of Isbester station.

625 In south end of east face—3 feet below top—of concrete retaining wall behind west abutment of Canadian Pacific railway bridge over Bar river, immediately west of Bar River flag-station.

626 In east face—6 feet from north end—of concrete head-wall at east end of circular culvert at the main corners of the village of Echo Bay; the culvert lies along the south line of the street to Ekoba station.

627 In south face of concrete retaining wall behind west abutment of Canadian Pacific railway bridge over the outlet of Echo bay, ¾ mile west of Ekoba.

628 In east end of north face of square concrete culvert under Canadian Pacific railway, 2½ miles west of Ekoba and at twelfth telegraph pole east of mile-post 119 from Webbwood.

629 In north face—4 feet below top—of northeast stone retaining wall of Canadian Pacific railway bridge over Garden river, ½ mile east of Garden station.

630 In north end of west face of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over Root river, 5½ miles east of Sault Ste. Marie, Ont., and at mileage 125·5 from Webbwood.

631 In east end—2 feet below top—of north face-wall of concrete culvert under a highway, 70 feet south of Canadian Pacific railway track, 2 miles east of Sault Ste. Marie, Ont., and opposite second telegraph pole east of mile-post 129 from Webbwood.

632 In second course of stonework below water-table course, in rear (or north) wall—10 feet from northeast corner—of post-office at Sault Ste. Marie, Ont.

633 In east stone foundation wall—3 feet 4 inches below brickwork and 4 feet 8 inches from southeast corner—of Carnegie Library at Sault Ste. Marie, Ont.

634 In front (or south) wall of Steelton post-office, 6 feet 6 inches below brickwork and 14 feet from southeast corner of building.

635 In third course of stonework below top, in south end of east face of southeast retaining wall of Canadian Pacific railway (swing) bridge over Canadian ship canal, between Sault Ste. Marie, Ont., and Sault Ste. Marie, Mich.

636 In west concrete foundation wall of Government power station, situated immediately north of the new ship canal at Sault Ste. Marie, Mich. The bench-mark is 19 inches below water-table and 4 feet 7 inches north of the doorway by which a spur line of railway enters the building.

BENCH-MARKS BETWEEN FORT FRANCES AND PORT ARTHUR, ONT., VIA CANADIAN NORTHERN RAILWAY.

31–E In south face of exposed rock surface, 3 feet south of north line of Canadian Northern railway right-of-way, directly in line with west wall of a log house on north side of railway, 2¾ miles east of Fort Frances and at eleventh telegraph pole east of mile-post 229 from Port Arthur.

32–E In north side of rock cut on Canadian Northern railway, 710 feet west of west end of a trestle over a part of Rainy lake, at the second telegraph pole east of a point of rock which separates the present right-of-way from the abandoned one lying to the south, and at mileage 224·5 from Port Arthur.

33–E In north face of exposed rock surface, 40 feet south of Canadian Northern railway track, 1,500 feet west of west end of a trestle bridge over a part of Rainy lake and 1,850 feet west of mile-post 221 from Port Arthur.

34–E In south face of exposed rock surface, 30 feet north of Canadian Northern railway track, 460 feet east of a timber bridge and 15 feet east of mile-post 218 from Port Arthur.

35–E In southwest face of exposed rock surface, 20 feet north of Canadian Northern railway track, 250 feet east of a wooden culvert, 20 feet east of mile-post 214 from Port Arthur and at western end of a rocky hill.

36–E In east face of ledge of rock, 33 feet north of Canadian Northern railway track, at first telegraph pole east of mile-post 211 from Port Arthur and opposite sign "Draw-span 1,200 feet"—west of bascule bridge over a channel of Rainy lake.

37–E In north face of flat mass of rock, 36 feet south of Canadian Northern railway main line, 730 feet west of Bear Pass station and 140 feet east of west switch of passing-track.

38–E In south face of flat boulder about 8 feet square and 2 feet high, 60 feet north of Canadian Northern railway track, 430 feet east of a timber bridge over a part of Rainy lake and at mileage 203·6 from Port Arthur.

39–E In north face of exposed rock surface, 30 feet south of Canadian Northern railway track, 630 feet west of a timber bridge and between seventh and eighth telegraph poles west of mile-post 199 from Port Arthur.

40–E In north face of exposed rock surface, 10 feet south of Canadian Northern railway track, opposite a whistle-post for westbound trains, 670 feet east of Olive west mile-board and 110 feet east of mile-post 196 from Port Arthur.

41–E In south face—near centre—of hill of rock about 400 feet long, and 50 feet north of Canadian Northern railway track; this is about $1\frac{3}{4}$ miles west of Mine Centre and between seventh and eighth telegraph poles west of mile-post 192 from Port Arthur.

42–E In northwest face of large mass of rock, 80 feet south of Canadian Northern railway main line, 200 feet east of Mine Centre station-house and 52 feet northeast of northeast corner of general store opposite the station.

43–E In concrete bench-mark pier, 42 feet south of Canadian Northern railway track, 275 feet west of Turtle west mile-board and 145 feet east of mile-post 188 from Port Arthur.

44–E In north face of sloping rock surface, 90 feet south of Canadian Northern railway track and at twelfth telegraph pole east of mile-post 185 from Port Arthur—immediately west of a shallow earth cut which is immediately west of a rock cut.

45–E In north face of sloping rock surface, 70 feet south of Canadian Northern railway main line—within the limits of Glenorchy passing-track—and between fourth and fifth telegraph poles east of mile-post 181 from Port Arthur.

46–E In south face of large flat rock exposure, 55 feet north of Canadian Northern railway track, 200 feet east of Mathieu west mile-board and 1,330 feet west of mile-post 177 from Port Arthur.

47–E In north face of exposed rock surface, 30 feet south of Canadian Northern railway track—slightly below rail level—2,060 feet west of bridge over Seine river and at third telegraph pole west of mile-post 174 from Port Arthur.

48-E In north face of exposed rock surface—about 7 feet in length and 2 feet in height—60 feet south of Canadian Northern railway main line, 1,200 feet east of La Seine station and at second telegraph pole west of mile-post 171 from Port Arthur.

49-E In west face of exposed rock surface—50 feet north of Canadian Northern railway track and about at rail level—at east end of a long deep fill, and at ninth telegraph pole east of mile-post 167 from Port Arthur.

50-E In south face of large mass of rock, 50 feet north of Canadian Northern railway track, 50 feet east of a whistle-post for westbound trains and at twelfth telegraph pole east of mile-post 163 from Port Arthur.

51-E In south side—at extreme west end—of long deep rock cut on Canadian Northern railway, 1,530 feet east of Banning station.

52-E In east face of exposed rock surface, 100 feet south of Canadian Northern railway track and about at rail level, between second and third telegraph poles west of mile-post 156 from Port Arthur.

53-E In north face of exposed rock surface, 100 feet south of Canadian Northern railway track and between second and third telegraph poles east of mile-post 152 from Port Arthur—½ mile east of east switch of Elizabeth passing-track.

54-E In south side of rock cut on Canadian Northern railway—at extreme east end of cut—at fourth telegraph pole east of mile-post 147 from Port Arthur.

55-E In north side of rock exposure about 40 feet long and 8 feet south of Canadian Northern railway track—in centre of shallow earth cut—between eighth and ninth telegraph poles west of Atikokan west mile-board and at mileage 143·8 from Port Arthur.

56-E In north end of west face of concrete retaining wall behind east abutment of Canadian Northern railway bridge over Atikokan river, 2½ miles east of Atikokan and at mileage 139·9 from Port Arthur.

57-E In south face—60 feet from west end—of high rocky bank immediately north of Canadian Northern railway track, 140 feet west of east switch of Olcott passing-track and between fifth and sixth telegraph poles east of mile-post 137 from Port Arthur.

58-E In south side of rock cut on Canadian Northern railway—200 feet from east end of cut—280 feet west of Hematite west mile-board and between second and third telegraph poles east of mile-post 133 from Port Arthur.

59-E In north side of long rock cut on Canadian Northern railway—150 feet from east end of cut—between second and third telegraph poles east of mile-post 128 from Port Arthur.

60-E In west face of exposed rock surface, 10 feet north of Canadian Northern railway track—at west end of a rock cut—2½ miles west of Kawene and at mile-post 124 from Port Arthur.

61-E In north face—near west end—of exposed rock surface about 70 feet long and 10 feet south of Canadian Northern railway track, ½ mile east of Kawene and 220 feet west of mile-post 121 from Port Arthur.

62-E In north side of rock cut on Canadian Northern railway—40 feet from east end of cut—at west end of a fill extending across a small bay of Mink lake, and at mile-post 117 from Port Arthur.

63-E In south side of rock cut on Canadian Northern railway—50 feet from west end of cut—at mile-post 113 from Port Arthur, on a very sharp curve.

64-E In south side of rock cut on Canadian Northern railway—near centre of cut—1¾ miles west of Windigo and between first and second telegraph poles west of mile-post 108 from Port Arthur.

65-E In southwest face of exposed rock surface, 70 feet north of Canadian Northern railway track, 2¼ miles east of Windigo and between second and third telegraph poles east of mile-post 104 from Port Arthur.

66–E In north face of exposed rock surface at west end of a rock cut, 10 feet south of Canadian Northern railway track, 2¾ miles west of Huronian and 64 feet east of mile-post 100 from Port Arthur.

67–E In concrete bench-mark pier, 32 feet north of Canadian Northern railway track, 210 feet west of Huronian east mile-board and 235 feet east of mile-post 96 from Port Arthur.

68–E In north face of exposed rock surface, 70 feet south of Canadian Northern railway track, ½ mile west of Keego section-house and 115 feet west of mile-post 92 from Port Arthur.

69–E In south side of large rock cut on Canadian Northern railway—80 feet from west end of cut—at sixth telegraph pole east of mile-post 89 from Port Arthur.

70–E In north face of exposed rock surface in a bank of earth, 20 feet south of Canadian Northern railway track, 580 feet east of a bridge over a creek and 250 feet east of mile-post 85 from Port Arthur.

71–E In west face of northeast concrete retaining wall—6 inches above bridge-seat and 10 inches from north end of retaining wall—of Canadian Northern railway bridge over Kashabowi river, 1½ miles east of Kashabowi.

72–E In north face of large boulder, 60 feet south of Canadian Northern railway track, 500 feet west of a section-house and directly behind a hand-car house—opposite mile-post 78 from Port Arthur.

73–E In south side of rock cut on Canadian Northern railway—near centre of cut—between third and fourth telegraph poles east of mile-post 75 from Port Arthur.

74–E In north face of large boulder, 45 feet south of Canadian Northern railway track—facing a small lake—45 feet east of a spring flowing through a wooden culvert and between twelfth and thirteenth telegraph poles east of mile-post 71 from Port Arthur.

75–E In east face of flat boulder, 45 feet north of Canadian Northern railway track, 150 feet west of mile-post 63 from Port Arthur and just at eastern extremity of (lower) lake Shebandowan.

76–E In north face—14 inches below top—of concrete footing at northeast corner of coal chute at Mabella.

77–E In south face of exposed rock surface, 7 feet north of Canadian Northern railway track, 2¾ miles east of Mabella and 140 feet west of mile-post 56 from Port Arthur—immediately west of a deep cut through clay and shale.

78–E In east face of small boulder, 30 feet south of Canadian Northern railway track and 230 feet east of mile-post 51 from Port Arthur.

79–E In concrete bench-mark pier, 38 feet north of Canadian Northern railway track, 130 feet east of a wooden culvert and 6 feet west of first telegraph pole west of mile-post 47 from Port Arthur.

80–E In exposed rock surface, 10 feet south of Canadian Northern railway track—at west end of a very sharp curve—1¾ miles east of Mattawin and at second telegraph pole west of mile-post 43 from Port Arthur.

81–E In east face of northwest retaining wall of small concrete culvert under Canadian Northern railway, in a deep fill, 5½ miles east of Mattawin and at mileage 39·4 from Port Arthur.

82–E In north side of rock cut on Canadian Northern railway—near west end of cut—between eleventh and twelfth telegraph poles west of mile-post 35 from Port Arthur, and opposite a point on Canadian Pacific railway 260 feet west of Kaministikwia west mile-board—the two railways being side by side at this point.

83–E In north face—8 inches below top and 33 inches from east end—of concrete foundation of Canadian Northern railway water-tank, 300 feet east of Mokomon station.
NOTE.—The superstructure of this tank has been burned down and only the foundation remains.

84–E In south side of rock cut on Canadian Northern railway—near centre of cut—300 feet west of the head of a waterfall on Kaministikwia river, at third telegraph pole east of Hume west mile-board and at fifth telegraph pole west of mile-post 28 from Port Arthur.

85–E In west face of concrete retaining wall behind east abutment of Canadian Northern railway bridge over an unused headrace, 450 feet east of bridge over Kaministikwia river and 1 mile west of Kakabeka Falls station. The bench-mark is 4 feet 2 inches above bridge-seat, 7 feet south of north end of retaining wall and midway between north and south girders of bridge.

86–E In south end of west concrete foundation wall—21 inches below brickwork—of general store and post-office at Stanley—opposite the station.

87–E In west end of south concrete foundation wall—21 inches below brickwork—of English church at Slate River.

88–E In concrete bench-mark pier, 9 feet north of south line of Canadian Northern railway right-of-way and at eleventh telegraph pole east of mile-post 11 from Port Arthur.

89–E In south face of corner stone at southwest corner—first course above doorsills—of ward IV fire-hall at Westfort.

90–E In third course of stonework below brickwork, in south face of corner stone at southeast corner of one-story extension at south side of Fort William post-office.

91–E In eleventh course of stonework below brickwork, in east face of corner store at southeast corner of Fort William city-hall.

92–E In first course of stonework below brickwork, in north (or end) wall of Canadian Pacific station-house at Fort William, 7 feet 3 inches from pilaster at northwest corner.

93–E In second course of stonework below brickwork, in north end of front (or west) wall of Canadian Northern station-house, Port Arthur.

94–E In first course of stonework above concrete sidewalk, in south (or Arthur street) wall—6 feet 4 inches from southeast corner—of Prince Arthur hotel, Port Arthur.

95–E In south stone foundation wall of Port Arthur post-office, at the corner of Arthur street and Court street north. The bench-mark is 2 feet 6 inches below brickwork and in the first stone east of central basement window.

BENCH-MARKS BETWEEN STANLEY AND NORTH LAKE, ONT., VIA CANADIAN NORTHERN RAILWAY.

96–E In small boulder, 10 feet south of Canadian Northern railway track and between second and third telegraph poles west of bridge over Whitefish river, 5¼ miles west of Stanley.

97–E In southwest face of northwest concrete retaining wall—5 feet below bridge-seat—of highway bridge over Whitefish river, 570 feet south of Canadian Northern railway track at Hymer.

98–E In south side of rock cut on Canadian Northern railway—25 feet from east end of cut—130 feet east of bridge over Whitefish river 4 miles west of Hymer.

99–E In north face of flat boulder, 13 feet south of north line of Canadian Northern railway right-of-way and between sixth and seventh telegraph poles west of station at Silver Mountain.

100–E In south face of exposed rock surface, 18 feet north of Canadian Northern railway track, ¾ mile west of Whitefish and 25 feet west of mile-post 24 from Stanley.

101-E In south side of shallow rock cut on Canadian Northern railway, 5 miles west of Whitefish and at third telegraph pole west of mile-post 28 from Stanley.

102-E In concrete bench-mark pier, 25 feet south of Canadian Northern railway track, 100 feet west of east end of a borrow pit on north side of track, and between ninth and tenth telegraph poles west of mile-post 32 from Stanley.

103-E In south face of exposed rock surface, 20 feet north of Canadian Northern railway track and 120 feet west of mile-post 39 from Stanley.

104-E In south side of small rock cut on Canadian Northern railway—near east end of cut—5½ miles east of North Lake and at fifth telegraph pole east of mile-post 45 from Stanley.

105-E In north face of exposed rock surface, 7 feet south of Canadian Northern railway track—directly below large prominent boulder on top of bank—2½ miles east of North Lake and at fifth telegraph pole east of mile-post 48 from Stanley.

106-E In north face of concrete pier (built originally for astronomical observations), 55 feet south of Canadian Northern railway track and 100 feet west of North Lake station.

BENCH-MARKS BETWEEN WAINWRIGHT AND EDMONTON, ALTA., VIA GRAND TRUNK PACIFIC RAILWAY.

37-H In south face of southeast concrete retaining wall of Grand Trunk Pacific railway (steel trestle) viaduct over Battle river, 3 miles west of Fabyan. The bench-mark is in vertical face of retaining wall, 2 feet below bottom of sloping portion.

38-H In concrete foundation—3 inches below woodwork and 2 feet 6 inches to the left of the spout—of Grand Trunk Pacific water-tank, 2½ miles east of Irma.

39-H In north concrete foundation wall—4 inches below galvanized iron sheeting and 8 inches from northeast corner—of engine house of Alberta Co-operative Elevator company's elevator (local No. 89) at Irma.

40-H In concrete bench-mark pier, 7 feet south of north line of Grand Trunk Pacific railway right-of-way, 130 feet west of west line of a highway crossing, 1 mile east of Jarrow and between second and third telegraph poles east of mile-post 691 from Winnipeg.

41-H In south face of small boulder, 57 feet south of north line of Grand Trunk Pacific railway right-of-way, 1½ miles west of Kinsella and 8 feet west of second telegraph pole west of mile-post 700 from Winnipeg (the fourth pole east of a highway crossing).

42-H In concrete foundation—3 inches below woodwork and 3 feet to the left of the spout—of Grand Trunk Pacific water-tank at Philips.

43-H In south concrete foundation wall—3 feet 7 inches below brickwork and 14 inches from southeast corner—of Viking public school.

44-H In concrete bench-mark pier, 5 feet south of north line of Grand Trunk Pacific railway right-of-way, 1 mile east of Nestor, 21 feet west of mile-post 717 from Winnipeg and 115 feet east of a whistle-post for west-bound trains.

45-H In south concrete foundation wall—2 inches below woodwork and 17 inches from southwest corner—of Security Elevator company's elevator at Bruce.

46–H In east concrete foundation wall—4 feet 6 inches below brickwork and 22 inches from southeast corner—of Holden public school.

47–H In west face of concrete steps at front entrance to Ryley public school. The bench-mark is 6 inches below top of top step and 15 inches south of south wall of building.

48–H In south face of concrete pier supporting lever for interlocking plant—at south side of Grand Trunk Pacific railway track—and at first semaphore west of diamond crossing of Canadian Northern railway, ¾ mile west of Ryley station.

49–H In concrete foundation—4 inches below woodwork and 40 inches to the right of the spout—of Grand Trunk Pacific water-tank, 1 mile east of Shonts.

50–H In rear (or north) concrete foundation wall—7 inches below woodwork and 30 feet from northeast corner—of Grand Trunk Pacific station-house at Tofield.

51–H In south concrete foundation wall—1 foot below galvanized iron sheeting and 1 foot from southeast corner—of town-hall and fire-station at Tofield.

52–H In concrete bench-mark pier, 55 feet south of north line of Grand Trunk Pacific railway right-of-way, 460 feet east of east end of a timber bridge and 23 feet east of second telegraph pole east of mile-post 760 from Winnipeg.

53–H In concrete foundation—4 inches below woodwork and 12 feet 6 inches to the right of the spout—of Grand Trunk Pacific water-tank at Cooking Lake.

54–H In concrete bench-mark pier, 9 feet south of north line of Grand Trunk Pacific railway right-of-way, 70 feet east of a farm crossing and 28 feet east of third telegraph pole east of mile-post 772 from Winnipeg.

55–H In east concrete foundation wall—3 inches below woodwork and 13 inches from northeast corner—of Grand Trunk Pacific railway section-house, at west end of passing-track at Ardrossan.

56–H In concrete bench-mark pier, 62 feet south of north line of Grand Trunk Pacific railway right-of-way, 108 feet east of a farm crossing, 6½ miles west of Ardrossan and 25 feet west of fifth telegraph pole west of mile-post 783 from Winnipeg.

57–H In west face of concrete retaining wall behind east abutment—3 feet 10 inches above bridge-seat and 4 feet 6 inches south of southerly girder—of Grand Trunk Pacific railway bridge over North Saskatchewan river, 6 miles east of Edmonton.

58–H In first course of sandstone above granite foundation wall, in north end of front (or east) wall of Edmonton court-house.

59–H In second course of stonework above concrete sidewalk, in west wall of Edmonton post-office, 4 feet south of south wall of clock tower.

60–H In east end of south face of concrete retaining wall behind north abutment of high-level bridge over North Saskatchewan river at Edmonton. The bench-mark is 4 feet below the rails of the street railway.

61–H In first course of stonework above ground, in west end of south wall of westerly wing of Provincial Parliament buildings at Edmonton. The bench-mark is 13 feet east of the three arches forming the western entrance to the buildings.

BENCH-MARKS BETWEEN CALGARY AND TOFIELD, ALTA., VIA GRAND TRUNK PACIFIC RAILWAY.

39–F In south end of west face of concrete retaining wall behind east abutment—9 inches above bridge-seat—of Grand Trunk Pacific railway bridge over Elbow river, ¾ mile east of Calgary city-hall.

40–F In north end of west face of concrete retaining wall behind east abutment of Grand Trunk Pacific railway bridge over Bow river, 3½ miles east of Calgary city-hall.

41–F In east concrete foundation wall—8 inches below brickwork and 17 inches from southeast corner—of Buckeye Machine company's shop, a large brick building immediately west of Grand Trunk Pacific railway and ½ mile north of Hubalta station.

42–F In concrete bench-mark pier, 7 feet east of west line of Grand Trunk Pacific railway right-of-way, 340 feet north of a timber subway and between first and second telegraph poles south of mile-post 186 from Tofield.

43–F In east end of south face of concrete retaining wall behind north abutment—20 inches above bridge-seat—of plate-girder bridge on Grand Trunk Pacific railway, 2 miles north of Delacour and at mileage 181·2 from Tofield.

44–F In north end of east face of square concrete culvert under Grand Trunk Pacific railway, ½ mile north of Kathyrn and at mileage 177·1 from Tofield.

45–F In centre of west face of square concrete culvert under Grand Trunk Pacific railway, at mileage 174·2 from Tofield.

46–F In centre of east face of square concrete culvert under Grand Trunk Pacific railway, 2½ miles south of Irricana and at mileage 171·1 from Tofield.

47–F In west face of concrete retaining wall behind south abutment of bridge by which Grand Trunk Pacific railway passes over Canadian Pacific railway, 2½ miles south of Beiseker. The bench-mark is 2 feet 9 inches below Grand Trunk Pacific rails.

48–F In south concrete foundation wall—2 inches below galvanized iron sheeting and 3 feet 6 inches from southwest corner—of Alberta Co-operative Elevator company's elevator (local No. 45) at Beiseker.

49–F In concrete bench-mark pier, 5 feet west of east line of Grand Trunk Pacific railway right-of-way, 100 feet south of a farm crossing and opposite third telegraph pole north of mile-post 155 from Tofield.

50–F In south concrete foundation wall—3 inches below galvanized iron sheeting and 8 inches from southwest corner—of Alberta-Pacific Grain company's elevator at Grainger.

51–F In west concrete foundation wall—19 inches below galvanized iron sheeting and 8 feet from southwest corner—of Alberta Co-operative Elevator company's elevator (local No. 48) at Swalwell.

52–F In west face of concrete footing—7 inches below woodwork and 40 inches to the right of the spout—of Grand Trunk Pacific water-tank, 1 mile north of Twining.

53–F In west concrete foundation wall—6 inches below galvanized iron sheeting and 2 feet from northwest corner—of engine house of Alberta-Pacific Grain company's elevator at Three Hills.

54–F In concrete bench-mark pier, 5 feet east of west line of Grand Trunk Pacific railway right-of-way, 3½ miles north of Three Hills and 12 feet north of mile-post 128 from Tofield.

55–F In west concrete foundation wall—2 feet below brickwork and 1 foot from southwest corner—of front (or westerly) section of Roman Catholic school at Trochu, ½ mile southeast of the station.

56–F In concrete bench-mark pier, 4 feet east of west line of Grand Trunk Pacific railway right-of-way, 15 feet south of a private crossing 1½ miles north of Huxley, and between third and fourth telegraph poles north of mile-post 113 from Tofield.

57–F In concrete bench-mark pier, 4 feet east of west line of Grand Trunk Pacific railway right-of-way, 200 feet south of a short deep clay cut, 4 miles north of Elnora and 60 feet south of mile-post 105 from Tofield.

58–F In west face of boulder at northwest corner—forming part of foundation—of J. W. Smith's general store at Lousana, 600 feet east of the station.

59–F In east concrete foundation wall—4 inches below galvanized iron sheeting and 9 inches from northeast corner—of engine house of Alberta Co-operative Elevator company's elevator (local No. 64) at Delburne.

60–F In concrete bench-mark pier, 3 feet east of west line of Grand Trunk Pacific railway right-of-way, at fourth telegraph pole north of a highway crossing and at second pole south of mile-post 85 from Tofield—1 mile south of bridge over Red Deer river.

61–F In southwest face of concrete footing of bridge by which Canadian Northern railway passes over Grand Trunk Pacific railway, ½ mile south of Grand Trunk Pacific station at Alix and 500 feet southwest of Canadian Northern station at Alix. The footing referred to is under a steel upright at north side of bridge and to the east of the Grand Trunk Pacific railway track.

62–F In west concrete foundation wall—12 inches below woodwork and 14 inches from northwest corner—of signal tower at diamond crossing of Grand Trunk Pacific and Canadian Pacific railways, ½ mile north of Grand Trunk Pacific station at Alix.

63–F In concrete foundation—10 inches below woodwork and 2 feet to the right of the spout—of Grand Trunk Pacific water-tank at Mirror.

64–F In concrete bench-mark pier, 4 feet east of west line of Grand Trunk Pacific railway right-of-way, 6 miles north of Mirror and at first telegraph pole south of mile-post 65 from Tofield.

65–F In west concrete foundation wall—21 inches below galvanized iron sheeting and 7 inches from northwest corner—of Alberta Co-operative Elevator company's elevator (local No. 67) at Bashaw.

66–F In south concrete foundation wall—7 inches below woodwork and 11 inches from southeast corner—of Strom Brothers' general store at Dorenlee, 500 feet northwest of the station.

67–F In north concrete foundation wall—5 inches below galvanized iron sheeting and 3 feet 8 inches from northeast corner—of Imperial Elevator and Lumber company's engine house at Ferintosh.

68–F In south concrete foundation wall—4 inches below galvanized iron sheeting and 2 feet from southwest corner—of Pioneer Grain company's elevator at New Norway.

69–F In concrete bench-mark pier, 4 feet west of east line of Grand Trunk Pacific railway right-of-way, at eighth telegraph pole south of south end of trestle bridge over Battle river and at seventh pole north of mile-post 34 from Tofield.

70–F In bevelled northwest corner—7 inches below top—of concrete foundation of signal tower at diamond crossing of Grand Trunk Pacific and Canadian Pacific railways, 800 feet north of Grand Trunk Pacific station at Camrose.

71–F In north wall of Camrose high school, in north face of concrete sill of fourth basement window from northeast corner of building.

72–F In northwest concrete foundation wall—3 inches below woodwork and 5 feet from west corner—of signal tower at diamond crossing of Grand Trunk Pacific and Canadian Northern railways, 2¼ miles north of Camrose.

73–F In west face of concrete footing—4 inches below woodwork and 3 feet 6 inches to the right of the spout—of Grand Trunk Pacific water-tank, ¾ mile south of Dinant.

74–F In concrete bench-mark pier, 4 feet east of west line of Grand Trunk Pacific railway right-of-way, 1 mile south of Kingman and 35 feet north of a private crossing at mile-post 13 from Tofield.

75–F In concrete bench-mark pier, 6 feet east of west line of Grand Trunk Pacific railway right-of-way and 150 feet south of south line of a highway crossing at mile-post 7 from Tofield.

76–F In west face of concrete footing—3 inches below woodwork and 3 feet 6 inches to the left of the spout—of Grand Trunk Pacific water-tank, 1¾ miles south of Tofield.

50–H In Grand Trunk Pacific station, Tofield—see line from Wainwright to Edmonton.

BENCH-MARKS BETWEEN CALGARY, ALTA., AND FIELD, B.C., VIA CANADIAN PACIFIC RAILWAY.

217–C In second course of stonework above concrete platform, in south end of west wall of Canadian Pacific station at Calgary—40 feet east of east wall of Palliser hotel.

218–C In south face of concrete retaining wall of subway by which Eighth street west passes under Canadian Pacific railway in Calgary. The wall referred to lies along the east side of the street, north of the railway; the bench-mark is 6 inches below top of concrete and 17 inches north of north railing of bridge.

219–C In first course of stonework below bridge-seat, in west face of west abutment of Canadian Pacific railway bridge over westerly channel of Bow river, at mileage 7·8 from Calgary. The bench-mark is directly in line with the southerly truss.

220–C In west end of south face of square concrete culvert under Canadian Pacific railway at mileage 12·3 from Calgary—at a gravel-washing plant.

221–C In east end of north face of square concrete culvert under Canadian Pacific railway at mileage 15·6 from Calgary.

222–C In south concrete foundation wall—2 feet 10 inches below brickwork and 2 feet from southeast corner—of front (or southerly) section of Cochrane public school.

223–C In south end of east face—8 inches below top—of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, ¾ mile west of Cochrane and at mileage 23·6 from Calgary.

224–C In north face—20 inches from west end—of concrete coping on northeast retaining wall of Canadian Pacific railway bridge over Bow river, 3 miles west of Cochrane and at mileage 25·7 from Calgary.

225–C In concrete bench-mark pier, 7 feet south of north line of Canadian Pacific railway right-of-way, ¾ mile east of Radnor and 1,315 feet west of mile-post 32 from Calgary.

226–C In east face of north face-wall of square concrete culvert under Canadian Pacific railway, 2 miles east of Morley and at twelfth telegraph pole east of mile-post 40 from Calgary.

227–C In concrete bench-mark pier, 5 feet south of north line of Canadian Pacific railway right-of-way, 50 feet west of mile-post 43 from Calgary and 135 feet west of Morley west mile-board.

228–C In east face of large flat boulder, 30 feet north of Canadian Pacific railway track and between second and third telegraph poles east of mile-post 50 from Calgary.

229–C In south face of west concrete abutment—20 inches below bridge-seat—of Canadian Pacific railway bridge over Kananaskis river, ½ mile east of Seebe and at mileage 51·9 from Calgary.

230–C In north face of west concrete abutment—20 inches below bridge-seat—of Canadian Pacific railway bridge over Bow river, 1 mile west of Seebe.

231–C In north end of west face of concrete retaining wall behind east abutment—3 feet above bridge-seat—of plate-girder bridge on Canadian Pacific railway, at east end of Exshaw passing-track.

232–C In west end of south face of concrete arch culvert under Canadian Pacific railway, 3½ miles west of Exshaw and at mileage 60·5 from Calgary.

233–C In west face of northeast retaining wall of square concrete culvert under Canadian Pacific railway at mileage 61·6 from Calgary.

234–C In east face—8 inches below top—of south face-wall of concrete arch culvert under Canadian Pacific railway, 1½ miles east of Canmore and at mileage 65·6 from Calgary.

235–C In east face of north face-wall of double concrete culvert under Canadian Pacific railway, 1,150 feet east of Canmore station.

236–C In east face of north face-wall of double concrete culvert under Canadian Pacific railway, 2½ miles west of Canmore and at mileage 69·6 from Calgary.

237–C In north end of west face of concrete retaining wall behind east abutment—31 inches above bridge-seat—of plate-girder bridge on Canadian Pacific railway, at mileage 73·1 from Calgary.

238–C In east face of south face-wall of triple concrete culvert under Canadian Pacific railway, 1 mile east of Anthracite and at mileage 76·2 from Calgary.

239–C In first course of stonework below bridge-seat, in south face of east abutment of steel truss bridge on Canadian Pacific railway, 1½ miles east of Bankhead and at mileage 78·3 from Calgary.

240–C In north end of west face of concrete retaining wall behind east abutment—21 inches above bridge-seat—of plate-girder bridge on Canadian Pacific railway, immediately west of Banff.

241–C In west wall of Banff public school, in west face of concrete sill of fifth basement window south of northerly entrance.

242–C In concrete bench-mark pier, 95 feet north of Canadian Pacific railway track, 1 mile west of Sawback and 110 feet west of mile-post 89 from Calgary—opposite a point where an inlet from the Bow river lies close beside the railway.

243–C In southeast face of southwest concrete retaining wall—17 inches above bridge-seat—of plate-girder bridge on Canadian Pacific railway, 2½ miles east of Mount Castle station and at mileage 96·3 from Calgary.

244–C In east end of south face of north concrete abutment of highway bridge over Bow river, 1¼ miles west of Mount Castle station and ¼ mile south of Canadian Pacific railway—at a point opposite mile-post 100 from Calgary.

245–C In east face of north face-wall of square concrete culvert under Canadian Pacific railway, 470 feet east of east switch at Eldon passing-track and at mileage 106·1 from Calgary.

246–C In north end of west face of concrete retaining wall behind east abutment—26 inches above bridge-seat—of Canadian Pacific railway bridge over Baker brook, at mileage 108·4 from Calgary.

247–C In west end of south face of double concrete culvert under Canadian Pacific railway, 3 miles east of Lake Louise station and at mileage 113·5 from Calgary.

248–C In second course of stonework above bridge-seat, in south end of east face of retaining wall behind west abutment of two-span plate-girder bridge on Canadian Pacific railway, ½ mile east of Lake Louise station.

249–C In first course of stonework above water-table course, in rear (or east) wall—8 feet 6 inches from southeast corner—of Canadian Pacific roundhouse at Lake Louise station.

250–C In north face of west concrete abutment—4 feet below bridge-seat—of Canadian Pacific railway bridge over Bath creek, 1½ miles west of Lake Louise station and at mileage 117·8 from Calgary.

251—C In south end of east face of conc ete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, at mileage 121·2 from Calgary.

252–C In north face of concrete base of interprovincial boundary monument between Alberta and British Columbia, 110 feet south of Canadian Pacific railway track at "The Great Divide"—immediately east of Stephen passing-track.

253–C In south end of east face of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, 200 feet west of Hector station.

254–C In north end of west face—11 inches below top—of concrete retaining wall behind west abutment of Canadian Pacific railway bridge over Kicking Horse river, 1 mile west of Hector and at mileage 125·9 from Calgary.

255–C In face of concrete head-wall at lower portal of "No. 1" spiral tunnel (the first tunnel west of Hector)—20 inches to the left of the entrance and 18 inches above rail level.

256–C In south end of east face—1 foot below top—of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over Kicking Horse river, at mileage 130·6 from Calgary—between "No. 1" and "No. 2" spiral tunnels. (It is assumed at this point that the railway runs in an easterly direction going towards Field).

257–C In west face of northeast concrete retaining wall—5 feet above bridge-seat—of three-span bridge over Kicking Horse river, 460 feet west of lower portal of "No. 2" spiral tunnel and at mileage 131·7 from Calgary.

258–C In north face of concrete lining of south wall of "No. 3" tunnel, 3½ miles east of Field and at mileage 133·2 from Calgary. The bench-mark is 22 inches from west (or lower) portal and 6 inches above rail level.

259–C In east face of north face-wall of square concrete culvert under Canadian Pacific railway, 1½ miles east of Field and at mileage 135·4 from Calgary.

260–C In north concrete wall of Canadian Pacific roundhouse at Field; the bench-mark is 2 feet 6 inches above ground and 10 feet from northeast corner of building or from entrance to first engine stall.

BENCH-MARKS BETWEEN VANCOUVER, B.C., AND BLAINE, WASH., VIA GREAT NORTHERN RAILWAY.

1–J In first course of stonework above concrete sidewalk, in west wall of front portico of Canadian Pacific station at Vancouver, 30 inches south of main front wall of building and 95 feet east of east line of Granville street.

2–J In first course of stonework above pavement (of lane running off Granville street), in north wall of Vancouver post-office, 38 inches from northeast corner.

3–J In second course of stonework below water-table course, in rear (or south) wall—4 feet from southeast corner of Carnegie public library, at corner of Main and Hastings streets, Vancouver.

4–J In water-table course of stonework, in east wall—26 feet from southeast corner—of fire-hall No. 1, at corner of Cordova street and Gore avenue, Vancouver.

5–J In southeast face—4 feet 6 inches below top—of concrete footing of bridge by which Broadway Drive passes over Great Northern railway about 2¼ miles southeast of Vancouver station. The footing referred to is under a steel upright at east side of bridge and on northeast side of railway.

6–J In south wall (facing Great Northern railway track) of Western Canada Power company's transformer station, a concrete building immediately east of diamond crossing of British Columbia Electric railway near Ardley. The bench-mark is in base of first concrete pilaster from southeast corner of building.

7–J In south face of west abutment-wall of square concrete culvert under Great Northern railway, 580 feet east of diamond crossing of British Columbia Electric railway near Ardley.

8–J In south face of concrete footing of Great Northern railway's northerly semaphore at Sapperton—120 feet north of a highway crossing.

9–J In south face of northeast concrete retaining wall of combined highway and railway bridge over Fraser river at New Westminster. The bench-mark is at the north end of the steel trestle approach carrying the highway, and is 13 feet from east face of north abutment and below the level of the bridge-seat.

10–J In south face of large block of granite at base of pilaster at southwest corner of New Westminster city-hall.

11–J In first course of stonework above water-table course, in west wall of New Westminster post-office, beneath second window from southwest corner.

12–J In first course of stonework below water-table course, in east wall of New Westminster court-house, 14 feet 6 inches from southeast corner. This is the northerly, or old section of the building, immediately north of the new section.

13–J In stone foundation of front (or south) wall of Canadian Pacific station-house at New Westminster, 3 feet 1 inch below brickwork and 4 feet 6 inches from southwest corner.

14–J In north face of large boulder immediately west of west line of Great Northern railway right-of-way, 200 feet north of mile-post 137 from Seattle and 20 feet south of a gate in right-of-way fence—at a diagonal highway crossing $\frac{3}{4}$ mile north of Townsend.

15–J In south face of boulder 20 feet east of Great Northern railway track, 630 feet north of an overhead (highway) bridge and 2 miles south of Townsend.

16–J In west face of large mass of rock on sea beach, 35 feet west of Great Northern railway track, about 2,700 feet south of mile-post 127 from Seattle and $\frac{3}{4}$ mile south of Crescent flag-station.

17–J In west face of north abutment—3 feet below top—of square concrete culvert under Great Northern railway, 720 feet north of Whiterock station.

18–J In west face of very large granite boulder—the "white rock"—on sea beach, $\frac{1}{4}$ mile south of Whiterock station.

19–J In concrete bench-mark pier at international boundary, 40 feet east of Great Northern railway track, 7 feet west of boundary monument No. 5, and $\frac{1}{2}$ mile north of Blaine station.

BENCH-MARKS BETWEEN COLEBROOK AND HUNTINGDON, B.C., VIA GREAT NORTHERN RAILWAY.

20–J In east stone foundation wall—5 feet below top of masonry and 10 feet from southeast corner—of municipal hall at Cloverdale.

21–J In south concrete wall of British Columbia Electric railway company's transformer station at Cloverdale, 17 inches below top of concrete plinth and 1 foot from southwest corner of building.

22–J In south face of southwesterly stone footing under water-tank of Great Northern railway at Lincoln.

23–J In east concrete foundation wall—4 feet 6 inches below woodwork and 3 feet 9 inches from northeast corner—of public school at Murrayville.

24–J In east concrete foundation wall—1 foot 6 inches below woodwork and 4 feet 2 inches from northeast corner—of public school at Aldergrove.

25–J In concrete bench-mark pier, 47 feet south of Great Northern railway track, 1½ miles west of Abbotsford, 580 feet east of a subway and 1,215 feet west of mile-post 31 from Colebrook.

26–J In east concrete foundation wall—5 feet 4 inches below woodwork and 3 feet 5 inches from southeast corner—of public school at Huntingdon.

27–J In north face of concrete base of international boundary monument No. 32, ¾ mile east of Great Northern railway at Huntingdon.

TABLE II.

RESULTS OF PRECISE LEVELLING.

HALIFAX, N.S., TO MONCTON, N.B.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 386-B.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	‡					12·590	‡
‡	386-B					60·743	386-B
386-B	387-B	1·0	1·0	−·013	−.013	21·575	387-B
386-B	388-B	2·9	2·9	−·014	−·014	40·963	388-B
388-B	MXXIX	1·1	4·0	−·011	−·025	13·730	MXXIX
MXXIX	MXXX	2·6	6·6	−·018	−·043	15·932	MXXX
MXXX	MXXXI	1·1	7·7	+·008	−·035	26·371	MXXXI
MXXXI	MXXXII	0·7	8·4	−·004	−·039	45·998	MXXXII
MXXXII	506-B	....	8·4	+·006	−·033	53·242	506-B
MXXXII	MXXXIII	1·4	9·8	−·016	−·055	135·084	MXXXIII
MXXXIII	MXXXIV	2·8	12·6	+·014	−·041	140·594	MXXXIV
MXXXIV	507-B	4·8	17·4	+·035	−·006	261·570	507-B
507-B	508-B	3·0	20·4	·000	−·006	362·973	508-B
508-B	509-B	3·6	24·0	−·001	−·007	458·933	509-B
509-B	510-B	3·2	27·2	+·010	+·003	505·799	510-B
510-B	511-B	3·0	30·2	+·013	+·016	439·222	511-B
511-B	512-B	3·5	33·7	+·007	+·023	408·569	512-B
512-B	513-B	1·8	35·5	+·007	+·030	312·469	513-B
513-B	514-B	2·5	38·0	−·015	+·015	174·353	514-B
514-B	515-B	2·7	40·7	−·015	·000	79·085	515-B
515-B	505-B*	4·2	44·9	−·002	−·002	29·428	505-B*
505-B*	516-B	3·8	48·7	+·001	−·001	30·019	516-B
516-B	517-B	6·1	54·8	+·025	+·024	114·318	517-B
517-B	518-B	3·2	58·0	−·010	+·014	32·691	518-B
518-B	519-B	2·7	60·7	−·018	−·004	45·463	519-B
519-B	520-B	2·2	62·9	+·016	+·012	64·228	520-B
520-B	521-B	0·8	63·7	+·002	+·014	66·993	521-B
521-B	522-B	1·6	65·3	+·018	+·032	75·896	522-B
522-B	523-B	5·4	70·7	+·019	+·051	95·484	523-B
523-B	524-B	0·5	71·2	+·004	+·055	95·353	524-B

‡Reference bench-mark, Department of the Naval Service.

*See also elevation of this bench-mark on page 176.

RESULTS OF PRECISE LEVELLING.

HALIFAX, N.S., TO MONCTON, N.B.—*Continued.*

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 386–B.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
524–B	525–B	2·0	73·2	+·003	+·058	103·270	525–B
525–B	526–B	2·1	75·3	+·009	+·067	112·386	526–B
526–B	527–B	5·5	80·8	+·002	+·069	122·876	527–B
527–B	528–B	3·5	84·3	−·026	+·043	52·486	528–B
528–B	529–B	1·9	86·2	+·004	+·047	39·638	529–B
529–B	530–B	6·6	92·8	+·001	+·048	153·182	530–B
530–B	531–B	2·9	95·7	−·002	+·046	30·851	531–B
531–B	532–B	5·0	100·7	+·011	+·057	31·280	532–B
532–B	533–B	1·1	101·8	+·005	+·062	41·420	533–B
533–B	MIII	0·7	102·5	−·002	+·060	57·107	MIII
MIII	534–B	0·7	103·2	−·005	+·055	51·629	534–B
534–B	535–B	....	103·2	·000	+·055	51·662	535–B
535–B	536–B	0·2	103·4	−·001	+·054	57·085	536–B
536–B	537–B	....	103·4	−·006	+·048	63·687	537–B
537–B	CMLXVI–A	0·4	103·8	−·005	+·043	54·923	CMLXVI–A
CMLXVI–A	CMLXVII	1·1	104·9	+·004	+·047	34·834	CMLXVII
CMLXVII	CMLXVIII	0·6	105·5	−·008	+·039	38·617	CMLXVIII
CMLXVIII	CMLXIX	1·4	106·9	+·018	+·057	82·057	CMLXIX
CMLXIX	CMLXX	1·4	108·3	−·018	+·039	82·691	CMLXX
CMLXX	CMLXXII	2·5	110·8	+·005	+·044	81·019	CMLXXII
CMLXXII	CMLXXIII	0·8	111·6	−·008	+·036	92·269	CMLXXIII
CMLXXIII	CMLXXIV	1·8	113·4	−·006	+·030	151·470	CMLXXIV
CMLXXIV	CMLXXV	1·5	114·9	−·002	+·028	145·497	CMLXXV
CMLXXV	CMLXXVI	1·0	115·9	+·002	+·030	157·024	CMLXXVI
CMLXXVI	CMLXXVII	1·6	117·5	−·014	+·016	185·613	CMLXXVII
CMLXXVII	CMLXXVIII	0·6	118·1	−·011	+·005	189·329	CMLXXVIII
CMLXXVIII	CMLXXIX	2·2	120·3	+·024	+·029	324·695	CMLXXIX
CMLXXIX	CMLXXX	1·9	122·2	+·004	+·033	383·595	CMLXXX
CMLXXX	CMLXXXI	0·6	122·8	−·012	+·021	426·062	CMLXXXI
CMLXXXI	CMLXXXII	1·9	124·7	+·011	+·032	504·202	CMLXXXII
CMLXXXII	CMLXXXIII	1·8	126·5	−·008	+·024	593·182	CMLXXXIII
CMLXXXIII	538–B	0·2	126·7	+·001	+·025	605·531	538–B
538–B	539–B	0·9	127·6	−·013	+·012	615·857	539–B
539–B	CMLXXXIV	0·6	128·2	+·009	+·021	608·920	CMLXXXIV
CMLXXXIV	CMLXV	0·8	129·0	+·013	+·034	579·481	CMLXV
CMLXV	CMLXIV	1·6	130·6	+·004	+·038	508·244	CMLXIV
CMLXIV	CMLXIII	0·8	131·4	−.004	+·034	466·396	CMLXIII
CMLXIII	CMLXII	0·8	132·2	−·001	+·033	462·178	CMLXII
CMLXII	CMLXI	2·8	135·0	−·010	+·023	399·701	CMLXI
CMLXI	CMLX	2·1	137·1	−·003	+·020	320·172	CMLX
CMLX	CMLIX	0·8	137·9	+·013	+·033	285·647	CMLIX
CMLIX	CMLVIII	1·3	139·2	+·019	+·052	266·586	CMLVIII

RESULTS OF PRECISE LEVELLING.

HALIFAX, N.S., TO MONCTON, N.B.—*Continued.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 386–B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
CMLVIII	CMLVII	1·3	140·5	−·009	+·043	238·431	CMLVII
CMLVII	CMLV	4·4	144·9	−·032	+·011	151·821	CMLV
CMLV	540–B	0·8	145·7	+·011	+·022	111·625	540–B
540–B	CMLIV	0·4	146·1	+·005	+·027	99·828	CMLIV
CMLIV	CMLIII	0·7	146·8	−·005	+·022	121·309	CMLIII
CMLIII	CMLII	1·1	147·9	+·011	+·033	103·283	CMLII
CMLII	CMLI	1·5	149·4	+·019	+·052	115·315	CMLI
CMLI	135–B*	1·2	150·6	−·018	+·034	89·824	135–B*
135–B*	CML	....	150·6	−·004	+·030	89·645	CML
CML	541–B	0·7	151·3	+·008	+·038	133·203	541–B
541–B	542–B	1·4	152·7	−·013	+·025	167·406	542–B
542–B	CMXLVIII	0·4	153·1	−·009	+·016	149·453	CMXLVIII
CMXLVIII	CMXLVII	1·3	154·4	−·003	+·013	115·227	CMXLVII
CMXLVII	CMXLVI	1·3	155·7	+·003	+·016	148·957	CMXLVI
CMXLVI	CMV	1·4	157·1	+·009	+·025	129·861	CMV
CMV	CMVI	0·9	158·0	·000	+·025	157·786	CMVI
CMVI	CMVII	1·6	159·6	+·005	+·030	231·478	CMVII
CMVII	CMVIII	1·4	161·0	+·006	+·036	261·832	CMVIII
CMVIII	CMIX	1·0	162·0	+·001	+·037	223·391	CMIX
CMIX	CMX	0·7	162·7	+·011	+·048	194·030	CMX
CMX	543–B	2·1	164·8	+·016	+·064	124·111	543–B
543–B	CMXI	0·8	165·6	−·010	+·054	93·688	CMXI
CMXI	CMXII	0·5	166·1	+·006	+·060	65·155	CMXII
CMXII	CMXIII	0·7	166·8	−·014	+·046	72·802	CMXIII
CMXIII	CMXIV	1·2	168·0	−·005	+·041	130·891	CMXIV
CMXIV	CMXV	1·6	169·6	+·006	+·047	85·482	CMXV
CMXV	CMXVI	2·3	171·9	+·006	+·053	33·560	CMXVI
CMXVI	CMXVII	1·9	173·8	−·010	+·043	28·652	CMXVII
CMXVII	CMXIX	2·2	176·0	−·011	+·032	28·556	CMXIX
CMXIX	CMXX	0·9	176·9	+·002	+·034	24·859	CMXX
CMXX	544–B	1·1	178·0	+·017	+·051	53·717	544–B
544–B	CMXXI	1·8	179·8	−·019	+·032	63·701	CMXXI
CMXXI	545–B	0·4	180·2	−·005	+·027	60·919	545–B
545–B	546–B	0·2	180·4	−·002	+·025	74·703	546–B
546–B	547–B	....	180·4	−·001	+·024	77·653	547–B
547–B	548–B	0·2	180·6	−·005	+·019	77·364	548–B
545–B	CMIV	0·7	180·9	+·010	+·037	26·013	CMIV
CMIV	CM	1·7	182·6	−·002	+·035	26·601	CM

*See introduction (this publication) page 141.

RESULTS OF PRECISE LEVELLING.

HALIFAX N.S., TO MONCTON, N.B.—*Concluded.*

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 386–B.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
CM	DCCCXCIX	0·8	183·4	−·002	+·033	30·856	DCCCXCIX
DCCCXCIX	DCCCXCVIII	5·4	188·8	+·016	+·049	26·188	DCCCXCVIII
DCCCXCVIII	MCCCCXXXVI	1·1	189·9	−·006	+·043	27·398	MCCCCXXXVI
MCCCCXXXVI	DCCCXCVII	....	189·9	−·002	+·041	19·038	DCCCXCVII
MCCCCXXXVI	CMI	0·7	190·6	+·011	+·054	86·762	CMI
CMI	CMII	....	190·6	+·004	+·058	86·431	CMII
CMII	CMIII	....	190·6	+·002	+·060	74·421	CMIII
MCCCCXXXVI	DCCCXCVI	1·9	191·8	+·014	+·057	33·123	DCCCXCVI
DCCCXCVI	DCCCXCIV	2·0	193·8	−·004	+·053	113·349	DCCCXCIV
DCCCXCIV	DCCCXCIII	2·5	196·3	−·014	+·039	204·038	DCCCXCIII
DCCCXCIII	DCCCXCII	0·8	197·1	+·010	+·049	169·617	DCCCXCII
DCCCXCII	DCCCLXCI	1·0	198·1	−·008	+·041	124·430	DCCCLXCI
DCCCLXCI	DCCCLXXXIX	2·1	200·2	+·006	+·047	32·804	DCCCLXXXIX
DCCCLXXXIX	DCCCLXXXVIII	1·1	201·3	−·013	+·034	138·283	DCCCLXXXVIII
DCCCLXXXVIII	DCCCLXXXVII	....	201·3	−·002	+·032	126·371	DCCCLXXXVII
DCCCLXXXVIII	CCCLIV	2·8	204·1	+·026	+·060	28·105	CCCLIV
CCCLIV	CCCLV	3·0	207·1	+·028	+·088	28·119	CCCLV
CCCLV	549–B	2·5	209·6	−·013	+·075	22·035	549–B
549–B	CCCLVIII	1·9	211·5	+·013	+·088	31·086	CCCLVIII
CCCLVIII	CCCLVIIII	1·1	212·6	+·008	+·096	25·124	CCCLVIIII
CCCLVIIII	CCCLX	1·0	213·6	+·015	+·111	42·370	CCCLX
CCCLX	CCCLXII	1·8	215·4	−·001	+·110	73·039	CCCLXII
CCCLXII	CCCLXIV	2·0	217·4	+·021	+·131	127·202	CCCLXIV
CCCLXIV	550–B	0·9	218·3	−·001	+·130	168·366	550–B
550–B	CCCLXV	0·8	219·1	+·017	+·147	157·047	CCCLXV
CCCLXV	MDXLIII	1·6	220·7	+·006	+·153	148·515	MDXLIII
MDXLIII	MDXLIV	1·4	222·1	−·008	+·145	126·358	MDXLIV
MDXLIV	MDXLV	0·9	223·0	+·006	+·151	129·467	MDXLV
MDXLV	MDXLVI	1·5	224·5	+·008	+·159	86·784	MDXLVI
MDXLVI	MDXLVII	2·3	226·8	−·008	+·151	40·821	MDXLVII
MDXLVII	132–B*	1·1	227·9	−·004	+·147	51·612	132–B*

* The elevation of bench-mark 132–B given on page 73, 1913 publication, is 51·413—see introduction (this publication) page 140.

RESULTS OF PRECISE LEVELLING.

BRIDGEWATER TO WINDSOR, N.S.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 411–B.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	411–B					44·491	411–B
411–B	466–B	2·0	2·0	–·012	–·012	64·411	466–B
466–B	467–B	3·3	5·3	+·010	–·002	104·621	467–B
467–B	468–B	4·4	9·7	–·030	–·032	120·864	468–B
468–B	469–B	2·6	12·3	–·021	–·053	122·159	469–B
469–B	469–B–2	3·1	15·4	–·005	–·058	198·567	469–B–2
469–B–2	470–B	2·7	18·1	–·001	–·059	222·818	470–B
470–B	471–B	4·8	22·9	–·008	–·067	412·136	471–B
471–B	472–B	2·4	25·3	+·017	–·050	547·937	472–B
472–B	473–B	4·1	29·4	–·009	–·059	601·055	473–B
473–B	474–B	4·7	34·1	+·005	–·054	613·138	474–B
474–B	475–B	3·4	37·5	–·020	–·074	574·971	475–B
475–B	476–B	2·6	40·1	–·012	–·086	577·027	476–B
476–B	476–B–2	1·0	41·1	–·001	–·087	579·046	476–B–2
476–B–2	477–B	0·8	41·9	–·003	–·090	567·329	477–B
477–B	478–B	3·8	45·7	+·020	–·070	469·222	478–B
478–B	479–B	3·4	49·1	–·021	–·091	184·147	479–B
479–B	480–B	0·6	49·7	+·013	–·078	151·282	480–B
480–B	481–B	2·8	52·5	+·001	–·077	38·212	481–B
481–B	482–B	1·4	53·9	–·020	–·097	73·776	482–B
482–B	483–B	0·3	54·2	–·004	–·101	70·778	483–B
482–B	484–B	2·3	56·2	–·002	–·099	69·711	484–B
484–B	485–B	2·5	58·7	+·011	–·088	52·711	485–B
485–B	486–B	2·5	61·2	+·016	–·072	86·909	486–B
486–B	487–B	4·4	65·6	+·006	–·066	83·551	487–B
487–B	488–B	7·2	72·8	+·025	–·041	144·180	488–B
488–B	489–B	3·2	76·0	+·017	–·024	81·983	489–B
489–B	490–B	2·3	78·3	+·001	–·023	60·078	490–B
490–B	491–B	2·8	81·1	+·010	–·013	57·238	491–B
491–B	492–B	4·1	85·2	–·013	–·026	39·252	492–B
492–B	493–B	0·2	85·4	·000	–·026	42·332	493–B
493–B	494–B	0·4	85·8	–·009	–·035	23·253	494–B
494–B	494–B–2	5·3	91·1	+·010	–·025	29·663	494–B–2
494–B–2	495–B	0·9	92·0	–·013	–·038	22·705	495–B
495–B	496–B	0·3	92·3	+·004	–·034	28·826	496–B
496–B	497–B	....	92·3	+·003	–·031	43·614	497–B
496–B	498–B	2·9	95·2	–·019	–·053	27·877	498–B

RESULTS OF PRECISE LEVELLING.

BRIDGEWATER TO WINDSOR, N.S.—*Continued.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 411-B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
498-B	499-B	4·0	99·2	+·002	−·051	71·085	499-B
499-B	500-B	3·9	103·1	−·008	−·059	49·230	500-B
500-B	501-B	2·2	105·3	−·010	−·069	47·628	501-B
501-B	502-B	4·3	109·6	+·005	−·064	33·285	502-B
502-B	503-B	0·6	110·2	+·001	−·063	38·063	503-B
503-B	504-B	....	110·2	+·001	−·062	41·811	504-B
503-B	505-B*	....	110·2	+·002	−·061	29·486	505-B*

*See also elevation of this bench-mark on page 171.

RESULTS OF PRECISE LEVELLING.

ST. LEONARD TO CAMPBELLTON, N.B.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 50-B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	50-B					449·126	50-B
50-B	1-G	3·5	3·5	−·004	−·004	494·067	1-G
1-G	2-G	7·0	10·5	+·001	−·003	555·985	2-G
2-G	3-G	3·7	14·2	+·004	+·001	602·125	3-G
3-G	4-G	0·2	14·4	+·001	+·002	603·766	4-G
4-G	5-G	4·3	18·7	+·020	+·022	667·317	5-G
5-G	6-G	6·1	24·8	+·018	+·040	724·485	6-G
6-G	7-G	5·4	30·2	−·001	+·039	844·897	7-G
7-G	8-G	4·8	35·0	+·012	+·051	760·751	8-G
8-G	9-G	3·0	38·0	−·006	+·045	910·979	9-G
9-G	10-G	5·6	43·6	+·003	+·048	830·483	10-G
10-G	11-G	2·3	45·9	+·022	+·070	920·650	11-G
11-G	12-G	8·5	54·4	−·011	+·059	934·534	12-G
12-G	13-G	4·0	58·4	−·010	+·049	935·544	13-G
13-G	14-G	2·3	60·7	−·004	+·045	941·758	14-G
14-G	15-G	7·7	68·4	−·023	+·022	1138·976	15-G
15-G	16-G	7·1	75·5	−·014	+·008	857·251	16-G
16-G	17-G	3·0	78·5	+·009	+·017	691·656	17-G
17-G	18-G	2·8	81·3	+·001	+·018	518·950	18-G
18-G	19-G	2·1	83·4	−·020	−·002	433·647	19-G
19-G	20-G	3·0	86·4	+·001	−·001	322·962	20-G
20-G	21-G	6·2	92·6	−·007	−·008	132·163	21-G
21-G	22-G	7·1	99·7	−·032	−·040	238·536	22-G
22-G	23-G	3·8	103·5	−·008	−·048	132·961	23-G
23-G	24-G	5·3	108·8	+·004	−·044	127·521	24-G
24-G	25-G	1·9	110·7	+·015	−·029	44·002	25-G
25-G	26-G	0·4	111·1	+·001	−·028	26·425	26-G

Connections at Campbellton with Public Works Dept's bench-marks:—

B.M.—MDXLIX—I.R.C. station, Elev. 44·192.

B.M.—MDL—Post-office, Elev. 26·415.

B.M.—CCLXXVII—Bank of Nova Scotia, Elev. 23·050.

B.M.—CCLXXV—I.R.C. culvert, Elev. 43·123.

RESULTS OF PRECISE LEVELLING.

McGIVNEY JUNCTION TO CHATHAM, N.B.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 333–B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	333–B					571·695	333–B
333–B	31–G	4·7	4·7	·000	·000	469·168	31–G
31–G	32–G	6·5	11·2	−·037	−·037	350·212	32–G
32–G	33–G	2·1	13·3	+·003	−·034	217·039	33–G
33–G	34–G	6·3	19·6	−·005	−·039	145·466	34–G
34–G	35–G	3·6	23·2	−·001	−·040	165·944	35–G
35–G	36–G	3·2	26·4	+·022	−·018	130·808	36–G
36–G	37–G	3·4	29·8	+·009	−·009	111·826	37–G
37–G	38–G	4·2	34·0	−·007	−·016	293·127	38–G
38–G	39–G	2·0	36·0	+·004	−·012	333·030	39–G
39–G	40–G	7·5	43·5	+·032	+·020	232·359	40–G
40–G	41–G	6·1	49·6	−·029	−·009	93·931	41–G
41–G	42–G	1·9	51·5	−·001	−·010	47·039	42–G
42–G	43–G	3·1	54·6	+·003	−·007	79·778	43–G
43–G	44–G	4·5	59·1	−·019	−·026	135·199	44–G
44–G	45–G	2·9	62·0	−·005	−·031	35·252	45–G
45–G	46–G	5·4	67·4	−·002	−·033	103·080	46–G
46–G	47–G	4·1	71·5	+·029	−·004	22·067	47–G
47–G	47–G–2	4·6	76·1	+·006	+·002	46·288	47–G–2
47–G–2	48–G	4·4	80·5	+·019	+·021	46·851	48–G
48–G	49–G	3·8	84·3	+·026	+·047	10·358	49–G

Connections with Public Works Dept's bench-marks:—

B.M.—DCCCXXVI—Bridge at Derby Jct., Elev. 30·582.

B.M.—MCCCCXIII—Chatham post-office, Elev. 10·218.

B.M.—MCCCCXII—Chatham Cathedral, Elev. 92·054.

RESULTS OF PRECISE LEVELLING.

ST. ANSELME TO LEVIS, QUE.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 214–B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	214–B					553·825	214–B
214–B	250–B	2·4	2·4	–·009	–·009	532·495	250–B
250–B	251–B	3·3	5·7	–·001	–·010	463·562	251–B
251–B	252–B	2·9	8·6	+·020	+·010	410·736	252–B
252–B	253–B	2·3	10·9	–·018	–·008	366·082	253–B
253–B	254–B	2·4	13·3	+·005	–·003	338·878	254–B
254–B	255–B	1·9	15·2	–·012	–·015	318·568	255–B
255–B	256–B	4·2	19·4	–·024	–·039	248·949	256–B
256–B	257–B	2·9	22·3	–·012	–·051	207·238	257–B
257–B	258–B	2·1	24·4	–·011	–·062	169·643	258–B
258–B	259–B	1·9	26·3	+·006	–·056	157·224	259–B.
258–B	222–B*	7·2	31·6	–·025	–·087	17·062	222–B*

*The elevation of bench-mark 222–B given on page 77, 1913 publication, is 17·038.

Connections between Chaudiére Jct. and Levis with Public Works Dept's bench-marks:—

B.M.—MCLXXIII—I.R.C. culvert, Elev. 164·508.

B.M.—MCLXXIV—I.R.C. culvert, Elev. 88·948.

B.M.—MCLXXV—I.R.C. bridge, Elev. 65·444.

RESULTS OF PRECISE LEVELLING.

COOKSHIRE, QUE., TO BEECHER FALLS, VT.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 10-A-3.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	10-A-3					770·911	10-A-3
10-A-3	551-B	3·8	3·8	+·025	+·025	801·414	551-B
551-B	552-B	3·5	7·3	−·004	+·021	905·617	552-B
552-B	553-B	2·0	9·3	−·024	−·003	948·095	553-B
553-B	554-B	6·5	15·8	+·021	+·018	1355·881	554-B
554-B	555-B	2·7	18·5	−·006	+·012	1542·868	555-B
555-B	556-B	6·2	24·7	+·019	+·031	1356·693	556-B
556-B	557-B	3·5	28·2	−·019	+·012	1223·763	557-B
557-B	558-B	2·4	30·6	−·003	+·009	1135·165	558-B
558-B	559-B	0·8	31·4	+·009	+·018	1121·751	559-B
559-B	560-B	3·2	34·6	−·010	+·008	1088·402	560-B
560-B	561-B	0·7	35·3	+·003	+·011	1099·376	561-B
561-B	562-B	0·7	36·0	+·004	+·015	1102·626	562-B

RESULTS OF PRECISE LEVELLING.

SUDBURY, ONT., TO SAULT STE. MARIE, MICH.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 454.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	454					845·151	454
454	567–A	0·2	0·2	+·011	+·011	859·395	567–A
454	568	2·0	2·0	+·004	+·004	849·569	568
568	569	4·4	6·4	+·001	+·005	875·515	569
569	570	3·0	9·4	−·029	−·024	789·776	570
570	571	3·3	12·7	+·002	−·022	821·650	571
571	572	1·3	14·0	+·010	−·012	785·975	572
572	573	2·2	16·2	−·004	−·016	791·351	573
573	574	1·0	17·2	+·014	−·002	791·756	574
574	575	3·0	20·2	+·010	+·008	826·003	575
575	576	3·3	23·5	+·003	+·011	807·273	576
576	577	2·8	26·3	+·002	+·013	756·173	577
577	578	3·6	29·9	+·030	+·043	698·223	578
578	579	2·5	32·4	·000	+·043	721·299	579
579	580	1·1	33·5	−·006	+·037	722·801	580
580	581	4·3	37·8	−·006	+·031	672·754	581
581	582	1·0	38·8	−·019	+·012	699·383	582
582	583	4·0	42·8	+·017	+·029	684·949	583
583	584	2·0	44·8	+·017	+·046	685·290	584
584	585	3·7	48·5	+·018	+·064	665·548	585
585	586	0·8	49·3	−·009	+·055	643·671	586
586	587	0·9	50·2	+·015	+·070	667·014	587
587	588	2·8	53·0	+·011	+·081	618·338	588
588	589	3·7	56·7	−·009	+·072	614·431	589
589	590	1·5	58·2	−·008	+·064	637·822	590
590	591	2·0	60·2	+·001	+·065	608·765	591
591	592	3·3	63·5	+·015	+·080	624·083	592
592	593	1·5	65·0	+·005	+·085	679·073	593
593	594	4·8	69·8	+·003	+·088	600·022	594
594	595	2·1	71·9	−·015	+·073	605·275	595
595	596	3·1	75·0	+·027	+·100	633·210	596
596	597	4·0	79·0	−·020	+·080	640·084	597
597	598	3·9	82·9	+·010	+·090	599·948	598
598	599	1·8	84·7	+·019	+·109	588·247	599
599	600	3·0	87·7	−·018	+·091	600·160	600
600	601	2·0	89·7	−·006	+·085	643·202	601
601	602	5·6	95·3	+·037	+·122	603·690	602
602	603	4·1	99·4	−·011	+·111	627·748	603
603	604	3·3	102·7	−·022	+·089	599·985	604
604	605	....	102·7	·000	+·089	600·891	605

RESULTS OF PRECISE LEVELLING.

SUDBURY, ONT., TO SAULT STE. MARIE, MICH.—*Continued.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 454.	Discrepancy		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
604	606	2·0	104·7	−·006	+·083	593·798	606
606	607	1·9	106·6	+·004	+·087	598·863	607
607	608	3·9	110·5	+·004	+·091	606·926	608
608	609	2·9	113·4	−·003	+·088	630·893	609
609	610	2·9	116·3	+·016	+·104	623·034	610
610	611	3·6	119·9	+·012	+·116	613·039	611
611	612	2·5	122·4	−·016	+·100	610·013	612
612	613	3·0	125·4	−·027	+·073	632·872	613
613	614	2·8	128·2	−·007	+·066	622·442	614
614	615	4·4	132·6	−·025	+·041	594·387	615
615	616	1·0	133·6	+·008	+·049	594·330	616
616	616–A	3·9	137·5	+·006	+·055	638·395	616–A
616–A	617	2·3	139·8	−·027	+·028	670·671	617
617	618	1·8	141·6	−·001	+·027	694·931	618
618	619	1·7	143·3	−·009	+·018	676·017	619
619	620	4·9	148·2	−·039	−·021	635·800	620
620	621	1·7	149·9	−·010	−·031	591·137	621
621	622	1·5	151·4	+·002	−·029	590·478	622
622	623	3·8	155·2	+·025	−·004	640·823	623
623	624	3·5	158·7	−·003	−·007	613·220	624
624	625	2·2	160·9	+·021	+·014	592·245	625
625	626	4·0	164·9	+·016	+·030	587·408	626
626	627	0·9	165·8	+·015	+·045	596·361	627
627	628	1·8	167·6	+·018	+·063	585·070	628
628	629	3·5	171·1	+·023	+·086	602·741	629
629	630	3·3	174·4	+·002	+·088	605·781	630
630	631	3·7	178·1	+·035	+·123	637·046	631
631	632	2·0	180·1	−·009	+·114	601·930	632
632	633	0·2	180·3	·000	+·114	598·848	633
632	634	1·5	181·6	+·008	+·122	601·622	634
634	635	1·3	182·9	+·018	+·140	618·213	635
635	636	1·0	183·9	+·005	+·145	610·176	636

Connections at Sault Ste. Marie, Mich. with bench-marks of United States Lake Survey:—

P.B.M.A.—On Weitzel lock, Elev. 605·122.

P.B.M.B.—On Poe lock, Elev. 587·564.

RESULTS OF PRECISE LEVELLING.

FORT FRANCES TO PORT ARTHUR, ONT.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 3–C.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	29–E		191·2		+·292	1119·617	29–E
29–E	31–E	2·7	193·9	+·018	+·310	1117·185	31–E
31–E	32–E	4·2	198·1	+·030	+·340	1121·376	32–E
32–E	33–E	3·1	201·2	+·003	+·343	1119·267	33–E
33–E	34–E	3·4	204·6	+·001	+·344	1116·702	34–E
34–E	35–E	3·8	208·4	+·019	+·363	1122·720	35–E
35–E	36–E	3·1	211·5	−·016	+·347	1114·275	36–E
36–E	37–E	3·6	215·1	−·007	+·340	1151·003	37–E
37–E	38–E	3·8	218·9	−·013	+·327	1110·606	38–E
38–E	39–E	4·5	223·4	+·035	+·362	1166·188	39–E
39–E	40–E	3·2	226·6	+·018	+·380	1181·375	40–E
40–E	41–E	3·8	230·4	−·023	+·357	1188·809	41–E
41–E	42–E	1·9	232·3	+·001	+·358	1199·848	42–E
42–E	43–E	2·4	234·7	+·014	+·372	1196·091	43–E
43–E	44–E	3·5	238·2	+·009	+·381	1189·923	44–E
44–E	45–E	3·7	241·9	−·011	+·370	1181·719	45–E
45–E	46–E	3·6	245·5	+·018	+·388	1213·359	46–E
46–E	47–E	3·1	248·6	−·033	+·355	1196·672	47–E
47–E	48–E	3·0	251·6	+·012	+·367	1181·532	48–E
48–E	49–E	4·4	256·0	−·001	+·366	1269·916	49–E
49–E	50–E	4·1	260·1	+·008	+·374	1261·393	50–E
50–E	51–E	2·9	263·0	+·011	+·385	1260·781	51–E
51–E	52–E	3·6	266·6	+·032	+·417	1269·376	52–E
52–E	53–E	4·2	270·8	+·026	+·443	1275·226	53–E
53–E	54–E	5·0	275·8	+·001	+·444	1276·893	54–E
54–E	55–E	3·0	278·8	−·008	+·436	1272·733	55–E
55–E	56–E	4·0	282·8	−·009	+·427	1322·563	56–E
56–E	57–E	3·0	285·8	−·010	+·417	1355·712	57–E
57–E	58–E	4·0	289·8	−·023	+·394	1385·754	58–E
58–E	59–E	5·0	294·8	+·038	+·432	1411·827	59–E
59–E	60–E	4·0	298·8	−·004	+·428	1451·269	60–E
60–E	61–E	2·9	301·7	−·012	+·416	1482·971	61–E
61–E	62–E	4·0	305·7	+·008	+·424	1458·593	62–E
62–E	63–E	4·0	309·7	−·007	+·417	1455·614	63–E
63–E	64–E	5·0	314·7	+·024	+·441	1497·104	64–E
64–E	65–E	4·1	318·8	+·009	+·450	1499·707	65–E
65–E	66–E	3·9	322·7	+·015	+·465	1532·170	66–E
66–E	67–E	4·0	326·7	−·009	+·456	1560·481	67–E
67–E	68–E	4·0	330·7	+·024	+·480	1550·337	68–E
68–E	69–E	3·2	333·9	+·009	+·489	1545·550	69–E
69–E	70–E	3·8	337·7	+·016	+·505	1520·365	70–E
70–E	71–E	4·3	342·0	−·007	+·498	1507·594	71–E

RESULTS OF PRECISE LEVELLING.

FORT FRANCES TO PORT ARTHUR, ONT.—*Continued.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 3-C.	Discrepancy.		Elevation above mean sea level	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
71-E	72-E	2·7	344·7	−·010	+·488	1533·529	72-E
72-E	73-E	3·0	347·7	+·016	+·504	1486·217	73-E
73-E	74-E	4·4	352·1	+·016	+·520	1503·553	74-E
74-E	75-E	7·6	359·7	−·046	+·474	1487·777	75-E
75-E	76-E	4·2	363·9	+·020	+·494	1443·867	76-E
76-E	77-E	2·8	366·7	+·018	+·512	1327·061	77-E
77-E	78-E	5·0	371·7	−·032	+·480	1214·844	78-E
78-E	79-E	3·9	375·6	−·005	+·475	1208·799	79-E
79-E	80-E	4·0	379·6	−·002	+·473	1156·238	80-E
80-E	81-E	3·7	383·3	+·015	+·488	1092·149	81-E
81-E	82-E	4·0	387·3	−·030	+·458	1062·547	82-E
82-E	83-E	3·3	390·6	−·025	+·433	1003·434	83-E
83-E	84-E	3·9	394·5	+·016	+·449	973·398	84-E
84-E	85-E	3·6	398·1	+·007	+·456	917·377	85-E
85-E	86-E	5·3	403·4	+·015	+·471	731·235	86-E
86-E	87-E	5·8	409·2	+·019	+·490	728·529	87-E
87-E	88-E	2·8	412·0	+·007	+·497	717·035	88-E
88-E	89-E	5·2	417·2	+·002	+·499	631·033	89-E
89-E	90-E	2·7	419·9	+·013	+·512	614·708	90-E
90-E	91-E	0·2	420·1	+·001	+·513	617·517	91-E
91-E	92-E	0·3	420·4	·000	+·513	618·626	92-E
92-E	93-E	4·3	424·7	+·006	+·519	617·119	93-E
93-E	94-E	0·1	424·8	−·004	+·515	635·155	94-E
94-E	95-E	0·2	425·0	−·002	+·513	657·107	95-E

For connection at Port Arthur with Hydrographic Survey bench-mark, see Introduction.

RESULTS OF PRECISE LEVELLING.

STANLEY TO NORTH LAKE, ONT.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 86–E.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	86–E					731·235	86–E
86–E	96–E	5·4	5·4	+·028	+·028	770·873	96–E
96–E	97–E	4·0	9·4	−·022	+·006	850·877	97–E
97–E	98–E	4·2	13·6	+·017	+·023	998·718	98–E
98–E	99–E	7·0	20·6	+·035	+·058	1277·534	99–E
99–E	100–E	3·9	24·5	−·023	+·035	1363·512	100–E
100–E	101–E	4·3	28·8	−·024	+·011	1438·281	101–E
101–E	102–E	4·5	33·3	+·018	+·029	1548·980	102–E
102–E	103–E	7·0	40·3	−·007	+·022	1589·457	103–E
103–E	104–E	5·8	46·1	−·004	+·018	1656·512	104–E
104–E	105–E	3·1	49·2	−·007	+·011	1614·552	105–E
105–E	106–E	2·2	51·4	−·001	+·010	1565·723	106–E

RESULTS OF PRECISE LEVELLING

WAINWRIGHT TO EDMONTON, ALTA.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 28–D.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	36–H		200·3		+·031	2236·888	36–H
36–H	37–H	9·8	210·1	+·021	+·052	2067·822	37–H
37–H	38–H	6·1	216·2	+·012	+·064	2198·247	38–H
38–H	39–H	2·6	218·8	+·008	+·072	2241·135	39–H
39–H	40–H	6·5	225·3	−·025	+·047	2337·185	40–H
40–H	41–H	9·0	234·3	−·012	+·035	2301·741	41–H
41–H	42–H	3·8	238·1	−·017	+·018	2297·138	42–H
42–H	43–H	7·8	245·9	+·031	+·049	2259·158	43–H

RESULTS OF PRECISE LEVELLING.

WAINWRIGHT TO EDMONTON, ALTA.—*Continued.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 28–D.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
43–H	44–H	6·3	252·2	−·007	+·042	2251·857	44–H
44–H	45–H	6·7	258·9	−·013	+·029	2239·803	45–H
45–H	46–H	9·2	268·1	+·051	+·080	2264·143	46–H
46–H	47–H	8·7	276·8	+·021	+·101	2268·646	47–H
47–H	48–H	1·5	278·3	−·001	+·100	2272·377	48–H
48–H	49–H	4·6	282·9	+·033	+·133	2232·044	49–H
49–H	50–H*	6·2	289·1	−·028	+·105	2293·944	50–H*
50–H*	51–H	0·3	289·4	−·006	+·099	2299·970	51–H
50–H*	52–H	6·9	296·0	+·004	+·109	2426·193	52–H
52–H	53–H	6·8	302·8	+·004	+·113	2432·680	53–H
53–H	54–H	5·2	308·0	+·012	+·125	2426·102	54–H
54–H	55–H	5·0	313·0	+·012	+·137	2336·510	55–H
55–H	56–H	6·1	319·1	+·010	+·147	2211·191	56–H
56–H	57–H	3·8	322·9	−·001	+·146	2129·988	57–H
57–H	58–H	6·6	329·5	−·010	+·136	2188·704	58–H
58–H	59–H	....	329·5	+·005	+·141	2188·052	59–H
58–H	60–H	1·8	331·3	+·005	+·141	2168·315	60–H
60–H	61–H	0·1	331·4	+·003	+·144	2163·805	61–H

*See also elevation of this bench-mark on page 187.

Connections at Edmonton with bench-marks of Topographical Surveys Branch, Dept. of the Interior:—

B.M. H–51, High-level bridge, Elev. 2172·126.

B.M. L–1, Queens Ave. school, Elev. 2187·245.

"City of Edmonton B.M.—12", Elev. 2194·232.

RESULTS OF PRECISE LEVELLING.

CALGARY TO TOFIELD, ALTA.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 51–D.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	51–D					3428·199	51–D
51–D	39–F	0·8	0·8	+·006	+·006	3416·388	39–F
39–F	40–F	2·9	3·7	+·008	+·014	3401·111	40–F
40–F	41–F	4·3	8·0	−·021	−·007	3473·085	41–F
41–F	42–F	7·9	15·9	−·010	−·017	3456·220	42–F
42–F	43–F	4·8	20·7	+·033	+·016	3309·688	43–F
43–F	44–F	4·1	24·8	−·001	+·015	3199·262	44–F
44–F	45–F	2·9	27·7	+·018	+·033	3115·246	45–F
45–F	46–F	3·0	30·7	+·004	+·037	3067·058	46–F
46–F	47–F	5·4	36·1	+·002	+·039	3034·393	47–F
47–F	48–F	2·8	38·9	−·010	+·029	2998·018	48–F
48–F	49–F	7·9	46·8	+·033	+·062	2943·801	49–F
49–F	50–F	4·4	51·2	−·021	+·041	2793·479	50–F
50–F	51–F	6·2	57·4	+·034	+·075	2953·784	51–F
51–F	52–F	7·4	64·8	−·042	+·033	2787·882	52–F
52–F	53–F	5·4	70·2	+·010	+·043	2934·911	53–F
53–F	54–F	3·5	73·7	+·011	+·054	2983·595	54–F
54–F	55–F	6·2	79·9	+·006	+·060	2863·894	55–F
55–F	56–F	9·1	89·0	−·034	+·026	2926·378	56–F
56–F	57–F	7·8	96·8	·000	+·026	2930·439	57–F
57–F	58–F	6·0	102·8	+·013	+·039	2967·282	58–F
58–F	59–F	6·6	109·4	+·022	+·061	2835·519	59–F
59–F	60–F	7·3	116·7	·000	+·061	2685·640	60–F
60–F	61–F	7·1	123·8	−·013	+·048	2622·316	61–F
61–F	62–F	1·1	124·9	+·022	+·070	2609·622	62–F
62–F	63–F	5·6	130·5	−·001	+·069	2603·558	63–F
63–F	64–F	6·1	136·6	+·023	+·092	2631·226	64–F
64–F	65–F	4·8	141·4	−·021	+·071	2602·346	65–F
65–F	66–F	8·5	149·9	−·042	+·029	2539·015	66–F
66–F	67–F	5·1	155·0	·000	+·029	2471·679	67–F
67–F	68–F	7·7	162·7	+·010	+·039	2458·180	68–F
68–F	69–F	5·2	167·9	+·009	+·048	2381·363	69–F
69–F	70–F	8·1	176·0	−·039	+·009	2431·551	70–F
70–F	71–F	0·4	176·4	·000	+·009	2428·335	71–F
70–F	72–F	2·2	178·2	+·009	+·018	2415·191	72–F
72–F	73–F	4·5	182·7	+·013	+·031	2446·688	73–F
73–F	74–F	6·1	188·8	−·025	+·006	2454·387	74–F
74–F	75–F	6·0	194·8	+·020	+·026	2385·842	75–F
75–F	76–F	5·2	200·0	−·005	+·021	2341·331	76–F
76–F	50–H*	1·8	201·8	+·021	+·042	2295·229	50–H*

*See also elevation of this bench-mark on page 186.

RESULTS OF PRECISE LEVELLING.

CALGARY, ALTA., TO FIELD, B.C.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 51-D.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	51-D					3428·199	51-D
51-D	217-C	0·4	0·4	−·004	−·004	3441·339	217-C
217-C	218-C	0·8	1·2	+·012	+·008	3449·278	218-C
218-C	219-C	7·0	8·2	+·010	+·018	3515·755	219-C
219-C	220-C	4·6	12·8	−·001	+·017	3598·733	220-C
220-C	221-C	3·2	16·0	−·002	+·015	3626·029	221-C
221-C	222-C	7·2	23·2	+·005	+·020	3771·003	222-C
222-C	223-C	0·8	24·0	−·006	+·014	3748·375	223-C
223-C	224-C	2·1	26·1	+·010	+·024	3727·944	224-C
224-C	225-C	6·5	32·6	+·027	+·051	3858·645	225-C
225-C	226-C	7·4	40·0	+·008	+·059	4063·436	226-C
226-C	227-C	3·3	43·3	−·010	+·049	4077·008	227-C
227-C	228-C	7·0	50·3	+·019	+·068	4222·877	228-C
228-C	229-C	1·9	52·2	−·019	+·049	4213·117	229-C
229-C	230-C	1·3	53·5	+·003	+·052	4208·011	230-C
230-C	231-C	3·8	57·3	−·013	+·039	4251·423	231-C
231-C	232-C	3·5	60·8	+·006	+·045	4237·092	232-C
232-C	233-C	1·1	61·9	+·007	+·052	4237·527	233-C
233-C	234-C	4·0	65·9	+·014	+·066	4293·308	234-C
234-C	235-C	1·3	67·2	−·016	+·050	4294·339	235-C
235-C	236-C	2·7	69·9	+·005	+·055	4339·829	236-C
236-C	237-C	3·5	73·4	+·002	+·057	4372·297	237-C
237-C	238-C	3·2	76·6	+·012	+·069	4454·270	238-C
238-C	239-C	2·2	78·8	−·020	+·049	4543·565	239-C
239-C	240-C	3·8	82·6	+·016	+·065	4531·828	240-C
240-C	241-C	0·6	83·2	+·001	+·066	4541·405	241-C
240-C	242-C	6·9	89·5	+·032	+·097	4564·110	242-C
242-C	243-C	7·3	96·8	−·004	+·093	4649·933	243-C
243-C	244-C	3·6	100·4	−·003	+·090	4688·465	244-C
244-C	245-C	6·1	106·5	+·017	+·107	4820·308	245-C

RESULTS OF PRECISE LEVELLING.

CALGARY, ALTA., TO FIELD, B.C.—*Continued.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 51-D.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
245-C	246-C	2·3	108·8	−·009	+·098	4874·895	246-C
246-C	247-C	5·1	113·9	+·007	+·105	4967·729	247-C
247-C	248-C	2·6	116·5	+·017	+·122	5045·816	248-C
248-C	249-C	0·5	117·0	+·007	+·129	5055·168	249-C
249-C	250-C	1·3	118·3	−·006	+·123	5078·239	250-C
250-C	251-C	3·4	121·7	+·005	+·128	5282·892	251-C
251-C	252-C	1·0	122·7	+·005	+·133	5344·598	252-C
252-C	253-C	2·8	125·5	+·005	+·138	5218·159	253-C
253-C	254-C	1·0	126·5	+·005	+·143	5178·526	254-C
254-C	255-C	3·5	130·0	+·001	+·144	4802·650	255-C
255-C	256-C	1·2	131·2	−·002	+·142	4675·667	256-C
256-C	257-C	1·1	132·3	−·010	+·132	4563·936	257-C
257-C	258-C	1·4	133·7	−·006	+·126	4413·235	258-C
258-C	259-C	2·1	135·8	−·018	+·108	4187·002	259-C
259-C	260-C	1·4	137·2	−·011	+·097	4074·638	260-C

Connections with bench-marks of Irrigation Branch, Dept. of the Interior:—

On C.P.R. bridge over Bow river, mileage 53·1 west of Calgary, Elev. 4205·153.

On S.W. ¼ sec. 2, tp. 26, rge. 12, W. 5th mer. (near Banff station), Elev. 4530·501.

On S.W. ¼ sec. 27, tp. 28, rge. 16, W. 5th mer. (mileage 116 west of Calgary), Elev. 5034·850.

RESULTS OF PRECISE LEVELLING.

VANCOUVER, B.C., TO BLAINE, WASH.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 1-J.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	1-J					43·446	1-J
1-J	2-J	....	....	−·002	−·002	53·684	2-J
2-J	3-J	0·8	0·8	+·002	·000	38·390	3-J
3-J	4-J	0·2	1·0	+·010	+·010	49·242	4-J
3-J	5-J	2·6	3·4	+·006	+·006	58·012	5-J
5-J	6-J	3·2	6·6	−·006	·000	53·925	6-J
6-J	7-J	0·1	6·7	+·005	+·005	48·771	7-J
7-J	8-J	5·5	12·2	+·039	+·044	38·503	8-J
8-J	9-J	2·5	14·7	−·002	+·042	40·157	9-J
9-J	10-J	0·6	15·3	+·012	+·054	43·293	10-J
10-J	11-J	....	15·3	+·001	+·055	44·110	11-J
11-J	12-J	....	15·3	+·001	+·056	57·703	12-J
11-J	13-J	0·4	15·7	+·001	+·056	13·383	13-J
9-J	14-J	4·8	19·5	−·002	+·040	23·046	14-J
14-J	15-J	2·8	22·3	−·007	+·033	26·734	15-J
15-J	16-J	7·8	30·1	+·017	+·050	10·561	16-J
16-J	17-J	4·2	34·3	+·006	+·056	11·136	17-J
17-J	18-J	0·4	34·7	+·003	+·059	7·877	18-J
18-J	19-J	2·4	37·1	+·007	+·066	18·119	19-J

RESULTS OF PRECISE LEVELLING.

COLEBROOK TO HUNTINGDON, B.C.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 15–J.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	15–J					26·734	15–J
15–J	20–J	9·6	9·6	+·036	+·036	14·195	20–J
20–J	21–J	....	9·6	+·004	+·040	7·336	21–J
20–J	22–J	7·9	17·5	+·022	+·058	183·866	22–J
22–J	23–J	0·6	18·1	+·001	+·059	163·805	23–J
23–J	24–J	7·6	25·7	+·021	+·080	336·591	24–J
24–J	25–J	8·6	34·3	+·036	+·116	172·075	25–J
25–J	26–J	4·4	38·7	−·013	+·103	72·863	26–J
26–J	27–J	1·0	39·7	+·009	+·112	32·356	27–J

TABLE III.

RAIL ELEVATIONS, HALIFAX, N.S., TO MONCTON, N.B.

(Elevations taken in 1914 and 1915).

		FEET
Intercolonial Railway—	Halifax	59·9
"	Richmond	20·0
"	Southwestern Junction	28·0
"	Fairview	13·1
"	Rockingham	10·0
"	Birch Cove	18·7
"	Prince Lodge	15·3
"	Mill View	11·0
"	Bedford	43·1
"	Sackville river; rail	45·4
"	Rocky lake; water, Aug. 10, 1914	128·7
"	Rocky Lake (station)	134·3
"	Lakeview	137·1
Dominion Atlantic Ry.—	Windsor Junction	129·0
"	Beaverbank	234·3
"	Horseshoe lake; water, Aug. 17, 1914	244·8
"	South Uniacke	457·9
"	Mount Uniacke	521·7
"	Uniacke lake; water, Aug. 21, 1914	497·5
"	Ellershouse	248·3
"	Hartville	182·7
"	St. Croix river; water, Aug. 26, 1914, 117·9; rail	178·1
"	Newport	111·3
"	Threemile Plains	82·2
"	Windsor	28·3
"	Brooklyn	34·1
"	Scotch Village	135·1
"	Mosherville	38·1
"	Stanley	41·2
"	Clarksville	70·7
"	Kennetcook	98·2
"	Kennetcook river; water, Sept. 14, 1914, 81·3; rail	99·1
"	Patterson	116·3
"	Doddridge	139·3
"	Burton	140·8
"	South Maitland	31·4
"	Greenoaks	85·3
"	Princeport Road	212·0
"	Clifton	32·1
"	McNutt Creek	34·8
"	Lower Truro	33·0
Intercolonial Railway—	Truro	61·8
"	Salmon river; water, Sept. 28, 1914, 35·1; rail	51·9
"	North river; water, Sept. 28, 1914, 26·8; rail	40·4
"	Onslow	48·3
"	Chiganois river; water, Sept. 30, 1914, 64·1; rail	83·7
"	Belmont	85·3
"	Debert	156·5
"	Debert river; water, Oct. 2, 1914, 134·2; rail	153·2

RAIL ELEVATIONS, HALIFAX, N.S., TO MONCTON, N.B.—*Continued.*

(Elevations taken in 1914 and 1915).

		FEET
Intercolonial Railway	East Mines	196·3
"	Folly river; water, Oct. 3, 1914, 110·0; rail	194·3
"	Londonderry	335·9
"	Probert	429·9
"	Folly lake; water, Oct. 6, 1914	600·6
"	Folleigh	612·5
"	Wentworth	470·4
"	Westchester	311·6
"	Greenville	284·3
"	Atkinson	246·6
"	Thompson	106·6
"	Oxford Junction (main line)	92·6
"	River Philip; water, Oct. 19, 1914, 41·5; rail	93·3
"	River Philip (station)	169·9
"	Salt Springs	151·2
"	Springhill Junction	199·3
"	Little Forks river; water, Oct. 29, 1914, 38·2; rail	72·0
"	Athol	134·2
"	Maccan	31·7
"	Nappan	28·7
"	Amherst	59·9
"	Fort Lawrence	33·9
"	Aulac	24·4
"	Sackville	24·9
"	Evans	200·1
"	Dorchester	21·5
"	Upper Dorchester	25·5
"	College Bridge	28·6
"	Memramcook	26·6
"	Gayton Crossing	46·5
"	Calhoun	50·5
"	Meadow Brook	82·7
"	Painsec	149·4
"	Cook	134·1
"	Harrisville	126·3
"	Buctouche Junction	68·6
"	Humphrey	57·5
"	Sunny Brae	42·8
"	Moncton	50·4

RAIL ELEVATIONS, BRIDGEWATER TO WINDSOR, N.S.

(Elevations taken in 1914).

		FEET
Halifax & Southwestern Ry.	Bridgewater	10·9
"	Mossman	134·9
"	Northfield	130·5
"	North brook; water, June 11, 1914, 113·4; rail	126·8
"	Riversdale	122·6
"	New Germany Junction	237·1
"	New Germany	258·3
"	Lahave river; water, June 12, 1914, 201·0; rail	214·7
"	Cherryfield	344·0
"	Hastings Junction	543·6
"	Springfield	548·9

RAIL ELEVATIONS, BRIDGEWATER TO WINDSOR, N.S.—*Continued.*

(Elevations taken in 1914).

		FEET
Halifax & Southwestern Ry.	—Freeman lake; water, June 19, 1914	543·1
"	Ridgeroad	574·7
"	Dalhousie	640·3
"	Waterloo river; water, June 26, 1914, 568·8; rail	580·0
"	Squirreltown	615·7
"	Albany	571·2
"	Alpena river; water, June 27, 1914, 528·3; rail	535·6
"	Alpena	531·3
"	Nictaux	150·1
"	Annapolis river; water, July 6, 1914, 26·0; rail	50·2
"	Dominion Atlantic railway (diamond crossing)	70·5
Dominion Atlantic Railway	—Middleton	70·1
"	Wilmot	69·5
"	Kingston	85·9
"	Auburn	94·9
"	Aylesford	100·3
"	Berwick	138·1
"	Waterville	93·5
"	Cambridge	65·4
"	Coldbrook	68·4
"	Kentville	35·0
"	Port Williams	31·3
"	Wolfville	27·0
"	Grand Pré	27·8
"	Horton Landing	42·1
"	Avonport	35·0
"	Hantsport	50·1
"	Mount Denison	50·2
"	Falmouth	30·5
"	Windsor	28·3

RAIL ELEVATIONS, ST. LEONARD TO CAMPBELLTON, N. B.

(Elevations taken in 1914).

		FEET
Canadian Pacific Ry.	—St. Leonard (taken in 1909)	509·4
Intercolonial Railway	—Jardine Brook	878·3
"	Nickel	907·1
"	Hazen	930·5
"	Anderson	914·3
"	Kedgwick	896·6
"	Upsalquitch	133·6
"	Upsalquitch river; water, Aug. 7, 1914, 115·4; rail	134·1
"	Campbellton	42·4

RAIL ELEVATIONS, McGIVNEY JUNCTION TO CHATHAM, N.B.

(Elevations taken in 1914 and 1915).

		FEET
Intercolonial Railway	—National Transcontinental railway (diamond crossing at McGivney Jct.)	571·6
"	Clearwater	503·5
"	Astle	517·4
"	Boiestown	235·7
"	Ludlow	178·8
"	McNamee	143·9
"	Carroll	166·1
"	Doaktown	121·0

RAIL ELEVATIONS, McGIVNEY JUNCTION TO CHATHAM, N.B.—*Continued.*

(Elevations taken in 1914 and 1915).

		FEET
Intercolonial Railway	Southwest Miramichi river; water, Oct. 21, 1914, 93·4; rail	115·0
"	Blissfield	250·6
"	Hurley Brook	332·9
"	Weaver	345·3
"	Upper Blackville	233·5
"	Forks	182·6
"	Keenan	70·0
"	Blackville	89·6
"	Bartholomew river; water, June 2, 1915, 33·1; rail	55·7
"	McLaggan	67·6
"	Underhill	58·0
"	Barnett	142·6
"	McCann	166·5
"	Renous river; water, June 3, 1915, 8·8; rail	69·8
"	Renous	70·7
"	Quarryville	33·1
"	Davidson	84·7
"	Park	93·6
"	Bryenton	102·6
"	Parker	55·3
"	Millerton	25·6
"	Amos	15·8
"	Derby Junction (Fredericton branch)	35·8
"	Nelson Junction (main line)	37·1
"	Nelson	50·8
"	Harper	78·8
"	Chatham	9·1

RAIL ELEVATIONS, ST. ANSELME TO LEVIS, QUE.

(Elevations taken in 1911).

		FEET
National Transcontinental Ry.	St. Anselme	566·7
"	St. Isidore	446·8
"	Intercolonial railway "cut-off" (diamond crossing at Diamond Junction).	209·4
Intercolonial Railway	St. Romuald	71·9
"	Hadlow	20·1
"	Pointe Levis	16·6
"	Levis	16·6

RAIL ELEVATIONS, COOKSHIRE, QUE., TO BEECHER FALLS, VERMONT.

(Elevations taken in 1915).

		FEET
Maine Central Railroad	Cookshire	681·7
"	Eaton Corner	806·9
"	Sawyerville	884·3
"	Clifton	1144·2
"	St. Isidore	1245·0
"	Camp Three	1343·5
"	Camp Four	1391·6
"	St. Malo	1505·5
"	Malvina	1437·5
"	Hall stream; water, July 2, 1915, 1346·1; rail	1359·4
"	Paquette	1237·3
"	East Hereford	1119·0
"	Comin Mills	1085·0
"	International boundary	1091·3

RAIL ELEVATIONS, SUDBURY TO SAULT STE. MARIE, ONT.

(Elevations taken in 1914 and 1915).

		FEET
Canadian Pacific Ry.—	Sudbury	856·6
"	Copper Cliff	859·8
"	Naughton	805·1
"	Vermilion river; water, Sept. 11, 1914, 767·8; rail	793·0
"	Whitefish	809·9
"	Victoria Mine	826·7
"	Worthington	775·2
"	Turbine	709·7
"	Nairn	721·1
"	Algoma Eastern railway (under crossing) rail, 698·6; C.P.R. rail	725·9
"	Spanish river; water, Aug. 11, 1915, 646·5; rail	676·0
"	Espanola	686·8
"	Webbwood	664·8
"	Birch brook; water, Sept. 28, 1914, 589·7; rail	647·2
"	River aux Sables; water, Oct. 5, 1914, 580·2; rail	640·2
"	Massey	638·8
"	Walford	672·5
"	Spanish	609·9
"	Cutler	612·3
"	Kennabutch	644·1
"	Serpent river; water, Oct. 16, 1914, 579·3; rail	602·4
"	Spragge	600·8
"	Lauzon river; water, Oct. 24, 1914, 582·4; rail	605·1
"	Algoma	604·3
"	Blind River (station)	601·1
"	Blind river; immediately west of Blind River station; water, Oct. 27, 1914, 590·9; rail	601·4
"	Blind river; 2 miles west of Blind River station; water, Oct. 29, 1914, 590·9; rail	596·0
"	Mississagi river; water, Oct. 29, 1914, 579·0; rail	605·8
"	Dean Lake	627·4
"	Dayton	604·0
"	Livingston	645·2
"	Thessalon	656·6
"	Sherwood	597·7
"	Nestorville	620·5
"	Glen Otter	646·5
"	Bruce	680·3
"	Lake Huron and Northern Ontario railway (diamond crossing)	680·6
"	Portlock	593·6
"	Desbarats	595·3
"	Isbester	600·5
"	Bar River (station)	596·0
"	Bar river; water, May 25, 1915, 580·5; rail	596·0
"	Ekoba	591·3
"	Echo bay; water, May 26, 1915, 579·1; rail (on bridge)	597·8
"	Garden river; water, May 27, 1915, 580·5; rail	607·3
"	Garden	607·2
"	Root river; water, June 9, 1915, 580·4; rail	609·5
"	Kabosa	622·4
"	Sault Ste. Marie, Ont	635·9
"	Algoma Central railway (under crossing) rail, 594·8; C.P.R. rail	618·0
"	Canadian ship canal; water, June 12, 1915, 600·4; rail (swing bridge)	620·9

RAIL ELEVATIONS, FORT FRANCES TO PORT ARTHUR, ONT.

(Elevations taken in 1913).

		FEET
Canadian Northern Ry.—	Fort Frances	1122·3
"	Duluth Junction	1123·1
"	Rainy lake; water, Sept. 9, 1913	1108·2
"	Rocky Inlet	1136·3
"	Sims	1113·6
"	Nickel Lake	1119·0
"	Bear Pass	1153·5
"	Mine Centre	1200·7
"	Seine river, 2·4 miles west of La Seine; rail	1179·4
"	La Seine	1180·1
"	Banning	1264·0
"	Elizabeth	1282·6
"	Overflow	1280·1
"	Atikokan	1284·2
"	Atikokan river, 2 miles east of Atikokan; water, Oct. 15, 1913, 1302·8; rail	1316·0
"	Atikokan river, 2·5 miles east of Atikokan; water, Oct. 15, 1913, 1316·5; rail	1332·4
"	Atikokan river, 3·4 miles east of Atikokan; water, Oct. 15, 1913, 1345·9; rail	1355·6
"	Atikokan river, 3 miles west of Hematite; water, Oct. 14, 1913, 1356·4; rail	1368·2
"	Hematite	1368·1
"	Atikokan river, 1·2 miles east of Hematite; water, Oct. 9, 1913, 1359·6; rail	1370·0
"	Atikokan river, 2 miles east of Hematite; rail	1374·5
"	Kawene	1483·1
"	Abiwin	1439·9
"	Windigo	1486·4
"	Huronian	1570·8
"	Crayfish creek, 3 miles west of Kashabowi; water, Sept. 19, 1913, 1512·4; rail	1520·6
"	Kashabowi	1531·2
"	Kashabowi river; water, Sept. 18, 1913, 1501·3; rail	1516·8
"	Rossmere	1481·8
"	Swamp river, 1·8 miles east of Rossmere; rail	1486·1
"	Annex	1474·7
"	Mabella	1442·4
"	Shebandowan river; water, Sept. 16, 1913, 1280·7; rail	1295·5
"	Shabakwa	1242·4
"	Mattawin river, 6 miles west of Mattawin; water, Sept. 5, 1913, 1200·8; rail	1218·0
"	Mattawin	1202·0
"	Mokomon	1003·7
"	Kakabeka Falls	915·4
"	Stanley	720·6
"	Slate River	727·4
"	Twin City Junction	723·3
"	National Transcontinental railway (diamond crossing)	635·8
"	Canadian Pacific railway (diamond crossing)	635·8
"	Westfort	629·8
"	Fort William	612·8
Canadian Pacific Ry.—	Fort William	617·4
Canadian Northern Ry.—	Canadian Pacific railway (diamond crossing)	607·2
"	Port Arthur	615·0
Canadian Pacific Ry.—	Port Arthur	614·5

RAIL ELEVATIONS, STANLEY TO NORTH LAKE, ONT.

(Elevations taken in 1913).

		FEET
Canadian Northern Ry.—	Stanley	720·6
"	Flint	780·0
"	Silver Creek	808·6
"	Hymer	860·2
"	Nolalu	1055·5
"	Hillside	1096·8
"	Silver Mountain	1278·8
"	Whitefish	1340·4
"	North Lake	1567·3

RAIL ELEVATIONS, WAINWRIGHT TO EDMONTON, ALTA.

(Elevations taken in 1914).

		FEET
Grand Trunk Pacific Ry.—	Wainwright	2222·1
"	Fabyan	2138·8
"	Hawkins	2132·5
"	Irma	2244·8
"	Jarrow	2347·0
"	Kinsella	2297·4
"	Philips	2297·7
"	Viking	2267·0
"	Nestor	2253·9
"	Bruce	2240·5
"	Holden	2253·7
"	Poe	2247·3
"	Ryley	2273·1
"	Canadian Northern railway, Vegreville-Calgary line (diamond crossing)	2274·8
"	Shonts	2235·5
"	Tofield	2294·8
"	Deville	2444·2
"	Cooking Lake	2433·7
"	Uncas	2459·3
"	Ardrossan	2339·9
"	Bremner	2249·3
"	Clover Bar	2155·1
"	North Saskatchewan river; water, Oct. 14, 1914, 2000; rail	2136·7
Canadian Northern Ry.—	Edmonton	2185·4
Canadian Pacific Ry.—	Edmonton	2182·9

RAIL ELEVATIONS, CALGARY TO TOFIELD, ALTA.

(Elevations taken in 1915).

		FEET
Grand Trunk Pacific Ry.—	Calgary (temporary station)	3418·1
"	Elbow river; water, April 29, 1915, 3404·2; rail	3420·5
"	Canadian Pacific railway, Calgary-Edmonton line (diamond crossing)	3408·6
"	Bow river; water, April 29, 1915, 3365·8; rail	3404·5
"	Hubalta	3471·8
"	Conrich	3486·1
"	Delacour	3368·3
"	Kathyrn	3212·2
"	Irricana	3061·0

RAIL ELEVATIONS, CALGARY TO TOFIELD, ALTA.—*Continued.*

(Elevations taken in 1915).

		FEET
Grand Trunk Pacific Ry—	Rosebud river; water, May 20, 1915, 2996·1; rail	3018·1
"	Canadian Pacific railway, Acme branch (under crossing), rail 3013·0; G.T.P. Ry. rail	3037·1
"	Beiseker	2999·5
"	Bircham	2966·3
"	Grainger	2795·7
"	Swalwell	2951·1
"	Twining	2827·2
"	Three Hills	2935·7
"	Trochu	2859·8
"	Huxley	2878·5
"	Elnora	3039·5
"	Lousana	2938·6
"	Delburne	2837·7
"	Ardley	2758·0
"	Red Deer river; water, July 3, 1915, 2503; rail	2651·3
"	Bullocksville	2672·3
"	Canadian Northern railway, branch from Warden (overhead crossing); G.T.P. Ry. rail	2623·3
"	Alix	2615·1
"	Canadian Pacific railway, Lacombe–Coronation line (diamond crossing)	2610·2
"	Mirror	2605·8
"	Bashaw	2602·3
"	Dorenlee	2537·1
"	Ferintosh	2478·4
"	New Norway	2460·5
"	Duhamel	2432·5
"	Battle river; water (flood), July 28, 1915, 2261; rail	2376·0
"	Olin	2458·1
"	Camrose	2430·4
"	Canadian Pacific railway, Portage-la-Prairie–Wetaskiwin line (diamond crossing)	2431·6
"	Canadian Northern railway, Camrose–Strathcona line (diamond crossing)	2417·7
"	Dinant	2476·5
"	Kingman	2426·5
"	Bardo	2405·3
"	Tofield	2296·1

RAIL ELEVATIONS, CALGARY, ALTA., TO FIELD, B.C.

(Elevations taken in 1915).

		FEET
Canadian Pacific Railway.—	Calgary	3439·4
"	Brickburn	3487·2
"	Bow river (mileage 7·7 from Calgary); water, May 19, 1915, 3500·8; rail	3521·5
"	Bow river (mileage 7·8 from Calgary); water, May 19, 1915, 3501·5; rail	3523·8
"	Keith	3565·5
"	Bearspaw	3626·8
"	Glenbow	3688·5
"	Cochrane	3760·8
"	Bow river (mileage 25·7 from Calgary); water, May 11, 1915, 3701·7; rail	3728·1
"	Mitford	3735·4
"	Radnor	3897·3
"	Cheneka	4015·5
"	Morley	4079·0
"	Ozada	4164·9

RAIL ELEVATIONS, CALGARY, ALTA., TO FIELD, B.C.—*Continued.*
(Elevations taken in 1915).

		FEET
Canadian Pacific Railway.—	Kananaskis river (mileage 51·9 from Calgary); water, May 29, 1915, 4194·8; rail	4218·0
"	Seebe	4219·1
"	Bow river (mileage 53·1 from Calgary); water, June 8, 1915, 4199·6; rail	4214·8
"	Kananaskis	4232·8
"	Exshaw	4261·2
"	Gap	4248·7
"	Canmore	4296·9
"	Duthil	4362·1
"	Bow river (mileage 73·1 from Calgary); water, June 14, 1915, 4359·9; rail	4374·9
"	Anthracite	4500·3
"	Devils Head creek (mileage 78·4 from Calgary); water, June 29, 1915, 4538·0; rail	4548·9
"	Bankhead	4584·3
"	Banff	4538·2
"	Echo river (mileage 82·1 from Calgary); water, June 22, 1915, 4524·3; rail	4534·3
"	Sawback	4549·9
"	Massive	4592·8
"	Mount Castle	4676·4
"	Eldon	4829·2
"	Temple	4925·0
"	Lake Louise	5051·0
"	Bow river (mileage 117·6 from Calgary); water, July 20, 1915, 5064·1; rail	5074·9
"	"The Great Divide" (rail)	5338·9
"	Stephen	5332·3
"	Hector	5220·0
"	Kicking Horse river (mileage 125·5 from Calgary); water, July 26, 1915, 5201·6; rail	5212·0
"	Kicking Horse river (mileage 125·9 from Calgary); water, July 26, 1915, 5173·0; rail	5179·9
"	Yoho	4725·0
"	Kicking Horse river (mileage 131·7 from Calgary); water, Aug. 2, 1915, 4512·1; rail	4566·6
"	Cathedral	4501·8
"	Field	4076·1

RAIL ELEVATIONS, VANCOUVER, B.C., TO BLAINE, WASH.

(Elevations taken in 1914).

		FEET
Canadian Pacific Railway—	Vancouver	17·5
Great Northern Railway—	Vancouver	16·3
"	Still Creek	100·4
"	Ardley	54·7
"	B. C. Electric railway (diamond crossing)	53·9
"	Burnaby	54·6
"	B. C. Electric railway (diamond crossing)	16·0
"	Sapperton	14·4
"	New Westminster	34·0
Canadian Pacific Railway—	New Westminster	11·3
Great Northern Railway—	Canadian Pacific railway (under crossing) rail 11·6; G. N. R. rail	34·3
"	Fraser river bridge, rail	33·9
"	Townsend	15·0
"	Colebrook	8·1
"	Crescent	17·7
"	Ocean Park	17·6
"	White Rock	14·7

RAIL ELEVATIONS, COLEBROOK TO HUNTINGDON, B.C.

(Elevations taken in 1914).

		FEET
Great Northern Railway—	Colebrook	8·1
"	Alluvia	5·5
"	Cloverdale	6·4
"	Lincoln	183·2
"	Otter	304·0
"	Aldergrove	344·2
"	Pinegrove	267·2
Canadian Pacific Railway—	Abbotsford	87·8
Great Northern Railway—	Abbotsford	139·1
"	Junction with Kilgard branch	123·6
"	Huntingdon	45·2

INDEX.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.

Note.—Under "Year of Publication,"

1910 refers to Appendix No. 5 to the Chief Astronomer's Report for 1910.

1913* refers to Vol. I, No. 2, on Precise Levelling.

1913 refers to Vol. I, No. 3, on Precise Levelling.

1914 refers to Vol. I, No. 8, on Precise Levelling.

1915 refers to Vol. II, No. 1, on Precise Levelling.

1916 refers to the present publication.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	B.			
Bala, Ont	408	1913	66	86
Banff, Alta	240–C, 241–C	1916	167	188
Barons, Alta	76–D, 77–D	1915	25	38
Barrington, N.S	444–B	1915	12	29
Barrington Passage, N.S	446–B	1915	12	29
Barrys Bay, Ont	523	1915	16	32
Bashaw, Alta	65–F	1916	165	187
Bath, N.B	35–B	1910	448	461
Bayfield, N.S	177–B	1913	48	75
Beamsville, Ont	204	1913	63	85
Beaudette, Minn	16–E	1914	226	239
Bedford, Que	66	1910	453	464
Bedford, N.S	506–B	1916	144	171
Beecher Falls, Vt	562–B	1916	153	180
Beeton, Ont	379	1913	64	86
Beiseker, Alta	48–F	1916	164	187
Belgrave, Ont	316	1913	61	83
Belle River, Ont	252	1913	57	81
Belleville, N.S	459–B	1915	13	30
Belleville, Ont	156, 157	1910	459	467
Bennett, Y.T	32–R	1913*	23	23
Benton, N.B	18–B	1910	447	460
Berwick, N.S	488–B	1916	148	175
Bethune, Sask	9–D	1913	71	90
Bienfait, Sask	61–C	1913	69	88
Biggar, Sask	12–H	1915	20	34
Blackie, Alta	63–D	1915	26	38
Bladworth, Sask	19–D	1914	227	240
Blaine, Wash	19–J	1916	169	190
Blind River, Ont	604, 605	1916	156	181
Bloomfield, N.B	111–B	1913	44	73
Bluevale, Ont	313	1913	61	83
Blyth, Ont	317	1913	61	83
Boharm, Sask	106–C	1914	229	241
Boiestown, N.B	33–G	1916	151	178
Boissevain, Man	31–C, 32–C	1913	67	87
Bolton, Ont	260	1913	58	82, 86
Bothwell, Ont	243	1913	57	81
Boundary Creek, N.B	128–B	1913	45	73
Bow Island, Alta	178–C, 179–C	1915	23	35
Bowmanville, Ont	177	1913	54	79
Braeburn, Y.T	57	1913*	27	27
Brant, Alta	65–D	1915	26	38
Brantford, Ont	219, 220	1913	55	80

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Bridgeburg, Ont	215–A	1913	64	85
Bridgewater, N.S.	409–B *to* 411–B	1915	10	28
Brierly Brook, N.S.	170–B	1913	47	74
Brigham Jct., Que.	60	1910	452	463
Brighton, Ont	163	1910	460	467
Bristol, N.B.	34–B	1910	448	461
Brockville, Ont	123	1910	458	466
Brome, Que	50	1910	454	464
Bruce, Alta	45–H	1916	162	186
Bruce Mines, Ont	619	1916	156	182
Brucefield, Ont	329	1913	62	84
Brunswick Jct., N.B.	6–B	1910	446	460
Brussels, Ont	312	1913	61	83
Burdett, Alta	180–C, 181–C	1915	23	35, 36
Burlington Jct., Ont	196	1913	55	80
Bury, Que	13–A–2	1913	49	76
	C.			
Calais, Maine	1–B	1910	446	460
Caldwell, Ont	512	1915	16	32
Caledon, Ont	265	1913	58	82
Calgary, Alta	50–D, 51–D, 52–D	1915	27	39
" "	39–F	1916	163	187
" "	217–C, 218–C	1916	166	188
Cambridge, N.S.	490–B	1916	148	175
Campbellton, N.B.	25–G, 26–G	1916	151	177
Camrose, Alta	70–F, 71–F	1916	165	187
Canmore, Alta	235–C	1916	167	188
Canterbury, N.B.	16–B	1910	447	460
Capelton, Que	26	1913	48	75
Cariboo, Y.T.	18–R	1913*	24	24
Carievale, Sask	49–C	1913	68	88
Carmangay, Alta	73–D, 74–D	1915	25	38
Carnduff, Sask	50–C	1913	68	88
Caron, Sask	108–C	1914	229	241
Cartwright, Man	20–C	1913	67	87
Cascades, Que	467	1914	218	234
Chamberlain, Sask	12–D	1913	72	90
Champion, Alta	71–D	1915	26	38
Chaplin, Sask	113–C	1914	229	241
Chatham, Ont	246–A, 247, 247–A	1913	57	81
" "	373, 247	1914	222	236
Chatham, N.B.	49–G	1916	152	178

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Chatsworth, Ont.	283	1913	59	82
Chauvin, Alta.	30–H	1915	21	34
Chelsea, Que.	464	1914	218	234
Chesley, Ont.	295, 296.	1913	60	83
Chester, N.S.	401–B	1915	10	28
Chesterville, Ont.	107	1910	457	466
Chin, Alta.	191–C	1915	23	36
Chipman, N.B.	352–B	1914	216	233
Clarkson, Ont.	192	1913	55	80
Clarksville, N.S.	520–B, 521–B	1916	145	171
Clinton, Ont.	320, 321	1913	62	83
Cloverdale, B.C.	20–J, 21–J	1916	169	191
Coaticook, Que.	14, 15, 16	1910	455	465
Coblenz, Sask.	17–H	1915	20	34
Cobourg, Ont.	171	1913	53	79
Cochrane, Alta.	222–C, 223–C	1916	166	188
Colborne, Ont.	166	1910	460	467
Coldbrook, N.S.	491–B	1916	148	175
Coldwater, Ont.	399–A	1913	65	86
Collins Bay, Ont.	144	1910	459	467
Compton, Que.	10	1910	455	465
Condie, Sask.	5–D	1913	71	90
Conn Mills, N.S.	139–B	1913	46	74
Cookshire, Que.	10–A–3, 11–A	1913	49	76
Copetown, Ont.	216–A	1913	55	80
Corbetton, Ont.	273	1913	59	82
Cornwall, Ont.	489, 490, 491	1914	219	235
Corunna, Ont.	361	1914	221	236
Coteau Jct., Que.	90	1910	456	466
Courtright, Ont.	363	1914	222	236
Coutts, Alta.	216–C†	1915	25	37
Craighurst, Ont.	392	1913	65	86
Craik, Sask.	16–D	1913	72	90
Crysler, Ont.	496	1914	220	235
Crystal City, Man.	16–C	1913	67	87
	D.			
Dalhousie Mills, Ont.	95	1910	456	466
Dauntless, Alta.	171–C	1915	22	35
Davidson, Sask.	18–D	1914	227	240
Dawson, Y.T.	223, 224	1913*	34	34
Dean Lake, Ont.	609	1916	156	182

†Also B.M. in International Boundary Monument.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of* Publication.	Description.	Elevation.
			Page.	Page.
Debec Jct., N.B.	20–B	1910	447	460
Delburne, Alta.	59–F	1916	165	187
Deloraine, Man.	36–C	1913	68	88
Denfield, Ont.	338	1913	62	84
Denmark, N.S.	149–B	1913	46	74
Depot Harbour, Ont.	566, 567	1915	13	31
Derby Jct., N.B.	47–G–2	1916	152	178
Desbarats, Ont.	622	1916	157	182
Devlin, Ont.	27–E	1914	226	239
Dinant, Alta.	73–F	1916	165	187
Disley, Sask.	8–D	1913	71	90
Doaktown, N.B.	37–G	1916	151	178
Dobbinton, Ont.	294	1913	60	83
Dorchester, N.B.	DCCCLXXXIX, *etc*	1916	‡	174
Dorenlee, Alta.	66–F	1916	165	187
Dresden, Ont.	370	1914	222	236
Drinkwater, Sask.	91–C	1913	70	89
Drummondville Jct., Que.	51	1910	454	464
Duck Lake, Sask.	42–D	1914	228	240
Dundalk, Ont.	274	1913	59	82
Dundas, Ont.	215	1913	55	80
Dundurn, Sask.	25–D	1914	227	240
Dunmore, Alta.	165–C	1915	22	35
	E.			
Eady, Ont.	398	1913	65	86
Eastman Jct., Que.	44	1910	452	463
East Pubnico, N.S.	453–B	1915	13	29
Eastwood, Ont.	225	1913	55	80
Echo Bay, Ont.	626	1916	157	182
Edgerton, Alta.	33–H	1915	21	34
Edmonton, Alta.	58–H *to* 61–H	1916	163	186
Edmundston, N.B.	58–B, 59–B, 60–B	1910	449	461
Eganville, Ont.	514	1915	16	32
Ekoba, Ont.	626	1916	157	182
Elmwood, Ont.	297	1913	60	83
Elva, Man.	44–C	1913	68	88
Embrun, Ont.	498	1914	220	235
Emerson, Man.	3–C	1913	66	87
Emo, Ont.	23–E, 24–E	1914	226	239
Ensign, Alta.	66–D	1915	26	38
Ernestown, Ont.	146	1910	459	467
Ernfold, Sask.	115–C	1914	229	241
Estevan, Sask.	62–C, 63–C	1913	69	88

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Eureka, Y.T.	187	1913*	33	33
Exeter, Ont.	332, 333	1913	62	84
	F.			
Fairville, N.B.	96–B	1910	451	462
Farnham Que.	62	1910	452	464
" "	63, 64	1910	453	464
Ferintosh, Alta.	67–F	1916	165	187
Field, B.C.	260–C	1916	168	189
Finch, Ont.	105	1910	457	466
" "	495	1914	219	235
Findlater, Sask.	11–D	1913	72	90
Flesherton, Ont.	277	1913	59	82
Forest, Ont.	351	1914	221	236
Fort Erie, Ont.	215–A	1913	64	85
Fort Frances, Ont.	29–E, 30–E	1914	226	239
Fort William, Ont.	90–E *to* 92–E	1916	161	184
Foster, Que.	47	1910	452	463
French Village, N.S.	393–B	1915	9	28
Frobisher, Sask.	58–C	1913	69	88
Fulford, Que.	56	1910	452	463
	G.			
Gainsborough, Sask.	47–C	1913	68	88
Girvin, Sask.	17–D	1913	72	90
Glacier, Y.T.	266	1913*	36	36
Glencoe, Ont.	241, 241–A	1913	56	81
Glen Ewen, Sask.	52–C	1913	68	88
Goderich, Ont.	325, 326, 327	1913	62	83, 84
Goodlands, Man.	38–C	1913	68	88
Gracefield, Que.	484	1914	219	234
Graceton, Minn.	14–E	1914	226	239
Grafton, Ont.	168	1913	53	79
Grainger, Alta.	50–F	1916	164	187
Grand Coulée, Sask.	101–C	1913	71	89
Grand Falls, N.B.	46–B	1910	448	461
Grand Ligne, Que.	78	1910	456	463
Grand Pré, N.S.	498–B	1916	149	175
Grandora, Sask.	3–H	1915	19	34
Grassy Lake, Alta.	182–C, 183–C	1915	23	36
Green River, N.B.	54–B	1910	449	461
Green Valley, Ont.	97	1910	456	466
Gretna, Man.	4–C	1913	66	87
Grimsby, Ont.	203	1913	63	85
Gull Lake, Sask.	136–C	1914	230	241

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	K.			
Kakabeka Falls, Ont	85-E	1916	161	184
Kazabazua, Que	479	1914	218	234
Kearney, Ont	552	1915	14	31
Keewatin, Ont	34-F	1915	19	33
Kempton, Ont	113	1910	457	466
Kemptville, Ont	113-A	1913	52	78
Kenaston, Sask	21-D	1914	227	240
Kennetcook, N.S	523-B, 524-B	1916	145	171
Kenora, Ont	36-F, 37-F, 38-F	1915	19	33
Kentville, N.S	492-B *to* 494-B	1916	148	175
Kilburn, N.B	37-B	1910	448	461
Killaloe, Ont	518, 519	1915	16	32
Killarney, Man	25-C	1913	67	87
Kingston, N.S	486-B	1916	148	175
Kingston, Ont	139, 141, 141-A, 142	1910	459	467
Kipp, Alta	81-D	1915	25	38
Kippen, Ont	330	1913	62	84
Kirkcaldy, Alta	70-D	1915	26	38
Kirk Ferry, Que	465, 466	1914	218	234
Kleinburg, Ont	258	1913	58	82
Knowlton, Que	49	1910	454	464
Komoka, Ont	237-A	1913	56	80
	L.			
Lake Louise, Alta	248-C, 249-C	1916	167	189
Landis, Sask	16-H	1915	20	34
Lansdowne, Ont	130, 131	1910	458	466
Leckford, Sask	41-D	1914	228	240
Leney, Sask	8-H	1915	19	34
Lennoxville, Que	6	1910	454	465
Lepreau, N.B	89-B	1910	451	462
Lethbridge, Alta	196-C *to* 200-C	1915	24	36
" "	83-D	1915	25	38
Levis,, Que	221-B, 222-B	1913	52	77
"	222-B	1916	153	179
Listowel, Ont	307, 308	1913	61	83
Little River, Y.T	34	1913*	26	26
Liverpool, N.S	418-B, 419-B, 420B	1915	11	29
Londesborough, Ont	318	1913	61	83
London, Ont	235, 236	1913	56	80
Londonderry, N.S	CMLXXIX	1916	‡	172
Longwood, Ont	239-A	1913	56	81

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Lousana, Alta	58-F	1916	165	187
Low, Que	476	1914	218	234
Lower Argyle, N.S.	455-B	1915	13	30
Lower East Pubnico, N.S.	452-B	1915	12	29
Lucan Crossing, Ont	337	1913	62	84
Lumsden, Sask	7-D	1913	71	90
Lyn, Ont	125	1910	458	466
Lynden, Ont	217	1913	55	80
Lyon Brook, N.S.	156-B	1913	47	74
	M.			
Maccan, N.S.	CMXVI	1916	‡	173
Macoun, Sask	69-C	1913	69	89
Madawaska, Ont	530, 531	1915	15	32
Magog, Que	40, 41, 41-A	1910	453	463
Maitland, Ont	121	1910	458	466
Malagash, N.S.	144-B	1913	46	74
Mallorytown, Ont	128	1910	458	466
Manitou, Man	11-C, 12-C	1913	66	87
Maple Creek, Sask	145-C, 146-C	1914	231	241
Markdale, Ont	279	1913	59	82
Marysville, Ont	152	1910	459	467
Massawippi, Que	28-A	1913	48	75
Massey, Ont	590	1916	155	181
Mather, Man	17-C	1913	67	87
McAdam Jct., N.B.	11-B	1910	447	460
McGivney Jct., N.B	333-B	1914	215	233
Meadowville, N.S.	153-B	1913	46	74
Medicine Hat, Alta	167-C, 168-C, 169-C	1915	22	35
Medora, Man	40-C	1913	68	88
Medway, N.S.	415-B	1915	10	28
Megantic, Que	21-A-2, 22-A	1913	50	76
Melancthon, Ont	271-A, 272	1913	59	82
Melita, Man	42-C, 43-C	1913	68	88
Memramcook, N.B.	549-B	1916	146	174
Merigomish, N.S.	164-B	1913	47	74
Merritton, Ont	209	1913	63	85
Midale, Sask	71-C	1913	69	89
Middleton, N.S.	482-B, 483-B	1916	148	175
Midhurst, Ont	390	1913	65	86
Midnapore, Alta	54-D	1915	27	39
Milan, Que	18-A-2	1913	50	76
Milestone, Sask	85-C	1913	70	89
Milk River, Alta	213-C, 214-C	1915	25	37

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Millerton, N.B.	47–G	1916	152	178
Mine Centre, Ont.	42–E	1916	158	183
Minto, Y.T.	106	1913*	30	30
Mirror, Alta.	63–F	1916	165	187
Molson, Man.	10–F	1915	17	33
Monckland, Ont.	102	1910	457	466
Moncton, N.B.	132-B, 133-B, 134-B	1913	45	73
" "	373-B, 374-B, 132-B	1914	217	233
" "	132–B	1916	146	174
Montague, Y.T.	69	1913*	28	28
Mooretown, Ont.	362	1914	221	236
Moosejaw, Sask.	94–C, 95–C, 96–C	1913	71	89
" "	103–C	1914	229	241
Morden, Man.	7–C, 8–C.	1913	66	87
Morse, Sask.	116–C, 117–C	1914	229	241
Mortlach, Sask.	110–C	1914	229	241
Mountain, Ont.	111	1910	457	466
Mulgrave, N.S.	185–B	1913	48	75
Muniac, N.B.	37–B	1910	448	461
Murrayville, B.C.	23–J	1916	170	191
Musquash, N.B.	91–B, 92–B	1910	451	462
Mystic, Que.	65	1910	453	464
	N.			
Nairn, Ont.	579, 580	1916	154	181
Napadogan, N.B.	323–B, 324–B	1914	215	232
Napanee, Ont.	149, 150	1910	459	467
Napinka, Man.	41–C	1913	68	88
Nappan, N.S.	CMXIX	1916	‡	173
Nauwigewauk, N.B.	107–B	1913	44	73
Nelson Jct., N.B.	47–G–2	1916	152	178
Newbury, Ont.	242	1913	56	81
Newcastle, Ont.	176	1913	53	79
New Dayton, Alta.	206–C, 207–C	1915	24	36
New Germany, N.S.	469–B–2	1916	147	175
New Glasgow, N.S.	160–B	1913	47	74
New Norway, Alta.	68–F	1916	165	187
New Westminster, B.C.	9–J *to* 13–J	1916	169	190
Nictaux, N.S.	480–B	1916	148	175
Ninga, Man.	29–C	1913	67	87
Nobleford, Alta.	79–D	1915	25	38
Nordenskiöld, Y.T.	47	1913*	27	27
Northfield, Ont.	494	1914	219	235
North Lake, Ont.	106–E	1916	162	185
North Portal, Sask.	†	1913	88	88
Northwood, Ont.	245	1913	57	81
Norton, N.B.	113–B	1913	44	73
Norton Mills, Vermont	23, 24, 25	1910	455	465
Notre-Dame-du-Lac, Que.	64–B	1910	449	461

‡ Refer to Public Works Dept.

†International Boundary Monument.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
	O.		Page.	Page.
Oak Bay, N.B.	4–B	1910	446	460
Oakville, Ont.	193	1913	55	80
Oban, Sask.	14–H	1915	20	34
Okotoks, Alta.	60–D	1915	26	38
Orangeville, Ont.	267	1913	58	82
Osgoode, Ont.	117–A, 118–A	1913	52	78
Oshawa, Ont.	178–A, 179, 179–A	1913	54	79
Osler, Sask.	36–D	1914	228	240
Ottawa, Ont.	125–A	1913	53	78
" "	503, 504	1914	220	235
Owen Sound, Ont.	286, 287, 288	1913	60	82
Oxbow, Sask.	55–C	1913	69	88
Oxford, Ont.	114	1910	457	466
Oxford, N.S.	136–B	1913	46	74
Oxford Jct., N.S.	135–B	1913	45	74
" "	135–B	1916	146	173
	P.			
Painsec, N.B.	MDXLIII	1916	‡	174
Palgrave, Ont.	376	1913	64	86
Palmerston, Ont.	305	1913	61	83
Paquette, Que.	557–B	1916	153	180
Paris, Ont.	222	1913	55	80
Parkbeg, Sask.	111–C	1914	229	241
Park Head Jct., Ont.	291	1913	60	83
Parkhill, Ont.	346	1914	221	236
Parry Sound, Ont.	419, 420	1914	223	237
Pasqua, Sask.	93–C	1913	71	89
Pelly, Y.T.	118, 119	1913*	30	30
Pense, Sask.	99–C	1913	71	89
Perth, N.B.	39–B	1910	448	461
Petitcodiac, N.B.	123–B	1913	45	73
Piapot, Sask.	141–C	1914	231	241
Pickering, Ont.	180–A–2	1913	54	79
Piedmont, N.S.	165–B	1913	47	74
Pierson, Man.	46–C	1913	68	88
Pike Creek, Ont.	253	1913	57	81
Pilot Mound, Man.	15–C	1913	67	87
Pinewood, Ont.	20–E	1914	226	239
Pinto, Sask.	67–C	1913	69	88
Plaster Rock, N.B.	301–B, 302–B	1914	213	232
Pomquet, N.S.	176–B	1913	48	74
Port Arthur, Ont.	93–E *to* 95–E	1916	161	184

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Port Clyde, N.S.	442–B	1915	12	29
Port Hope, Ont	172, 172–A, 173	1913	53	79
Port Robinson, Ont	212	1913	63	85
Port Saxon, N.S.	441–B	1915	12	29
Port Union, Ont	182	1913	54	79
Prescott, Ont	119	1910	458	466
Prince Albert, Sask	47–D, 48–D, 49–D	1914	228	240
Princeton, Ont	224	1913	55	80
Pubnico, N.S.	454–B	1915	13	30
	Q.			
Quarryville, N.B	45–G	1916	152	178
	R.			
Rainy River, Ont	17–E	1914	226	239
Reford, Sask	18–H	1915	20	34
Regina, Sask	1–D, 2–D, 3–D	1913	71	90
Renfrew, Ont	505, 506, 507	1915	17	32
River Glade, N.B.	125–B	1913	45	73
Rivière-du-Loup, Que	76–B, 77–B, 78–B	1910	450	461
Roche-Percée, Sask	65–C	1913	69	88
Rock Island, Que	33–A	1913	49	75
Roosevelt, Minn	13–E	1914	226	239
Rose Point, Ont	565	1915	13	31
Rosthern, Sask	40–D	1914	228	240
Rothesay, N.B.	103–B, 104–B	1913	44	73
Rouleau, Sask	88–C, 89–C	1913	70	89
Rush Lake, Sask	120–C	1914	230	241
Russell, Ont	499	1914	220	235
Ryley, Alta	47–H, 48–H	1916	163	186
	S.			
Sable River, N.S	427–B	1915	11	29
Sackville, N.B.	MCCCCXXXVI, *etc.*	1916	‡	174
Sandstone, Alta	58–D	1915	26	38
Sarnia, Ont	357, 358, 359, 360	1914	221	236
Saskatoon, Sask	29–D *to* 33–D	1914	227, 228	240
Sault Ste. Marie, Ont	632, 633	1916	157	182
Sault Ste. Marie, Mich	636	1916	157	182
Sawyerville, Que	552–B	1916	153	180
Scotia Jct., Ont	553	1915	14	31

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ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Scotstown, Que	16–A–2	1913	49	76
Scott, Sask	19–H	1915	20	34
Shag Harbour, N.S.	449–B	1915	12	29
Shallow Lake, Ont	290	1913	60	83
Shannonville, Ont	154	1910	459	467
Shelburne, N.S.	433–B *to* 436–B	1915	11, 12	29
Shelburne, Ont	271	1913	59	82
Sherbrooke, Que	1, 2, 3	1910	454	465
" "	35, 36	1910	453	463
Sigas, N.B.	51–B	1910	449	461
Slate River, Ont	87–E	1916	161	184
South Maitland, N.S.	528–B, 529–B	1916	145	172
South Stukely, Que	45	1910	452	463
Sprague, Man	10–E	1914	225	239
Springfield, N.S.	472–B	1916	147	175
Springhill, Que	19–A–2, 20–A	1913	50	76
Springhill Jct., N.S.	CMX	1916	‡	173
Sprucedale, Ont	556	1915	14	31
Stanbridge, Que	67	1910	453	464
Stanley, Ont	86–E	1916	161	184
Stanstead, Que	34	1913	49	75
Steelton, Ont	634, 635	1916	157	182
Stephen, Minnesota	1–C	1913	66	87
Stevens, Y.T.	148	1913*	31	31
Stewart Crossing, Y.T.	162, 163	1913*	32	32
Stickney, N.B.	32–B	1910	448	461
Stirling, Alta	203–C, 204–C	1915	24	36
Stoney Creek, Ont	201	1913	63	85
Stoney Point, Ont	250	1913	57	81
Stottsville, Que	79	1910	456	463
Sudbury Ont	454, 454–A	1914	225	238
" "	567–A	1916	154	181
Sussex, N.B.	117–B	1913	44	464
Sutton, Que	52	1910	454	73
Swalwell, Alta	51–F	1916	164	187
Swift Current, Sask	126–C, 127–C	1914	230	241
	ST.			
St. Anselme, Que	214–B	1913	52	77
St. Armand, Que	68, 69, 70	1910	453	464
St. Catharines, Ont	207, 208	1913	63	85
St. Evariste, Que	195–B, 196–B	1913	51	77
St. George, N.B.	83–B	1910	451	462

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ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Ste. Henedine, Que	212–B	1913	52	77
St. Henri, Que. (Levis County)	216–B	1913	52	77
St. Honoré, Que	70–B	1910	450	461
St. John, N.B	97–B *to* 100–B	1910	452	462
St. Johns, Que	75	1910	452	463
" "	76	1910	455	463
St. Joseph-de-Lévis, Que	220–B	1913	52	77
St. Louis, Que. (Beauharnois County)	88	1910	456	466
St. Malo, Que. (Compton County)	555–B	1916	153	180
St. Margaret, N.S	394–B	1915	9	28
St. Mary, Que. (Beauce County)	209–B	1913	51	77
St. Polycarpe Jct., Que	92	1910	456	466
Ste. Rose, Que. (Temiscouata County)	62–B	1910	449	461
St. Stephen, N.B	2–B, 3–B	1910	446	460
	T.			
Taber, Alta	186–C, 187–C	1915	23	36
Takhini, Y.T	20, 21	1913*	25	25
Tako, Sask	20–H	1915	20	34
Tara, Ont	293	1913	60	83
Tatamagouche, N.S	147–B	1913	46	74
Thamesville, Ont	243–A	1913	57	81
Thedford, Ont	349	1914	221	236
Thornhill, Man	9–C	1913	66	87
Thorold, Ont	210, 211	1913	63	85
Three Hills, Alta	53–F	1916	164	187
Tofield, Alta	50–H, 51–H	1916	163	186
Tompkins, Sask	138–C	1914	231	241
Toronto, Ont	185 *to* 189	1913	54	79
Tottenham, Ont	377–A	1913	64	86
Trenton, Ont	161	1910	460	467
Tring Jct., Que	204–B	1913	51	77
Trochu, Alta	55–F	1916	164	187
Truro, N.S	534–B *to* 537–B	1916	146	172
Tupperville, Ont	369	1914	222	236
Tusket, N.S	460–B	1915	13	30
	U.			
Unity, Sask	22–H	1915	20	34
Upper Woods Harbour, N.S	451–B	1915	12	29
Utopia, Ont	387	1913	65	86

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	V.			
Valleyfield, Que	89	1910	456	466
Valley Jct., Que	207-B	1913	51	77
Vancouver, B.C	1-J *to* 5-J	1916	168	190
Vera, Sask	23-H	1915	20	34
Versailles, Que	72	1910	452	463
Viking, Alta	43-H	1916	162	185
Vulcan, Alta	68-D, 69-D	1915	26	38
	W.			
Wainwright, Alta	36-H	1915	21	34
Wakefield, Que	469, 470	1914	218	234
Wallaceburg, Ont	367	1914	222	236
Walsh, Alta	155-C	1915	22	35
Warman, Sask	35-D	1914	228	240
Warner, Alta	209-C, 210-C	1915	24	36, 37
Warroad, Minn	12-E	1914	226	239
Waterville, N.S	489-B	1916	148	175
Waterville, Que	9	1910	455	465
Webb, Sask	132-C	1914	230	241
Webbwood, Ont	585	1916	155	181
Welland, Ont	213	1913	64	85
Welland Jct., Ont	214	1913	64	85
Westchester, N.S	CMLX	1916	‡	172
Westfort, Ont	89-E	1916	161	184
West Merigomish, N.S	163-B	1913	47	74
Weston, Ont	256-A	1913	58	82
Weyburn, Sask	80-C, 81-C	1913	70	89
Whitby, Ont	180-A	1913	54	79
Whitehorse, Y.T	1	1913*	25	25
Whitemouth, Man	14-F	1915	18	33
White Pass, Y.T	42-R, 43-R	1913*	23	23
Whiterock, B.C	17-J, 18-J	1916	169	190
Whitewater, Man	35-C	1913	68	88
Whitney, Ont	536	1915	15	31
Wilcox, Sask	86-C, 87-C	1913	70	89
Wilmot, N.S	485-B	1916	148	175
Winchester, Ont	109	1910	457	466
Windsor, Ont	255	1913	57	81
Windsor, N.S	502-B *to* 505-B	1916	149	176
Windsor Jct., N.S	MXXXIV	1916	‡	171
Wingham, Ont	314	1913	61	83

‡Refer to Public Works Dept.

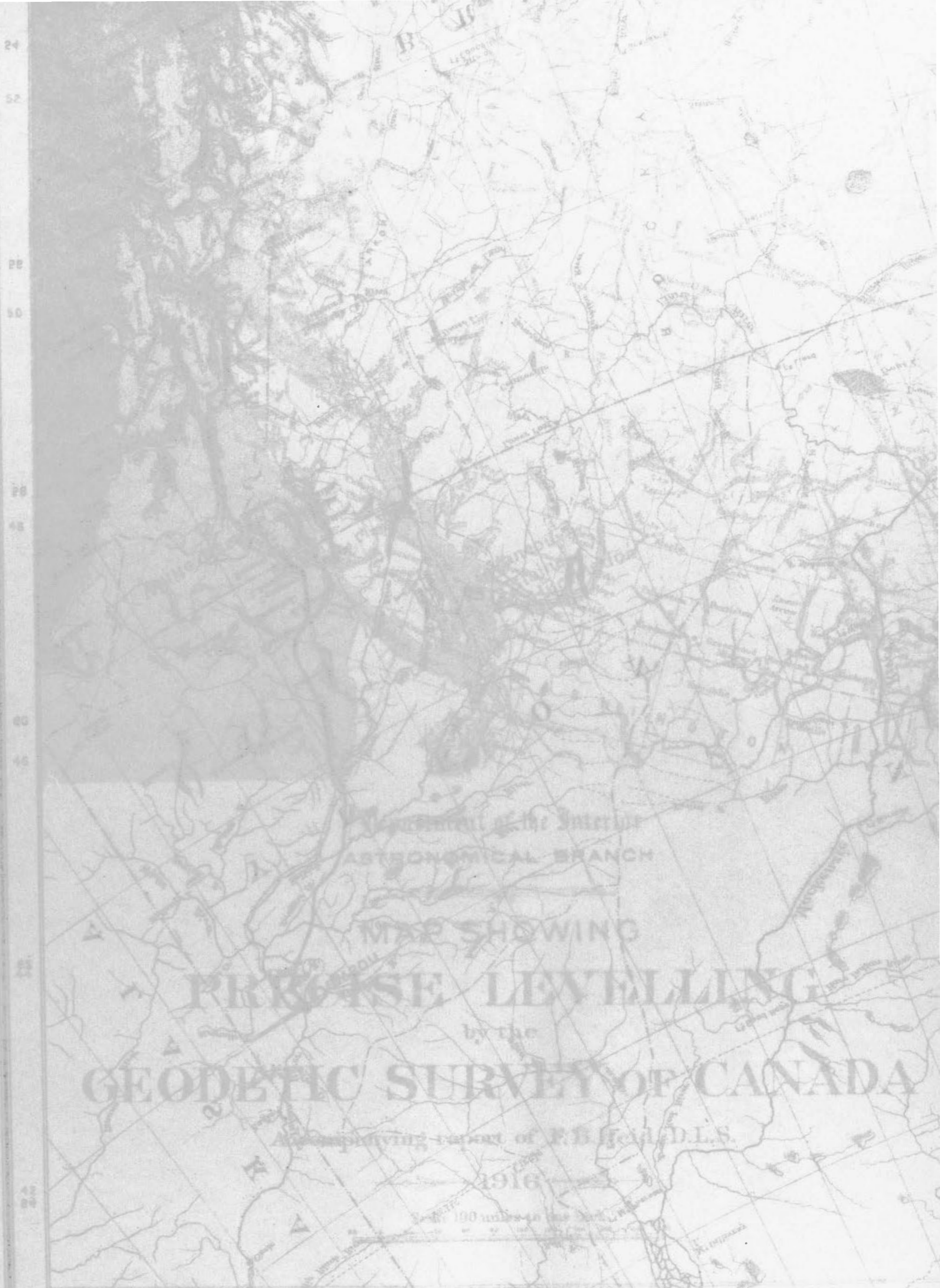
ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Concluded.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Winnifred, Alta	176–C	1915	23	35
Winnipeg, Man	1–F, 2–F, 3–F	1915	17	33
Winona, Ont	202	1913	63	85
Winter, Sask	25–H	1915	20	34
Wolfville, N.S	495–B *to* 497–B	1916	148, 149	175
Woodstock, Ont	226, 227	1913	55	80
Woodstock, N.B	25–B, 26–B, 27–B	1910	447	460
Worthington, Ont	577	1916	154	181
Wounded Moose, Y.T	179	1913*	33	33
	Y.			
Yarmouth, N.S	463-B, 464-B, 465-B	1915	13	30
Yellow Grass, Sask	83–C	1913	70	89
Yukon Crossing, Y.T	94	1913*	29	29
	Z			
Zumbro, Sask	27–H	1915	20	34

Dominion Observatory,

Ottawa,

February, 1916


Department of the Interior
ASTRONOMICAL BRANCH
MAP SHOWING
PRECISE LEVELLING
by the
GEODETIC SURVEY OF CANADA
Accompanying report of F.B. Reid, D.L.S.
1916
Scale 100 miles to one inch

DEPARTMENT OF THE INTERIOR
CANADA

HON. W. J. ROCHE, *Minister*. W. W. CORY, C.M.G., *Deputy Minister*.

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

W. F. KING, C.M.G., LL.D., *Director*.

Vol. III, No. 7

Orbit of the Spectroscopic Binary 14 Aurigæ

BY

W. E. HARPER, M.A.

OTTAWA
GOVERNMENT PRINTING BUREAU
1916

1457—1

ORBIT OF THE SPECTROSCOPIC BINARY 14 AURIGÆ.

BY W. E. HARPER, M.A.

No measures of this star ($\alpha = 5^h\ 09^m$, $\delta = +32°\ 35'$) have been previously published. It was placed on our programme last January on the suggestion of Professor Frost, director of the Yerkes observatory, who noted it as "probably a spectroscopic binary." Shortly afterwards he sent us the velocities of their five plates which showed a range of variation of 40 km., and its discovery as a spectroscopic binary is therefore due to the Yerkes observatory.

The approximate period of the star had been obtained when the Yerkes' results were received. This period of 3·78 days, modified to 3·789 by the Yerkes' results and additional plates of our own, suits all the observations except the first one taken at the Yerkes observatory. Professor Frost, with his usual kindness in such matters, has re-measured this plate which he states to be of good quality. The mean of their two measures, which differ very little, is still about 13 km. too positive for our curve. Allowing for a possible systematic difference of 3 km. between our observations there is still a residual of 10 km. This is larger than is natural to expect in a star of type A2, whose lines are much better than the average. A value of the period of 3·7898 days suits the Yerkes' results much better, but our own not so well, which are probably best satisfied by a period of 3·7885 days. I have, therefore, a rounded off value of 3·789 days as a compromise between these two extremes.

There is a suspicion, from the way the observations group themselves in some of the periods tested, that the spectrum of the component star is bright enough to influence the measures, causing the well known blend effect. As the range in the variation of the primary is barely over 40 km., it would be hopeless to expect to separate the component spectra with our single-prism instrument. The star is of photographic magnitude 5·2, and is thus rather faint to permit the use of our three-prism spectrograph to advantage.

Thirty-seven plates of the star were obtained in 1915 and from these the elements have been determined. In the following table are given the principal lines, the number of times used and the average residual for each from the mean of the plates. The wave-lengths were adopted from the star 1149 Groombridge, with slight modifications, and have not been corrected for the residuals shown in the table.

WAVE-LENGTHS OF LINES IN 14 AURIGÆ.

Wave-Length.	Number of times used.	Residual.	Wave-Length.	Number of times used.	Residual.
4572·199	16	+ 0·6	4260·513	13	− 1·7
4549·746	35	+ 0·2	4250·637	11	+ 3·6
4534·139	19	− 1·2	4235·991	11	− 0·6
4501·423	10	+ 0·4	4233·421	33	− 0·3
4481·464	36	− 0·9	4227·124	21	+ 1·2
4415·333	15	− 0·8	4215·745	30	+ 0·9
4404·857	13	− 0·3	4202·278	5	− 6·3
4395·147	6	− 0·5	4198·719	19	+ 3·0
4351·991	30	+ 1·0	4143·839	28	− 0·1
4340·667	32	+ 1·5	4101·890	5	− 0·6
4325·707	26	+ 0·6	4077·862	14	+ 0·1
4307·980	17	+ 0·4	4071·861	8	− 0·3
4294·369	5	+ 0·7	4063·706	25	− 1·8
4290·070	35	+ 1·2	4045·929	35	− 0·8
4271·645	33	− 2·1	4005·402	12	− 0·9

MEASURES OF 14 AURIGÆ.

λ	6722		6798		6808		6829		6837		6856		6864	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4563·939	+28·1	1					+47·5	½						
4549·746			+21·4	1	+42·6	1	39·6	1	− 2·9	1	+19·3	1	+38·0	1½
4534·139			+16·8	1					−10·4	½	26·4	1		
4508·455			+25·3	1										
4501·423	18·6	½					39·1	½	− 4·7	1				
4481·464			+20·7	1	29·1	½	55·3	½	−10·2	1	13·8	1	47·7	1
4443·976			− 1·7	1										
4415·333	27·2	½					16·7	½			19·4	1	49·3	1
4404·857									−11·0	½				
4395·147			+16·5	1	50·5	½	14·4	½	−15·0	½				
4351·991			+10·5	1	47·0	½	30·4	½	− 1·5	½	16·6	1	23·1	½
4340·667	22·4	1	+16·9	1	31·7	½	24·6	1	− 8·4	1	19·4	1	38·6	1
4325·707	17·1	½	+15·5	1			38·4	¾	− 4·5	1				
4307·980			+19·5	1	34·7	1			+ 0·4	½	13·4	1	42·8	1
4294·369													43·1	1
4290·070	25·0	½	− 5·3	1			31·2	¾	− 2·0	¾	13·5	1	38·3	1
4271·645	20·5	1	+13·5	1	37·1	1	11·5	½	− 3·8	½	16·1	1		
4260·513											13·6	1	34·1	1
4235·991											15·1	1		
4233·421	35·9	1	+15·1	1	29·6	½	39·1	¾	− 3·1	¾	27·0	1	40·2	1
4227·124					37·1	1	21·2	½			18·3	1		
4215·745	28·7	½	+15·4	1	40·1	1			+10·7	1	19·5	1	36·9	1
4202·278											17·1	1		
4198·719	26·7	½	+14·1	1			34·2	½						
4143·839	26·0	1	+ 9·4	1	41·4	1	36·4	1	+ 3·5	1½	15·1	1	40·3	1
4101·890							27·6	¾						
4077·862													39·7	1
4063·706	24·9	1			36·4	1	36·2	½	− 7·5	¾	17·6	1	44·0	1
4045·929	25·9	1	+10·9	1	+48·8	1	24·5	¾	− 4·6	1	17·7	1	+37·5	1
4005·402	+30·8	1					+27·9	¾			+26·8	1		
Weighted mean	+ 26·01		+ 13·80		+ 39·60		+ 31·62		− 3·60		+ 18·19		+ 39·56	
V_a	− 19·36		− 27·78		− 27·96		− 29·33		− 29·38		− 29·53		− 29·45	
V_d	− ·20		− ·16		− ·20		− ·23		− ·23		− ·22		− ·22	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 6·2		− 14·4		+ 11·2		+ 1·8		− 33·5		− 11·8		+ 9·6	

MEASURES OF 14 AURIGÆ—*Continued.*

λ.	6868		6874		6886		6891		6893		6899		6906	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4563·939														
4549·746	+11·5	1	+56·4	1	+ 0·3	1	− 8·8	1	+41·2	1	+28·8	1	+29·6	¾
4534·139	10·4	1			+ 3·8	1					28·8	1	+17·6	½
4522·907	9·1	1												
4481·464	13·6	1	32·7	½	+14·4	1	− 7·6	1	40·0	1	23·5	1	− 0·8	½
4415·333	12·5	1					−26·7	¾					− 5·0	1
4404·857	25·6	1			+ 7·2	1			39·3	1				
4395·147							− 4·2	1						
4351·991	2·3	1	42·3	1			+ 1·2	½	22·2	1	34·5	1	+28·1	½
4340·667	8·9	1	35·6	1	+ 1·6	1	+ 2·0	½	36·0	1	19·3	1	+ 2·8	¾
4325·707	11·1	1	50·7	1					43·2	1			− 5·9	1
4307·980	12·7	1	41·4	1	+ 9·6	1								
4294·369	7·8	1									19·7	1	+15·8	½
4290·070	7·1	1	35·3	1	− 6·3	1	− 6·0	1	30·8	1	24·7	1	+ 2·4	½
4271·645	17·2	1	44·2	1	+ 3·7	1	− 2·8	1	50·8	1	20·8	1	+ 6·0	¾
4260·513	8·4	1	47·2	1			− 3·4	½	49·4	1	28·8	1		
4250·637	7·5	1												
4235·991					+ 9·4	1	− 7·8	1			21·1	1	+14·8	1
4233·421	7·5	1	54·1	1	+ 1·7	1	− 2·6	1	41·6	1	22·2	1	+ 6·0	½
4227·124	10·2	1	42·0	1			− 6·0	1	49·2	1			+ 4·5	½
4215·745	8·3	1	34·5	1	− 8·2	1	− 6·9	1	48·2	1	32·6	1		
4202·278									46·8	1				
4198·719			34·1	1	− 4·2	1			42·0	1			+ 4·2	1
4143·839	0·0	1	40·0	1	+ 0·1	1	+ 2·9	¾			28·8	1	+ 2·5	1
4101·890	14·1	1							45·6	1				
4077·862					− 1·0	1			41·0	1	29·8	1	+ 8·4	¾
4071·861	17·7	1			+ 2·9	1								
4063·706	5·3	1	49·5	1	+ 2·2	1	− 1·9	1			29·8	1	+ 2·6	1
4045·929	9·0	1	44·8	1	+ 5·8	1	0·0	1	+47·4	1	23·2	1	+ 5·8	1
4005·402	+ 7·5	1	+37·7	1	+ 1·1	1					+26·6	1	+11·8	½
Weighted mean	+ 10·18		+ 42·80		+ 2·46		− 4·04		+ 42·04		+ 27·86		+ 6·54	
V_a	− 29·42		− 29·24		− 28·78		− 28·25		− 27·93		− 27·41		− 26·13	
V_d	− ·16		− ·16		− ·15		− ·18		− ·26		− ·18		− ·26	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 19·7		+ 13·1		− 26·8		− 32·7		+ 13·6		0·0		− 20·1	

MEASURES OF 14 AURIGÆ—*Continued.*

λ	6912		6924		7192		7198		7219		7225		7247	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4584·018					−57·3	½								
4572·199									−25·7	1	−30·9	½	−35·6	1
4563·939														
4549·746	+ 0·9	1	+18·4	1	44·2	1	−72·0	1	25·1	1	62·0	1	45·6	1
4534·139							74·5	1			62·7	1	47·4	1
4522·907	− 8·0	½												
4515·508													57·8	1
4501·423									28·7	1	67·2	½		
4481·464	+10·8	1	21·3	1	44·1	1	68·9	1	34·9	1	60·8	1	46·9	1
4469·058					40·6	1								
4415·333													57·0	1
4404·857	− 1·8	1									67·7	1		
4400·315													48·3	1
4395·147													45·9	1
4351·991			16·8	1	40·2	¾	54·6	1	18·3	1	58·0	1	46·4	1
4340·667	− 8·2	1	23·6	1	56·6	½	62·2	1	37·0	½	72·4	½		
4325·707			25·3	1	38·0	½	50·4	1	18·7	1	62·4	½		
4307·980													50·7	1
4300·211					45·5	½								
4294·369	− 3·5	1												
4290·070	+ 4·3	1	13·9	1	40·0	1	52·6	1	18·3	½	45·7	1		
4271·645	− 8·6	1	12·2	1	35·2	1	51·6	1	8·6	1	43·7	1		
4260·513													52·6	1
4250·637			19·7	1					32·7	1	65·3	1		
4235·991									32·9	1	57·3	1		
4233·421	− 7·0	1	15·6	1	36·9	1	68·0	1	32·5	1	55·3	1	46·7	1
4227·124	−16·3	½	14·9	1	47·1	¾			21·9	1	36·0	½	39·1	1
4215·745	−11·7	1	23·8	1	41·0	1	85·3	1	22·4	1	65·3	1		
4202·278											43·9	1		
4198·719			9·3	1	49·7	1			20·8	1	67·6	1	54·0	1
4143·839	− 4·4	1	10·4	1	41·9	1	63·7	1						
4101·890	− 4·6	1												
4077·862			19·0	1	44·1	1							46·5	1
4071·861	− 6·9	1									56·1	1		
4063·706	+ 7·2	1	13·0	1	34·9	1					60·9	1		
4045·929	+ 3·0	1	15·1	1	−41·8	1	−69·2	1	−26·9	1	−46·1	1½	−55·5	1
4005·402	+ 0·6	1	+17·4	1										
Weighted mean	− 2·62		+ 17·04		− 42·48		− 64·42		− 25·17		− 56·63		− 48·50	
V_a	− 25·90		− 24·30		+ 28·66		+ 28·74		+ 29·09		+ 29·15		+ 29·13	
V_d	− ·23		− ·27		− ·15		+ ·22		+ ·16		+ ·22		+ ·14	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 29·0		− 7·8		− 14·0		− 35·7		+ 3·8		− 27·5		− 19·5	

MEASURES OF 14 AURIGÆ—*Continued.*

λ	7255		7276		7277		7285		7286		7297		7306	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4584·018			−56·5	½					−35·3	½				
4572·199	−36·5	½	54·3	½	−58·6	½	−34·3	¾	48·0	½	−41·6	1	−71·6	1
4563·939													60·4	1
4549·746	29·8	1	63·3	1½	56·5	1	42·4	1	40·0	1	60·4	1	52·9	1
4534·139			66·2	½	44·3	1	51·4	½	31·2	½	43·6	½	39·5	1
4508·455											51·4	½		
4501·423					42·8	1							56·6	1
4481·464	31·8	1	54·3	¾	60·3	1	41·2	¾	10·8	¾	54·3	1	53·0	1
4469·058					57·2	1								
4415·333	24·3	1									40·7	1	38·5	1
4404·857			64·4	½										
4395·147											45·8	1		
4351·991	34·7	1			53·4	½			57·0	½			54·2	1
4340·667	1·7	½			56·0	1			17·8	¾	53·0	1	50·1	1
4325·707	27·6	½	72·9	½					47·5	½	65·8	1	52·0	1
4307·980			60·0	½	45·5	¾					60·0	1	50·7	1
4300·211											83·0	1		
4290·070	22·5	½	53·4	1	61·1	¾	−34·8	½	33·4	½	45·0	1	52·6	1
4271·645	11·5	1	60·5	1	52·7	1			43·4	1	52·0	1	45·3	1
4260·513			55·0	1					22·2	¾				
4250·637	24·5	½												
4246·996	21·4	1												
4235·991	21·8	½	44·7	¾										
4233·421	27·2	½	54·9	½	61·6	1½			35·6	¾	56·3	1	38·8	1
4227·124									28·3	½	64·5	1	50·8	1
4215·745	14·3	½	46·0	½	65·6	1							45·6	1
4202·278					39·2	1								
4198·719					55·3	1								
4143·839	13·5	1			72·0	1			34·9	¾	49·0	1		
4077·862											58·2	1		
4071·861			69·1	½									51·2	1
4063·706					55·0	1					52·0	1	46·5	1
4045·929	−14·2	½	−52·6	½	−55·8	1			−42·2	½	−49·3	1	−52·3	1
Weighted mean	− 22·77		− 59·03		− 55·35		− 40·60		− 34·49		− 54·31		− 50·66	
V_a	+ 29·04		+ 28·80		+ 28·80		+ 28·72		+ 28·72		+ 28·05		+ 27·90	
V_d	+ ·12		+ ·25		+ ·22		+ ·23		+ ·19		+ ·19		+ ·09	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 6·1		− 30·3		− 26·6		− 11·9		− 5·9		− 26·4		− 23·0	

MEASURES OF 14 AURIGÆ—*Continued.*

λ	7314		7331		7332		7344		7361		7397		7446	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4584·018							−32·2	½						
4572·199	−36·9	½					17·8	½	−41·2	1	−28·8	½	−35·3	½
4563·939	23·2	½	−47·4	½			28·3	1						
4549·746	21·2	½	71·4	1	−57·4	1			43·0	1	26·5	1	14·0	1
4534·139	46·0	½			56·7	½								
4515·508											5·2	½		
4508·455							23·3	½						
4501·423			58·9	1					29·6	1	27·0	¾		
4481·464	16·8	½	58·3	1	51·2	1	20·0	1	38·3	1	16·0	¾	28·0	1
4415·333	14·3	½	62·9	1	43·9	1	24·5	½						
4404·857	28·3	½	53·4	1	64·9	½			28·3	1			25·7	1
4395·147														
4351·991			66·9	1	72·0	½	29·5	1	35·0	1	21·4	½	19·1	1
4340·667	42·8	½	56·0	½	58·3	½	22·1	1	32·5	1				
4325·707			47·1	1	54·2	½	26·2	1	40·6	½	22·8	½	39·5	1
4307·980	29·8	½	65·6	1	67·6	½							30·8	1
4290·070	32·5	½	54·9	½	54·3	1	27·4	1	32·0	1	27·1	½	36·0	1
4271·645	17·7	½	44·7	1	65·5	1	31·1	1	19·4	1	26·5	½		
4260·513	13·4	½			67·1	1							17·9	1
4250·637					46·1	1	25·0	1	44·5	1			34·1	1
4235·991							29·7	1	24·3	1				
4233·421			60·9	1	61·6	½	25·8	1			20·4	½	33·0	1
4227·124					73·0	1			26·1	½			41·1	1
4215·745	18·8	½	54·3	1	70·6	1	17·0	1	27·3	1	25·9	½	34·3	1
4198·719			54·4	½			26·0	1	32·8	1	26·6	½	36·4	1
4143·839	28·8	½	57·2	1	56·3	½	16·7	1	32·7	1	15·3	½	24·1	1½
4101·890							23·5	½						
4077·862			56·2	½			17·1	1	31·3	1			31·3	1
4071·861					43·0	½								
4063·706			53·1	1			18·3	1	24·9	1	9·0	½	24·0	1
4045·929	−20·9	½	−55·9	1	−53·2	1	−16·0	1	32·4	1	−23·8	½	−25·8	1
4005·402									−36·9	1				
Weighted mean	− 26·09		− 59·41		− 58·60		− 23·61		− 32·62		− 21·76		− 29·15	
V_a	+ 27·76		+ 25·82		+ 25·82		+ 24·56		+ 21·81		+ 14·33		+ 0·53	
V_d	+ ·19		+ ·14		+ ·07		+ ·15		+ ·14		+ ·24		+ ·21	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 1·6		− 33·7		− 33·0		+ 0·8		− 11·0		− 7·5		− 28·7	

MEASURES OF 14 AURIGÆ—*Concluded.*

λ	7449		7453											
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·199			+ 2·6	1										
4549·746	− 3·4	1	+ 3·6	1										
4534·139			+ 4·8	1										
4522·907	− 2·4	½												
4481·464	+13·5	1	− 5·2	1										
4404·857	+ 6·4	½												
4351·991	+17·0	1	− 6·3	1										
4340·667	+ 7·0	1	− 2·2	1										
4325·707	+10·0	½	+ 0·7	1										
4290·070	− 4·4	½	− 2·0	1										
4271·645	+12·3	1	+ 2·1	1										
4250·637	− 3·7	1	− 4·8	1										
4233·421	+11·0	1	− 1·8	1										
4227·124			+ 2·2	1										
4215·745	+13·4	1	+ 2·6	1										
4202·278			− 2·1	1										
4198·719	+11·4	½												
4143·839	+ 0·1	½												
4077·862			− 6·7	1										
4071·861			− 5·3	1										
4063·706	+ 0·6	½	+ 0·4	1										
4045·929	+ 6·0	1	+ 0·6	1										
4005·402	+15·2	½												
Weighted mean	+ 7·18		− 0·93											
V_a	− 0·07		− 4·70											
V_d	·00		+ ·14											
Curv.	− ·28		− ·28											
Radial Velocity	+ 6·8		− 5·8											

YERKES' OBSERVATIONS OF 14 AURIGÆ.

Date.	Julian Date G.M.T.	Phase.	Velocity.	O–C.
1913				
Oct. 2	2,420,043·864	2·74	+ 4·8	+ 12·8
1914				
Feb. 20	184·567	3·25	+11·0	+ 3·0
Mar. 13	205·542	1·49	−31·0	0·0
Mar. 16	208·553	0·71	− 8·0	+ 2·0
Mar. 23	215·605	0·18	+10·0	+ 3·0

OTTAWA OBSERVATIONS OF 14 AURIGÆ.

Plate.	Observer.*	Date.	Julian Date G.M.T.	Phase.	Velocity.	Weight.	O–C.
		1915					
6722	C–P¹	Jan. 20	2,420,518·730	0·19	+ 6·2	2·5	− 0·8
6798	H	Feb. 18	547·616	2·56	−14·4	3·4	+ 0·1
6808	C	Feb. 19	548·657	3·60	+11·2	2·4	− 0·3
6829	H	Mar. 3	560·647	0·43	+ 1·8	3·1	+ 1·6
6837	H	Mar. 4	561·642	1·43	−33·5	3·1	− 3·7
6856	H	Mar. 11	568·608	0·81	−11·8	3·8	+ 1·7
6864	Y	Mar. 14	571·600	0·01	+ 9·6	3·0	− 0·4
6868	H	Mar. 15	572·557	0·97	−19·7	4·6	− 0·7
6874	H	Mar. 18	575·547	0·17	+13·1	3·4	+ 5·8
6886	Y	Mar 23	580·514	1·35	−26·8	3·2	+ 2·0
6891	H	Mar. 27	584·524	1·57	−32·7	3·0	− 1·3
6893	H	Mar. 29	586·616	3·66	+13·6	2·9	+ 2·1
6899	H	April 1	589·519	2·78	0·0	2·9	+ 6·7
6906	H	April 7	595·582	1·26	−20·1	3·3	+ 6·9
6912	H	April 8	596·541	2·22	−29·0	3·3	− 4·5
6924	H	April 14	602·592	0·69	− 7·8	3·4	+ 1·4
7192	H	Sept. 1	742·885	0·79	−14·0	3·3	− 0·9
7198	Y	Sept. 2	743·827	1·73	−35·7	2·4	− 4·1
7219	H	Sept. 8	749·862	0·19	+ 3·8	2·8	− 2·9
7225	Y	Sept. 9	750·810	1·14	−27·5	4·0	− 3·2
7247	H	Sept. 14	755·865	2·41	−19·5	3·2	− 0·6
7255	C	Sept. 15	756·867	3·41	+ 6·1	3·0	− 4·2
7276	Y–H	Sept. 21	762·729	1·69	−30·3	2·7	+ 1·3
7277	H	Sept. 21	762·782	1·74	−26·6	3·7	+ 5·0
7285	C	Sept. 22	763·750	2·71	−11·9	0·8	− 3·1
7286	C	Sept. 22	763·799	2·76	− 5·9	2·5	+ 0·9
7297	H	Sept. 28	769·784	1·17	−26·4	3·7	− 1·4
7306	C	Sept. 29	770·850	2·24	−23·0	3·8	+ 0·8
7314	Y	Sept. 30	771·774	3·16	+ 1·6	2·2	− 3·8
7331	H	Oct. 10	781·785	1·80	−33·7	3·5	− 2·5
7332	H	Oct. 10	781·832	1·85	−33·0	3·3	− 2·4
7344	C	Oct. 15	786·767	3·00	+ 0·8	4·0	− 0·2
7361	Y	Oct. 24	795·748	0·61	−11·0	3·9	− 4·1
7397	C	Nov. 12	814·605	0·52	− 7·5	2·3	− 4·0
7446	C	Dec. 10	842·570	1·97	−28·7	3·6	+ 0·7
7449	P	Dec. 11	843·698	3·09	+ 6·8	2·7	+ 3·0
7453	P	Dec. 20	852·597	0·62	− 5·8	3·6	+ 0·7

* C = Cannon; H = Harper; P = Plaskett; P¹ = Parker; Y = Young.

The preceding table gives the data of the measures. The phases are based on the final elements. The residuals are scaled from the curve representing the final elements. The probable error of a plate obtained from the last two columns is $\pm 2\cdot 0$ km. per second, which is lower than expected and quite satisfactory for the dispersion employed. The observations were grouped according to phase into ten normal places as given in the accompanying table, the weights assigned each group being approximately one-tenth of the sum of the weights of the plates contained therein. Preliminary elements were obtained by the graphical method as follows:—

$$P = 3\cdot 789 \text{ days}$$
$$e = \cdot 05$$
$$\omega = 15^\circ$$
$$K = 21\cdot 75 \text{ km.}$$
$$\gamma = -11\cdot 30 \text{ km.}$$
$$T = \text{J. D. } 2{,}420{,}802\cdot 660.$$

NORMAL PLACES.

—	Phase from preliminary *T*.	Phase from final *T*.	Velocity.	Weight.	O–C preliminary.	O–C final.	Equation-Ephemeris.
1	2·189	2·134	−26·7	1·1	+0·1	−0·4	0·0
2	2·530	2·475	−16·9	0·7	+·06	−0·1	+0·1
3	2·811	2·756	− 3·9	0·6	+3·9	+3·2	0·0
4	3·207	3·152	+ 3·6	1·2	−1·5	−1·7	0·0
5	3·674	3·619	+12·5	0·5	+1·0	+1·0	0·0
6	·166	·111	+10·0	0·9	+1·9	+1·6	0·0
7	·497	·442	− 1·9	1·2	−0·2	−1·2	0·0
8	·774	·719	−11·1	1·4	+0·8	−0·5	−0·1
9	1·209	1·154	−24·0	1·9	+1·6	+0·8	0·0
10	1·744	1·689	−32·0	2·2	0·0	−0·4	0·0

Using the differential formula of Lehmann-Filhés, with an additional term for γ, and making the substitutions,

$$x = \delta\gamma$$
$$y = \delta K$$
$$z = K.\delta e$$
$$u = K.\delta\omega$$
$$v = \frac{K}{(1-e^2)^{\frac{3}{2}}} \cdot \mu \cdot \delta T = [1 \cdot 55878] \delta T,$$

the following observation equations resulted, the weight of each being given in the normal places above.

OBSERVATION EQUATIONS FOR 14 AURIGÆ.

	x	y	z	u	v	$-n$
1.	1·000	− ·714	+ ·421	+ ·635	− ·591	−0·1 = 0
2.	1·000	− ·284	− ·573	+ ·930	− ·891	−0·6
3.	1·000	+ ·160	− ·998	+ ·981	− ·980	+3·9
4.	1·000	+ ·753	− ·284	+ ·697	− ·745	+1·5
5.	1·000	+1·047	+ ·988	− ·065	+ ·058	−1·0
6.	1·000	+ ·891	+ ·634	− ·550	+ ·590	−1·9
7.	1·000	+ ·445	− ·498	− ·931	+ ·976	+0·2
8.	1·000	− ·024	−1·007	−1·010	+1·015	−0·8
9.	1·000	− ·658	− ·250	− ·721	+ ·673	−1·6
10.	1·000	− ·951	+ ·981	+ ·022	− ·032	0·0

NORMAL EQUATIONS.

$$
\begin{array}{rrrrrr}
11\cdot700x - 1\cdot504y & - \cdot141z & -1\cdot604u & +1\cdot604v & -7\cdot200 & =0 \\
5\cdot625y & -1\cdot517z & - \cdot043u & + \cdot090v & +1\cdot265 & =0 \\
 & 5\cdot924z & +1\cdot116u & -1\cdot113v & +2\cdot214 & =0 \\
 & & 5\cdot939u & -5\cdot926v & +2\cdot559 & =0 \\
 & & & 5\cdot936v & -2\cdot590 & =0
\end{array}
$$

From these equations resulted the corrections,

$$
\begin{aligned}
\delta\gamma &= + \cdot 56 \text{ km.} \\
\delta K &= - \cdot 19 \text{ km.} \\
\delta e &= - \cdot 017 \\
\delta\omega &= +4^\circ \cdot 70 \\
\delta T &= + \cdot 055 \text{ day.}
\end{aligned}
$$

The final values of the elements with their probable errors are, then, as follows:—

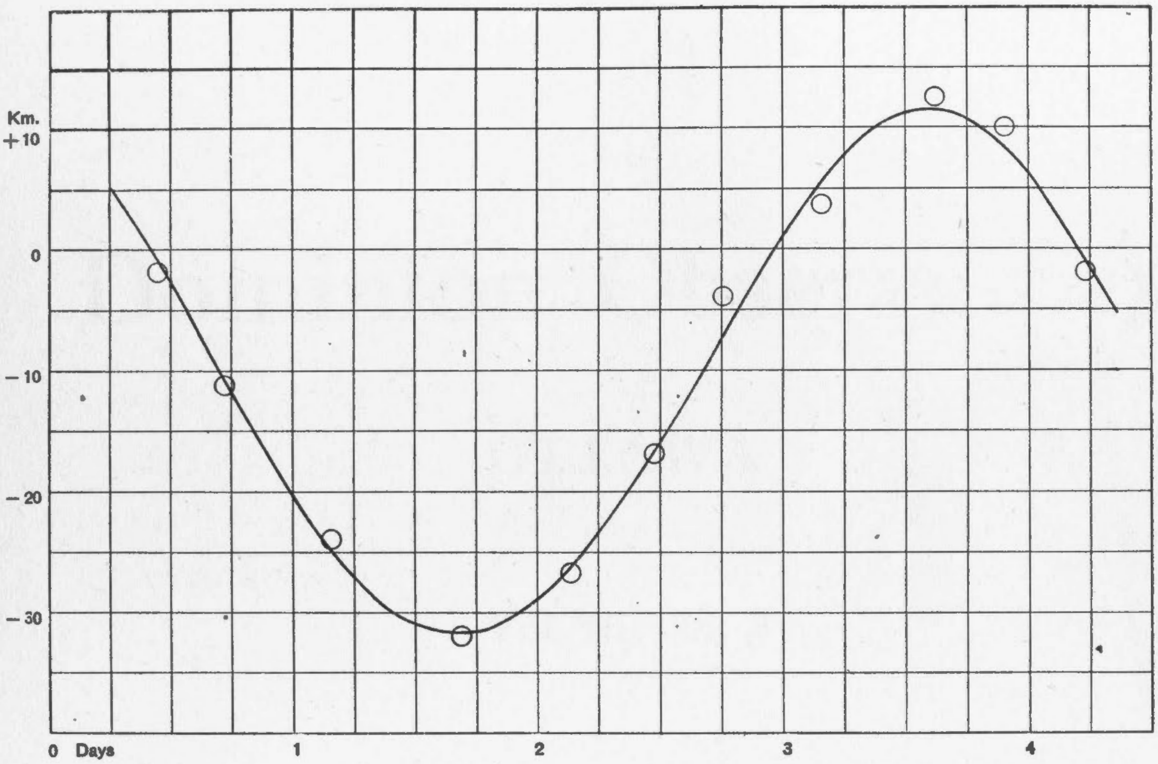
$$
\begin{aligned}
P &= 3\cdot789 \text{ days} \\
e &= \cdot033 \pm \cdot022 \\
\omega &= 19^\circ\cdot70 \pm 19^\circ\cdot70 \\
K &= 21\cdot56 \text{ km.} \pm 0\cdot50 \text{ km.} \\
\gamma &= -10\cdot74 \text{ km.} \pm 0\cdot34 \text{ km.} \\
T &= \text{J. D. } 2{,}420{,}802\cdot715 \pm \cdot206 \text{ day} \\
a \sin i &= 1{,}122{,}600 \text{ km.}
\end{aligned}
$$

The graph represents the final elements with the observations as grouped.

Dominion Observatory,

Ottawa,

January, 1916.



Radial Velocity Curve of 14 Aurigæ.

DEPARTMENT OF THE INTERIOR
CANADA
HON. W. J. ROCHE, *Minister*. W. W. CORY, C.M.G., *Deputy Minister*.

PUBLICATIONS

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OTTAWA

Vol. III, No. 8

Precise Levelling

BY

F. B. REID, B.A.Sc., D.L.S.

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PRECISE LEVELLING.

BY F. B. REID, B.A.Sc., D.L.S.

Supervisor of Levelling.

CONTENTS.

PRECISE LEVELLING.

This publication is the sixth of the "Publications of the Dominion Observatory" on the subject of precise levelling by the Geodetic Survey of Canada, the ones previously issued being as follows:—

Vol. I, No. 2, issued in 1913*
Vol. I, No. 3, " 1913
Vol. I, No. 8, " 1914
Vol. II, No. 1, " 1915
Vol. III, No. 6, " 1916

Previous to the above a set of results was published as an appendix to the Chief Astronomer's report for the year 1910; these results have now been revised and are reprinted in standard form in this issue.

The present publication is arranged in the same general form as the previous ones, the results of the levelling being set forth in three tables; each table, however, has been subdivided into two sections, the first section containing work now published for the first time and the second containing the reprint of the work published in 1910. The index and map included herein are complete for all the work previously published, as well as that in the present publication; the index indicates in which publication descriptions and elevations of bench-marks published before this may be found.

Tables I and I–A indicate the routes followed between terminal points and give complete descriptions of all bench-marks established along these routes.

Tables II and II–A show in the first two columns the numbers of the bench-marks; in the third and fourth columns the approximate distance (in miles) between bench-marks, and from the initial bench-mark of the line; the fifth and sixth columns (headed "Discrepancy") give the difference (in feet) between the forward levelling and the backward levelling for each section between bench-marks and the accumulated difference from the

*Levelling in Yukon territory only.

initial bench-mark. The seventh column gives the elevations of the bench-marks shown in the second column; for convenience, these bench-marks are repeated (in the eighth column) in order that the number of any bench-mark and its elevation may be in adjoining columns. In these tables are shown also the elevations determined by the Geodetic Survey for certain bench-marks established by other surveys and connected with our levelling.

Tables III and III–A show the elevations at railway stations and at crossings of intersecting railways; also on the bridges over rivers and lakes and the more important streams. Rail elevations were in all cases taken on top of the rail, in front of the telegraph office at telegraph stations and opposite the shelter or platform at flag-stations.

The results are given (in Tables I, II and III) for the following lines of new levelling:—

1. St. Anselme, Que., to Edmundston, N.B.
2. Harlaka Jct. to Rivière-du-Loup, Que., with branch to Bretagne.
3. Ottawa to Renfrew, Ont.
4. Kempton to Ivanhoe, Ont., with branches to Carleton Place, Brockville, Renfrew, Kingston and Belleville.
5. Steelton to Franz, Ont., with branch to Michipicoten.
6. Kipp, Alta., to Golden, B.C.
7. Bull River to Kootenay Landing, B.C.
8. Field to Revelstoke, B.C.
9. Edmonton to Jasper, Alta.

Results for the following lines are reprinted (in Tables I–A, II–A and III–A):—

a. St. Stephen, N.B., to Rivière-du-Loup, Que.
b. Brunswick to St. John, N.B.
c. Rouse Point, N.Y., to Sherbrooke, Que.
d. Farnham to St. Armand, Que.
e. Foster to Abercorn, Que.
f. Sherbrooke, Que., to Norton Mills, Vt.
g. Rouse Point, N.Y., to Colborne, Ont.

Lines 1 and 2 were started from the Megantic-Levis line (1913 publication) and closed upon the St. Stephen-Rivière-du-Loup line at Edmundston and Rivière-du-Loup respectively; the new elevations are at the former place 0·102 foot and at the latter 0·432 foot lower than those formerly carried from St. Stephen. The large circuit—St. Anselme-Edmundston-Rivière-du-Loup-Harlaka Jct.—is divided by the cross-country line from St. Philippe-de-Neri to Bretagne, the closing errors of the two smaller circuits thus formed being 0·087 and 0·243 foot. The levelling along line 2 has been connected with a large number of bench-marks established by the Public Works Department of Canada; these bench-marks are designated by Roman numerals. For their descriptions the reader is referred to that department. Table II in the present publication gives their elevations as determined by the Geodetic Survey.

Line 3 forms the closing link in a large circuit of levels extending through Renfrew, Depot Harbour, Toronto, Prescott and Ottawa. The closing error of the circuit is 0·196 foot—the difference between the two elevations for the junction bench-mark at Renfrew. Line 4 was started from the Rouse Point-Toronto line; five subsidiary lines branch north and south from it, each terminating at a point on the circumference of the large circuit referred to in connection with line 3. The five small circuits thus formed at the easterly end of the main circuit have closures varying from 0·028 to 0·162 foot.

Line 5 commences at bench-mark 634 on the Sudbury-Sault Ste. Marie line (1916 publication). In Table II connections are shown with three bench-marks of the United States Lake Survey; two of these appeared in last year's publication, but owing to incorrect information the elevation there given for "P.B.M.—B." was in error. At Michipicoten a connection was made with a bench-mark of the Hydrographic Survey, Department of the Naval Service; the elevation of this, derived by water transfers during the years 1915 and 1916, between automatic gauges at Michipicoten and Port Arthur is 626·352; the elevation obtained by us by our line of precise levels from Rouse Point, N.Y., via Toronto, Sudbury, etc., is 625·079.

Line 6 commences at bench-mark 81-D on the Lethbridge-Calgary line (1915 publication); line 7 is a branch from line 6 and is connected at Porthill, Idaho, with a bench-mark of the United States Coast and Geodetic Survey. At Golden, B.C., line 6 is closed upon line 8—a continuation of the Calgary-Field line (1916 publication). The closing error of the 623-mile circuit, Calgary-Kipp-Bull River-Golden, is 0·115 foot. Line 9 is a continuation of the Saskatoon-Wainwright-Edmonton line (1915 and 1916 publications).

The elevations along lines *a* and *b* are based, as formerly, upon a provisional datum at St. Stephen, N.B., established by United States engineers; these elevations have now been checked by precise level connections with the Naval Service Department's tide-gauge at Halifax and with the United States Coast and Geodetic Survey bench-mark at Rouse Point, N.Y. The differences are comparatively small—see last year's publication and also lines 1 and 2 of the present publication—consequently it has been considered better to adhere to the originally published figures until such time as more permanent values may be fixed by means of a proper adjustment of the levels.

Line *c* and the branch lines *d*, *e* and *f* are based upon the Coast and Geodetic Survey bench-mark at Rouse Point, N.Y. Line *g* was also started from this bench-mark; regarding the elevations along line *g*, attention is called to the fact that the originally published elevations of all bench-marks between and including Nos. 124 and 145 have been lowered by one foot, this being due to errors in the field work which were detected only recently. At Kingston the Hydrographic Survey has determined the elevation of G.S.C. bench-mark 142 as 259·506, this value being obtained by water transfers from Tibbets Point, N.Y., during six years between the years 1909 and 1915. The elevation obtained by us by our line of precise levels from Rouse Point is 258·688—see page 321.

As in previous publications all elevations are instrumental and have had no adjustments applied to them, consequently changes may be made in the future; it should be noted, however, that in almost all cases where circuits have been closed, the closing errors are quite small.

The standard bench-mark adopted consists of a copper bolt, three-quarters of an inch in diameter and four inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench-mark). The bolt is sunk horizontally in rock or masonry so that only the circular end is visible; the number of the bench-mark is stamped on this end as well as the letters mentioned above, and a horizontal chisel line is cut, upon which the elevation is taken. At certain points concrete bench-mark piers have been built; these project from six inches to one foot above the ground and extend below the frost line; the copper bolt upon which the elevation is taken is placed horizontally as in other cases, and is about nine inches below the top of the pier.

TABLE I.

BENCH-MARKS BETWEEN ST. ANSELME, QUE., AND EDMUNDSTON, N.B., VIA NATIONAL TRANSCONTINENTAL RAILWAY.

Elevations on page 289.

223-B In east face of coping on south end of large concrete arch culvert under National Transcontinental railway, 3 miles east of St. Anselme and at mileage 76·3 from Monk.

224-B In east face—6 inches below top—of coping on north end of concrete arch culvert under National Transcontinental railway, ½ mile west of Ste. Claire and at mileage 73·3 from Monk.

225-B In east end of south face of concrete coping on south end of iron-pipe culvert under National Transcontinental railway, between first and second telegraph poles east of mile-post 71 from Monk.

226-B Destroyed.

227-B In west end of south face—15 inches below top—of southwest concrete retaining wall of National Transcontinental railway bridge over Etchemin river, immediately west of Ste. Malachie.

228-B In centre of south face of small stone culvert under National Transcontinental railway, 50 feet west of a private crossing at mileage 63·2 from Monk.

229-B In west face of northwest concrete retaining wall of National Transcontinental railway bridge over Abenakis river, 2 miles east of Abenakis.

230-B In west face—14 inches below top—of south face-wall of concrete culvert under National Transcontinental railway, in a deep fill, at sixth telegraph pole west of mile-post 57 from Monk.

231-B In west face of north face-wall of concrete arch culvert under National Transcontinental railway, 1¾ miles east of St. Damien and at mileage 54·7 from Monk.

232-B Destroyed.

233-B In west end of south face of small concrete arch culvert under National Transcontinental railway, at mileage 49·1 from Monk.

234-B In east end of north face of small concrete arch culvert under National Transcontinental railway, ¼ mile west of Armagh and at mile-post 46 from Monk.

235-B In west face of north face-wall of concrete arch culvert under National Transcontinental railway, at third telegraph pole east of mile-post 43 from Monk.

236-B In east end of south face of small concrete arch culvert under National Transcontinental railway, at sixteenth telegraph pole east of mile-post 40 from Monk.

237-B In east end of south face of small concrete arch culvert under National Transcontinental railway, ¾ mile east of St. Euphemie and at thirteenth telegraph pole east of mile-post 37 from Monk.

238-B In west face of coping on north end of large concrete arch culvert under National Transcontinental railway, 2 miles west of Rosaire and at mileage 33·6 from Monk.

239-B In east face—8 inches below top—of coping on north end of large concrete arch culvert under National Transcontinental railway, 1¼ miles east of Rosaire and at mileage 30·4 from Monk.

240-B In west face of coping on south end of concrete arch culvert under National Transcontinental railway, 4½ miles east of Rosaire and at mileage 27·2 from Monk.

241–B In west face of southeast concrete retaining wall—6 inches below bridge-seat—of plate-girder bridge on National Transcontinental railway, at mile-post 25 from Monk.

242–B Destroyed.

243–B In north sloping face—5 inches below top—of concrete retaining wall behind east abutment of plate-girder bridge over Méchant-pouce river, 0·4 mile west of Ste. Appoline.

244–B In north face of half buried boulder, in an earth cut, at south side of National Transcontinental railway track and at fourth telegraph pole west of mile-post 18 from Monk.

245–B In west face of concrete retaining wall behind west abutment of plate-girder bridge over Bras d'Apic river (west), ½ mile west of Bras d'Apic. The bench-mark is 8 feet south of track and 6 inches below top of retaining wall.

246–B In west end of south face—7 inches below top—of concrete arch culvert under National Transcontinental railway, 2½ miles east of Bras d'Apic and at mileage 12·3 from Monk.

247–B In east face of large prominent boulder in ditch at south side of National Transcontinental railway track, between eleventh and twelfth telegraph poles east of mile-post 10 from Monk.

248–B In south face of boulder—12 feet by 8 feet—6 feet north of north line of National Transcontinental railway right-of-way, 500 feet east of a wooden culvert and between twentieth and twenty-first telegraph poles east of mile-post 7 from Monk.

249–B In south face of flat boulder—9 feet by 7 feet—35 feet north of National Transcontinental railway track and at eighth telegraph pole west of mile-post 3 from Monk.

385–B In rear (or south) concrete foundation wall—9 inches below woodwork and 40 inches from southeast corner—of station-house at Monk.

384–B In west face of north face-wall—9 inches below top—of very large concrete arch culvert through which rivière Ouelle flows under National Transcontinental railway, ½ mile west of Lafontaine.

383–B In east face of south face-wall—15 inches below top—of concrete arch culvert under National Transcontinental railway, at sixth telegraph pole west of mile-post 116 from Edmundston.

382–B In north side of rock cut on National Transcontinental railway—165 feet east of west end of cut and at rail level—1,023 feet east of mile-post 114 from Edmundston.

381–B In north face of boulder, 10 feet south of National Transcontinental railway track—near centre of shallow earth cut—1 mile west of Lefebvre and between sixth and seventh telegraph poles west of mile-post 109 from Edmundston.

380–B In east concrete foundation wall—20 inches below woodwork and 22 inches from southeast corner—of station-house at Lefebvre.

379–B In east face of south face-wall—11 inches below top—of large concrete arch culvert under National Transcontinental railway, 2½ miles east of Lefebvre and at mileage 105·7 from Edmundston.

378–B In south end of east face of concrete retaining wall behind west abutment of plate-girder bridge on National Transcontinental railway, 1¾ miles west of Holliday and at mileage 101·3 from Edmundston.

377–B In south face of boulder, 10 feet north of National Transcontinental railway track, 2 miles west of Bretagne and 110 feet west of mile-post 97 from Edmundston.

376–B In north end of east face of concrete retaining wall behind west abutment—32 inches above bridge-seat—of three-span bridge over rivière-du-Loup, 3 miles east of Bretagne.

375–B In south end of east face of concrete retaining wall behind west abutment of plate-girder bridge over river Manie, ¼ mile east of River Manie station.

288–B In east face of boulder, 15 feet south of National Transcontinental railway track—in small cut—1 mile east of Lapointe and between fourth and fifth telegraph poles west of mile-post 81 from Edmundston.

287–B Destroyed.

286–B In south side of rock cut on National Transcontinental railway—at rail level and near first rock exposure from west end of cut—1¼ miles west of Picard and between sixth and seventh telegraph poles west of mile-post 76 from Edmundston.

285–B In south end of west face of concrete retaining wall behind east abutment of plate-girder bridge over rivière Fourchu, ½ mile east of Picard.

284–B In east face of north face-wall of very large concrete arch culvert under National Transcontinental railway, 600 feet west of a deep rock cut, 1¼ miles east of Picard and at mileage 73·7 from Edmundston.

283–B In south end of west face of concrete retaining wall behind east abutment of plate-girder bridge over rivière Rocheuse, 1¾ miles west of Pelletier.

282–B In west concrete foundation wall—4 inches below woodwork and 1 foot from northwest corner—of station-house at Pelletier.

281–B In west end of south face of small concrete arch culvert under National Transcontinental railway, 4 miles east of Pelletier.

280–B In north end of east face of concrete retaining wall behind west abutment of long steel trestle bridge on National Transcontinental railway, 2½ miles west of St. Eleuthère.

279–B In east face of south face-wall—1 foot below top—of large concrete arch culvert under National Transcontinental railway, 1¾ miles west of St. Eleuthère and at mileage 61·3 from Edmundston.

278–B In east end of north face of large concrete arch culvert under National Transcontinental railway, 1¼ miles east of St. Eleuthère and at mileage 58·4 from Edmundston.

277–B In north face of concrete base of international boundary monument No. 178, 10 feet south of south line of National Transcontinental railway right-of-way and ½ mile west of Estcourt—on west bank of St. Francis river.

276–B In south end of west face of concrete retaining wall behind east abutment—9 inches above bridge-seat—of National Transcontinental railway bridge over St. Francis river, ½ mile west of Estcourt.

NOTE.—Check levelling in 1916 indicates that the abutment has shifted slightly since the original levelling was done; the elevation of this bench-mark must therefore be considered unreliable.

275–B In south end of west face of concrete retaining wall behind east abutment—14 inches above bridge-seat—of plate-girder bridge on National Transcontinental railway, 2¾ miles east of Estcourt.

274–B In south end of west face of concrete retaining wall behind east abutment—3 feet 6 inches above bridge-seat—of plate-girder bridge over Blue river, 1 mile west of Blue River station.

273–B In east end of south face of small concrete arch culvert under National Transcontinental railway, 3 miles east of Blue River station and at mileage 42·4 from Edmundston.

272–B In north face—directly above northeast wing-wall—of concrete arch culvert under National Transcontinental railway, 3¼ miles west of Glendyne and at mileage 38·8 from Edmundston.

271–B In south end of east face of concrete retaining wall behind west abutment—30 inches above bridge-seat—of plate-girder bridge over the narrows of Long lake, 1½ miles east of Glendyne.

270–B In east face of north face-wall of large concrete arch culvert under National Transcontinental railway, ½ mile west of Courchesne.

269–B In south end of east face of concrete retaining wall behind west abutment—27 inches above bridge-seat—of plate-girder bridge on National Transcontinental railway, 4½ miles west of Lac Baker.

268–B In north face of small concrete arch culvert under National Transcontinental railway, 2¼ miles west of Lac Baker.

267–B In east face—7 feet 6 inches below bridge-seat—of north concrete abutment of highway bridge over National Transcontinental railway, 0·6 mile east of Lac Baker.

266–B In east face of coping on south end of large concrete arch culvert under National Transcontinental railway, 2½ miles east of Lac Baker.

265–B In east face of coping on north end of concrete arch culvert under National Transcontinental railway, 3 miles west of Baker Brook.

264–B In east face—north side of track—of concrete retaining wall behind east abutment of plate-girder bridge on National Transcontinental railway, ¼ mile west of Baker Brook.

263–B In east face of coping on south end of large concrete arch culvert under National Transcontinental railway, 1¼ miles east of Baker Brook and ½ mile east of Temiscouata railway diamond crossing.

262–B In north face of small concrete arch culvert under National Transcontinental railway, 270 feet west of a highway crossing, 1 mile west of St. Hilaire and at mileage 8·5 from Edmundston.

261–B In east face of north face-wall of large concrete arch culvert under National Transcontinental railway, 1½ miles east of St. Hilaire and at fifth telegraph pole west of mile-post 6 from Edmundston.

260–B In west face of south face-wall of large concrete arch culvert under National Transcontinental railway, at first telegraph pole east of mile-post 3 from Edmundston.

58–B In Temiscouata railway bridge over Madawaska river at Edmundston—see line from St. Stephen to Rivière-du-Loup.

BENCH-MARKS BETWEEN HARLAKA JUNCTION AND RIVIERE-DU-LOUP, QUE., VIA INTERCOLONIAL RAILWAY, WITH CROSS-COUNTRY BRANCH LINE FROM ST. PHILIPPE-DE-NERI TO BRETAGNE.

Elevations on page 291.

563–B In north face-wall of concrete tile culvert under Intercolonial railway, immediately west of La Durantaye station.

564–B In side of concrete bench-mark pier, 6 feet south of north line of Intercolonial railway right-of-way, 1¼ miles west of St. Pierre and 1,050 feet west of mile-post 84 from Rivière-du-Loup—about midway between two farm crossings 600 feet apart.

565–B In second course below top, in north face of west abutment of small square stone culvert under Intercolonial railway, ¾ mile east of St. Pierre and 870 feet west of mile-post 82 from Rivière-du-Loup.

566–B In south end of east face of concrete retaining wall behind west abutment—18 inches above bridge-seat—of plate-girder bridge over bras St. Nicholas, rivière-du-Sud, ½ mile east of Montmagny.

567–B In north face of very large flat boulder, immediately south of north line of Intercolonial railway right-of-way and 70 feet west of easterly switch of passing-track at Cap St. Ignace—0·6 mile east of the station.

568–B In stone water-table course, in west foundation wall of Intercolonial station-house at L'Islet—10 feet from southwest corner of building.

569–B In south end of east face of concrete retaining wall behind west abutment—27 inches above bridge-seat—of plate-girder bridge on Intercolonial railway, 1 mile east of L'Islet and at mileage 63·6 from Rivière-du-Loup.

570–B In north end of east face of concrete retaining wall behind west abutment—13 inches above bridge-seat—of plate-girder bridge on Intercolonial railway, 1¾ miles west of St. Jean Port Joli and immediately east of a highway crossing.

571–B In east end of south face-wall of concrete tile culvert under Intercolonial railway—at a farm crossing—1 mile west of Elgin Road flag-station and at mileage 53·3 from Rivière-du-Loup.

572–B In south face of large irregular boulder, 10 feet north of south line of Intercolonial railway right-of-way, 120 feet east of a farm crossing and 2,000 feet east of mile-post 46 from Rivière-du-Loup.

573–B In east end—20 inches below top—of south face-wall of (double) concrete tile culvert under Intercolonial railway, 170 feet east of railway section post between sections 8 and 9 and at mileage 43·7 from Rivière-du-Loup.

574–B In side of concrete bench-mark pier, 4 feet south of north line of Intercolonial railway right-of-way, 130 feet east of one and 270 feet west of another farm crossing, 1¾ miles west of St. Pacôme and between fifteenth and sixteenth telegraph poles east of mile-post 39 from Rivière-du-Loup.

Cross-country branch line to Bretagne.

27–G In west end—1 foot below top—of south face-wall of concrete tile culvert under Intercolonial railway, 450 feet east of St. Philippe-de-Neri station.

28–G In third course of stonework above ground, in south wall—3 feet from front (or west) wall—of Roman Catholic church at Mont Carmel.

29–G In northeast face of large mass of rock, 20 feet from southeast corner of George Russell's house and 3 miles south of Mont Carmel Roman Catholic church.

30–G In east face of large boulder in field belonging to Antoine St. Onge, 100 feet from northwest corner of his house and on opposite side of road. This is about 3¼ miles north of Bretagne—on road to St. Philippe-de-Neri.

377–B In boulder beside National Transcontinental railway, 2 miles west of Bretagne—see line from St. Anselme to Edmundston.

Main line, continued.

575–B In east end—3 feet 8 inches below top—of north face-wall of (triple) concrete tile culvert under Intercolonial railway, 1½ miles east of St. Philippe-de-Neri and at mileage 29·7 from Rivière-du-Loup.

576–B In south end of east face of concrete retaining wall behind west abutment—22 inches above bridge-seat—of plate-girder bridge on Intercolonial railway, 1¼ miles west of St. Paschal and at mileage 26·6 from Rivière-du-Loup.

577–B In north face—5 feet 3 inches from east end—of concrete coping on northeast masonry retaining wall of plate-girder bridge on Intercolonial railway, ½ mile east of Dessaint and at mileage 21·7 from Rivière-du-Loup.

578–B In east end—2 feet below top—of north face-wall of concrete tile culvert under Intercolonial railway, 80 feet east of station-house at Ste. Hélène.

NOTE.—This bench-mark has been rendered inaccessible by a timber extension constructed at north end of culvert.

579–B In second course of stonework below top, in south face of east abutment of old stone culvert under Intercolonial railway, 1½ miles east of St. André and at mileage 14·6 from Rivière-du-Loup.

579–B–2 In west end—19 inches below top—of south face-wall of concrète tile culvert under Intercolonial railway, 1 mile east of Old Lake Road station and 440 feet west of mile-post 5 from Rivière-du-Loup.

580–B In side of concrete bench-mark pier, 4 feet north of south line of Intercolonial railway right-of-way, 12 feet east of a farm crossing, 945 feet west of mile-post 2 from Rivière-du-Loup and 25 feet west of a small rocky knoll between track and south fence of right-of-way.

77–B In Intercolonial railway bridge immediately north of Rivière-du-Loup station—see line from St. Stephen to Rivière-du-Loup.

BENCH-MARKS BETWEEN OTTAWA AND RENFREW, ONT., VIA CANADIAN PACIFIC RAILWAY TO ARNPRIOR AND GRAND TRUNK RAILWAY TO RENFREW.

Elevations on page 293.

Note.—These descriptions are written with the assumption that the railway runs in a southwesterly direction from Ottawa to Carleton Place, thence northwesterly to Arnprior and thence westerly to Renfrew.

50–G In northeast end of northwest face of small square concrete culvert under Canadian Pacific railway, at mileage 1·7 west of Ottawa (Broad street station).

51–G In northeast end of northwest face of (double) square concrete culvert under Canadian Pacific railway, ¾ mile northeast of Britannia flag-station and at mileage 4·4 from Ottawa.

52–G In northwest face of masonry retaining wall beside Canadian Pacific railway track along the shore of lake Deschênes. The bench-mark is 14 inches below top of concrete coping of wall and immediately northeast of culvert at mileage 6·1 from Ottawa.

53–G In north end of east face of west concrete abutment—18 feet below bridge-seat—of bridge by which Canadian Northern railway passes over Canadian Pacific railway, at mileage 8·2 from Ottawa (Broad street station).

54–G In northeast end of northwest face of square concrete culvert under Canadian Pacific railway, 110 feet southwest of southwesterly switch of Nepean passing-track and at mileage 10·9 from Ottawa.

55–G In northeast end of northwest face of square concrete culvert under Canadian Pacific railway, ¾ mile northeast of Stittville and at mileage 14·1 from Ottawa.

56–G In northeast end of northwest face of square concrete culvert under Canadian Pacific railway, at mileage 17·5 from Ottawa.

57–G In northeast end of northwest face of square concrete culvert under Canadian Pacific railway, at mileage 20·5 from Ottawa.

58–G In southwest end of northwest face of square concrete culvert under Canadian Pacific railway, ¾ mile northeast of Ashton and at mileage 22·8 from Ottawa.

59–G In southwest face—10 inches below top—of northwest face-wall of square concrete culvert under Canadian Pacific railway, 2½ miles northeast of Carleton Place and at northeast line of a highway crossing at mile-post 26 from Ottawa.

60–G In east end of north wall—31 inches below water-table—of Canadian Pacific machine shop at Carleton Place—a large stone building immediately west of the station.

61–G In fourth course of stonework below water-table course, in north end of front (or west) wall of Carleton Place post-office.

62–G In fourth course of stonework below top, in west face of coping on east end of first pier from southerly abutment of Canadian Pacific railway bridge over Mississippi river, ½ mile northwest of station at Carleton Place.

63–G In southeast end of northeast face of large square concrete culvert under Canadian Pacific railway, 4 miles northwest of Carleton Place and at mileage 32·5 from Ottawa.

64–G In eighth course of stonework below water-table course, in south end of front (or east) wall of Almonte town-hall.

65–G In west foundation wall—2 feet 3 inches above concrete sidewalk and 3 feet from southwest corner—of Almonte post-office.

66–G In southwest end of northwest face of concrete retaining wall behind southeast abutment of Canadian Pacific railway bridge over Mississippi river, ¼ mile northwest of station at Almonte.

67–G In side of concrete bench-mark pier, 8 feet northeast of southwest line of Canadian Pacific railway right-of-way, at fifth telegraph pole northwest of mile-post 40 from Ottawa, 1 mile northwest of Snedden flag-station and 30 feet southeast of a private crossing leading to James Temmen's (red brick) farm house which is situated about 100 yards northeast of the railway.

68–G In northwest face—22 inches above bridge-seat—of concrete retaining wall behind southeast abutment of subway under Canadian Pacific railway, 800 feet southeast of Pakenham station. The bench-mark is 5 feet northeast of northeasterly girder of bridge.

69–G In second course of stonework below iron sheeting, in east end of north foundation wall of Renfrew Flour Company's flour shed at Pakenham—a sheet-iron covered building immediately east of Canadian Pacific railway and ¼ mile north of the station.

70–G In southeast end of northeast face of square concrete culvert under Canadian Pacific railway—at a diagonal highway crossing—between third and fourth telegraph poles northwest of mile-post 46 from Ottawa.

71–G In northwest end of northeast face of square concrete culvert under Canadian Pacific railway—at a highway crossing—100 feet southeast of southeasterly switch of Waba passing-track and between first and second telegraph poles northwest of mile-post 48 from Ottawa.

72–G In top course of stonework, in northeast face—near centre—of east retaining wall of plate-girder subway under Canadian Pacific railway, 1½ miles southeast of Arnprior and at mileage 50·4 from Ottawa.

73–G In front (or west) wall of Canadian Pacific station-house at Arnprior, 15 inches below plinth course and 4 feet from northwest corner of building.

74–G In ninth course of stonework below brickwork, in north wall of Arnprior town-hall—facing Madawaska street. The bench-mark is 38 feet from northwest corner of building and is in north face of corner stone at northwest corner of a projection from the north wall.

75–G In second course of stonework below water-table course, in west wall of Arnprior post-office, between the two basement windows which are between the letter-drop and the doorway of custom-office.

76–G In second course of stonework below top, in west end of south face of southwest retaining wall of plate-girder bridge on Grand Trunk railway, 2¾ miles east of Glasgow and at mileage 176·6 from Alburgh Junction.

77–G In second course of stonework below top, in west end of north face of northwest retaining wall of plate-girder bridge on Grand Trunk railway, 1 mile west of Glasgow.

78–G In north face of rock exposure at northerly side of a rocky hill skirted by Grand Trunk railway, $5\frac{1}{2}$ miles east of Renfrew and at mileage 182·4 from Alburgh Jct. The bench-mark is 15 feet south of south line of right-of-way, 340 feet east of a small wooden culvert and 55 feet east of a whistle-post.

79–G In side of concrete bench-mark pier, 7 feet south of north line of Grand Trunk railway right-of-way, 490 feet west of a small culvert, 2 miles east of Renfrew and 350 feet west of mile-post 186 from Alburgh Junction.

505 In third course of stonework below water-table course, in front (or west) wall of Renfrew post-office, 8 feet to the south of the letter-drop.

BENCH-MARKS BETWEEN KEMPTON AND IVANHOE, ONT., VIA CANADIAN PACIFIC RAILWAY, WITH BRANCH LINES FROM SMITHS FALLS TO CARLETON PLACE AND BROCKVILLE, SHARBOT LAKE TO RENFREW AND KINGSTON AND (ALONG GRAND TRUNK RAILWAY) FROM IVANHOE TO BELLEVILLE.

Elevations on pages 295 to 301.

80–G In second course of stonework below top, in east end of north face of northeast retaining wall of Canadian Pacific railway bridge over Kemptville creek, 2 miles west of Kempton.

81–G In west face of coping on north end of small concrete arch culvert under Canadian Pacific railway, at the east line of a highway crossing at mileage 108·4 from Montreal West.

82–G In east face of coping on south end of concrete arch culvert under Canadian Pacific railway, $\frac{1}{4}$ mile east of Burritt flag-station and at mileage 110·6 from Montreal West.

83–G In west end of north face of square concrete culvert under Canadian Pacific railway, at mile-post 113 from Montreal West.

84–G In north face—8 inches below top—of concrete retaining wall behind east abutment of subway under Canadian Pacific railway, 0·6 mile east of Merrickville and 400 feet east of east end of bridge over Rideau river.

85–G In west end of north face—1 foot below top—of square concrete culvert under Canadian Pacific railway, 50 feet east of a farm crossing at mileage 116·7 from Montreal West.

86–G In north end of west face—4 inches below top—of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, 500 feet east of Rosedale flag-station and at mileage 119·8 from Montreal West.

87–G In east face of coping on south end of small concrete arch culvert under Canadian Pacific railway, $1\frac{1}{3}$ miles east of Smiths Falls station and at mileage 122·5 from Montreal West.

88–G In concrete foot-subway under Canadian Pacific railway at north end of station platform at Smiths Falls. The bench-mark is in east wall of Herbert street approach—from the direction of the station, 15 inches below top of wall and 36 feet south of south side of passageway under tracks. (The railway is assumed to run north and south at Smiths Falls).

89–G In southeast face of concrete retaining wall behind north abutment—3 feet above bridge-seat—of subway by which Canadian Northern railway passes under Canadian Pacific railway (main line and branch to Carleton Place), $\frac{1}{2}$ mile north of Smiths Falls station. The bench-mark is 2 feet east of easterly girder on Carleton Place line.

Branch line to Carleton Place.

90–G In west face—near centre—of square concrete culvert under Canadian Pacific railway, $1\frac{3}{4}$ miles north of Smiths Falls station and at mileage 15·2 from Carleton Place.

91–G In south end of east face of square concrete culvert under Canadian Pacific railway, $\frac{1}{2}$ mile north of Welsh flag-station and between second and third telegraph poles north of mile-post 13 from Carleton Place.

92–G In north end of east face of square concrete culvert under Canadian Pacific railway, $1\frac{1}{4}$ miles south of Franktown and at mileage 9·4 from Carleton Place.

93–G In north end of west face of square concrete culvert under Canadian Pacific railway, at ninth telegraph pole south of mile-post 5 from Carleton Place.

94–G In east face—near centre—of small square concrete culvert under Canadian Pacific railway, $2\frac{3}{4}$ miles south of Carleton Place and at the south line of a highway crossing.

60–G In Canadian Pacific machine shop at Carleton Place—see line from Ottawa to Renfrew.

Branch line to Brockville.

95–G In second course of stonework below top, in south end of east face of southwest retaining wall of subway under Canadian Pacific railway, 200 feet south of bridge over Rideau river and $1\frac{1}{4}$ miles south of Smiths Falls station.

96–G In south face of west face-wall of square concrete culvert under Canadian Pacific railway, $2\frac{1}{4}$ miles north of Jasper and at mileage 21·7 from Carleton Place.

97–G In east end of south face of concrete retaining wall behind north abutment of Canadian Pacific railway bridge over Irish creek, immediately south of Jasper station.

98–G In north end of west face of coping on west end of small concrete arch culvert under Canadian Pacific railway, $2\frac{1}{2}$ miles south of Jasper and at mileage 26·5 from Carleton Place.

99–G In second course of stonework below top, in south end of east face of small masonry culvert under Canadian Pacific railway, at second telegraph pole south of mile-post 30 from Carleton Place.

100–G In north end of west face of square concrete culvert under Canadian Pacific railway, $\frac{1}{2}$ mile north of Jelly flag-station and at mileage 32·5 from Carleton Place.

101–G In south end of east face of large square concrete culvert under Canadian Pacific railway, $\frac{3}{4}$ mile north of Bellamy and at mileage 34·6 from Carleton Place.

102–G In south end of west face of square concrete culvert under Canadian Pacific railway at south line of highway crossing at Hawkens flag-station.

103–G In south end of east face of square concrete culvert under Canadian Pacific railway, $4\frac{1}{2}$ miles north of Brockville and at mileage 40·5 from Carleton Place.

104–G In side of concrete bench-mark pier, 7 feet west of east line of Canadian Pacific railway right-of-way, $2\frac{1}{2}$ miles north of Brockville and 33 feet south of sixth telegraph pole south of a highway crossing—the road allowance between concessions II and III.

123 In culvert under Grand Trunk railway in Brockville—see line from Rouse Point to Colborne.

105–G In south end of west wall of Brockville court-house, 1 foot below sills of basement windows facing on William street.

106–G In first course of stonework above concrete sidewalk, in north wall of Brockville post-office. The bench-mark is in north side of pillar between the two arches at northeast corner of building.

Main line, continued.

107–G In first course of stonework below water-table course, in east (or Market street) wall of Smiths Falls post-office—28 feet from southeast corner of building.

108–G In first course of stonework above water-table, in south face of pilaster at southeast corner of Smiths Falls town-hall—at northeast corner of Church and Beckwith streets.

109–G In east end of south face-wall of concrete tile culvert under Canadian Pacific railway, 3½ miles west of Smiths Falls and 630 feet east of a farm crossing.

110–G In east end of south face of eight-foot concrete culvert under Canadian Pacific railway, ½ mile east of Elmsley and at mileage 5·2 from Smiths Falls.

111–G In west end of north face of square concrete culvert under Canadian Pacific railway, at third telegraph pole east of mile-post 8 from Smiths Falls.

112–G In east end of south face of square concrete culvert under Canadian Pacific railway, 1,200 feet east of Perth station.

113–G In masonry base of Canadian Pacific water-tank at Perth, 7 feet to the left of the doorway underneath tank and in third course of stonework above doorsill.

114–G In south stone foundation wall of Perth public library, 4 feet west of main entrance and 13 inches above concrete sidewalk on Gore street.

115–G In water-table course of stonework, in front (or north) wall of Perth town-hall, 10 feet 6 inches from northeast corner of building.

116–G In north face-wall of small triangular concrete culvert under Canadian Pacific railway, 2¼ miles west of Perth and at fourth telegraph pole east of mile-post 14 from Smiths Falls.

117–G In west end of north face of square concrete culvert under Canadian Pacific railway, 150 feet west of Glentay station.

118–G In north face of concrete retaining wall behind west abutment of small plate-girder bridge on Canadian Pacific railway, ¼ mile east of Bathurst.

119–G In centre of north face of small square concrete culvert under Canadian Pacific railway—at the east line of a highway crossing—at third telegraph pole west of mile-post 6 from Glentay.

120–G In north side of curved rock cut on Canadian Pacific railway, 430 feet east of east line of a highway crossing and 55 feet east of mile-post 9 from Glentay.

121–G In west end of north face of large square concrete culvert under Canadian Pacific railway, 140 feet west of westerly switch of Maberley passing-track and 65 feet east of a hand-car house.

122–G In south face—slightly below rail level—of large mass of rock on north side of Canadian Pacific railway track, immediately east of a small rock cut; also 380 feet west of mile-post 14 from Glentay and 40 feet west of a wooden culvert.

123–G In east end of north face of small concrete arch culvert under Canadian Pacific railway, at mileage 17·4 from Glentay—within the limits of Ungava passing-track.

124–G In south side of rock cut on Canadian Pacific railway at Sharbot Lake station—48 feet east of westerly switch leading from main line to passing-track and 370 feet west of water column on main line opposite Union hotel.

Branch line to Renfrew.

125–G In west side of rock cut on Canadian Pacific railway—100 feet from south end of cut—2¾ miles north of Sharbot Lake station and 160 feet south of mile-post 54 from Renfrew.

126–G In east face—near centre—of exposed rock surface immediately west of Canadian Pacific railway track, 1,080 feet south of a wooden culvert at mileage 51·2 from Renfrew; this exposure is on the side of a hill of rock which has been partly cut away to allow the track to pass.

127-G In east side of rock cut on Canadian Pacific railway—near centre of cut—¼ mile north of Clarendon, 200 feet north of a wooden culvert and 370 feet north of a whistle-post for southbound trains.

128-G In north end of east face of coping on east end of large square concrete culvert under Canadian Pacific railway, 1½ miles south of Mississippi and at mileage 45·7 from Renfrew.

129-G In east face of concrete retaining wall behind south abutment of plate-girder bridge on Canadian Pacific railway, ½ mile north of Snow Road and at mileage 41·8 from Renfrew.

130-G In north end of east face of square concrete culvert under Canadian Pacific railway, at mileage 39·2 from Renfrew.

131-G In west side of small rock cut on Canadian Pacific railway, 520 feet south of mile-post 36 from Renfrew and 420 feet north of a white frame house on east side of track—immediately north of Wilbur station.

132-G In east side of rock cut on Canadian Pacific railway, 700 feet south of mile-post 33 from Renfrew and 350 feet north of sign "Lavant 1 mile"—north of station.

133-G In west face of concrete retaining wall behind south abutment of plate-girder bridge on Canadian Pacific railway, 4¼ miles north of Lavant and at mileage 30·2 from Renfrew.

134-G In east side of rock cut on Canadian Pacific railway—near south end of cut—1,110 feet north of mile-post 27 from Renfrew; this cut is on the first curve (about ½ mile) north of Clyde Forks.

135-G In north end of west face of large square concrete culvert under Canadian Pacific railway, 1 mile north of Flower and at mileage 24·5 from Renfrew; this structure is the farther north of two culverts about 25 feet apart.

136-G In north end of west face of square concrete culvert under Canadian Pacific railway, at mileage 22·4 from Renfrew.

137-G In east face of half-buried boulder, immediately west of Canadian Pacific Railway track and at south end of a small earth cut at mileage 19·7 from Renfrew. The bench-mark is 90 feet north of a small wooden culvert and 170 feet south of a whistle-post for northbound trains.

138-G In east side of rock cut on Canadian Pacific railway—near centre of cut—¾ mile south of Barryvale and 215 feet south of mile-post 17 from Renfrew.

139-G In west end of south face of concrete retaining wall behind north abutment of highway bridge over Madawaska river, 100 yards south of Calabogie station and immediately east of Canadian Pacific railway bridge.

140-G In west side of rock cut on Canadian Pacific railway—80 feet from north end of cut—240 feet south of a small stone culvert at mileage 11·6 from Renfrew and 460 feet south of sign "Ashdod 1 mile"—south of station.

141-G In east face of large boulder, immediately west of Canadian Pacific railway track at mileage 7·6 from Renfrew—570 feet south of a whistle-post for southbound trains and 870 feet south of a small waterfall on opposite side of track.

142-G In east side of rock cut on Canadian Pacific railway—100 feet from north end of cut—580 feet south of milepost 5 from Renfrew and just at the head of a grade.

143-G In south end of west face of coping on west end of concrete arch culvert under Canadian Pacific railway, at mileage 2·3 from Renfrew.

505 In third course of stonework below water-table course, in front (or west) wall of Renfrew post-office, 8 feet to the south of the letter-drop.

Branch line to Kingston.

144–G In west side of small rock cut on Canadian Pacific railway, 2¾ miles south of Sharbot Lake station and at mileage 59·6 from Renfrew. The bench-mark is 9 feet south of a whistle-post for southbound trains and 940 feet south of south line of a highway crossing.

145–G In east face—near north end—of large sloping mass of rock immediately west of Canadian Pacific railway track and at mileage 62·4 from Renfrew; this is 200 feet south of a rock cut which is at the south end of a rather deep fill.

146–G In south face, 7 inches below top, of disused block of concrete—2 feet by 3 feet—originally used in connection with interlocking plant at Tichborne; this is immediately east of Canadian Pacific railway track (Kingston subdivision) and 300 feet north of diamond crossing of main line.

147–G In first course of stonework above bridge-seat, in west face of south abutment of small plate-girder bridge on Canadian Pacific railway, 1½ miles south of Tichborne and at mileage 66·7 from Renfrew.

148–G In west side of small shallow rock cut on Canadian Pacific railway, 40 feet south of a farm crossing, 60 feet north of mile-post 69 from Renfrew and 2½ miles north of Hinchinbrooke flag-station.

149–G In south face of west face-wall of large square concrete culvert under Canadian Pacific railway, 145 feet north of mile-post 71 from Renfrew and 0·4 mile north of Hinchinbrooke.

150–G In third course of stonework below bridge-seat, in west face of north abutment of plate-girder bridge on Canadian Pacific railway, ¼ mile north of Godfrey.

151–G In west side of shallow rock cut on Canadian Pacific railway—near north end of cut—30 feet south of a whistle-post for northbound trains and between eighth and ninth telegraph poles north of mile-post 77 from Renfrew.

152–G In east face—8 inches below top—of north concrete abutment of plate-girder bridge on Canadian Pacific railway, at a water-tank, ¾ mile south of Verona.

153–G In east face—near centre—of square concrete culvert under Canadian Pacific railway, 1,850 feet south of Hartington station.

154–G In south end of east face of coping on east end of concrete arch culvert under Canadian Pacific and Canadian Northern railways, 220 feet north of Harrowsmith station.

155–G In east face of south concrete abutment—6 inches below bridge-seat—of plate-girder bridge on Canadian Pacific railway, 2¼ miles south of Harrowsmith and at mileage 87·3 from Renfrew.

156–G In south end of east face of square concrete cattle-pass under Canadian Pacific railway, ¼ mile south of Murvale.

157–G In west side of shallow limestone cut on Canadian Pacific railway, ¾ mile north of Glenvale and 330 feet north of an old stone culvert at mileage 92·7 from Renfrew.

158–G In west side—near centre—of long curved limestone cut on Canadian Pacific railway, 1¼ miles south of Glenvale and at mileage 94·7 from Renfrew. The bench-mark is at the centre of a smooth clean-cut exposure about 30 feet in length, and is 885 feet north of north line of a highway crossing.

159–G In west face of square concrete culvert running diagonally under Canadian Pacific railway—in a rock cut—360 feet south of highway crossing at "Jackson's mill" and at mileage 96·3 from Renfrew. The bench-mark is 15 inches south of northwesterly outlet of culvert and 7 feet east of west side of rock cut.

160–G In side of concrete bench-mark pier, 7 feet east of west line of Canadian Pacific railway right-of-way and 235 feet south of a small open culvert with stone abutments; this is at mileage 99·2 from Renfrew and 2¾ miles northwest of Grand Trunk station at Kingston Junction.

139 In Grand Trunk station-house at Kingston Junction—see line from Rouse Point to Colborne.

Main line, continued.

161–G In south end of east face of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, 2½ miles west of Sharbot Lake station and at mileage 23·9 from Glentay.

162–G In south face-wall of small triangular concrete culvert under Canadian Pacific railway, at mileage 27·3 from Glentay—within the limits of Olden passing-track.

163–G In east end of north face of square concrete culvert under Canadian Pacific railway, at the east line of a highway crossing immediately east of Mountain Grove station.

164–G In north side of rock cut on Canadian Pacific railway, 515 feet west of mile-post 33 from Glentay and 450 feet west of a private crossing beside which is situated a square frame house about 200 feet south of the railway.

165–G In second course of stonework below coping, in east end of north face of northeast retaining wall of plate-girder bridge on Canadian Pacific railway, ¾ mile east of Ardendale.

166–G In south face of exposed rock surface, 10 feet north of Canadian Pacific railway track, 140 feet east of a farm crossing and 200 feet west of a concrete tile culvert at mileage 38·2 from Glentay.

167–G In north face of exposed rock surface, 25 feet north of south line of Canadian Pacific railway right-of-way, 860 feet east of westerly switch of Kennebec passing-track and at (approximate) mileage 41·3 from Glentay.

168–G In south side of long curved rock cut on Canadian Pacific railway—near centre of cut—370 feet east of a triangular concrete culvert and 225 feet west of mile-post 44 from Glentay.

169–G In west end of south face—14 inches below top— of (double) stone and concrete culvert under Canadian Pacific railway, 2½ miles west of Kaladar and at mileage 48·7 from Glentay.

170–G In west end of south face of (double) square concrete culvert under Canadian Pacific railway, at mileage 50·9 from Glentay.

171–G In north face of exposed rock surface, 10 feet south of Canadian Pacific railway track—near rail level—740 feet east of easterly switch of Hungerford passing-track and at twenty-second telegraph pole west of mile-post 54 from Glentay.

172–G. In south face of small stone and concrete culvert under Canadian Pacific railway, ¼ mile west of Sulphide and at mileage 57·6 from Glentay.

173–G In third course of stonework above bridge-seat, in south end of west face of retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 2½ miles east of Tweed and at mileage 60·1 from Glentay.

174–G In first course of stonework below cap-stone, in east end of south face of northwest retaining wall of Canadian Pacific railway bridge over Moira river, ¼ mile east of Tweed.

175–G In east concrete foundation wall of Orange hall at Tweed, 7 inches below brickwork and at base of first pilaster from southeast corner of building.

176–G In east wall of tower of Tweed Methodist church, 5 feet from southeast corner of tower and 6 feet 6 inches below the lowest of the three small windows.

177–G In south face of small stone and concrete culvert under Canadian Pacific railway, 2¾ miles west of Tweed and at mileage 65·3 from Glentay.

178–G In north side of rock cut on Canadian Pacific railway, 650 feet east of a concrete culvert and 700 feet west of mile-post 68 from Glentay.

179–G In south face of concrete coping on stone retaining wall behind east abutment of bridge by which Canadian Pacific railway passes over Grand Trunk railway, 1 mile east of Ivanhoe C.P.R. station and ¼ mile south of Crookston G.T.R. station.

Branch line to Belleville.

180–G In boulder 13 feet east of Grand Trunk railway track, 520 feet north of a highway crossing, 100 feet north of a red brick farm house and at mileage 18·3 from Belleville harbour.

181–G In boulder 17 feet east of Grand Trunk railway track, on north side of public highway immediately north of West Huntingdon station.

182–G In north face of large boulder, 93 feet east of Grand Trunk railway track, on south line of public highway immediately north of Madoc Junction station—at the foot of a large elm tree.

183–G In side of concrete bench-mark pier on Grand Trunk railway right-of-way, between track and line of telegraph poles, at seventh pole north of a highway crossing or fifteenth pole north of mile-post 10 from Belleville harbour—at the south end of an old gravel pit.

184–G In first altar step below top, in east face of southeast concrete retaining wall of Grand Trunk railway bridge over Moira river, immediately south of Foxboro.

185–G In first course of stonework below bridge-seat, in east face of south abutment of small plate-girder bridge on Grand Trunk railway, 400 feet south of main road crossing at Corbyville.

186–G In south face of very large boulder lying on east line of Grand Trunk railway right-of-way, 1·6 miles north of Belleville station and between seventh and eighth telegraph poles south of mile-post 4 from Belleville harbour.

156 In Grand Trunk station-house at Belleville—see line from Rouse Point to Colborne.

BENCH-MARKS BETWEEN STEELTON AND FRANZ, ONT., VIA ALGOMA CENTRAL AND HUDSON BAY RAILWAY, WITH BRANCH LINE TO MICHIPICOTEN.

Elevations on page 302.

637 In south face—16 inches below top—of west face-wall of concrete arch culvert under Algoma Central railway, at mileage 3·2 from Sault Ste. Marie.

638 In north face—8 inches below top—of coping on west end of large concrete arch culvert through which Root river flows under Algoma Central railway, at mileage 6·8 from Sault Ste. Marie.

639 In east side of small rock cut on Algoma Central railway— near north end of cut—37 feet south of first telegraph pole south of mile-post 10 from Sault Ste. Marie.

640 In west side of small rock cut on Algoma Central railway—2 feet above rail level—380 feet north of Heyden section-house and 15 feet south of mile-post 13 from Sault Ste. Marie.

641 In east side of rock cut on Algoma Central railway—near centre of cut—780 feet north of Island Lake station and 45 feet south of mile-post 16 from Sault Ste. Marie.

642 In east face of exposed rock surface, 45 feet west of Algoma Central railway track, 180 feet north of north end of a long steel trestle bridge and ½ mile north of Bellevue.

643 In west face of small boulder, 30 feet east of Algoma Central railway track and 25 feet south of second telegraph pole north of mile-post 22 from Sault Ste. Marie.

644 In north face—9 inches below top—of east face-wall of concrete arch culvert under Algoma Central railway, at mile-post 25 from Sault Ste. Marie.

645 In east side of rock cut on Algoma Central railway—14 feet from north end of cut—720 feet south of road crossing at Glendale and between second and third telegraph poles south of mile-post 28 from Sault Ste. Marie.

646 In south face—18 inches below top—of southeast concrete retaining wall of steel truss bridge over Goulais river, ½ mile south of Searchmont.

647 In west face of mass of rock—12 feet east of Algoma Central railway track and at south end of a clay cut—between third and fourth telegraph poles south of mile-post 33 from Sault Ste. Marie.

648 In west face of small boulder, 15 feet west of Algoma Central railway track and at ninth telegraph pole north of mile-post 36 from Sault Ste. Marie.

649 In west face of concrete retaining wall behind north abutment of plate-girder bridge over Achigan river, 2½ miles south of Achigan and at mileage 38·5 from Sault Ste. Marie.

650 In east side of rock cut on Algoma Central railway—12 feet from south end of cut and near rail level—½ mile north of Achigan, 220 feet north of a whistle-post for northbound trains and at mileage 41·5 from Sault Ste. Marie.

651 In east face of boulder, half buried in side of clay bank—15 feet west of Algoma Central railway track and 3 feet above rail level—160 feet south of Bucyrus station and between first and second telegraph poles north of mile-post 45 from Sault Ste. Marie.

652 In west side of large rock cut on Algoma Central railway—100 feet from south end of cut and near rail level—½ mile north of Ogadaki and 60 feet north of third telegraph pole south of mile-post 48 from Sault Ste. Marie.

653 In east face of concrete retaining wall behind south abutment of plate-girder bridge over south branch of Chippawa river, at mile-post 51 from Sault Ste. Marie.

654 In west side of rock cut on Algoma Central railway—50 feet from north end of cut and near rail level—480 feet south of Mashkode south mile-board and at mileage 54·3 from Sault Ste. Marie.

655 In west side of rock and clay cut on Algoma Central railway, between first and second telegraph poles north of mile-post 57 from Sault Ste. Marie and 160 feet south of south end of trestle over a small bay of Trout lake.

656 In west side of rock cut on Algoma Central railway—near centre of cut and 1 foot above rail level—between first and second telegraph poles north of mile-post 60 from Sault Ste. Marie and 400 feet north of north end of a long trestle over a ravine.

657 In west side of rock cut on Algoma Central railway—50 feet from south end of cut and 1 foot above rail level—¾ mile south of Mekatina and at mile-post 63 from Sault Ste. Marie.

658 In west side of rock cut on Algoma Central railway—50 feet from south end of cut and 1 foot above rail level—2½ miles north of Mekatina and 110 feet north of mile-post 66 from Sault Ste. Marie.

659 In east face of concrete retaining wall behind south abutment of plate-girder bridge over north branch of Chippawa river, at mileage 69·2 from Sault Ste. Marie.

660 In east face of exposed rock surface, 25 feet west of Algoma Central railway track, 200 feet north of south switch of Summit siding and 60 feet south of mile-post 72 from Sault Ste. Marie.

661 In west side of rock cut on Algoma Central railway, 360 feet south of stopping-point for "cottages 4 and 5" (owned by railway company), and at third telegraph pole south of mile-post 75 from Sault Ste. Marie.

662 In west side of rock cut on Algoma Central railway—near centre of cut—1 mile south of Batchawana and 30 feet south of third telegraph pole north of mile-post 78 from Sault Ste. Marie.

663 In east face of concrete retaining wall behind south abutment of plate-girder bridge over Batchawana river, ½ mile north of Batchawana.

664 In west side of large rock cut on Algoma Central railway—80 feet from south end of cut and 1 foot above rail level—2 miles north of Batchawana and 15 feet south of third telegraph pole north of mile-post 81 from Sault Ste. Marie.

665 In east side of rock cut on Algoma Central railway—200 feet from north end of cut—20 feet south of seventh telegraph pole north of mile-post 84 from Sault Ste. Marie.

666 In east side of rock cut on Algoma Central railway—near rail level—220 feet south of Regent south mile-board and between first and second telegraph poles south of mile-post 87 from Sault Ste. Marie.

667 In south end of east face—6 inches below top—of southeast concrete retaining wall of long steel trestle bridge over Montreal river, 3½ miles south of Montreal section-house.

668 In east face of small boulder, 20 feet west of Algoma Central railway track, 460 feet north of Montreal section-house and at third telegraph pole south of mile-post 95 from Sault Ste. Marie.

NOTE.—Owing to the danger of this boulder being affected by frost, the elevation of this bench-mark must be considered unreliable.

669 In west side of rock cut on Algoma Central railway—near rail level—25 feet south of second telegraph pole south of mile-post 98 from Sault Ste. Marie.

670 In west face of coffin-shaped mass of rock, about 12 feet in length, 20 feet east of Algoma Central railway track, 1 mile south of Frater and 25 feet south of mile-post 101 from Sault Ste. Marie.

NOTE.—Owing to the danger of this boulder being affected by frost, the elevation of this bench-mark must be considered unreliable.

671 In west side of rock cut on Algoma Central railway—75 feet from north end of cut—40 feet south of mile-post 104 from Sault Ste. Marie and 150 feet south of south end of long curved trestle bridge 2 miles north of Frater.

672 In east side of rock cut on Algoma Central railway—near north end of cut and at rail level—320 feet south of south end of a trestle bridge and 65 feet north of mile-post 107 from Sault Ste. Marie.

673 In east side of rock cut on Algoma Central railway—near rail level—240 feet south of south end of a small trestle and 50 feet south of mile-post 110 from Sault Ste. Marie.

674 In vertical rock surface, 20 feet west of Algoma Central railway track and 75 feet south of eighth telegraph pole south of mile-post 113 from Sault Ste. Marie.

675 In west side of large rock cut on Algoma Central railway—at extreme north end of cut—30 feet south of first telegraph pole north of mile-post 116 from Sault Ste. Marie and at northerly entrance of Agawa river canyon.

676 In north face of exposed rock surface, 25 feet west of Algoma Central railway track and 30 feet south of second telegraph pole north of mile-post 119 from Sault Ste. Marie.

677 In west face of exposed rock surface, 20 feet east of Algoma Central railway track, 50 feet north of a small rock cut and at second telegraph pole south of mile-post 121 from Sault Ste. Marie.

678 In east face of boulder, half buried in hillside, 30 feet west of Algoma Central railway track and 100 feet south of mile-post 124 from Sault Ste. Marie.

679 In west face of exposed rock surface, 40 feet east of Algoma Central railway track, 630 feet north of north end of a trestle bridge and 20 feet north of fourth telegraph pole south of mile-post 128 from Sault Ste. Marie.

680 In west face of exposed rock surface, 30 feet east of Algoma Central railway track, ½ mile north of Agawa section-house and 25 feet north of twelfth telegraph pole north of mile-post 131 from Sault Ste. Marie.

681 In west face of boulder, 30 feet east of Algoma Central railway track and 95 feet south of mile-post 134 from Sault Ste. Marie.

682 In west face of large white boulder, half buried in hillside, 12 feet east of Algoma Central railway track and at fifth telegraph pole north of mile-post 137 from Sault Ste. Marie.

683 In east face of small boulder, 65 feet west of Algoma Central railway track, 460 feet north of southerly switch of Tabor passing-track and at third telegraph pole north of mile-post 140 from Sault Ste. Marie.

684 In west face of large white boulder, partly buried in hillside, 15 feet east of Algoma Central railway track and between first and second telegraph poles south of mile-post 143 from Sault Ste. Marie.

685 In east side of rock cut on Algoma Central railway—near centre of cut—450 feet north of north end of a trestle bridge and between fifth and sixth telegraph poles south of mile-post 146 from Sault Ste Marie.

686 In east face of concrete retaining wall behind south abutment of plate-girder bridge over Michipicoten river, at mileage 151·6 from Sault Ste. Marie.

687 In east face of large black boulder, 30 feet west of Algoma Central railway track and between fourteenth and fifteenth telegraph poles south of mile-post 155 from Sault Ste. Marie.

688 In east face of exposed rock surface—10 feet west of Algoma Central railway track and about 1 foot below rail level—at first telegraph pole south of mile-post 158 from Sault Ste. Marie.

689 In west face of exposed rock surface—27 feet east of Algoma Central railway track and near rail level—1¾ miles south of station at Hawk Junction and at fourth telegraph pole north of mile-post 162 from Sault Ste. Marie.

Michipicoten branch line.

690 In south face of vertical rock surface of steep rocky hill immediately west of Algoma Central railway track (Michipicoten branch), ¾ mile north of station at Hawk Junction, at eleventh telegraph pole north of mile-post 26 from Michipicoten and opposite a point on main line at mileage 164·8 from Sault Ste. Marie. The bench-mark is 90 feet west of track, 3 feet above ground and about at rail level.

691 In south side of rock cut on Algoma Central railway—15 feet south of track and near centre of cut—at mile-post 23 from Michipicoten.

692 In north side of wide rock cut on Algoma Central railway, 35 feet north of track, 100 feet west of sixth telegraph pole west of mile-post 20 from Michipicoten and 600 feet east of a concrete culvert—the first one west of spur line to Josephine mine.

693 In north face of exposed rock surface, 35 feet south of Algoma Central railway track and 100 feet west of mile-post 17 from Michipicoten.

694 In north face of exposed rock surface at the base of a rocky hill, immediately south of Algoma Central railway track and 70 feet east of mile-post 13 from Michipicoten—facing a large muskeg.

695 In north side of rock cut on Algoma Central railway, 2 feet above rail level and 60 feet east of mile-post 11 from Michipicoten.

696 In west face of flat mass of rock, 100 feet south of Algoma Central railway track and 75 feet west of first telegraph pole west of mile-post 8 from Michipicoten.

697 In south side of rock cut on Algoma Central railway, at eleventh telegraph pole east of mile-post 3 from Michipicoten.

698 In square-cut mass of rock, 230 feet south of Algoma Central railway track and 275 feet east of hotel at Michipicoten.

Main line, continued.

699 In east side of small rock cut on Algoma Central railway—30 feet from south end of cut—4 miles north of station at Hawk Junction and at fifth telegraph pole south of mile-post 168 from Sault Ste. Marie. This cut is at the south end of a long muskeg.

700 In south face of vertical rock surface, 20 feet west of Algoma Central railway track and at the south end of a rock cut. The bench-mark is 300 feet south of a trestle bridge and at eighth telegraph pole north of mile-post 171 from Sault Ste. Marie.

701 In west face of vertical rock exposure—2 feet above ground— 200 feet east of Algoma Central railway track and at third telegraph pole south of mile-post 174 from Sault Ste. Marie.

702 In west face of large rough mass of rock—at north end of long deep rock cut—50 feet east of Algoma Central railway track and between eighth and ninth telegraph poles south of Goudreau section-house, or south of mile-post 177 from Sault Ste. Marie.

703 In east face of boulder, half buried in hillside, 40 feet west of Algoma Central railway track, 50 feet south of a deep rock cut and at first telegraph pole north of mile-post 180 from Sault Ste. Marie—3 miles north of Goudreau section-house.

704 In west face of vertical rock surface, 70 feet east of Algoma Central railway track and between first and second telegraph poles south of mile-post 183 from Sault Ste. Marie. This rock surface forms the northwest corner of a rocky hill; a muskeg lies immediately to the north.

705 In south face of large pyramid shaped boulder, 90 feet east of Algoma Central railway track, 1½ miles south of Wanda section-house and tank, and between second and third telegraph poles south of mile-post 186 from Sault Ste. Marie. This boulder is also opposite a borrow pit at north end of a long deep fill.

706 In east face of exposed rock surface, 37 feet west of Algoma Central railway track, 2 miles north of Wanda section-house and tank, and between thirteenth and fourteenth telegraph poles north of mile-post 189 from Sault Ste. Marie. This exposure forms a small vertical surface in a sloping hill of rock at north end of a large ballast pit.

707 In south face of large triangular boulder, 30 feet west of Algoma Central railway track, 2½ miles south of Franz and 100 feet north of mile-post 192 from Sault Ste. Marie.

708 In west face of exposed rock surface, 65 feet east of Algoma Central railway track at Franz, 650 feet south of diamond crossing of Canadian Pacific railway and 120 feet south of home semaphore of interlocking plant.

BENCH-MARKS BETWEEN KIPP, ALTA., AND GOLDEN, B.C., VIA CANADIAN PACIFIC RAILWAY THROUGH CROWSNEST AND COLVALLI.

Elevations on page 304.

Note.—These descriptions are written with the assumption that the railway runs in a westerly direction from Kipp to Colvalli and thence northerly to Golden.

84–D In west concrete foundation wall—16 inches below woodwork and 4 feet from southwest corner—of Canadian Bank of Commerce at Monarch.

85–D In west face of southeast concrete retaining wall of steel trestle viaduct over Oldman river, 4 miles west of Monarch.

86–D In side of concrete bench-mark pier, 8 feet south of north line of Canadian Pacific railway right-of-way, 350 feet east of a highway crossing, 5½ miles east of Macleod and 268 feet west of mile-post 26 from Lethbridge.

87–D In second course of stonework below water-table course, in east end of north wall of Macleod court-house.

88–D In second course of stonework below water-table course, in east end of north wall of westerly wing of Macleod public school—9 feet west of main entrance.

89–D In north concrete foundation wall—6 inches below woodwork and 10 feet 6 inches from northwest corner—of Canadian Pacific section-house, at east end of Stowe passing-track.

90–D In south end of east face of west abutment of large square concrete culvert under Canadian Pacific railway, at mileage 40·4 from Lethbridge.

91–D In west face of north face-wall of (double) square concrete culvert under Canadian Pacific railway, 100 feet west of westerly switch of Piegan passing-track and at mileage 41·7 from Lethbridge.

92–D In side of concrete bench-mark pier, 8 feet south of north line of Canadian Pacific railway right-of-way, 1,000 feet east of Chokio west mile-board and 23 feet west of mile-post 48 from Lethbridge.

93–D In north end of east face of concrete retaining wall behind west abutment—3 feet above bridge-seat—of steel trestle bridge over Pincher creek, 1¾ miles west of Brocket.

94–D In east stone foundation wall—11 inches below woodwork and 20 inches from northeast corner—of Canadian Pacific section-house at Pincher, 270 feet east of the station.

95–D In west face of south face-wall of square concrete culvert under Canadian Pacific railway, 2¾ miles east of Cowley and at mileage 65·3 from Lethbridge.

96–D In east face of northwest concrete retaining wall—2 feet 8 inches above bridge-seat—of steel trestle bridge over south fork of Oldman river, 2¼ miles east of Cowley.

97–D In north concrete foundation wall—1 foot below top of foundation and 4 feet from northeast corner—of public school at Cowley, ¼ mile southwest of the station.

98–D In east end of north face—3 feet below top—of concrete arch culvert under Canadian Pacific railway, 1½ miles east of Lundbreck and at second telegraph pole west of mile-post 71 from Lethbridge.

99–D In west face of concrete retaining wall behind east abutment—2 feet above bridge-seat and almost in line with northerly truss—of Canadian Pacific railway bridge over Crowsnest river, 2½ miles west of Lundbreck.

100–D In west face of south face-wall of concrete arch culvert under Canadian Pacific railway, 1¾ miles west of Burmis and at mileage 80·9 from Lethbridge.

101–D In south face of wall of rock, immediately north of Canadian Pacific railway track, 330 feet west of Passburg west mile-board and 120 feet west of mile-post 83 from Lethbridge. The bench-mark is 1 foot above rail level.

102–D In south face of triple concrete culvert under Canadian Pacific railway, 400 feet east of Frank station. The bench-mark is in wall between centre and western arches, 4 feet below top of concrete.

103–D In north face of east concrete abutment—22 inches below bridge-seat—of plate-girder bridge on Canadian Pacific railway, 0·4 mile east of Blairmore and at mileage 87·8 from Lethbridge.

104–D In west end of south face of square concrete culvert under Canadian Pacific railway, 1¾ miles east of Coleman and at mileage 90·1 from Lethbridge.

105–D In east end of north face of square concrete culvert under Canadian Pacific railway, ¼ mile west of Coleman and at mileage 92·1 from Lethbridge.

106–D In north face of small square concrete culvert under Canadian Pacific railway, 60 feet east of a highway crossing and at first telegraph pole east of mile-post 94 from Lethbridge.

107–D In north face of east concrete abutment—18 inches below bridge-seat—of plate-girder bridge on Canadian Pacific railway, at mileage 95·6 from Lethbridge and at east end of Sentry passing-track.

108–D In east face of south face-wall—16 inches below top—of large concrete arch culvert under Canadian Pacific railway, 2¾ miles east of Crowsnest and at mileage 98·3 from Lethbridge; at "The cave, main source of Oldman river."

109–D In south face of concrete base of interprovincial boundary monument between Alberta and British Columbia, 50 feet north of Canadian Pacific railway main track at "The Great Divide"—530 feet east of Crowsnest station.

110–D In west end of south face of small square concrete culvert under Canadian Pacific railway, at mileage 1·9 from Crowsnest.

111–D In west face—10 inches below top—of concrete coping on top of a stone retaining wall lying along north side of Canadian Pacific railway track, at mileage 3·9 from Crowsnest.

112–D In south face —20 inches below top—of concrete retaining wall behind west abutment of plate-girder bridge over Michel creek, immediately west of McGillivray station.

113–D In north face of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 2½ miles west of McGillivray and at mileage 9·2 from Crowsnest.

114–D In front (or east) face of concrete platform extending along front of Trites-Wood company's general store at Michel—a large concrete building immediately northwest of the station. The bench-mark is 2 feet 9 inches below top of platform and 6 feet from southeast corner.

115–D In north face of west concrete abutment—1 foot below bridge-seat—of plate-girder bridge over Michel creek, 1½ miles west of Natal and at mileage 15·8 from Crowsnest.

116–D In north face of west abutment of square concrete culvert under Canadian Pacific railway, 150 feet east of Wardrop west mile-board and at mileage 21·5 from Crowsnest.

117–D In west end of south face of small concrete arch culvert under Canadian Pacific railway, at mileage 24·2 from Crowsnest.

118–D In north face of west concrete abutment—10 inches below seat of I-beams—of open culvert under Canadian Pacific railway, 2¼ miles east of Hosmer and at mileage 26·2 from Crowsnest.

119–D In east end of north face of concrete arch culvert under Canadian Pacific railway, 1¼ miles west of Hosmer and at mileage 29·6 from Crowsnest.

120–D In south face of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, 3¼ miles east of Fernie and at mileage 32·6 from Crowsnest.

121–D In third course of stonework below water-table course, in east face of corner stone at southeast corner of Fernie post-office.

122–D In north concrete foundation wall—4 feet below brickwork and 8 feet from northeast corner—of Provincial Government building at Fernie.

123–D In side of concrete bench-mark pier, 3 feet south of north line of Canadian Pacific railway right-of-way, 180 feet west of a highway crossing, 1 mile west of Fernie and 330 feet west of mile-post 37 from Crowsnest.

124–D In north face of east concrete abutment—20 inches below seat of I-beams—of open culvert under Canadian Pacific railway, at mileage 39·8 from Crowsnest.

125–D In south face of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, ¾ mile east of Morrissey and at mileage 43·5 from Crowsnest.

126–D In north face of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 2½ miles west of Morrissey and at mileage 46·7 from Crowsnest.

127–D In north face of concrete retaining wall behind west abutment—4 feet 10 inches above bridge-seat—of through-truss bridge over Elk river, 1½ miles east of Elko.

128–D In west face of exposed rock surface, 55 feet south of north line of Canadian Pacific railway right-of-way, 1,740 feet east of mile-post 57 from Crowsnest and 100 feet west of a rock cut.

129–D In west end of north face of concrete arch culvert under Canadian Pacific railway, in a deep fill, 250 feet west of westerly switch of Caithness passing-track and at mileage 59·1 from Crowsnest.

130–D In north face of west concrete abutment—6 inches below bridge-seat—of plate-girder bridge on Canadian Pacific railway, 3 miles east of Jaffray and at mileage 63·8 from Crowsnest.

131–D In south face of southwest concrete retaining wall—3 feet 6 inches below bridge-seat—of plate-girder bridge on Canadian Pacific railway, at easterly switch of passing-track at Jaffray.

132–D In south concrete foundation wall—20 inches below woodwork and 7 inches from southwest corner—of Jaffray public school.

133–D In south concrete foundation wall—9 inches below woodwork and 14 inches from southwest corner—of Canadian Pacific section-house at Colvalli.

134–D In side of concrete bench-mark pier, 5 feet east of west line of Canadian Pacific railway right-of-way and 100 feet south of mile-post 5 from Colvalli.

135–D In south face of south concrete pier—6 inches below top of pier and 2 feet east of easterly girder—of Canadian Pacific railway bridge over Bull river, ¼ mile north of Bull River station.

136–D In south face of large square boulder on east bank of Kootenay river, 42 feet west of centre line of Canadian Pacific railway track and 560 feet north of mile-post 14 from Colvalli.

137–D In north face of large flat mass of rock on east bank of Kootenay river, 28 feet west of centre line of Canadian Pacific railway track, 600 feet south of Steele south mile-board and between fourteenth and fifteenth telegraph poles north of mile-post 21 from Colvalli.

138–D In rear (or east) concrete foundation wall—1 foot below woodwork and 7 feet south of rear entrance—of Canadian Pacific station-house at Steele.

139–D In north (vertical) face of large white boulder, 40 feet west of centre line of Canadian Pacific railway track, 520 feet south of a whistle-post for southbound trains and 2080 feet south of mile-post 26 from Colvalli.

140–D In north face of large irregular boulder, 15 feet east of Canadian Pacific railway track—in the side of a gravelly cut—150 feet north of a whistle-post for southbound trains and between eighth and ninth telegraph poles north of mile-post 29 from Colvalli.

141–D In side of concrete bench-mark pier, 2 feet east of west line of Canadian Pacific railway right-of-way, 450 feet north of highway crossing at northerly end of Wasa passing-track and between fourth and fifth telegraph poles south of mile-post 36 from Colvalli.

142–D In south face of concrete retaining wall behind east abutment—2 feet above bridge-seat—of Canadian Pacific railway bridge over Kootenay river, 3 miles north of Wasa.

143–D In northwest face of large black boulder, 80 feet east of east line of Canadian Pacific railway right-of-way and between seventeenth and eighteenth telegraph poles south of mile-post 44 from Colvalli.

144–D In south face—3 feet 2 inches below top and 4 feet from east end—of north concrete abutment of steel truss bridge over Skookumchuck creek, at mileage 46·6 from Colvalli.

145–D In east face of outcrop of rock, 60 feet west of west line of Canadian Pacific railway right-of-way, 1,250 feet south of a highway crossing and between second and third telegraph poles south of mile-post 50 from Colvalli.

146–D In west face of small rock exposure, 20 feet west of east line of Canadian Pacific railway right-of-way, 310 feet south of a whistle-post for southbound trains and between seventh and eighth telegraph poles south of mile-post 54 from Colvalli—opposite the centre of a high rocky hill immediately east of track.

147–D In south face—1 foot below top and 5 feet from west end—of north concrete abutment of steel truss bridge on Canadian Pacific railway, at mileage 59·7 from Colvalli.

148–D In east face of exposed rock surface, 20 feet west of Canadian Pacific railway track and 115 feet north of mile-post 62 from Colvalli.

149–D In exposed rock surface—20 feet west of Canadian Pacific railway track and near rail level—210 feet south of a rock cut and between sixth and seventh telegraph poles north of mile-post 65 from Colvalli.

150–D In side of concrete bench-mark pier, 3 feet east of west line of Canadian Pacific railway right-of-way, 18 feet north of a whistle-post for southbound trains and between sixteenth and seventeenth telegraph poles south of mile-post 75 from Colvalli—about 200 feet north of a small inlet which the railway has cut off from Columbia lake.

151–D Destroyed.

152–D In side of concrete bench-mark pier, 2 feet east of west line of Canadian Pacific railway right-of-way, 1,000 feet north of a private crossing and 730 feet south of bridge over small brook at mileage 86·7 from Colvalli.

153–D In south concrete foundation wall—2 feet 9 inches below woodwork and 1 foot 5 inches from southeast corner—of Canadian Pacific section-house at Athalmer, ½ mile south of the station.

154–D In east end of north face of concrete retaining wall behind south abutment—1 foot above bridge-seat—of Canadian Pacific railway swing bridge over a channel of Columbia river, 1½ miles north of Athalmer and at mileage 94·2 from Colvalli.

155–D In north face of boulder on east bank of Columbia river, 85 feet west of Canadian Pacific railway track and between fifteenth and sixteenth telegraph poles south of mile-post 99 from Colvalli—opposite the centre of a steep gravelly bank lying on east side of track.

156–D In side of concrete bench-mark pier, 3 feet west of east line of Canadian Pacific railway right-of-way, 1,240 feet north of northerly switch of Edgewater passing-track, 140 feet north of a galvanized iron culvert and 400 feet north of north end of a vertical clay bank about 100 feet in height lying on east side of track.

157–D In side of concrete bench-mark pier, 2 feet west of east line of Canadian Pacific railway right-of-way, 27 feet south of a gate in the right-of-way fence and between fourth and fifth telegraph poles north of mile-post 115 from Colvalli.

158–D In side of concrete bench-mark pier, 2 feet west of east line of Canadian Pacific railway right-of-way, 760 feet south of a private crossing, 2¾ miles south of Spillimacheen and between eighth and ninth telegraph poles south of mile-post 123 from Colvalli.

159–D In south concrete foundation wall—8 inches below woodwork and 22 inches from southwest corner—of Canadian Pacific section-house at Spillimacheen.

160–D In south concrete foundation wall—8 inches below woodwork and 2 feet from southwest corner—of Canadian Pacific section-house at south end of Harrogate passing-track.

161–D In side of concrete bench-mark pier, 3 feet west of east line of Canadian Pacific railway right-of-way, 25 feet north of a private crossing and 320 feet north of mile-post 140 from Colvalli.

162–D In concrete foundation—4 inches below woodwork and 2 feet to the right of the doorway—of Canadian Pacific water-tank at Parson.

163–D In west concrete foundation wall—4 inches below woodwork and 2 feet from southwest corner—of Canadian Pacific section-house at Parson.

164–D In west concrete foundation wall—4 inches below woodwork and 3 feet from southwest corner—of Canadian Pacific section-house at Mons.

165–D In side of concrete bench-mark pier, 3 feet west of east line of Canadian Pacific railway right-of-way, 250 feet north of a rock cut and 750 feet north of mile-post 160 from Colvalli.

166–D In north concrete foundation wall—11 inches below woodwork and 18 inches from northeast corner—of Canadian Pacific section-house at Nicholson.

273–C In Canadian Pacific railway bridge over Kicking Horse river at Golden—see line from Field to Revelstoke.

BENCH-MARKS BETWEEN BULL RIVER AND KOOTENAY LANDING, B.C., VIA CANADIAN PACIFIC RAILWAY, WITH BRANCH LINE FROM CRESTON, B.C., TO PORTHILL, IDAHO, VIA GREAT NORTHERN RAILWAY.

Elevations on page 307.

Note.—These levels were carried across the Kootenay river from Bull River to a point on the railway near Wardner and thence westerly. The descriptions are written with the assumption that the railway runs in a westerly direction from Wardner to Creston and thence northerly to Kootenay Landing.

167–D In south side of rock cut on Canadian Pacific railway—80 feet from west end of cut—between ninth and tenth telegraph poles east of Tokay west mile-board, 4½ miles west of Wardner and at mileage 81·6 from Crowsnest.

168–D In north face of boulder embedded in steep hillside, 100 feet south of south line of Canadian Pacific railway right-of-way, ¾ mile east of Rampart flag-station and between tenth and eleventh telegraph poles west of mile-post 88 from Crowsnest.

169–D In north side of rock cut on Canadian Pacific railway—30 feet from west end of cut and near rail level—400 feet east of a whistle-post for eastbound trains, 2 miles west of Rampart flag-station and at first telegraph pole east of mile-post 91 from Crowsnest.

170–D In south face of exposed rock surface in side of steep hill, 20 feet north of Canadian Pacific railway track and 40 feet east of third telegraph pole east of mile-post 94 from Crowsnest—this mile-post being at easterly switch of Eager passing-track.

171–D In east end of north face—3 feet below top—of concrete arch culvert under Canadian Pacific railway, 2 miles east of Cranbrook and at mileage 96·9 from Crowsnest.

172–D In east end of north face—18 inches below top—of concrete arch culvert under Canadian Pacific railway, 1,600 feet east of Cranbrook station.

173–D In third course of stonework above concrete sidewalk, in centre of south (or Baker street) wall of Imperial Bank at Cranbrook.

174–D In second course of stonework below brickwork, in north (or Baker street) wall of Cranbrook post-office—2 feet west of west wall of clock tower.

175–D In east end of north face—15 inches below top—of concrete arch culvert under Canadian Pacific railway, in a ravine, 2¼ miles west of Cranbrook.

176–D In side of concrete bench-mark pier, 10 feet south of north line of Canadian Pacific railway right-of-way, 670 feet east of easterly switch of Fassiferne passing-track and 30 feet west of third telegraph pole west of mile-post 5 from Cranbrook.

177–D In west end of south face of square concrete culvert under Canadian Pacific railway, 150 feet east of easterly switch of Swansea passing-track and at mileage 9·3 from Cranbrook.

178–D In south end of west face of concrete retaining wall behind east abutment of plate-girder bridge over Moyie river, at mileage 10·9 from Cranbrook.

179–D In north face of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, at mileage 13·3 from Cranbrook.

180–D In north face of exposed rock surface—immediately south of Canadian Pacific railway track and 2 feet above rail level—170 feet west of a permanent slow-sign for westbound trains, 3 miles east of Moyie and between fifth and sixth telegraph poles east of mile-post 17 from Cranbrook.

181–D In north end of west face of concrete retaining wall behind east abutment of open culvert under Canadian Pacific railway, 0·3 mile east of Moyie.

182–D In south face of concrete retaining wall behind east abutment—3 feet above bridge-seat—of plate-girder bridge over Moyie river, 2½ miles west of Moyie and at mileage 22·5 from Cranbrook.

183–D In north end of west face of concrete retaining wall behind east abutment of open culvert under Canadian Pacific railway, at mileage 25·8 from Cranbrook.

184–D In south end of east face of concrete retaining wall behind west abutment of open culvert under Canadian Pacific railway, at mileage 29·2 from Cranbrook.

185–D In south face—8 inches below top—of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, at mileage 31·9 from Cranbrook.

186–D In north face of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 3½ miles east of Yahk and at mileage 37·4 from Cranbrook.

187–D In west face of south face-wall of small concrete arch culvert under Canadian Pacific railway, 470 feet west of Yahk east mile-board and at mileage 39·6 from Cranbrook.

188–D In side of concrete bench-mark pier, 9 feet south of north line of Canadian Pacific railway right-of-way, 100 feet west of a whistle-post for eastbound trains, 3 miles west of Yahk and 540 feet east of a concrete arch culvert at mileage 43·7 from Cranbrook.

189–D In north end of west face of concrete retaining wall behind east abutment of open culvert under Canadian Pacific railway, at mileage 46·5 from Cranbrook.

190–D In west face—1 foot below top—of south face-wall of concrete arch culvert under Canadian Pacific railway, at mileage 50·8 from Cranbrook.

191–D In south face—immediately above southwest wing-wall—of concrete arch culvert under Canadian Pacific railway, 2½ miles east of Cadorna and at mileage 53·1 from Cranbrook.

192–D In north face of concrete retaining wall behind east abutment of two-span open culvert under Canadian Pacific railway, immediately west of Cadorna.

193–D In south face—immediately above southwest wing-wall—of concrete arch culvert under Canadian Pacific railway, in a deep fill at an old saw-mill, 3 miles west of Cadorna and at mileage 58·5 from Cranbrook.

194–D In north face—14 inches below top—of a concrete pedestal used in connection with electric signal system. The pedestal is on north side of Canadian Pacific railway track, 20 feet east of east end of bridge over Goat river canyon and ¼ mile west of Canyon station.

195–D In concrete footing—18 inches below woodwork and 18 feet to the left of the spout—of Canadian Pacific water-tank at Creston.

196–D In west face of small boulder, 30 feet east of west line of Canadian Pacific railway right-of-way, 160 feet south of a farm crossing, ¾ mile north of Creston and between tenth and eleventh telegraph poles north of mile-post 68 from Cranbrook.

197–D In east side of rock cut on Great Northern railway—near south end of cut—780 feet north of north end of trestle No. 14 and 3½ miles north of Porthill, Idaho.

198–D In north face of concrete base of international boundary monument No. 207, on top of hill, immediately east of Great Northern railway at Porthill.

199–D In south end of east face of concrete arch culvert under Canadian Pacific railway, 1¾ miles north of Creston and at mileage 69·2 from Cranbrook.

200–D In east face—immediately above southeast wing-wall—of concrete arch culvert under Canadian Pacific railway, 1 mile south of Duck Creek flag-station and at mileage 72·7 from Cranbrook.

201–D In east side of rock cut on Canadian Pacific railway—25 feet from north end of cut and near rail level—3¾ miles south of Sirdar and 90 feet north of mile-post 76 from Cranbrook.

202–D In west face of exposed rock surface—immediately east of Canadian Pacific railway track and near rail level—1¾ miles south of Sirdar and at first telegraph pole south of mile-post 78 from Cranbrook.

203–D In south end of east face of small concrete arch culvert under Canadian Pacific railway, 0·6 mile north of Sirdar and at mileage 80·4 from Cranbrook.

204–D In side of concrete bench-mark pier, 35 feet west of Canadian Pacific railway track, 33 feet north of northerly switch of Atbara passing-track and 890 feet southeast of east end of steel truss bridge over Kootenay river. This bench-mark is about midway between Sirdar and Kootenay Landing.

205–D In west side of large rock cut on Canadian Pacific railway—near rail level—660 feet southeast of east end of steel truss bridge over Kootenay river and 10 feet north of point at which abandoned Great Northern railway to Kuskonook diverges from Canadian Pacific railway, *i.e.*, north of point of rock separating the two tracks. This bench-mark is about midway between Sirdar and Kootenay Landing.

BENCH-MARKS BETWEEN FIELD AND REVELSTOKE, B.C., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 309.

261–C In east end of north face of cap-stone on northeast retaining wall of plate-girder bridge on Canadian Pacifie railway, at mileage 3·8 from Field.

262–C In east end of south concrete face-wall of tile pipe culvert under Canadian Pacific railway, at mileage 6·17 from Field.

263–C In north end of west face of concrete retaining wall behind east abutment of through-truss bridge over Kicking Horse river, 1 mile west of Ottertail and at mileage 9·25 from Field.

264–C In south face—in top course of stonework—of retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, at mileage 11·56 from Field.

265–C In west end of south face of square concrete culvert under Canadian Pacific railway, ½ mile east of Leanchoil and at mileage 16·4 from Field.

266–C In east end of north concrete face-wall of tile culvert under Canadian Pacific railway, 2½ miles west of Leanchoil and at mileage 19·45 from Field.

267–C In south end of east face—in top course of stonework—of retaining wall behind east abutment of through-truss bridge over Kicking Horse river, at mileage 21·6 from Field.

268–C In north face of southeast retaining wall of tunnel on Canadian Pacific railway, at mileage 24·5 from Field. The bench-mark is 2 feet above ground and 47 feet east of head-wall at eastern portal of tunnel.

269–C In second course of stonework above bridge-seat, in north end of west face of retaining wall behind east abutment of deck-truss bridge over Kicking Horse river, 2¼ miles east of Glenogle and at mileage 25·7 from Field.

270–C In first course of stonework below coping, in west end of north face of stone arch bridge on Canadian Pacific railway, ¾ mile east of Glenogle and at mileage 27·25 from Field.

271–C In west face of concrete head-wall at western portal of tunnel on Canadian Pacific railway, 3 miles west of Glenogle and at mileage 31·08 from Field. The bench-mark is near rail level and 1 foot 6 inches south of south side of tunnel.

272–C In centre of south face of stone coping on southeast retaining wall of through-truss bridge over Kicking Horse river, 2 miles east of Golden and at mileage 33·24 from Field.

273–C In northeast face of concrete retaining wall behind southeast abutment—2 feet 7 inches above bridge-seat—of two-span truss bridge over Kicking Horse river, 0·3 mile east of Golden—on Kootenay Central subdivision of Canadian Pacific railway.

274–C In south face of concrete retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 1¾ miles west of Golden and at mileage 36·93 from Field.

275–C In east end of north concrete face-wall of galvanized iron pipe culvert under Canadian Pacific railway, 3¾ miles west of Golden and at mile-post 39 from Field.

276–C In side of concrete bench-mark pier, 47 feet north of Canadian Pacific railway main track, 2,175 feet west of Moberly station-house and 153 feet west of mile-post 42 from Field.

277–C In east end of south face of stone coping on southeast retaining wall of through-truss bridge over Blaeberry river, at mile-post 45 from Field.

278–C In east end of north concrete face-wall of tile pipe culvert under Canadian Pacific railway, at mileage 48·2 from Field.

279–C In west end of north concrete face-wall of tile pipe culvert under Canadian Pacific railway, ½ mile east of Donald and at mileage 51·23 from Field.

280–C In second course of stonework above bridge-seat, in north end of west face of retaining wall behind east abutment of plate-girder bridge over Columbia river, 1 mile west of Donald.

281–C In north face of southeast retaining wall of tunnel on Canadian Pacific railway, 2¾ miles west of Donald and at mileage 54·32 from Field. The bench-mark is 2 feet above ground and 15 feet east of head-wall at eastern portal of tunnel.

282–C In south face of northeast retaining wall of tunnel on Canadian Pacific railway, at mileage 57·81 from Field. The bench-mark is 2 feet above ground and 27 feet east of head-wall at eastern portal of tunnel.

283–C In face of northwest wing-wall of square concrete culvert under Canadian Pacific railway, at mileage 59·25 from Field.

284–C In south end of west face of retaining wall behind east abutment of plate-girder bridge over Quartz creek, immediately east of Beavermouth.

285–C In second course of stonework above bridge-seat, in south face of retaining wall behind east abutment of through-truss bridge over Beaver river, 3 miles west of Beavermouth.

286–C In west face of concrete retaining wall behind east abutment of plate-girder bridge over Sixmile creek, at mileage 68·3 from Field. The bench-mark is 1 foot 4 inches below top of concrete—between guard timber and southerly girder.

287–C In east end of north face of coping on north end of stone arch culvert under Canadian Pacific railway, 1½ miles east of Sturdee and at mileage 72·13 from Field.

288–C In east end of south face of coping on south end of stone arch culvert under Canadian Pacific railway, ½ mile west of Sturdee and at mileage 74·1 from Field.

289–C In east end of north face of stone coping on northeast retaining wall of Canadian Pacific railway bridge over Stony creek, 1½ miles east of Bear Creek station and at mileage 76·4 from Field.

290–C In west end of south face of coping on south end of stone arch culvert under Canadian Pacific railway, 2 miles west of Bear Creek station and at mile-post 80 from Field.

291–C In east face of coping on south end of concrete arch culvert under Canadian Pacific railway, 1 mile east of Rogers Pass station and at mileage 83·26 from Field.

292–C In side of concrete bench-mark pier on abandoned grade lying immediately to the north of present (1915) track of Canadian Pacific railway. The pier is 81 feet north of present track, 366 feet east of east end of a snow-shed, 1 mile west of Rogers Pass station and 97 feet east of mile-post 85 from Field.

293–C In north face-wall of (double) pipe culvert under Canadian Pacific railway, 1¼ miles east of Glacier station and at mile-post 86 from Field.

294–C In east end of north face of coping on north end of stone arch culvert under Canadian Pacific railway, at mileage 87·1 from Field—near east end of platform at Glacier station.

295–C In north face of stone coping on northwest retaining wall of plate-girder bridge on Canadian Pacific railway at Cambie— mileage 90·1 from Field.

296–C In southwest face of southeast concrete wing-wall—1 foot above bridge-seat—of through-truss bridge over Illecillewaet river, 1¾ miles west of Cambie and at mileage 91·84 from Field.

297–C In south face of stone coping on southeast retaining wall of through-truss bridge over Illecillewaet river, ½ mile west of Ross Peak station and at mileage 94·7 from Field.

298–C In top course of stonework, in south end of west face of retaining wall behind west abutment of through-truss bridge over Illecillewaet river, 3½ miles west of Ross Peak and at mileage 97·6 from Field.

299–C In west end of south face of (double) square concrete culvert under Canadian Pacific railway, 3¼ miles east of Illecillewaet and at mileage 99·5 from Field.

300–C In top course of stonework, in north end of east face of retaining wall behind east abutment of deck-truss bridge over Illecillewaet river, ½ mile east of Illecillewaet and at mileage 102·2 from Field.

301–C In top course of stonework, in east face of northeast retaining wall of stone arch bridge on Canadian Pacific railway, 1¼ miles west of Illecillewaet and at mile-post 104 from Field.

302–C In centre of south face of square concrete culvert under Canadian Pacific railway, 1¾ miles east of Albert Canyon and at mileage 107·4 from Field.

303–C In south end of west face of concrete retaining wall behind east abutment—2 feet above bridge-seat—of plate-girder bridge on Canadian Pacific railway, immediately west of Albert Canyon station.

304–C In east face of concrete head-wall at eastern portal of tunnel on Canadian Pacific railway, 1½ miles west of Albert Canyon and at mileage 110·75 from Field. The bench-mark is 2 feet above ground and 8 inches north of north side of tunnel.

305–C In east end of north face-wall of concrete tile culvert under Canadian Pacific railway, at mileage 114·35 from Field—150 feet east of telephone house at Lauretta.

306–C In north end of west face of concrete retaining wall behind east abutment—1 foot 6 inches above bridge-seat—of plate-girder bridge on Canadian Pacific railway, 1½ miles east of Twin Butte and at mile-post 118 from Field.

307–C In west end of south face—4 feet below top—of square concrete culvert under Canadian Pacific railway, 0·4 mile west of Twin Butte and at mileage 119·9 from Field.

308–C In first course of stonework below bridge-seat, in west face—4 feet from south end—of east abutment of plate-girder bridge on Canadian Pacific railway, 3¾ miles west of Twin Butte and at mileage 123·3 from Field.

309–C In north face of solid rock cliff—adjacent to a rocky mountain—130 feet south of Canadian Pacific railway track, 4½ miles east of Revelstoke and 1,600 feet east of mile-post 126 from Field.

310–C In east face of mass of rock, 47 feet north of Canadian Pacific railway track, 2¾ miles east of Revelstoke and at mileage 127·45 from Field.

311–C In second course of stonework below brickwork, in east wall of Canadian Pacific station-house at Revelstoke, 16 feet from southeast corner of building.

312–C In west end of north face of small square concrete culvert under Canadian Pacific railway, 1,600 feet west of station and 35 feet west of west line of Campbell avenue, Revelstoke.

313–C In east concrete foundation wall—6 feet below brickwork and 4 feet from northeast corner—of Revelstoke high school, on south side of Second street.

314–C In first course of stonework below basement window sills, in north wall of Revelstoke court-house, 4 feet from northeast corner of building.

BENCH–MARKS BETWEEN EDMONTON AND JASPER, ALTA., VIA GRAND TRUNK PACIFIC RAILWAY.

Elevations on page 311.

62–H In south face of concrete footing of semaphore on north side of Grand Trunk Pacific railway track. This is the first (or home) semaphore east of diamond crossing of Canadian Northern railway, ¾ mile east of Bissell.

63–H In side of concrete bench-mark pier, 4 feet south of north line of Grand Trunk Pacific railway right-of-way, 1,260 feet east of a highway crossing, 1½ miles east of Acheson and 275 feet west of mile-post 806 from Winnipeg.

64–H In south concrete foundation wall—1 foot below woodwork and 8 inches from southwest corner—of front (or southerly) section of Sprucegrove public school.

65–H In north concrete foundation wall—6 inches below woodwork and 29 feet from northwest corner—of planing mill at Stonyplain, immediately south of Grand Trunk Pacific railway.

Note.—This bench-mark has been rendered inaccessible by a covered driveway constructed along north side of building.

66–H In side of concrete bench-mark pier, 7 feet south of north line of Grand Trunk Pacific railway right-of-way, 275 feet east of mile-post 822 from Winnipeg, 4½ miles west of Stonyplain and at twenty-first telegraph pole east of a highway crossing.

67–H In concrete foundation—5 inches below woodwork and 3 feet 6 inches to the right of the spout—of Grand Trunk Pacific water-tank, 0·6 mile west of Carvel.

68–H In side of concrete bench-mark pier, 5 feet south of north line of Grand Trunk Pacific railway right-of-way, 18 feet west of a farm crossing, 1 mile west of Duffield and between fifth and sixth telegraph poles east of mile-post 833 from Winnipeg.

69–H In east concrete foundation wall—3 feet below woodwork and 8 inches from southeast corner—of Wabamun hotel, Wabamun.

70–H In side of concrete bench-mark pier, 36 feet south of Grand Trunk Pacific railway track, 1¾ miles west of Fallis and 10 feet east of fifth telegraph pole west of mile-post 847 from Winnipeg—at east side of small gully which crosses track in centre of a long clay cut.

71–H In concrete foundation—1 foot below woodwork and 2 feet to the right of the spout—of Grand Trunk Pacific water-tank at Gainford.

72–H In south end of west face of concrete retaining wall behind east abutment—4 feet 8 inches above bridge-seat—of steel trestle bridge over Pembina river, 1 mile west of Entwistle.

73–H In side of concrete bench-mark pier, 4 feet north of south line of Grand Trunk Pacific railway right-of-way, 330 feet west of a farm crossing, 2¾ miles east of Junkins and 60 feet east of mile-post 868 from Winnipeg.

74–H In side of concrete bench-mark pier, 3 feet south of north line of Grand Trunk Pacific railway (or south line of Canadian Northern railway) right-of-way, 100 feet west of a gate in the right-of-way fence, 220 feet west of mile-post 873 from Winnipeg and opposite eleventh telegraph pole east of C.N.R. mile-post 85 from Edmonton.

75–H In west face—6 inches below top—of concrete footing of semaphore on north side of Grand Trunk Pacific railway track. This is the first (or home) semaphore east of diamond crossing of Canadian Northern railway, 1¼ miles east of Leaman and ½ mile west of C.N.R. station at Chiplake.

76–H In concrete foundation—3 inches below woodwork and directly beneath the spout—of Grand Trunk Pacific water-tank, 1¼ miles west of Leaman.

77–H In side of concrete bench-mark pier, 49 feet north of Grand Trunk Pacific railway track, 2 miles east of Niton and 4 feet east of mile-post 891 from Winnipeg.

78–H In concrete foundation—4 inches below woodwork and directly beneath the spout—of Grand Trunk Pacific water-tank, 2½ miles west of Otley.

79–H In side of concrete bench-mark pier, 65 feet south of Grand Trunk Pacific railway track, 920 feet east of a small wooden culvert, 2¼ miles east of Rosevear and between fifth and sixth telegraph poles west of mile-post 907 from Winnipeg.

80–H In south end of east face—3 feet below top—of concrete retaining wall behind west abutment of steel trestle bridge over McLeod river, 1½ miles east of Yates.

81–H In west concrete foundation wall—5 feet 9 inches below brickwork and 5 inches from southwest corner—of Edson public school.

82–H In north face of concrete foundation—5 inches below woodwork and 3 feet to the left of the spout—of Grand Trunk Pacific water-tank at Edson, ⅓ mile west of the station.

83–H In northwest face of west concrete retaining wall of north abutment of bridge by which Grand Trunk Pacific railway passes over Canadian Northern railway, 6½ miles west of Edson. The bench-mark is 3 feet below G.T.P. rails and 4 feet 6 inches from northerly end of retaining wall—it being assumed that the G.T.P. railway at this point runs in a southwesterly direction.

84–H In side of concrete bench-mark pier, 52 feet south of Grand Trunk Pacific railway track—at west end of a long clay cut—between fifth and sixth telegraph poles east of mile-post 935 from Winnipeg and opposite a point between twelfth and thirteenth poles east of C.N.R. mile-post 12 from Tollerton.

85–H In side of concrete bench-mark pier, 35 feet south of Grand Trunk Pacific railway track at mile-post 941 from Winnipeg—opposite a point between sixth and seventh telegraph poles east of C.N.R. mile-post 18 from Tollerton.

86–H In concrete foundation—5 inches below woodwork and 3 feet 6 inches to the right of the spout—of Grand Trunk Pacific water-tank at Medicine Lodge.

87–H In side of concrete bench-mark pier, 60 feet south of Grand Trunk Pacific railway track and between seventh and eighth telegraph poles east of mile-post 957 from Winnipeg—on top of a gently sloping bank about 300 feet east of east end of a curve.

88–H In north side of sandstone rock cut on Grand Trunk Pacific railway—160 feet from west end of cut—620 feet east of east end of a trestle bridge, 1¾ miles east of Roundcroft and 37 feet east of eighth telegraph pole west of mile-post 962 from Winnipeg.

89–H In southwest face of smooth white boulder, 20 feet north of Grand Trunk Pacific railway track— in the side of a long clay cut—1 mile west of Roundcroft and at mile-post 965 from Winnipeg.

90–H In side of concrete bench-mark pier, 40 feet north of south line of Grand Trunk Pacific railway right-of-way, 200 feet west of west end of a trestle bridge, 0·6 mile west of Pedley and between third and fourth telegraph poles east of mile-post 971 from Winnipeg.

91–H In circular concrete base of inlet pipe of steel water-tank on Grand Trunk Pacific railway, at west end of Hinton passing-track. The bench-mark faces south.

92–H In south end of east face of concrete retaining wall behind west abutment—4 feet 6 inches above bridge-seat—of long steel trestle bridge over Prairie creek, 3 miles west of Hinton.

93–H In south side of deep rock cut on Grand Trunk Pacific railway— near west end of cut and at rail level—1 mile west of Dyke and 12 feet west of mile-post 984 from Winnipeg. This is on a quarter-mile section of straight track about midway between two sharp curves.

94–H In northwest face of vertical rock surface, 20 feet south of Grand Trunk Pacific railway track and at third telegraph pole east of mile-post 987 from Winnipeg—about 300 feet west of a rock cut and at east end of a sharp curve on a deep fill.

95–H In side of concrete bench-mark pier, 28 feet north of Grand Trunk Pacific railway track, ¾ mile east of Parkgate and 12 feet east of mile-post 991 from Winnipeg—on a small point of land on shore of Brûlé lake.

96–H In south end of west face of concrete retaining wall behind east abutment—4 feet 3 inches above bridge-seat—of two-span truss bridge over Fiddle creek, at mileage 997·5 from Winnipeg.

97–H In south side of long curved rock cut on Grand Trunk Pacific railway—150 feet from west end of cut and near rail level—2¾ miles west of Pocahontas, ¼ mile east of a lime kiln and between fifteenth and sixteenth telegraph poles east of mile-post 1004 from Winnipeg.

98–H In north end of west face of concrete retaining wall behind east abutment—5 feet above bridge-seat—of through-truss bridge over Rocky river, ¾ mile east of Hawes.

99–H In south side of rock cut on Grand Trunk Pacific railway, 60 feet west of a prominent point of rock—the highest in the cut—1 mile east of Interlachen and between fifth and sixth telegraph poles east of mile-post 1011 from Winnipeg.

100–H In north end of west face of concrete retaining wall behind east abutment—5 feet above bridge-seat—of through-truss bridge over Athabaska river, at mileage 1015·1 from Winnipeg.

101–H In east face of concrete retaining wall behind west abutment —4 feet 4 inches above bridge-seat and immediately north of southerly truss—of two-span truss bridge on Grand Trunk Pacific railway, 2 miles east of Henry House and at mileage 1017·2 from Winnipeg.

102–H In north end of east face of concrete retaining wall behind west abutment—4 feet 5 inches above bridge-seat—of bridge by which Grand Trunk Pacific railway passes over Canadian Northern railway, 1 mile west of Henry House and at mileage 1020·3 from Winnipeg. This is at C.N.R. mile-post 99 from Tollerton.

103–H In north side of rock cut on Grand Trunk Pacific railway—70 feet from west end of cut, in projection of rock facing east —3½ miles east of Jasper, 30 feet west of fourth telegraph pole east of mile-post 1024 from Winnipeg and 100 yards west of C.N.R. water-tank at Maligne.

104–H In southeast corner of Jasper Park administration building, immediately west of Grand Trunk Pacific station at Jasper. The bench-mark is 1 foot above ground, in large stone in south face of buttress at southeast corner of a one-story extension from main building.

TABLE I–A.

BENCH-MARKS BETWEEN ST. STEPHEN, N.B., AND RIVIERE-DU-LOUP, QUE., VIA CANADIAN PACIFIC RAILWAY THROUGH BRUNSWICK, McADAM, AROOSTOOK AND EDMUNSTON; THENCE TEMISCOUATA RAILWAY TO RIVIERE-DU-LOUP.

Elevations on page 313.

Note.—These descriptions are written with the assumption that the railway runs in an easterly direction from St. Stephen to Brunswick, thence northerly to Grand Falls and thence northwesterly to Rivière-du-Loup.

1–B In northeast wall of rear section of City Building—on Church street—Calais, Maine. The bench-mark is 2 feet above ground and 3 feet 7 inches to the rear of front section of building.

2–B In first course of stonework below water-table course, in south end of east wall of Bank of British North America at St. Stephen, N.B.

3–B In first course of stonework below water-table course, in front (or north) wall of St. Stephen post-office—to the west of easterly doorway.

4–B In north face of large boulder, 10 feet south of Canadian Pacific railway track, ½ mile west of Oak Bay station and 1040 feet east of mile-post 5 from St. Stephen.

5–B In top course of stonework, in south face of east abutment of small plate-girder bridge on Canadian Pacific railway, 4¾ miles west of Brunswick and 200 feet east of mile-post 10 from St. Stephen.

6–B In north face of boulder, 10 feet north of Canadian Pacific railway track and 200 feet west of diamond crossing at Brunswick.

7–B In east face of boulder, 25 feet west of Canadian Pacific railway track and at seventh telegraph pole north of mile-post 5 from Watt.

8–B In small boulder 8 feet east of west line of Canadian Pacific railway right-of-way, 65 feet north and 85 feet west of northwest corner of station-house at Watt.

9–B In boulder 18 feet east of Canadian Pacific railway track, 4¾ miles north of Watt and 100 feet north of mile-post 10 from McAdam.

10–B In boulder 15 feet west of Canadian Pacific railway track and 390 feet south of mile-post 5 from McAdam—at north end of a small cut.

11–B In third course of stonework above platform, in north wall of Canadian Pacific station-house at McAdam, between fifth and sixth doorways from east end of building.

12–B In sixth course of stonework below bridge-seat, in north end of west face of east abutment of subway under main line of Canadian Pacific railway, 5½ miles west of McAdam and 330 feet east of bridge over St. Croix river.

13–B In third course of stonework below top, in south face of southeast retaining wall of bridge over St. Croix river, on main line of Canadian Pacific railway, 5½ miles west of McAdam.

14–B In west face of large mass of granite, 12 feet east of Canadian Pacific railway track, 580 feet north of northerly switch at Sugar Brook siding and between eleventh and twelfth telegraph poles north of mile-post 10 from McAdam.

15–B In south face of large granite boulder, 40 feet east of Canadian Pacific railway track, 480 feet south of northerly switch at Deer Lake siding and between twelfth and thirteenth telegraph poles north of mile-post 16 from McAdam.

16–B In northwesterly concrete footing under Canadian Pacific water-tank at Canterbury.

17–B In exposed rock surface, 10 feet east of west line of Canadian Pacific railway right-of-way, ½ mile south of Scott, 20 feet south of a small gate in right-of-way fence and at tenth telegraph pole south of mile-post 27 from McAdam.

18–B In third course of stonework below top, in east end of south face of retaining wall behind north abutment of plate-girder bridge over Eel river, 300 feet south of Benton station.

19–B In east side of small rock cut on Canadian Pacific railway, 25 feet north of mile-post 37 from McAdam.

20–B In northwesterly concrete footing under Canadian Pacific water-tank at Debec.

21–B In south face of boulder, 15 feet north of Canadian Pacific railway track (Houlton branch), 4·6 miles west of Debec and at twelfth telegraph pole east of international boundary monument No. 14–A.

22–B In north face of international boundary monument No. 14–A, 5 miles west of Debec, on Houlton branch of Canadian Pacific railway.

23–B In top course of stonework, in south end of west face of easterly footing of highway bridge over Canadian Pacific railway, 450 feet north of Teeds Mill and at mileage 45·1 from McAdam.

24–B In south end of west face of coping on west end of stone arch culvert under Canadian Pacific railway, 1½ miles south of Woodstock.

25–B In second course of stonework below top, in south end of west face of southwest retaining wall of Canadian Pacific railway bridge over Meduxnekeag river at Woodstock.

26–B In second course of stonework above ground, in north end of west wall of Woodstock post-office.

27–B In third course of stonework below water-table course, in north end of east wall of Armoury at Woodstock.

28–B In south face—3 feet 3 inches below top—of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over westerly channel of St. John river at Upper Woodstock.

29–B In north face of coping on east end of concrete arch culvert under Canadian Pacific railway, 2½ miles north of Newburg and at mileage 57·7 from McAdam.

30–B In third course of stonework below top, in north end of east face of northeast retaining wall of small bridge on Canadian Pacific railway, 2½ miles south of Hartland.

31–B In second course of stonework above bridge-seat, in east end of south face of retaining wall behind north abutment of plate-girder bridge over Becaguimec river, ½ mile north of Hartland.

32–B In second course of stonework below cap-stone, in east face of south abutment of plate-girder bridge on Canadian Pacific railway, 450 feet north of Stickney station.

33–B In west face of exposed rock surface at east side of Canadian Pacific railway track, 120 feet south of a small culvert, 780 feet south of a farm crossing and 1½ miles south of Florenceville.

34–B In west face of concrete retaining wall behind north abutment of plate-girder bridge on Canadian Pacific railway at Bristol.

35–B In third course of stonework below top, in south end of west face of southwest retaining wall of Canadian Pacific railway bridge over Monquart river, ½ mile north of Bath.

36–B In south end of west face of concrete arch culvert under Canadian Pacific railway, in a deep ravine, 1 mile north of Beechwood.

37–B In top course of stonework, in west end of south face of retaining wall behind north abutment of plate-girder bridge on Canadian Pacific railway, at Muniac flag-station—mileage 91·9 from McAdam.

38–B In south face of north concrete abutment—26 inches below bridge-seat—of small plate-girder bridge on Canadian Pacific railway, 1¼ miles south of Perth.

39–B In north end of west face—19 inches below top—of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over St. John river, between Perth and Andover.

40–B In south wall of Victoria county court-house at Andover—15 inches above water-table and 2 feet from southeast corner of building.

41–B In west face—9 inches below top—of concrete retaining wall behind south abutment of bridge over Aroostook river, ½ mile north of Aroostook, on Edmundston branch of Canadian Pacific railway.

42–B In south face of concrete base of international boundary monument No. 82, 4¾ miles west of Aroostook, on Aroostook branch of Canadian Pacific railway.

43–B In boulder in field, 220 feet west of Canadian Pacific railway track (Edmundston branch) and 430 feet south of mile-post 5 from Aroostook—behind a small frame schoolhouse.

44–B In south face of small boulder, 15 feet west of Canadian Pacific railway track and 160 feet south of southerly switch at Limestone siding.

45–B In face of northeast wing-wall of concrete arch culvert under Canadian Pacific railway at Argosy flag-station—mileage 13·8 from Aroostook.

46–B In west wall of south transept of Grand Falls Roman Catholic church, in corner stone of fourth course below water-table.

47–B In east end of north face of concrete retaining wall behind north abutment of Canadian Pacific railway bridge over St. John river, 1¼ miles north of Grand Falls.

48–B In southwest face of small concrete arch culvert under National Transcontinental railway, opposite a point on Canadian Pacific railway at tenth telegraph pole northwest of mile-post 24 from Aroostook.

49–B In northeast face of small concrete arch culvert under National Transcontinental railway, opposite a point on Canadian Pacific railway 2,100 feet northwest of mile-post 28 from Aroostook.

50–B In northeast face of concrete retaining wall behind southeast abutment of Canadian Pacific railway bridge over Grand river, 2¼ miles northwest of St. Leonard and at mileage 33·4 from Aroostook.

51–B In easterly concrete footing under Canadian Pacific water-tank at Siegas.

52–B In northwest face of coping on northeast end of concrete arch culvert under National Transcontinental railway, opposite a point on Canadian Pacific railway at mileage 38·9 from Aroostook.

53–B In southwest concrete face-wall of tile culvert under National Transcontinental railway, opposite a point on Canadian Pacific railway at second telegraph pole northwest of mile-post 43 from Aroostook.

54–B In southwest end of southeast face—23 inches below top—of concrete retaining wall behind northwest abutment of Canadian Pacific railway bridge over Green river, ¾ mile southeast of Green River station.

55–B In northeast concrete face-wall of tile culvert under National Transcontinental railway, opposite a point on Canadian Pacific railway at eighth telegraph pole northwest of mile-post 50 from Aroostook.

56–B In southeast end of northeast face of concrete arch culvert under Canadian Pacific railway, ½ mile southeast of St. Basil and between first and second telegraph poles northwest of mile-post 52 from Aroostook.

57–B In exposed rock surface in field, about 150 feet northeast of Canadian Pacific railway track, 2 miles southeast of Edmundston and opposite fifth telegraph pole northwest of mile-post 55 from Aroostook.

58–B In second course of stonework above bridge-seat, in east end of north face of northwest retaining wall of Temiscouata railway bridge over Madawaska river, at Edmundston.

59–B In face of northeast concrete wing-wall of subway under National Transcontinental railway, 300 feet west of bridge over Madawaska river, at Edmundston.

60–B In face of rock cut at north side of railway track, 140 feet west of west wall of Canadian Pacific station-house at Edmundston.

61–B In southwest face of cap-stone on south retaining wall of Temiscouata railway bridge over Madawaska river, 2½ miles northwest of Edmundston.

62–B In first course of stonework below water-table course, in south wall of Roman Catholic church at Ste. Rose, 10 feet from front (or east) wall of building.

63–B In southwest side of rock cut on Temiscouata railway—near centre of cut—435 feet southeast of a trestle bridge, 3 miles northwest of Ste. Rose and at ninth telegraph pole southeast of mile-post 57 from Rivière-du-Loup.

64–B In southwest side of rock cut on Temiscouata railway, 70 feet northwest of a blacksmith shop, 1 mile southeast of Notre-Dame-du-Lac and 220 feet northwest of mile-post 53 from Rivière-du-Loup.

65–B In northeast side of rock cut on Temiscouata railway, 2 miles northwest of Notre-Dame-du-Lac and 250 feet southeast of mile-post 50 from Rivière-du-Loup.

66–B In east face of granite boulder, 10 feet southwest of Temiscouata railway track, 2¾ miles southeast of Cabano and at ninth telegraph pole northwest of mile-post 46 from Rivière-du-Loup.

67–B In northeast side of rock cut on Temiscouata railway—42 feet from northwest end of cut—3½ miles northwest of Cabano; this is the first rock cut northwest of Cabano.

68–B In west face of boulder, 6 feet northeast of northeast line of Temiscouata railway right-of-way, 1½ miles southeast of Vauban and opposite fifth telegraph pole southeast of mile-post 35 from Rivière-du-Loup.

69–B In exposed rock surface at northeast side of Temiscouata railway track, 2½ miles northwest of Vauban and 360 feet southeast of mile-post 31 from Rivière-du-Loup.

70–B In east face of small boulder, 9 feet northeast of Temiscouata railway track and ¼ mile northwest of St. Honoré.

71–B In exposed rock surface at southwest side of Temiscouata railway track, 4¾ miles northwest of St. Honoré and close to first telegraph pole southeast of mile-post 22 from Rivière-du-Loup.

72–B In northeast side of rock cut on Temiscouata railway—on curve at summit of grade—3¼ miles southeast of Whitworth and ½ mile northwest of mile-post 20 from Rivière-du-Loup.

73–B In northeast side of shallow rock cut on Temiscouata railway, 2¼ miles northwest of Whitworth and at first telegraph pole northwest of mile-post 14 from Rivière-du-Loup.

74–B In east face of large boulder, 25 feet northeast of Temiscouata railway track, 1½ miles southeast of Ste. Modéste and between fifteenth and sixteenth telegraph poles southeast of mile-post 8 from Rivière-du-Loup.

75–B In large piece of rock, 8 feet southwest of southwest line of Temiscouata railway right-of-way and 250 feet southeast of mile-post 3 from Rivière-du-Loup.

76–B In sixth course of stonework below bridge-seat, in northeast face of northwest abutment of Temiscouata railway bridge over rivière-du-Loup, 1 mile southeast of Rivière-du-Loup station.

77–B In second course of stonework below top, in north end of west face of northwest retaining wall of Intercolonial railway bridge over rivière-du-Loup, immediately north of Rivière-du-Loup station.
NOTE.—In this description the railway is assumed to run north and south.

78–B In first course of stonework above water-table, in south wall of St. François-Xavier Roman Catholic church at Rivière-du-Loup, 3 feet 3 inches from front (or west) wall of building.

BENCH-MARKS BETWEEN BRUNSWICK AND ST. JOHN, N.B., VIA CANADIAN PACIFIC RAILWAY, SHORE LINE SUBDIVISION.

Elevations on page 316.

79–B In large piece of rock, 70 feet south of Canadian Pacific railway track, on east side of public highway, 1½ miles west of Dyer and at seventeenth telegraph pole west of mile-post 20 from St. Stephen.

80–B In south face of large boulder at south side of Canadian Pacific railway track, 1½ miles east of Dyer and at sixteenth telegraph pole west of mile-post 23 from St. Stephen.

81–B In north face of boulder, 8 feet south of Canadian Pacific railway track, 1¾ miles west of Bonny River station and 65 feet east of mile-post 28 from St. Stephen.

82–B In exposed rock surface, 25 feet south of Canadian Pacific railway track, 1¼ miles east of Bonny River station and 135 feet west of mile-post 31 from St. Stephen.

83–B In second course of stonework below woodwork, in front (or north) wall of Roman Catholic church at St. George—8 feet 6 inches from northeast corner of building.

84–B In boulder—8 feet by 12 feet—12 feet south of south line of Canadian Pacific railway right-of-way and ¼ mile east of Utopia.

85–B In west face of vertical rock surface in side of rocky hill, 75 feet north of Canadian Pacific railway track and 1¾ miles west of Pennfield.

86–B In boulder—6 feet by 8 feet—37 feet south of Canadian Pacific railway track, 3 miles west of Pocologan and 1,750 feet west of mile-post 48 from St. Stephen.

87–B In fourth course of stonework below concrete, in north end of west face of east abutment of Canadian Pacific railway bridge over Little New river, 2½ miles east of Pocologan.

88–B In east face of boulder, 16 feet south of Canadian Pacific railway track, 2 miles east of New River station and 2,400 feet west of mile-post 56 from St. Stephen.

89–B In second course of stonework below bridge-seat, in north face of east abutment of steel truss bridge over Lepreau river, ¼ mile east of Lepreau.

90–B In south side of small rock cut on Canadian Pacific railway, 3¼ miles east of Lepreau and 420 feet east of mile-post 62 from St. Stephen.

91–B In third course of stonework below bridge-seat, in south face of west abutment of Canadian Pacific railway bridge over west branch of Musquash river, 1¼ miles west of Musquash.

92–B In south end of west face of block of concrete on top of east pier of swing span in Canadian Pacific railway bridge over east branch of Musquash river, 1 mile east of Musquash.

93–B In south side of rock cut on Canadian Pacific railway, 2¼ miles east of Prince of Wales and 1,220 feet east of mile-post 72 from St. Stephen.

94–B In exposed rock surface at south side of Canadian Pacific railway track, 35 feet east of west end of rock and 1,400 feet east of Allan Cot station.

95–B In southwest corner of rocky hill, 33 feet north of north line of Canadian Pacific railway right-of-way, 1,500 feet west of Duck Cove station and immediately east of lane leading to St. John Asylum annex.

96–B In second course of stonework above bridge-seat, in north end of east face of retaining wall behind west abutment of steel trestle approach at Fairville end of cantilever bridge over St. John river—on Canadian Pacific railway—between Fairville and St. John.

97–B In first course of stonework above sidewalk, in south wall—immediately to the rear of portico—of St. John union station.

98–B In granite foundation stone of rear (or west) wall of St. John post-office, 16 inches from southwest corner of building.

99–B In second course of stonework above sidewalk, in south end of front (or east) wall of St. John custom-house.

100–B In water-table course of stonework, in centre of north wall of Nase's grocery store, at southwest corner of Bridge and Main streets—near Indiantown wharf—St. John.

BENCH-MARKS BETWEEN ROUSE POINT, N.Y., AND SHERBROOKE, QUE., VIA GRAND TRUNK RAILWAY TO ST. JOHNS, QUE., AND CANADIAN PACIFIC RAILWAY THROUGH FARNHAM AND FOSTER TO SHERBROOKE.

Elevations on page 317.

⊕ United States Coast and Geodetic Survey bench-mark in Chapman Block, Rouse Point.

81 In north stone abutment of plate-girder bridge on Grand Trunk railway, 2½ miles south of Lacolle Junction.

80 Destroyed.

79 In third course of stonework below water-table course, in north face of pilaster at northeast corner of Roman Catholic church at Stottsville.

78 In south face of corner-stone—second course above ground—at southwest corner of central section of Roman Catholic church at Grand Ligne.

77 In second course of stonework below top, in southeast face of southeast curved retaining wall of plate-girder bridge on Grand Trunk railway, 1½ miles south of St. Johns.

76 In water-table course of stonework, in west end of south wall of Grand Trunk station-house at St. Johns.

75 In third course of stonework below water-table course, in south end of west wall of St. Johns post-office.

74 In north end of east face of west concrete abutment—3 feet above roadway—of subway under Canadian Pacific railway, 200 feet east of bridge over Richelieu river, between St. Johns and Iberville.

73 Destroyed.

72 In boulder 15 feet south of Canadian Pacific railway track and 20 feet west of highway crossing at Versailles.

71 In boulder 25 feet north of Canadian Pacific railway track and 60 feet east of highway crossing at St. Brigide.

62 In top course of stonework, in east end of front (or south) wall of Canadian Pacific station-house at Farnham.

61 In second course of stonework below top, in southwest retaining wall of small bridge on Canadian Pacific railway, 3·1 miles west of Brookport.

60 In northeasterly concrete footing under Canadian Pacific water-tank at Brookport.

59 In boulder beside elm tree, 45 feet east and 100 feet south of southeast corner of Adamsville station-house.

58 In boulder 10 feet south of Canadian Pacific railway track, 3¾ miles east of Adamsville and at second telegraph pole east of mile-post 118 from Megantic.

57 In west face of stone coping on northwest retaining wall of Canadian Pacific railway bridge over north branch of Yamaska river, 1¼ miles east of West Shefford.

56 In south side of rock cut on Canadian Pacific railway, 800 feet east of Fulford station and 230 feet east of mile-post 109 from Megantic.

47 In west foundation wall of Railroad hotel at Foster, 4 feet south of northwest corner of building.

46 In west face of stone coping on southwest retaining wall of plate-girder bridge on Canadian Pacific railway, 2 miles east of Foster and at mileage 103·7 from Megantic.

45 In south end of west face of east abutment of small concrete culvert under Canadian Pacific railway, ½ mile east of South Stukely and at mileage 100·3 from Megantic.

44 In boulder 6 feet south of north line of Canadian Pacific railway right-of-way, 150 feet east of a tool house and 1,200 feet west of Eastray station.

43 In exposed rock surface on north side of Canadian Pacific railway track, 18 feet east of sixth telegraph pole west of mile-post 93 from Megantic.

42 In west face of stone coping on northwest retaining wall of Canadian Pacific railway bridge over Castle creek, 3 miles west of Magog and at mileage 89·8 from Megantic.

41–A In third course of stonework below water-table course, in west end of south wall of Magog post-office.

41 In second course of stonework above ground, in masonry base of Canadian Pacific water-tank at Magog, 15 feet to the right of the doorway underneath tank.

40 In boulder 200 feet south of southwest corner of Magog station-house, 50 feet west of main line of Canadian Pacific railway, and on south street line of road to Magog wharf.

39 In north end of west face of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, 1½ miles east of Magog and at mileage 85·4 from Megantic.

38 In boulder at north side of Canadian Pacific railway track, 1¼ miles west of Scaswan flag-station and close to culvert at mileage 79·23 from Megantic.

37 In east face of south face-wall of stone culvert under Canadian Pacific railway at mileage 74·5 from Megantic.

36 In east face of stone coping on southeast retaining wall of Canadian Pacific railway bridge over Magog river, about 1 mile west of Sherbrooke station.

35 In water-table course of stonework, in south end of west wall of old Canadian Pacific station-house at Sherbrooke—at the corner of Belvidere and Frontenac streets.

1 In Sherbrooke post-office—see line from Sherbrooke to Norton Mills.

BENCH-MARKS BETWEEN FARNHAM AND INTERNATIONAL BOUNDARY NEAR ST. ARMAND, QUE., VIA CANADIAN PACIFIC RAILWAY TO STANBRIDGE AND CENTRAL VERMONT RAILWAY FROM STANBRIDGE TO BOUNDARY.

Elevations on page 318.

63 Destroyed.

64 In top course of granite foundation, in south end of west wall of Canadian Bank of Commerce at Farnham.

65 In exposed rock surface, 15 feet west of Canadian Pacific railway track and 720 feet south of Mystic station.

66 In top course of granite foundation, in south end of west wall of Canadian Bank of Commerce at Bedford.

67 In top course of stone foundation, in west end of south wall of post-office and general store at Stanbridge station.

68 In second course of brickwork below water-table, in east end of north wall of Central Vermont station-house at St. Armand.

69 In second course below top, in west face of north abutment of old stone culvert under Central Vermont railway, ½ mile south of St. Armand.

70 In small granite boulder, 20 feet west of Central Vermont railway track, 190 feet south of international boundary post and 1¼ miles south of St. Armand.

BENCH-MARKS BETWEEN FOSTER AND INTERNATIONAL BOUNDARY NEAR ABERCORN, QUE., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 318.

48 In east side of rock cut on Canadian Pacific railway, 1¼ miles north of Knowlton and 20 feet north of fourth telegraph pole north of mile-post 8 from Enlaugra.

49 In fourth course of stonework below water-table, in northeast end of northwest wall of Knowlton Academy, about 500 feet south of Canadian Pacific station.

50 In west face of second foundation pier from north end of oil tank, directly opposite Canadian Pacific station at Brome.

51 In square boulder, 15 feet west of Canadian Pacific railway track at Enlaugra and 70 feet south of south end of station platform.

52 In first course of stonework below brickwork, in west end of north wall of Mountain View hotel at Sutton.

53 In cap-stone on west end of old granite culvert under Canadian Pacific railway, 1½ miles north of Abercorn and at mileage 23·4 from Brookport.

54 In west face of concrete culvert under Canadian Pacific railway, 960 feet north of Abercorn station and at mileage 24·7 from Brookport.

55 In east face of concrete culvert under Canadian Pacific railway, 250 feet north of a diagonal highway crossing, 1 mile south of Abercorn and at mileage 25·8 from Enlaugra.

BENCH-MARKS BETWEEN SHERBROOKE, QUE., AND INTERNATIONAL BOUNDARY NEAR NORTON MILLS, VERMONT, VIA GRAND TRUNK RAILWAY.

Elevations on page 319.

1 In first course of stonework below water-table course, in south face of pilaster at southwest corner of Sherbrooke post-office.

2 In water-table course of stonework, in north wall of Canadian Bank of Commerce at Sherbrooke—21 feet from northeast corner of building.

3 In second course of stonework below top, in west end of south face of retaining wall behind north abutment of Grand Trunk railway bridge over Magog river at Sherbrooke, 2,000 feet north of the station.

4 In east side of rock cut on Grand Trunk railway, 1½ miles south of Sherbrooke station. This is the second rock cut south of Sherbrooke.

5 In second course below top, in south end of east face of stone culvert under Canadian Pacific railway, at mileage 66·2 from Megantic—¼ mile north of diamond crossing of Grand Trunk and Canadian Pacific railways between Sherbrooke and Lennoxville.

6 In top course of stonework, in west end of north face of retaining wall behind north abutment of Grand Trunk railway bridge over Massawippi river, ½ mile south of Lennoxville.

7 In top course of stonework, in west end of north face of retaining wall behind north abutment of Grand Trunk railway bridge over Salmon river, 1¾ miles south of Lennoxville.

8 In large stone—58 feet from south end—of dry stone retaining wall lying along east side of Grand Trunk railway track, 1¾ miles north of Waterville; this is the farther north of the two retaining walls near this point.

9 In north face of cap-stone on northwest retaining wall of Grand Trunk railway bridge over Coaticook river, ¼ mile north of Waterville.

10 In west side of rock cut on Grand Trunk railway, 200 feet south of a farm crossing, ¾ mile north of Compton and 1,925 feet north of mile-post 114 from Montreal.

11 In west side of rock cut on Grand Trunk railway—2 feet from south end of cut—420 feet north of a subway, 1¼ miles south of Compton and 2,040 feet north of mile-post 116 from Montreal.

12 Destroyed.

13 In top course of stonework, in rear (or northwest) face of retaining wall behind north abutment of subway under Grand Trunk railway, ½ mile south of Hillhurst.

14 In north face of northwest cap-stone of subway under Grand Trunk railway at Coaticook.

15 In first course of stonework below water-table course, in centre of west wall of Canadian Bank of Commerce at Coaticook.

16 In first course of stonework below water-table course, in west wall of Coaticook post-office, 8 feet south of main entrance.

17 In west side of rock cut on Grand Trunk railway—near south end of cut—1 mile south of Coaticook. This is the first rock cut south of Coaticook.

18 In east side of rock cut on Grand Trunk railway, 2½ miles south of Coaticook and 278 feet north of mile-post 125 from Montreal.

19 In centre of east side of rock cut on Grand Trunk railway, 1½ miles north of Dixville and 870 feet south of mile-post 126 from Montreal.

20 Destroyed.

21 In west side of rock cut on Grand Trunk railway—50 feet from north end of cut—on a sharp curve, 1½ miles south of Dixville and 225 feet north of mile-post 129 from Montreal.

22 In west side of rock cut on Grand Trunk railway—20 feet from south end of cut—on a sharp curve, 1¾ miles south of Dixville and 2,440 feet south of mile-post 129 from Montreal.

23 In second course of stonework below top, in southeast face of southeast curved retaining wall of Grand Trunk railway bridge at international boundary, 400 feet north of Norton Mills station.

24 In second course of stonework above ground, in east end of south face of north abutment of Grand Trunk railway bridge at international boundary, 400 feet north of Norton Mills station.

25 In first course of stonework above ground, in east end of north face of south abutment of Grand Trunk railway bridge at international boundary, 400 feet north of Norton Mills station.

BENCH-MARKS BETWEEN ROUSE POINT, N.Y., AND COLBORNE, ONT., VIA GRAND TRUNK RAILWAY TO ST. POLYCARPE JUNCTION, CANADIAN PACIFIC RAILWAY TO PRESCOTT AND GRAND TRUNK RAILWAY TO COLBORNE.

Elevations on page 320.

⊕ United States Coast and Geodetic Survey bench-mark in Chapman Block, Rouse Point.

81 In north stone abutment of plate-girder bridge on Grand Trunk railway, 2½ miles south of Lacolle Junction.

82 Destroyed.

83 In second course of stonework below cap-stone, in north face of east abutment of small culvert under Grand Trunk railway, 1½ miles west of Henrysburg and 1,560 feet west of mile-post 16 from Alburgh Junction.

84 Destroyed.

85 In south side of small rock cut on Grand Trunk railway, 120 feet east of a farm crossing and ½ mile east of Holton.

86 In third course below cap-stone, in south face of west abutment of small dry stone culvert under Grand Trunk railway, 1¼ miles west of Aubrey and at twelfth telegraph pole east of mile-post 33 from Alburgh Junction.

87 In third course of stonework below top, in southwest face of southwest retaining wall of circular stone culvert under Grand Trunk railway, ½ mile east of Howick Junction and at third telegraph pole west of a highway crossing.

88 In top course of stonework, in northeast face of northeast retaining wall of circular cattle-pass under Grand Trunk railway, 720 feet east of St. Louis station.

89 In first course above platform, in west face of corner stone at southwest corner of Grand Trunk station-house at Valleyfield.

90 In north face of northeasterly stone footing under Grand Trunk water-tank at Coteau Junction.

91 In southwest face—1 foot below top—of south concrete retaining wall of open culvert under Grand Trunk railway, 1¾ miles southeast of St. Polycarpe.

92 In fourth course of stonework below top, in southwest face of northwest abutment of open culvert under Grand Trunk railway, 1,600 feet southeast of St. Polycarpe Junction.

93 In west face of stone coping on southwest retaining wall of Canadian Pacific railway bridge over Delisle river, 1 mile west of St. Polycarpe Junction.

94 In top of south end of 36-inch concrete tile culvert under Canadian Pacific railway, ½ mile west of St. Télesphore flag-station.

95 In masonry base of Canadian Pacific water-tank at Dalhousie Mills, 7 feet to the left of the doorway underneath tank and 7 inches above door sill.

96 In south face of concrete arch culvert under Canadian Pacific railway, 2¾ miles west of Dalhousie Mills and at mileage 44·5 from Montreal West.

97 In south face of boulder—6 feet by 6 feet—15 feet south of north line of Canadian Pacific railway right-of-way and 1 mile east of Green Valley.

98 In north face of boulder—4 feet by 4 feet—9 feet north of south line of Canadian Pacific railway right-of-way, 220 feet east of a concrete tile culvert and ½ mile east of Glenroy flag-station.

99 In east face of boulder, 15 feet north of south line of Canadian Pacific railway right-of-way, 3 miles west of Glenroy flag-station and 460 feet west of mile-post 55 from Montreal West.

100 In west face of stone coping on northwest retaining wall of plate-girder bridge on Canadian Pacific railway, ¾ mile east of Apple Hill.

101 In north face of boulder, 10 feet north of south line of Canadian Pacific railway right-of-way, 1,000 feet east of a subway, 2 miles west of Apple Hill and 650 feet east of mile-post 60 from Montreal West.

102 In masonry base of Canadian Pacific water-tank at Monckland, 18 inches to the left of the doorway underneath tank and 20 inches above door sill.

103 In first course of stonework below brickwork, in east end of north wall of Avonmore Presbyterian church.

104 In south face of square concrete culvert under Canadian Pacific railway, 1½ miles west of Avonmore.

105 In south face of stone coping on retaining wall behind west abutment of plate-girder bridge over Payne river, ½ mile east of Finch.

106 In south face of square concrete culvert under Canadian Pacific railway, 3 miles west of Finch and ½ mile east of east end of a long curve.

107 In masonry base of Canadian Pacific water-tank at Chesterville, 15 feet to the left of the doorway underneath tank and 4 feet above ground.

108 In south face of concrete retaining wall behind west abutment of subway under Canadian Pacific railway, 2¾ miles east of Winchester.

109 In south face of boulder on Canadian Pacific railway right-of-way—close to north fence—50 feet west of road from Winchester station to village.

110 In south face of square concrete culvert under Canadian Pacific railway, ⅓ mile west of Inkerman.

111 In east stone foundation wall—5 feet 3 inches from southeast corner—of frame schoolhouse at Mountain station.

112 In south face of small square concrete culvert under Canadian Pacific railway, 2 miles east of Kempton.

113 In masonry base of Canadian Pacific water-tank at Kempton, 2 feet 5 inches to the right of the doorway underneath tank and 3 feet 8 inches above doorsill.

114 In east face of square concrete culvert under Canadian Pacific railway, 1 mile north of Oxford.

115 In north face of boulder—6 feet by 6 feet—on east side of Canadian Pacific railway track, 3 miles south of Oxford and 750 feet south of mile-post 38 from Ottawa.

116 In south wall of stone schoolhouse, 200 feet east of Canadian Pacific railway track and 1¾ miles north of Spencerville. The bench-mark is 30 inches below water-table and 10 inches from southwest corner of building.

117 In east face of square concrete culvert under Canadian Pacific railway, 2¾ miles south of Spencerville.

118 In north face of east stone abutment of bridge by which Grand Trunk railway main line passes over Canadian Pacific railway, 1½ miles east of Prescott. The bench-mark is a few inches above Canadian Pacific rails.

119 In third course of stonework above water-table, in east end of front(or north) wall of Grand Trunk station-house at Prescott.

120 In east face of cap-stone on south end of stone arch culvert under Grand Trunk Railway, 3¼ miles west of Prescott.

121 In south face of southeast cap-stone of plate-girder bridge on Grand Trunk railway, 1 mile east of Maitland.

122 In south face of southwest cap-stone of plate-girder bridge on Grand Trunk railway, 1¾ miles west of Maitland.

123 In south face of cap-stone on south end of small stone culvert under Grand Trunk railway, 100 feet east of Ormond street, Brockville, and 190 feet west of mile-post 209 from Toronto.

124 In centre of north face of south stone abutment of bridge by which Canadian Northern railway (Brockville-Westport line) passes over Grand Trunk railway, 1½ miles west of Brockville. The bench-mark is 1 foot above Grand Trunk rails.

125 In east end of south face of stone coping on southeast retaining wall of plate-girder bridge on Grand Trunk railway, 1000 feet west of Lyn.

126 In top course of stonework, in south face of east abutment of cattle-pass under Grand Trunk railway, 2¾ miles west of Lyn.

127 In top course of stonework, in south face of west abutment of cattle-pass under Grand Trunk railway, 2 miles east of Mallorytown.

128 In south face of cap-stone on south end of square stone culvert under Grand Trunk railway, 1 mile west of Mallorytown and 400 feet east of a highway crossing.

129 In west end of south face of coping on south end of square stone culvert under Grand Trunk railway, 3½ miles west of Mallorytown and 1,000 feet east of mile-post 192 from Toronto.

130 In top course of stonework, in north face of east abutment of open culvert under Grand Trunk railway, ½ mile east of Lansdowne.

131 In first course of stonework above water-table, in west end of south wall of Lansdowne town-hall.

132 In top course of stonework, in north face of east abutment of open culvert under Grand Trunk railway—beside a highway crossing—4¼ miles east of Gananoque Junction.

133 In top course of stonework, in north face of east abutment of open culvert under Grand Trunk railway, 2 miles east of Gananoque Junction.

134 In east end of north face of stone coping on northeast retaining wall of Grand Trunk railway bridge over Gananoque river, 1¾ miles west of Gananoque Junction.

135 In south face of southwest cap-stone of plate-girder bridge on Grand Trunk railway, 1¼ miles east of Findley.

136 In north face of northeast cap-stone of plate-girder bridge on Grand Trunk railway, 2 miles west of Findley.

137 In east end of north face of cap-stone on north end of square stone culvert under Grand Trunk railway, 5 miles west of Findley and 1,200 feet west of a highway crossing.

138 In east face of stone coping on northeast retaining wall of Grand Trunk railway bridge over Rideau canal at Kingston Mills, ½ mile west of Rideau station.

139 In first course of stonework above water-table, in east end of front (or north) wall of Grand Trunk station-house at Kingston Junction.

140 In south face of southwest cap-stone of Grand Trunk railway bridge over Little Cataraqui creek, 2¾ miles west of Kingston Junction, 870 feet east of mile-post 158 from Toronto and ½ mile east of crossing of main road from Kingston to Cataraqui.

141 In second course of stonework above concrete sidewalk, in south face of pilaster on south wall of Kingston city-hall. The pilaster referred to is immediately east of rounded southwest corner of building.

141–A In second course above concrete sidewalk, in north face of large corner stone at northeast corner of Kingston post-office—at southeast corner of Clarence and Wellington streets. The bench-mark is 28 feet east of centre line of the three arches forming main entrance to building.

142 In first course of stonework below water-table course, in west end of south wall of Canadian Pacific station-house at Kingston.

143 In south face of southwest cap-stone of open culvert under Grand Trunk railway, 1¾ miles east of Collins Bay and 1,220 feet east of mile-post 155 from Toronto.

144 In west face of cap-stone on southwest retaining wall of plate-girder bridge on Grand Trunk railway, 0·4 mile west of Collins Bay.

145 In west end of south face of coping on south end of stone arch culvert under Grand Trunk railway, 3¼ miles west of Collins Bay and 1,100 feet east of a highway crossing which is at mile-post 150 from Toronto.

146 In first course of stonework above water-table, in front (or south) wall of Grand Trunk station-house at Ernestown—3 feet west of waiting-room door.

147 In first course of stonework below southwest cap-stone, in east face of west abutment of small square culvert under Grand Trunk railway, 4 miles west of Ernestown and 470 feet west of mile-post 142 from Toronto.

148 In west face of coping on south end of stone arch subway under Grand Trunk railway, 3 miles east of Napanee.

149 In first course of stonework below water-table course, in east wall of Napanee court-house, 1 foot 6 inches south of first window from northeast corner of building.

150 In front (or north) wall of Grand Trunk station-house at Napanee, 1 foot east of westerly doorway.

150–A In first course of stonework above ground, in west wall of Napanee post-office, 8 feet 6 inches south of centre line of main entrance.

150–A–2 In fifth course of stonework below water-table course, in east face of pilaster at southeast corner of Armoury at Napanee.

151 In east face of southwest cap-stone of plate-girder bridge on Grand Trunk railway, 3½ miles west of Napanee. This bridge is the farther east of the two bridges near this point.

152 In west face of coping on north end of stone arch culvert under Grand Trunk railway, ⅓ mile east of Marysville.

153 In east face of stone coping on northeast retaining wall of Grand Trunk railway bridge over Salmon river, 1½ miles east of Shannonville.

154 In first course above water-table, in north face of corner stone at northwest corner of Grand Trunk station-house at Shannonville.

155 In north face of northeast cap-stone of plate-girder bridge on Grand Trunk railway, 4½ miles east of Belleville and 1,000 feet west of a highway crossing.

156 In first course of stonework above water-table, in front (or north) wall of Grand Trunk station-house at Belleville—immediately west of easterly doorway.

157 In rear (or east) foundation wall of Belleville city-hall, 16 inches below water-table course of stonework and 4 feet 6 inches south of first basement window from northeast corner of building.

157–A In third course of stonework below brickwork, in west end of north wall of Armoury at Belleville.

157–A–2 In north face—33 inches below top of coping—of concrete pier of Canadian Pacific railway bridge over Moira river at Belleville. The pier referred to is immediately east of small subway leading to park.

158 In east face of northeast cap-stone of plate-girder bridge on Grand Trunk railway, 3 miles west of Belleville and at mileage 110·4 from Toronto.

159 In southeast face of southwest cap-stone of open culvert under Grand Trunk railway, 5½ miles west of Belleville.

160 In north face of northeast cap-stone of open culvert under Grand Trunk railway, 3¾ miles east of Trenton and at mile-post 105 from Toronto.

161 In top course of stonework, in rounded southeast corner of east abutment of bridge by which Grand Trunk railway passes over Canadian Northern railway (Trenton-Maynooth line), at Trenton station.

162 In north face of northeast cap-stone of open culvert under Grand Trunk railway, 1 mile east of Smithfield flag-station.

163 In east face of northeast cap-stone of open culvert under Grand Trunk railway, ¾ mile east of Brighton.

164 In north face of northeast cap-stone of open culvert under Grand Trunk railway, 1½ miles west of Brighton and midway between two highway crossings.

165 In east face of coping on north end of stone arch culvert under Grand Trunk railway, 4½ miles west of Brighton.

166 In fourth course of stonework below top, in north end of west face of east abutment of open culvert under Grand Trunk railway, 0·4 mile east of Colborne.

TABLE II.

RESULTS OF PRECISE LEVELLING.

ST. ANSELME, QUE., TO EDMUNDSTON, N.B.

Run by T. C. Dennis and J. E. Ratz.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 214-B.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	214–B					553·825	214–B
214–B	223–B	2·4	2·4	+·026	+·026	604·835	223–B
223–B	224–B	3·2	5·6	+·025	+·051	671·009	224–B
224–B	225–B	2·4	8·0	−·011	+·040	710·349	225–B
225–B	227–B	5·1	13·1	−·013	+·027	765·004	227–B
227–B	228–B	2·6	15·7	+·019	+·046	810·759	228–B
228–B	229–B	3·4	19·1	−·026	+·020	869·029	229–B
229–B	230–B	2·7	21·8	+·007	+·027	900·590	230–B
230–B	231–B	2·5	24·3	+·010	+·037	948·882	231–B
231–B	232–B	2·8	27·1	+·003	+·040	970·240	232–B
232–B	233–B	2·8	29·9	·000	+·040	989·834	233–B
233–B	234–B	3·1	33·0	+·015	+·055	984·248	234–B
234–B	235–B	3·1	36·1	+·020	+·075	1007·299	235–B
235–B	236–B	3·4	39·5	+·009	+·084	1061·743	236–B
236–B	237–B	2·9	42·4	−·004	+·080	1116·177	237–B
237–B	238–B	3·2	45·6	−·005	+·075	1170·944	238–B
238–B	239–B	3·1	48·7	−·020	+·055	1230·211	239–B
239–B	240–B	3·2	51·9	+·013	+·068	1280·157	240–B
240–B	241–B	2·3	54·2	−·008	+·060	1300·981	241–B
241–B	242–B	2·5	56·7	−·021	+·039	1281·969	242–B
242–B	243–B	2·3	59·0	−·002	+·037	1225·149	243–B
243–B	244–B	2·1	61·1	+·010	+·047	1266·834	244–B
244–B	245–B	2·7	63·8	+·014	+·061	1222·519	245–B
245–B	246–B	3·0	66·8	+·006	+·067	1230·500	246–B
246–B	247–B	2·8	69·6	+·012	+·079	1292·751	247–B
247–B	248–B	3·3	72·9	+·026	+·105	1253·525	248–B
248–B	249–B	3·2	76·1	+·002	+·107	1209·387	249–B
249–B	385–B	3·2	79·3	−·029	+·078	1160·619	385–B
385–B	384–B	2·5	81·8	−·011	+·067	1064·415	384–B
384–B	383–B	5·1	86·9	−·019	+·048	1129·830	383–B
383–B	382–B	2·4	89·3	−·020	+·028	1122·474	382–B
382–B	381–B	4·6	93·9	−·011	+·017	1195·343	381–B
381–B	380–B	1·0	94·9	+·003	+·020	1200·772	380–B
380–B	379–B	2·6	97·5	−·019	+·001	1143·835	379–B
379–B	378–B	4·2	101·7	−·028	−·027	1082·654	378–B
378–B	377–B*	4·3	106·0	−·010	−·037	1094·480	377–B*
377–B*	376–B	4·9	110·9	+·020	−·017	1003·001	376–B

*See also elevation of this bench-mark on page 292.

RESULTS OF PRECISE LEVELLING.

ST. ANSELME, QUE., TO EDMUNDSTON, N.B.—*Concluded.*

Run by T. C. Dennis and J. E. Ratz.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 214-B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
376–B	375–B	6·5	117·4	+·034	+·017	1079·260	375–B
375–B	288–B	4·4	121·8	+·033	+·050	1142·737	288–B
288–B	287–B	0·6	122·4	−·001	+·049	1144·473	287–B
287–B	286–B	4·5	126·9	+·020	+·069	1209·691	286–B
286–B	285–B	1·7	128·6	+·017	+·086	1197·271	285–B
285–B	284–B	0·8	129·4	−·017	+·069	1177·829	284–B
284–B	283–B	4·2	133·6	−·016	+·053	1231·385	283–B
283–B	282–B	1·7	135·3	−·010	+·043	1259·350	282–B
282–B	281–B	4·0	139·3	−·025	+·018	1173·841	281–B
281–B	280–B	1·9	141·2	−·007	+·011	1078·238	280–B
280–B	279–B	0·9	142·1	−·004	+·007	1020·236	279–B
279–B	278–B	2·8	144·9	+·007	+·014	874·645	278–B
278–B	276–B	3·1	148·0	+·016	+·030	709·119	276–B
276–B	277–B	....	148·0	−·002	+·028	685·581	277–B
276–B	275–B	3·3	151·3	+·017	+·047	706·983	275–B
275–B	274–B	5·9	157·2	·000	+·047	644·351	274–B
274–B	273–B	3·9	161·1	+·016	+·063	675·274	273–B
273–B	272–B	3·6	164·7	+·030	+·093	662·967	272–B
272–B	271–B	4·7	169·4	−·001	+·092	669·176	271–B
271–B	270–B	4·7	174·1	+·023	+·115	704·845	270–B
270–B	269–B	3·7	177·8	+·011	+·126	680·706	269–B
269–B	268–B	2·2	180·0	·000	+·126	676·659	268–B
268–B	267–B	2·9	182·9	−·004	+·122	696·228	267–B
267–B	266–B	2·0	184·9	+·022	+·144	651·596	266–B
266–B	265–B	3·6	188·5	−·020	+·124	579·532	265–B
265–B	264–B	2·8	191·3	+·018	+·142	514·403	264–B
264–B	263–B	1·5	192·8	+·001	+·143	493·481	263–B
263–B	262–B	3·0	195·8	−·009	+·134	497·273	262–B
262–B	261–B	2·5	198·3	+·013	+·147	488·485	261–B
261–B	260–B	3·2	201·5	−·006	+·141	470·438	260–B
260–B	58–B*	3·1	204·6	+·001	+·142	473·540	58–B*

*See also elevation of this bench-mark on page 314.

RESULTS OF PRECISE LEVELLING.

HARLAKA JUNCTION TO RIVIERE-DU-LOUP, QUE.

Run by G. F. Dalton.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 219-B	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	219–B					177·096	219–B
219–B	MCXXXV	1·0	1·0	+·007	+·007	239·622	MCXXXV
MCXXXV	MCXXXIV	2·1	3·1	−·010	−·003	299·144	MCXXXIV
MCXXXIV	MCXXXIII	2·7	5·8	−·002	−·005	306·637	MCXXXIII
MCXXXIII	MCXXXII	2·5	8·3	+·011	+·006	322·696	MCXXXII
MCXXXII	MCXXXI	2·1	10·4	−·007	−·001	283·202	MCXXXI
MCXXXI	MCXXX	2·1	12·5	−·001	−·002	205·189	MCXXX
MCXXX	MCXXIX	1·1	13·6	−·010	−·012	167·476	MCXXIX
MCXXIX	MCXXVIII	1·7	15·3	+·004	−·008	178·004	MCXXVIII
MCXXVIII	563–B	1·0	16·3	+·003	−·005	169·441	563–B
563–B	MCXXVI	1·0	17·3	+·011	+·006	164·310	MCXXVI
MCXXVI	MCXXV	2·1	19·4	+·004	+·010	146·516	MCXXV
MCXXV	MCXXIV	1·2	20·6	+·018	+·028	151·125	MCXXIV
MCXXIV	MCX	3·6	24·2	−·011	+·017	128·817	MCX
MCX	MCXI	1·7	25·9	+·004	+·021	127·714	MCXI
MCXI	564–B	0·9	26·8	−·001	+·020	135·892	564–B
564–B	565–B	2·0	28·8	+·012	+·032	123·193	565–B
565–B	MCXIII	2·4	31·2	−·013	+·019	90·969	MCXIII
MCXIII	566–B	2·2	33·4	−·016	+·003	53·498	566–B
566–B	MCXV	1·2	34·6	+·008	+·011	53·781	MCXV
MCXV	MCXVI	0·5	35·1	+·003	+·014	54·231	MCXVI
MCXVI	MCXVII	1·0	36·1	+·004	+·018	72·703	MCXVII
MCXVII	MCXVIII	2·0	38·1	−·003	+·015	105·921	MCXVIII
MCXVIII	567–B	2·2	40·3	−·004	+·011	122·619	567–B
567–B	MCXIX	3·5	43·8	+·023	+·034	107·889	MCXIX
MCXIX	MCXX	1·5	45·3	+·017	+·051	104·350	MCXX
MCXX	568–B	0·8	46·1	+·001	+·052	104·842	568–B
568–B	MCXXI	0·3	46·4	+·001	+·053	91·620	MCXXI
MCXXI	569–B	0·8	47·2	−·001	+·052	77·130	569–B
569–B	MCXXII	0·3	47·5	−·003	+·049	71·749	MCXXII
MCXXII	MCXXIII	2·0	49·5	+·010	+·059	79·246	MCXXIII
MCXXIII	MCIX	0·9	50·4	−·013	+·046	99·455	MCIX
MCIX	MCVIII	1·6	52·0	−·022	+·024	136·074	MCVIII
MCVIII	570–B	1·2	53·2	+·004	+·028	153·267	570–B
570–B	MCVI	0·7	53·9	+·008	+·036	162·109	MCVI
MCVI	571–B	3·6	57·5	+·019	+·055	165·734	571–B
571–B	MCV	1·9	59·4	+·007	+·062	146·827	MCV
MCV	MCIV	1·5	60·9	+·005	+·067	129·746	MCIV
MCIV	MCII	2·6	63·5	·000	+·067	108·366	MCII
MCII	572–B	1·7	65·2	−·006	+·061	101·465	572–B
572–B	573–B	1·9	67·1	−·002	+·059	93·964	573–B

RESULTS OF PRECISE LEVELLING.

HARLAKA JUNCTION TO RIVIERE-DU-LOUP, QUE.—*Concluded.*

Run by G. F. Dalton.‡

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 219–B.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
573–B	MXCIX	2·4	69·5	+·006	+·065	96·158	MXCIX
MXCIX	MXCVIII	1·9	71·4	–·017	+·048	70·388	MXCVIII
MXCVIII	574–B	0·9	72·3	+·002	+·050	74·210	574–B
574–B	MXCVI	1·7	74·0	–·020	+·030	53·766	MXCVI
MXCVI	MXCV	1·4	75·4	+·008	+·038	35·158	MXCV
MXCV	MCXXXVII	0·6	76·0	+·005	+·043	48·384	MCXXXVII
MCXXXVII	MCXXXVIII	1·1	77·1	–·010	+·033	62·546	MCXXXVIII
MCXXXVIII	MCXXXIX	1·2	78·3	+·011	+·044	97·899	MCXXXIX
MCXXXIX	MCXLII	1·1	79·4	–·011	+·033	135·937	MCXLII
MCXLII	27–G	0·4	79·8	+·002	+·035	145·018	27–G
27–G	28–G	2·5	82·3	+·003	+·038	564·311	28–G
28–G	29–G	3·0	85·3	+·010	+·048	740·743	29–G
29–G	30–G	2·5	87·8	+·012	+·060	1045·489	30–G
30–G	377–B*	5·4	93·2	+·027	+·087	1094·393	377–B*
MCXLII	575–B	1·8	81·2	–·005	+·028	178·186	575–B
575–B	MCXLIII	1·5	82·7	–·004	+·024	191·738	MCXLIII
MCXLIII	576–B	1·7	84·4	+·003	+·027	173·478	576–B
576–B	MCXLIV	1·0	85·4	–·007	+·020	184·767	MCXLIV
MCXLIV	MCXLVI	0·5	85·9	+·008	+·028	183·841	MCXLVI
MCXLIV	MCXLV	1·3	86·7	–·018	+·002	219·395	MCXLV
MCXLV	577–B	2·6	89·3	+·001	+·003	308·741	577–B
577–B	MCXLVIII	1·0	90·3	–·006	–·003	311·482	MCXLVIII
MCXLVIII	578–B	0·9	91·2	–·016	–·019	314·473	578–B
578–B	MCXLIX	3·1	94·3	+·017	–·002	338·183	MCXLIX
MCXLIX	579–B	2·1	96·4	–·019	–·021	345·261	579–B
579–B	MCL	2·0	98·4	+·016	–·005	370·612	MCL
MCL	MCLI	0·7	99·1	–·002	–·007	369·472	MCLI
MCLI	MCLII	2·0	101·1	–·006	–·013	414·476	MCLII
MCLII	MCLXVII	2·3	103·4	–·007	–·020	376·160	MCLXVII
MCLXVII	MCLXVI	1·4	104·8	+·001	–·019	336·502	MCLXVI
MCLXVI	579–B–2	1·0	105·8	+·005	–·014	350·611	579–B–2
579–B–2	MCLXV	1·2	107·0	+·008	–·006	329·949	MCLXV
MCLXV	MCLXIV	1·5	108·5	–·009	–·015	321·892	MCLXIV
MCLXIV	580–B	0·2	108·7	–·004	–·019	329·674	580–B
580–B	MCLXIII	2·4	111·1	–·010	–·029	311·262	MCLXIII
MCLXIII	77–B†	....	111·1	+·003	–·026	313·176	77–B†

‡Branch from MCXLII to 377–B was run by H. P. Moulton.
*See also elevation of this bench-mark on page 289.
†See also elevation of this bench-mark on page 315.

RESULTS OF PRECISE LEVELLING.

OTTAWA TO RENFREW, ONT.

Run by H. P. Moulton.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 125-A	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	125–A					277·639	125–A
125–A	50–G	3·0	3·0	−·004	−·004	201·410	50–G
50–G	51–G	2·7	5·7	−·016	−·020	186·753	51–G
51–G	52–G	1·7	7·4	+·001	−·019	197·594	52–G
52–G	53–G	2·2	9·6	+·021	+·002	272·271	53–G
53–G	54–G	2·7	12·3	+·021	+·023	367·718	54–G
54–G	55–G	3·1	15·4	+·014	−·037	366·885	55–G
55–G	56–G	3·5	18·9	+·010	+·047	433·497	56–G
56–G	57–G	2·9	21·8	−·004	+·043	445·745	57–G
57–G	58–G	2·4	24·2	−·002	+·041	450·023	58–G
58–G	59–G	3·1	27·3	+·020	+·061	427·484	59–G
59–G	60–G*	2·4	29·7	+·004	+·065	449·509	60–G*
60–G*	61–G	0·4	30·1	+·003	+·068	451·241	61–G
61–G	62–G	0·2	30·3	−·001	+·067	443·194	62–G
62–G	63–G	3·5	33·8	+·002	+·069	411·347	63–G
63–G	64–G	2·8	36·6	−·021	+·048	393·084	64–G
64–G	65–G	....	36·6	+·002	+·050	393·769	65–G
64–G	66–G	0·1	36·7	+·002	+·050	399·567	66–G
66–G	67–G	4·7	41·4	−·025	+·025	377·820	67–G
67–G	68–G	3·8	45·2	−·019	+·006	317·560	68–G
68–G	69–G	0·4	45·6	−·002	+·004	337·535	69–G
69–G	70–G	1·6	47·2	+·015	+·019	332·174	70–G
70–G	71–G	2·0	49·2	+·002	+·021	333·625	71–G
71–G	72–G	2·4	51·6	−·022	−·001	317·131	72–G
72–G	73–G	1·5	53·1	−·003	−·004	300·415	73–G
73–G	74–G	0·1	53·2	+·001	−·003	299·031	74–G
74–G	75–G	0·2	53·4	·000	−·003	278·255	75–G
74–G	76–G	5·0	58·2	+·012	+·009	389·915	76–G

*See also elevation of this bench-mark on page 297.

RESULTS OF PRECISE LEVELLING.

OTTAWA TO RENFREW, ONT.—*Concluded.*

Run by H. P. Moulton.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 125–A	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
76–G	77–G	3·8	62·0	+·031	+·040	452·091	77–G
77–G	78–G	2·0	64·0	+·003	+·043	490·863	78–G
78–G	79–G	3·7	67·7	+·024	+·067	468·449	79–G
79–G	505*	1·9	69·6	–·004	+·063	425·824	505*

*The elevation of bench-mark 505 given on page 32, 1915 publication, is 425·628—see introduction (this publication) page 241. See also elevation on page 299.

Connections with Public Works Dept's bench-marks:—

B.M.—CCCCLXVI—C.P.R. Broad St. station, Ottawa, Elev. 184·059.
B.M.—CCCCLXII—J. Whitton's house, Britannia, Elev. 202·728.
B.M.—CCCCLXXVII—C.P.R. station, Arnprior, Elev. 300·060.
B.M.—CCCCLXXXV—C.P.R. water-tank, Renfrew, Elev. 418·065.

RESULTS OF PRECISE LEVELLING.

KEMPTON TO IVANHOE, ONT.

Run by H. P. Moulton.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 113.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	113					337·269	113
113	80–G	2·0	2·0	+·016	+·016	323·710	80–G
80–G	81–G	3·4	5·4	–·005	+·011	321·933	81–G
81–G	82–G	2·2	7·6	+·015	+·026	350·790	82–G
82–G	83–G	2·4	10·0	+·007	+·033	363·035	83–G
83–G	84–G	1·1	11·1	–·005	+·028	358·640	84–G
84–G	85–G	2·5	13·6	+·005	+·033	348·847	85–G
85–G	86–G	3·1	16·7	–·004	+·029	355·646	86–G
86–G	87–G	2·6	19·3	–·022	+·007	397·618	87–G
87–G	88–G	1·5	20·8	+·010	+·017	425·121	88–G
88–G	107–G	0·5	21·3	+·005	+·022	427·273	107–G
107–G	108–G	0·1	21·4	+·001	+·023	430·201	108–G
88–G	89–G	0·5	21·3	·000	+·017	427·737	89–G
89–G	109–G	2·8	24·1	–·015	+·002	413·572	109–G
109–G	110–G	1·8	25·9	–·004	–·002	423·687	110–G
110–G	111–G	2·6	28·5	–·009	–·011	437·342	111–G
111–G	112–G	3·6	32·1	–·005	–·016	434·536	112–G
112–G	113–G	0·2	32·3	+·002	–·014	439·743	113–G
113–G	114–G	0·5	32·8	+·004	–·010	440·201	114–G
114–G	115–G	....	32·8	+·001	–·009	440·729	115–G
113–G	116–G	2·4	34·7	–·018	–·032	458·781	116–G
116–G	117–G	1·6	36·3	+·021	–·011	466·709	117–G
117–G	118–G	3·5	39·8	–·004	–·015	480·003	118–G
118–G	119–G	2·7	42·5	+·011	–·004	518·327	119–G
119–G	120–G	2·9	45·4	+·015	+·011	617·126	120–G
120–G	121–G	2·6	48·0	·000	+·011	576·661	121–G
121–G	122–G	2·5	50·5	–·012	–·001	584·383	122–G
122–G	123–G	3·4	53·9	–·011	–·012	690·278	123–G
123–G	124–G	4·1	58·0	–·014	–·026	649·083	124–G
124–G	161–G	2·5	60·5	+·004	–·022	641·982	161–G
161–G	162–G	3·3	63·8	–·019	–·041	732·765	162–G
162–G	163–G	3·1	66·9	+·007	–·034	682·448	163–G
163–G	164–G	2·7	69·6	·000	–·034	654·117	164–G
164–G	165–G	2·2	71·8	–·017	–·051	618·937	165–G
165–G	166–G	3·0	74·8	+·007	–·044	663·797	166–G
166–G	167–G	3·0	77·8	+·011	–·033	666·962	167–G
167–G	168–G	2·8	80·6	+·008	–·025	690·759	168–G
168–G	169–G	4·5	85·1	+·009	–·016	649·942	169–G

RESULTS OF PRECISE LEVELLING.

KEMPTON TO IVANHOE, ONT.—*Concluded.*

Run by H. P. Moulton.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 113.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
169–G	170–G	2·3	87·4	+·002	−·014	585·077	170–G
170–G	171–G	3·6	91·0	+·020	+·006	564·168	171–G
171–G	172–G	3·0	94·0	+·007	+·013	478·677	172–G
172–G	173–G	2·5	96·5	·000	+·013	466·853	173–G
173–G	174–G	2·2	98·7	+·014	+·027	476·576	174–G
174–G	175–G	0·2	98·9	−·004	+·023	481·256	175–G
175–G	176–G	....	98·9	+·001	+·024	484·292	176–G
175–G	177–G	2·8	101·7	+·018	+·041	588·355	177–G
177–G	178–G	2·9	104·6	+·021	+·062	615·686	178–G
178–G	179–G	2·5	107·1	+·005	+·067	586·659	179–G

RESULTS OF PRECISE LEVELLING.

SMITHS FALLS TO CARLETON PLACE, ONT.

Run by H. P. Moulton.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 89-G	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	89–G					427·737	89–G
89–G	90–G	1·3	1·3	−·004	−·004	410·329	90–G
90–G	91–G	2·3	3·6	−·004	−·008	433·082	91–G
91–G	92–G	3·5	7·1	−·007	−·015	451·164	92–G
92–G	93–G	4·2	11·3	+·004	−·011	457·718	93–G
93–G	94–G	2·5	13·8	+·023	+·012	457·743	94–G
94–G	60–G*	2·7	16·5	+·029	+·041	449·669	60–G*

*See also elevation of this bench-mark on page 293.

RESULTS OF PRECISE LEVELLING.

SMITHS FALLS TO BROCKVILLE, ONT.

Run by H. P. Moulton.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 88-G.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	88–G					425·121	88–G
88–G	95–G	1·5	1·5	−·014	−·014	379·402	95–G
95–G	96–G	3·3	4·8	−·019	−·033	346·176	96–G
96–G	97–G	2·3	7·1	+·009	−·024	342·737	97–G
97–G	98–G	2·5	9·6	+·005	−·019	363·710	98–G
98–G	99–G	3·5	13·1	−·002	−·021	383·546	99–G
99–G	100–G	2·5	15·6	+·011	−·010	374·064	100–G
100–G	101–G	2·0	17·6	+·006	−·004	364·479	101–G
101–G	102–G	2·3	19·9	−·027	−·031	391·039	102–G
102–G	103–G	3·6	23·5	+·025	−·006	371·084	103–G
103–G	104–G	2·1	25·6	−·004	−·010	342·052	104–G
104–G	123*	2·7	28·3	+·003	−·007	295·605	123*
123*	105–G	0·7	29·0	+·005	−·002	313·075	105–G
105–G	106–G	0·1	29·1	−·001	−·003	298·690	106–G

*The elevation of bench-mark 123 given on page 321, this publication, is 295·634; hence, to reduce all Brockville bench-marks to that datum, 0·029 foot should be added to the elevations given above for bench-marks 123, 105–G, 106–G.

RESULTS OF PRECISE LEVELLING.

SHARBOT LAKE TO RENFREW, ONT.

Run by H. P. Moulton.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 124-G.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	124-G					649·083	124-G
124-G	125-G	2·8	2·8	·000	·000	692·028	125-G
125-G	126-G	2·6	5·4	+·001	+·001	668·016	126-G
126-G	127-G	3·7	9·1	-·027	-·026	765·733	127-G
127-G	128-G	2·2	11·3	+·007	-·019	727·814	128-G
128-G	129-G	3·8	15·1	-·012	-·031	695·775	129-G
129-G	130-G	2·7	17·8	+·006	-·025	801·096	130-G
130-G	131-G	3·0	20·8	-·004	-·029	889·065	131-G
131-G	132-G	3·0	23·8	+·015	-·014	830·892	132-G
132-G	133-G	3·0	26·8	+·018	+·004	685·272	133-G
133-G	134-G	3·3	30·1	+·017	+·021	612·298	134-G
134-G	135-G	2·3	32·4	-·003	+·018	630·209	135-G
135-G	136-G	2·2	34·6	-·006	+·012	648·393	136-G
136-G	137-G	2·8	37·4	+·005	+·017	608·257	137-G
137-G	138-G	2·5	39·9	+·002	+·019	552·131	138-G
138-G	139-G	2·6	42·5	-·017	+·002	512·589	139-G
139-G	140-G	2·9	45·4	-·011	-·009	569·709	140-G
140-G	141-G	4·0	49·4	-·013	-·022	572·130	141-G
141-G	142-G	2·6	52·0	-·013	-·035	529·917	142-G
142-G	143-G	2·7	54·7	+·007	-·028	407·692	143-G
143-G	505*	2·3	57·0	+·017	-·011	426·025	505*

*See also elevations of this bench-mark on page 294.

RESULTS OF PRECISE LEVELLING.

SHARBOT LAKE TO KINGSTON, ONT.

Run by H. P. Moulton.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 124–G	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	124–G					649·083	124–G
124–G	144–G	2·7	2·7	−·014	−·014	656·086	144–G
144–G	145–G	2·8	5·5	−·019	−·033	665·324	145–G
145–G	146–G	2·6	8·1	+·006	−·027	651·287	146–G
146–G	147–G	1·7	9·8	·000	−·027	593·025	147–G
147–G	148–G	2·3	12·1	−·015	−·042	603·290	148–G
148–G	149–G	2·0	14·1	−·002	−·044	561·739	149–G
149–G	150–G	3·0	17·1	+·002	−·042	500·977	150–G
150–G	151–G	2·9	20·0	+·012	−·030	469·018	151–G
151–G	152–G	2·5	22·5	−·002	−·032	452·715	152–G
152–G	153–G	3·1	25·6	−·003	−·035	518·949	153–G
153–G	154–G	2·5	28·1	+·014	−·021	483·895	154–G
154–G	155–G	2·4	30·5	−·019	−·040	411·662	155–G
155–G	156–G	2·4	32·9	−·020	−·060	464·888	156–G
156–G	157–G	3·0	35·9	+·012	−·048	454·625	157–G
157–G	158–G	2·0	37·9	−·016	−·064	398·001	158–G
158–G	159–G	1·5	39·4	−·011	−·075	317·368	159–G
159–G	160–G	3·0	42·4	−·004	−·079	265·285	160–G
160–G	139*	2·7	45·1	+·020	−·059	276·749	139*

*See also elevation of this bench-mark on page 321.

RESULTS OF PRECISE LEVELLING.

IVANHOE TO BELLEVILLE, ONT.

Run by W. N. McGrath.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 179-G.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	179–G					586·659	179–G
179–G	180–G	4·7	4·7	−·026	−·026	457·339	180–G
180–G	181–G	1·9	6·6	−·009	−·035	447·381	181–G
181–G	182–G	1·8	8·4	+·014	−·021	509·318	182–G
182–G	183–G	4·1	12·5	+·025	+·004	363·930	183–G
183–G	184–G	2·0	14·5	+·016	+·020	356·684	184–G
184–G	185–G	3·6	18·1	+·021	+·041	329·160	185–G
185–G	186–G	1·1	19·2	+·001	+·042	324·461	186–G
186–G	156*	1·6	20·8	−·001	+·041	288·337	156*

*See also elevation of this bench-mark on page 322.

RESULTS OF PRECISE LEVELLING.

STEELTON TO FRANZ, ONT.

Run by A. J. Rainboth.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 634	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	634					601·622	634
634	637	3·0	3·0	−·017	−·017	660·677	637
637	638	3·8	6·8	+·018	+·001	869·863	638
638	639	3·1	9·9	−·021	−·020	1024·359	639
639	640	3·1	13·0	+·016	−·004	1074·048	640
640	641	3·0	16·0	+·014	+·010	1100·973	641
641	642	3·3	19·3	+·015	+·025	1142·893	642
642	643	2·8	22·1	−·004	+·021	1091·677	643
643	644	3·0	25·1	+·012	+·033	1011·648	644
644	645	2·9	28·0	·000	+·033	845·407	645
645	646	2·5	30·5	−·006	+·027	776·692	646
646	647	2·5	33·0	+·003	+·030	904·036	647
647	648	3·4	36·4	+·008	+·038	995·795	648
648	649	2·3	38·7	−·002	+·036	1080·422	649
649	650	3·1	41·8	+·017	+·053	1103·066	650
650	651	3·5	45·3	+·008	+·061	1153·723	651
651	652	2·9	48·2	−·001	+·060	1207·961	652
652	653	3·1	51·3	+·007	+·067	1026·701	653
653	654	3·3	54·6	+·038	+·105	1106·150	654
654	655	2·8	57·4	+·017	+·122	1129·000	655
655	656	3·1	60·5	−·019	+·103	1284·159	656
656	657	2·9	63·4	+·037	+·140	1431·139	657
657	658	3·0	66·4	+·021	+·161	1369·153	658
658	659	3·1	69·5	+·024	+·185	1236·084	659
659	660	2·8	72·3	+·007	+·192	1426·144	660
660	661	2·9	75·2	+·013	+·205	1249·215	661
661	662	3·3	78·5	+·024	+·229	1070·833	662
662	663	1·5	80·0	−·009	+·220	1031·592	663
663	664	1·4	81·4	+·004	+·224	1146·968	664
664	665	3·0	84·4	+·015	+·239	1369·639	665
665	666	2·7	87·1	−·015	+·224	1344·305	666
666	667	4·6	91·7	+·027	+·251	1277·914	667
667	668	3·3	95·0	−·028	+·223	1514·793	668
668	669	3·0	98·0	−·021	+·202	1477·079	669
669	670	3·1	101·1	+·004	+·206	1457·502	670
670	671	2·9	104·0	+·001	+·207	1348·433	671
671	672	3·0	107·0	·000	+·207	1153·807	672
672	673	2·8	109·8	+·037	+·244	964·321	673
673	674	2·9	112·7	−·014	+·230	938·798	674
674	675	3·3	116·0	+·010	+·240	1025·757	675
675	676	3·0	119·0	+·019	+·259	1034·951	676

RESULTS OF PRECISE LEVELLING.

STEELTON TO FRANZ, ONT.—*Concluded.*

Run by A. J. Rainboth.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 634.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
676	677	1·9	120·9	+·007	+·266	1047·723	677
677	678	3·1	124·0	−·002	+·264	1058·819	678
678	679	3·8	127·8	−·031	+·233	1081·673	679
679	680	3·5	131·3	+·010	+·243	1110·034	680
680	681	2·7	134·0	+·004	+·247	1234·044	681
681	682	3·2	137·2	+·001	+·248	1236·272	682
682	683	3·0	140·2	−·022	+·226	1266·619	683
683	684	2·8	143·0	−·017	+·209	1181·477	684
684	685	2·9	145·9	−·003	+·206	1075·012	685
685	686	5·7	151·6	−·005	+·201	923·567	686
686	687	3·1	154·7	+·031	+·232	1031·080	687
687	688	3·3	158·0	+·033	+·265	1080·570	688
688	689	4·1	162·1	+·009	+·274	1080·833	689
689	690	2·6	164·7	+·003	+·277	1078·301	690
690	691	2·8	167·5	−·014	+·263	1191·273	691
691	692	3·2	170·7	−·027	+·236	1141·068	692
692	693	2·8	173·5	+·019	+·255	1070·233	693
693	694	4·0	177·5	+·013	+·268	1077·015	694
694	695	2·0	179·5	−·017	+·251	1122·188	695
695	696	3·1	182·6	−·012	+·239	961·024	696
696	697	4·6	187·2	+·028	+·267	944·688	697
697	698	3·0	190·2	−·007	+·260	626·615	698
690	699	3·1	167·8	−·021	+·256	1126·566	699
699	700	3·4	171·2	+·018	+·274	1162·643	700
700	701	2·7	173·9	+·021	+·295	1179·952	701
701	702	2·8	176·7	+·002	+·297	1216·295	702
702	703	3·2	179·9	+·024	+·321	1187·550	703
703	704	2·9	182·8	−·029	+·292	1118·551	704
704	705	3·0	185·8	+·022	+·314	1140·025	705
705	706	3·5	189·3	+·013	+·327	1198·549	706
706	707	2·6	191·9	+·014	+·341	1219·895	707
707	708	2·3	194·2	+·021	+·362	1219·304	708

Connections at Sault Ste. Marie, Mich., with bench-marks of United States Lake Survey:—

P.B.M.—A—On Weitzel lock, Elev. 605·122.
P.B.M.—B—On Poe lock, Elev. 587·678.
P.B.M.—"Meridian," Elev. 606·876.

For connection at Michipicoten with Hydrographic Survey bench-mark, see Introduction.

RESULTS OF PRECISE LEVELLING.

KIPP, ALTA., to GOLDEN, B.C.

Run by G. S. Raley and D. McMillan.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 81–D	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	81–D					3058·150	81–D
81–D	84–D	7·4	7·4	+·032	+·032	3102·276	84–D
84–D	85–D	4·1	11·5	+·016	+·048	3075·079	85–D
85–D	86–D	6·4	17·9	−·022	+·026	3091·696	86–D
86–D	87–D	6·3	24·2	−·005	+·021	3106·486	87–D
87–D	88–D	0·4	24·6	−·007	+·014	3112·798	88–D
87–D	89–D	5·4	29·6	+·022	+·043	3225·298	89–D
89–D	90–D	4·0	33·6	+·016	+·059	3290·749	90–D
90–D	91–D	1·3	34·9	+·002	+·061	3320·100	91–D
91–D	92–D	6·2	41·1	−·001	+·060	3450·363	92–D
92–D	93–D	5·9	47·0	+·013	+·073	3506·058	93–D
93–D	94–D	7·2	54·2	·000	+·073	3766·492	94–D
94–D	95–D	4·3	58·5	+·013	+·086	3732·968	95–D
95–D	96–D	0·4	58·9	−·007	+·079	3724·339	96–D
96–D	97–D	2·7	61·6	−·012	+·067	3838·602	97–D
97–D	98–D	2·6	64·2	+·005	+·072	3870·277	98–D
98–D	99–D	4·0	68·2	+·022	+·094	3821·005	99–D
99–D	100–D	6·1	74·3	+·030	+·124	3988·433	100–D
100–D	101–D	2·0	76·3	+·013	+·137	4059·478	101–D
101–D	102–D	3·1	79·4	+·004	+·141	4208·259	102–D
102–D	103–D	1·8	81·2	+·009	+·150	4224·045	103–D
103–D	104–D	2·2	83·4	+·024	+·174	4275·968	104–D
104–D	105–D	2·1	85·5	+·007	+·181	4311·156	105–D
105–D	106–D	1·8	87·3	−·016	+·165	4367·586	106–D
106–D	107–D	1·6	88·9	−·001	+·164	4440·254	107–D
107–D	108–D	2·7	91·6	+·020	+·184	4428·622	108–D
108–D	109–D	2·6	94·2	+·016	+·200	4457·336	109–D
109–D	110–D	2·0	96·2	−·012	+·188	4406·208	110–D
110–D	111–D	2·0	98·2	−·011	+·177	4308·578	111–D
111–D	112–D	2·8	101·0	−·001	+·176	4167·831	112–D
112–D	113–D	2·5	103·5	+·016	+·192	4036·765	113–D
113–D	114–D	3·4	106·9	+·006	+·198	3855·557	114–D
114–D	115–D	3·1	110·0	+·012	+·210	3720·381	115–D
115–D	116–D	5·7	115·7	−·025	+·185	3581·059	116–D
116–D	117–D	2·7	118·4	−·006	+·179	3509·572	117–D
117–D	118–D	2·0	120·4	+·006	+·185	3468·157	118–D
118–D	119–D	3·4	123·8	−·003	+·182	3408·799	119–D

RESULTS OF PRECISE LEVELLING.

KIPP, ALTA., TO GOLDEN, B.C.—*Continued.*

Run by G. S. Raley and D. McMillan.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 81–D	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
119–D	120–D	3·0	126·8	+·011	+·193	3341·058	120–D
120–D	121–D	3·3	130·1	−·003	+·190	3310·423	121–D
121–D	122–D	....	130·1	+·005	+·195	3304·053	122–D
121–D	123–D	1·1	131·2	−·023	+·167	3279·586	123–D
123–D	124–D	2·7	133·9	−·010	+·157	3209·702	124–D
124–D	125–D	3·8	137·7	+·013	+·170	3145·325	125–D
125–D	126–D	3·2	140·9	+·020	+·190	3106·222	126–D
126–D	127–D	5·9	146·8	+·011	+·201	3034·338	127–D
127–D	128–D	4·0	150·8	+·011	+·212	2961·349	128–D
128–D	129–D	2·5	153·3	+·032	+·244	2792·003	129–D
129–D	130–D	4·7	158·0	+·033	+·277	2855·681	130–D
130–D	131–D	2·8	160·8	+·018	+·295	2707·558	131–D
131–D	132–D	0·2	161·0	−·001	+·294	2705·436	132–D
132–D	133–D	4·4	165·4	+·025	+·319	2661·577	133–D
133–D	134–D	4·9	170·3	+·022	+·341	2523·666	134–D
134–D	135–D	4·3	174·6	+·017	+·358	2473·546	135–D
135–D	136–D	4·9	179·5	+·015	+·373	2463·583	136–D
136–D	137–D	7·3	186·8	+·024	+·397	2493·512	137–D
137–D	138–D	1·7	188·5	+·002	+·399	2523·630	138–D
138–D	139–D	2·5	191·0	+·016	+·415	2526·141	139–D
139–D	140–D	3·7	194·7	−·005	+·410	2529·938	140–D
140–D	141–D	6·6	201·3	+·005	+·415	2538·475	141–D
141–D	142–D	2·6	203·9	−·006	+·409	2537·633	142–D
142–D	143–D	5·0	208·9	+·019	+·428	2604·384	143–D
143–D	144–D	3·1	212·0	+·007	+·435	2617·416	144–D
144–D	145–D	3·4	215·4	+·005	+·440	2592·025	145–D
145–D	146–D	3·9	219·3	+·021	+·461	2600·105	146–D
146–D	147–D	5·9	225·2	+·007	+·468	2643·120	147–D
147–D	148–D	2·3	227·5	+·002	+·470	2665·501	148–D
148–D	149–D	3·2	230·7	−·009	+·461	2663·485	149–D
149–D	150–D	9·3	240·0	−·004	+·457	2668·285	150–D
150–D	151–D	1·0	241·0	−·010	+·447	2676·955	151–D
151–D	152–D	11·0	252·0	+·009	+·456	2644·197	152–D
152–D	153–D	5·7	257·7	+·051	+·507	2640·726	153–D
153–D	154–D	2·1	259·8	+·012	+·519	2629·188	154–D
154–D	155–D	4·3	264·1	−·010	+·509	2619·097	155–D
155–D	156–D	9·0	273·1	+·028	+·537	2613·083	156–D
156–D	157–D	7·6	280·7	+·049	+·586	2614·559	157–D
157–D	158–D	7·7	288·4	+·022	+·608	2607·519	158–D

RESULTS OF PRECISE LEVELLING.

KIPP, ALTA., TO GOLDEN, B.C.—*Concluded.*

Run by G. S. Raley and D. McMillan.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 81–D	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
158–D	159–D	2·7	291·1	+·001	+·609	2601·229	159–D
159–D	160–D	6·8	297·9	−·021	+·588	2598·619	160–D
160–D	161–D	7·7	305·6	−·013	+·575	2591·049	161–D
161–D	162–D	3·3	308·9	+·004	+·579	2590·390	162–D
162–D	163–D	0·3	309·2	−·006	+·573	2592·847	163–D
163–D	164–D	7·8	317·0	−·018	+·555	2597·521	164–D
164–D	165–D	8·8	325·8	+·009	+·564	2582·033	165–D
165–D	166–D	1·5	327·3	−·013	+·551	2579·101	166–D
166–D	273–C*	4·7	332·0	−·003	+·548	2591·580	273–C*

*See also elevation of this bench-mark on page 309.

RESULTS OF PRECISE LEVELLING.

BULL RIVER TO KOOTENAY LANDING, B.C.

Run by N. H. Smith.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 135–D	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	135–D					2473·546	135–D
135–D	167–D	1·9	1·9	+·020	+·020	2620·056	167–D
167–D	168–D	6·7	8·6	+·018	+·038	2723·528	168–D
168–D	169–D	2·8	11·4	+·008	+·046	2750·348	169–D
169–D	170–D	2·9	14·3	−·023	+·023	2888·570	170–D
170–D	171–D	2·9	17·2	+·002	+·025	2929·369	171–D
171–D	172–D	1·8	19·0	−·016	+·009	3003·235	172–D
172–D	173–D	0·2	19·2	−·001	+·008	3019·608	173–D
173–D	174–D	....	19·2	+·004	+·012	3013·399	174–D
173–D	175–D	2·4	21·6	−·021	−·013	3080·361	175–D
175–D	176–D	2·9	24·5	+·021	+·008	3256·448	176–D
176–D	177–D	4·2	28·7	−·008	·000	3192·616	177–D
177–D	178–D	1·6	30·3	+·006	+·006	3140·735	178–D
178–D	179–D	2·5	32·8	−·003	+·003	3052·584	179–D
179–D	180–D	3·5	36·3	+·014	+·017	3057·054	180–D
180–D	181–D	2·7	39·0	+·010	+·027	3051·615	181–D
181–D	182–D	2·9	41·9	+·003	+·030	3046·584	182–D
182–D	183–D	3·4	45·3	−·026	+·004	3006·049	183–D
183–D	184–D	3·4	48·7	+·017	+·021	2978·601	184–D
184–D	185–D	2·8	51·5	+·007	+·028	2969·604	185–D
185–D	186–D	5·5	57·0	+·033	+·061	2885·327	186–D
186–D	187–D	2·1	59·1	−·020	+·041	2831·406	187–D
187–D	188–D	4·0	63·1	·000	+·041	2844·076	188–D
188–D	189–D	2·9	66·0	−·005	+·036	2895·026	189–D
189–D	190–D	4·4	70·4	+·006	+·042	2650·748	190–D
190–D	191–D	2·2	72·6	+·016	+·058	2550·985	191–D
191–D	192–D	2·3	74·9	−·001	+·057	2440·468	192–D
192–D	193–D	3·1	78·0	−·009	+·048	2267·750	193–D
193–D	194–D	4·2	82·2	+·033	+·081	2087·332	194–D
194–D	195–D	4·5	86·7	+·023	+·104	1986·302	195–D
195–D	196–D	0·8	87·5	+·010	+·114	1944·967	196–D
196–D	197–D	4·7	92·2	−·034	+·080	1798·797	197–D
197–D	198–D	3·7	95·9	−·022	+·058	1793·914	198–D
196–D	199–D	1·0	88·5	−·016	+·098	1883·951	199–D
199–D	200–D	3·4	91·9	+·012	+·110	1853·324	200–D
200–D	201–D	3·4	95·3	+·029	+·139	1827·310	201–D
201–D	202–D	1·9	97·2	+·001	+·140	1816·340	202–D

RESULTS OF PRECISE LEVELLING.

BULL RIVER TO KOOTENAY LANDING, B.C.—*Concluded.*

Run by N. H. Smith.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 135–D	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
202–D	203–D	2·5	99·7	−·022	+·118	1786·853	203–D
203–D	204–D	0·9	100·6	+·005	+·123	1773·349	204–D
204–D	205–D	....	100·6	+·002	+·125	1774·669	205–D

Connection at Porthill with bench-mark of U.S. Coast and Geodetic Survey:—

B.M.—V-10, iron pipe 4 ft. west of international boundary monument No. 207, Elev. 1794·336.

RESULTS OF PRECISE LEVELLING.

FIELD TO REVELSTOKE, B.C

Run by G. S. Raley and D. McMillan.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 51–D	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	260–C	....	137·2	....	+·097	4074·638	260–C
260–C	261–C	3·8	141·0	+·023	+·120	3923·040	261–C
261–C	262–C	2·4	143·4	+·017	+·137	3785·203	262–C
262–C	263–C	3·0	146·4	−·010	+·127	3700·990	263–C
263–C	264–C	2·6	149·0	+·014	+·141	3696·099	264–C
264–C	265–C	4·8	153·8	+·010	+·151	3649·049	265–C
265–C	266–C	3·0	156·8	−·008	+·143	3484·402	266–C
266–C	267–C	2·1	158·9	−·010	+·133	3308·334	267–C
267–C	268–C	2·8	161·7	+·007	+·140	3224·611	268–C
268–C	269–C	1·2	162·9	·000	+·140	3153·075	269–C
269–C	270–C	1·6	164·5	−·008	+·132	3041·706	270–C
270–C	271–C	3·8	168·3	+·005	+·137	2752·568	271–C
271–C	272–C	2·1	170·4	−·005	+·132	2643·855	272–C
272–C	273–C*	1·7	172·1	−·010	+·122	2591·465	273–C*
273–C*	274–C	2·0	174·1	+·008	+·130	2566·916	274–C
274–C	275–C	2·0	176·1	+·004	+·134	2557·387	275–C
275–C	276–C	3·0	179·1	+·011	+·145	2554·282	276–C
276–C	277–C	3·0	182·1	+·022	+·167	2575·942	277–C
277–C	278–C	3·2	185·3	+·040	+·207	2557·044	278–C
278–C	279–C	3·0	188·3	+·023	+·230	2571·953	279–C
279–C	280–C	1·4	189·7	−·001	+·229	2555·582	280–C
280–C	281–C	1·7	191·4	−·003	+·226	2591·855	281–C
281–C	282–C	3·4	194·8	·000	+·226	2502·041	282–C
282–C	283–C	1·5	196·3	−·007	+·219	2455·669	283–C
283–C	284–C	3·8	200·1	·000	+·219	2432·623	284–C
284–C	285–C	3·1	203·2	+·015	+·234	2552·448	285–C
285–C	286–C	2·0	205·2	−·006	+·228	2607·820	286–C
286–C	287–C	3·8	209·0	+·015	+·243	3009·581	287–C
287–C	288–C	2·0	211·0	−·009	+·234	3230·756	288–C
288–C	289–C	2·2	213·2	−·006	+·228	3486·262	289–C
289–C	290–C	3·6	216·8	−·002	+·226	3896·121	290–C
290–C	291–C	3·3	220·1	−·021	+·205	4225·922	291–C
291–C	292–C	2·0	222·1	+·014	+·219	4350·362	292–C
292–C	293–C	1·0	223·1	−·007	+·212	4222·220	293–C
293–C	294–C	1·0	224·1	+·014	+·226	4096·983	294–C
294–C	295–C	2·8	226·9	+·001	+·227	3795·070	295–C
295–C	296–C	1·9	228·8	+·002	+·229	3583·514	296–C
296–C	297–C	2·9	231·7	+·018	+·247	3400·350	297–C
297–C	298–C	2·9	234·6	+·004	+·251	3104·002	298–C
298–C	299–C	1·9	236·5	−·002	+·249	2982·068	299–C

*See also elevation of this bench-mark on page 306.

RESULTS OF PRECISE LEVELLING.

FIELD TO REVELSTOKE, B.C.—*Concluded.*

Run by G. S. Raley and D. McMillan.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 51–D	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
299–C	300–C	2·7	239·2	+·008	+·257	2759·404	300–C
300–C	301–C	1·8	241·0	+·008	+·265	2644·203	301–C
301–C	302–C	3·5	244·5	+·016	+·281	2415·733	302–C
302–C	303–C	1·9	246·4	−·003	+·278	2224·159	303–C
303–C	304–C	1·4	247·8	−·004	+·274	2120·964	304–C
304–C	305–C	3·6	251·4	+·008	+·282	1959·266	305–C
305–C	306–C	3·7	255·1	+·015	+·297	1944·805	306–C
306–C	307–C	1·9	257·0	+·002	+·299	1853·800	307–C
307–C	308–C	3·4	260·4	+·003	+·302	1693·148	308–C
308–C	309–C	2·4	262·8	·000	+·302	1646·930	309–C
309–C	310–C	1·8	264·6	+·002	+·304	1610·926	310–C
310–C	311–C	2·7	267·3	−·027	+·277	1498·698	311–C
311–C	312–C	0·3	267·6	+·001	+·278	1500·262	312–C
312–C	313–C	0·3	267·9	−·005	+·273	1500·294	313–C
312–C	314–C	0·6	268·2	−·012	+·266	1512·387	314–C

RESULTS OF PRECISE LEVELLING.

EDMONTON TO JASPER, ALTA.

Run by N. H. Smith.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 28–D.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	60–H		331·3		+·141	2168·315	60–H
60–H	62–H	6·5	337·8	−·026	+·115	2227·347	62–H
62–H	63–H	6·2	344·0	−·030	+·085	2316·466	63–H
63–H	64–H	7·3	351·3	+·038	+·123	2324·926	64–H
64–H	65–H	4·2	355·5	−·016	+·107	2327·306	65–H
65–H	66–H	4·5	360·0	·000	+·107	2405·293	66–H
66–H	67–H	4·7	364·7	+·013	+·120	2454·116	67–H
67–H	68–H	6·2	370·9	−·020	+·100	2375·798	68–H
68–H	69–H	4·9	375·8	+·032	+·132	2398·127	69–H
69–H	70–H	9·3	385·1	−·012	+·120	2433·818	70–H
70–H	71–H	4·3	389·4	+·013	+·133	2443·358	71–H
71–H	72–H	9·5	398·9	−·005	+·128	2556·447	72–H
72–H	73–H	7·1	406·0	+·009	+·137	2586·859	73–H
73–H	74–H	5·0	411·0	+·017	+·154	2606·514	74–H
74–H	75–H	7·1	418·1	−·047	+·107	2597·338	75–H
75–H	76–H	2·4	420·5	+·005	+·112	2609·379	76–H
76–H	77–H	8·4	428·9	−·002	+·110	2701·454	77–H
77–H	78–H	7·9	436·8	−·013	+·097	2746·646	78–H
78–H	79–H	8·2	445·0	+·030	+·127	2841·548	79–H
79–H	80–H	9·0	454·0	+·048	+·175	2874·836	80–H
80–H	81–H	6·8	460·8	+·038	+·213	3043·192	81–H
81–H	82–H	0·4	461·2	+·008	+·221	2984·703	82–H
82–H	83–H	6·0	467·2	+·022	+·243	3062·350	83–H
83–H	84–H	5·7	472·9	+·042	+·285	3164·177	84–H
84–H	85–H	6·0	478·9	+·019	+·304	3243·383	85–H
85–H	86–H	7·8	486·7	+·008	+·312	3390·290	86–H
86–H	87–H	8·0	494·7	+·005	+·317	3558·488	87–H
87–H	88–H	5·4	500·1	+·018	+·335	3490·786	88–H
88–H	89–H	2·8	502·9	+·006	+·341	3477·472	89–H
89–H	90–H	5·9	508·8	−·012	+·329	3467·128	90–H
90–H	91–H	7·4	516·2	+·001	+·330	3320·343	91–H
91–H	92–H	2·7	518·9	+·003	+·333	3265·260	92–H
92–H	93–H	3·0	521·9	−·001	+·332	3292·605	93–H
93–H	94–H	2·9	524·8	+·022	+·354	3305·813	94–H
94–H	95–H	4·1	528·9	−·005	+·349	3305·551	95–H
95–H	96–H	6·4	535·3	+·025	+·374	3252·325	96–H
96–H	97–H	6·2	541·5	+·029	+·403	3267·050	97–H
97–H	98–H	2·6	544·1	+·017	+·420	3293·750	98–H
98–H	99–H	4·6	548·7	−·017	+·403	3295·985	99–H
99–H	100–H	4·3	553·0	−·020	+·383	3302·979	100–H
100–H	101–H	2·3	555·3	−·014	+·369	3316·640	101–H

RESULTS OF PRECISE LEVELLING.

EDMONTON TO JASPER, ALTA.—*Concluded.*

Run by N. H. Smith.

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 28–D.	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
101–H	102–H	3·0	558·3	+·005	+·374	3345·163	102–H
102–H	103–H	3·6	561·9	−·016	+·358	3420·654	103–H
103–H	104–H	3·4	565·3	+·003	+·361	3483·531	104–H

Connection at Jasper with bench-mark of Irrigation Branch, Dept. of the Interior:—
On N.W. ¼ sec. 15, tp. 45, rge. 1, W. 6th mer. (iron post), Elev. 3382·654.

TABLE II–A.

RESULTS OF PRECISE LEVELLING.

ST. STEPHEN, N.B., TO RIVIERE–DU–LOUP, QUE.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 1–B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	1–B					53·578	1–B
1–B	2–B	1·0	1·0	+·005	+·005	26·064	2–B
2–B	3–B	....	1·0	+·001	+·006	23·239	*3–B
3–B	4–B	5·3	6·3	+·011	+·017	82·584	4–B
4–B	5–B	4·7	11·0	+·013	+·030	135·118	5–B
5–B	6–B	4·7	15·7	+·008	+·038	275·905	6–B
6–B	7–B	5·8	21·5	−·025	+·013	216·340	7–B
7–B	8–B	4·7	26·2	−·028	−·015	313·253	8–B
8–B	9–B	5·0	31·2	−·028	−·043	412·622	9–B
9–B	10–B	5·0	36·2	−·023	−·066	421·679	10–B
10–B	11–B	5·0	41·2	+·017	−·049	461·832	11–B
11–B	12–B	5·5	46·7	+·010	−·039	382·637	12–B
12–B	13–B	......	46·7	·000	−·039	388·423	13–B
11–B	14–B	10·2	51·4	+·018	−·031	484·243	14–B
14–B	15–B	6·0	57·4	+·018	−·013	541·108	15–B
15–B	16–B	6·3	63·7	−·018	−·031	563·625	16–B
16–B	17–B	4·2	67·9	+·025	−·006	464·068	17–B
17–B	18–B	6·2	74·1	−·008	−·014	412·210	18–B
18–B	19–B	4·0	78·1	−·026	−·040	549·955	19–B
19–B	20–B	3·5	81·6	−·017	−·057	548·292	20–B
20–B	21–B	4·6	86·2	+·013	−·044	544·508	21–B
21–B	22–B	0·4	86·6	−·002	−·046	530·198	22–B
20–B	23–B	4·5	86·1	−·017	−·074	394·075	23–B
23–B	24–B	4·5	90·6	+·022	−·052	189·781	24–B
24–B	25–B	2·0	92·6	+·003	−·049	142·014	25–B
25–B	26–B	0·5	93·1	+·004	−·045	197·885	26–B
26–B	27–B	....	93·1	+·003	−·042	186·200	27–B
26–B	28–B	2·3	95·4	−·010	−·055	149·367	28–B
28–B	29–B	4·0	99·4	+·016	−·039	132·082	29–B
29–B	30–B	4·0	103·4	−·020	−·059	143·431	30–B
30–B	31–B	2·8	106·2	+·018	−·041	158·366	31–B
31–B	32–B	6·0	112·2	+·015	−·026	172·021	32–B
32–B	33–B	3·0	115·2	−·015	−·041	181·791	33–B

RESULTS OF PRECISE LEVELLING.

ST. STEPHEN, N.B., TO RIVIERE-DU-LOUP, QUE.—*Continued.*

Bench-Mark. From	Bench-Mark. To	Distance between successive bench-marks.	Distance from bench-mark 1-B	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.	Bench-Mark.
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
33–B	34–B	4·5	119·7	+·013	−·028	200·344	34–B
34–B	35–B	3·5	123·2	−·018	−·046	202·812	35–B
35–B	36–B	4·5	127·7	−·019	−·065	213·799	36–B
36–B	37–B	5·8	133·5	−·004	−·069	237·576	37–B
37–B	38–B	6·9	140·4	−·031	−·100	285·937	38–B
38–B	39–B	1·5	141·9	−·001	−·101	257·296	39–B
39–B	40–B	0·3	142·2	−·002	−·103	261·503	40–B
40–B	41–B	5·5	147·7	+·002	−·101	279·292	41–B
41–B	42–B	4·7	152·4	−·002	−·103	373·065	42–B
41–B	43–B	4·5	152·2	+·020	−·081	407·970	43–B
43–B	44–B	3·7	155·9	−·010	−·091	334·720	44–B
44–B	45–B	5·0	160·9	+·002	−·089	287·758	45–B
45–B	46–B	5·5	166·4	−·017	−·106	513·117	46–B
46–B	47–B	1·5	167·9	+·002	−·104	467·698	47–B
47–B	48–B	4·2	172·1	+·001	−·103	497·302	48–B
48–B	49–B	4·5	176·6	+·031	−·072	442·633	49–B
49–B	50–B	5·0	181·6	−·014	−·086	449·126	50–B
50–B	51–B	2·5	184·1	+·015	−·071	451·834	51–B
51–B	52–B	3·0	187·1	+·019	−·052	439·205	52–B
52–B	53–B	4·0	191·1	+·002	−·050	459·917	53–B
53–B	54–B	3·5	194·6	+·021	−·029	457·010	54–B
54–B	55–B	3·8	198·4	+·015	−·014	478·167	55–B
55–B	56–B	1·8	200·2	−·013	−·027	475·713	56–B
56–B	57–B	3·0	203·2	+·006	−·021	511·944	57–B
57–B	60–B	2·0	205·2	−·014	−·035	482·942	60–B
60–B	58–B*	0·5	205·7	+·003	−·032	473·642	58–B*
58–B*	59–B	....	205·7	+·004	−·028	461·816	59–B
60–B	61–B	2·5	207·7	+·009	−·026	485·214	61–B
61–B	62–B	18·7	226·4	−·019	−·045	531·111	62–B
62–B	63–B	3·3	229·7	+·021	−·024	513·118	63–B
63–B	64–B	4·2	233·9	−·024	−·048	521·975	64–B
64–B	65–B	3·0	236·9	+·002	−·046	512·770	65–B
65–B	66–B	4·3	241·2	+·013	−·033	514·376	66–B
66–B	67–B	6·2	247·4	−·027	−·060	709·814	67–B
67–B	68–B	4·5	251·9	+·014	−·046	987·119	68–B
68–B	69–B	4·0	255·9	−·006	−·052	1118·094	69–B
69–B	70–B	4·5	260·4	+·009	−·043	1295·992	70–B

*See also elevation of this bench-mark on page 290.

RESULTS OF PRECISE LEVELLING.

ST. STEPHEN, N.B., TO RIVIERE-DU-LOUP, QUE.—*Concluded.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 1–B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
70–B	71–B	4·5	264·9	−·007	−·050	1165·164	71–B
71–B	72–B	2·5	267·4	−·022	−·072	1081·000	72–B
72–B	73–B	5·5	272·9	+·021	−·051	846·736	73–B
73–B	74–B	5·5	278·4	−·024	−·075	653·057	74–B
74–B	75–B	5·5	283·9	+·032	−·043	338·673	75–B
75–B	76–B	2·5	286·4	+·023	−·020	307·535	76–B
76–B	77–B†	1·0	287·4	−·013	−·033	313·608	77–B†
77–B†	78–B	0·2	287·6	−·001	−·034	412·589	78–B

†See also elevation of this bench-mark on page 292.

RESULTS OF PRECISE LEVELLING.

BRUNSWICK TO ST. JOHN, N.B.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 6–B.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	6–B					275·905	6–B
6–B	79–B	4·7	4·7	+·028	+·028	127·400	79–B
79–B	80–B	3·0	7·7	+·018	+·046	159·387	80–B
80–B	81–B	5·5	13·2	−·024	+·022	98·941	81–B
81–B	82–B	3·0	16·2	−·019	+·003	68·744	82–B
82–B	83–B	4·5	20·7	+·021	+·024	88·274	83–B
83–B	84–B	3·0	23·7	−·021	+·003	128·680	84–B
84–B	85–B	4·8	28·5	+·028	+·031	262·279	85–B
85–B	86–B	4·5	33·0	+·013	+·044	236·010	86–B
86–B	87–B	4·5	37·5	−·004	+·040	168·028	87–B
87–B	88–B	3·3	40·8	−·006	+·034	179·420	88–B
88–B	89–B	3·5	44·3	−·005	+·029	60·782	89–B
89–B	90–B	3·0	47·3	+·021	+·050	86·890	90–B
90–B	91–B	3·3	50·6	−·020	+·030	33·126	91–B
91–B	92–B	2·3	52·9	−·020	+·010	15·928	92–B
92–B	93–B	4·7	57·6	−·004	+·006	204·967	93–B
93–B	94–B	3·0	60·6	−·026	−·020	204·662	94–B
94–B	95–B	5·0	65·6	+·002	−·018	68·498	95–B
95–B	96–B	2·5	68·1	−·026	−·044	86·440	96–B
96–B	97–B	1·7	69·8	+·008	−·036	21·776	97–B
97–B	98–B	0·5	70·3	−·008	−·044	20·770	98–B
98–B	99–B	0·3	70·6	−·007	−·051	42·722	99–B
96–B	100–B	1·8	69·9	−·008	−·052	20·352	100–B

RESULTS OF PRECISE LEVELLING.

ROUSE POINT, N.Y., TO SHERBROOKE, QUE.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark ⊕	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	⊕					107·950	⊕
⊕	81	3·3	3·3	−·022	−·022	111·595	81
81	79	7·2	10·5	+·016	−·006	156·371	79
79	78	6·0	16·5	−·059	−·065	140·678	78
78	77	5·0	21·5	+·023	−·042	121·014	77
77	76	1·5	23·0	+·015	−·027	122·124	76
76	75	0·3	23·3	−·005	−·032	123·885	75
76	74	0·5	23·5	−·008	−·035	103·856	74
74	72	6·3	29·8	+·013	−·022	182·229	72
72	71	2·3	32·1	−·008	−·030	159·204	71
71	62	4·4	36·5	−·008	−·038	195·121	62
62	61	3·0	39·5	+·012	−·026	225·117	61
61	60	2·3	41·8	+·016	−·010	264·818	60
60	59	4·8	46·6	−·034	−·044	377·565	59
59	58	3·9	50·5	+·005	−·039	357·644	58
58	57	4·8	55·3	·000	−·039	432·236	57
57	56	4·2	59·5	−·042	−·081	589·078	56
56	47	3·5	63·0	+·051	−·030	703·135	47
47	46	1·9	64·9	+·011	−·019	731·218	46
46	45	3·5	68·4	+·007	−·012	859·930	45
45	44	2·7	71·1	+·012	·000	914·749	44
44	43	4·4	75·5	−·005	−·005	934·811	43
43	42	3·3	78·8	+·015	+·010	814·758	42
42	41	3·0	81·8	−·037	−·027	689·780	41
41	41–A	0·5	82·3	−·002	−·029	707·298	41–A
41	40	0·1	81·9	−·001	−·028	689·123	40
40	39	1·4	83·3	+·002	−·026	676·635	39
39	38	6·2	89·5	−·030	−·056	651·376	38
38	37	4·7	94·2	−·055	−·111	660·471	37
37	36	5·0	99·2	−·051	−·162	595·667	36
36	35	1·2	100·4	−·011	−·173	611·198	35
35	1	0·5	100·9	−·004	−·177	541·862	1

⊕ United States bench-mark on Chapman Block, Rouse Point, N.Y.

Connections with Public Works Dept's bench-marks:—
B.M.—DCI—D. & H. station, Rouse Point, Elev. 123·761.
B.M.—DCII—G.T.R. bridge, Elev. 109·310.
B.M.—DCIII—G.T.R. bridge, Elev. 129·930.
B.M.—DCIV—G.T.R. culvert, Elev. 137·118.
B.M.—MCCCXXV—St. Johns post-office, Elev. 125·776.

RESULTS OF PRECISE LEVELLING.

FARNHAM TO ST. ARMAND, QUE.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 62.	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	62					195·121	62
62	63	0·2	0·2	−·002	−·002	193·031	63
63	64	0·1	0·3	−·003	−·005	192·787	64
62	65	9·3	9·3	+·001	+·001	186·334	65
65	66	2·4	11·7	+·020	+·021	178·185	66
66	67	2·6	14·3	−·006	+·015	167·611	67
67	68	6·4	20·7	+·010	+·025	123·626	68
68	69	0·6	21·3	+·003	+·028	107·323	69
69	70	0·7	22·0	+·003	+·031	108·161	70

RESULTS OF PRECISE LEVELLING.

FOSTER TO ABERCORN, QUE.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 47	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	47					703·135	47
47	48	4·2	4·2	−·033	−·033	666·742	48
48	49	1·2	5·4	−·038	−·071	690·592	49
49	50	3·4	8·8	−·025	−·096	679·176	50
50	51	3·7	12·5	+·015	−·081	554·849	51
51	52	3·1	15·6	+·010	−·071	591·272	52
52	53	4·0	19·6	+·002	−·069	492·870	53
53	54	1·2	20·8	+·014	−·055	485·656	54
54	55	1·1	21·9	+·013	−·042	492·526	55

RESULTS OF PRECISE LEVELLING.

SHERBROOKE, QUE., TO NORTON MILLS, VERMONT.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark 1	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	1					541·862	1
1	2	....	....	−·001	−·001	533·543	2
2	3	0·2	0·2	−·007	−·008	484·318	3
3	4	1·9	2·1	+·008	·000	498·756	4
4	5	0·7	2·8	−·003	−·003	488·547	5
5	6	1·4	4·2	+·003	·000	495·522	6
6	7	1·2	5·4	+·010	+·010	495·050	7
7	8	3·5	8·9	−·056	−·046	597·624	8
8	9	1·5	10·4	+·008	−·038	643·148	9
9	10	2·7	13·1	+·018	−·020	707·196	10
10	11	2·0	15·1	+·015	−·005	747·534	11
11	13	2·1	17·2	+·029	+·024	829·940	13
13	14	4·8	22·0	+·036	+·060	1005·416	14
14	15	0·4	22·4	+·017	+·077	963·679	15
15	16	....	22·4	·000	+·077	963·015	16
14	17	1·1	23·1	+·018	+·078	1040·109	17
17	18	1·4	24·5	+·022	+·100	1069·878	18
18	19	1·2	25·7	+·007	+·107	1101·157	19
19	21	2·8	28·5	+·025	+·132	1166·804	21
21	22	0·5	29·0	−·009	+·123	1187·171	22
22	23	2·6	31·6	+·008	+·131	1247·750	23
23	24	....	31·6	·000	+·131	1213·468	24
24	25	....	31·6	·000	+·131	1212·040	25

RESULTS OF PRECISE LEVELLING.

ROUSE POINT, N.Y., TO COLBORNE, ONT.

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark ⊕	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
	⊕					107·950	⊕
⊕	81	3·3	3·3	−·022	−·022	111·595	81
81	83	8·9	12·2	−·024	−·046	192·365	83
83	85	9·2	21·4	+·062	+·016	200·904	85
85	86	7·2	28·6	−·010	+·006	132·917	86
86	87	3·6	32·2	−·006	·000	125·239	87
87	88	6·1	38·3	+·007	+·007	130·729	88
88	89	8·9	47·2	−·004	+·003	162·081	89
89	90	5·5	52·7	−·011	−·008	157·040	90
90	91	1·9	54·6	−·013	−·021	162·816	91
91	92	3·8	58·4	−·008	−·029	186·360	92
92	93	1·4	59·8	−·017	−·046	193·504	93
93	94	3·0	62·8	+·021	−·025	213·997	94
94	95	2·1	64·9	−·006	−·031	226·446	95
95	96	2·8	67·7	+·005	−·026	263·469	96
96	97	3·9	71·6	+·001	−·025	268·499	97
97	98	3·3	74·9	−·023	−·048	277·283	98
98	99	3·5	78·4	+·013	−·035	271·914	99
99	100	2·3	80·7	−·020	−·055	286·115	100
100	101	2·8	83·5	+·009	−·046	317·830	101
101	102	3·2	86·7	−·012	−·058	335·602	102
102	103	5·0	91·7	·000	−·058	327·566	103
103	104	1·7	93·4	−·001	−·059	297·254	104
104	105	4·3	97·7	−·032	−·091	275·786	105
105	106	3·4	101·1	+·007	−·084	247·071	106
106	107	4·5	105·6	−·025	−·109	242·401	107
107	108	3·3	108·9	−·005	−·114	268·870	108
108	109	2·6	111·5	−·018	−·132	250·268	109
109	110	3·7	115·2	−·026	−·158	258·740	110
110	111	4·3	119·5	+·010	−·148	270·325	111
111	112	5·2	124·7	+·011	−·137	329·122	112
112	113	1·9	126·6	−·002	−·139	337·269	113
113	114	3·4	130·0	+·001	−·138	335·400	114
114	115	4·1	134·1	−·009	−·147	338·808	115
115	116	2·7	136·8	+·034	−·113	335·573	116
116	117	4·5	141·3	−·022	−·135	300·295	117
117	118	5·3	146·6	−·029	−·164	288·676	118
118	119	1·5	148·1	−·022	−·186	313·837	119
119	120	3·3	151·4	−·008	−·194	284·563	120
120	121	2·4	153·8	−·002	−·196	302·944	121
121	122	2·9	156·7	−·009	−·205	323·077	122

⊕ United States bench-mark on Chapman Block, Rouse Point, N.Y.

RESULTS OF PRECISE LEVELLING.

ROUSE POINT, N.Y., TO COLBORNE, ONT.—*Continued.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark ⊕	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
122	123*	2·6	159·3	+·013	−·192	295·634	123*
123*	124	2·0	161·3	+·011	−·181	283·149	124
124	125	2·9	164·2	+·009	−·172	285·823	125
125	126	2·7	166·9	−·021	−·193	320·389	126
126	127	3·4	170·3	−·017	−·210	289·107	127
127	128	3·1	173·4	+·018	−·192	319·552	128
128	129	2·7	176·1	−·024	−·216	315·413	129
129	130	4·2	180·3	−·017	−·233	324·846	130
130	131	0·7	181·0	+·001	−·232	375·174	131
131	132	3·5	184·5	−·032	−·264	313·225	132
132	133	2·2	186·7	−·016	−·280	324·320	133
133	134	3·8	190·5	+·009	−·271	292·687	134
134	135	3·0	193·5	−·022	−·293	342·482	135
135	136	3·3	196·8	+·024	−·269	350·746	136
136	137	2·9	199·7	+·013	−·256	314·551	137
137	138	4·2	203·9	−·038	−·294	309·785	138
138	139†	3·7	207·6	−·003	−·297	276·940	139†
139†	141	2·3	209·9	−·036	−·333	263·699	141
141	141–A	....	209·9	+·003	−·330	275·986	141–A
141	142	....	209·9	·000	−·333	258·688	142
139†	140	2·8	210·4	−·018	−·315	254·646	140
140	143	2·9	213·3	+·003	−·312	264·945	143
143	144	2·1	215·4	+·002	−·310	271·991	144
144	145	3·0	218·4	−·001	−·311	314·191	145
145	146	4·3	222·7	−·030	−·341	327·440	146
146	147	4·0	226·7	−·023	−·364	340·144	147
147	148	3·9	230·6	+·016	−·348	296·034	148
148	149	2·8	233·4	+·016	−·332	314·333	149
149	150	0·4	233·8	−·006	−·338	316·141	150
150	150–A	0·4	234·2	+·005	−·333	304·699	150–A
150–A	150–A–2	0·1	234·3	−·006	−·339	294·646	150–A–2
150	151	3·4	237·2	−·008	−·346	290·623	151
151	152	4·4	241·6	+·024	−·322	338·579	152
152	153	5·3	246·9	−·008	−·330	284·481	153
153	154	1·5	248·4	+·007	−·323	337·466	154
154	155	2·9	251·3	−·024	−·347	317·206	155

*See also elevation of this bench-mark on page 298.
†See also elevation of this bench-mark on page 300.

RESULTS OF PRECISE LEVELLING.

ROUSE POINT, N.Y., TO COLBORNE, ONT.—*Concluded.*

Bench-Mark.		Distance between successive bench-marks.	Distance from bench-mark ⊕	Discrepancy.		Elevation above mean sea level.	Bench-Mark.
From	To			Partial.	Total.		
No.	No.	Miles.	Miles.	Feet.	Feet.	Feet.	No.
155	156*	4·2	255·5	+·009	−·338	288·567	156*
156*	157	1·5	257·0	−·001	−·339	257·005	157
157	157–A	0·1	257·1	+·013	−·326	261·329	157–A
157–A	157–A–2	0·3	257·4	+·008	−·318	250·813	157–A–2
156*	158	2·9	258·4	+·012	−·326	307·205	158
158	159	2·6	261·0	+·023	−·303	306·755	159
159	160	2·8	263·8	+·001	−·302	306·251	160
160	161	3·8	267·6	−·035	−·337	283·887	161
161	162	4·5	272·1	−·023	−·360	314·101	162
162	163	3·8	275·9	+·003	−·357	306·996	163
163	164	2·1	278·0	+·003	−·354	310·872	164
164	165	3·1	281·1	+·003	−·351	283·401	165
165	166	2·7	283·8	+·007	−·344	298·946	166

*See also elevation of this bench-mark on page 301.

Connections with Public Works Dept's bench-marks—

Between Rouse Point and Coteau Jct.:—

DCI	Elev.	123·761	DCCCXV	Elev.	129·406
DCII	"	109·310	DCCCXIV	"	129·363
DCCCXIX	"	156·782	DCCCXIII	"	135·688
DCCCXX	"	161·906	DCCCXII	"	130·097
DCCCXXIV	"	182·666	DCCCX	"	153·200
DCCCXXV	"	187·814	DCCCVII	"	142·900
DCCCXXVI	"	192·284	DCCCV	"	157·285
DCCCXXXV	"	204·208	DCCXCVII	"	174·176
DCCCXVIII	"	137·755	CCCCXXVIII	"	160·901

East and west of Coteau Jct. on G.T.R. main line:—
DCCCLXIV—Bridge over Delisle river, Elev. 158·849
DLXXVIII—Bridge at St. Zotique, Elev. 154·703
DLXXVII—Bridge at River Beaudette, Elev. 169·517

Between Trenton and Brighton:—
MCXCIX = G.S.C. bench-mark 161.
MCXCVII = G.S.C. bench-mark 163.

For connection at Kingston with Hydrographic Survey levels, see Introduction.

TABLE III.

RAIL ELEVATIONS, ST. ANSELME, QUE., TO EDMUNDSTON, N.B.

(Elevations taken in 1915 and 1916).

		FEET
National Transcontinental Ry.—	St. Anselme	566·7
"	Ste. Claire	682·9
"	Frampton	746·0
"	Etchemin river; water, July 17, 1915, 710·0; rail	767·5
"	Ste. Malachie	769·8
"	Abenakis	837·3
"	Abenakis river; water, July 21, 1915, 822·0; rail	871·3
"	St. Damien	935·7
"	St. Lazare	959·9
"	Armagh	998·1
"	Rivière-du-Pin; water, July 24, 1915, 984; rail	1046·6
"	St. Euphemie	1115·9
"	Rosarie	1215·4
"	Langelier (water-tank)	1315·2
"	Méchant-pouce river; water, July 28, 1915, 1185·1; rail	1227·3
"	Ste. Appoline	1233·0
"	Bras d'Apic	1215·8
"	Bras d'Apic river (east); water, July 28, 1915, 1177·4; rail	1208·9
"	Therien	1266·2
"	Monk	1162·1
"	Lafontaine	1092·2
"	Lefebvre	1202·7
"	Holliday	1110·4
"	Bretagne	1093·6
"	Rivière-du-Loup; water, Aug. 7, 1916, 966·2; rail	1010·9
"	River Manie (station)	1090·5
"	River Manie; water, Aug. 8, 1916, 1066·6; rail	1087·1
"	Lapointe	1139·6
"	Picard	1207·1
"	Pelletier	1260·3
"	St. Eleuthère	946·7
"	St. Francis river; water, Aug. 21, 1916, 678; rail	715·0
"	Estcourt	710·5
"	Blue river; water, Aug. 24, 1916, 591; rail	650·5
"	Blue River (station)	670·0
"	Long Lake	695·1
"	Glendyne	675·2
"	Long lake narrows; water, Sept. 1, 1916, 648·4; rail	671·4
"	Courchesne	728·3
"	Lac Baker	682·3
"	Caron Brook	608·6
"	Baker brook; water, Sept. 6, 1916, 493·4; rail	516·1
"	Baker Brook (station)	517·4
"	Temiscouata railway (diamond crossing)	521·6
"	St. Hilaire	493·1

RAIL ELEVATIONS, HARLAKA JUNCTION TO RIVIERE-DU-LOUP, QUE.

(Elevations taken in 1915).

		FEET
Intercolonial Railway	Harlaka Junction	241·2
"	Ville Marie	324·4
"	Lake Beaumont; water, Aug. 8, 1915	320·2
"	St. Charles Junction	297·1
"	Boyer river; water, Aug. 12, 1915, 121·4; rail	171·4
"	La Durantaye	172·0
"	St. Vallier	156·7
"	St. Francois	134·8
"	St. Pierre	132·1
"	Montmagny	55·0
"	Rivière-du-Sud; water, Aug. 19, 1915, 44·4; rail	56·8
"	Bras St. Nicholas, rivière-du-Sud; water, Aug. 19, 1915, 43·1; rail	57·1
"	Cap St. Ignace	130·1
"	L'Anse-à-Giles	118·3
"	L'Islet	104·0
"	Trois Saumons	99·9
"	St. Jean Port Joli	176·7
"	Elgin Road	163·5
"	Ste. Louise	120·4
"	Pointe Rouge	97·6
"	Ste. Anne	101·4
"	St. Pacôme	54·3
"	Rivière Ouelle; water, Sept. 8, 1915, 18·6; rail	42·8
"	Rivière Ouelle Junction	46·9
"	St. Philippe-de-Neri	143·9
"	St. Paschal	192·4
"	Dessaint	301·5
"	Ste. Hélène	319·1
"	St. André	345·9
"	St. Alexandre	369·7
"	Old Lake Road	349·9
"	Rivière-du-Loup	315·1

RAIL ELEVATIONS, OTTAWA TO RENFREW, ONT.

(Elevations taken in 1915).

		FEET.
Canadian Pacific Railway	Ottawa (Broad street station)	181·0
"	Ottawa river, below Deschênes rapids; water, May 29, 1915	182·4
"	Britannia	202·4
"	Lake Deschênes; water, May 29, 1915	192·5
"	Grand Trunk railway, Ottawa division (overhead crossing) rail 241·5; C.P.R. rail	217·1
"	Canadian Northern railway, main line (overhead crossing) rail 299·9; C.P.R. rail	272·7
"	Stittville	398·6
"	Ashton	448·6
"	Carleton Place	450·2
"	Mississippi river; water, May 19, 1915, 428·6; rail	445·9
"	Almonte	397·4
"	Mississippi river; water, May 20, 1915, 385·1; rail	401·7
"	Snedden	378·8
"	Mississippi river; water, May 28, 1915, 289·1; rail	322·5
"	Pakenham	321·4
"	Madawaska river; water, June 5, 1915, 254·6; rail	288·3
"	Arnprior	298·3

RAIL ELEVATIONS, OTTAWA TO RENFREW, ONT.—*Concluded.*

(Elevations taken in 1915).

		FEET.
Grand Trunk Railway	Arnprior	298·1
"	Canadian Pacific railway (diamond crossing)	299·7
"	Glasgow	445·1
"	Goshen	494·2
"	Renfrew	421·1

RAIL ELEVATIONS, KEMPTON TO IVANHOE, ONT.

(Elevations taken in 1915).

		FEET.
Canadian Pacific Railway	Kempton	332·8
"	Canadian Pacific railway, Ottawa-Prescott line (diamond crossing)	333·2
"	Kemptville creek; water, June 21, 1915, 304·1; rail	326·6
"	Swan	338·1
"	Burritt	366·6
"	Rideau river; water, June 25, 1915, 312·2; rail	357·6
"	Merrickville	355·1
"	Rosedale	360·2
"	Smiths Falls	426·6
"	Canadian Northern railway, Toronto–Ottawa line (under crossing) rail 403·4; C.P.R. rail	429·4
"	Elmsley	441·9
"	Perth	439·2
"	Glentay	472·6
"	Bathurst	484·0
"	Maberley	578·1
"	Fall river; water, Aug. 17, 1915, 578·5; rail	595·6
"	Sharbot Lake (main line)	647·9
"	Sharbot lake; water, Oct. 21, 1915	636·8
"	Olden	733·6
"	Mountain Grove	683·2
"	Ardendale	620·1
"	Salmon river; water, Oct. 27, 1915, 613; rail	632·1
"	Kennebec	667·2
"	Kaladar	704·8
"	Addington	590·6
"	Hungerford	557·5
"	Sulphide	485·2
"	Bogart	477·9
"	Moira river; water, Nov. 9, 1915, 458·2; rail	475·0
"	Tweed	478·2
"	Canadian Northern railway, Bannockburn branch (diamond crossing)	484·4
"	Buller	592·6
"	Grand Trunk railway, Madoc branch (under crossing) rail 562·1; C.P.R. rail	587·6
"	Ivanhoe	610·3

RAIL ELEVATIONS, CARLETON PLACE TO BROCKVILLE, ONT.

(Elevations taken in 1915).

		FEET
Canadian Pacific Railway	Carleton Place (main line)	450·3
"	Beckwith	464·1
"	Franktown	480·6
"	Welsh	433·0

RAIL ELEVATIONS, CARLETON PLACE TO BROCKVILLE, ONT.—*Concluded.*

(Elevations taken in 1915).

		FEET
Canadian Pacific Railway—	Canadian Northern railway, Toronto-Ottawa line (under crossing) rail 403·4; C.P.R. rail	429·4
"	Smiths Falls	426·6
"	Rideau river; water, July 14, 1915, 348·6; rail	382·3
"	Jasper	343·4
"	Irish creek; water, July 15, 1915, 337·3; rail	343·8
"	Yule	398·5
"	Bell	390·0
"	Jelly	375·9
"	Bellamy	397·0
"	Hawkens	392·7
"	Clark	417·9
"	Fairfield	397·8

RAIL ELEVATIONS, RENFREW TO KINGSTON, ONT.

(Elevations taken in 1915 and 1916).

		FEET
Canadian Pacific Railway—	Renfrew	416·4
"	Grand Trunk railway, Ottawa division (diamond crossing)	402·9
"	Ashdod	567·1
"	Madawaska river; water, Sept. 8, 1915, 492·8; rail	518·4
"	Calabogie	515·8
"	Madawaska river; water, Sept. 8, 1915, 499·9; rail	515·1
"	Barryvale	533·9
"	Flower	625·0
"	Clyde Forks	608·2
"	Folger	809·0
"	Lavant	841·4
"	Wilbur	884·0
"	Snow Road	695·7
"	Mississippi river; water, Aug. 30, 1915, 645·7; rail	656·4
"	Mississippi	683·0
"	Clarendon	759·5
"	Oso	679·4
"	Sharbot Lake (Kingston subdivision)	647·3
"	Sharbot lake; water, Sept. 22, 1915	637·0
"	Oconto	674·7
"	Canadian Pacific railway, main line (diamond crossing at Tichborne)	650·5
"	Hinchinbrooke	560·3
"	Godfrey	498·6
"	Verona	459·0
"	Hartington	530·5
"	Harrowsmith	491·2
"	Murvale	478·5
"	Glenvale	419·4
"	Grand Trunk railway, main line (diamond crossing)	287·1
"	Grand Trunk railway, Kingston branch (diamond crossing)	254·7
"	Kingston	253·7
"	Lake Ontario; water, Sept. 26, 1916	245·5

RAIL ELEVATIONS, IVANHOE TO BELLEVILLE, ONT.

(Elevations taken in 1916).

		FEET
Grand Trunk Railway—	Ivanhoe	468·7
"	West Huntingdon	446·0
"	Madoc Junction	503·9
"	Holloway	426·1
"	Foxboro	358·2
"	Moira river; water, April 26, 1916, 335·0; rail	358·2
"	Corbyville	332·8
"	Belleville	285·8

RAIL ELEVATIONS, STEELTON TO FRANZ, ONT.

(Elevations taken in 1915).

		FEET
Algoma Central Railway—	Steelton	616·3
"	Odena	926·1
"	Granite	1018·4
"	Root river; water, June 23, 1915, 1030·4; rail	1046·0
"	Heyden	1070·7
"	Gilbert	1076·6
"	Island Lake	1088·8
"	Bellevue	1140·6
"	Northfield	1080·4
"	Glendale	836·5
"	Goulais	768·9
"	Goulais river; water, June 30, 1915, 755·6; rail	778·8
"	Searchmont	779·7
"	Wabos	944·1
"	Superior Jct	1104·3
"	Achigan	1112·2
"	Achigan lake; water, July 7, 1915, 1103·7; rail (on bridge)	1112·8
"	Lunar	1114·7
"	Bucyrus	1151·6
"	Ogadaki	1227·3
"	South branch, Chippawa river; water, July 8, 1915, 1017·1; rail	1027·7
"	Chippawa	1029·4
"	Mashkode	1143·0
"	Trout lake; water, July 15, 1915, 1118·9; rail	1127·6
"	Alva	1278·8
"	Mekatina	1452·9
"	Pangis	1279·8
"	North branch, Chippawa river; water, July 23, 1915, 1188·2; rail	1237·5
"	Spruce	1325·3
"	Summit	1412·9
"	Mongoos lake; water, July 27, 1915, 1230·9; rail (on bridge)	1241·9
"	Mongoos	1242·2
"	Batchawana	1022·2
"	Batchawana river; water, July 26, 1915, 1000·9; rail	1033·9
"	Rand	1395·4
"	Regent	1337·6
"	Montreal river; water, Aug. 3, 1915, 1181; rail	1283·4
"	Montreal	1514·3
"	Frater	1462·0
"	Little Agawa river (mileage 109·1 from Sault Ste. Marie); water, Aug. 11, 1915, 998·3; rail	1017·0
"	Agawa river (mileage 111·5 from Sault Ste. Marie); water, Aug. 19, 1915, 911·7; rail	933·9

RAIL ELEVATIONS, STEELTON TO FRANZ, ONT.—*Concluded.*

(Elevations taken in 1915).

		FEET
Algoma Central Railway—	Canyon	937·3
"	Eton	1030·6
"	Agawa river (mileage 119·9 from Sault Ste. Marie); water, Aug. 19, 1915, 1016·4; rail	1034·9
"	Agawa river (mileage 122·0 from Sault Ste. Marie); water, Aug. 20, 1915, 1030·0; rail	1045·7
"	Agawa river (mileage 125·0 from Sault Ste. Marie); water, Aug. 20, 1915, 1036·9; rail	1049·4
"	Agawa river (mileage 126·9 from Sault Ste. Marie); water, Aug. 20, 1915, 1049·7; rail	1060·1
"	Agawa river (mileage 127·4 from Sault Ste. Marie); water, Aug. 20, 1915, 1060·1; rail	1076·8
"	Agawa river (mileage 127·9 from Sault Ste. Marie); water, Aug. 20, 1915, 1067·7; rail	1085·7
"	Agawa	1109·9
"	Agawa river (mileage 130·8 from Sault Ste. Marie); water, Sept. 1, 1915, 1099·0; rail	1110·2
"	Agawa river (mileage 131·8 from Sault Ste. Marie); water, Sept. 1, 1915, 1099·3; rail	1114·4
"	Sand lake; water, Sept. 2, 1915, 1214·0; rail	1224·4
"	Tabor	1260·9
"	Perry	989·3
"	Michipicoten river; water, Sept. 16, 1915, 901·3; rail	924·6
"	Limer	1062·3
"	Hawk Junction (station)	1040·1
	Michipicoten branch:—	
"	Magpie Junction	1055·9
"	Helen Junction	1108·8
"	Magpie river; water, Oct. 1, 1915, 847·0; rail	871·8
"	Brient	745·3
	Main line, continued:—	
"	Alden	1173·7
"	Goudreau	1211·9
"	Wanda	1167·7
"	Canadian Pacific railway (diamond crossing at Franz)	1216·5

RAIL ELEVATIONS, KIPP, ALTA., TO GOLDEN, B.C.

(Elevations taken in 1914 and 1915).

		FEET
Canadian Pacific Railway—	Kipp	3059·5
"	Monarch	3103·7
"	Oldman river; water, Aug. 26, 1914, 2934·4; rail	3079·6
"	Pearce	3099·2
"	Macleod	3116·1
"	Stowe	3230·6
"	Piegan	3321·9
"	Chokio	3433·9
"	Brocket	3512·4
"	Pincher creek; water, Sept. 16, 1914, 3394·1; rail	3511·1
"	Maunsell	3619·9
"	Pincher	3771·2
"	South fork, Oldman river; water, Sept. 25, 1914, 3590·0; rail	3731·0
"	Cowley	3842·4

RAIL ELEVATIONS, KIPP, ALTA., TO GOLDEN, B.C.—*Concluded.*

(Elevations taken in 1914 and 1915).

		FEET
Canadian Pacific Railway—	Lundbreck	3918·3
"	Crowsnest river (first crossing); water, Oct. 2, 1914, 3805·0; rail	3825·3
"	Burmis	4004·5
"	Passburg	4044·3
"	Hillcrest	4122·5
"	Frank	4212·2
"	Crowsnest river (second crossing); water, Oct. 8, 1914, 4182·2; rail	4192·7
"	Blairmore	4235·9
"	Crowsnest river (third crossing); water, Oct. 9, 1914, 4266·8; rail	4277·0
"	Coleman	4312·3
"	Sentry	4448·5
"	Crowsnest	4450·8
"	Loop	4249·3
"	McGillivray	4172·8
"	Michel creek; immediately west of McGillivray; water, May 5, 1915, 4149·2; rail	4169·8
"	Michel	3861·8
"	Natal	3782·4
"	Sparwood	3648·3
"	Hosmer	3457·8
"	Fernie	3313·4
"	Coal creek; water, May 20, 1915, 3287·1; rail	3312·2
"	Cokato	3232·8
"	Morrissey	3139·4
"	Morrissey creek; water, May 24, 1915, 3099·6; rail	3109·2
"	Courier	3084·0
"	Elk river; water, May 29, 1915, 3016·1; rail	3036·9
"	Elko	3089·0
"	Great Northern railway (overhead crossing) rail 3116·3; C.P.R. rail	3089·4
"	Caithness	2851·5
"	Galloway	2849·1
"	Jaffray	2703·4
"	Colvalli	2660·7
"	Bull River (station)	2476·0
"	Bull river; water, June 11, 1915, 2468·8; rail	2479·3
"	Fenwick	2485·5
"	Steele	2524·0
"	Wasa	2537·2
"	Kootenay river; water, June 25, 1915, 2522·4; rail	2540·7
"	Skookumchuck creek; water, July 6, 1915, 2607·5; rail	2624·7
"	Torrent (section-house)	2607·3
"	Canalflat	2666·4
"	Radium	2659·2
"	Athalmer	2633·3
"	Columbia river (mileage 98·6 from Colvalli); water, Aug. 4, 1915	2617·8
"	Columbia river (mileage 102·0 from Colvalli); water, July 30, 1915, 2610·2; rail	2617·7
"	Columbia river (mileage 102·7 from Colvalli); water, July 30, 1915, 2609·3; rail	2616·9
"	Edgewater	2613·3
"	Brisco	2601·5
"	Spillimacheen	2603·6
"	Harrogate	2594·8
"	Parson	2588·4
"	Mons	2585·9
"	Nicholson	2580·5
"	Kicking Horse river; water, Sept. 2, 1915, 2584·1; rail	2594·1
"	Golden	2583·8

RAIL ELEVATIONS, BULL RIVER TO KOOTENAY LANDING, B.C.

(Elevations taken in 1916).

		FEET
Canadian Pacific Railway—	Bull River	2476·0
"	Mayook	2710·1
"	Rampart	2691·9
"	Eager	2897·0
"	Cranbrook	3019·3
"	Fassiferne	3262·8
"	Wattsburg	3236·3
"	Swansea	3195·6
"	Moyie river (mileage 10·9 from Cranbrook); water, May 15, 1916, 3133·5; rail	3144·4
"	Moyie river (mileage 13·1 from Cranbrook); water, May 15, 1916, 3042·6; rail	3055·3
"	Pea Vine creek (mileage 13·3 from Cranbrook); water, May 15, 1916, 3042·3; rail	3054·2
"	Jerome	3056·6
"	Moyie	3051·7
"	Aldridge	3057·3
"	Moyie river; water, May 17, 1916, 3037·4; rail	3048·5
"	Tochty	2970·0
"	Ryan	2903·8
"	Yahk	2823·1
"	Curzon	2815·8
"	Goatfell	2909·6
"	Cadorna	2441·1
"	McNeillie	2130·0
"	Canyon	2096·8
"	Goat river; water, June 17, 1916, 1948; rail	2088·8
"	Erickson	2112·7
"	Creston	1988·5
"	Wynndel	1856·7
"	Duck Creek	1850·5
"	Sirdar	1807·9
"	Kootenay lake; water, June 21, 1916	1760·2

RAIL ELEVATIONS, FIELD TO REVELSTOKE, B.C.

(Elevations taken in 1915 and 1916.)

		FEET
Canadian Pacific Railway—	Field	4076·1
"	Emerald	3899·9
"	Ottertail river (mileage 6·25 from Field); water, Aug. 6, 1915, 3749·0; rail	3780·6
"	Ottertail	3703·8
"	Kicking Horse river (mileage 9·25 from Field); water, Aug. 14, 1915, 3691·2; rail	3703·8
"	Leanchoil	3685·6
"	Kicking Horse river (mileage 21·6 from Field); water, Aug. 17, 1915, 3296·5; rail	3309·7
"	Palliser	3288·6
"	Kicking Horse river (mileage 25·7 from Field); water, Aug. 24, 1915, 3120·4; rail	3156·6
"	Glenogle	3009·8

RAIL ELEVATIONS, FIELD TO REVELSTOKE, B.C.—*Concluded.*

(Elevations taken in 1915 and 1916).

		FEET
Canadian Pacific Railway—	Kicking Horse river (mileage 31·6 from Field); water, Aug. 25, 1915, 2701·8; rail	2719·9
"	Kicking Horse river (mileage 32·0 from Field); water, Aug. 25, 1915, 2683·1; rail	2702·3
"	Kicking Horse river (mileage 32·75 from Field); water, Aug. 25, 1915, 2654·5; rail	2668·9
"	Kicking Horse river (mileage 33·24 from Field); water, Aug. 25, 1915, 2629·0; rail	2645·4
"	Golden	2583·7
"	Moberly	2559·4
"	Donald	2581·3
"	Columbia river (mileage 52·7 from Field); water, Sept. 6, 1915, 2519·4; rail	2561·2
"	Redgrave	2535·1
"	Beavermouth	2434·4
"	Beaver river (mileage 66·1 from Field); water, Sept. 16, 1915, 2527·4; rail	2556·9
"	Anzac	2592·7
"	Sturdee	3168·9
"	Cutbank	3329·1
"	Bear Creek	3665·7
"	Rogers Pass	4306·8
"	Summit of Selkirk range (rail)	4341·6
"	Glacier	4091·1
"	Cambie	3779·3
"	Illecillewaet river (mileage 90·4 from Field); water, Oct. 22, 1915, 3690·7; rail	3740·7
"	Illecillewaet river (mileage 90·8 from Field); water, Oct. 21, 1915, 3652·4; rail	3701·8
"	Illecillewaet river (mileage 91·8 from Field); water, Oct. 21, 1915, 3572·3; rail	3584·8
"	Ross Peak	3435·2
"	Illecillewaet river (mileage 94·7 from Field); water, Oct. 21, 1915, 3388·2; rail	3401·4
"	Illecillewaet river (mileage 95·1 from Field); water, Oct. 21, 1915, 3330·8; rail	3363·8
"	Illecillewaet river (mileage 97·6 from Field); water, Oct. 15, 1915, 3095·0; rail	3106·3
"	Flat Creek	3094·7
"	Illecillewaet river (mileage 98·9 from Field); water, Oct. 15, 1915, 2994·1; rail	3017·7
"	Illecillewaet river (mileage 102·2 from Field); water, Oct. 23, 1915, 2716·6; rail	2758·5
"	Illecillewaet	2713·6
"	Illecillewaet river (mileage 106·2 from Field); water, Oct. 25, 1915, 2424·7; rail	2480·1
"	Albert Canyon	2227·1
"	Lauretta	1962·3
"	Twin Butte	1879·9
"	Illecillewaet river (mileage 126·8 from Field); water, July 25, 1916, 1602·4; rail	1635·9
"	Revelstoke	1496·7

RAIL ELEVATIONS, EDMONTON TO JASPER, ALTA.

(Elevations taken in 1915 and 1916).

		FEET
Canadian Northern Railway—Edmonton		2185·4
Grand Trunk Pacific Ry.—Canadian Northern railway, main line (diamond crossing)		2229·5
"	Bissell	2235·8
"	Acheson	2339·7
"	Sprucegrove	2325·5
"	Stonyplain	2323·4
"	Carvel	2460·0
"	Duffield	2382·2
"	Wabamun lake; water, Sept. 3, 1915, 2376·8; rail (on bridge)	2388·1
"	Wabamun	2384·1
"	Fallis	2395·7
"	Seba Beach	2452·3
"	Gainford	2440·0
"	Entwistle	2570·9
"	Pembina river; water, Sept. 20, 1915, 2356; rail	2562·5
"	Imrie	2580·9
"	Junkins	2622·8
"	Keston	2621·1
"	Canadian Northern railway (diamond crossing)	2599·5
"	Leaman	2613·0
"	Mackay	2657·6
"	Niton	2737·4
"	Otley	2767·6
"	Peers	2786·3
"	Rosevear	2840·7
"	Thornton	2854·1
"	Wolf river; water, Oct. 14, 1915, 2754; rail	2879·2
"	McLeod river; water, Oct. 14, 1915, 2760; rail	2879·1
"	Yates	2892·1
"	Edson	2985·6
"	Ansell	3036·7
"	Canadian Northern railway (under crossing) rail, 3034·4; G. T. P. Ry. rail	3065·4
"	Sundance creek; water, Oct. 22, 1915, 2943·8; rail	3067·3
"	Bickerdike	3117·5
"	Dandurand	3194·5
"	Galloway	3271·7
"	Medicine Lodge	3396·5
"	Hargwen	3486·2
"	Obed	3562·6
"	Roundcroft	3467·2
"	Pedley	3471·5
"	Hinton	3326·6
"	Dyke	3288·3
"	Parkgate	3308·0
"	Fiddle creek; water, July 27, 1916, 3241·4; rail	3256·5
"	Pocahontas	3260·0
"	Rocky river; water, Aug. 1, 1916, 3282·2; rail	3296·1
"	Hawes	3287·7
"	Interlachen	3290·2
"	Athabaska river; water, Aug. 4, 1916, 3288·8; rail	3305·1
"	Henry House	3333·8
"	Canadian Northern railway (under crossing) rail, 3320·9; G. T. P. Ry. rail	3348·8
"	Jasper	3469·7

TABLE III-A.

RAIL ELEVATIONS, ST. STEPHEN, N.B., TO RIVIERE-DU-LOUP, QUE.

(Elevations taken in 1909).

		Feet
Canadian Pacific Railway	St. Stephen	15·1
"	Oak Bay	72·5
"	Brunswick	279·6
"	Hewitt	303·8
"	Dumbarton	230·0
"	Watt	312·3
"	McAdam	458·6
"	Canterbury	563·1
"	Benton	415·6
"	Debec	551·3
"	International boundary (on Houlton Branch)	525·9
"	Woodstock (old yard station)	148·3
"	Upper Woodstock	158·7
"	Hartland	169·1
"	Florenceville	191·5
"	Bristol	206·1
"	Bath	218·0
"	Kilburn	286·0
"	Perth	257·8
"	Andover	268·6
"	Aroostook	276·0
"	International boundary (on Aroostook branch)	372·9
"	Grand Falls	504·8
"	St. Leonard	509·4
"	Green River	485·6
"	Edmundston	478·9
Temiscouata Railway	Edmundston	478·4
"	Ste. Rose	505·8
"	Notre-Dame-du-Lac	529·9
"	Cabano	563·1
"	Vauban	1058·0
"	St. Honoré	1302·0
"	Whitworth	879·2
"	Ste. Modéste	547·6
Intercolonial Railway	Rivière-du-Loup	315·6

RAIL ELEVATIONS, BRUNSWICK TO ST. JOHN, N.B.

(Elevations taken in 1909).

		Feet
Canadian Pacific Railway	Brunswick	279·6
"	Dyer	104·1
"	Bonny River	72·4
"	St. George	89·4
"	Utopia	112·0
"	Pennfield	226·5
"	Pocologan	203·8
"	New River	172·5
"	Lepreau	78·2
"	Musquash	16·6
"	Prince of Wales	118·2
"	Allan Cot	208·0
"	Spruce Lake	205·6
"	Duck Cove	68·6
Intercolonial Railway	St. John	20·6

RAIL ELEVATIONS, ST. JOHNS TO SHERBROOKE, QUE.

(Elevations taken in 1907).

		Feet
Canadian Pacific Railway—	Iberville	109·3
"	Iberville Junction	114·9
"	Versailles	186·5
	Branch line to international boundary:—	
"	Mystic	180·8
"	Bedford	179·0
Central Vermont Railway—	St. Armand	122·0
	Main line, continued:—	
Canadian Pacific Railway—	Brookport	267·7
"	Adamsville	376·0
"	West Shefford	428·0
"	Fulford	584·3
"	Foster	696·4
	Branch line to international boundary:—	
"	Knowlton	680·2
"	Brome	676·9
"	Enlaugra	557·8
"	Sutton	581·2
"	Abercorn	485·7
	Main line, continued:—	
"	South Stukely	837·0
"	Eastray	910·2
"	Magog	688·7
"	Scaswan	647·7
"	Rock Forest	700·5

RAIL ELEVATIONS, SHERBROOKE, QUE., TO NORTON MILLS, VERMONT.

(Elevations taken in 1907).

		Feet
Grand Trunk Railway—	Sherbrooke	485·1
"	Lennoxville	498·6
"	Waterville	645·0
"	Compton	733·0
"	Hillhurst	818·7
"	Coaticook	1006·2
"	Dixville	1126·8

RAIL ELEVATIONS, COTEAU JUNCTION, QUE., TO COLBORNE, ONT.

(Elevations taken in 1908).

		Feet
Grand Trunk Railway—	Coteau Junction	160·1
"	St. Polycarpe	176·0
Canadian Pacific Railway—	St. Polycarpe Junction	194·0
"	St. Télesphore	213·7
"	Dalhousie Mills	226·5
"	Glen Norman	253·0
"	Green Valley	281·5
"	Apple Hill	301·5

RAIL ELEVATIONS, COTEAU JUNCTION, QUE., TO COLBORNE, ONT.—*Concluded.*

(Elevations taken in 1908).

		FEET
Canadian Pacific Railway—	Monckland	330·8
"	Avonmore	327·0
"	Ottawa & New York railway (diamond crossing at Finch)	274·9
"	Chesterville	240·1
"	Winchester	249·9
"	Inkerman	267·1
"	Mountain	272·5
"	Kempton	332·8
"	Canadian Pacific railway, Ottawa-Prescott line (diamond crossing)	333·2
"	Oxford	354·5
"	Spencerville	318·5
Grand Trunk Railway—	Prescott	310·9
"	Maitland	329·7
"	Brockville	282·6
"	Lyn	287·4
"	Yonge Mills	301·9
"	Lansdowne	336·6
"	Gananoque Junction	345·6
"	Findley	367·7
"	Rideau	305·2
"	Kingston Junction	274·8
"	Canadian Pacific railway, Kingston-Renfrew line (diamond crossing)	287·3
"	Collins Bay	284·1
"	Ernestown	325·0
"	Fredericksburg	308·2
"	Napanee	314·3
"	Canadian Northern railway, Toronto-Ottawa line (diamond crossing)	326·5
"	Marysville	335·8
"	Shannonville	334·8
"	Belleville	286·0
"	Trenton	285·3
"	Brighton	303·7
"	Colborne	321·8

INDEX.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.

Note.—"Year of Publication" refers to the "Publications of the Dominion Observatory" as follows:—

1913*—Vol. I, No. 2	**1915—Vol. II, No. 1**
1913—Vol. I, No. 3	**1916—Vol. III, No. 6**
1914—Vol. I, No. 8	**1917—this publication.**

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	B.			
Baker Brook, N.B.	264–B	1917	247	290
Bala, Ont.	408	1913	66	86
Banff, Alta.	240–C, 241–C	1916	167	188
Barons, Alta.	76–D, 77–D	1915	25	38
Barrington, N.S.	444–B	1915	12	29
Barrington Passage, N.S.	446–B	1915	12	29
Barrys Bay, Ont.	523	1915	16	32
Bashaw, Alta.	65–F	1916	165	187
Bath, N.B.	35–B	1917	276	314
Bayfield, N.S.	177–B	1913	48	75
Beamsville, Ont.	204	1913	63	85
Beaudette, Minn.	16–E	1914	226	239
Beavermouth, B.C.	284–C	1917	269	309
Bedford, Que.	66	1917	282	318
Bedford, N.S.	506–B	1916	144	171
Beecher Falls, Vt.	562–B	1916	153	180
Beeton, Ont.	379	1913	64	86
Beiseker, Alta.	48–F	1916	164	187
Belgrave, Ont.	316	1913	61	83
Belle River, Ont.	252	1913	57	81
Belleville, N.S.	459–B	1915	13	30
Belleville, Ont.	156 *to* 157–A–2	1917	288	322
Bennett, B.C.	32–R	1913*	23	23
Benton, N.B.	18–B	1917	276	313
Berwick, N.S.	488–B	1916	148	175
Bethune, Sask.	9–D	1913	71	90
Bienfait, Sask.	61–C	1913	69	88
Biggar, Sask.	12–H	1915	20	34
Blackie, Alta.	63–D	1915	26	38
Bladworth, Sask.	19–D	1914	227	240
Blaine, Wash.	19–J	1916	169	190
Blairmore, Alta.	103–D	1917	262	304
Blind River, Ont.	604, 605	1916	156	181
Bloomfield, N.B.	111–B	1913	44	73
Bluevale, Ont.	313	1913	61	83
Blyth, Ont.	317	1913	61	83
Boharm, Sask.	106–C	1914	229	241
Boiestown, N.B.	33–G	1916	151	178
Boissevain, Man.	31–C, 32–C	1913	67	87
Bolton, Ont.	260	1913	58	82, 86
Bothwell, Ont.	243	1913	57	81
Boundary Creek, N.B.	128–B	1913	45	73
Bow Island, Alta.	178–C, 179–C	1915	23	35
Bowmanville, Ont.	177	1913	54	79
Braeburn, Y.T.	57	1913*	27	27
Brant, Alta.	65–D	1915	26	38
Brantford, Ont.	219, 220	1913	55	80

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Bridgeburg, Ont.	215–A	1913	64	85
Bridgewater, N.S.	409–B *to* 411–B	1915	10	28
Brierly Brook, N.S.	170–B	1913	47	74
Brighton, Ont.	163	1917	288	322
Bristol, N.B.	34–B	1917	276	314
Brockville, Ont.	123, 124	1917	286	321
"	105–G, 106–G	1917	252	298
Brome, Que.	50	1917	282	318
Brookport, Que.	60	1917	281	317
Bruce, Alta.	45–H	1916	162	186
Bruce Mines, Ont.	619	1916	156	182
Brucefield, Ont.	329	1913	62	84
Brunswick, N.B.	6–B	1917	275	313
Brussels, Ont.	312	1913	61	83
Bull River, B.C.	135–D	1917	264	305
Burdett, Alta.	180–C, 181–C	1915	23	35, 36
Burlington Jct., Ont.	196	1913	55	80
Bury, Que.	13–A–2	1913	49	76
	C.			
Calabogie, Ont.	139–G	1917	254	299
Calais, Maine	1–B	1917	275	313
Caldwell, Ont.	512	1915	16	32
Caledon, Ont.	265	1913	58	82
Calgary, Alta.	50–D, 51–D, 52–D	1915	27	39
" "	39–F	1916	163	187
" "	217–C, 218–C	1916	166	188
Cambridge, N.S.	490–B	1916	148	175
Campbellton, N.B.	25–G, 26–G	1916	151	177
Camrose, Alta.	70–F, 71–F	1916	165	187
Canmore, Alta.	235–C	1916	167	188
Canterbury, N.B.	16–B	1917	276	313
Capelton, Que.	26	1913	48	75
Cap St. Ignace, Que.	567–B	1917	247	291
Cariboo, Y.T.	18–R	1913*	24	24
Carievale, Sask.	49–C	1913	68	88
Carleton Place, Ont.	60–G, 61–G, 62–G	1917	249, 250	293
Carmangay, Alta.	73–D, 74–D.	1915	25	38
Carnduff, Sask.	50–C	1913	68	88
Caron, Sask.	108–C	1914	229	241
Cartwright, Man.	20–C	1913	67	87
Cascades, Que.	467	1914	218	234
Chamberlain, Sask.	12–D	1913	72	90
Champion, Alta.	71–D	1915	26	38
Chaplin, Sask.	113–C	1914	229	241

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Chatham, Ont	246–A, 247, 247–A	1913	57	81
"	373, 247	1914	222	236
Chatham, N.B	49–G	1916	152	178
Chatsworth, Ont	283	1913	59	82
Chauvin, Alta	30–H	1915	21	34
Chelsea, Que	464	1914	218	234
Chesley, Ont	295, 296	1913	60	83
Chester, N.S	401–B	1915	10	28
Chesterville, Ont	107	1917	285	320
Chin, Alta	191–C	1915	23	36
Chipman, N.B	352–B	1914	216	233
Clarkson, Ont	192	1913	55	80
Clarksville, N.S	520–B, 521–B	1916	145	171
Clinton, Ont	320, 321	1913	62	83
Cloverdale, B.C	20–J, 21–J	1916	169	191
Coaticook, Que	14, 15, 16	1917	283	319
Coblenz, Sask	17–H	1915	20	34
Cobourg, Ont	171	1913	53	79
Cochrane, Alta	222–C, 223–C	1916	166	188
Colborne, Ont	166	1917	288	322
Coldbrook, N.S	491–B	1916	148	175
Coldwater, Ont	399–A	1913	65	86
Collins Bay, Ont	144	1917	287	321
Compton, Que	10	1917	283	319
Condie, Sask	5–D	1913	71	90
Conn Mills, N.S	139–B	1913	46	74
Cookshire, Que	10–A–3, 11–A	1913	49	76
Copetown, Ont	216–A	1913	55	80
Corbetton, Ont	273	1913	59	82
Corbyville, Ont	185–G	1917	257	301
Cornwall, Ont	489, 490, 491	1914	219	235
Corunna, Ont	361	1914	221	236
Coteau Jct., Que	90	1917	284	320
Courtright, Ont	363	1914	222	236
Coutts, Alta	216–C†	1915	25	37
Cowley, Alta	97–D	1917	262	304
Craighurst, Ont	392	1913	65	86
Craik, Sask	16–D	1913	72	90
Cranbrook, B.C	172–D *to* 174–D	1917	266	307
Creston, B.C	195–D, 196–D	1917	268	307
Crowsnest, B.C	109–D	1917	263	304
Crysler, Ont	496	1914	220	235
Crystal City, Man	16–C	1913	67	87

†Also B.M. in International Boundary Monument.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	D.			
Dalhousie Mills, Ont	95	1917	285	320
Dauntless, Alta	171–C	1915	22	35
Davidson, Sask	18–D	1914	227	240
Dawson, Y.T	223, 224	1913*	34	34
Dean Lake, Ont	609	1916	156	182
Debec, N.B	20–B	1917	276	313
Delburne, Alta	59–F	1916	165	187
Deloraine, Man	36–C	1913	68	88
Denfield, Ont	338	1913	62	84
Denmark, N.S	149–B	1913	46	74
Depot Harbour, Ont	566, 567	1915	13	31
Derby Jct., N.B	47–G–2	1916	152	178
Desbarats, Ont	622	1916	157	182
Devlin, Ont	27–E	1914	226	239
Dinant, Alta	73–F	1916	165	187
Disley, Sask	8–D	1913	71	90
Doaktown, N.B	37–G	1916	151	178
Dobbinton, Ont	294	1913	60	83
Dorchester, N.B	DCCCLXXXIX, *etc*	1916	‡	174
Dorenlee, Alta	66–F	1916	165	187
Dresden, Ont	370	1914	222	236
Drinkwater, Sask	91–C	1913	70	89
Duck Lake, Sask	42–D	1914	228	240
Dundalk, Ont	274	1913	59	82
Dundas, Ont	215	1913	55	80
Dundurn, Sask	25–D	1914	227	240
Dunmore, Alta	165–C	1915	22	35
	E.			
Eady, Ont	398	1913	65	86
Eastman, Que	44	1917	281	317
East Pubnico, N.S	453–B	1915	13	29
Eastray, Que	44	1917	281	317
Eastwood, Ont	225	1913	55	80
Echo Bay, Ont	626	1916	157	182
Edgerton, Alta	33–H	1915	21	34
Edmonton, Alta	58–H *to* 61–H	1916	163	186
Edmundston, N.B	58–B, 59–B, 60–B	1917	278	314
Edson, Alta	81–H, 82–H	1917	272	311
Eganville, Ont	514	1915	16	32
Ekoba, Ont	626	1916	157	182
Elmwood, Ont	297	1913	60	83
Elva, Man	44–C	1913	68	88

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Embrun, Ont	498	1914	220	235
Emerson, Man	3–C	1913	66	87
Emo, Ont	23–E, 24–E	1914	226	239
Enlaugra, Que	51	1917	282	318
Ensign, Alta	66–D	1915	26	38
Ernestown, Ont	146	1917	287	321
Ernfold, Sask	115–C	1914	229	241
Estevan, Sask	62–C, 63–C	1913	69	88
Eureka, Y.T	187	1913*	33	33
Exeter, Ont	332, 333	1913	62	84
	F.			
Fairville, N.B	96–B	1917	280	316
Farnham, Que	62	1917	281	317
"	63, 64	1917	282	318
Ferintosh, Alta	67–F	1916	165	187
Fernie, B.C	121–D *to* 123–D	1917	263	305
Field, B.C	260–C	1916	168	189
Finch, Ont	105	1917	285	320
"	495	1914	219	235
Findlater, Sask	11–D	1913	72	90
Flesherton, Ont	277	1913	59	82
Forest, Ont	351	1914	221	236
Fort Erie, Ont	215–A	1913	64	85
Fort Frances, Ont	29–E, 30–E	1914	226	239
Fort William, Ont	90–E *to* 92–E	1916	161	184
Foster, Que	47	1917	281	317
Frank, Alta	102–D	1917	262	304
Franz, Ont	708	1917	261	303
French Village, N.S	393–B	1915	9	28
Frobisher, Sask	58–C	1913	69	88
Fulford, Que	56	1917	281	317
	G.			
Gainsborough, Sask	47–C	1913	68	88
Girvin, Sask	17–D	1913	72	90
Glacier, B.C	294–C	1917	270	309
Glacier, Y.T	266	1913*	36	36
Glencoe, Ont	241, 241–A	1913	56	81
Glen Ewen, Sask	52–C	1913	68	88
Glentay, Ont	117–G	1917	253	295
Goderich, Ont	325, 326, 327	1913	62	83, 84
Godfrey, Ont	150–G	1917	255	300
Golden, B.C	273–C	1917	269	309

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Goodlands, Man	38-C	1913	68	88
Gracefield, Que	484	1914	219	234
Graceton, Minn	14-E	1914	226	239
Grafton, Ont	168	1913	53	79
Grainger, Alta	50-F	1916	164	187
Grand Coulée, Sask	101-C	1913	71	89
Grand Falls, N.B	46-B	1917	277	314
Grand Ligne, Que	78	1917	280	317
Grand Pré, N.S	498-B	1916	149	175
Grandora, Sask	3-H	1915	19	34
Grassy Lake, Alta	182-C, 183-C	1915	23	36
Green River, N.B	54-B	1917	277	314
Green Valley, Ont	97	1917	285	320
Gretna, Man	4-C	1913	66	87
Grimsby, Ont	203	1913	63	85
Gull Lake, Sask	136-C	1914	230	241
	H.			
Hague, Sask	38-D	1914	228	240
Halbrite, Sask	73-C	1913	69	89
Halifax, N.S	386-B, 387-B	1915	9	28
"	386-B, 387-B	1916	144	171
Hallock, Minn	2-C	1913	66	87
Hamilton, Ont	198, 199, 200	1913	63	85
Hampton, N.B	109-B	1913	44	73
Hanley, Sask	23-D	1914	227	240
Hanover, Ont	298, 299	1913	60	83
Harlaka Jct., Que	219-B	1913	52	77
Harriston, Ont	303, 304	1913	61	83
Harrowsmith, Ont	154-G	1917	255	300
Hartland, N.B	31-B	1917	276	313
Hatton, Sask	151-C	1915	21	35
Heath, Alta	34-H	1915	21	34
Henfryn, Ont	310	1913	61	83
Herbert, Sask	118-C	1914	230	241
Hillhurst, Que	13	1917	283	319
Holden, Alta	46-H	1916	163	186
Holland Centre, Ont	281	1913	59	82
Holmesville, Ont	322	1913	62	83
Holmfield, Man	22-C	1913	67	87
Howick Jct., Que	87	1917	284	320
Hubbards, N.S	397-B	1915	9	28
Hull, Que	459, 460	1914	217	234
Humes, Y.T	132	1913*	31	31
Huntingdon, B.C	26-J, 27-J	1916	170	191
Hyde Park Jct., Ont	341	1913	63	84

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	I.			
Iberville, Que	74	1917	280	317
Ilderton, Ont	339	1913	63	84
Indian River, Y.T	205	1913*	33	33
Ingersoll, Ont	229, 230	1913	56	80
Inkerman, Ont	110	1917	285	320
Irma, Alta	39–H	1916	162	185
Irvine, Alta	159–C, 160–C	1915	22	35
Ivanhoe, Ont	179–G	1917	257	296
	J.			
Jaffray, B.C	131–D, 132-D	1917	264	305
James River, N.S	169–B	1913	47	74
Jasper, Alta	104–H	1917	274	312
Jasper, Ont	97–G	1917	252	298
Jeannette, Ont	249–A	1913	57	81
Jordan, Ont	205	1913	63	85
Juniata, Sask	6–H	1915	19	34
	K.			
Kakabeka Falls, Ont	85–E	1916	161	184
Kazabazua, Que	479	1914	218	234
Kearney, Ont	552	1915	14	31
Keewatin, Ont	34–F	1915	19	33
Kempton, Ont	113	1917	286	320
Kemptville, Ont	113–A	1913	52	78
Kenaston, Sask	21–D	1914	227	240
Kennetcook, N.S	523–B, 524–B	1916	145	171
Kenora, Ont	36–F, 37–F, 38–F	1915	19	33
Kentville, N.S	492–B *to* 494–B	1916	148	175
Kilburn, N.B	37–B	1917	277	314
Killaloe, Ont	518,519	1915	16	32
Killarney, Man	25–C	1913	67	87
Kingston, N.S	486–B	1916	148	175
Kingston, Ont	139, 141, 141–A, 142	1917	287	321
Kipp, Alta	81–D	1915	25	38
Kippen, Ont	330	1913	62	84
Kirkcaldy, Alta	70–D	1915	26	38
Kirk Ferry, Que	465, 466	1914	218	234
Kleinburg, Ont	258	1913	58	82
Knowlton, Que	49	1917	282	318
Komoka, Ont	237–A	1913	56	80
Kootenay Landing, B.C	204–D, 205–D	1917	268	308

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	L.			
Lac Baker, N.B	267–B	1917	247	290
Lake Louise, Alta	248–C, 249–C	1916	167	189
Landis, Sask	16–H	1915	20	34
Lansdowne, Ont	130, 131	1917	286	321
Leckford, Sask	41–D	1914	228	240
Leney, Sask	8–H	1915	19	34
Lennoxville, Que	6	1917	283	319
Lepreau, N.B	89–B	1917	279	316
Lethbridge, Alta	196–C *to* 200–C	1915	24	36
" "	83–D	1915	25	38
Levis, Que	221–B, 222–B	1913	52	77
"	222–B	1916	153	179
L'Islet, Que	568–B	1917	248	291
Listowel, Ont	307,308	1913	61	83
Little River, Y.T	34	1913*	26	26
Liverpool, N.S	418–B, 419–B, 420–B	1915	11	29
Londesborough, Ont	318	1913	61	83
London, Ont	235, 236	1913	56	80
Londonderry, N.S	CMLXXIX	1916	‡	172
Longwood, Ont	239–A	1913	56	81
Lousana, Alta	58–F	1916	165	187
Low, Que	476	1914	218	234
Lower Argyle, N.S	455–B	1915	13	30
Lower East Pubnico, N.S	452–B	1915	12	29
Lucan Crossing, Ont	337	1913	62	84
Lumsden, Sask	7–D	1913	71	90
Lyn, Ont	125	1917	286	321
Lynden, Ont	217	1913	55	80
Lyon Brook, N.S	156–B	1913	47	74
	M.			
Maccan, N.S	CMXVI	1916	‡	173
Macleod, Alta	87–D, 88–D	1917	262	304
Macoun, Sask	69–C	1913	69	89
Madawaska, Ont	530, 531	1915	15	32
Madoc Jct., Ont	182–G	1917	257	301
Magog, Que	40, 41, 41–A	1917	281	317
Maitland, Ont	121	1917	286	320
Malagash, N.S	144–B	1913	46	74
Mallorytown, Ont	128	1917	286	321
Manitou, Man	11–C, 12–C	1913	66	87
Maple Creek, Sask	145–C, 146–C	1914	231	241
Markdale, Ont	279	1913	59	82

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ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Marysville, Ont	152	1917	288	321
Massawippi, Que	28–A	1913	48	75
Massey, Ont	590	1916	155	181
Mather, Man	17–C	1913	67	87
McAdam, N.B	11–B	1917	275	313
McGivney Jct., N.B	333–B	1914	215	233
Meadowville, N.S	153–B	1913	46	74
Medicine Hat, Alta	167–C, 168–C,169–C	1915	22	35
Medora, Man	40–C	1913	68	88
Medway, N.S	415–B	1915	10	28
Megantic, Que	21–A–2, 22–A	1913	50	76
Melancthon, Ont	271–A, 272	1913	59	82
Melita, Man	42–C, 43–C	1913	68	88
Memramcook, N.B	549–B	1916	146	174
Merigomish, N.S	164–B	1913	47	74
Merrickville, Ont	84–G	1917	251	295
Merritton, Ont	209	1913	63	85
Michel, B.C	114–D	1917	263	304
Michipicoten, Ont	698	1917	261	303
Midale, Sask	71–C	1913	69	89
Middleton, N.S	482–B, 483–B	1916	148	175
Midhurst, Ont	390	1913	65	86
Midnapore, Alta	54–D	1915	27	39
Milan, Que	18–A–2	1913	50	76
Milestone, Sask	85–C	1913	70	89
Milk River, Alta	213–C, 214–C	1915	25	37
Millerton, N.B	47–G	1916	152	178
Mine Centre, Ont	42–E	1916	158	183
Minto, Y.T	106	1913*	30	30
Mirror, Alta	63–F	1916	165	187
Molson, Man	10–F	1915	17	33
Monarch, Alta	84–D	1917	261	304
Monckland, Ont	102	1917	285	320
Moncton, N.B	132–B, 133–B, 134–B	1913	45	73
"	373–B, 374–B, 132–B	1914	217	233
"	132–B	1916	146	174
Monk, Que	385–B	1917	245	289
Montague, Y.T	69	1913*	28	28
Mont Carmel, Que	28–G	1917	248	292
Montmagny, Que	566–B	1917	247	291
Mooretown, Ont	362	1914	221	236
Moosejaw, Sask	94–C, 95–C, 96–C	1913	71	89
"	103–C	1914	229	241
Morden, Man	7–C, 8–C	1913	66	87
Morse, Sask	116–C, 117–C	1914	229	241
Mortlach, Sask	110–C	1914	229	241
Mountain, Ont	111	1917	285	320
Moyie, B.C	181–D	1917	267	307

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Mulgrave, N.S.	185–B	1913	48	75
Muniac, N.B.	37–B	1917	277	314
Murrayville, B.C.	23–J	1916	170	191
Musquash, N.B.	91–B, 92–B	1917	279	316
Mystic, Que.	65	1917	282	318
	N.			
Nairn, Ont.	579, 580	1916	154	181
Napadogan, N.B.	323–B, 324–B	1914	215	232
Napanee, Ont.	149 *to* 150–A–2	1917	287	321
Napinka, Man.	41–C	1913	68	88
Nappan, N.S.	CMXIX	1916	‡	173
Nauwigewauk, N.B.	107–B	1913	44	73
Nelson Jct., N.B.	47–G–2	1916	152	178
Newbury, Ont.	242	1913	56	81
Newcastle, Ont.	176	1913	53	79
New Dayton, Alta.	206–C, 207–C	1915	24	36
New Germany, N.S.	469–B–2	1916	147	175
New Glasgow, N.S.	160–B	1913	47	74
New Norway, Alta.	68–F	1916	165	187
New Westminster, B.C.	9–J *to* 13–J	1916	169	190
Nictaux, N.S.	480–B	1916	148	175
Ninga, Man.	29–C	1913	67	87
Nobleford, Alta.	79–D	1915	25	38
Nordenskiöld, Y.T.	47	1913*	27	27
Northfield, Ont.	494	1914	219	235
North Lake, Ont.	106–E	1916	162	185
North Portal, Sask.	†	1913	88	88
Northwood, Ont.	245	1913	57	81
Norton, N.B.	113–B	1913	44	73
Norton Mills, Vermont	23, 24, 25	1917	284	319
Notre-Dame-du-Lac, Que.	64–B	1917	278	314
	O.			
Oak Bay, N.B.	4–B	1917	275	313
Oakville, Ont.	193	1913	55	80
Oban, Sask.	14–H	1915	20	34
Okotoks, Alta.	60–D	1915	26	38
Orangeville, Ont.	267	1913	58	82
Osgoode, Ont.	117–A, 118–A	1913	52	78
Oshawa, Ont.	178–A, 179, 179–A	1913	54	79

‡Refer to Public Works Dept.
†International Boundary Monument.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Osler, Sask	36–D	1914	228	240
Ottawa, Ont	124–A, 125–A	1913	53	78
" "	503, 504, 124–A	1914	220	235
Owen Sound, Ont	286, 287, 288	1913	60	82
Oxbow, Sask	55–C	1913	69	88
Oxford, Ont	114	1917	286	320
Oxford, N.S	136–B	1913	46	74
Oxford Jct., N.S	135–B	1913	45	74
" "	135–B	1916	146	173
	P.			
Painsec, N.B	MDXLIII	1916	‡	174
Pakenham, Ont	68–G, 69–G	1917	250	293
Palgrave, Ont	376	1913	64	86
Palmerston, Ont	305	1913	61	83
Paquette, Que	557–B	1916	153	180
Paris, Ont	222	1913	55	80
Parkbeg, Sask	111–C	1914	229	241
Park Head Jct., Ont	291	1913	60	83
Parkhill, Ont	346	1914	221	236
Parry Sound, Ont	419, 420	1914	223	237
Pasqua, Sask	93–C	1913	71	89
Pelly, Y.T	118, 119	1913*	30	30
Pense, Sask	99–C	1913	71	89
Perth, Ont	112–G *to* 115–G	1917	253	295
Perth, N.B	39–B	1917	277	314
Petitcodiac, N.B	123–B	1913	45	73
Piapot, Sask	141–C	1914	231	241
Pickering, Ont	180–A–2	1913	54	79
Piedmont, N.S	165–B	1913	47	74
Pierson, Man	46–C	1913	68	88
Pike Creek, Ont	253	1913	57	81
Pilot Mound, Man	15–C	1913	67	87
Pincher, Alta	94–D	1917	262	304
Pinewood, Ont	20–E	1914	226	239
Pinto, Sask	67–C	1913	69	88
Plaster Rock, N.B	301–B, 302–B	1914	213	232
Pomquet, N.S	176–B	1913	58	74
Port Arthur, Ont	93–E *to* 95–E	1916	161	184
Port Clyde, N.S	442–B	1915	12	29
Porthill, Idaho	198–D	1917	268	307
Port Hope, Ont	172, 172–A, 173	1913	53	79
Port Robinson, Ont	212	1913	63	85
Port Saxon, N.S	441–B	1915	12	29

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Port Union, Ont	182	1913	54	79
Prescott, Ont	118, 119	1917	286	320
Prince Albert, Sask	47–D, 48–D, 49–D	1914	228	240
Princeton, Ont	224	1913	55	80
Pubnico, N.S	454–B	1915	13	30
	Q.			
Quarryville, N.B	45–G	1916	152	178
	R.			
Rainy River, Ont	17–E	1914	226	239
Reford, Sask	18–H	1915	20	34
Regina, Sask	1–D, 2–D, 3–D	1913	71	90
Renfrew, Ont	505, 506, 507	1915	17	32
"	505	1917	251, 254	294, 299
Revelstoke, B.C	311–C *to* 314–C	1917	271	310
River Glade, N.B	125–B	1913	45	73
Rivière-du-Loup, Que	76–B, 77–B, 78–B	1917	279	315
Rivière Ouelle Jct., Que	MCXXXVII	1917	‡	292
Roche-Percée, Sask	65–C	1913	69	88
Rock Island, Que	33–A	1913	49	75
Roosevelt, Minn	13–E	1914	226	239
Rose Point, Ont	565	1915	13	31
Rosthern, Sask	40–D	1914	228	240
Rothesay, N.B	103–B, 104–B	1913	44	73
Rouleau, Sask	88–C, 89–C	1913	70	89
Rush Lake, Sask	120–C	1914	230	241
Russell, Ont	499	1914	220	235
Ryley, Alta	47–H, 48–H	1916	163	186
	S.			
Sable River, N.S	427–B	1915	11	29
Sackville, N.B	MCCCCXXXVI, *etc.*	1916	‡	174
Sandstone, Alta	58–D	1915	26	38
Sarnia, Ont	357, 358, 359, 360	1914	221	236
Saskatoon, Sask	29–D *to* 33–D	1914	227, 228	240
Sault Ste. Marie, Ont	632, 633	1916	157	182
Sault Ste. Marie, Mich	636	1916	157	182
Sawyerville, Que	552–B	1916	153	180
Scotia Jct., Ont	553	1915	14	31

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Scotstown, Que	16–A–2	1913	49	76
Scott, Sask	19–H	1915	20	34
Shag Harbour, N.S	449–B	1915	12	29
Shallow Lake, Ont	290	1913	60	83
Shannonville, Ont	154	1917	288	321
Sharbot Lake, Ont	124–G	1917	253	295
Shelburne, N.S	433–B *to* 436–B	1915	11, 12	29
Shelburne, Ont	271	1913	59	82
Sherbrooke, Que,	1, 2, 3	1917	283	319
"	35, 36	1917	281	317
Siegas, N.B	51–B	1917	277	314
Sirdar, B.C	203–D	1917	268	308
Slate River, Ont	87–E	1916	161	184
Smiths Falls, Ont	88–G, 89–G, 107–G, 108–G	1917	251 to 253	295
South Maitland, N.S	528–B, 529–B	1916	145	172
South Stukely, Que	45	1917	281	317
Spillimacheen, B.C	159–D	1917	265	306
Sprague, Man	10–E	1914	225	239
Springfield, N.S	472–B	1916	147	175
Springhill, Que	19–A–2, 20–A	1913	50	76
Springhill Jct., N.S	CMX	1916	‡	173
Sprucedale, Ont	556	1915	14	31
Sprucegrove, Alta	64–H	1917	271	311
Stanbridge, Que	67	1917	282	318
Stanley, Ont	86–E	1916	161	184
Stanstead, Que	34	1913	49	75
Steele, B.C	138–D	1917	264	305
Steelton, Ont	634, 635	1916	157	182
Stephen, Minnesota	1–C	1913	66	87
Stevens, Y.T	148	1913*	31	31
Stewart Crossing, Y.T	162, 163	1913*	32	32
Stickney, N.B	32–B	1917	276	313
Stirling, Alta	203–C, 204–C	1915	24	36
Stittville, Ont	55–G	1917	249	293
Stoney Creek, Ont	201	1913	63	85
Stoney Point, Ont	250	1913	57	81
Stonyplain, Alta	65–H	1917	271	311
Stottsville, Que	79	1917	280	317
Sudbury, Ont	454, 454–A	1914	225	238
"	567–A	1916	154	181
Sussex, N.B	117–B	1913	44	73
Sutton, Que	52	1917	282	318
Swalwell, Alta	51–F	1916	164	187
Swift Current, Sask	126–C, 127–C.	1914	230	241

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
	ST.			
St. Alexandre, Que. (Kamouraska Co.)	MCLI	1917	‡	292
Ste. Anne, Que. (Kamouraska Co.)	MXCIX	1917	‡	292
St. Anselme, Que	214–B	1913	52	77
St. Armand, Que	68, 69, 70	1917	282	318
St. Catharines, Ont	207, 208	1913	63	85
St. Charles Jct., Que	MCXXXI	1917	‡	291
St. Evariste, Que	195–B, 196–B	1913	51	77
St. George, N.B	83–B	1917	279	316
Ste. Henedine, Que	212–B	1913	52	77
St. Henri, Que. (Levis County)	216–B	1913	52	77
St. Hilaire, N.B	262–B	1917	247	290
St. Honoré, Que	70–B	1917	278	314
St. Jean Port Joli, Que	MCVI	1917	‡	291
St. John, N.B	97–B *to* 100–B	1917	280	316
St. Johns, Que	75, 76	1917	280	317
St. Joseph-de-Lévis, Que	220–B	1913	52	77
St. Leonard, N.B	50–B	1917	277	314
St. Louis, Que. (Beauharnois County)	88	1917	284	320
Ste. Malachie, Que	227–B	1917	244	289
St. Malo, Que. (Compton County)	555–B	1916	153	180
St. Margaret, N.S	394–B	1915	9	28
St. Mary, Que. (Beauce County)	209–B	1913	51	77
St. Pacôme, Que	MXCVI	1917	‡	292
St. Paschal, Que	MCXLVI	1917	‡	292
St. Philippe-de-Neri, Que	27–G	1917	248	292
St. Pierre, Que. (Montmagny Co.)	565–B	1917	247	291
St. Polycarpe Jct., Que	92	1917	285	320
Ste. Rose, Que (Temiscouata County)	62–B	1917	278	314
St. Stephen, N.B	2–B, 3–B	1917	275	313
St. Vallier, Que	MCXXV	1917	‡	291
	T.			
Taber, Alta	186–C, 187–C	1915	23	36
Takhini, Y.T	20, 21	1913*	25	25
Tako, Sask	20–H	1915	20	34
Tara, Ont	293	1913	60	83
Tatamagouche, N.S	147–B	1913	46	74
Thamesville, Ont	243–A	1913	57	81
Thedford, Ont	349	1914	221	236
Thornhill, Man	9–C	1913	66	87
Thorold, Ont	210, 211	1913	63	85
Three Hills, Alta	53–F	1916	164	187
Tichborne, Ont	146–G	1917	255	300

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Continued.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Tofield, Alta	50–H, 51–H	1916	163	186
Tompkins, Sask	138–C	1914	231	241
Toronto, Ont	185 *to* 189	1913	54	79
Tottenham, Ont	377–A	1913	64	86
Trenton, Ont	161	1917	288	322
Tring Jct., Que	204–B	1913	51	77
Trochu, Alta	55–F	1916	164	187
Truro, N.S	534–B *to* 537–B	1916	146	172
Tupperville, Ont	369	1914	222	236
Tusket, N.S	460–B	1915	13	30
Tweed, Ont	174–G *to* 176–G	1917	256	296
	U.			
Unity, Sask	22–H	1915	20	34
Upper Woods Harbour, N.S	451–B	1915	12	29
Utopia, Ont	387	1913	65	86
	V.			
Valleyfield, Que	89	1917	284	320
Valley Jct., Que	207–B	1913	51	77
Vancouver, B.C	1–J *to* 5–J	1916	168	190
Vera, Sask	23–H	1915	20	34
Verona, Ont	152–G	1917	255	300
Versailles, Que	72	1917	280	317
Viking, Alta	43–H	1916	162	185
Vulcan, Alta	68–D, 69–D	1915	26	38
	W.			
Wabamun, Alta	69–H	1917	272	311
Wainwright, Alta	36–H	1915	21	34
Wakefield, Que	469, 470	1914	218	234
Wallaceburg, Ont	367	1914	222	236
Walsh, Alta	155–C	1915	22	35
Warman, Sask	35–D	1914	228	240
Warner, Alta	209–C, 210–C	1915	24	36, 37
Warroad, Minn	12–E	1914	226	239
Waterville, N.S	489–B	1916	148	175
Waterville, Que	9	1917	283	319
Webb, Sask	132–C	1914	230	241
Webbwood, Ont	585	1916	155	181
Welland, Ont	213	1913	64	85
Welland Jct., Ont	214	1913	64	85

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.—*Concluded.*

Place.	B.M. Number.	Year of Publication.	Description.	Elevation.
			Page.	Page.
Westchester, N.S.	CMLX	1916	‡	172
Westfort, Ont.	89–E	1916	161	184
West Huntingdon, Ont.	181–G	1917	257	301
West Merigomish, N.S.	163–B	1913	47	74
Weston, Ont.	256–A	1913	58	82
Weyburn, Sask.	80–C, 81–C	1913	70	89
Whitby, Ont.	180–A	1913	54	79
Whitehorse, Y.T.	1	1913*	25	25
Whitemouth, Man.	14–F	1915	18	33
White Pass, B.C.	42–R, 43–R	1913*	23	23
Whiterock, B.C.	17–J, 18–J	1916	169	190
Whitewater, Man.	35–C	1913	68	88
Whitney, Ont.	536	1915	15	31
Wilcox, Sask.	86–C, 87–C	1913	70	89
Wilmot, N.S.	485–B	1916	148	175
Winchester, Ont.	109	1917	285	320
Windsor, Ont.	255	1913	57	81
Windsor, N.S.	502–B *to* 505–B	1916	149	176
Windsor Jct., N.S.	MXXXIV	1916	‡	171
Wingham, Ont.	314	1913	61	83
Winnifred, Alta.	176–C	1915	23	35
Winnipeg, Man.	1–F, 2–F, 3–F	1915	17	33
Winona, Ont.	202	1913	63	85
Winter, Sask.	25–H	1915	20	34
Wolfville, N.S.	495–B *to* 497–B	1916	148, 149	175
Woodstock, Ont.	226, 227	1913	55	80
Woodstock, N.B.	25–B, 26–B, 27–B	1917	276	313
Worthington, Ont.	577	1916	154	181
Wounded Moose, Y.T	179	1913*	33	33
	Y.			
Yahk, B.C.	187–D	1917	267	307
Yarmouth, N.S.	463-B, 464-B, 465-B	1915	13	30
Yellow Grass, Sask.	83–C	1913	70	89
Yukon Crossing, Y.T.	94	1913*	29	29
	Z.			
Zumbro, Sask.	27–H	1915	20	34

‡Refer to Public Works Dept.

Dominion Observatory,

Ottawa,

February, 1917.

DEPARTMENT OF THE INTERIOR
CANADA
HON. ARTHUR MEIGHEN, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

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OTTAWA

OTTO KLOTZ, LL.D., D.Sc., *Director*

Vol. III, No. 9

Gravity

BY

F. A. McDIARMID, B.A.

OTTAWA
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FOREWORD

With the view of reducing the cost of publication the greater part of the tabular matter, the illustrations and the formulæ have been omitted.

OTTO KLOTZ
Director.

November, 1917.

GRAVITY

By F. A. McDIARMID, B.A.

During the season of 1915 there were observed in Canada twenty-four gravity stations as follows:—St. John, N.B.; Moncton, N.B.; Charlottetown, P.E.I.; Sydney, N.S.; Truro, N.S.; Halifax, N.S.; Yarmouth, N.S.; Woodstock, N.B.; Edmundston, N.B.; Bathurst, N.B.; Percé, Que.; Kenora, Ont.; Winnipeg, Man.; Brandon, Man.; Moosejaw, Sask.; Medicine Hat, Alta.; Calgary, Alta.; Banff, Alta.; Field, B.C.; Glacier, B.C.; Revelstoke, B.C.; Kamloops, B.C.; North Bend, B.C.; and Vancouver, B.C. Two other stations—Dunmore, Alta., and Yale, B.C.—were on the observing programme prepared by Dr. Klotz, Assistant Chief Astronomer, under whose supervision the gravity work is carried on, but the difficulty of securing suitable observing rooms led to their abandonment.

The first observations were made at St. John on the eleventh of May, and the last at Vancouver on the seventh of September. During that interval more than two weeks were spent in Ottawa standardizing the pendulums. The eleven stations in eastern Canada were observed in six weeks, and the thirteen in western Canada in less than eight weeks.

The instruments, their use, the method of observing, the determination of the instrumental coefficients are all described in the *Publications of the Dominion Observatory*, Vol. II, No. 10. In the observing, only knife-edge No. 1 was used and the pendulums were all swung with the direct face toward the flash apparatus. The flexure was determined by the same method as in 1914.

The observing chronometers were rated by comparisons with standard sidereal clocks. Through the kindness of Mr. D. L. Hutchinson, Director of the St. John, N.B., meteorological observatory, clock signals were sent twice a day from the St. John clock to the stations occupied in eastern Canada, and for the work in western Canada time signals were obtained from the Dominion Observatory Riefler standard sidereal clock. The St. John clock is a Riefler of the latest type, is splendidly mounted in a constant temperature room, and is enclosed under constant pressure. Its rate during the whole of the gravity campaign in the east was very nearly zero, and very constant. Mr. Hutchinson, largely on his own initiative, had built a splendid observatory. It is well equipped with modern instruments and the excellent results show a thorough knowledge of practical observing.

STANDARDIZING OF PENDULUMS

During the season of 1914 considerable difficulty was experienced due to changes in the lengths of the pendulums. On account of some injury to pendulum No. 2, it would only swing a very few hours, and the observations of that year were carried on with the two pendulums Nos. 1 and 3. Previous to commencing the 1915 work, pendulum No. 2 was repaired by slightly grinding the head of the pendulum where it rests on the lifter, and it has behaved very satisfactorily since. The periods of the three pendulums were determined in April, before commencing the season's campaign, again in July between the eastern and western work, and also in September after completing the season's work. There were changes in the lengths of the different pendulums during the summer, and these will be referred to later under "Variation in lengths of pendulums."

DESCRIPTIONS OF STATIONS

The pendulum stations observed in 1915 were referred, when possible to astronomic stations, and when no astronomic station was available, to survey posts. They are described as follows:—

St. John, N.B.—The pendulum pier was in the basement of the meteorological observatory, Douglas Ave., 109 ft. above mean sea-level, and 3284 ft. south and 4476 ft. west of astronomic station near corner of Lombard and Southwark streets, distance to astronomic station scaled from map of the city of St. John.

Moncton, N.B.—The pendulum pier was in the basement of the general offices of the Intercolonial railway, 7 ft. below the level of the G.S.C. (Geodetic Survey of Canada) bench-mark on the east wall of the general office building, and 200 ft. north and 1000 ft. east of astronomic station, distance to astronomic station measured.

Charlottetown, P.E.I.—The pendulum pier was in the battery room of the Western Union Telegraph company, 25 ft. above mean sea-level, and 329 ft. south and 57 ft. west of astronomic station, distance to astronomic station measured.

Sydney, N.S.—The pendulum pier was in the basement of the Maritime Telephone and Telegraph office on Pitt street, 42 ft. above mean tide water, and 674 ft. south and 679 ft. east of astronomic station, distance to astronomic station scaled from map of the town of Sydney.

Truro, N.S.—The pendulum pier was in the Western Union Telegraph stores, nearly opposite the I. C. R. station, on level with rail opposite station, and 722 ft. south and 785 ft. west of astronomic station, distance to astronomic station scaled from map of the town of Truro.

Halifax, N.S.—The pendulum pier was in the battery room of the Western Union Telegraph company, near corner of Sackville and Hollis streets, 30 ft.

above mean sea-level, and 4029 ft. north and 10730 ft. east of astronomic station, distance to astronomic station scaled from map of the city of Halifax.

Yarmouth, N.S.—The pendulum pier was in the battery room of the Western Union Telegraph company, 30 ft. above mean sea-level, and 66 ft. east and 787 ft. south of astronomic station, distance to astronomic station scaled from map of the town of Yarmouth.

Woodstock, N.B.—The pendulum pier was in the furnace room of the armoury, 14 ft. below the level of the G. S. C. bench-mark in the Woodstock post-office, and 2887 ft. north and 1403 ft. east of astronomic station, distance to astronomic station scaled from map of the town of Woodstock.

Edmundston, N.B.—The pendulum pier was in the basement of the Edmundston hotel, 2 ft. above the G. S. C. bench-mark near the C. P. R. station, and 415 ft. north and 421 ft. east of astronomic station, distance to astronomic station measured.

Bathurst, N.B.—The pendulum pier was in the basement of the Bathurst post-office, 15 ft. above mean sea-level, and 268 ft. south and 734 ft. east of astronomic station, distance to astronomic station measured.

Percé, Que.—The pendulum pier was in the cellar of Mr. Biard's house, 20 ft. above mean sea-level, 4118 ft. north and 1717 ft. east of astronomic station, distance to astronomic station measured.

Kenora, Ont.—The pendulum pier was in the battery room of the C. P. R. Telegraph company, in the basement of the C. P. R. station, 8 ft. below the G. S. C. bench-mark in the wall of the C. P. R. station. Geographical position, as scaled from the Department of Interior large scale map of the Northwest, is latitude 49° 46′ and longitude 94° 30′.

Winnipeg, Man.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company in the C. P. R. station, 10 ft. below the G. S. C. bench-mark in the Union station, and 7280 ft. north and 3500 ft. west of astronomic station, distance to astronomic station scaled from map of the city of Winnipeg.

Brandon, Man.—The pendulum pier was in the battery room of the C. P. R. Telegraph company, near corner of Rosser avenue and Tenth street, 10 ft. above rail in front of C. P. R. station, and 60 ft. west and 40 ft. north of northwest corner of Rosser avenue and Tenth street, city of Brandon.

Moosejaw, Sask.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company, 5 ft. below the G. S. C. bench-mark in the C. P. R. station, and 50 ft. east and 2640 ft. south of the northwest corner of section 33, township 16, range 26, west of the second meridian, distance measured.

Medicine Hat, Alta.—The pendulum pier was in the battery room of the C. P. R. Telegraph company in the C. P. R. station, 5 ft. below the level of the bench-mark in the C. P. R. station, and 900 ft. east and 270 ft. south of the northwest corner of the southeast quarter of section 31, township 12, range 5, west of the fourth meridian, distance scaled from map of the town of Medicine Hat.

Calgary, Alta.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company in the C. P. R. station, 7 ft. below the level of the G. S. C. bench-mark in the station, and 350 ft. north and 400 ft. east of the astronomic station, distance to astronomic station scaled from map of the city of Calgary.

Banff, Alta.—The pendulum pier was in the cellar of the C. P. R. station, 4 ft. below the level of the G. S. C. bench-mark in bridge over the stream just west of Banff station, and 900 ft. south and 8880 ft. west of the northwest corner of township 25, range 12, west of the fifth meridian, distance scaled from map of the town of Banff.

Field, B.C.—The pendulum pier was in the basement of the Mount Stephen hotel, 6 ft. above the rail in front of the C. P. R. station, 645 ft. north and 700 ft. west of astronomic station, distance to astronomic station measured.

Glacier, B.C.—The pendulum pier was in the furnace room of the Glacier house, 4 ft. above the level of the rail in front of the C. P. R. station, and 396 ft. west and 3234 ft. south of the northeast corner of section 36, township 26, range 26, west of the fifth meridian, distance scaled from map of the township.

Revelstoke, B.C.—The pendulum pier was in the battery room of the C. P. R. Telegraph company, 10 ft. below the level of the rail in front of the C. P. R. station, and 1552 ft. west and 262 ft. north of astronomic station, distance to astronomic station measured.

Kamloops, B.C.—The pendulum pier was in the battery room of the C. P. R. company in the C. P. R. station, 5 ft. below the level of the rail in front of the station, and 660 ft. south and 640 ft. east of astronomic station, distance to astronomic station measured.

North Bend, B.C.—The pendulum pier was in the basement of the Fraser Canyon hotel, 4 ft. above the level of the rail in front of the C. P. R. station, and 794 ft. south and 14200 ft. west of the northeast corner of township 10, range 26, west of the sixth meridian, distance scaled from map of the township.

Vancouver, B.C.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company in the C. P. R. station, 15 ft. above the rail in front of the station, and 1409 ft. east and 5755 ft. south of the astronomic station at Brockton Point, distance to astronomic station scaled from the map of the city of Vancouver.

In the following table are given brief descriptions of the pendulum piers, the longitude, the latitude, and the altitude of each station. At every station the pendulum apparatus was mounted on a concrete floor, on three stones set in plaster of Paris. The method of mounting and the description of instruments are given in the *Publications of the Dominion Observatory*, Vol. II, No. 10. The temperature conditions were very satisfactory at all the stations, the temperature rarely having a range exceeding three degrees Centigrade.

Station	Longitude			Latitude			Altitude	Description of Station
	h.	m.	s.	°	′	″	metres	
St. John	4	24	20	45	16	03	33	Pier in basement of meteorological observatory.
Moncton	4	19	09	46	05	04	14	Pier in basement of I.C.R. offices.
Charlottetown	4	12	30	46	13	55	8	Pier in cellar of Western Union Telegraph office.
Sydney	4	00	47	46	08	21	12	Pier in basement of Maritime Telegraph and Telephone company's office.
Truro	4	13	06	45	21	40	18	Pier in Western Union Telegraph stores.
Halifax	4	14	15	44	40	47	9	Pier in battery room of Western Union Telegraph company.
Yarmouth	4	24	29	43	50	07	9	Pier in battery room of Western Union Telegraph company.
Woodstock	4	30	18	46	09	02	56	Pier in furnace room of armoury.
Edmundston	4	33	18	47	22	11	148	Pier in cellar of Edmundston hotel.
Bathurst	4	22	36	47	37	10	5	Pier in cellar of Bathurst post-office.
Percé	4	16	51	48	31	33	6	Pier in cellar of Mr. Biard's house.
Kenora	6	18	00	49	46	00	330	Pier in battery room of C.P.R. Telegraph company.
Winnipeg	6	28	32	49	54	23	231	Pier in terminal room of C.P.R. Telegraph company.
Brandon	6	39	47	49	50	54	366	Pier in battery room of C.P.R. Telegraph company.
Moosejaw	7	02	07	50	23	26	541	Pier in battery room of C.P.R. Telegraph company.
Medicine Hat	7	22	40	50	02	25	664	Pier in battery room of C.P.R. Telegraph company.
Calgary	7	36	15	51	02	43	1044	Pier in terminal room of C.P.R. Telegraph company.
Banff	7	42	18	51	10	53	1376	Pier in basement of C.P.R. station.
Field	7	45	59	51	23	42	1239	Pier in basement of Mount Stephen hotel.
Glacier	7	49	58	51	15	44	1248	Pier in furnace room of Glacier house.
Revelstoke	7	52	47	50	59	48	453	Pier in battery room of C.P.R. Telegraph company.
Kamloops	8	01	18	50	40	42	352	Pier in battery room of C.P.R. Telegraph company.
North Bend	8	05	48	49	52	17	152	Pier in basement of Fraser Canyon hotel.
Vancouver	8	12	27	49	16	49	6	Pier in terminal room of C.P.R. Telegraph company.

RATING OF CHRONOMETERS

To all the stations, as stated above, clock signals were sent from standard sidereal clocks, time being secured for the eastern work from the St. John meteorological observatory, and for the western work from the Dominion Observatory.

Below follow tables of chronometer comparisons, the deduced daily rates, and the corrections to the periods of the pendulums due to clock rates. An examination of the corrections to the periods of the pendulums due to clock rates will show the absolute necessity of not depending on the chronometers for more than a very few minutes. The rates of the two observing chronometers, Bond 519 and Dent 48419, were constantly changing with changes of temperature and from other causes. Both of these chronometers, the best procurable, occasionally changed their daily rates as much as two seconds in a couple of hours. The rate of the observing chronometers is one of the most important considerations in pendulum observations, hence the necessity of making the time of observing coincidences coincide nearly with the time of clock comparisons. The standard clocks both at St. John and Ottawa have very constant rates, and the errors from these sources are nearly zero.

CHRONOMETER COMPARISONS AND DEDUCED CORRECTIONS TO PENDULUM PERIOD

Station	Date	Comparison of Chronometers						Relative daily rate B to R	Daily Rates		Corrections to 7th place of period	
		Bond			Riefler				Riefler	Bond	Riefler	Bond
	1915	h.	m.	s.	h.	m.	s.					
Ottawa....................	April 7	4	08	00	4	07	58·16					
								−1·673	−0·140	−1·813	−8	−105
	" 7	10	44	00	10	43	57·70					
								−2·128	−0·140	−2·268	−8	−132
	" 7	18	17	00	18	16	57·03					
								−2·108	−0·140	−2·248	−8	−130
	" 8	3	46	00	3	45	56·22					
								−1·690	−0·140	−1·830	−8	−106
	" 8	11	09	00	11	08	55·68					
								−1·559	−0·140	−1·699	−8	− 99
	" 8	18	14	00	18	13	55·22					
								−1·899	−0·140	−2·039	−8	−118
	" 9	3	35	00	3	34	54·48					
								−1·865	−0·140	−2·005	−8	−116
	" 9	10	32	00	10	31	53·94					
								−1·928	−0·140	−2·068	−8	−120
	" 9	18	23	00	18	22	53·31					
								−2·223	−0·140	−2·363	−8	−137
	" 10	4	06	00	4	05	52·41					

CHRONOMETER COMPARISONS AND DEDUCED CORRECTIONS TO PENDULUM PERIOD—*Con.*

Station	Date	Comparison of Chronometers						Relative daily rate	Daily Rates		Corrections to 7th place of period	
		Bond			Riefler			B to R	Riefler	Bond	Riefler	Bond
	1915	h.	m.	s.	h.	m.	s.					
Ottawa	April 19	17	00	00	17	00	14·77					
								−2·513	−0·140	−2·653	−8	−154
"	19	0	27	00	0	27	13·99					
								−2·532	−0·140	−2·672	−8	−155
"	20	8	59	00	8	59	13·09					
								−1·976	−0·140	−2·116	−8	−123
"	20	16	09	00	16	09	12·50					
								−2·090	−0·140	−2·230	−8	−129
"	20	23	23	00	23	23	11·87					
								−2·179	−0·140	−2·319	−8	−135
"	21	8	38	00	8	38	11·03					
								−1·758	−0·140	−1·898	−8	−110
"	21	15	44	00	15	44	10·51					
								−1·800	−0·140	−1·940	−8	−113
"	21	23	36	00	23	36	9·92					
								−2·206	−0·140	−2·346	−8	−138
"	22	8	51	00	8	51	9·07					
								−1·906	−0·140	−2·046	−8	−119
"	22	16	24	00	16	24	8·47					

REDUCTION OF OBSERVATIONS

The formulae and methods of reduction of the observations are given in the *Publications of the Dominion Observatory*, Vol. II, No. 10, and will not be repeated here.

VARIATION IN LENGTHS OF PENDULUMS

During the season of 1914 the pendulums changed their lengths at least three times. Fortunately, it was possible to secure frequent observations at Ottawa, the base point, and so from the periods obtained at the different stations, a reliable gravity result was secured. Also, during 1914, only pendulums Nos. 1 and 3 were used, some accident rendering No. 2 useless. The changes in the periods of the pendulums always showed themselves after a trip where there was frequent handling of the boxes. This led to the conclusion that better packing boxes might greatly lessen the trouble. During the winter new and more substantial boxes were made, the small box holding the pendulums was placed in a large box fitted with three-inch hair pads. This made a splendid carrying case, and as a result there has been very little trouble during the past summer. Pendulum No. 2 has been repaired by grinding out a small portion of the head, and the complete set has been used all the past season.

The pendulums were standardized at the Dominion Observatory in April, and after observing at all the stations in eastern Canada it was found that the differences of the periods of the pendulums agreed with the differences obtained at Ottawa. Observations were again made at Ottawa in July, and it was found that there were slight changes in the periods from those obtained in April. Pendulum No. 1 had changed its period from 0.5013225 second to 0.5013240 second, and pendulum No. 2 from 0.5014422 second to 0.5014408 second, while pendulum No. 3 remained constant at 0.5014109 second. The outfit was then taken to Kenora, and here another change was detected. Special precautions were then taken in handling the pendulums for the rest of the summer, and there were no further changes. On restandardizing at Ottawa in September, the periods of the three pendulums Nos. 1, 2 and 3 were 0.5013244 second, 0.5014431 second and 0.5014102 second respectively. These changes although small are very troublesome to good work, and if they had occurred in the middle of a trip would have necessitated the repetition of a part of the work.

The pendulum apparatus of the United States Coast and Geodetic Survey gave considerable trouble due to changing lengths of the pendulum. A careful examination of the pendulums failed to reveal any faults in construction, but on account of the trouble appearing frequently, the experiment was tried of putting a rivet through the bob of the pendulum and the stem. This seems to have removed the trouble, and there have been no further changes. Mr. Bowie, chief of the Department of Geodesy of the Coast and Geodetic Survey, recently informed the writer that it was the intention to treat all their pendulums in the same manner, and certainly some steps must be taken to provide pendulums of constant length, if satisfactory results are to be obtained. The three Ottawa pendulums have now each had the bob and stem rigidly connected by means of a rivet.

DEDUCTION OF ABSOLUTE GRAVITY

The ratio of gravity at two places is readily obtained from the fundamental formula of the simple pendulum, $P=2\pi\sqrt{\frac{l}{g}}$, where P is the period, and l the length of the corresponding pendulum, and g is the force of gravity. There is then obtained the relation $P^2 : P_o^2 = g_o : g$, or $g_o = \frac{P^2}{P_o^2} g$, where P and g are the period and gravity at the base point, and P_o is the period at the field station.

The gravity at Ottawa as determined from Washington in 1914 is 980.615 dynes, and all our field stations are based on this value for Ottawa. In deducing the gravity for the field stations, two different sets of values for the periods of the pendulums at Ottawa were used. The changes in the periods of the pendulums have already been discussed. For the stations, St. John, Moncton, Charlottetown, Sydney, Truro, Halifax, Yarmouth, Woodstock, Edmundston, Bathurst and Percé the periods obtained at Ottawa in April were used; and for the stations, Kenora, Winnipeg, Brandon, Moosejaw, Medicine Hat, Calgary, Banff, Field, Glacier, Revelstoke, Kamloops, North Bend and Vancouver the values obtained in September were used. The periods of the pendulums obtained in Ottawa in July were discarded entirely, as there were changes in the lengths of the pendulums between Percé and Ottawa, and also between Ottawa and Kenora.

In the following table are given the periods of the three pendulums for the different stations, and the deduced value of gravity in dynes.

Station	Periods of Pendulums in Seconds			Value of g in dynes			
	1	2	3	1	2	3	Mean
Ottawa	·5013226	·5014422	·5014109	....	....	....	980·615
St. John	·5013108	·5014306	·5013997	980·660	980·660	980·659	980·660
Moncton	·5012945	·5014140	·5013830	980·725	980·725	980·724	980·725
Charlottetown	·5012930	·5014125	·5013814	980·730	980·731	980·730	980·730
Sydney	·5012938	·5014130	·5013818	980·727	980·729	980·729	980·728
Truro	·5013112	·5014309	·5013997	980·659	980·659	980·659	980·659
Halifax	·5013339	·5014531	·5014221	980·570	980·575	980·571	980·571
Yarmouth	·5013418	·5014610	·5014300	980·540	980·541	980·540	980·540
Woodstock	·5013018	·5014212	·5013901	980·696	980·697	980·696	980·696
Edmundston	·5012825	·5014023	·5013713	980·772	980·771	980·771	980·771
Bathurst	·5012667	·5013863	·5013553	980·834	980·834	980·832	980·833
Percé	·5012378	·5013572	·5013265	980·946	980·948	980·946	980·947
Kenora	·5012331	·5013522	·5013195	980·972	980·971	980·971	980·971
Winnipeg	·5012293	·5013479	·5013151	980·987	980·987	980·987	980·987
Brandon	·5012381	·5013568	·5013239	980·952	980·953	980·953	980·953
Moosejaw	·5012409	·5013603	·5013276	980·942	980·939	980·938	980·940
Medicine Hat	·5012606	·5013795	·5013465	980·865	980·864	980·865	980·865
Calgary	·5012725	·5013906	·5013579	980·819	980·820	980·820	980·820
Banff	·5012900	·5014089	·5013758	980·750	980·749	980·750	980·750
Field	·5012911	·5014100	·5013775	980·745	980·745	980·744	980·745
Glacier	·5012928	·5014117	·5013788	980·739	980·738	980·738	980·738
Revelstoke	·5012515	·5013705	·5013377	980·900	980·900	980·899	980·900
Kamloops	·5012407	·5013590	·5013264	980·943	980·944	980·944	980·944
North Bend	·5012551	·5013740	·5013412	980·886	980·886	980·885	980·886
Vancouver	·5012398	·5013584	·5013254	980·946	980·946	980·947	980·946
Ottawa	·5013244	·5014431	·5014102	....	....	....	980·615

COMPUTATION OF THE INTENSITY OF GRAVITY AT ANY SELECTED STATION

To compute the intensity of gravity at any point on the earth, account must be taken of the altitude of the point, of the effect of the attraction of all the topography upon the earth upon a unit mass at the point, and of the isostatic compensation of that topography.

This problem has been very fully and ably dealt with in Hayford and Bowie's publication*, "The Effect of Topography and Isostatic Compensation upon the Intensity of Gravity"; and the method there set forth has been followed in the reduction of the Canadian observations.

There are two other methods of reducing the value of the force of gravity from sea-level to the observing station. These are known as the "free-air" method and Bouguer's method. As stated in the *Publications of the Dominion Observatory,* Vol. II, No. 10, the free-air method takes account only of the elevation above sea-level. The station is considered as if it were suspended in the air at a height equal to the elevation. In Bouguer's method $dg = -\frac{2g^H}{r}(1-\frac{3\delta}{4\Delta})$, on the supposition that the station is situated on an indefinitely extended plain. Here dg is the correction to computed gravity g, at sea-level, H is the elevation above sea-level, r is the radius of the earth, δ is the density of the matter lying above sea-level and Δ is the mean density of the earth. The Bouguer method takes no account of the isostatic compensation and neglects all curvature of the sea-level surface, the topography being treated as if it were on a plain of indefinite extent. The results from applying these two methods seem to lead to the conclusion that general continental elevations are compensated for by a deficiency of density in the matter below sea-level, but that local topographical irregularities, whether elevations or depressions, are not compensated for, such irregularities being maintained by the partial rigidity of the earth's crust.

A comparison of the anomalies from the three methods of reduction will be given in the table entitled "Table of anomalies from different methods of reduction." A comparison of the anomalies by the new method of Hayford and Bowie, on the one hand, with those by the two older methods on the other hand will show the merits of the Hayford and Bowie method in comparison with the Bouguer and free-air methods.

The means of the anomalies with regard to sign from the new method, the Bouguer and the free-air method are respectively -0.001, -0.042 and -0.011

* Special Publication No. 10, Coast and Geodetic Survey, Washington.

dynes; and the means without regard to sign are 0.012, 0.049 and 0.026 dynes respectively, thus showing that as far as our Canadian work is concerned the new method is vastly superior to the other two methods.

PRINCIPAL FACTS FOR GRAVITY STATIONS OBSERVED IN 1914 AND 1915

Station	Longitude	Latitude	Altitude	Computed g at sea-level	Corrections: Altitude	Corrections: Topography and Isostatic Compensation	Computed Gravity	Observed Gravity	Anomaly O−C
	h. m. s.	° ′ ″	metres	dynes	dynes	dynes	dynes	dynes	dynes
1. Ottawa	5 02 52	45 23 39	83	980·651	−·026	·000	980·625	980·615	−·010
2. Maniwaki	5 03 55	46 22 28	169	980·740	−·052	−·001	980·687	980·685	−·002
3. Kingston	5 05 55	44 14 37	79	980·547	−·024	·008	980·531	980·527	−·004
4. Roberval	4 48 54	48 30 54	107	980·933	−·033	−·015	980·885	980·865	−·020
5. Tadoussac	4 38 52	48 08 25	12	980·900	−·004	−·004	980·892	980·901	·009
6. Portneuf	4 47 35	46 42 32	59	980·770	−·018	·005	980·757	980·760	·003
7. St. Jérôme	4 56 00	45 46 34	107	980·686	−·033	·006	980·659	980·678	·019
8. Ste. Anne-de-Bellevue	4 55 46	45 24 27	34	980·653	−·010	·003	980·646	980·660	·014
9. Mattawa	5 14 49	46 18 43	170	980·734	−·052	−·013	980·669	980·647	−·022
10. Liskeard	5 18 41	47 30 34	194	980·843	−·060	−·004	980·779	980·785	·006
11. Cochrane	5 24 05	49 03 44	277	980·983	−·085	−·004	980·894	980·880	−·014
12. Sault Ste. Marie	5 37 18	46 30 26	186	980·752	−·057	−·005	980·690	980·677	−·013
13. Chapleau	5 33 37	47 50 27	430	980·872	−·133	·012	980·751	980·763	·012
14. Port Arthur	5 56 52	48 26 00	189	980·926	−·058	−·014	980·854	980·817	−·037
15. Rose Point	5 20 10	45 19 02	183	980·644	−·056	·001	980·589	980·603	·014
16. Whitby	5 15 46	43 52 43	84	980·514	−·026	−·004	980·484	980·458	−·026
17. Woodstock (Ont.)	5 23 08	43 08 33	299	980·448	−·093	−·002	980·353	980·349	−·004
18. Windsor	5 32 10	42 19 16	178	980·373	−·055	·000	980·318	980·338	·020
19. St. John	4 24 20	45 16 03	33	980·640	−·010	·016	980·646	980·660	·014
20. Moncton	4 19 09	46 05 04	14	980·713	−·004	·014	980·723	980·725	·002
21. Charlottetown	4 12 30	46 13 55	8	980·727	−·002	·013	980·738	980·730	−·008
22. Sydney	4 00 47	46 08 21	12	980·719	−·004	·014	980·729	980·728	−·001
23. Truro	4 13 06	45 21 40	18	980·649	−·006	·014	980·657	980·659	·002
24. Halifax	4 14 15	44 40 47	9	980·587	−·003	·008	980·592	980·571	−·021
25. Yarmouth	4 24 29	43 50 07	9	980·510	−·003	·014	980·521	980·540	·019
26. Woodstock (N.B.)	4 30 18	46 09 02	56	980·720	−·017	·008	980·711	980·696	−·015
27. Edmundston	4 33 18	47 22 11	148	980·830	−·046	−·010	980·774	980·771	−·003
28. Bathurst	4 22 36	47 37 10	5	980·853	−·002	·000	980·851	980·833	−·018
29. Percé	4 16 51	48 31 33	6	980·935	−·002	−·002	980·931	980·947	·016
30. Kenora	6 18 00	49 46 00	330	981·046	−·102	·018	980·962	980·971	·009
31. Winnipeg	6 28 [illegible]2	49 54 23	231	981·057	−·071	·002	980·988	980·987	−·001
32. Brandon	6 39 47	49 50 54	366	981·053	−·113	−·002	980·938	980·953	·015

PRINCIPAL FACTS FOR GRAVITY STATIONS OBSERVED IN 1914 AND 1915—*Concluded*

Station	Longitude	Latitude	Altitude	Computed g at sea-level	Corrections		Computed Gravity	Observed Gravity	Anomaly O−C
					Altitude	Topography and Isostatic Compensation			
	h. m. s.	° ′ ″	metres	dynes	dynes	dynes	dynes	dynes	dynes
33. Moosejaw	7 02 07	50 23 26	541	981·101	−·167	·003	980·937	980·940	·003
34. Medicine Hat	7 22 40	50 02 25	664	981·070	−·205	−·002	980·863	980·865	·002
35. Calgary	7 36 15	51 02 43	1044	981·160	−·322	−·022	980·816	980·820	·004
36. Banff	7 42 18	51 10 53	1376	981·172	−·425	−·012	980·735	980·750	·015
37. Field	7 45 59	51 23 42	1239	981·190	−·382	−·060	980·748	980·745	−·003
38. Glacier	7 49 58	51 15 44	1248	981·179	−·385	−·066	980·729	980·738	·010
39. Revelstoke	7 52 47	50 59 48	453	981·155	−·140	−·080	980·935	980·900	−·035
40. Kamloops	8 01 18	50 40 42	352	981·127	−·109	−·073	980·945	980·944	−·001
41. North Bend	8 05 48	49 52 17	152	981·055	−·047	−·122	980·886	980·886	·000
42. Vancouver	8 12 27	49 16 49	6	981·002	−·002	−·046	980·954	980·946	−·008

TABLE OF ANOMALIES FROM DIFFERENT METHODS OF REDUCTION

Station	Anomaly		
	Hayford and Bowie's new method	Bouguer method	Free-air method
1. Ottawa	—·010	—·020	—·010
2. Maniwaki	—·002	—·022	—·003
3. Kingston	—·004	—·005	·004
4. Roberval	—·020	—·047	·035
5. Tadoussac	·009	·003	·005
6. Portneuf	·003	·001	·008
7. St. Jérôme	·019	·013	·025
8. Ste. Anne-de-Bellevue	·014	·013	·017
9. Mattawa	—·022	—·054	—·035
10. Liskeard	·006	—·021	·002
11. Cochrane	—·014	—·050	—·018
12. Sault Ste. Marie	—·013	—·039	—·018
13. Chapleau	·012	—·026	·024
14. Port Arthur	—·037	—·073	—·051
15. Rose Point	·014	—·006	·015
16. Whitby	—·026	—·040	—·030
17. Woodstock (Ont.)	—·004	—·039	—·006
18. Windsor	·020	—·001	·020
19. St. John	·014	·026	·030
20. Moncton	·002	·015	·016
21. Charlottetown	—·008	·005	·005
22. Sydney	—·001	·011	·013
23. Truro	·002	·013	·016
24. Halifax	—·021	—·014	—·013
25. Yarmouth	·019	·032	·033
26. Woodstock (N.B.)	—·015	—·013	—·007
27. Edmundston	—·003	—·030	—·013
28. Bathurst	—·018	—·019	—·018
29. Percé	·016	·013	·014
30. Kenora	·009	—·011	·027
31. Winnipeg	—·001	—·025	·001
32. Brandon	·015	—·029	·013
33. Moosejaw	·003	—·057	·006
34. Medicine Hat	·002	—·077	·000
35. Calgary	·004	—·139	—·018
36. Banff	·015	—·156	·003
37. Field	—·003	—·206	—·063
38. Glacier	·010	—·200	—·056
39. Revelstoke	—·035	—·168	—·115
40. Kamloops	—·001	—·115	—·074
41. North Bend	·000	—·140	—·122
42. Vancouver	—·008	—·055	—·054
Mean with regard to sign	—·001	—·042	—·011
Mean without regard to sign	·012	·049	·026

Canada has now a line of gravity stations right across the continent covering more longitude than is covered by any other series of stations on the American continent. These in conjunction with the gravity observations taken in other parts of the world will give valuable additional information for the determination of the figure of the earth, and in a few years, if the gravity observations are continued, Canada will be able to supply to the world valuable scientific knowledge concerning the earth. Mr. Wm. Bowie, Chief of the Department of Geodesy of the United States Coast and Geodetic Survey, is at present combining the Canadian observations with those of the United States in his new publication on the " Figure of the Earth."

Dominion Observatory
Ottawa
April, 1916.

Dominion Observatory

OTTAWA

[illegible]

[illegible]

Orbit of the [illegible]

DEPARTMENT OF THE INTERIOR
CANADA

HON. A. MEIGHEN, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

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Orbit of the Spectroscopic Binary Boss 6142

BY

REYNOLD K. YOUNG, Ph. D.

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ORBIT OF THE SPECTROSCOPIC BINARY BOSS 6142

By REYNOLD K. YOUNG, Ph.D.

The binary character of Boss 6142 (α, 1900, $= 23^h\ 50^m.5$, $\delta = +56°\ 23'$, type Bp, mag. 6·05) was announced by Adams in the *Astrophysical Journal*, April, 1912. Plates taken here indicate that the *H* and *K* lines do not shift their position with the others and remain fixed. Fifty-three spectrograms have been used in determining an orbit. On seven of these the secondary spectrum was measured. There are indications of its presence on many plates where it could not be used. On those plates where the lines due to the primary and those due to the secondary are just separating, the spectral lines are very diffuse, and the spectrum is sometimes almost continuous. Where the stars are moving across the line of sight, the lines are fair. Table I gives a list of all those which were used in reducing the measures.

TABLE I

Element	Wave-Length	Element	Wave-Length
Calcium	3933·825	Hydrogen	4340·634
Calcium	3968·625	Helium	4388·100
Helium	4026·352	Helium	4471·676
Hydrogen	4101·890	Silicon	4552·750
Helium	4143·928	Silicon	4567·950

Difficulty was encountered in obtaining a period which would satisfy the observations taken on Mount Wilson. The interval covered by our own series is about four hundred and six days, while the Mount Wilson observations cover three hundred and thirty-three, and three of their observations out of four lie within a space of time of sixty-seven days. These intervals give little latitude for adjusting the period. The first of their observations seems to be inconsistent with the others. Of course, several velocities obtained here are nearly forty kilometres in error and it may be that the residual of sixty-eight kilometres in the first observation taken on Mount Wilson is accidental and does not indicate any departure from elliptic motion. Dr. Adams reports that the spectrum is certainly composite on the plate taken November first, and that the settings were made on the most intense parts of the absorption lines. A remeasure of this plate yielded practically the same result as published.

The period finally adopted was 13·435 days and then the observations were grouped into normals, preliminary elements obtained and corrected in the usual manner. The different steps in the solution follow.

MOUNT WILSON OBSERVATIONS OF BOSS 6142

Date	Julian Date	Phase from J.D. 2,420,800	Vel.	O–C
1911, Nov. 1	2,419,342·758	7·03	− 53	+68
1912, Jan. 6	406·662	3·76	− 11	−26
1912, Jan. 9	409·633	6·73	−133	−15
1912, Sept. 30	675·811	4·21	− 23	−13

OBSERVATIONS OF BOSS 6142

Plate	Observer*	Date	Julian Date	Phase from J. D. 2,420,800	Velocity Primary	Wt.	Velocity from *H* and *K*	O–C	Velocity Secondary
		1915							
6747	H	Jan. 28..	2,420,526·535	8·67	−133	1	−16	− 4	+105
6756	C	" 29..	527·528	9·66	−120	1	−23	− 9	
6766	C	Feb. 3..	532·599	1·30	+ 81	1	−38	−19	
6773	H	" 4..	533·541	2·24	+104	1	....	+19	
7077	Y	June 27..	676·720	11·07	− 39	½	....	+12	
7085	H–Y	July 1..	680·742	1·66	+108	1	....	+11	−189
7093	C	" 9..	688·699	9·61	− 93	½	....	+19	
7103	C	" 14..	693·818	1·30	....	....	−24	....	
7113	Y–H	" 20..	699·745	7·22	−108	1	....	+ 4	
7116	Y	" 22..	701·754	9·23	−126	1	−21	− 5	
7125	C	" 26..	705·833	13·31	+ 59	½	−21	− 9	
7128	Y–H	" 27..	706·726	0·77	+ 93	1	−30	− 3	−155
7130	C	" 28..	707·824	1·87	+ 95	1	−29	+ 2	
7137	Y	Aug. 1..	711·764	5·81	− 75	1	−22	+11	
7141	Y	" 5..	715·772	9·82	−104	1	−40	+ 1	
7148	Y	" 10..	720·677	1·29	+102	1	−28	+ 2	−168
7157	Y	" 14..	724·764	5·37	− 35	1	....	+32	
7159	Y	" 17..	727·677	8·29	−124	1	....	+ 8	+170
7160	Y	" 17..	727·820	8·43	−130	1	−30	0	+133
7170	Y	" 26..	736·650	3·82	− 16	1	−18	−28	
7171	Y	" 26..	736·706	3·88	− 19	1	− 2	−28	

OBSERVATIONS OF BOSS 6142—*Concluded*

Plate	Observer*	Date	Julian Date	Phase from J. D. 2,420,800	Velocity Primary	Wt.	Velocity from *H* and *K*	O–C	Velocity Secondary
		1915							
7188	P^{II}	Sept. 1..	2,420,742·694	9·87	−106	½	....	− 2	
7222	H	" 9..	750·687	4·43	− 34	1	....	−15	
7237	Y	" 11..	752·765	6·50	−120	½	−30	−11	
7262	C–P^{II}	" 17..	758·747	12·49	− 13	1	....	−41	
7269	Y	" 19..	760·663	0·97	+102	1	−33	+ 4	−165
7275	Y	" 21..	762·670	2·97	+ 56	1	−26	− 3	
7292	Y	" 28..	769·547	9·85	−105	½	....	− 1	
7301	Y	" 29..	770·611	10·92	− 39	1	−24	+20	
7309	H	" 30..	771·563	11·87	− 38	1	....	−30	
7318	Y	Oct. 3..	774·555	1·42	+ 99	1	....	0	−197
7328	Y	" 10..	781·601	8·47	−132	1	−20	− 1	
7329	Y	" 10..	781·672	8·54	−147	1	....	−17	
7341	Y	" 15..	786·534	13·40	+100	1	−17	+29	−141
7343	Y	" 15..	786·660	0·10	+ 71	½	....	− 6	
7356	Y	" 21..	792·525	5·96	− 80	1	....	+11	
7370	Y–H	" 28..	799·753	13·19	+ 47	½	−26	−12	
7405	Y	Nov. 13..	815·697	2·26	+ 86	1	−19	+ 2	
7410	Y	" 16..	818·514	5·08	− 49	1	....	+ 3	
7411	Y	" 16..	818·597	5·16	− 46	1	−20	+10	
7413	C	" 17..	819·500	6·07	−118	1	−25	−23	
7426	Y	" 24..	826·526	13·09	+ 41	½	....	−17	
7436	P	Dec. 1..	833·595	6·72	−119	½	−28	− 4	
7456	Y	" 28..	860·482	6·74	− 76	½	....	+39	
		1916							
7473	H	Jan. 6..	869·506	2·33	+ 57	1	....	−26	
7484	Y	" 14..	877·483	10·31	−110	1	−20	−23	
7485	Y	" 14..	877·531	10·36	− 67	½	....	+17	
7489	C	" 17..	880·531	13·36	+ 73	½	....	+ 3	
7491	Y	" 23..	886·515	5·91	− 68	1	−19	+22	
7493	Y	" 28..	891·519	10·91	− 74	1	−23	−14	
7499	P	" 29..	892·507	11·90	− 19	1	....	−13	
7503	Y	Feb. 10..	904·521	10·48	− 56	½	− 3	+23	
7541	H	Mar. 9..	932·514	11·60	− 23	1	....	0	

* H = Harper: C = Cannon: P = J. S. Plaskett: P^{II} = H. Plaskett: Y = Young

MEASURES OF BOSS 6142

λ	6747				6756		6766		6773		7077		7541	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825	+ 0·8	¼	....	....	− 9·6	½	− 8·0	½	....	....	....	....	....	....
3968·625	+ 4·9	¼	....	....	+ 8·3	¼	− 19·0	¼	....	....	....	....	....	....
4026·352	−112	½	....	....	....	....	....	....	....	....	....	....	....	....
4101·890	−124	¼	+120	¼	− 92	¼	....	....	....	....	....	....	....	....
4340·634	−146	¼	+129	¼	−119	¼	+121	¼	+142	¼	−64	¼	+ 2·3	½
4388·100	....	....	....	....	....	....	....	....	+146	¼	....	....	−12·4	½
4471·676	−128	¼	+125	¼	....	....	+117	¼	+102	½	−52	½	−11·8	½
4552·750	− 87	½	....	....	−109	¼	+ 64	¼	....	....	....	....	−17·2	¼
4567·950	....	....	....	....	− 82	¼	....	....	....	....	....	....	....	....
Weighted mean	−113·7		+124·7		−100·5		+100·1		+123·0		− 56·0		− 10·1	
V_s	− 18·85		− 18·85		− 18·80		− 18·45		− 18·38		+ 16·74		− 12·21	
V_d	− 0·17		− 0·17		− 0·17		− 0·18		− 0·17		+ 0·18		− 0·13	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	−133·		+105·		−120·		+ 81·		+104·		− 39·		− 23·	
H and *K*	− 16·		....	....	− 23·		− 38·		....	....	....	....	....	....

MEASURES OF BOSS 6142—*Continued*

λ	7085				7093		7103		7113		7116		7125	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825							−41·6	½	− 46·9	¼	− 38·1	½	−40·5	½
3968·625									− 36·2	¼	− 39·5	½	−35·3	¼
4026·352											− 94	¼	+69	¼
4101·890									−106	¼	−138	½	+30	¼
4340·634	+ 86	½			−106	½			−160	¼	−165	½	+25	¼
4388·100					− 77	¼								
4471·676	+111	½	−189	¼	−155	¼			−120	½			+40	¼
4552·750	+ 60	¼									−156	½		
Weighted mean	+ 90·8		−189·0		−111·0		− 41·6		−126·5		−144·4		+ 41·0	
V_a	+ 17·14		+ 17·14		+ 17·94		+ 18·20		+ 18·41		+ 18·43		+ 18·40	
V_d	+ 0·17		+ 0·17		+ 0·18		+ 0·10		+ 0·12		− 0·12		+ 0·03	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		0·28		0·28		0·28	
Radial Velocity	+108·		−172·		− 93·				−108·		−126·		+ 59·	
H and *K*							− 24·		− 23·		− 21·		− 21·	

MEASURES OF BOSS 6142—*Continued*

λ	7128				7130		7137		7141		7148			
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825	−51·3	½	....	....	−40·0	½	− 54·8	¼	....	....	−48·5	¼	....	....
3968·625	−42·7	¼	....	....	−60·1	¼	− 25·5	¼	− 57·5	¼	−42·7	¼	....	....
4026·352	+74	¼	−152	¼	+86	¼	....	....	....	....	....	....	....	....
4101·890	....	....	....	....	....	....	− 40	¼	−133	¼	....	....	....	....
4143·928	....	....	....	....	....	....	....	....	....	....	+93	½	....	....
4340·634	+72	¼	−179	¼	+59	¼	−115	½	−140	½	+93	¼	−195	¼
4388·100	....	....	....	....	+94	¼	− 78	¼	....	....	....	....	....	....
4471·676	+99	¼	−191	¼	+68	¼	−107	½	−102	¼	+67	....	−176	¼
4552·750	+76	¼	....	....	....	....	....	....	....	....	....	....	....	....
4567·950	....	....	....	....	....	....	....	....	− 95	¼	....	....	....	....
Weighted mean	+ 74·4		−174·0		+ 76·8		− 93·3		−122·0		+ 84·3		−185·5	
V_a	+ 18·38		+ 18·38		+ 18·36		+ 18·21		+ 17·97		+ 17·57		+ 17·57	
V_d	+ 0·12		+ 0·12		+ 0·04		+ 0·09		+ 0·04		+ 0·12		+ 0·12	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	+ 93·		−155·		+ 95·		− 75·		−104·		+102·		−168·	
H and *K*	− 30·		....		− 29·		− 22·		− 40·		− 28·		....	

MEASURES OF BOSS 6142—*Continued*

λ	7157		7159				7160				7170		7171	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825	...	...	...	...	...	...	− 60	½	...	...	−33	½	−17·5	½
3968·625	...	...	...	...	...	...	− 33	½	...	...	...	...	...	...
4026·352	...	...	...	...	...	...	...	...	...	...	−38	½	...	...
4101·890	−36	½	...	...	...	...	...	...	...	...	−34	½	−20	¼
4143·928	−55	¼	...	...	...	...	...	...	...	...	−29	½	...	...
4340·634	−66	½	−140	1	+153	½	−124	½	+147	¼	−47	½	−40	½
4388·100	...	...	...	...	...	...	−134	¼	...	...	...	...	−37	½
4471·676	−42	½	−141	½	...	...	−171	½	...	...	−35	½	−34	½
4552·750	−75	¼	...	...	...	...	−155	¼	+ 85	¼	0	¼	−33	¼
4567·950	...	...	...	...	...	...	...	...	...	...	− 4	¼	−33	¼
Weighted mean	− 52·2		−140·5		+153·0		−146·7		+116·0		− 30·9		− 34·2	
V_a	+ 17·15		+ 16·79		+ 16·79		+ 16·79		+ 16·79		+ 15·45		+ 15·45	
V_d	+ 0·04		+ 0·11		+ 0·11		+ 0·11		+ 0·11		+ 0·12		+ 0·08	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 35·		−124·		+170·		−130·		+133·		− 16·		− 19·	
H and *K*	...		...		...		− 30·		...		− 18·		− 2·	

MEASURES OF BOSS 6142—*Continued*

λ	7188		7222		7237		7262		7269				7275	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825					− 47	½			− 42·5	½			−45·3	½
3968·625					− 37	½			− 42·7	½			−24·6	½
4026·352			−55	½					+ 94	¼			+38	½
4101·890			−56	¼					+ 84	¼			+28	½
4143·928			−10	¼	−118	½	−23	½	+110	¼	−146	¼	+67	½
4340·634	−120	¼	−32	½					+ 99	½	−203	¼	+49	½
4388·100									+114	¼				
4471·676			−56	1	−156	½	−23	½	+ 61	¼			+36	½
4552·750					−123	¼								
Weighted mean	−120·0		− 46·4		−132·3		− 23·0		+ 91·8		−174·5		+ 46·2	
V_a	+ 14·32		+ 12·62		+ 12·10		+ 10·65		+ 10·14		+ 10·14		+ 9·61	
V_d			+ 0·05		+ 0·11		− 0·04		+ 0·05		+ 0·05		+ 0·04	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	−106·		− 34·		−120·		− 13·		+102·		−165·		+ 56·	
H and *K*					− 30·				− 33·				− 26·	

MEASURES OF BOSS 6142—*Continued*

λ	7292		7301		7309		7318				7328			
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825	.....	.....	−31·0	½	.....	.....	.....	.....	.....	.....	− 28·0	1	.....	.....
3968·625	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	− 19·3	1	.....	.....
4026·352	−106	¼	−30	½	.....	.....	.....	.....	.....	.....	−108	½	.....	.....
4101·890	.....	.....	.....	.....	−32	½	+113	¼	.....	.....	.....	.....	+ 86	¼
4143·928	.....	.....	−16	¼	.....	.....	.....	.....	.....	.....	−119	½	+ 95	½
4340·634	−112	¼	−74	½	−64	1	+ 98	¼	−197	¼	−139	½	.....	.....
4388·100	−105	¼	.....	.....	−69	½	.....	.....	.....	.....	− 80	¼	.....	.....
4471·676	−121	½	−48	½	−38	1	+ 70	½	−210	¼	−163	½	+135	¼
4552·750	.....	.....	.....	.....	−14	½	+102	½	.....	.....	−149	½	.....	.....
Weighted mean	−113·0		− 45·7		− 45·7		+ 92·5		−203·5		−135·6		+102·7	
V_a	+ 7·67		+ 7·36		+ 7·08		+ 6·19		.....		+ 4·01		.....	
V_d	− 0·12		+ 0·08		+ 0·12		+ 0·12		.....		+ 0·08		.....	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		.....		− 0·28		.....	
Radial Velocity	−105·		− 39·		− 38·		+ 99·		−197·		−132·		+106·	
H and *K*	.....		− 24·		.....		.....		.....		− 20·		.....	

MEASURES OF BOSS 6142—*Continued*

λ	7329		7341				7343		7356		7370		7405	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825	......	......	− 20·8	1	......	......	......	......	......	......	− 24·2	½	− 8·8	½
3968·625	......	......	− 18·1	½	......	......	......	......	......	......	......	......	− 14·9	½
4026·352	......	......	+117	¼	......	......	......	......	− 53	¼	......	......	+105	¼
4101·890	......	......	......	......	......	......	......	......	− 62	¼	......	......	......	......
4143·928	......	......	+103	¼	......	......	......	......	......	......	......	......	......	......
4340·634	−162	½	+ 98	½	−143	½	......	......	−113	½	......	......	+ 80	½
4388·100	−100	¼	+ 87	½	......	......	......	......	− 76	½	......	......	......	......
4471·676	−152	½	......	......	......	......	+ 69	½	− 75	½	+ 49	¼	+109	¼
4552·750	−162	½	......	......	......	......	......	......	− 96	¼	......	......	......	......
4567·950	−152	½	......	......	......	......	......	......	− 61	¼	......	......	......	......
Weighted mean	−150·7		+ 98·3		−143·0		+ 69·0		− 80·0		+ 49·0		+ 93·5	
V_a	+ 3·99		+ 2·32		+ 2·32		+ 2·29		+ 0·50		− 1·84		− 6·93	
V_d	+ 0·03		+ 0·10		+ 0·10		− 0·03		+ 0·03		− 0·14		− 0·12	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	−147·		+100·		−141·		+ 71·		− 80·		+ 47·		+ 86·	
H and *K*	......		− 17·		......		......		......		− 26·		− 19·	

MEASURES OF BOSS 6142—*Continued*

λ	7410 Vel.	7410 Wt.	7411 Vel.	7411 Wt.	7413 Vel.	7413 Wt.	7426 Vel.	7426 Wt.	7436 Vel.	7436 Wt.	7456 Vel.	7456 Wt.	7473 Vel.	7473 Wt.
3933·825	....	....	− 8·8	½	− 22·4	½	....	....	− 15·2	½	....	....	....	....
3968·625	....	....	− 13·6	½	− 10·7	½	....	....	....	....	....	....	....	....
4026·352	− 35	¼	....	....	−114	¼	....	....	....	....	....	....	....	....
4101·890	....	....	− 46	¼	− 82	¼	....	....	−129	¼	....	....	+ 54	¼
4143·928	....	....	− 21	¼	....	....	....	....	....	....	....	....	....	....
4340·634	− 44	¼	− 34	½	− 88	¼	+ 33	½	−113	½	− 60	¼	+ 96	¼
4388·100	....	....	− 18	¼	....	....	....	....	....	....	....	....	....	....
4471·676	− 42	¼	− 71	¼	−125	¼	+ 98	¼	− 74	¼	....	....	+ 73	¼
4552·750	− 44	½	− 42	½	−138	¼	....	....	....	....	....	....	....	....
4567·950	....	....	− 29	¼	....	....	+ 41	¼	−103	¼	....	....	....	....
Weighted mean	− 41·2		− 37·5		−109·4		+ 51·2		−106·4		− 60·0		+ 74·3	
V_a	− 7·74		− 7·81		− 8·09		− 10·21		− 12·04		− 15·86		− 16·81	
V_d	+ 0·03		− 0·03		+ 0·04		0·00		− 0·09		0·00		− 0·06	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	− 49·		− 46·		−118·		+ 41·		−119·		− 76·		+ 57·	
H and K	....		− 20·		− 25·		....		− 28·		....		....	

MEASURES OF BOSS 6142—*Concluded*

λ	7484		7485		7489		7491		7493		7499		7503	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
3933·825	− 11·2	¼					− 6·4	½	− 4	½			+ 4·0	¼
3968·625	+ 6·6	¼					+ 7·4	½					+ 23·8	¼
4026·352							− 65	¼						
4101·890	−116	¼							− 74	½				
4340·634	− 86	¼	− 41	½	+ 66	·¼	− 50	½	− 42	½	− 5	½		
4388·100	− 68	¼												
4471·676	− 36	¼	− 65	¼	+116	¼	− 44	¼	− 27	½	+ 4	½	− 26·8	½
4552·750	− 97	¼					− 37	¼	− 98	¼	− 1	½		
4567·950									− 61	¼	+ 3	½	− 51·5	½
Weighted mean	− 91·7		− 49·0		+ 91·0		− 49·2		− 55·6		+ 0·2		− 39·1	
V_c	− 17·75		− 17·75		− 18·06		− 18·71		− 18·88		− 18·75		− 16·68	
V_d	− 0·08		− 0·08		− 0·10		− 0·08		− 0·11		− 0·11		− 0·16	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	−110·		− 67·		+ 73·		− 68·		− 74·		− 19·		− 56·	
H and *K*	− 20·						− 19·		− 23·				− 3·	

NORMAL PLACES

	Julian Date	Phase from J.D. 2,420,800	Observed Velocity	Weight	Computed Velocity Preliminary	Computed Velocity Final	O–C Preliminary	O–C Final
1	2,420,800·50	0·50	+ 94·4	1·2	+ 88·4	+ 89·4	+6·0	+ 5·0
2	801·42	1·42	+ 97·5	1·3	+ 98·4	+ 99·5	−0·9	− 2·0
3	802·17	2·17	+ 85·5	1·3	+ 84·9	+ 85·2	+0·6	+ 0·3
4	802·97	2·97	+ 56·0	0·4	+ 55·1	+ 53·3	+0·9	+ 2·7
5	804·62	4·62	− 33·2	2·0	− 25·4	− 30·3	−7·8	− 2·9
6	805·89	5·89	− 74·3	1·0	− 80·7	− 85·4	+6·4	+11·1
7	806·63	6·63	−112·2	1·1	−105·0	−108·6	−7·2	− 3·6
8	808·48	8·48	−133·2	1·7	−131·0	−130·6	−2·2	− 2·6
9	809·46	9·46	−119·7	0·8	−120·5	−118·5	+0·8	− 1·2
10	809·84	9·84	−104·8	0·7	−111·4	−109·1	+6·6	+ 4·3
11	810·55	10·55	− 81·8	1·0	− 86·5	− 84·1	+4·7	+ 2·3
12	811·69	11·69	− 27·5	1·8	− 27·9	− 26·6	+0·4	− 0·9
13	813·25	13·25	+ 56·1	0·6	+ 62·2	+ 62·6	−6·1	− 6·5

PRELIMINARY ELEMENTS

$$
\begin{aligned}
P &= 13\cdot435 \text{ days}\\
T &= \text{J. D. } 2{,}420{,}800\cdot336\\
e &= 0\cdot10\\
\omega &= 330^\circ\\
K &= 115 \text{ km.}\\
\gamma &= -26\cdot06 \text{ km.}
\end{aligned}
$$

OBSERVATION EQUATIONS

	x	y	z	p	q	$-n$	Weight
1	1·000	+0·996	+0·948	−0·466	−0·503	−6·0	1·2
2	1·000	+1·083	+0·754	−0·042	+0·108	+0·9	1·3
3	1·000	+0·965	+0·029	−0·428	+0·529	−0·6	1·3
4	1·000	+0·706	−0·701	−0·736	+0·808	−0·9	0·4
5	1·000	+0·006	−0·729	−0·947	+0·886	+7·8	2·0
6	1·000	−0·475	+0·169	−0·777	+0·685	−6·4	1·0
7	1·000	−0·686	+0·667	−0·584	+0·515	+7·2	1·1
8	1·000	−0·913	+0·835	+0·081	−0·026	+2·2	1·7
9	1·000	−0·821	+0·198	+0·468	−0·371	−0·8	0·8
10	1·000	−0·742	−0·127	+0·610	−0·512	−6·6	0·7
11	1·000	−0·525	−0·708	+0·841	−0·770	−4·7	1·0
12	1·000	−0·016	−1·005	+1·045	−1·079	−0·4	1·8
13	1·000	+0·768	+0·411	+0·782	−0·879	+6·1	0·6

where
$$x = d\gamma$$
$$y = dK$$
$$z = Kde$$
$$p = Kd\omega$$
$$q = \frac{K\mu}{(1-e^2)^{\frac{3}{2}}}dT$$

NORMAL EQUATIONS

$$14{\cdot}900x +0{\cdot}101y +0{\cdot}539z +0{\cdot}471p -0{\cdot}368q + 6{\cdot}670=0$$
$$+7{\cdot}840y +0{\cdot}670z -0{\cdot}310p +0{\cdot}320q - 3{\cdot}384=0$$
$$+7{\cdot}244z -0{\cdot}657p +0{\cdot}760q - 3{\cdot}744=0$$
$$+6{\cdot}975p -6{\cdot}811q -21{\cdot}883=0$$
$$+6{\cdot}719q +20{\cdot}244=0$$

whence	$x = -0{\cdot}67$		$d\gamma = -0{\cdot}67$ km.
	$y = +0{\cdot}50$		$dK = +0{\cdot}50$ km.
	$z = +0{\cdot}55$		$de = +0{\cdot}005$
	$p = +19{\cdot}2$		$d\omega = +9^\circ{\cdot}56$
	$q = +16{\cdot}3$		$dT = +0{\cdot}30$ day

FINAL ELEMENTS

P	$= 13 \cdot 435$ days	
T	$=$ J. D. $2{,}420{,}800 \cdot 634$	$\pm\ 0 \cdot 271$ day
e	$= 0 \cdot 105$	$\pm\ 0 \cdot 013$
ω	$= 339° \cdot 56$	$\pm\ 7° \cdot 1$
K	$= 115 \cdot 5$ km.	$\pm\ 1 \cdot 33$ km.
γ	$= -26 \cdot 7$ km.	$\pm\ 0 \cdot 90$ km.
$a \sin i$	$= 21{,}200{,}000$ km.	
$\frac{m_1^3 \sin^3 i}{(m + m_1)^2}$	$= 2 \cdot 11 \odot$	

The residuals which these elements give for the individual observations are shown in the tables of observations under the heading O–C. The probable error of an average plate is eleven kilometres.

SECONDARY SPECTRUM

The above elements rest entirely on measures of the primary. The measures of the secondary were grouped into two normal places as follows:—

Phase	Velocity	Weight	O–C
2·03	−169	5	0
8·46	+136	3	0

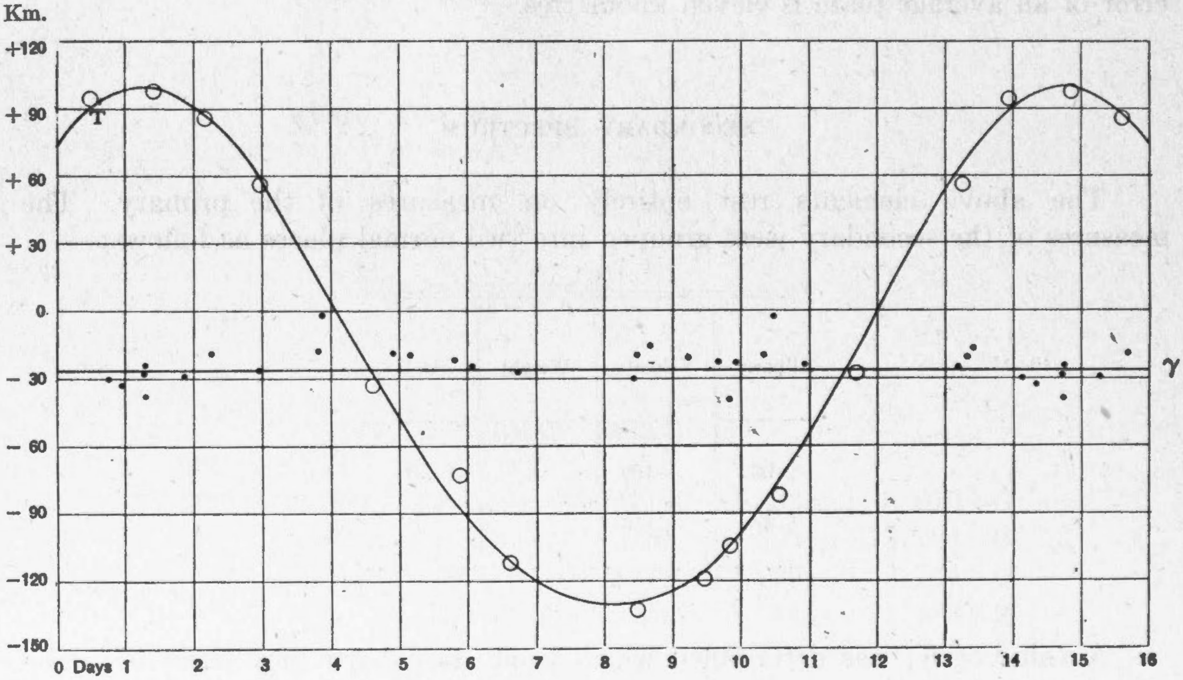
A value of K_1 was determined which would best harmonize these with the elements of the primary. It was possible to adjust the value of K_1 so as to leave no residuals, but, nevertheless, we must regard the value of the amplitude of the secondary given as only roughly approximate. We have the following additional elements:—

$$K_1 = 167 \text{ km.}$$
$$K{:}K_1 = 1 : 1 \cdot 45$$
$$a_1 \sin i = 30{,}700{,}000 \text{ km.}$$
$$m \sin i = 18 \cdot 5 \odot$$
$$m_1 \sin i = 12 \cdot 7 \odot$$

H AND *K* LINES

The phenomenon that these lines present in this star is quite similar to that presented in several other stars of this type. There seems to be no evidence of variation in their position. On many plates the spectrum is too faint to show *H* and *K*, and on others the measurement of the *H* line is interfered with by the presence of H_ϵ, but in general the lines are narrow and sharp in striking contrast to the other lines of the star. Regarding their position as fixed, they yield a velocity − 24·0 km. ± 4·9 km.

Dominion Observatory
Ottawa
April, 1916.



RADIAL VELOCITY CURVE OF BOSS 6142

DEPARTMENT OF THE INTERIOR
CANADA
HON. ARTHUR MEIGHEN, *Minister* W. W. CORY, C. M. G., *Deputy Minister*

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Orbits of the Spectroscopic Components of Boss 2484

BY

W. E. HARPER, M. A.

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52199—1

ORBITS OF THE SPECTROSCOPIC COMPONENTS OF BOSS 2484

BY W. E. HARPER, M.A.

This star ($\alpha = 9^h\ 10^m \cdot 8$, $\delta = +47°\ 14'$) was announced by Adams as a spectroscopic binary in the *Publications of the Astronomical Society of the Pacific* in December, 1914. Professor Adams kindly communicated the velocities of their five plates shortly after I undertook the investigation of its orbit. In reply to my query as to the presence of the spectrum of the second component, which in the meantime had been recorded here, he stated that both components of the magnesium line λ 4481 had been measured on one plate, though with considerable uncertainty in the case of the fainter component. The measures appear later on.

The star is of photographic magnitude 5·8 and of type A2. While some of the early plates show numerous lines, probably because in many of these the component spectra were superposed, thereby increasing the contrast, yet in nearly all the later plates, upon which the orbit mainly depends, the hydrogen lines with the magnesium λ 4481 and calcium λ 3933 are all that are available for measurement. The orbit proves to be quite eccentric ($e = \cdot 5$) and for about 13 days of its 16-day period the spectra are too close to be resolved with our present equipment. Fortunately, the general form of the curve was obtained from the first few revolutions, so that only a limited number of observations have not been made use of. While the influence of the secondary spectrum upon the measures of the main one seems to be much less than might be expected, yet it was felt that the only plates that could be depended upon were those wherein the components were completely separated or centrally superposed. The practice was thus adopted of observing the star only at the times when the lines were completely resolved. Adams' observations taken in conjunction with our own gave a period of 15·986 days, a value so close to the even day that observations at any one season on the three particular nights would give only three points on the curve. Consequently, it was very disappointing that the desired nights in the autumn of 1915, when different phases could have been observed, were for the most part cloudy. The star is still available at time of writing, but it is felt that observations now would not add any special weight to the determination.

As the spectral lines have been resolved over such a limited portion of the orbit, it is hoped that when the large reflector at Victoria is ready for use, additional observations, using greater dispersion, will be secured and the orbit determined with greater precision. For this reason the present determination is considered only a preliminary one. On 28, out of the total of 49 plates secured, the spectra are separated, and these 28 measures of the primary, together with 2 plates where the spectra must be nearly superposed, are used in the determination. The spectrum of the secondary component is so poorly defined that only 13 measures of it have been accepted as at all trustworthy. In some cases only a single line is used. These 13 measures, duly weighted, have been combined with the 30 just mentioned in the solution. All the plates have been made on Seed 27 emulsion with spectrograph I[1] whose dispersion is 32·3 Å per millimetre at the minimum deviation, λ 4325.

The following table gives the wave-lengths which were used for the lines measured. They were adopted from a star of similar type, 14 Aurigæ, and have not been revised for this star. The number of times measured on 28 plates with the residuals for each line from the mean of the plate is also shown. After this table the detailed measures of the plates are given.

TABLE OF WAVE-LENGTHS

λ	n	Mean Numerical Residual	Mean Algebraic Residual	λ	n	Mean Numerical Residual	Mean Algebraic Residual
4572·190	1	....	+10·3	4236·000	5	6·9	+ 5·3
4549·743	8	10·4	− 1·9	4233·425	11	13·6	+ 4·4
4481·477	26	7·7	− 0·3	4202·366	1	....	− 5·1
4415·345	1	....	+ 3·3	4143·839	3	15·7	+ 6·5
4404·861	2	15·8	− 9·2	4101·898	6	6·7	− 5·9
4340·645	14	9·2	− 0·1	4077·862	1	....	+ 2·3
4325·698	3	9·5	0·0	4071·865	7	4·8	− 1·4
4307·974	5	15·3	+ 9·3	4063·730	3	2·9	+ 2·9
4271·675	6	8·7	− 2·6	4045·940	8	10·7	+ 4·1
4260·537	1	....	−19·0	3933·825	14	6·9	− 3·8

MEASURES OF BOSS 2484 (primary)

λ	6790		6800		6809		6816		6823		6830		6838	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549	+23·2	½	......	......	......	......	......	......	+72·0	¼	+24·8	½	......	......
4481	+ 6·6	½	−15·0	¾	− 5·2	¼	−34·2	¼	92·7	1	7·9	½	+23·1	¼
4340	+13·4	¾	+ 1·5	½	−23·5	½	......	......	86·2	1	12·8	½	30·8	½
4325	......	......	......	......	......	......	......	......	......	......	38·6	¼	......	......
4271	+ 6·8	1¼	......	......	......	......	−28·6	½	94·8	¼	......	......	......	......
4233	......	......	− 7·3	½	......	......	......	......	......	......	......	......	1·8	½
4143	+23·8	½	......	......	......	......	......	......	......	......	......	......	......	......
4101	−22·0	½	......	......	+17·2	¼	......	......	109·7	¼	......	......	2·8	½
4077	......	......	......	......	......	......	......	......	......	......	31·4	¼	......	......
4071	+ 4·7	½	......	......	......	......	......	......	......	......	......	......	......	......
4063	−27·1	½	......	......	......	......	......	......	......	......	......	......	1·1	¾
4045	− 2·9	½	−10·7	½	......	......	......	......	94·0	¼	......	......	......	......
4005	+ 8·7	½	......	......	+ 1·5	½	......	......	......	......	......	......	10·4	¼
3933	......	......	−10·3	½	− 7·6	¼	−17·8	¼	+104·7	1	+23·4	½	+ 6·4	¾
Weighted mean	+ 4·40		− 8·90		− 5·66		−27·33		+94·05		+20·80		+ 9·10	
V_s	− 9·95		−10·39		−10·83		−11·71		−14·76		−15·46		−15·81	
V_d	− ·03		− ·05		− ·04		− ·05		− ·15		− ·10		− ·08	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 5·9		− 19·4		− 16·8		− 39·3		+ 78·9		+ 5·0		− 7·1	

52199—2½

MEASURES OF BOSS 2484 (primary)—*Continued*

λ	6846		6852		6861		6865		6870		6876		6881	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549	−28·1	¾			−10·6	¾	+13·3	½	0·0	1			− 8·5	¼
4481	−20·6	¼	−21·0	¾	−10·2	¾	−16·4	½	+ 8·2	1	+71·4	½	+ 9·7	½
4404									9·1	¾			+23·7	½
4351													−12 8	¼
4340	− 0·1	¾	21·8	¾	−32·0	½	+12·6		8·3	¾	97·3	½	+ 2·1	½
4325									20·1	½				
4307									24·5	1	69·3	½		
4294									1·9	1				
4271	+ 7·6	½							11·7	1			+ 5·8	¼
4233	−11·4	¼	30·6	¾			− 5·4	¾	5·9	1			+11·8	¾
4227					− 5·3	½			14·4	¾				
4202									6·1	1				
4198							+ 4·5	½						
4101					+14·9	½	+ 4·3	½			89·1	¾		
4077			20·9	½	− 2·3	½								
4071			18·4	½					12·0	½	87·4	½		
4063							+ 3·2	¼						
4045	− 6·8	½	31·2	½					+25·4	1	78·3	¼		
3933	−15·1	½	−22·2	½	− 5·6	1	− 2·9	¼			+92·0	1½	+28·9	¾
Weighted mean	− 9·10		−24·00		− 7·50		+ 1·40		+11·30		+86·04		+10·30	
V_s	−16·83		−17·51		−18·81		−19·10		−19·39		−20·25		−20·54	
V_d	− ·09		− ·02		− ·13		− ·06		− ·06		− ·04		− ·06	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	−26·3		−41·8		−26·7		−18·0		− 8·4		+65·5		−10·6	

MEASURES OF BOSS 2484 (primary)—*Continued*

λ	6897		6900		6902		6915		6921		6932		6934	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572	+ 9·4	¼											+80·1	½
4549	0·0	½					+ 8·8	¼	+ 2·4	¼			94·4	½
4481	+ 9·3	¼	+107·3	½	+23·9	¾	−21·2	¼	−12·5	½	+46·1	½	62·9	¼
4415													87·1	¼
4340			127·2	¼	10·9	1	+ 5·9	¾	− 7·5	½			94·6	¼
4325	−14·2	¼												
4307	+23·3	¾							− 1·3	¼				
4271									+28·1	½				
4236							− 4·3	¼						
4233			115·0	¼			+19·4	½					103·6	¼
4143									+ 2·2	¼				
4101			97·5	¼										
4071													88·8	½
4063	+ 5·1	½												
4045			89·7	¾			−36·1	½	+ 6·4	½			+119·6	¼
3933	−29·4	¼	+99·2	¾	+29·7	½					+56·9	¾		
Weighted mean	+ 5·00		+100·91		+28·67		− 3·67		+ 2·93		+52·57		+90·36	
V_s	−23·09		− 23·81		−23·98		−25·00		−25·13		−25·46		−25·62	
V_d	− ·02		+ ·03		− ·04		− ·15		− ·12		− ·16		− ·15	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	−18·4		+ 76·8		+ 4·4		−29·1		−22·6		+26·7		+64·3	

MEASURES OF BOSS 2484 (primary)—*Continued*

λ	6965		6986		7325		7333		7337		7338		7367	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572					−25·5	¼								
4549	+63·8	½			45·8	½					+19·3	¼		
4534					38·3	¼								
4481	66·7	½	−20·5	¾	69·7	¼	+15·1	¾	+48·7	½	8·5	½	+25·6	1
4404			−14·1	¼										
4351	+63·4	¼												
4340					27·7	½								
4325											31·0	¼		
4307					21·6	¼	44·4	¼						
4271			+20·0	¼	17·3	¼								
4260							+46·1	¼						
4233					27·7	¼			24·9	¼	+22·1	¼		
4143					45·6	¼								
4063			−17·8		36·7	¼								
4045					34·4	½			+66·0	½				
3933					−30·5	¾								
Weighted mean	+64·88		−13·03		−34·28		+27·12		+50·86		+17·85		+25·56	
V_a	−25·41		−24·63		+24·90		+24·76		+24·62		+24·48		+26·07	
V_d	− ·23		− ·17		+ ·13		+ ·18		+ ·13		+ ·19		+ ·09	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+39·0		−38·1		− 9·0		+51·8		+75·3		+42·8		+51·4	

MEASURES OF BOSS 2484 (primary)—*Continued*

λ	7403		7404		7408		7461		7468		7469		7486	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549	+53·1	¼					−22·8	¾	+80·4	½	+80·0	¼		
4481	55·9	½	+64·0	½	+10·4	¾	23·9	½	65·3	½	+92·2	½	+38·6	½
4351							16·0	¾						
4340	52·7	½							55·2	½				
4325	70·0	¼	57·4	¼										
4307							21·7	½						
4271			73·1	¼										
4236													28·0	½
4233			52·8	½	+ 1·3	½	22·2	¼	48·6	½			21·8	¼
4198							21·3	¼						
4143			40·2	½			1·9	½						
4063									59·1	¼				
4045	32·4	½	+49·5	¼					+36·1	¼				
3933	+58·0	½					−26·5	½					+40·5	¼
Weighted mean	+52·22		+54·90		+ 8·12		−19·24		+59·42		+88·13		+25·87	
V_a	+25·28		+25·28		+25·16		+12·73		+11·89		+11·89		+ 5·46	
V_d	+ ·13		+ ·05		+ ·14		+ ·03		+ ·07		− ·03		+ ·13	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+77·4		+80·0		+33·1		− 6·8		+71·1		+99·7		+31·2	

MEASURES OF BOSS 2484 (primary)—*Continued*

λ	7487		7500		7534		7535		7537		7538		7544	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt
4549									+47·3	½				
4481	+41·1	½	+82·7	¼	+14·7	½	+40·0	¾	56·9	¾	+103·1	¾	− 9·0	½
4340			+51·6	¾					61·0	¼				
4307			+33·1	¼					55·1	¼				
4202					31·4	¾								
4071					30·3	½								
4045	+31·4	¼					+31·9	½						
3933					+26·4	½			54·7	½				
Weighted mean	+37·87		+54·12		+26·27		+36·80		+54·40		+103·10		− 9·00	
V_a	+ 5·46		− 2·76		−15·29		−15·29		−15·29		− 15·66		−18·42	
V_d	+ ·09		+ ·10		+ ·18		+ ·11		− ·03		+ ·13		− ·11	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+43·1		+51·2		+10·9		+21·4		+38·8		+87·3		−27·8	

MEASURES OF BOSS 2484 (primary)—*Continued*

λ	7557		7559		7560		7599		7600		7602		7603	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481	+ 98·6	½	+115·7	¾	+106·0	¾	+ 37·4	¼	....	....	+ 78·0	½	....	....
4404	....	....	100·4	½	....	....	....	....	....	....	....	....	....	....
4340	125·6	½	88·4	½	87·2	½	59·8	¼	....	....	71·6	½	+ 64·2	½
4325	....	....	....	....	....	....	34·9	½	+ 67·0	¼	70·4	¼	....	....
4307	....	....	....	....	....	....	....	....	50·7	¼	....	....	....	....
4271	....	....	....	....	....	....	54·0	½	....	....	....	....	64·8	¼
4236	107·9	½	....	....	70·4	¼	....	....	....	....	....	....	....	....
4233	....	....	....	....	....	....	....	....	....	....	....	....	62·9	¼
4143	....	....	....	....	....	....	....	....	....	....	81·0	½	....	....
4101	....	....	....	....	113·4	¼	....	....	....	....	....	....	80·5	½
4077	....	....	104·4	¼	....	....	....	....	....	....	....	....	....	....
4071	....	....	130·5	¼	....	....	51·9	¼	....	....	63·6	½	73·2	½
4063	....	....	....	....	....	....	....	....	69·4	½	....	....	64·0	¼
4045	115·5	¾	....	....	91·4	½	47·5	½	+82·2	½	....	....	89·7	¼
3933	+ 95·2	½	+107·2	½	+117·0	½	+ 74·8	¼	....	....	+ 67·2	½	+ 79·5	¾
Weighted mean	+108·84		+106·73		+99·35		+49·64		+70·20		+71·82		+73·60	
V_a	− 20·70		− 20·70		−20·70		−23·94		−23·94		−24·26		−24·26	
V_d	+ ·05		− ·11		− ·18		− ·03		− ·12		− ·09		− ·15	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+87·9		+85·6		+78·2		+25·4		+45·9		+47·2		+48·1	

MEASURES OF BOSS 2484 (secondary)—*Continued*

λ	6823		7408		7468		7469		7486		7487		7535	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549	− 91·7	⅛			−118·1	½	−135·7	¼						
4481	128·7	¼	−104·0	¼			−144·7	¼					−66·0	½
4340					126·2	¼								
4307									−81·6	¼				
4271	99·0	¼												
4250					−138·6	½								
4101	114·7	⅛												
4045											−85·3	¼		
3933	−125·1	½												
Weighted mean	−116·32		−104·00		−127·92		−140·20		−81·60		−85·30		−66·00	
V_a	− 14·76		+ 25·16		+ 11·89		+ 11·89		+ 5·46		+ 5·46		−15·29	
V_d	− ·15		+ ·14		+ ·07		− ·03		+ ·13		+ ·09		+ ·11	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	−131·		− 79·		−116·		−129·		− 76·		− 80·		− 81·	

MEASURES OF BOSS 2484 (secondary)—*Concluded*

λ	7538		7557		7559		7560		7602		7603			
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481	−104·8	¾	−77·8	¼	−104·8	½	− 78·3	½						
4404					77·9	½								
4271					111·0	½								
4233			65·5	¼	149·0	¼								
4143			112·8	½										
4101							108·7	¼						
4045			105·6	¼					−64·3	¼	−50·9	¼		
3933			−119·2	¼	− 89·4	¼	−114·0	½	−52·5	¼	−59·1	½		
Weighted mean	−104·80		− 98·93		−103·20		− 98·64		− 58·40		− 55·00			
V_s	− 15·66		− 20·70		− 20·70		− 20·70		− 24·26		− 24·26			
V_d	+ ·13		+ ·05		− ·11		− ·18		− ·09		− ·15			
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28			
Radial Velocity	−121·		−120·		−124·		−120·		− 83·		− 80·			

SUMMARY OF OTTAWA MEASURES OF BOSS 2484

Plate	Observer*	Date	Julian Date 2,420,000 +	Phase	Primary Vel.	Primary Wt.	Primary O–C	Secondary Vel.	Secondary Wt.	Secondary O–C
		1915								
6790	H	Feb. 17	546·664	3·63	− 5·9					
6800	H–Y	" 18	547·730	4·70	−19·4					
6809	C	" 19	548·710	5·68	−16·8					
6816	Y	" 21	550·723	7·69	−39·3					
6823	H	Mar. 1	558·776	15·74	+78·9	4	+ 2·3	−131	1	−14
6830	H–C	" 3	560·721	17·69	+ 5·0					
6838	H	" 4	561·696	2·68	− 7·1	4	+ 1·0			
6846	Y	" 7	564·692	5·67	−26·3					
6852	Y	" 9	566·651	7·63	−41·8					
6861	P	" 13	570·730	11·71	−26·7					
6865	Y	" 14	571·656	12·64	−18·0					
6870	H	" 15	572·656	13·64	− 8·4	11	+ 1·7			
6876	H	" 18	575·635	0·63	+65·5	4	+ 0·5			
6881	Y	" 19	576·653	1·65	−10·6					
6897	Y	" 30	587·591	12·59	−18·4					
6900	H	April 3	591·536	0·54	+76·8	3	+ 6·8			
6902	Y	" 4	592·583	1·59	+ 4·4					
6915	H	" 12	600·678	9·69	−29·1					
6921	Y	" 13	601·627	10·64	−22·6					
6932	P	" 17	605·674	14·68	+26·7	1	+ 3·7			
6934	C	" 19	607·660	0·68	+64·3	3	+ 2·0			
6965	C	May 5	623·672	0·71	+39·0					
6986	H	" 13	631·573	8·61	−38·1					
7325	Y	Oct. 9	780·927	14·09	− 9·0					
7333	H	" 10	781·862	15·02	+51·8	1	+11·2			
7337	C	" 11	782·927	0·10	+75·3	1·4	− 6·7			
7338	H	" 12	783·927	1·10	+42·8	1·6	− 0·2			
7367	H	" 26	797·938	15·11	+51·4	1	+ 6·0			
7403	H	Nov. 12	814·858	0·06	+77·4	3	− 4·6			
7404	H	" 12	814·915	0·12	+80·0	2·6	− 2·0			
7408	Y	" 13	815·849	1·05	+33·1	1	− 6·9	− 79	0·5	+ 3
7461	H	Dec. 28	860·802	14·03	− 6·8					
7468	Y	" 30	862·767	0·01	+71·1	3	−10·9	−116	1	+ 8
7469	Y	" 30	862·840	0·09	+99·7	1	+17·7	−129	1	− 5
		1916								
7486	Y–H	Jan. 14	877·669	14·92	+31·2	2	− 3·8	− 76	0·5	− 7
7487	H	" 14	877·725	14·97	+43·1	1	+ 4·1	− 80	0·5	−18
7500	Y–H	Feb. 1	895·650	0·92	+51·2	1	− 0·8			
7534	H	Mar. 2	925·509	14·80	+10·9	1	−17·1			
7535	H	" 2	925·570	14·86	+21·4	1	−11·2	− 81	0·5	−15
7537	H–Y	" 2	925·681	14·97	+38·8	2	− 0·2			
7538	H	" 3	926·570	15·86	+87·3	1	+ 7·3	−121	1	± 0
7544	P	" 11	934·716	8·02	−27·8					
7557	Y	" 19	942·564	15·87	+87·9	3	+ 7·9	−120	1	+ 1
7559	H	" 19	942·694	0·01	+85·6	3	+ 3·6	−124	1	± 0
7560	H	" 19	942·764	0·08	+78·2	3	− 3·8	−120	1	− 4
7599	H	April 3	957·581	14·90	+25·4	3	− 7·6			
7600	H	" 3	957·663	14·98	+45·9	2	+ 6·9			
7602	H	" 5	959·625	0·96	+47·2	3	− 4·4	− 83	1	+ 5
7603	H	" 5	959·694	1·03	+48·1	3·4	+ 0·7	− 80	1	+ 4

*C = Cannon, H = Harper, P = Plaskett, Y = Young

MOUNT WILSON OBSERVATIONS

Date	Julian Date	Phase	Primary Vel.	Primary O–C	Secondary Vel.
1912, Jan. 28	2,419,410·976	2·95	−13·7		
April 28	521·740	1·82	+ 1·		
May 28	551·674	15·76	+76·	− 2	−151
Dec. 28	765·912	6·19	−22·8		
1913, Mar. 25	852·748	13·10	− 9·4		

The 30 measures of the primary, previously referred to as most trustworthy, were grouped according to phase into 8 normal places and the 13 measures of the secondary into 3 others. These were combined into one least-squares solution as indicated in the *Publications of the Dominion Observatory*, Vol. I, page 327.

NORMAL PLACES

	Velocity	Wt.	Phase from T Preliminary	Phase from T Final	Residual O–C Preliminary	Residual O–C Final
1	+ 23·2	·6	14·83	14·84	− 6·6	− 7·9
2	+ 45·1	·7	14·99	15·00	+ 7·3	+ 5·8
3	+ 81·2	1·4	15·87	15·88	+ 1·6	+ 0·8
4	+ 80·0	1·1	·07	·08	− 1·5	− 2·0
5	+ 68·5	1·0	·61	·62	+ 2·0	+ 1·9
6	+ 45·2	·9	·98	·99	− 3·2	− 3·1
7	− 7·1	·3	2·67	2·68	+ 0·5	+ 1·0
8	− 8·4	·8	13·64	13·65	+ 1·5	+ 1·7
9	− 79·0	·1	14·90	14·91	−12·5	−10·6
10	−122·9	·4	15·93	15·94	+ 1·2	+ 0·1
11	− 80·7	·2	·98	·99	+ 4·4	+ 3·8

The following were chosen as preliminary elements.

$$P = 15\cdot 986 \text{ days}$$
$$e = \cdot 51$$
$$\omega = 355^\circ$$
$$K = 62 \text{ km.}$$
$$K_1 = 75 \text{ km.}$$
$$\gamma = 12\cdot 0 \text{ km.}$$
$$T = \text{J.D. } 2{,}419{,}408\cdot 04$$

The period was considered fixed from a comparison of Mount Wilson observations with our own and observation equations were built up connecting the residuals with the remaining six elements. Making the transformations,

$$\begin{aligned} x &= \delta\gamma \\ y &= \delta K \\ z &= \delta K_1 \\ u &= 100.\delta e \\ v &= 100.\delta\omega \\ w &= [1\cdot 79075]\cdot\delta T \end{aligned}$$

The observation and resulting normal equations are as follows:—

OBSERVATION EQUATIONS

	Weight	x	y	z	u	v	w	$-n$
1.	·6	1·000	+ ·675	....	− ·704	+ ·639	− ·778	+ 6·6=0
2.	·7	1·000	+ ·804	....	− ·628	+ ·619	− ·843	− 7·3
3.	1·4	1·000	+1·477	....	+ ·912	+ ·180	− ·346	− 1·6
4.	1·1	1·000	+1·508	....	+ ·994	+ ·020	+ ·017	+ 1·5
5.	1·0	1·000	+1·267	....	+ ·078	− ·376	+ ·742	− 2·0
6.	·9	1·000	+ ·974	....	− ·504	− ·521	+ ·787	+ 3·2
7.	·3	1·000	+ ·071	....	− ·128	− ·531	+ ·304	− 0·5
8.	·8	1·000	+ ·034	....	− ·222	+ ·573	− ·348	− 1·5
9.	·1	1·000	....	− ·726	+1·035	− ·765	+ ·975	+12·5
10.	·4	1·000	....	−1·494	− ·960	− ·158	+ ·284	− 1·2
11.	·2	1·000	....	− ·974	+ ·820	+ ·631	− ·952	− 4·4

NORMAL EQUATIONS

$$
\begin{array}{rrrrrrrl}
7\cdot500x & +6\cdot876y & -\ \cdot866z & +\ \cdot798u & +\ \cdot479v & -\ \cdot296w & -2\cdot320 & = 0 \\
+6\cdot876x & +8\cdot716y & & +2\cdot575u & +\ \cdot076v & +\ \cdot159w & -2\cdot009 & = 0 \\
-\ \cdot866x & & 1\cdot138z & +\ \cdot346u & +\ \cdot027v & -\ \cdot055w & +\ \cdot663 & = 0 \\
+\ \cdot798x & +2\cdot575y & +\ \cdot346z & +3\cdot663u & -\ \cdot082v & -\ \cdot114w & -\ \cdot189 & = 0 \\
+\ \cdot479x & +\ \cdot076y & +\ \cdot027z & -\ \cdot082u & +1\cdot395v & -1\cdot852w & -3\cdot700 & = 0 \\
-\ \cdot296x & +\ \cdot159y & -\ \cdot055z & -\ \cdot114u & -1\cdot852v & +2\cdot647w & +5\cdot164 & = 0
\end{array}
$$

From these the following corrections were obtained.

$$
\begin{aligned}
\delta\gamma &= -1\cdot11 \text{ km.} \\
\delta K &= +1\cdot34 \text{ km.} \\
\delta K_1 &= -1\cdot36 \text{ km.} \\
\delta e &= -\ \cdot006 \\
\delta\omega &= +0^\circ\cdot17 \\
\delta T &= -0\cdot013 \text{ day}
\end{aligned}
$$

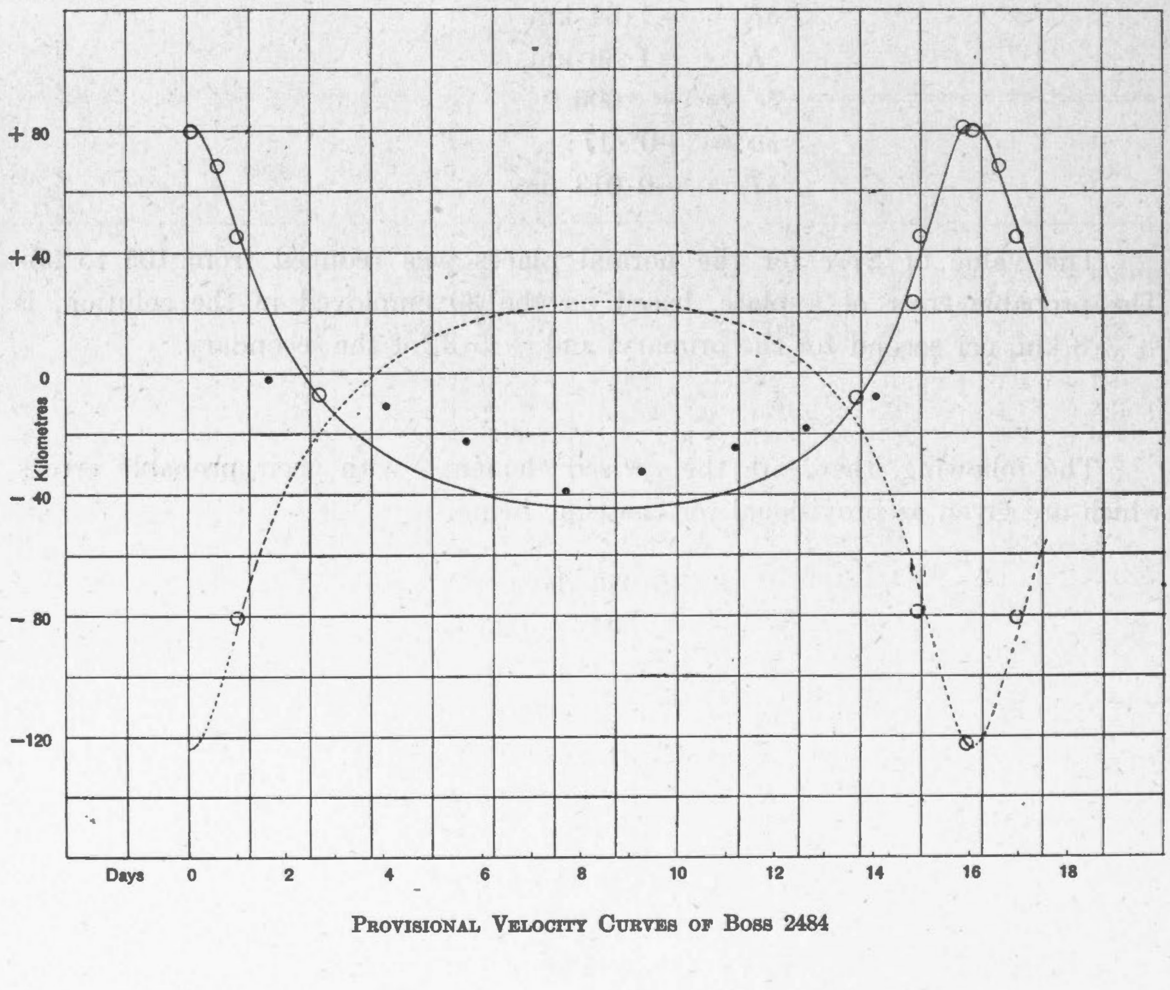
The value of Σpvv for the normal places was reduced from 105 to 95. The probable error of a plate, based on the 30 employed in the solution, is $\pm$ 3·8 km. per second for the primary, and $\pm$ 5·3 for the secondary.

The following, then, are the revised elements, with their probable errors which are given as provisional for the time being.

$$
\begin{aligned}
P &= 15\cdot986 \text{ days} \\
e &= \cdot504 \ \pm\cdot025 \\
\omega &= 355^\circ\cdot2 \ \pm7^\circ\cdot0 \\
\omega_1 &= 175^\circ\cdot2 \ \pm7^\circ\cdot0 \\
K &= 63\cdot34 \text{ km.} \ \pm\ 3\cdot35 \text{ km.} \\
K_1 &= 73\cdot64 \text{ km.} \ \pm3\cdot98 \text{ km.} \\
\gamma &= -13\cdot11 \text{ km.} \ \pm3\cdot50 \text{ km.} \\
T &= \text{J.D. } 2{,}419{,}408\cdot027 \ \pm\cdot143 \\
a \sin i &= 12{,}026{,}000 \text{ km.} \\
a_1 \sin i &= 13{,}981{,}000 \text{ km.} \\
m \sin^3 i &= 1\cdot48 \odot \\
m_1 \sin^3 i &= 1\cdot27 \odot
\end{aligned}
$$

In the accompanying graph the continuous curve represents the primary, the dotted curve the secondary. The open circles represent the grouped observations used in the least-squares solution, while the dots represent the unused observations grouped usually two together. The latter show the effect of the blending of the spectra on the measurement, as they all fall off the main curve on the side towards the γ-line. This condition is preferred, however, to using their erroneous values in the solution.

Dominion Observatory
Ottawa
April, 1916.



PROVISIONAL VELOCITY CURVES OF BOSS 2484

DEPARTMENT OF THE INTERIOR

CANADA

Hon. A. Meighen, *Minister* W. W. Cory, C.M.G., *Deputy Minister*

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

Otto Klotz, LL.D., D.Sc., *Director*

Vol. III, No. 12

Orbit of the Spectroscopic Binary 125 Tauri

BY

J. B. CANNON, M.A.

OTTAWA
Government Printing Bureau
1918

52201—1

ORBIT OF THE SPECTROSCOPIC BINARY 125 TAURI

BY J. B. CANNON, M.A.

This star ($\alpha = 5^h\ 34^m$, $\delta = +25°\ 50'$) was announced a binary by O. J. Lee (*Astrophysical Journal*, January, 1914) from the measures of 3 plates (Table II) giving a range of 62 km. The type is B3, the lines being, on the whole, rather poor. Table I gives the lines measured with the wave-lengths and the elements to which they are due.

TABLE I

LINES MEASURED

λ	Element	λ	Element
4481·400	*Mg*	4101·890	*H*
4471·676	*He*	4026·352	*He*
4388·100	*He*	3970·177	*H*
4340·634	*H*	3933·825	*Ca*
4267·301	*Fe*		

TABLE II

LEE'S OBSERVATIONS

Date	Julian Day	Phase	Velocity	O–C
1911				
Dec. 3..........................	2,419,374·748	17·701	+13	+10·6
1912				
Dec. 10..........................	747·733	0·590	+63	+10·2
Dec. 30..........................	767·656	20·513	+ 1	− 1·4

The determination of the elements of the orbit is based on the measures of 79 plates (Tables III and IV). These 79 plates were grouped into 14 normal places (Table V), and the best curve possible drawn through these.

TABLE III

OTTAWA OBSERVATIONS

Plate	Observer*	Date	Exposure	Julian Day	Phase	Vel.	Wt.	O–C
		1914	m.					
6608	H	Dec. 6	60	2,420,473·861	2·254	+43·6	3	+ 5·1
6618	P[1]	" 11	65	478·783	7·266	+20·9	2	+ 6·5
6630	H	" 15	66	482·785	11·178	+ 7·6	1	+ 0·6
6640	P[1]	" 16	70	483·830	12·223	+13·1	1	+ 7·3
6644	Y	" 17	60	484·764	13·157	+ 8·7	2	+ 3·7
6669	Y	" 30	65	497·682	26·375	+20·3	4	− 6·3
		1915						
6681	C	Jan. 4	65	502·800	3·329	+25·3	2	− 5·2
6687	Y	" 5	75	503·696	4·225	+22·6	4	− 2·4
6694	C–P[1]	" 8	65	506·737	7·266	+25·1	3	+10·5
6703	Y	" 10	60	508·634	9·163	+21·6	4	+11·4
6709	Y	" 12	82	510·659	11·188	+ 7·7	4	+ 0·7
6721	C	" 20	85	518·668	19·197	+13·4	3	+11·4
6735	C–P[1]	" 25	70	523·701	24·230	+ 6·8	1	− 1·4
6743	P[1]	" 27	60	525·639	26·168	+25·4	2	+ 1·0
6749	H	" 28	80	526·665	27·194	+27·6	4	−11·6
6759	C	" 29	85	527·692	28·221	+44·0	2	− 8·8
6767	C	Feb. 3	60	532·649	5·314	+24·3	3	+ 3·8
6784	C	" 12	80	541·694	14·359	− 0·4	1	− 4·4
6789	H	" 17	64	546·644	19·309	− 2·0	2	− 4·0
6797	H	" 18	60	547·570	20·235	− 3·1	3	− 5·3
6807	C	" 19	55	548·616	21·281	+ 3·9	1	+ 1·1
6813	Y	" 21	55	550·542	23·207	+23·3	2	+17·9
6828	H	Mar. 3	55	560·604	5·505	+ 7·9	2	−12·1
6836	H	" 4	60	561·596	6·397	+ 4·1	1	−12·7
6843	Y	" 7	60	564·528	9·329	+17·4	2	+ 7·4
6860	P	" 13	70	570·667	15·568	+ 5·8	2	+ 2·4
6869	H	" 15	59	572·600	17·501	− 2·4	3	− 4·8
6875	H	" 18	46	575·584	20·385	+11·1	3	+ 8·7
6880	Y	" 19	60	576·601	21·402	+15·3	2	+12·3
6890	H	" 24	57	581·515	26·316	+10·3	3	−15·2
6913	H	April 8	57	596·584	13·521	+ 6·6	2	+ 2·7
6920	Y	" 13	56	601·578	18·515	− 5·5	2	− 7·5
7248	H	Sept. 14	47	755·908	5·661	+11·4	2	− 7·6
7263	P[11]	" 17	60	758·816	8·569	+13·6	1	+ 2·2
7279	H	" 21	63	762·853	12·606	+10·3	3	+ 5·0
7287	C	" 22	75	763·852	13·605	− 0·2	1	− 4·8
7298	H	" 28	63	769·832	19·585	+ 1·4	3	− 0·8
7307	C	" 29	58	770·896	20·649	− 6·4	3	− 8·8
7335	C	Oct. 11	80	782·753	4·642	+13·8	1	− 9·4
7339	H	" 12	65	783·928	5·817	+30·6	2	+12·0
7346	C	" 15	71	786·868	8·757	+21·3	2	+ 9·9
7363	Y	" 24	70	795·840	17·729	+ 4·3	2	+ 1·9
7367	H	" 26	60	797·799	19·688	+ 0·9	1	− 1·3

TABLE III

OTTAWA OBSERVATIONS—*Concluded*

Plate	Observer*	Date	Exposure	Julian Day	Phase	Vel.	Wt.	O–C
		1915	m.					
7382	C	Nov. 6	60	2,420,808·729	2·754	+22·8	1	−20·2
7389	C	" 7	65	809·686	3·709	+20·3	2	− 7·7
7390	C	" 7	60	809·729	3·754	+28·9	1	− 0·1
7402	H	" 12	75	814·794	9·834	+23·5	2	+14·5
7407	Y	" 13	60	815·809	10·849	+ 9·7	2	+ 2·1
7416	C	" 17	80	819·669	13·694	− 0·4	2	− 5·0
7432	H	" 25	70	827·635	21·660	+23·1	2	+20·0
7442	C	Dec. 3	60	835·712	1·873	+39·5	3	− 2·7
7443	C	" 3	64	835·759	1·920	+46·2	3	+ 4·0
7445	C	" 3	65	835·869	2·030	+32·4	1	− 9·0
7459	H	" 28	58	860·702	26·863	+36·1	2	+ 1·6
7460	H	" 28	65	860·744	26·905	+33·0	2	− 1·5
7462	C	" 29	60	861·760	27·921	+53·2	3	+ 2·4
7463	C	" 29	50	861·799	27·960	+52·7	4	+ 1·9
7464	H	" 30	60	862·541	28·702	+49·6	3	− 2·2
7465	H	" 30	60	862·583	28·744	+52·0	2	+ 0·2
		1916						
7470	C	Jan. 3	70	866·576	4·873	+16·5	2	− 5·5
7471	C	" 3	60	866·622	4·919	+15·8	1	− 6·2
7476	C	" 7	60	870·562	8·859	+ 9·9	2	− 1·0
7477	C	" 7	60	870·604	8·901	+ 9·2	1	− 1·7
7490	C	" 19	60	882·559	20·856	− 0·3	1	− 2·7
7495	Y–C	" 28	60	891·620	2·053	+36·2	3	− 4·8
7496	C	" 28	67	891·669	2·102	+26·4	4	−14·6
7509	P	Feb. 19	58	913·522	23·955	+12·3	4	+ 4·8
7511	Y	" 20	70	914·501	24·934	+22·9	4	+10·9
7514	Y	" 20	64	914·644	25·077	+22·0	3	+ 9·0
7515	H	" 21	124	915·528	25·961	+ 8·2	3	−13·2
7516	C	" 23	60	917·500	27·933	+48·7	4	− 2·1
7545	H	Mar. 16	165	939·547	22·116	+15·7	4	+12·3
7547	Y	" 17	60	940·503	23·072	− 1·8	3	− 7·0
7556	Y	" 19	60	942·507	25·076	+12·3	3	− 0·7
7564	Y	" 21	38	944·593	27·162	+39·8	2	+15·8
7570	H	" 23	60	946·573	29·142	+44·6	2	− 4·2
7609	P	April 12	24	966·547	21·252	+12·3	3	+ 9·3
7614	H	" 13	60	967·594	22·299	+10·7	2	+ 6·8
7616	P	" 19	74	973·547	28·252	+64·9	4	+11·9

*P=Plaskett, J. S.; H=Harper; Y=Young; P[I]=Parker; P[II]=Plaskett, H. H.; C=Cannon

TABLE IV

MEASURES OF 125 TAURI

λ	6608		6618		6630		6640		6644		6669		6681	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	+48·45	¼	+21·28	¼	....	....	+26·54	¼	+16·53	¼	+31·42	½	+43·07	¼
4471·676	+39·81	¼	+19·41	¼	....	....	+ 8·33	¼	+ 2·36	¼	+23·64	¼	+22·89	¼
4340·634	+39·92	½	+20·36	½	+ 8·60	½	+10·52	½	− 2·26	½	+41·28	¼	....	....
4267·301	....	....	....	....	....	....	....	....	+24·27	¼	....	....	+42·65	¼
4101·890	+44·13	½	+13·62	¼	+ 2·05	¼	....	....	+18·66	¼	+31·07	½	+35·27	¼
4026·352	....	....	....	....	....	....	....	....	....	....	+34·44	¼	....	....
3970·177	+33·40	¼	....	....	....	....	....	....	....	....	+19·77	¼	....	....
3933·825	+31·64	½	....	....	+12·30	¼	....	....	....	....	+19·33	½	....	....
Weighted mean	+39·23		+19·00		+ 7·88		+13·97		+ 9·93		+28·28		+35·98	
V_a	+ 4·87		+ 2·30		+ 0·19		− ·36		− ·85		− 7·60		−10·19	
V_d	− ·20		− ·11		− ·14		− ·20		− ·08		− ·06		− ·23	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+43·6		+20·9		+ 7·6		+13·1		+ 8·7		+20·3		+25·3	

MEASURES OF 125 TAURI—*Continued*

λ	6687		6694		6703		6709		6721		6735		6743	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	+11·64	¼	+40·90	¼	+37·43	¼	+ 7·01	½	+40·06	¼	....	....	+41·70	¼
4471·676	....	....	....	....	+11·44	¼	+21·15	¼	....	....	....	....	....	....
4388·100	+44·85	¼	....	....	+47·78	¼	....	....	....	....	....	....	+63·95	¼
4340·634	+29·07	½	+32·80	¼	+35·85	½	+13·57	½	+23·68	½	+21·50	½	+30·88	½
4267·301	+45·75	¼	+15·39	¼	+16·68	¼	....	....	+51·21	¼	....	....	....	....
4101·890	+40·49	½	+43·48	¼	+35·92	½	+45·81	½	+34·71	¼	+37·50	½	+63·20	¼
4026·352	+36·80	¼	....	....	....	....	+12·82	½	....	....	+16·56	¼	....	....
3970·177	....	....	+38·21	¼	+39·61	¼	....	....	+34·78	¼	....	....	....	....
3933·825	+24·13	¼	+46·50	½	+42·03	½	+26·69	½	+11·51	¼	....	....	....	....
Weighted mean	+33·48		+37·69		+34·60		+21·99		+31·38		+26·91		+46·12	
V_a	−10·60		−12·12		−13·04		−13·99		−17·55		−19·71		−20·39	
V_d	− ·04		− ·16		± ·00		− ·04		− ·11		− ·17		− ·09	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+22·6		+25·1		+21·6		+ 7·7		+13·4		+ 6·8		+25·4	

MEASURES OF 125 TAURI—*Continued*

λ	6749		6759		6767		6784		6789		6797		6807	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	+60·72	¼	....	....	+64·57	¼	....	....	+24·58	¼	+20·68	¼	....	....
4471·676	+86·90	¼	+67·58	¼	+45·62	¼	....	....	....	....	+22·12	¼	....	....
4388·100	+67·58	¼	....	....	....	....	....	....	....	....	....	....	....	....
4340·634	+34·70	½	+52·62	½	+36·00	½	+31·68	½	+19·79	½	+24·41	¼	+26·00	¼
4267·301	+46·90	¼	....	....	+50·43	¼	....	....	....	....	+42·70	¼	....	....
4101·890	+24·51	½	+67·62	¼	+60·70	¼	+ 9·33	¼	+19·85	¼	+12·20	¼	+34·48	½
3970·177	....	....	+87·80	¼	....	....	....	....	....	....	....	....	....	....
3933·825	+59·40	¼	....	....	+40·20	¼	+30·38	¼	+43·18	¼	....	....	....	....
Weighted mean	+48·80		+65·64		+47·65		+25·76		+25·42		+24·42		+31·65	
V_e	−20·78		−21·17		−22·93		−25·66		−26·93		−27·14		−27·37	
V_d	− ·13		− ·17		− ·12		− ·22		− ·17		− ·08		− ·14	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+27·6		+44·0		+24·3		− 0·4		− 2·0		− 3·1		+ 3·9	

MEASURES OF 125 TAURI—*Continued*

λ	6813		6828		6836		6843		6860		6869		6875	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	+36·43	¼	+45·98	¼	+13·89	¼	......	...	+50·02	¼	+22·28	¼	+25·42	¼
4471·676	......	...	......	...	......	...	......	...	......	...	+13·06	¼	+57·68	¼
4340·634	+76·40	½	+30·31	½	+44·35	½	+38·49	¼	+26·80	½	+23·72	½	+47·85	½
4267·301	+34·42	¼	......	...	......	...	......	...	+51·82	¼	+28·20	¼	......	...
4101·890	+42·40	½	+43·92	¼	......	...	+54·20	¼	+25·45	¼	......	...	+28·22	¼
4026·352	......	...	......	...	......	...	+47·52	¼	......	...	......	...	......	...
3970·177	......	...	......	...	......	...	......	...	......	...	......	...	+49·12	¼
3933·825	......	...	......	...	+33·21	¼	+49·25	¼	......	...	+42·50	½	+45·30	¼
Weighted mean	+51·41		+37·63		+33·95		+47·36		+36·18		+27·99		+41·39	
V_a	−27·75		−29·26		−29·37		−29·62		−29·85		−29·88		−29·80	
V_d	− ·04		− ·17		− ·17		− ·08		− ·28		− ·22		− ·21	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+23·3		+ 7·9		+ 4·1		+17·4		+ 5·8		− 2·4		+11·1	

MEASURES OF 125 TAURI—*Continued*

λ	6880		6890		6913		6920		7248		7263		7279	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	+49·45	¼	+39·53	¼	+40·18	¼	+16·65	¼	−14·90	¼	−17·45	½	−16·98	¼
4471·676	....	....	+42·15	¼	....	....	+22·25	¼	−18·56	¼	−25·72	¼	−19·45	¼
4340·634	+52·05	¼	+53·75	¼	+29·27	½	+38·25	¼	−20·61	¼	− 3·27	¼	− 1·13	¼
4267·301	+43·80	¼	....	....	+38·71	¼	+40·24	¼	....	....	....	....	−21·38	¼
4101·890	....	....	+54·70	¼	....	....	+12·32	½	....	....	....	....	−32·91	½
4026·352	....	....	....	....	....	....	....	....	....	....	....	....	−14·74	¼
3970·177	....	....	+20·32	½	....	....	....	....	....	....	....	....	−13·15	¼
3933·825	+37·15	¼	+44·68	¼	....	....	+20·30	¼	....	....	....	....	....	....
Weighted mean	+45·61		+40·21		+34·36		+23·19		−18·01		−15·97		−19·07	
V_a	−29·77		−29·50		−27·31		−28·20		+29·58		+29·61		+29·54	
V_d	− ·22		− ·13		− ·24		− ·25		+ ·11		+ ·22		+ ·16	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+15·3		+10·3		+ 6·5		− 5·5		+11·4		+13·6		+10·3	

MEASURES OF 125 TAURI—*Continued*

λ	7287		7298		7307		7335		7339		7346		7363	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	−69·42	$\frac{1}{4}$	....		−35·28	$\frac{1}{4}$	−33·80	$\frac{1}{4}$	−10·96	$\frac{1}{4}$	−28·55	$\frac{1}{4}$	−24·40	$\frac{1}{2}$
4471·676	− 3·22	$\frac{1}{4}$	−30·80	$\frac{1}{4}$	....		−13·74	$\frac{1}{2}$	+ 8·30	$\frac{1}{4}$	....		+ 8·33	$\frac{1}{4}$
4388·100	....		−23·44	$\frac{1}{4}$	....		....		....		....		....	
4340·634	−26·66	$\frac{1}{4}$	−28·12	$\frac{1}{2}$	−39·63	$\frac{1}{2}$	+ 1·46	$\frac{1}{4}$	−11·49	$\frac{1}{4}$	+ 1·13	$\frac{1}{2}$	−24·88	$\frac{1}{4}$
4267·301	....		....		−36·08	$\frac{1}{4}$	....		+ 6·91	$\frac{1}{4}$	+ 3·19	$\frac{1}{4}$	−31·62	$\frac{1}{4}$
4101·890	−19·11	$\frac{1}{4}$	−23·48	$\frac{1}{4}$	−36·34	$\frac{1}{4}$	− 6·12	$\frac{1}{4}$	+19·30	$\frac{1}{4}$	−22·80	$\frac{1}{4}$	−34·57	$\frac{1}{4}$
4026·352	....		−31·18	$\frac{1}{4}$	−24·00	$\frac{1}{4}$	....		+12·66	$\frac{1}{4}$	+14·04	$\frac{1}{4}$	− 0·96	$\frac{1}{4}$
3933·825	....		....		....		....		....		− 0·32	$\frac{1}{4}$	....	
Weighted mean	−29·60		−27·52		−35·15		−13·19		+4·12		− 4·60		−18·93	
V_a	+29·47		+29·07		+28·96		+27·08		+26·83		+26·17		+23·49	
V_d	+ ·14		+ ·14		+ ·04		+ ·22		− ·08		+ ·02		+ ·03	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 0·2		+ 1·4		− 6·4		+13·8		+30·6		+21·3		+ 4·3	

MEASURES OF 125 TAURI—*Continued*

λ	7367		7382		7389		7390		7402		7407		7416	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	....	....	+67·80	½	+17·27	¼	+25·15	¼	....	....	+ 2·88	¼	....	....
4471·676	−12·12	¼	....	....	....	....	+ 9·83	½	−12·62	¼	+13·68	¼	....	....
4388·100	....	....	....	....	....	....	....	....	....	....	−15·46	¼	− 0·58	¼
4340·634	−18·80	½	+28·28	½	+ 2·04	½	+19·34	¼	+ 7·54	¼	− 8·71	½	−23·51	½
4267·301	−39·70	¼	....	....	−12·18	½	....	....	+28·50	¼	− 7·72	¼	− 6·94	¼
4101·890	....	....	+14·36	¼	−18·27	¼	−12·96	¼	+ 0·93	¼	−19·10	¼	−26·81	¼
3970·177	....	....	....	....	+ 4·79	¼	....	....	+11·28	¼	....	....	− 7·40	¼
3933·825	....	....	....	....	+29·22	¼	....	....	....	....	....	....	....	....
Weighted mean	−22·35		+41·30		+ 1·60		+10·24		+ 7·12		− 6·16		−14·79	
V_a	+23·40		−19·40		+18·77		+18·77		+16·64		+16·10		+14·48	
V_d	+ ·09		+ ·17		+ ·20		+ ·14		+ ·02		− ·02		+ ·17	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 0·9		+22·8		+20·3		+28·9		+23·5		+ 9·7		− 0·4	

MEASURES OF 125 TAURI—*Continued*

λ	7432		7442		7443		7445		7459		7460		7462	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400			+25·58	¼	+33·02	¼			+69·60	¼	+31·91	¼	+46·41	¼
4471·676	+ 8·70	¼	+19·15	¼	+26·12	¼	+40·02	¼			+49·42	¼	+87·50	¼
4388·100			+33·93	¼										
4340·634	+ 7·16	¼	+35·61	½	+45·43	½	+23·51	¼	+37·80	½	+48·61	¼	+41·74	¼
4267·301	+17·06	½					+11·97	¼						
4101·890					+34·21	¼	+29·28	¼	+26·30	¼	+29·26	¼	+67·06	¼
4026·352			+48·83	¼	+55·20	¼							+76·82	¼
3970·177													+44·30	¼
Weighted mean	+12·50		+33·11		+39·89		+26·19		+42·88		+39·80		+60·64	
V_a	+10·67		+ 6·65		+ 6·65		+ 6·65		− 6·46		− 6·46		− 7·00	
V_d	+ ·20		+ ·06		− ·04		− ·20		− ·04		− ·11		− ·14	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+23·1		+39·5		+46·2		+32·4		+36·1		+33·0		+53·2	

MEASURES OF 125 TAURI—*Continued*

λ	7463		7464		7465		7470		7471		7476		7477	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	+74·43	¼	+71·80	¼	+64·20	¼	...	...	+15·64	¼	+28·15	¼	+14·15	¼
4471·676	+38·90	½	+46·00	¼	...	...	...	...	...	...	+ 3·23	¼	...	...
4340·634	+87·30	½	+66·18	¼	+51·70	½	+33·12	½	+32·68	¼	+27·48	¼	+ 2·82	¼
4267·301	+57·50	¼	+44·55	¼	...	...	+22·33	½	...	...	+23·81	¼	...	...
4101·890	+42·89	¼	...	...	+70·65	¼	+19·58	¼	+28·08	¼	+24·37	¼	+33·00	½
4026·352	+57·60	¼	...	...	...	...	...	...	...	...	...	...	...	...
3933·825	+64·42	¼	...	...	...	...	...	...	...	...	...	...	...	...
Weighted mean	+60·14		+57·13		+59·56		+26·09		+25·47		+21·41		+20·74	
V_e	− 7·00		− 7·41		− 7·41		− 9·47		− 9·47		−11·40		−11·40	
V_d	− ·20		+ ·20		+ ·14		+ ·14		+ ·08		+ ·14		+ ·09	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+52·7		+49·6		+52·0		+16·5		+15·8		+ 9·9		+ 9·2	

MEASURES OF 125 TAURI—*Continued*

λ	7490		7495		7496		7509		7511		7514		7515	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	+17·31	¼	+46·42	¼	+26·18	¼	....	...	+64·33	½	+54·24	¼	+43·40	½
4471·676	+34·63	¼	+74·81	¼	+43·40	¼	....	...	+41·33	¼	+58·62	¼	....	...
4340·634	+ 0·23	¼	+52·92	½	+63·55	½	+34·72	½	+51·00	½	+37·90	¼	+34·98	½
4267·301	+15·49	¼	....	...	+51·40	¼	+42·42	¼	+37·61	¼	....	...	+27·98	½
4101·890	....	...	+61·30	¼	....	...	+43·90	¼	+38·02	¼	+53·22	½	+53·16	¼
4026·352	....	...	+55·21	¼	+40·42	¼	+53·05	¼	....	...	+18·90	¼	....	...
3970·177	....	...	....	...	+43·46	¼	+32·30	¼	+57·21	¼	....	...	....	...
3933·825	....	...	....	...	....	...	+31·62	¼	....	...	+61·82	½	+30·50	¼
Weighted mean	+16·91		+57·26		+47·41		+39·82		+50·60		+49·97		+36·14	
V_s	−17·00		−20·67		−20·67		−27·26		−27·47		−27·47		−27·68	
V_d	+ ·11		+ ·06		− ·09		+ ·02		+ ·05		− ·20		± ·00	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 0·3		+36·2		+26·4		+12·3		+22·9		+22·0		+ 8·2	

MEASURES OF 125 TAURI—*Continued*

λ	7516		7545		7547		7556		7564		7570		7609	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	....	....	+37·19	¼	+28·68	¼	+40·96	¼	+72·95	¼	....	....	+40·15	½
4471·676	+53·11	¼	+36·92	¼	+28·95	¼	+51·42	¼	+69·50	¼	+40·02	¼	+58·30	¼
4340·634	+99·62	¼	+40·82	½	+26·33	½	+37·67	¼	+73·50	½	+84·80	½	+21·94	½
4267·301	+78·66	¼	+59·10	¼	+29·70	¼	+35·70	¼	+60·22	¼	+53·36	¼	+60·22	¼
4101·890	+81·90	¼	+54·20	¼	....	....	+46·63	¼	....	....	+109·70	¼	+30·50	¼
4026·352	+57·80	¼	+32·85	¼	+30·85	¼	....	....	....	....	....	....	....	....
3970·177	+106·50	¼	....	....	....	....	....	....	....	....	....	....	....	....
3933·825	+61·02	¼	....	....	....	....	....	....	....	....	....	....	....	....
Weighted mean	+76·94		+45·99		+28·47		+42·48		+69·94		+74·53		+39·04	
V_s	−27·96		−29·86		−29·84		−29·77		−29·63		−29·49		−26·21	
V_d	+ ·04		− ·14		− ·14		− ·11		− ·23		− ·14		− ·25	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+48·7		+15·7		− 1·8		+12·3		+39·8		+44·6		+12·3	

MEASURES OF 125 TAURI—*Concluded*

λ	7614		7616											
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4481·400	....	....	+105·90	¼	....	....	....	....	....	....	....	....	....	....
4471·676	+ 36·51	¼	+ 92·00	¼	....	....	....	....	....	....	....	....	....	....
4340·634	+ 34·64	½	+ 96·60	½	....	....	....	....	....	....	....	....	....	....
4267·301	+ 48·80	¼	+ 88·20	¼	....	....	....	....	....	....	....	....	....	....
4101·890	+ 31·28	¼	+ 53·30	¼	....	....	....	....	....	....	....	....	....	....
4026·352	....	....	+ 96·20	¼	....	....	....	....	....	....	....	....	....	....
Weighted mean	+37·18		+89·83		....		....		....		....		....	
V_a	−25·96		−24·36		....		....		....		....		....	
V_d	− ·28		− ·27		....		....		....		....		....	
Curv.	− ·28		− ·28		....		....		....		....		....	
Radial Velocity	+10·7		+64·9		....		....		....		....		....	

TABLE V

NORMAL PLACES

No.	Julian Day	Phase	Velocity	Weight	O-C
1	2,420,852·514	1·957	+39·8	1·0	−2·1
2	661·557	3·103	+27·6	2·0	−4·5
3	711·496	5·036	+19·4	1·0	−2·1
4	603·354	6·374	+18·4	1·3	+1·6
5	695·533	9·120	+18·1	1·5	+7·7
6	580·109	11·231	+ 8·9	1·0	+1·7
7	685·444	13·217	+ 6·0	1·0	+1·0
8	624·063	16·619	+ 1·4	1·0	−1·2
9	639·685	19·891	+ 1·8	2·5	−0·3
10	847·908	22·114	+12·8	2·5	+9·2
11	761·936	25·676	+17·4	2·5	−0·8
12	743·874	27·064	+32·8	1·0	−5·4
13	827·528	0·119	+50·2	1·5	−1·4
14	918·193	0·762	+54·7	1·0	+2·4

This curve was determined graphically by successive trials. The elements are :

$$
\begin{aligned}
\mathrm{P} &= 27{\cdot}864 \text{ days}\\
e &= \;{\cdot}55\\
\omega &= 335^\circ\\
K &= 25{\cdot}5 \text{ km.}\\
\gamma &= 14{\cdot}8 \text{ km.}\\
T &= 2{,}420{,}471{\cdot}607 \text{ J.D.}\\
a \sin i &= 8{,}160{,}000 \text{ km.}
\end{aligned}
$$

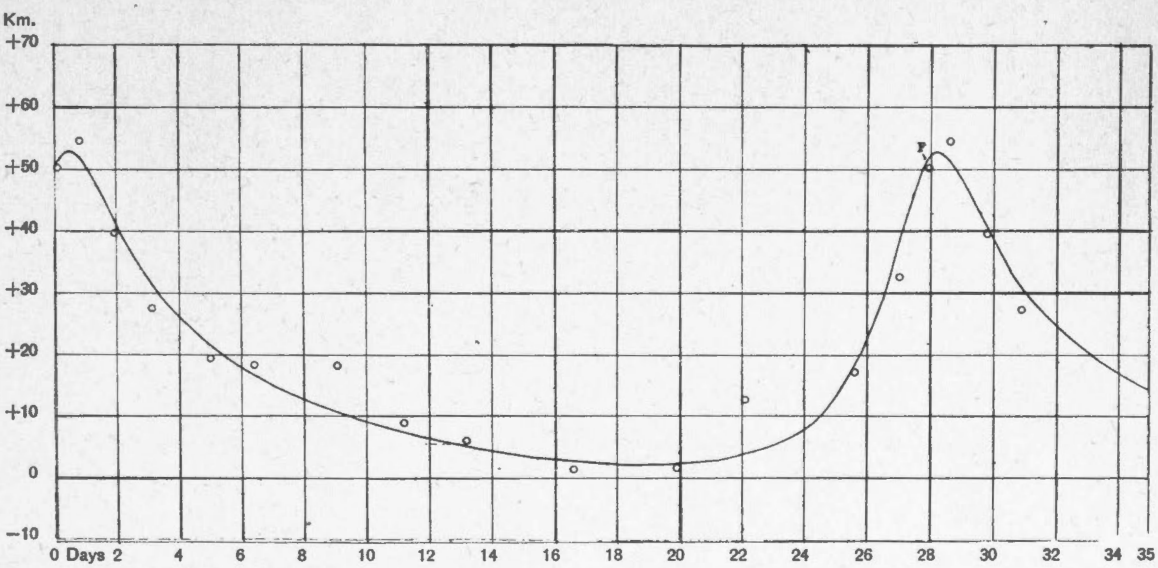
It will be seen that the residuals are unusually large and that the form of the curve which would go through, or approximately through, all the normal places would suggest the results of blends. Starting at phase 1 (on curve) it will be seen that the residuals become negative and continue so until about phase 6 days, when they become positive. They remain positive until about phase 14 days.

The similar feature is marked in the up-curve. This would be the effect of a blended spectrum caused by the light of the second body of the system if its spectrum were affecting the lines of the spectrum of the primary. It is impossible to say whether the curve given is low enough at the minimum or high enough at the maximum. Although, on some three or four plates one or two lines show a suspicion of doubling, there are none clearly enough defined to measure, so that there is no possible means of determining the true maximum and minimum. Mr. Lee in his announcement of the three measures referred to above, describes the lines as "simple," although one of his plates is taken at the maximum of the curve.

The lines of the spectrum, although not good at all, should allow of much closer measurement than the residuals indicate, and the blend theory seems the only one that would explain the regular variation of the residuals of the normal places. Similar effects have been found in systems where the secondary has been measurable at the maximum and minimum.

No least-squares solution was applied as any effect the solution might have, could hardly serve to approach nearer the true elements than those arrived at graphically. On account of the probability of blends affecting the velocities of the plates, no probable error was computed for either normal places or individual plates.

Dominion Observatory
Ottawa
June, 1916.



RADIAL VELOCITY CURVE OF 125 TAURI