REPORT

RELATIVE TO

MEASUREMENT OF LONGITUDE BETWEEN WELLINGTON AND OTAGO

BY MEANS OF ELECTRIC TELEGRAPH.

PRESENTED TO BOTH HOUSES OF THE GENERAL ASSEMBLY, BY COMMAND OF HIS EXCELLENCY.

WELLINGTON.

1871.

REPORT RELATIVE TO MEASUREMENT OF LONGITUDE BETWEEN WELLINGTON AND OTAGO BY MEANS OF ELECTRIC TELEGRAPH.

No. 1.

Messrs. JACKSON and THOMSON to the Hon. W. GISBORNE.

SIR,— Wellington, 21st September, 1871.

We do ourselves the honor of forwarding, for the information of the New Zealand Government, the results of our observations for the measurement of longitude between Wellington and Otago, by means of the Electric Telegraph.

As the subject of absolute or independent longitude is of primary importance not only to Colonial surveyors, but also to geographers and mariners, we had for some time past been occupied in determining it for our respective Provinces; the practical object being to establish a geographical position for the initial point of the surveys conducted under our supervision.

The method adopted to determine the absolute longitude in each case, was that technically termed, by "Moon Culminations." Observations by this system were commenced in Otago on the 15th September, 1869, and the results are now given in Appendix A, herewith enclosed. The Wellington observations were published in the *New Zealand Gazette*, No. 12, 1871.

Two meridians in the Colony having been thus independently determined by different observers, it became a matter of great interest to ascertain their comparative agreement, and hence their absolute value. For this object, the kind offices of the Hon. F. Dillon Bell, then Minister of Public Works, were solicited, to obtain the sanction of Government in granting us the use of the Electric Telegraph, which were readily accorded.

With the Electric Telegraph, it was in our power to compare the differences of our local times by "Star Transits:" a method which had been largely employed, and with extraordinary success, in America, at a very early period in the history of the Electric Telegraph. Since the lowest estimate of the velocity of the electric current is 16,000 miles per second, and as the distance between the Hutt and Caversham (the sites of our respective private observatories) is about 320 miles only, the transmission of an electric signal, denoting the transit of a star across the wires of a transit telescope, from one of the observatories, is practically received by the other instantaneously.

The two observatories having been placed in electric communication, the mode of proceeding may briefly be described as follows:—A list of stars was selected from the British Association Catalogue, and furnished to both observatories. Preparations having been made, the observer at the Hutt pointed the telescope of his transit instrument to one of the stars passing the meridian, and struck the signal key at the instant the star appeared to coincide with the transit wires; thus the times of the star's transits were simultaneously recorded from the chronometers at both observatories. As the stars selected followed in succession, by about four minutes interval, generally from two to three stars were taken at the Hutt before the first star arrived at the meridian of Rockyside, which was known to be approximately $17^{m.}$ $45^{s.}$ distant from that of the Hutt. The observer at Rockyside now pointed the telescope of his transit instrument, and the instants of the transits of the same stars were similarly recorded at both observatories. The time elapsing between the star's passage from one meridian to the other, subject to certain corrections for instrumental and chronometer errors, is the difference of longitude between the two stations. In this manner the observations were repeated as often as desired.

The observatories were placed in electric communication in the month of June, but owing to the prevalence of bad weather at this season of the year, no observations could be obtained until the 6th of July, since when, until about three weeks ago, only four nights were favourable for the operations.

As a report of this nature might be deemed incomplete without a brief description of the instruments used, and the modes practised for their adjustments, we beg to state that the instrument at Rockyside is a 24-inch transit instrument, by Troughton and Simms. It was mounted on a stone pedestal, built 3 feet into the ground, and rising $2\frac{1}{2}$ feet above the floor, from which it was entirely disconnected. Over this a wooden house was erected, about 9 feet square, with the usual slot from horizon to horizon, and opening with shutters. A mean-time chronometer, by Barraud, was used. In the observations for longitude by moon culminations, the transit instrument at Rockyside was always brought to true adjustment for azimuth, level, and collimation; but during the observations for electric difference of longitude, a different course was adopted. The azimuth of the meridian mark was again tested by eight sets of high and low and circumpolar stars. The level of the horizontal axis was tried before and after the observations of each night, and the errors were duly allowed for in the computations. As this instrument was not provided with a micrometer, the collimation was set true by carefully reversing upon the meridian mark, excepting on the night of the 23rd July, when this error was determined by observing the transits of a circumpolar star across Nos. 1 and 2 wires; then reversing the instrument, the transits were again taken on the same wires in a reverse order. The rate of the chronometer was tested at intervals of three to four days. The times of transits were noted from the chronometer by an assistant, at a signal from the observer.

The Hutt instrument, and the modes practised for its adjustment, have been fully described in the Report published in the *New Zealand Gazette*, No. 12, 1871. The times of transits here were registered by a chronograph, consisting of an ordinary Siemen's Register, but fitted with two sets of electro-magnets and armature levers; one set of electro-magnets and its armature lever being in circuit with a signal key, upon which the seconds of the chronometer were beaten, and the other with the observer's key for sending signals. By an arrangement of the wires, the instant of a star's transit were precisely recorded by the observer, with an embossed dot upon a fillet of paper moving between the rollers of the register, and simultaneously transmitted to Rockyside. The second beats of the chronometer were similarly embossed with the other electro-magnet and armature lever upon the same fillet of paper, but upon a line separated about ¼-inch from the line of transit dots. The register was started and stopped for each star, taking care to note the exact beat by chronometer of the first beat on starting, and of the last beat after stopping the register. The times of a star's transits were afterwards read off by transferring the transit dots into the line of chronometer second dots: and thus the exact second and fraction of a second, whenever the observer tapped his signal key, became precisely measured. The signals given from Rockyside were also registered by the Hutt chronometer in the above manner.

The personal equation of the observers was determined at the Hutt, by one of them observing the transits of a star over the first two wires of the transit instrument, and the other, of the same star over the last two wires. The times were recorded by chronograph. Each transit was then reduced to the mean wire by the known equatorial interval between each wire and the mean wire. The difference between each observer's independent determination of the star's transit by chronometer over the mean wire, is the personal equation. The mean of several trials furnished this equation with precision. The personal equation of the telegraphist at Rockyside, is the time elapsing between the instants of the observer giving the signal of a transit occurring, and the telegraphist transmitting the same to the Hutt. It was found, by placing two signal keys in circuit with a Morse's Register. The observer tapped one of the keys at the instant he gave the usual signal of a transit, and the telegraphist tapped upon the other key as when transmitting. The space between the two dots on the fillet of paper, when referred to the length of paper run out by the register in five to eight seconds of time by chronometer, represented, in time, how much later the telegraphist tapped his key after the usual transit signal had been given by the observer.

By reference to Appendix D, herewith enclosed, it will be seen that, when the mean electric difference of longitude is applied to the Rockyside absolute longitude, the so deduced longitude of the Hutt Observatory almost identically coincides with its absolute determination. In fact, the absolute or independent difference of longitude, as observed between the two stations, agrees to within 25 feet of the measured electric difference. That so close an agreement is a mere coincidence, cannot be doubted, as we expected to differ by about three seconds of time. But, as it is nevertheless a positive fact, brought about by two different observers, neither having a previous knowledge that the boon of being able to measure their difference of longitude by the telegraph would ever have been accorded, we beg to state that the longitude of the Hutt Observatory, as derived from sixty-two moon culminations, is $11^{h.}\ 39^{m.}\ 50{\cdot}72^{s.}$ East from Greenwich, and that, according to probability, its error does not exceed one second of time.

Since the difference of longitude between the Hutt and Wellington Observatories has been measured by triangulation, we have also been enabled to compare our result with the determinations of our predecessors on this subject.

	H.	M.	S.
Chronometric measurement by Captain Stokes, R.N., between Fort Macquarie, Sydney, and Pipitea Point	1	34	15·53
Sydney Observatory, West of Fort Macquarie		+	02·26
Difference of longitude, Sydney Observatory and Pipitea Point ...	1	34	17·79
Ditto Wellington Observatory and Pipitea Point		—	2·88
Ditto Wellington and Sydney Observatories ...	1	34	14·91
Longitude, Wellington Observatory	11	39	15·31
Ditto Sydney Observatory	10	05	00·40
Ditto ditto as given in *Nautical Almanack*, 1871	10	04	59·86
Difference		,,	0·54

Captain Carkeek had for many years pursued observations for longitude by lunars, Jupiter's satellites, lunar eclipses, and moon culminations. Unfortunately his calculations have been destroyed by fire, otherwise we would have desired to incorporate his result with ours. He gives the

	H.	M.	S.
Longitude of the Time Ball, Wellington	11	39	17·00
Difference of Longitude, Time Ball and Wellington Observatory ...	—		1·25
Longitude of Wellington Observatory	11	39	15·75

The longitude of Otago will now be adopted from that of Wellington; and, as the longitude of Tauranga will also be speedily determined in the same manner, by Mr. Heale, Inspector of Surveys under the Native Lands Act, there will thus be three points in New Zealand, extending nearly along its whole length, two of which will have been referred to an initial meridian at Wellington. Such being the case, and actuated by the same motives which first induced us to determine the absolute longitudes in our respective Provinces, we beg to submit for the consideration of the Government, that there shall be an initial meridian for the reference of all longitudes in New Zealand, at Wellington; which, as its capital, and from its central position, is the most eligible site that could be chosen; and that this initial meridian be that of the Government Observatory, of which the longitude East from Greenwich is $11^{h.}\ 39^{m.}\ 15{\cdot}31^{s.}$

In conclusion, we beg to record the valuable services rendered to us by Mr. Lemon and the officers of the Electric Telegraph Department. The arrangements made by them for the working of the wires were most complete, and to their cheerful assistance, we are indebted, in a great measure, for the success of our operations. Our cordial thanks are also due to Mr. James McKerrow, who, at Rockyside Observatory, assisted at the observations, and calculated their results independently, by way of check. He also, night after night, in the inclement season of winter, was in attendance either at the Electric Telegraph Office, Dunedin, or the Observatory, involving a journey of six and twelve miles respectively.

We have, &c.,

J. T. Thomson, F.R.G.S.

Henry Jackson, F.R.G.S.

The Hon. the Colonial Secretary, Wellington.

TABLE OF OBSERVATIONS TAKEN AT THE ROCKYSIDE OBSERVATORY FOR LONGITUDE.—APPENDIX A.

Date.	Star.	Position of Axis.	Observed Times of Transits by Solar Chron. Wires. 1	2	3	4	5	Mean of Wires. H	M	S	Daily Rate of Chron. s	Longitude East. H	M	S	Probable Error. s	Weight.	Remarks.
1869. Sept. 15	Sagittarii ...	C.W.	30·5	44·0	56·0	08·0	22·5	7	43	56·2	12·0 gaining	11	22	04·1	7·6	0·450	Observed by J. T. Thomson.
„ „	Moon I. ...	„	05·0	18·5	31·0	43·5	58·0	8	01	31·2							
„ „	Capricorni ...	„	39·5	52·5	05·0	16·5	31·0	8	51	04·9							
„ 16	Capricorni ...	„	54·0	08·0	20·0	32·0	46·0	8	47	20·2	12·6 „	„	„	15·3	7·9	0·417	Ditto.
„ „	Moon I. ...	„	13·0	26·0	39·0	50·5	05·5	8	51	38·8							
„ „	Capricorni ...	„	05·0	18·0	30·5	43·0	57·0	8	58	30·7							
„ 17	Capricorni ...	„	38·5	52·5	04·5	16·0	29·5	9	37	04·2	13·0 „	„	„	09·2	8·2	0·387	Ditto.
„ „	Moon I. ...	„	18·5	33·0	45·0	57·5	11·0	9	39	45·0							
„ „	Capricorni ...	„	28·0	42·5	53·5	07·0	19·0	9	54	54·1							
Nov. 20	Tauri ...	„	48·5	01·5	...	26·0	38·0	12	51	13·5	„ „	„	„	00·0	7·7	0·439	Ditto.
„ „	Moon II. ...	„	33·5	47·0	58·5	13·0	25·5	1	10	59·5							
„ „	Tauri ...	„	01·5	14·5	26·0	39·5	51·5	1	22	26·6							
„ 22	Geminorum ...	„	51·5	03·5	15·5	29·0	41·5	2	36	16·2	„ „	„	„	09·6	7·2	0·502	Ditto.
„ „	Moon II. ...	„	19·0	32·5	45·5	59·5	12·5	2	55	45·8							
„ „	Geminorum ...	„	53·5	06·5	18·5	32·0	44·5	3	11	19·0							
Dec. 17	Tauri ...	„	04·0	17·0	30·0	42·0	56·0	11	03	29·8	„ „	„	„	00·8	7·8	0·428	Ditto.
„ „	Moon I. ...	„	09·0	22·0	35·0	48·0	03·0	11	07	35·4							
„ „	Tauri ...	„	28·0	42·0	54·0	07·0	20·0	11	10	54·2							
„ 19	Geminorum ...	„	20·5	34·5	46·5	00·5	14·5	12	41	47·1	„ „	„	„	04·0	7·2	0·502	Ditto.
„ „	Geminorum ...	„	23·0	37·0	49·5	02·5	17·0	12	49	49·8							
„ „	Moon II. ...	„	13·5	27·5	40·5	54·0	10·0	12	54	41·1							
1870. Jan. 15	Orionis ...	„	39·0	53·0	04·0	18·0	33·0	10	41	05·4	„ „	„	„	08·8	7·2	0·502	Ditto.
„ „	Moon I. ...	„	28·0	42·0	55·0	08·0	23·0	10	45	55·2							
„ „	Orionis ...	„	09·0	21·0	35·0	48·0	03·0	10	50	35·2							
„ 16	Geminorum ...	„	26·5	40·5	52·5	06·5	20·5	11	46	53·3	„ „	„	„	02·5	7·0	0·531	Ditto.
„ „	Geminorum ...	„	38·5	51·5	03·5	17·0	31·5	12	01	04·4							
„ „	Moon I. ...	„	44·5	58·5	11·0	25·5	40·5	11	41	12·0							
„ 17	Geminorum ...	„	49·0	02·0	14·5	29·0	43·5	12	23	15·6	„ „	„	„	12·7	6·8	0·563	Ditto.
„ „	Moon II. ...	„	59·5	13·0	25·5	40·0	54·5	12	40	26·5							
„ „	Cancri ...	„	16·5	30·0	41·5	55·5	10·0	12	46	42·7							
„ 18	Cancri ...	„	38·5	52·0	04·0	17·0	31·5	1	20	04·6	„ „	„	„	08·5	7·0	0·531	Ditto.
„ „	Moon II. ...	„	07·0	20·5	33·5	47·5	02·5	1	37	34·2							
„ „	83 Cancri ...	„	59·0	12·0	24·5	38·5	51·5	1	54	25·1							
Feb. 15	Cancri ...	„	18·0	32·0	44·0	57·0	11·0	12	06	44·4	„ „	„	„	05·2	6·9	0·547	Ditto.
„ „	83 Cancri ...	„	57·5	12·0	23·0	37·0	51·0	12	10	24·1							
„ „	Moon I. ...	„	50·0	04·0	16·0	30·0	44·5	12	22	16·9							

TABLE OF OBSERVATIONS, &c.—*continued.*

Date.	Star.	Position of Axis.	Observed Times of Transits by Solar Chron. Wires. 1	2	3	4	5	Mean of Wires. H	M	S	Daily Rate of Chron. s	Longitude E. H	M	S	Probable Error.	Weight.	Remarks.
1870.															s		
Mar. 17	Virginis ...	C.W.	32·5	45·0	57·0	10·0	23·0	12	45	57·5							
" "	Virginis ...	"	17·0	29·0	41·0	53·5	07·0	12	50	41·5							
" "	Moon I. ...	"	58·0	11·0	23·0	36·5	50·0	12	58	23·7	13·0 gaining	11	21	58·9	7·1	0·516	Observed by J. T. Thomson.
" "	Moon II. ...	"	17·0	30·0	42·0	55·5	10·0	1	00	42·9	" "	"	"	59·0	7·1	0·516	Ditto.
" 18	37 Virginis ...	"	28·0	41·0	53·0	05·5	19·0	1	47	53·3	13·1 "	"	"	59·0	7·1	0·516	Ditto.
" "	Moon II. ...	"	08·5	21·5	33·5	46·0	00·5	1	55	34·0							
" "	48 Virginis ...	"	40·0	53·0	04·0	16·5	30·0	2	00	04·7							
" 19	Moon II. ...	"	54·5	07·0	19·0	32·0	46·0	2	50	19·7	" "	"	22	06·8	7·5	0·463	Observed by Jas. McKerrow.
" "	95 Virginis ...	"	23·0	36·0	47·0	01·5	14·5	2	58	48·4							
April 17	Moon II. ...	"	59·0	13·0	24·0	38·5	52·5	2	31	25·4	12·7 "	"	"	00·3	7·2	0·502	Ditto.
" "	Libræ ...	"	42·0	54·5	06·0	19·5	33·5	2	39	07·1							
" 21	Sagittarii ...	"	05·5	18·5	30·5	44·0	58·0	6	09	31·3	" "	"	"	17·5	7·1	0·516	Ditto.
" "	Moon II. ...	"	16·0	30·5	43·0	57·0	12·0	6	23	43·7							
" "	Sagittarii ...	"	40·0	53·0	05·5	19·0	33·5	6	34	06·2							
May 10	Leonis ...	"	45·5	58·0	10·0	23·0	36·5	8	28	10·6	12·8 "	"	"	06·6	7·8	0·428	Ditto.
" "	Moon I. ...	"	34·5	47·5	59·5	13·5	27·0	8	41	00·4							
" "	Leonis ...	"	35·0	48·0	00·0	14·0	26·5	8	44	00·7							
" 11	Virginis ...	"	40·0	52·0	03·5	17·0	30·5	9	21	04·6	" "	"	"	03·6	7·8	0·428	Ditto.
" "	Moon I. ...	"	57·0	10·5	22·0	36·0	50·0	9	33	23·1							
" 12	Virginis ...	"	41·5	54·0	06·0	18·5	32·0	10	13	06·4	" "	"	"	04·4	7·4	0·475	Ditto.
" "	38 Virginis ...	"	07·0	19·5	31·5	44·5	58·0	10	24	32·1							
" "	Moon I. ...	"	45·5	58·0	10·0	23·5	37·0	10	26	10·8							
1871.																	
May 27	Moon I. ...	"	19·0	33·0	46·0	59·0	13·0	6	02	46·0	15·9 losing	"	21	55·2	8·1	0·397	Observed by J. T. Thomson.
" "	Leonis ...	"	14·0	27·0	39·0	51·0	04·0	6	05	39·0							
" "	Leonis ...	"	29·0	43·0	54·0	07·0	19·0	6	37	54·4							
" 31	Moon I. ...	"	11·5	24·0	37·0	50·0	03·5	9	16	37·2	14·5 "	"	"	54·7	7·5	0·463	Ditto.
" "	94 Virginis ...	"	22·0	35·0	47·5	59·5	13·5	9	21	47·5							
" "	Virginis ...	"	53·5	07·5	19·0	31·0	45·0	9	28	19·2							
June 1	Libræ ...	C.E.	10·0	56·0	43·5	31·5	17·5	10	01	43·7	" "	"	22	08·7	6·9	0·546	Ditto.
" "	Moon I. ...	"	37·5	23·0	11·0	58·0	43·0	10	10	10·5							
" "	Libræ ...	"	48·5	35·0	22·5	09·5	56·5	10	17	22·4							
" 2	Moon I. ...	"	03·0	49·0	36·5	23·0	07·5	11	07	35·8	15·6 "	"	"	06·9	6·5	0·616	Ditto.
" "	Scorpii ...	"	57·0	42·0	30·5	17·5	03·5	11	11	30·1							
" "	Scorpii ...	"	29·0	15·0	03·0	49·5	36·0	11	18	02·5							
" 4	Sagittarii ...	C.W.	24·0	39·0	51·0	03·5	17·5	1	10	51·0	15·3 "	"	"	13·9	6·1	0·669	Ditto.
" "	Moon II. ...	"	44·5	59·5	13·0	26·0	42·0	1	15	13·0							
" "	Sagittarii ...	"	18·5	33·0	46·5	59·5	14·5	1	24	46·4							
	Mean Longitude by Weights, 26 Observations ...											11	22	06·19	1·4	12·850	

J. T. THOMSON, F.R.G.S.

HUTT OBSERVATORY—APPENDIX B.

Date.	Star.	Position of Axis.	Observed Times of Transits by Sid. Chron. — Wires. 1	2	3	4	5	Mean of Wires.	Instrumental Errors. a	b	c	True Meridian Transits. H	M	S	Chron. Error from the N.A. Stars. H	M	S	Mean Chron. Error. H	M	S	Rate of Chron.	Apparent Right Ascensions from Observations H	M	S	Position of Axis.	Observed Times of Rockyside Transits given by Electric Signal. — Wires. 1	2	3	4	·5	Mean of Wires.	Instrumental Corrections.	True Meridian Transits. H	M	S	Diff. of Longitude. H	M	S
1871.			s	s	s	s	s	s	s	s											s					s	s	s	s	s	s	s						
July 6	B.A.C. 5324	E.	04·42	51·86	39·20	26·82	14·43	39·35	+0·38	−0·05	+0·096	14	01	39·48	...	...	...	...	...	...	+1.75	15	57	18·30	W.	58·60	12·70	25·00	38·20	50·30	24·98	−0·23	14	19	24·75	0	17	45·29
„ „	„ 5548	„	50·91	38·34	26·24	13·71	01·11	26·06	„	„	„	14	34	26·20	...	...	...	...	...	...	„	16	30	05·06	„	45·70	59·43	12·15	24·45	36·84	11·71	−0·23	14	52	11·48	„	„	45·30
„ „	„ 5621	„	26·03	13·34	00·92	48·71	35·86	00·99	„	„	„	14	44	01·22	...	...	...	...	...	...	„	16	39	40·10	„	21·39	34·58	47·29	59·25	12·13	46·93	−0·35	15	01	46·58	„	„	45·38
„ „	„ 5808	„	15·67	01·75	48·04	34·21	20·31	48·00	„	„	„	15	11	48·05	...	...	...	...	...	...	„	17	07	26·95	„	05·63	19·68	33·60	47·22	01·50	33·53	−0·12	15	29	33·41	„	„	45·38
„ „	„ 5844	„	05·63	52·51	39·52	26·26	13·00	39·38	„	−0·09	„	15	17	39·51	...	...	...	...	...	...	„	17	13	18·44	„	58·07	11·91	25·34	37·96	51·42	24·94	−0·16	15	35	24·78	„	„	45·29
„ „	„ 5876	„	19·60	06·09	52·64	39·16	25·71	52·64	„	„	„	15	22	52·75	...	...	...	...	...	...	„	17	18	31·68	„	10·41	25·03	38·55	51·56	05·29	38·17	−0·14	15	40	38·03	„	„	45·30
„ „	„ 6355	„	28·60	12·55	57·22	40·84	25·68	56·98	„	−0·13	„	16	36	57·36	1	55	38·99				„	18	32	36·38	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ „	„ 6429	„	10·95	56·24	41·70	26·94	12·36	41·64	„	„	„	16	49	42·00	„	„	39·06	1	55	39·05	„	18	45	21·03	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ „	„ 6487	„	34·20	21·48	08·69	56·14	43·25	08·75	„	„	„	16	58	09·05	...	...	...			H. M.	„	18	53	18·09	„	28·57	42·26	54·64	07·52	20·48	54·69	−0·39	17	15	54·30	„	„	45·27
„ „	„ 6646	„	46·68	34·59	22·18	10·06	57·42	22·19	„	−0·10	„	17	23	22·43	„	„	39·04	at	S.T.	19 06	„	19	19	01·49	„	42·77	56·10	08·52	20·37	33·23	08·20	−0·31	17	41	07·89	„	„	45·48
„ „	„ 6833	„	45·77	33·41	21·38	08·31	56·38	21·05	„	„	„	17	53	21·29	„	„	39·13				„	19	49	00·39	„	41·45	55·06	07·15	19·25	32·14	07·01	−0·33	18	11	06·68	„	„	45 41
„ „	„ 6870	„	33·95	20·06	06·15	52·20	38·07	06·08	„	„	„	17	59	06·18	...	...	...	...	...	...	„	19	54	45·29	„	22·71	37·73	51·65	05·34	19·65	51·42	−0·11	18	16	51·31	„	„	45·15
„ 9	„ 5735	W.	08·72	23·73	38·31	53·56	07·93	38·45	+0·31	+0·25	−0·096	15	00	38·32	...	...	...	...	...	...	Nil.	16	56	22·46	E.	53·33	38·11	23·09	08·81	53·49	23·38	+0·10	15	18	23·48	„	„	45·16
„ „	„ 5781	„	51·03	03·69	16·51	29·27	...	16·49	„	„	„	15	07	16·49	...	...	...	...	...	...	„	17	03	00·63	„	27·70	13·97	01·19	48·74	35·65	01·45	+0·29	15	25	01·74	„	„	45·25
„ „	„ 5941	„	49·11	01·65	14·23	26·80	39·35	14·23	„	„	„	15	33	14·44	1	55	44·15				„	17	28	58·58	„	25·30	11·49	59·06	46·93	33·37	59·23	+0·27	15	50	59·50	„	„	45·06
„ „	„ 5987	„	33·44	46·79	00·00	13·33	26·45	00 00	„	„	„	15	39	59·96	...	...	...				„	17	35	44·10	„	11·95	57·93	44·84	32·10	18·30	45·02	+0·15	15	57	45·17	„	„	45·21
„ „	„ 6021	„	14·18	27 92	42·00	56·06	09·74	41·98	„	+0·33	„	15	45	42·28	1	55	44·23				„	17	41	26·42	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ „	„ 6168	„	54·59	07·78	20·82	34·12	47·18	20·90	„	+0·29	„	16	10	20·83	1	55	44·12	1	55	44·14	„	18	06	04·97	„	33·28	18·70	05·80	53·07	38·93	05·96	+0·16	16	28	06·12	„	„	45·29
„ „	„ 6209	„	33·89	48·21	02·23	16·58	30·66	02·31	„	„	„	16	17	02·16	...	...	...			H. M.	„	18	12	46·30	„	16.14	00·75	46·88	33·49	18·08	47·07	+0·12	16	34	47·19	„	„	45·03
„ „	„ 6263	„	51·31	05·04	18·65	32·53	45·82	18·67	„	„	„	16	24	18·56	...	...	...	at	S.T.	18·06	„	18	20	02·70	„	31·42	16·84	03·35	50·00	35·88	03·50	+0·14	16	42	03·64	„	„	45·08
„ „	„ 6487	„	38·05	50·77	03·65	16·47	29·08	03 60	„	„	„	16	58	03·80	...	...	...				„	18	53	47·94	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ „	„ 6528	„	21·04	33·73	46·52	59·19	11·64	46·42	„	+0·25	„	17	03	46·63	1	55	44·08				„	18	59	30·77	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ 21	„ 6168	W.	41·81	54·60	07·72	21·00	34·18	07·86	+0·28	+0·19	−0·096	16	10	07·87	...	...	...	...	...	...	Nil.	...	...	...	W.	...	...	52·93	06·07	19·80	53·06	+0·07	16	27	53·13	„	„	45·26
„ „	„ 6209	„	20·93	35·30	49·26	03·66	17·95	49·42	„	+0·14	„	16	16	49·44	...	...	...	...	...	...	„	...	...	...	„	...	20·00	34·58	48·63	...	34·30	+0·02	16	34	34·32	„	„	44·88
„ „	„ 6371	„	13·20	27·10	40·76	54·86	08·43	40·87	„	„	„	16	41	40·90	...	...	...	...	...	...	„	...	...	...	„	57·74	12·17	26·00	39·25	53·44	25·72	+0·03	16	59	25·75	„	„	44·85
„ 23	„ 4969	W.	29·00	42·60	56·16	10·38	24·27	56·48	+0·307	−0·03	−0·096	13	02	56·92	1	55	59·24				Nil.	14	58	56·16	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ „	„ 5227	„	19·00	33·83	47·90	03·10	17·40	48·25	„	+0·17	„	13	46	48·21	...	...	...				„	15	42	47·45	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ „	„ 5284	„	05·84	18·75	31·40	44·24	57·12	31·47	„	+0·20	„	13	54	31·72	...	...	...				„	15	50	30·96	E.	43·32	29·77	16·60	04·70	51·54	17·19	−0·11	14	12	17·08	„	„	45·36
„ „	„ 6107	„	21·00	35·63	49·67	03·82	17·97	49·62	„	+0·09	„	16	00	49·70	...	...	...				„	17	56	48·94	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ „	„ 6168	„	39·30	52·48	05·55	19·10	32·10	05·71	„	„	„	16	10	05·83	1	55	59·16				„	18	06	05·07	„	18·70	04·10	51·08	38·63	24·64	51·43	−0·37	16	27	51·06	„	„	45·23
„ „	„ 6263	„	36·07	49·94	03·10	17·00	30·83	03·39	„	+0·13	„	16	24	03·45	...	...	...	1	55	59·24	„	18	20	02·69	„	16·95	02·53	49·00	35·78	21·70	49·19	−0·41	16	41	48·78	„	„	45·33
„ „	„ 6487	„	23·32	35·94	48·70	01·20	13·96	48·62	„	+0·17	„	16	57	48·88	...	...	...			H. M.	„	18	53	48·12	„	00·20	46·47	33·82	21·76	08·30	34·11	−0·12	17	15	33·99	„	„	45·11
„ „	„ 6528	„	05·97	18·58	31·13	44·24	56·60	31·30	„	+0·21	„	17	03	31·53	1	55	59·24	at	S.T.	18·33	„	18	59	30·77	„	42·90	29·27	16·37	04·33	51·16	16·81	−0·13	17	21	16·68	„	„	45·15
„ „	„ 6575	„	13·70	26·93	40·75	54·47	08·18	40·81	„	+0·24	„	17	11	40·75	...	...	...				„	19	07	39·99	„	54·16	39·70	26·13	12·66	58·45	26·22	−0·41	17	29	25·81	„	„	45·06
„ „	„ 6772	„	44·97	57·80	09·96	22·78	35·16	10·13	„	+0·22	„	17	44	10·33	1	55	59·30				„	19	40	09·57	„	21·28	07·63	55·15	43·33	30·50	55·58	−0·14	18	01	55·44	„	„	45·11
„ „	„ 6802	„	06·93	19·42	32·00	44·50	56·67	31·90	„	„	„	17	48	32·09	1	55	59·30				„	19	44	31·33	„	42·90	29·54	17·04	05·10	52·09	17·33	−0·15	18	06	17·18	„	„	45·09
„ „	„ 6833	„	36·50	48·95	01·05	13·63	25·87	01·20	„	+0·20	„	17	53	01·39	1	55	59·22				„	19	49	00·63														

	H	M	S
Mean of Observations	0	17	45·206
Personal Equation of Observers	...	—	0·384
Personal Equation of Telegraphist at Rockyside ...	...	—	0·198
Resulting Diff. of Longitude between Hutt and Rockyside given by the Hutt Chron. and Observations on 28 Stars	0	17	44·624

HENRY JACKSON, F.R.G.S.

ROCKYSIDE OBSERVATORY—APPENDIX C.

Date.	Star.	Position of Axis.	Observed Times of Transits by Solar Chronometer. Wires. 1	2	3	4	5	Reduction to Mean Wire. H	M	S	Instrumental Errors. a	b	c	True Meridian Transits by Chronometer. H	M	S	Transits at Hutt by Electric Signal. Position of Axis.	Wires. 1	2	3	4	5	Reduction to Mean Wire at Hutt. H	M	S	Daily Rate of Chron. S	Correction for Rate. S	Correction for Sidereal Time. S	Correction to True Meridian at Hutt. S	Difference of Longitude. H	M	S
1871.		Circle.									s	s					Circle.									Losing.						
July 6	B.A.C. 5324	W.	07·0	21·0	33·0	45·5	58·5	8	47	33·0	−0·46	−0·05	Nil.	8	47	32·771	E.	16·0	03·5	51·0	38·5	26·5	8	29	51·1	16·4	+0·200	+2·908	−0·13	0	17	44·649
,, ,,	,, 5548	,,	48·5	02·0	14·5	26·5	39·5	9	20	14·2	,,	,,	,,	9	20	13·967	,,	57·0	44·5	32·0	19·5	07·0	9	02	32·0	,,	,,	+2·910	−0·14	,,	,,	44·937
,, ,,	,, 5621	,,	22·0	35·5	48·0	00·0	13·0	9	29	47·7	,,	,,	,,	9	29	47·349	,,	30·0	17·5	05·0	53·0	40·5	9	12	05·2	,,	,,	+2·911	−0·23	,,	,,	45·030
,, ,,	,, 5808	,,	01·5	15·5	29·5	43·0	57·5	9	57	29·4	,,	,,	,,	9	57	29·278	,,		01·5	47·5	33·5	20·0	9	39	47·49	,,	,,	+2·910	−0·05	,,	,,	44·838
,, ,,	,, 5844	,,	53·0	07·0	20·0	33·0	46·0	10	03	19·8	,,	,,	,,	10	03	19·638	,,	04·0	50·5	38·0	24·5	11·5	9	45	37·7	,,	,,	+2·910	−0·13	,,	,,	44·918
,, ,,	,, 5876	,,	04·5	19·0	32·5	45·5	59·0	10	08	32·1	,,	,,	,,	10	08	31·960	,,	17·0	03·5	50·0	36·5	23·5	9	50	50·1	,,	,,	+2·910	−0·11	,,	,,	44·860
,, ,,	,, 6487	,,	06·0	19·5	32·0	45·0	57·75	11	43	32·05	,,	,,	,,	11	43	31·660	,,	15·0	02·25	49·5	37·0	24·0	11	25	49·55	,,	,,	+2·911	−0·30	,,	,,	44·921
,, ,,	,, 6646	,,	15·5	29·0	41·5	53·5	06·0	12	08	41·1	,,	,,	,,	12	08	40·785	,,	23·0	11·0	58·5	46·5	34·5	11	50	58·7	,,	,,	+2·911	−0·24	,,	,,	44·956
,, ,,	,, 6833	,,	09·25	22·5	35·0	47·0	00·0	12	38	34·75	,,	,,	,,	12	38	34·415	,,	17·0	04·5	52·5	39·5	27·5	12	20	52·2	,,	,,	+2·912	−0·24	,,	,,	45·087
,, ,,	,, 6870	,,	49·5	04·5	18·5	32·0	46·25	12	44	18·15	,,	,,	,,	12	44	18·040	,,	04·0	50·0	36·25	22·5	08·5	12	26	36·25	,,	,,	+2·910	−0·10	,,	,,	44·800
,, 9	,, 5735	E.	17·5	02·5	47·5	33·0	18·0	9	33	47·7	+0·31	−0·017	,,	9	33	47·797	W.	37·0	52·0	06·5	21·5	35·5	9	16	06·5	16·6	+0·210	+2·908	+0·13	,,	,,	44·545
,, ,,	,, 5781	,,	51·0	37·0	24·5	12·0	59·0	9	40	24·7	,,	,,	,,	9	40	24·876	,,	18·0	30·5	43·5	56·0	...	9	22	43·36	,,	+0·209	+2·906	0·00	,,	,,	44·631
,, ,,	,, 5941	,,	44·0	30·0	17·5	05·5	52·0	10	06	17·8	,,	,,	,,	10	06	18·078	,,	11·5	24·0	36·5	49·0	01·5	9	48	36·5	,,	+0·209	+2·906	−0·21	,,	,,	44·483
,, ,,	,, 5987	,,	29·5	15·0	02·5	49·5	35·5	10	13	02·4	,,	,,	,,	10	13	02·551	,,	54·5	07·5	21·0	34·0	47·0	9	55	20·8	,,	+0·209	+2·908	+0·04	,,	,,	44·908
,, ,,	,, 6168	,,	45·0	30·5	17·5	05·0	51·0	10	43	17·8	,,	,,	,,	10	43	17·954	,,	10·0	23·5	36·5	49·5	02·5	10	25	36·4	,,	+0·209	+2·908	+0·07	,,	,,	44·741
,, ,,	,, 6209	,,	27·0	11·5	57·5	44·0	29·0	10	49	57·8	,,	,,	,,	10	49	57·916	,,	48·5	02·5	16·5	31·0	45·0	10	32	16·7	,,	+0·207	+2·907	+0·15	,,	,,	44·480
,, ,,	,, 6263	,,	40·5	26·0	12·5	59·5	45·5	10	57	12·8	,,	,,	,,	10	57	12·935	,,	04·5	18·0	31·5	45·5	58·5	10	39	31·6	,,	+0·209	+2·906	+0·11	,,	,,	44·560
,, ,,	,, 6487	,,	18·5	05·0	52·0	40·0	27·0	11	30	52·5	,,	,,	,,	11	30	52·786	,,	45·0	57·5	10·5	23·5	36·0	11	13	10·5	,,	+0·209	+2·908	−0·20	,,	,,	45·203
,, ,,	,, 6528	,,	00·5	46·5	34·5	22·0	08·5	11	36	34·4	,,	,,	,,	11	36	34·682	,,	27·0	39·5	52·5	05·0	17·5	11	18	52·3	,,	+0·209	+2·908	−0·21	,,	,,	45·289
,, 21	,, 6168	W.	...	...	51·5	04·5	18·0	9	52	51·49	+0·31	+0·073	,,	9	52	51·529	,,	43·5	56·5	09·5	22·5	35·5	9	35	09·5	16·0	+0·194	+2·910	−0·01	,,	,,	45·126
,, ,,	,, 6209	,,	01·5	17·0	31·5	45·5	...	9	59	31·02	,,	,,	,,	9	59	31·053	,,	21·5	35·5	49·5	04·0	18·0	9	41	49·7	,,	+0·193	+2·908	−0·02	,,	,,	44·408
,, ,,	,, 6371	,,	50·5	05·0	18·5	32·0	46·0	10	24	18·4	,,	,,	,,	10	24	18·434	,,	09·5	23·5	37·0	51·0	04·5	10	06	37·1	,,	+0·193	+2·908	−0·03	,,	,,	44·405
,, 23	,, 5227	E.	02·0	46·5	31·5	17·5	02·0	7	21	31·9	+0·31	+0·206	+0·285	7	21	31·401	,,	20·5	35·0	49·0	04·0	18·5	7	03	49·4	16·4	+0·200	+2·910	+0·04	,,	,,	45·151
,, ,,	,, 5284	,,	39·5	26·0	13·0	01·0	48·0	7	29	13·5	,,	,,	,,	7	29	13·385	,,	...	...	31·5	44·0	57·0	7	11	31·39	,,	+0·200	+2·908	−0·25	,,	,,	44·853
,, ,,	,, 6107	,,	38·5	23·5	09·5	55·75	41·5	9	35	09·75	,,	,,	,,	9	35	09·293	,,	59·0	13·0	27·0	41·5	55·5	9	17	27·2	,,	+0·200	+2·910	−0·08	,,	,,	45·123
,, ,,	,, 6168	,,	51·0	36·5	23·5	11·0	57·0	9	44	23·80	,,	,,	,,	9	44	23·437	,,	15·5	28·5	41·5	55·0	08·0	9	26	41·7	,,	+0·200	+2·908	−0·12	,,	,,	44·725
,, ,,	,, 6263	,,	46·75	32·5	19·0	05·5	51·5	9	58	19·05	,,	,,	,,	9	58	18·642	,,	09·75	23·5	36·5	50·5	04·0	9	40	36·83	,,	+0·200	+2·908	−0·06	,,	,,	44·860
,, ,,	,, 6487	,,	24·0	10·5	57·75	45·5	32·5	10	31	58·05	,,	,,	,,	10	31	57·932	,,	51·0	03·5	16·0	28·5	41·5	10	14	16·1	,,	+0·200	+2·908	−0·26	,,	,,	44·680
,, ,,	,, 6528	,,	05·5	52·0	39·5	27·5	14·0	10	37	39·7	,,	,,	,,	10	37	39·574	,,	32·5	45·0	57·5	10·5	23·0	10	19	57·7	,,	+0·200	+2·908	−0·23	,,	,,	44·752
,, ,,	,, 6575	,,	15·5	01·0	47·5	34·0	20·0	10	45	47·6	,,	,,	,,	10	45	47·190	,,	39·0	52·0	05·5	19·5	33·0	10	28	05·8	,,	+0·200	+2·907	+0·06	,,	,,	44·557
,, ,,	,, 6772	,,	37·0	23·5	11·0	59·0	46·5	11	18	11·4	,,	,,	,,	11	18	11·255	,,	04·5	17·0	29·5	42·0	54·5	11	00	29·5	,,	+0·200	+2·908	−0·20	,,	,,	44·663
,, ,,	,, 6802	,,	57·75	44·5	32·0	20·0	07·0	11	22	32·25	,,	,,	,,	11	22	32·096	,,	25·5	38·5	50·5	03·0	15·0	11	04	50·5	,,	+0·200	+2·907	−0·19	,,	,,	44·513
,, ,,	,, 6833		25·5	13·5	00·25	48·5	36·0	11	27	00·75				11	27	00·607		54·5	06·5	18·5	31·0	43·5	11	09	18·8	,,	+0·200	+2·908	−0·19	,,	,,	44·725

	H	M	S
Mean of observations	0	17	44·799
Personal equation of observers	...	—	0·384
Resulting difference of longitude between Rockyside and Hutt, given by Rockyside chronometer and observations on 33 stars	0	17	44·415

J. T. THOMSON, F.R.G.S.

Appendix D.

	H.	M.	S.	s
Electric Difference of Longitude, Hutt and Rockyside Observations by Rockyside Observations	0	17	44·415	
Ditto ditto Hutt „	0	17	44·624	
Mean	0	17	44·519	
Longitude, Rockyside Observatory, by J. T. Thompson, 26 observations, weight 12·850	11	22	06·190	± 1·4
Longitude, Hutt ditto ditto ditto ditto	11	39	50·709	
Ditto ditto H. Jackson 36 ditto weight 25·880	11	39	50·730	± 1·0
Mean Longitude of Hutt Observatory, 62 observations, weight 38·730	11	39	50·723	± 0·82
Difference of Longitude for Bearing, 235° 28′ 53·5″. Distance, 49215·7 feet		—	35·413	
Longitude of Wellington Observatory	11	39	15·310	± 0·82

J. T. Thompson, F.R.G.S.
Henry Jackson, F.R.G.S.