SESSION II.
1921.
NEW ZEALAND.

DEPARTMENT OF LANDS AND SURVEYS:

SURVEYS

(ANNUAL REPORT ON).

Presented to both Houses of the General Assembly by Command of His Excellency.

CONTENTS.

The SURVEYOR-GENERAL to the Hon. MINISTER OF LANDS.

SIR,— Wellington, 30th August, 1921.

I have the honour to present herewith the report on survey operations for the year ended 31st March, 1921. In doing so I would draw attention to the fact that the Surveyor-General in charge of these operations until the 25th October, 1920, was Mr. T. N. Brodrick, Under-Secretary for Lands. The following report is therefore partly based upon the work carried out under his guidance.

I have, &c.,
W. T. NEILL,
Surveyor-General.

Hon. D. H. Guthrie, Minister of Lands.

REPORT.

THE attached tables show that the volume of work handled by the Department for the last year has been maintained. The tables give a concise summary of the amount of work completed. Full details are contained in the reports supplied by the Chief Surveyors, which are filed as departmental records.

Under the heading of "Rural Surveys," in Table B, an area of 440,448 acres is shown as completed work, as compared with 613,810 acres for last year. The falling-off in the acreage returned is due to the smaller area of pastoral country included in this year's return.

The area of Native land surveyed shows an increase from 122,248 acres to 266,890 acres.

The average cost per acre of rural surveys has advanced from 2s. to 2s. 2d., and the average cost per acre of Native-land surveys has decreased from 2s. 4d. to 1s. 6d., as compared with the prices ruling last year. These figures show that the work is being done at a reasonable price.

A second increase of 20 per cent. to the schedule of rates for the surveys of Native and Crown lands, making a total of 40 per cent. on the 1913 schedule, was authorized on the 10th March. The effect of this increase will make the cost of surveys done by the staff surveyors more in agreement with the cost of the work done by contract surveyors.

The number of surveyors employed during the year under report was eighty, consisting of forty staff, four temporary, and thirty-six on contract, sixty-three of whom were employed in the North Island and seventeen in the South Island.

TABLE A.

Class of Work.	Area, &c.	Average Cost.	Total Cost.
			£ s. d.
Triangulation, by staff surveyors	38,100 acres	2·2d. per acre	356 17 11
Topographical, for selection, by staff surveyors	3,576 acres	0·42s. „	75 13 0
Rural	438,925 acres	1·96s. „	43,087 14 7
Village and suburban, by staff surveyors	503·5 acres	20s. „	503 9 11
Village and suburban, by licensed surveyors	69·1 acres	41·45s. „	142 15 0
Town, by staff surveyors	249 sec.	45·14s. per section	562 0 0
Town, by licensed surveyors	140 sec.	30·91s. „	216 7 3
Native Land Court, by staff surveyors	6,193 acres	3·36s. per acre	1,041 10 6
Native Land Court, by licensed surveyors	246,452 acres	1·50s. „	18,540 3 7
Native Land Court (paid by applicants)	14,245 acres	..	..
Coal- and gold-mining areas (paid by applicants)	2,669 acres	..	..
Sawmill areas (paid by applicants)	1,523 acres	..	..
Roads, by staff surveyors	197·06 miles	£27·91 per mile	5,499 7 6
Roads, by licensed surveyors	13·38 miles	£30·22 „	405 0 3

TABLE B.

Land District.	Rural Surveys.	Native Land Court Surveys.
	Acres.	Acres.
North Auckland	43,588	17,490
Auckland	102,550	110,839
Hawke's Bay	55,513	42,702
Taranaki	19,307	5,574
Wellington	40,578	88,770
Marlborough	6,474	3,038
Nelson	40,331	..
Westland	2,936	..
Canterbury	9,825	107
Otago	102,278	344
Southland	17,068	1,026
Totals	440,448	266,890

MINOR TRIANGULATION.

An area of 38,100 acres is shown under this heading. The bulk of the work is in Auckland District, and a small area in Taranaki, and was undertaken to control the settlement surveys.

TOPOGRAPHICAL, FOR SELECTION.

A small area of 3,576 acres is shown under this heading, at a cost of 0·42s. per acre. This work is done as a preliminary to settlement surveys, and a portion of the area is on the Great Barrier Island.

SETTLEMENT SURVEYS.

The settlement surveys comprise Crown lands, land for settlement, and land for discharged soldiers. The bulk appears in Table A under the head of "Rural," the acreage there shown being 438,925 acres, while the remainder includes village and suburban and town lands, totalling 787 acres.

NATIVE SURVEYS.

During the year an area of 6,193 acres was completed by the staff surveyors, while an area of 260,697 acres was surveyed by private surveyors. The area surveyed in each land district is given in Table B.

GOLD- AND COAL-MINING SURVEYS.

An area of 2,669 acres is shown under this head. The surveys were made by private surveyors, and the fees paid by the applicants.

MAJOR TRIANGULATION.

This survey is held in abeyance, both as regards the field-work and the office computations.

STANDARD SURVEYS.

Two experienced surveyors are at present engaged on these useful surveys—Messrs. C. A. Mountfort and H. M. Kensington, District Surveyors in Palmerston North and Gisborne respectively.

Mr. Mountfort has completed the field-work of twenty-eight miles of road traverse in the vicinity of Feilding, on Bunnythorpe–Palmerston Road, Feilding-Colyton–Ashhurst Road, and Bunnythorpe–Ashhurst Road. He has also revised part of the Marton standard survey, and is extending the survey of Palmerston North.

Mr. Kensington returns thirty-three miles of streets, the plans of which have been completed during the year under report, in the City of Auckland, and reports that the field-work of the standard survey of Gisborne is about half-finished.

An examination of the traverse closures shows that the high standard of precision aimed at in these surveys has been maintained.

TOPOGRAPHICAL SURVEY.

This survey is held in abeyance.

INSPECTIONS.

A certain amount of inspection work has been carried on by the Chief Draughtsmen and staff surveyors, but on account of the pressure of work in connection with settlement surveys not much of this necessary work has been done during the year.

It is essential that more inspections should be made, so that an adequate check can be kept on the work of the staff and surveyors in private practice.

TIDAL SURVEY.

The work for the year comprised the preparation of the data to enable a tide-table for the year 1922 to be prepared by means of the tide-predicting machine at the National Physical Laboratory, Teddington, England, of the ports of Auckland, Wellington, Lyttelton, Dunedin, Bluff, and Westport. All the computations pertaining to the work required to evaluate the harmonic constants have been completed by Mr. E. J. Williams, Tide-computer, with a certain amount of temporary assistance.

Tidal records and other meteorological data, together with the surface temperature of the sea, have been received regularly from New Plymouth.

Fresh analyses of the six standard ports for which predictions are required have been commenced, and will be continued during next year.

In the report of Mr. E. J. Williams, Tide-computer, appended hereto, are given details of the tidal work, and a table showing the sea-temperature at New Plymouth.

The computing division is at a great disadvantage on account of the depletion of the staff and the difficulty of securing a suitable computer. The appointment of an assistant computer is indispensable in order that the essential duplicate check is made on all important calculations.

Magnetic Observatory.

During the year under report the work of the Magnetic Observatory at Christchurch and the sub-station at Amberley has been efficiently carried on by the Director, Mr. H. F. Skey, B.Sc. His full report with diagrams, tables, and seismic records is published as an appendix hereto.

Two outstanding events in the history of the Observatory have occurred within the last year. The first is the discovery by Mr. Skey of a new period in the variation of the horizontal force, which repeats itself in about 329 days, and is almost exactly equal to twelve synodic rotations of the sun. This result was obtained from a preliminary mathematical discussion of the observations at Christchurch, the details of which are published in the appendix.

The second event of special importance was the visit of the survey yacht "Carnegie," of the department of terrestrial magnetism of the Carnegie Institute, Washington. This vessel, under the command of Captain J. P. Ault, arrived at Lyttelton in October, 1920. During the visit a valuable comparison was made between the Observatory standards and those of the Carnegie Institution by the scientific staff of the vessel, assisted by the Observatory staff. It is just five years since the last visit of the "Carnegie" to Lyttelton on her fourth cruise (1915–16). The object of the present cruise is to obtain information regarding the rate of change of the magnetic elements, in order to determine the extent and character of the corrections which the existing magnetic charts require to bring them up to date. In this connection a repeat observation at the principal magnetic stations of the Dominion is a pressing work, and should be undertaken as soon as possible.

In addition to the current work of the year the records for the year 1910 were also measured and the results published in the appendix. These comprise various diagrams, tables of the hourly values of the magnetic declination and horizontal force, also a list of the earthquakes recorded at Christchurch during 1920 by Milne seismograph No. 16. The mean annual values of the magnetic elements as far as they are available are given in Table C following:—

Table C.—Mean Annual Values of the Magnetic Elements at Christchurch Observatory.

Date.	Declination E. of N.	Annual Change.	Horizontal Force.	Annual Change.	Vertical Force.	Annual Change.	Inclination South.	Annual Change.	Published in Annual Report.
	° ′	′	C.G.S. Unit.	γ	C.G.S. Unit.	γ	° ′	′	
1902 ..	16 15·1	+3·2	0·22694	−25	0·55277	+ 9	67 40·8	+1·50	1912–13
1903 ..	16 18·3	+3·5	0·22669	−25	0·55286	+21	67 42·3	+1·80	1912–13
1904 ..	16 21·8	+3·6	0·22644	−16	0·55307	+41	67 44·1	+1·70	1912–13
1905 ..	16 25·4	+2·4	0·22628	−23	0·55348	+28	67 45·8	+1·80	1919–20
1906 ..	..	..	..	..	..	..	..	..	..
1907 ..	..	..	..	..	..	..	..	..	..
1908 ..	..	..	..	..	..	..	..	..	..
1909 ..	..	..	..	..	..	..	..	..	..
1910 ..	16 37·6	+1·4	0·22515	−27	0·55485	+12	67 54·8	+1·40	1920–21
1911 ..	16 39·0	+2·5	0·22494	−23	0·55497	− 9	67 56·2	+1·00	..
1912 ..	..	..	..	..	..	..	..	..	..
1913 ..	16 44·0	+0·8	0·22449	−35	0·55478	−13	67 58·2	+1·60	1913–14
1914 ..	16 44·8	+2·2	0·22414	−27	0·55465	+ 7	67 59·8	+1·67	1914–15
1915 ..	16 47·0	+2·8	0·22387	−32	..	..	..	..	*Sept., 1918
1916 ..	16 49·8	+3·2	0·22355	−27	..	..	..	..	*Sept., 1918
1917 ..	16 53·0	+2·7	0·22328	−24	0·55486	+30	68 04·8	+1·90	*Mar., 1921
1918 ..	16 55·7	+2·9	0·22304	−24	0·55516	− 9	68 06·7	+1·10	1918–19
1919 ..	16 58·6	+3·1	0·22280	−19	0·55507	+18	68 07·8	+1·40	1919–20
1920 ..	17 01·7	..	0·22261	..	0·55525	..	68 09·2	..	1920–21

* Published in *New Zealand Journal of Science and Technology*.

Proposed Operations for 1921–22.

Triangulation.—This survey for the time being is discontinued, but it is anticipated that a start may be made during the coming year.

Standard Surveys.—Mr. C. A. Mountfort, District Surveyor, will complete the standard survey of Palmerston North. He will also complete the standard survey of a portion of the Borough of Hamilton, which was commenced in 1907 and left in an incomplete state, and continue the rural standard traverse work in Wellington District. Mr. A. C. Haase, surveyor, is attached to Mr. Mountfort's party in order to receive training and gain experience in this class of work. It is important that more surveyors should be trained to this work as soon as circumstances permit.

Mr. H. M. Kensington, District Surveyor, will be fully occupied with the standard survey of Gisborne.

Pressing demands for these surveys are being received from all parts of the Dominion, and it is essential that a staff be organized to conduct the standard survey so that in the near future the work may be undertaken in a more uniform and comprehensive manner.

Topographical Survey.—It is proposed to start this work as soon as it is sanctioned by the Government. There is now sufficient equipment on hand to provide at least one party with the necessary instruments for commencing the survey.

Survey Regulations.—It is proposed to recast and issue a new edition of the Survey Regulations for the guidance of Surveyors under the Surveyors' Institute and Board of Examiners Act, 1908, and the Rules and Directions for the guidance of the officers in the Department under the Land Act, 1908.

GENERAL.

Explorations between Milford Sound and the Hollyford River.—During February Mr. D. Macpherson was allowed to join Mr. S. Turner's expedition to explore the country between the head of Milford Sound and the Hollyford River, the objects of the expedition being to climb Mount Tutoko and examine the Darran Mountain Range for a pass leading from the head of the Cleddan Valley to the Hollyford. An account of the trip, compiled from the reports supplied by Messrs. Turner and Macpherson, with illustrations, is given in Appendix III hereto.

Extract from Report by H. M. Skeet, Chief Surveyor, Auckland.—"Another young Samoan, Mr. A. S. Meredith, was sent by his home authorities to New Zealand to study our methods of office routine and field surveying. After a short period in the office he joined Mr. L. J. Poff's survey party in the Urewera country. Mr. J. Melei, who is being relieved by Mr. Meredith, left for his home early in January."

Extract from Report by G. H. M. McClure, Chief Surveyor, Wellington.—"Water-supplies to soldier settlements: The only work under this heading was the water-supply installed in the Awapuni Settlement, just beyond the Borough of Palmerston North. A bore was sunk here to a depth of 374 ft., the result being very successful, the pressure at the bore being sufficient to lift water in a pipe to a height of 45 ft. above the level of the ground. The supply of water from the Awapuni well is more than sufficient for the requirements of the settlement, and negotiations are in progress for disposing of the surplus at a fixed rate to neighbouring settlers and others."

Full details of the personnel of the staff, both field and office, are given in the report by the Under-Secretary for Lands.

In conclusion I am pleased to place on record the appreciation by the various Chief Surveyors of the manner in which their officers, both permanent and temporary, have carried out their duties during the year, and I desire to convey my thanks to the whole of the Survey staff for their good work.

APPENDIX I.

(a.) REPORT BY M. CROMPTON SMITH, CHIEF DRAUGHTSMAN.

HEAD OFFICE DRAUGHTING STAFF.

LAST year's report gave a *résumé* of the volume of work ahead of this office as a result of a consideration of the state of the map publications of the Department. At the end of the year it is disappointing to find that no map on the newly projected series has achieved publication yet, though several are in hand as stock jobs.

Present exigencies make it impossible to think of increasing staff, which remains below normal. Claims of other Departments for urgent work, such as census maps, have therefore pushed aside and stopped altogether the Department's own work, and finally such general maps as have been produced have been held up owing to difficulties created by pressure of work at the Printing Office.

Two much-needed city maps—Auckland and Christchurch—are being drawn by draughtsmen in these towns; four borough maps are in hand, and one draughtsman is engaged on cadastral two-mile series. Provisional maps of seven counties have been prepared and sent to the Printer; four new cadastral two-mile maps are completed, and five in hand, but it is useless sending them for printing under present conditions. The Auckland and Wellington topo. 1/12500 have been reprinted during the year, and altogether 111 maps have been sent to the Printer during the year.

Maps for the census of 1921 were prepared, and all those for New Zealand prepared by the district offices were checked and entered into sub-enumerators' books, and the maps for the Representation Commission begun. Town schemes for the Minister's approval continued in numbers without any serious dimunition till the end of the year. Descriptions, maps, &c., for other Departments during the year amounted to £638, including census maps.

Lithographs issued without charge were about 1,600 in number, estimated at about £250 in value.

DRAUGHTSMAN'S EXAMINATION.

Owing to pressure of work this examination was not held till November, when five candidates sat. A first-class certificate as computer was gained by Mr. E. J. Williams; first-class certificates in draughting were granted to Messrs. C. E. Pfeifer and W. Bardsley, and a second-grade certificate to Mr. C. D. Maher.

The examination has emphasized very strongly the need, always felt, of a departmental handbook covering all the grounds of the technical branches of the office, both draughting and computing and field. The book is now being planned, and several of the sections are being written by experienced officers in charge of the principal branches. The professional handbooks now in existence will be revised and incorporated in the plan.

Surveyors' Board.

At the examination in September, 1920, twenty-six candidates sat, and twelve passed; and at the March examination fifteen candidates sat, and six passed.

At the end of the March examination the Board considered very fully the position regarding the issue of new Survey Regulations, and came to a conclusion regarding it, enabling the revision to be undertaken during the ensuing year.

(*b*.) Computation of Tidal Constants by E. J. Williams, Tide-computer.

The computations required to evaluate the harmonic constants used in predicting the tides of the six standard ports for the year 1922 have been completed.

From the harmonic analysis of the measured hourly heights of the tide-gauge records of any port extending over a period of 370 days is obtained one value of H (semi-range) and one value of K (epoch) for each component for each year of hourly heights analysed.

For the larger tides, M2, S2, &c., the values obtained are fairly concordant. In the smaller tides, however, on account of tidal observations not being exactly in accordance from year to year, there are considerable discrepancies. Therefore it is necessary to extend the observations over a number of years, and to accept the mean of the values of H and K for each tide, for the completed years of analysis, as the best result. In accordance with the above the following table was prepared and forwarded to the Director, National Physical Laboratory, Teddington, London, England, on the 1st June, 1920, for employment in the tide-predicting machine, and the tide-tables for 1922 were received in Wellington on the 4th January, 1921.

Mean Values of the Harmonic Constants used in preparing the Tide-tables for 1922.

Tide Symbol.	Auckland. $A_0 = 5 \cdot 74$ ft.		Bluff. $A_0 = 5 \cdot 38$ ft.		Dunedin. $A_0 = 3 \cdot 23$ ft.		Lyttelton. $A_0 = 3 \cdot 20$ ft.		Wellington. $A_0 = 2 \cdot 93$ ft.		Westport. $A_0 = 5 \cdot 00$ ft.	
	H.	K.	H.	K.	H.	K.	H.	K.	H.	K.	H.	K.
Short Period.	Ft.	°	Ft.	°	Ft.	°	Ft.	°	Ft.	°	Ft.	°
S1	0·009	11·03	0·007	68·10	0·012	337·40	0·035	31·12	0·005	228·48	0·013	74·64
S2	0·597	263·50	0·509	48·50	0·236	129·95	0·173	141·42	0·098	329·46	0·983	331·69
S4	0·019	336·59	0·008	233·57	0·006	301·85	0·011	188·72	0·005	188·20	0·008	54·92
S6	0·002	50·98	0·004	176·56	0·004	123·00	0·014	348·69	0·005	309·32	0·003	334·63
M1	0·011	141·89	0·011	84·79	0·009	128·68	0·010	105·35	0·006	49·45	0·013	340·63
M2	3·794	204·00	2·862	35·13	2·506	123·38	2·883	125·36	1·597	135·35	3·762	304·20
M3	0·048	204·02	0·008	281·81	0·013	245·63	0·019	108·63	0·025	192·86	0·024	202·01
M4	0·110	127·80	0·095	228·49	0·257	179·05	0·014	81·25	0·037	286·46	0·066	35·28
M6	0·023	294·55	0·086	77·28	0·076	359·86	0·021	66·42	0·016	100·77	0·026	38·59
O1	0·062	136·62	0·108	75·29	0·087	75·72	0·087	62·78	0·105	34·45	0·096	48·26
K1	0·234	167·74	0·061	113·16	0·071	89·15	0·144	84·56	0·086	79·98	0·075	184·91
K2	0·142	251·27	0·118	57·84	0·096	127·52	0·054	101·96	0·046	340·07	0·287	327·05
P1	0·073	167·06	0·021	103·64	0·025	96·80	0·052	116·79	0·030	67·31	0·023	110·12
J1	0·016	214·22	0·004	207·39	0·005	126·14	0·008	89·85	0·006	140·90	0·015	273·15
Q1	0·011	59·44	0·024	43·55	0·021	355·66	0·018	43·24	0·029	22·22	0·037	38·40
L2	0·190	212·64	0·127	28·87	0·189	101·32	0·094	108·35	0·055	140·74	0·110	269·18
N2	0·781	169·09	0·661	14·04	0·549	104·89	0·670	93·58	0·389	99·67	0·745	288·44
ν2	0·202	180·03	0·099	68·00	0·053	157·88	0·118	145·96	0·108	109·38	0·173	316·14
μ2	0·104	168·04	0·065	8·37	0·034	17·52	0·087	65·45	0·081	86·45	0·111	273·67
T2	0·077	103·24	0·023	111·74	0·022	262·01	0·032	220·40	0·040	308·20	0·042	44·18
(MS)4	0·176	193·71	0·080	359·97	0·106	141·93	0·104	128·62	0·036	134·61	0·106	301·30
(2SM)2	0·063	307·32	0·038	120·79	0·043	4·23	0·077	25·77	0·033	5·18	0·078	203·68
R2	..	..	0·018	119·43	0·016	171·69	0·011	172·05	..	..	0·049	244·29
Long Period.												
Mm	0·123	211·63	0·059	184·50	0·055	84·43	0·055	185·59	0·087	308·38	0·016	117·13
Mf	0·055	258·88	0·069	161·91	0·063	173·15	0·066	187·65	0·065	158·15	0·033	303·53
MSf	0·075	153·37	0·077	201·00	0·066	31·88	0·150	159·87	0·098	13·79	0·060	99·27
Sa	0·230	54·00	0·073	26·81	0·105	272·79	0·087	245·99	0·138	192·55	0·126	62·55
Ssa	0·107	293·67	0·120	88·39	0·063	86·02	0·109	124·65	0·073	191·54	0·130	97·45

Continuous records are still being obtained at the New Plymouth tidal station of the tide curve from the self-registering tide-gauge, and other meteorological data, together with the temperature of the sea.

The mean values for each month of the temperature of the air, surface of the sea, and height of the barometer from the 1st April, 1920, to the 31st March, 1921, are given below:—

New Plymouth Tidal Station.—Mean Monthly Values.

Date.	Barometer.	Attached Thermometer.	Temperature of Air.	Temperature of Sea.
1920.	In.	Deg. (F.)	Deg. (F.)	Deg. (F.)
April	30·16	59·26	59·30	58·90
May	29·90	52·81	53·16	55·52
June	30·14	51·47	51·30	53·20
July	30·19	49·07	48·55	51·45
August	29·94	49·68	49·00	49·51
September	30·06	52·63	53·47	51·60
October	30·17	56·61	56·67	54·52
November	30·01	58·67	58·23	54·50
December	30·03	61·71	62·84	56·13
1921.				
January	30·12	65·90	67·32	59·36
February	30·13	63·21	64·29	58·25
March	30·12	61·51	63·10	58·71

Considerable difficulty has been experienced in preparing some of the diagrams of the self-registering tide-gauges of Dunedin, Lyttelton, and to a lesser extent Westport, for measurement at the exact local mean-time hours, due apparently to defects in the mechanism of the various tide-gauges. The diagrams show in some cases the recording-pencil to be marking in advance of the clock, in others behind the clock, occasionally exceeding half an hour in time, this necessitating an adjustment whenever met with, which not only takes up time but also leaves a certain element of doubt as to whether the adjustment represents the true tidal curve. With the introduction of new tide-gauges, and further co-operation on the part of the authorities concerned, difficulties of this nature should be almost entirely eliminated.

The substitute for the apparatus, or abacus, designed by Sir George Darwin for facilitating the reduction of tidal observations has been devised and completed by the purchase of 150 celluloid strips, cut and ruled to required size, and mounting these strips on heavy linoleum (also cut to required size) with small brass pins. This substitute, while being neither as strong nor as ornamental in appearance as the original apparatus purchased twelve years ago from the Cambridge Scientific-instrument Company, answers its purpose equally well, and has one great advantage—that in the event of breakages it can be repaired at a minimum of cost and time.

Table 1.—Return of Field-work executed by Head Office Staff from 1st April, 1920, to 31st March, 1921.

Land District.	Standard Surveys				Rural Standard Surveys				Other Work.
	Completed.		In Progress.		Completed.		In Progress.		
	Miles.	Cost per Mile.	Miles.	Total cost.	Miles.	Cost per Mile.	Miles.	Cost per Mile.	
		£		£ s. d.				£	£ s. d.
Auckland	32·9	41·82	14	639 10 0	..	..	..	..	160 5 2
Wellington	..	..	..	492 2 6	..	..	28	25·72	123 11 5
Hawke's Bay	..	..	40	1,121 3 9	..	..	..	..	..

Table 2.—RETURN OF FIELD-WORK EXECUTED BY STAFF AND CONTRACT SURVEYORS ON LANDS ADMINISTERED BY LANDS AND SURVEY DEPARTMENT, FROM 1ST APRIL, 1920, TO 31ST MARCH, 1921.

Land District.	Minor Triangulation.		Topography.		Rural.		Village and Suburban.			Town.			Roads, &c.		Other Work.	Total Cost of Completed Work from 1st April, 1920, to 31st March, 1921.
	Acres.	Cost per Acre.	Acres.	Cost per Acre.	Acres.	Cost per Acre.	Acres.	Number of Sections	Cost per Acre.	Acres.	Number of Sections	Cost per Section.	Miles.	Cost per Mile.		
		d.		s.		s.			s.			s.		£	£ s. d.	£ s. d.
North Auckland	..	..	3,576	0·42	43,588	2·55	168	51	22·9	19·48	82	142·8	9·16	29·32	2,366 17 2	8,735 3 0
Auckland	32,100	2·5	..	..	102,550	2·21	169	32	18·9	117·0	78	36·7	106·75	22·50	2,935 7 6	14,982 5 7
Hawke's Bay ..	..	..	..	..	47,876	1·97	..	..	..	9·25	28	54·3	9·25	17·70	859 18 8	4,800 15 10
Taranaki	6,000	0·8	..	..	19,307	4·83	114·1	31	28·6	21·0	60	26·6	2·96	32·78	294 9 3	4,529 14 0
Wellington	..	..	..	..	40,578	2·14	..	..	..	..	..	..	5·75	31·75	83 9 8	6,299 5 9
Nelson	..	..	..	..	40,331	2·70	..	..	..	18·0	15	33·3	18·29	25·06	239 6 6	4,849 0 11
Marlborough ..	..	..	..	..	6,474	1·97	..	..	..	..	..	..	2·25	39·53	307 17 8	1,456 5 8
Westland	..	..	..	..	2,936	4·14	31	1	26·8	..	..	..	9·5	53·60	14 5 2	2,054 0 7
Canterbury	..	..	..	..	9,825	2·03	63	13	20·0	..	..	..	16·0	66·57	198 17 6	1,314 0 6
Otago	..	..	..	..	102,278	0·68	27·5	5	18·97	75·0	34	20·09	12·0	7·14	732 15 10	5,612 0 8
Southland	..	..	..	..	17,068	0·80	..	..	..	0·25	1	8·4	6·38	26·52	19 10 2	579 4 9
Means and totals ..	38,100	2·2	3,576	0·42	432,811	2·37	572·6	133	22·70	259·98	298	38·92	197·29	27·88	8,052 15 1	55,211 17 3

Table 3.—Return of Field-work executed by Staff and Contract Surveyors on Lands administered by other Departments from 1st April, 1920, to 31st March, 1921.

Land District.	Rural.		Village and Suburban.			Town.			Roads, &c.		Native-land Survey.			Mining.			Other Work.	Total Cost of Completed Work from 1st April, 1920, to 31st March, 1921.
	Acres.	Cost per Acre.	Acres.	Number of Sections.	Cost per Acre.	Acres.	Number of Sections.	Cost per Section.	Miles.	Cost per Mile.	Acres.	Number of Sub-divisions.	Cost per Acre.	Acres.	Number of Sections.	Cost per Acre.		
		s.			s.			s.		£			s.			s.	£ s. d.	£ s. d.
North Auckland	..	..	..	..	..	..	..	..	..	..	17,490	268	3·12	..	..	..	..	2,012 10 5
Auckland..	..	..	..	..	..	..	..	..	7·0	33·7	93,594	664	1·5	..	..	..	..	6,997 9 5
Hawke's Bay	7.637	2·023	..	..	..	..	..	..	..	..	42,702	243	1·73	..	..	..	..	3,329 6 10
Taranaki	..	..	..	..	..	..	..	..	6·15	27·37	5,574	131	3·98	..	..	..	..	1,301 17 0
Wellington	..	..	..	..	..	..	..	..	..	..	88,770	235	1·12	..	..	..	..	4,934 8 5
Nelson	..	..	..	..	..	..	..	..	..	..	..	..	..	2,564	11	*	..	..
Marlborough	..	..	..	..	..	..	..	..	..	..	3,038	37	2·5	..	..	..	..	377 7 10
Canterbury	..	..	..	..	..	22	91	43·63	..	..	107	10	9·35	..	..	..	..	248 10 0
Otago	..	..	..	..	..	..	..	..	..	..	344	24	17·1	105	6	..	..	509 3 6
Southland	..	..	..	..	..	..	..	..	..	..	1,026	17	1·7	..	..	..	..	87 3 2
Means and totals	7,637	2·023	..	..	..	22	91	43·63	13·15	30·75	252,645	1,629	1·49	..	..	..	..	19,797 16 7
*Licensed surveyors (costs unobtainable)	..	..	..	..	..	..	..	..	..	..	14,245	113	..	2,669	17	..	..	..

Table 4.—Return showing Surveyors employed and the Work on Hand on 1st April, 1921.

Names of Chief Surveyors.	Surveyors employed.			Work on Hand.				
	Staff.	Temporary.	Contract.	District.	Settlement.	Native Blocks, &c.	Roads, &c.	Town.
					Acres.	Acres.	Miles.	Acres.
R. P. Greville, F.R.G.S.	4	1	7	North Auckland	51,526	10,404	4 1/10	..
H. M. Skeet	12	..	..	Auckland	155,795	51,868	194	5
W. F. Marsh	4	1	9	Hawke's Bay	..	23,259	13½	..
H. J. Lowe	4	..	6	Taranaki	34,929	34,293	3¾	..
G. H. M. McClure	3	..	12	Wellington	7,780	51,034	..	..
G. Cook	2	..	..	Marlborough	..	1,560	50	..
H. D. McKellar	2	2	..	Nelson	28,575	..	..	..
R. S. Galbraith	2	..	1	Westland	18,581	326	5	8
G. H. Bullard	1	..	..	Canterbury	..	..	..	..
R. T. Sadd	5	..	..	Otago	299,115	48	5⅝	..
T. Brook	1	..	1	Southland	14,200	..	..	..
Totals	40	4	36	..	610,501	172,792	276·0	13

Table 5.—Principal Classes of Office-work done from 1st April, 1919, to 31st March, 1921.

District.	Plans placed on Instrument of Title.			Deeds and other Instruments passed.	Plans examined and passed.	Deeds or other Instruments written.	Maps drawn for Lithography.		Lithographs published.	Lithographs sold.
	Leases and Licenses.	Freehold.	Miscellaneous.				Standard Publications.	Sale Plans.		£ s. d.
North Auckland	1,038	4,983	1,350	2,603	859	..	10	44	..	133 8 0
Auckland	1,294	5,702	1,894	2,603	1,228	..	..	73	..	298 16 11
Hawke's Bay	468	2,180	1,103	2,421	551	889	..	14	..	63 12 0
Taranaki	346	1,378	1,356	1,449	459	896	5	18	..	44 9 0
Wellington	1,437	6,737	778	3,844	689	950	..	29	..	..
Marlborough	215	468	131	164	150	..	..	7	..	25 0 3
Nelson	392	753	522	366	102	400	..	10	..	51 3 8
Westland	206	194	16	..	38	222	1	2	..	61 17 0
Canterbury	549	5,855	51	3,107	586	..	..	27	..	33 7 6
Otago	519	2,013	66	950	194	580	7	23	956	126 12 0
Southland	172	1,684	247	737	205	..	4*	13	..	40 6 6
Totals	6,636	31,947	7,514	18,244	5,061	3,937	27	260	956	878 12 10

* Revised.

APPENDIX II.

THE MAGNETIC OBSERVATORY, CHRISTCHURCH.

ANNUAL REPORT OF THE DIRECTOR (H. F. SKEY, B.Sc.).

During the past year the Magnetic Observatory, Christchurch, and the substation at Amberley have operated successfully.

At Christchurch the Adie magnetographs have been kept in continuous operation, and the resulting magnetograms have been developed and measured at instantaneous Greenwich hours, as has been the practice in previous years. The adoption of Greenwich time for curve-measurement is now practically certain to be universal at magnetic observatories very shortly, but it is also certain that, instead of instantaneous values at the hours, mean values over the hour, centring at the Greenwich hour, will be usually published; but for some researches it will probably be found advisable to also publish instantaneous values for certain days.

The mean values of the magnetic elements for the year 1920 are—

	Mean Values, 1920.	Change since 1919.
Magnetic declination (east)	17° 01·7′	+3·1′
Magnetic horizontal force	0·22261 C.G.S. unit	—19γ
Magnetic inclination (south)	68° 09·2′	+1·4′
Northerly component	0·21284 C.G.S. unit	—25γ
Easterly component	0·06518	+13γ
Vertical component	0·55525	+18γ
Total magnetic force	0·59820	+8γ

The decrease of magnetic horizontal force from 1919 to 1920 was noticeably smaller than for the previous year, during which it was 24γ, or very nearly the average yearly decrease from 1902 to 1920. Similarly, from 1902 to 1904 the decrease was 25γ for each year, and for 1904 to 1905 the amount of decrease diminished to only 16γ. The provisional value of H for 1912 shows that a similar diminished decrease occurred from 1911 to 1912 (18γ).

Preliminary Analysis of Apparent Annual Inequalities of H.F. in successive Years.

It was felt desirable, in view of the relationship shown in last year's report to exist between the annual variations in 1905, 1910, 1914, and 1919, that some investigation should be made of the apparent inequalities in various years. It is fairly evident that some relationship existed between the inequalities in years 5 or 9 years apart, or both, independently of any direct connection with position in the sun-spot cycle, and that if the data in every available year were analysed in the same manner, treating it provisionally as entirely cyclic within the twelve months, some indication of periodical order at least might be obtained.

The following table gives the results of the analysis for the first four harmonic terms. Correction for secular change was applied to the apparent inequalities according to the known amounts at the time. The phase angles, of course, are given for January 0d.

It must not be forgotten that the analysis is really a measure of conditions existing over the whole year, and in some degree an averaging of those conditions. If conditions changed very slowly we would expect a progressive change of the phase angles. Rapid changes in periods other than the year would make these angles appear to vary irregularly.

At the right-hand side of the table are given some results of similarly analysing the *average* annual marches in the stated groups of years.

During the period including the years treated of, the years 1905, 1907, and 1918 were years of sun-spot maximum; 1901 and 1913 were years of sun-spot minimum. The years 1905 and 1915 were years of maximum solar constant, as observed elsewhere; 1912 was a year of secondary maximum of solar constant; 1910 and 1913 were years of solar constant minimum.

Analysis of Successive Annual Marches of Magnetic Horizontal Force at Christchurch

(Treated as entirely cyclic within the year; 0°=January 0d.)

—	Years.													Averaged Marches.					
	1902.	1903.	1904.	1905.	1910.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1902, 1903, 1904.	1914 to 1919.	1914, 1919.	1916, 1917.	1905, 1910.	1915, 1920.
	γ																		γ
P_1 ..	2·77	7·5	4·87	3·13	8·47	1·03	0·43	3·05	7·99	3·05	4·37	3·63	9·09	3·96	2·77	0·80	4·41	3·72	4·6
P_2 ..	4·04	5·5	3·36	5·88	7·57	3·61	2·37	1·88	7·24	6·22	5·09	6·94	8·74	4·25	4·59	6·20	5·12	7·07	5·3
P_3 ..	4·66	4·4	2·28	1·20	2·86	0·32	1·83	1·92	2·87	1·70	2·56	2·32	2·86	2·48	1·34	0·34	1·99	1·35	1·5
P_4 ..	2·95	3·2	3·20	1·44	1·06	2·70	0·36	0·44	2·11	2·49	1·26	1·69	1·44	2·24	0·42	0·92	0·50	0·79	0·9
A_1 ..	314°	276°	194°	257°	123°	227°	240°	66°	88°	67°	98°	170°	165°	255°	101°	360°	81°	142°	145°
A_2 ..	39	39	48	124	109	83	72	87	84	168	64	104	73	38	98	90	58	119	71
A_3 ..	18	28	253	172	243	364	52	56	26	302	353	231	310	369	349	354	340	221	350
A_4 ..	45	119	151	55	197	206	200	358	322	128	343	64	296	148	22	55	81	96	308

Looking at the amplitudes of these first four components, we see that P_1 is large in the years 1903, 1910, 1916, 1920, and small in the year 1913, of sun-spot minimum, and the following year 1914. P_2 is largest in 1910, 1916, and 1920, the year 1910 being a year of maximum of solar constant and of sun-spottedness, and 1920 being possibly a year of maximum solar constant, but the solar constant data for 1920 are not yet all available. P_2 is generally large from 1916 to 1920 inclusive. P_3 is largest in 1902 and 1903, diminishing to 1905.

The constancy of P_3 at 2·86γ in 1910, 1916, and 1920 is as remarkable as the largeness of P_1 and P_2 in those years. P_4 is large in 1902, and slightly larger and constant in 1903 and 1904. The equality of P_4 at 1·44 in 1905 and 1920 is noteworthy, and also the fact that it is almost exactly one-half of 2·86, the value for P_3 just noted above. Since P_4 in 1905 = P_4 in 1920, it is probably not mere coincidence that P_2 in 1905=P_2 in 1920—P_3 in 1920 [5·88=8·74—2·86], but that systematic effects are responsible. It was found that the value 1·44γ for P_4 (1905 and 1920) also occurred thus: a_3 in 1914 = + 1·44; a_3 in 1917 = — 1·44. And two numerically equal values of b_4 occurred thus: b_4 in 1917 = — 1·21; b_4 in 1918 = + 1·21. These are further evidences of systematic effect.

Other indications exist, but enough is pointed out to show that the curve representing the march of H.F. throughout the years is a true periodogram involving other periodicities than the year, and that it is worth while investigating it by the regular methods. This work will be proceeded with; it is probably a more difficult undertaking than ordinary tidal analysis, but no accurate prediction of future magnetic values can be made without it. Work of that kind may be expected to throw light upon the relationship between the annual and diurnal variations, and it may eventually enable the solar constant curve to be obtained from the results of magnetic observation alone: such would be the ideal result.

As was to be expected, the analyses of the march of H.F. for the years 1905, 1910, 1914, 1920 shows in each case striking characteristics. It must be the case that when two melodies played simultaneously yield almost the same symphony as two other melodies played simultaneously, each melody of each pair must be principally a simple composition, or at least they must all differ simply. The table shows the results of the analysis for the four presumably chief harmonic components in these years, and we see that the sum of the phase angles A_2+A_4=180° in 1905, and=271° in 1914;

also, $A_3-A_1=120°$ in 1910, and $=61°$ in 1919. If we go back to 1904 we find almost the same difference for A_3-A_1 [59°] as in 1919, suggesting a completion of some effect in a period of 15 years, and this is strengthened by the identity of P_4 in 1905 and 1920.

We must eventually inquire why P_4 completely changes the sign of its phase angle between 1919 and 1920 [64°+ 296° = 360°], while P_1 changes only $-4\frac{1}{2}°$ in phase. Also it must be investigated why A_4 in 1920 is 240° larger than in 1905. Has the equality of the ratio $\frac{P_2}{P_4}$ in 1905 and 1915, and the fact of A_2+A_4 summing a simple multiple of $\frac{\pi}{2}$ in those years, anything to do with the fact that both 1905 and 1915 were years of maximum solar constant as observed at the Solar Physics Observatories ? Also, have the simple relations between phase angles in 1910 any connection with the fact that 1910 was a year of minimum solar constant ? Analysis of all curves by proper periodogram methods will surely show, when sufficient accurate observations have been obtained. But with regard to the value 2·86 occurring for P_3 in 1910, 1916, and 1920, it will be interesting to see whether 1906 or 1907, or perhaps both, have that value for P_3. Unfortunately, our measures for these years are not yet completed, though under way.

It is of especial importance to note that producing the analysed results backward a time is found for each year's components at which the P_1 and P_2 components are in the same phase, and it is found that in the above analysis between the years 1913 and 1920 these points of time in successive years are separated by 12 synodic solar rotations, taking the solar equatorial belt. This shows the all-compelling power of the sun's rotation on the phenomena, and connects the effects with that period.

An investigation has been made, by what may be called the method of jumbles, of the amount of the variation of H.F. at Christchurch in the period of 12 synodic solar rotations, denoted for convenience $\odot_{s\,12}$, the s suffix denoting synodic, to distinguish from $\odot_{12}$, the length of 12 absolute periods of rotation of which $\odot_{s\,12}$ is the synodic correspondence.

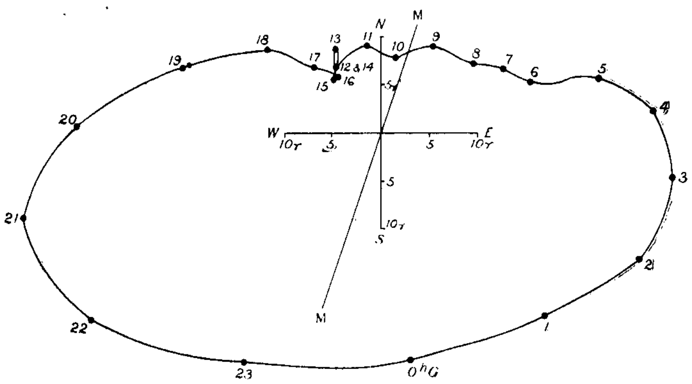
The investigations shows that after correcting for the separate average annual variations of H during the two intervals 1902 to 1905 (4 years) and 1913 to 1920 (8 years) a decided variation in $\odot_{s\,12}$ remains, and, plotting the results for the two intervals, two very similar curves result, with slightly different amplitudes ; and in phase the two curves differ by the expected amount, calculated from the middle of the one interval to the middle of the other, which shows that other variations are coming in also. Indeed, it is probable that periodicities occur of lengths that are simple multiples of $\odot_{s\,1}$, of which all the lowest come into the same relative phases in 9 years, most of them also in 3 or 6 years. They may be due to the earth's influence upon the outlying solar atmosphere, periodically affecting the quantity of radiant energy arriving at the earth. They may be due to such a semi-tidal effect with some kind of valve-action coming in. The sun, being fluid, can oscillate about its mean form quite well ; perhaps it does ; its heating and shrinking while rotating, and consequent ebullition, may make it do so. Such oscillations could be maintained by the minutest tidal forces under certain circumstances. We all know that it takes a considerable push to set the heavy pendulum of a clock swinging, but a very little power will keep it going, if the periodical application of the power is exactly synchronized, as the escapement ensures. Where can such easily maintained undamped oscillations exist in the sun ? I do not think they can be primarily electrical.

It is easy to suggest quite another thing to prove ; but it seems likely that in addition periodicities will be found of lengths that are simple multiples of the sun's absolute rotation period. Such periodicities will come again into the same relative phase in five of our years, and this would explain the connection found between 1914 change of H and 1919 change of H. Action in a period of 10 or 15 years would also be apparent. But why should 1914 and 1919 yield such a degree of symmetry in the average H curve ? To what epoch are they so relatively situated that effects should be complementary ? Was 1917·0 a node of all solar action, or the reverse, or of any particular solar action ?

The two curves over $\odot_{s\,12}$ are reproduced, also the average annual curves for the two intervals, and it will be seen that both year curves and $\odot_{s\,12}$ curves differ over the two intervals. But it seems that there is in them almost as much justification for the reality of the $\odot_{s\,12}$ periodicity as for the yearly periodicity, which is undoubtedly real.

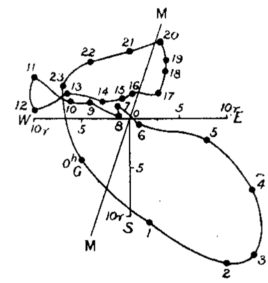
The length of $\odot_{s\,12}$ found is almost exactly 328·7 days, or 0·9 of 1 year. The following table gives approximately the durations of 12, 11, 10 ... to 1 synodic solar revolutions, length in years, &c. :—

Synodic Solar Rotations.	Length in Years.	Number of Periods in						
		1 Year.	3 Years.	$4\frac{1}{2}$ Years.	5 Years.	8 Years.	9 Years.	15 Years.
$\odot_s$ 12	0·900	1·1̇	3·3̇	5·0	5·5̇	8·8̇	10·0	16·6̇
11	0·825	1·2̇1̇	3·6̇3̇	5·4̇5̇	6·0̇6̇	9·6̇9̇	10·9̇0̇	18·1̇7̇
10	0·750	1·3̇	4·0	6·0	6·6̇	10·6̇	12·0	20·0
9	0·675	1·4̇81̇	4·4̇	6·6̇	7·4̇07̇	11·85	13·3̇	22·2̇
8	0·600	1·6̇	5·0	7·5	8·3̇	13·3̇	15·0	25·0
7	0·525	1·905	5·715	8·58	9·525	15·24	17·15	28·57
6	0·450	2·2̇	6·6̇	10·0	11·1̇	17·7̇	20·0	33·3̇
5	0·375	2·6̇	8·0	12·0	13·3̇	21·3̇	24·0	40·0
4	0·300	3·3̇	10·0	15·0	16·6̇	26·6̇	30·0	50·0
3	0·225	4·4̇	13·3̇	20·0	22·2̇	35·5	40·0	66·6̇
2	0·150	6·6̇	20·0	30·0	33·3̇	53·3̇	60·0	100·0
1	0·075	13·3̇	40·0	60·0	66·6̇	106·6̇	120·0	200·0



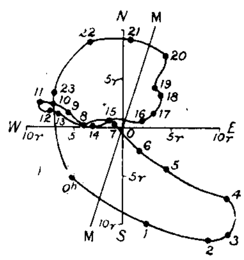
VECTOR DIAGRAM FOR SUMMER MONTHS, 1920—ALL DAYS.

O (origin) = N. 0·21292 C.G.S.; E. 0·06518 C.G.S.



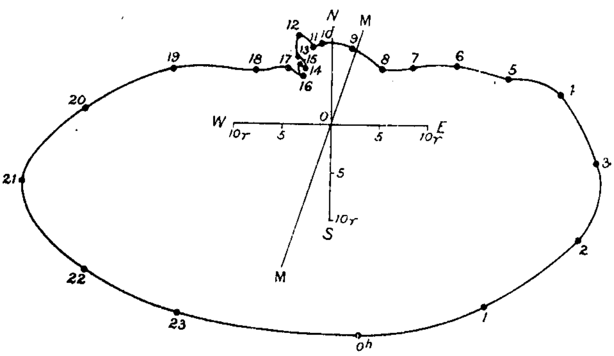
VECTOR DIAGRAM FOR WINTER MONTHS, 1920—ALL DAYS.

O (origin) = N. 0·21286 C.G.S.; E. 0·06520 G.C.S.



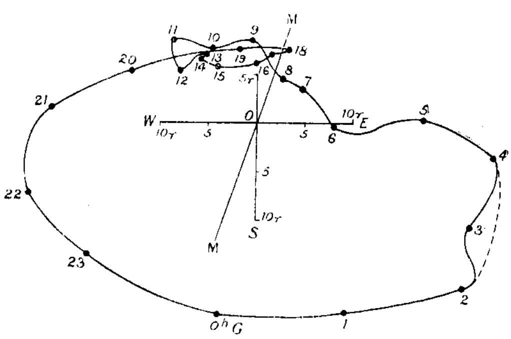
VECTOR DIAGRAM FOR WINTER MONTHS, 1910—ALL DAYS.

O (origin) = N. 0·21571 C.G.S.; E. 0·06438 C.G.S.



VECTOR DIAGRAM OF DIURNAL HORIZONTAL DISTURBING FORCE FOR SUMMER MONTHS, 1910—ALL DAYS.

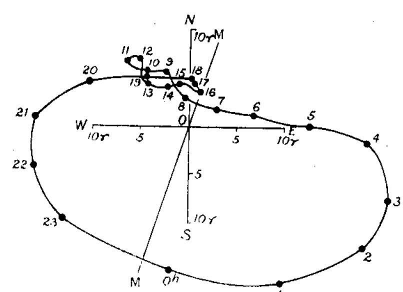
O (origin) = N. 0·21583 C.G.S.; E. 0·06445 C.G.S.



VECTOR DIAGRAM FOR EQUINOCTIAL MONTHS, 1920—ALL DAYS.

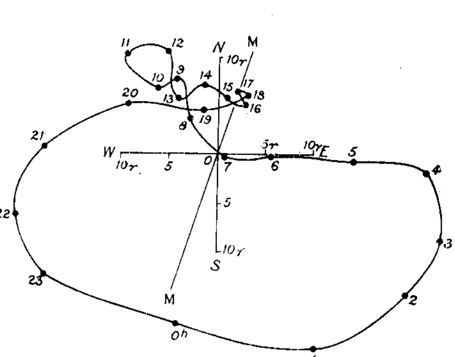
O (origin) = N. 0·21277 C.G.S.; E. 0·06517 C.G.S.

A great storm on 23rd March is principally responsible for invagination at 3 h.



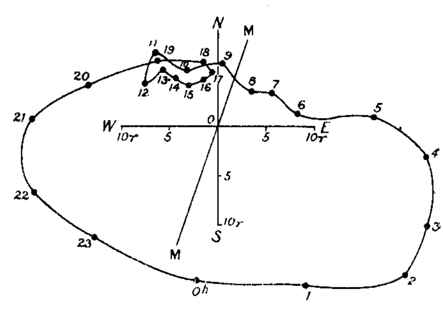
VECTOR DIAGRAM FOR YEAR 1910—ALL DAYS.

O (origin) = N. 0·21574 C.G.S.; E. 0·06441 C.G.S.



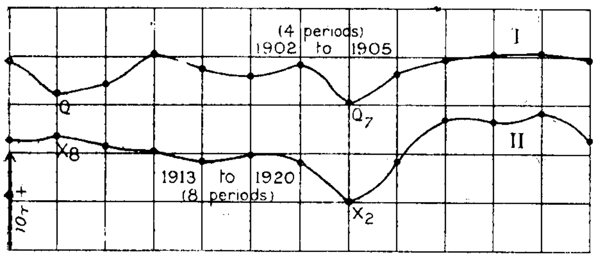
VECTOR DIAGRAM FOR EQUINOCTIAL MONTHS, 1910—ALL DAYS.

O (origin) = N. 0·21568 C.G.S.; E. 0·06442 C.G.S.



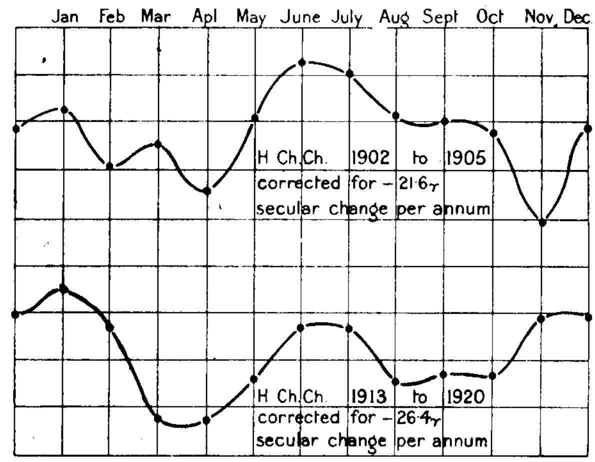
VECTOR DIAGRAM OF MEAN DIURNAL HORIZONTAL DISTURBING FORCES FOR YEAR 1920 (ALL DAYS) AT CHRISTCHURCH.

Greenwich hours indicated: 0 h. = midnight at Greenwich.
MM = Magnetic meridian.
O (origin) = N. 0·21285 C.G.S.; E. 0·06519 C.G.S.



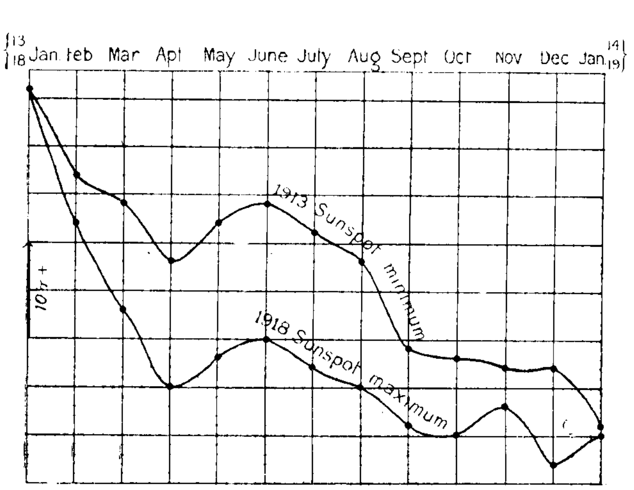
H.F. Variation in 328·8-day Period.

(Average annual variation removed.)
Mid-epoch of I = 1917·0; mid-epoch of II = 1903·8: difference = 14·6 periods.

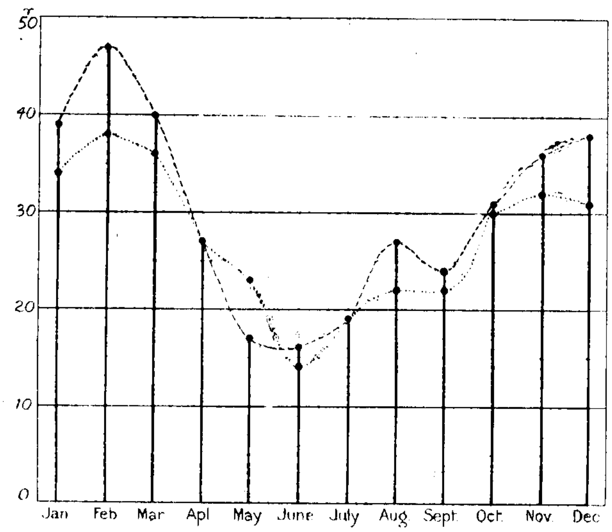


Mean Monthly Values for all Days.

(Secular-change values are average values over the intervals.)

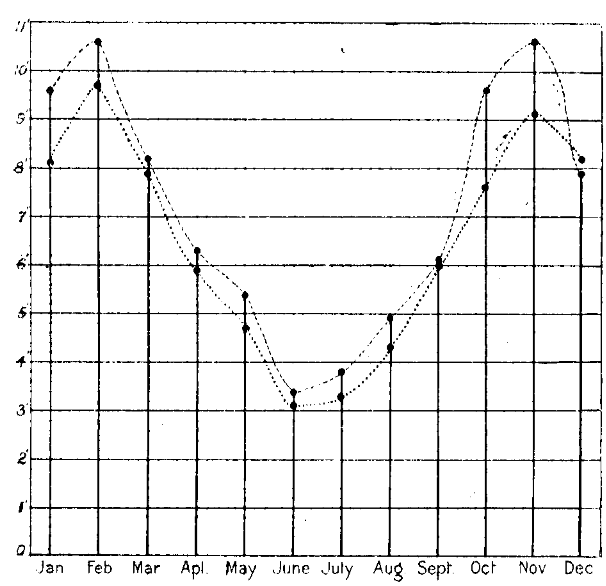


March of H.F. in 1913 and in 1918 at Christchurch—all Days.



Curve showing Mean Diurnal Range of Horizontal Force (Inequalities) at Christchurch.

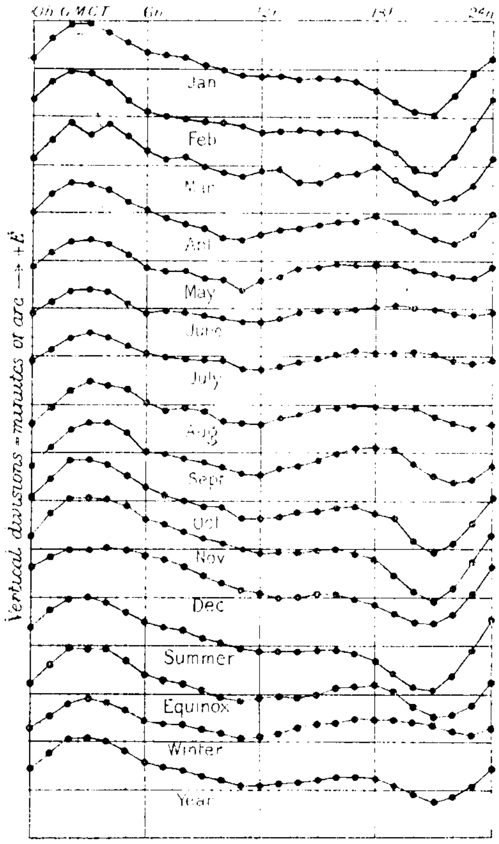
For 1920 thus - - - - - - - - for 1910 thus . . . .



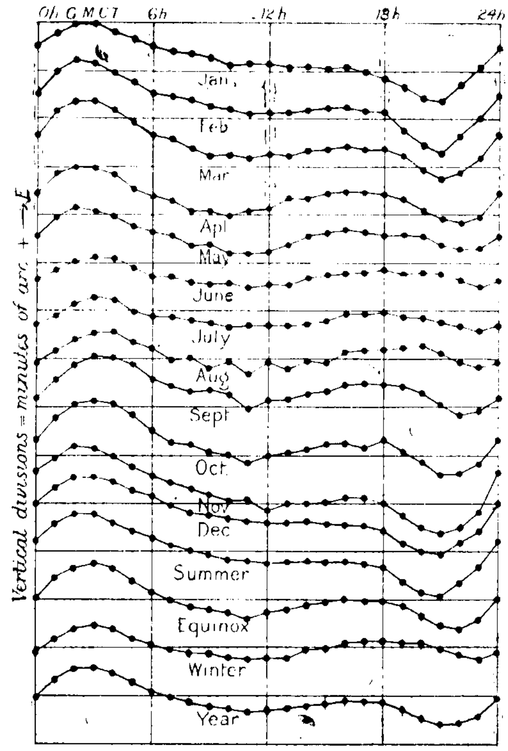
Curve showing Mean Diurnal Range of Declination (Inequalities) at Christchurch.

For 1920 thus - - - - - - - - for 1910 thus . . . .

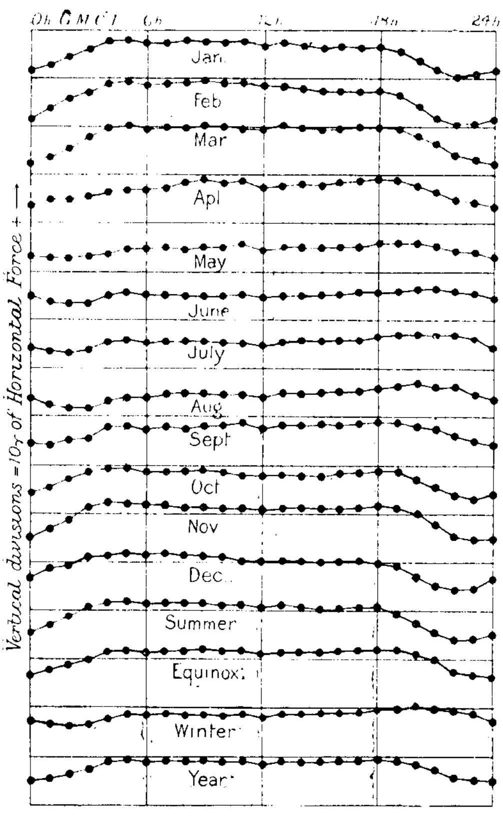
(Note at three-monthly intervals minima of difference.)



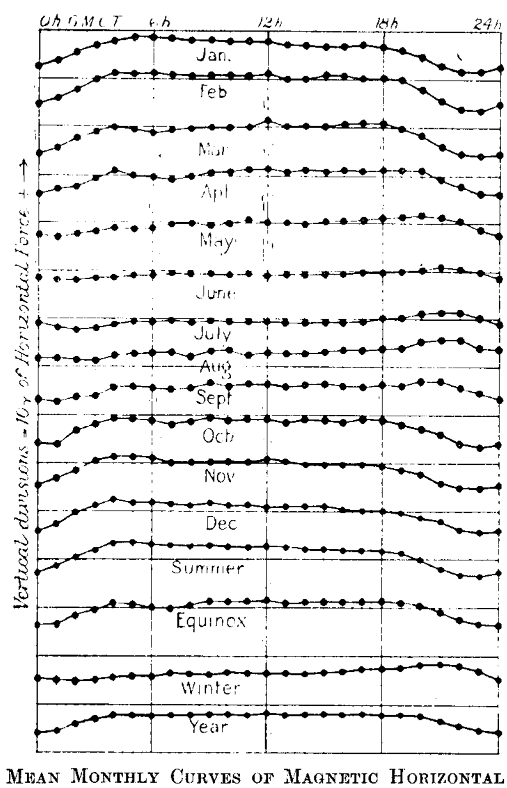
MEAN MONTHLY CURVES OF MAGNETIC DECLINATION, 1920.



MEAN MONTHLY CURVES OF MAGNETIC DECLINATION, 1910.



MEAN MONTHLY CURVES OF MAGNETIC HORIZONTAL FORCE, 1920.



MEAN MONTHLY CURVES OF MAGNETIC HORIZONTAL FORCE, 1910.

The following table gives the corresponding figures for the corresponding length of an absolute rotation :—

Absolute Solar Rotations.	Length in Years.	Number of Periods in	
		1 Year.	5 Years.
⊙ 12	0·835	1·198	6·0
11	..	1·31	6·55
10	..	1·44	7·2
9	..	1·6	8·0
8	..	1·8	9·0
7	..	2·06	10·3
6	..	2·4	12·0
5	..	2·88	14·4
4	..	3·6	18·0
3	..	4·8	24·0
2	..	7·2	36·0
1	..	14·4	72·0

Granted sustained small oscillatory changes in the above periods, it is easy to see that a resultant 15-year periodicity would ensue.

$\odot_{s\ 11}$ and $\odot_{12}$ both approximate closely to 10 months in length. By a combination of years we found we could produce symmetry for 10 months, and in 1913 and 1918 we could trace similarity of trend over 10 months. It may be, then, that the amplitude in one or both of these periods is considerable. As a working hypothesis the above may be of service in the analysis of our magnetic periodogram.

Mean Diurnal Inequalities.

The curves of mean monthly and mean seasonal diurnal change of D and of H are reproduced as usual.

The curves in D are very similar to those in 1919. The peculiar flattening indicating constancy of declination from 2h. to 6h. G. in January, 1919, has a distinct tendency to be repeated nearly two years later, in December, 1920, but it is not so pronounced. The extraordinary drop at 3h. G. in the March curve for 1920 D is almost entirely due to the influence of a very stormy day, the 23rd March ; but the peak at 18h. in March is repeated in April, and is a systematic effect. This is not to say, however, that the apparently abnormal storms may not be ultimately found to be systematic in their occurrence. The rapid turn of the curve at 6h. G. in September finds its counterpart in July and August of 1919. The fall from 10h. to 11h. in September, 1919, is repeated in the 1920 October curve.

The average curves for the years 1919 and 1920 differ principally about 12h., owing chiefly to differences in the winter and equinoctial months about that hour.

As to the corresponding H curves, the June and July curves are generally smoother in 1920 than in 1919. The drop of H at 12h. in the average curve for the year is found also in the summer, winter, and equinoctial curves.

Mean Monthly Ranges of the Diurnal Inequalities.

In H the maximum range in 1920 is found in February, as was the case in 1919.

Reference to the diagram published in last year's report will show that for the second half of the year 1920 the trend of the curve follows that for 1918 much more closely than that for 1919. In both 1918 and 1920 there was a large range in August.

In the corresponding ranges for D, in both 1919 and 1920 the maximum range occurred in February and November, being almost equal in these two months ; the minimum range occurred in June.

The tendency in 1919 to a peak of range in May and August is in 1920 very much less.

It is rather to be expected that relationships exist between the annual marches of the mean monthly ranges of the diurnal inequality in different years, and indeed it is significant that some such relationship is shown by these in 1910 and 1920, especially in regard to the declination. The accompanying diagram shows these, and shows clearly the minima of difference at three-monthly intervals, and the strikingly similar annual march. In the corresponding ranges of H (diagram given) similar "nodes" occur, but one month later than in D. In fact, the average ranges of the diurnal inequality in H in the months April, July, and October were almost identical in 1910 and 1920.

In 1919 peaks of D range occurred in February, May, August, and November ; in 1910 peaks occurred in H range in these months, while in 1920 pronounced peaks occurred in February and August. Generally the 1910 D range curve much more closely resembles in trend the 1920 range curve than it does the 1919 D range curve. The mean range of the diurnal inequality of D in 1910 was 6·6′ ; in 1920 it was 7·2′. In H the corresponding figures were 27·3γ and 30·4γ. The difference of range in E_m was therefore about 3·6γ and in H about 3·1γ.

The variation of the mean monthly diurnal inequality of D and of H has certainly a well-defined annual part, and the analysis of the curves for a number of years must be undertaken before the connection between diurnal and annual variations can be made clear.

I have not had time to investigate the question whether the seasonal diurnal variations in H in the years 1905, 1910, 1914, and 1919 are related at all in the same way as the annual marches of H in these years have been shown to be related—it seems most probable that they are; and, if so, some relationship will be definitely shown to exist for Christchurch between the annual and diurnal variations. It would indeed be pleasant to have a clerical staff at the Observatory sufficient to enable such work to be rapidly dealt with. One naturally wants to get the cream from the milk, and such is only possible by the proper machine.

As further showing the connection between annual marches of H.F. five years apart, it is notable that the year 1918 of sun-spot maximum was five years after the year of sun-spot minimum, 1913. The curves of annual march of H.F. for these years (see diagrams) exhibit a surprising general resemblance, much more than we should expect if sun-spottedness was the only variable correlated with the trend of the curves. It is noteworthy that the areal differences of these two curves are equal on either side of the mid-year ordinate, suggesting that the excess of the drop from January to April in 1918 was exactly balanced by the excess of the drop from June to September in 1913. The total change of H.F. from January, 1913, to January, 1914, happened to be only 1γ less than the total change from January, 1918, to January, 1919. The mid-points of excess of fall differ by four years and a half, changing in that time from late winter to late summer. The mid-points of defect differ by five years and a half, changing in that time from late summer to late winter. After October they seem to become opposite, the similarity of trend being confined to ten months of the year, a fact apparently not unconnected with what was found in the mean curve of H.F. for 1914 and 1919, that symmetry could only be found to exist over ten months of the year, and that beyond that the asymmetry exceeded possible observational errors.

The curve for the previous sun-spot minimum, 1901, is not available for Christchurch, as magnetograph registration only commenced here at the end of 1901. The sun-spot maximum previous to 1918 was in 1907, and measurements of magnetograms for that year are in progress. Nine months of declination curves have been measured and declination values got out, but it is not expected to have H.F. hourly values tabulated for 1907 for some months yet. The measurements of 1912 magnetograms have been completed, but the conversion of ordinates and tabulation are still incomplete. It is hoped to complete it this year. The provisional value of H.F. for 1912 is 0·22476, which shows a small secular change of 18γ from 1911. Similar small changes occurred from 1904 to 1905, and from 1919 to 1920, and were both accompanied by marked change in the form of the curves representing the march of H.F. throughout the years. Between 1904 and 1905 a certain amount of inversion of the curve is noticeable, evidenced in the analysis by the change of A_2 to the adjacent quadrant. From 1919 to 1920 a slight amount of inversion may be perceived; the change of A_2 is in the opposite direction. The sum of A_2's in 1904 and 1905 is 173°; in 1919 and 1920 it is 177°.

Seasonal Vector Diagrams of Mean Diurnal Horizontal Disturbing Forces.

These are published for 1910 and 1920 herewith, and require some comments. Those for 1905 and 1919 were published in the preceding year's report.

Looking at these one is struck by the very great similarity in general shape of the summer diagrams in 1919 and 1920, and the decided difference in the winter diagrams. From 21h. to 2h. G. the winter diagrams do not differ much, except that the earlier hours are retarded on the diagram (or the variation accelerated), but from 16h. on to 20h. the difference is marked, and during these hours 1905 and 1910 winter diagrams correspond fairly closely, while from 17h. to 20h. the general trend is somewhat the same, only somewhat smoother and inclined to the full rounded nature characterizing the whole winter diagram in 1919, in which year it indeed seems that the whole diurnal variation in winter was of simpler composition, and gives one the impression of a series of spirals, curves which I believe have in the past been unsuccessfully invoked in the interpretation of these phenomena. It is curious, however, that in many of these curves the position of the hours on the diagram gives one the impression of action in spirals.

The slight constriction between 1h. and 6h. evident in the 1919 diagram is also seen in the 1920 diagram.

In the winter of 1910, 1919, 1920 the westerly disturbing force at about local midnight is large, and exceeds that at 23h. G. to 0h. G., or local late morning. In the equinoctial night variation, 1910 much more closely resembles 1919 than it does 1920.

A striking difference between the winter vector diagrams in 1905 and 1919 occurs between 6h. and 10h. G. In both years this part of the curve is full and rounded, but the convexity is directed inwards and south in 1905, and outwards and north in 1919. 2h. G. seems to generally occupy the same position on the diagram, which means that at that time of day the direction and intensity of the disturbing force has on the average for the season the most constancy in the different years.

Visit of the "Carnegie."

The ocean magnetic surveying-yacht "Carnegie," of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, revisited Lyttelton in October. The following account of her voyage from Fremantle is taken from the official report of Commander Ault, and after reading it one is able to comprehend the difficulties and dangers that this gallant little vessel and her crew encounter in their successful efforts to add to our knowledge of terrestrial magnetism. Captain Ault writes :—

"After a delay of one day spent in preparing records ready for the mail, and in securing two seamen needed to fill the ship's complement, we left Fremantle on October 1 at 10.20 a.m., and were towed well out against a light head wind. During the night the north-west and west-north-west wind together with a southerly current set the vessel well in towards Cape Naturaliste, so that by 8 o'clock on October 2 we were only 10 miles off the cape. A gale from the west was blowing at the time, with heavy squalls, making it uncertain that the vessel could clear Cape Leeuwin. It was decided to run the engine and proceed, trusting that the wind would not shift ahead until we got clear of the cape. The engine held the vessel up to her course very well, probably overcoming a point of leeway.

"We were thus skirting the coast at a distance of about 10 miles from 8h. until 21h., the wind shifting ahead just slowly enough to allow us to keep a clear course with careful steering, as the direction of the coast-line changed from south by west to south-south-east. We cleared the dangerous point of Cape Leeuwin at a distance or three miles. The gale died down to a calm during the night as we proceeded on our way south into the cold and stormy regions of high latitudes.

"On October 5 the next gale began from the north-east, and continued with fog, mist, and rain until October 7, shifting through west to south-west.

"Another short gale blew from the north-west on the night of October 10. A display of aurora australis was visible during the entire night of October 10, 1920, and again on October 11, in the form of a series of arches of white light stretched across the southern sky, with white vertical streamers extending up to the zenith.

"At 8h. 15m., October 12, the vessel was within one mile of the charted position of the Royal Company Islands. Stieler's Atlas gives the position as 50° 24′ S., 142° 45′ E.; H. R. Mill gives 50° 15′ S. and 142° 45′ E.; and Bartholomew gives 50° 18′ S. and 143° 00′ E.: the mean of these, 50° 20′ S. and 142° 50′ E., was the position assumed. Nothing was in sight for a radius of forty miles with very good visibility. The 'Carnegie' sailed eastward all day at about 50° 20′ S. latitude, and there were no signs of land. These islands have been searched for unsuccessfully by several navigators, and they might well be eliminated from the charts. Our own experience in these latitudes in 1915–16 showed the ease with which icebergs could be taken for land when seen at distances even less than 5 miles. For several days before reaching the position given for the Royal Company Islands birds were particularly numerous—albatross, molly-mawks, petrels, Cape pigeons, &c.—and penguins were heard near the vessel at night. Floating kelp was passed in considerable quantities. But these indications cannot be taken always as signs of the proximity of land, as has often been done by earlier navigators in confirmation of their reports of new islands found.

"Our heaviest weather began on October 12, a westerly wind developing into a gale, shifting to north-west, back to south-west, again to north-west, and back again to south-west on October 15, moderating at south on October 16, and maintaining a force of 7 to 9 during the entire five days.

"The heavy wind and sea from the north-west prevented our making the northing necessary for a passage through Cook Strait useful, so it was decided to proceed to Lyttelton by way of the Snares, south of South Island, a much easier, safer, and direct route.

"The Snares were picked up on October 17 as calculated, and anchor was dropped in Lyttelton Harbour at 3 a.m. of October 21. Owing to calms and head winds the engine was operated for two days before arrival at Lyttelton. The last fifty miles were made running before a heavy south-east wind that came out of a practically clear sky, within one minute of the dying-out of the north-east wind that had been blowing for several hours.

"The usual meteorological conditions for these latitudes were experienced, but a fairly complete programme of observations was carried out in spite of fogs, storms, and heavy seas. Declination observations were made daily, and usually twice a day. The total number of miles traversed from Fremantle to Lyttelton was 3,157: hence the average daily run for the 19·7 days at sea was 160·3 nautical miles."

It is fairly obvious that the existence of the Royal Company Islands above water is disproved. Nothing but marine surveys and soundings can show whether there are not shallows which might account for the floating kelp; if there were shallows the possibility is then that the islands first discovered have become submerged.

The largest chart error in declination on the voyage was found just off the coast of Australia in latitude 33° 09′ S., longitude 114° 43′ E., when the declination was observed to be 4·8° W., whereas on the British Admiralty chart the declination for that place is given as 6·3° W., and on the United States chart as 6·4° W.

The second-largest chart error in declination on the voyage was found by the "Carnegie" at 50° 20′ S. lat., 142° 25′ E. long., when the declination was found to be 6·8° E., while the British Admiralty chart showed for that point 5·5° E., and the United States chart 5·8° E.

The declination observed at 44° 16′ S. and 173° 03′ E. was 17·6° E., a value 0·3° larger than the values given on both the British and United States charts. This point is approximately 34 statute miles south of East Head.

At 44° 42′ S. lat. and 172° 30′ E. long. the value found by the "Carnegie" was 17·6° E., a value 0·2° larger than the British and 0·3° larger than the United States chart value. The value at Christchurch Observatory for October, 1920, was about 17·1° E., and the Magnetic Survey of New Zealand showed an increasing value for declination of approximately + 0·2° for each + 1° of latitude, so that the chart values agree with the Observatory values fairly well if we neglect the merely local peculiarities revealed by the survey.

A large chart error was also found by the "Carnegie" at a point 47° 59′ S., 165° 53′ E., the observed declination being 18·4° E., whereas on the charts it is given as 17·5° E. This point is about 100 miles to the south-west of Stewart Island.

At 47° 59′ S. 163° 46′ E., some 2° west of the above in longitude, the observed value was only 16·9° E. and the chart error only 0·1°. The magnetograms for that day were tolerably quiet so that there is there shown a change of declination of + 1·5° in about 95 miles easting—very much more than was expected.

It seems, then, that a magnetically disturbed area exists to the south-west of New Zealand.

In the December number of the *Journal of Terrestrial Magnetism and Atmospheric Electricity* a list of the latest annual values at observatories is published. Christchurch values for 1917, 1918, and 1919 are included, and the provisional values for Samoa (Apia) for these years also, and provisional values for Potsdam for 1918, 1919, and for Seddon for 1919. The list comprises results from thirty-eight magnetic observatories, and values for 1919, final or provisional, are given for ten observations. Melbourne values from absolute observations only are included for 1918 and 1919.

Comparison Observations with "Carnegie" Observers.

On the 3rd and 4th November, 1920, comparison of declination standards was effected, the observers and instruments alternating their stations. The stations were East Pillar (E.P.) of the Absolute House, and Jarrah Peg (J.P.), the station used in the previous comparison in 1915–16. The results of all these comparisons are being published by the Carnegie Institution, and the results cannot be published as regards comparison of standards until the final checking of "Carnegie" results at Washington and comparison of "Carnegie" instruments with the Department's standards are available.

In declination the station difference established was E.P. = J.P. − 0·27′ by simultaneous observations, exchanging stations. In H.F. the difference established was E.P. = J.P. + 0·00004 C.G.S. In inclination the difference established was W.P. = J.P. + 0·0′.

The comparison was satisfactory, and the differences of Christchurch standards from the international magnetic standard were not appreciably changed, but this will be better shown later, as indicated above. Twelve sets of observations were made of declination, twelve of horizontal magnetic force, and twelve of inclination, positions alternating. Using the observations with the Christchurch inductor E.I. 109 at E.P. and J.P. made for the comparison, reference to the magnetograph curves shows that in vertical force W.P. = J.P. + 5γ.

Diurnal Inequality of Vertical Magnetic Force on Four Extremely Quiet Days.

The four days, 31st October, and 1st, 2nd, and 3rd November were extremely quiet days, and in order to get a comparison of the vertical disturbing force, and the shape of the October–November vector diagram of diurnal disturbing forces in the vertical planes, these days were measured up. The average V.F. inequalities over these days are, for Greenwich civil hours (0h = Greenwich midnight) in γ—

0h.	− 1·6	6h.	+ 0·4	12h.	+ 4·8	18h.	− 4·1
1h.	− 4·4	7h.	+ 2·0	13h.	+ 3·9	19h.	− 2·2
2h.	− 5·1	8h.	+ 3·2	14h.	+ 2·9	20h.	+ 0·0
3h.	− 4·4	9h.	+ 4·5	15h.	+ 0·7	21h.	− 0·6
4h.	− 3·2	10h.	+ 4·8	16h.	− 1·2	22h.	− 0·3
5h.	− 1·2	11h.	+ 4·5	17h.	− 3·5	23h.	− 0·9

Instantaneous ordinates were measured at the Greenwich hour.

It is hoped to publish vertical-force monthly curves for quiet days for 1921. I am afraid that an accession of staff will be needed before I can publish accurate vertical-force data for every hour of the year regularly.

It is true that a very great deal can be achieved from the discussion of D and H data alone, but quiet-day results for V will further some investigations. Our Adie vertical-force balance was not working at all well in the early years of the existence of the Observatory, but now I feel that the vertical-force curves from the Eschenhagen magnetograph we have working at Amberley are satisfactory, and we should at least measure quiet days.

With regard to the provisional Samoan results, it may be noted that in spite of the great difference of geographical position, the change of mean annual values of D and of H is almost the same as at Christchurch, and the change of inclination is not very different.

Acknowledgments.

I am grateful for the temporary services of Mr. D. H. Black, B.Sc., which were kindly granted by the Public Service Commissioner for some time commencing from the visit of the "Carnegie." Mr. Black was of very great assistance in the reduction of observations made during the inter-comparison of instruments, so that results could be gauged as the work progressed. I must also express my thanks to my assistant, Mr. H. F. Baird, for his willing help during the year, and to Mr. V. J. Rhodes for consenting to change papers for me at Amberley. Grateful acknowledgments must also be made for the numerous reports and publications kindly sent to this Observatory by other institutions.

EARTHQUAKE REPORTS.

Symbols, Notation, etc.

1. Character of the earthquake :—

d Local shock perceptible at station, its intensity being expressed on the Rossi-Forel scale thus: RF 1, &c.
v Near shock (origin less than 9°, or 1,000 kilometres, distant).
r Distant shock (origin from 9° to 45°, or 1,000 to 5,000 kilometres, distant).
u Very distant shock or teleseism (origin more than 45°, or 5,000 kilometres, distant).

2. Phases of the seismogram [each of the following symbols may denote—(*a*) the phase itself; or (*b*) the time of arrival of the first waves of that phase at the station; or (*c*) the time of transit of those waves from the origin in seconds: there will be no ambiguity]:—

P .. .. Longitudinal waves, direct (first phase or first preliminary tremors).
PR (or PR_1), PR_2 .... PR_n .. Longitudinal waves, reflected once, twice, *n* times, at the earth's surface.
S .. .. Transverse waves, direct (second phase or second preliminary tremors).
SR (or SR_1), SR_2 .... SR_n .. Transverse waves, reflected once, twice, *n* times, at the earth's surface.
S—P .. .. .. Interval (in seconds) between the arrival of the P waves and the S waves.
PS .. .. Waves changed from longitudinal to transverse oscillation, or *vice versa*, through reflection at the earth's surface.
L .. .. Long waves (chief phase or principal part; regular waves).
L_1, L_2, ... L_n .. .. Successive series of L waves.
L_j .. .. Long waves passing along the major arc of the great circle through the epicentrum and the observatory.

(Repeats of L or L_j after a circuit or circuits of the earth are noted in the "Remarks.")

M .. .. Greatest motion in the chief phase.
M_j .. .. Maximum of the L_j waves.
C .. .. Tail or end portion.
F .. .. End of discernible movement.

3. Nature of the motion :—

i sudden / or / *e* gradual } .. .. .. { Beginning of the motion, used either alone or with one of the symbols in 2 denoting phase.
T (period) .. .. .. Time of one complete oscillation (to and fro).
A .. .. Amplitude of the motion, measured from the median line, in millimetres (mm., as shown on the seismogram), or in mikrons (μ, actual movement of the ground): ($\mu = 1/1000$ mm.).
A_e .. .. E-W component of A.
A_n .. .. N-S component of A.
A_v .. .. Vertical component of A.

4. General :—

Time .. .. .. G.C.M.T., Greenwich civil mean time, 0 h. or 24 h. = midnight.
E (epicentrum) .. .. Position of epicentre.
O (origin) .. .. .. Time of shock at origin.
ϕ .. .. Latitude.
λ .. .. Longitude from Greenwich.
Δ .. .. Distance from epicentre in degrees (°) or in kilometres (kms.).

5. The Observatory :—

(*a*.) Its position: Lat. 43° 31′ 48″ S., long. 172° 37′ 13″ E.
Its height above mean sea-level: 8 metres (25 ft.).
(*b*.) The kind of seismograph: Milne No. 16 (ordinary boom).
How installed: Boom N.-S.
Natural period: 16 seconds.
Magnification: 8.
Damping: Nil.

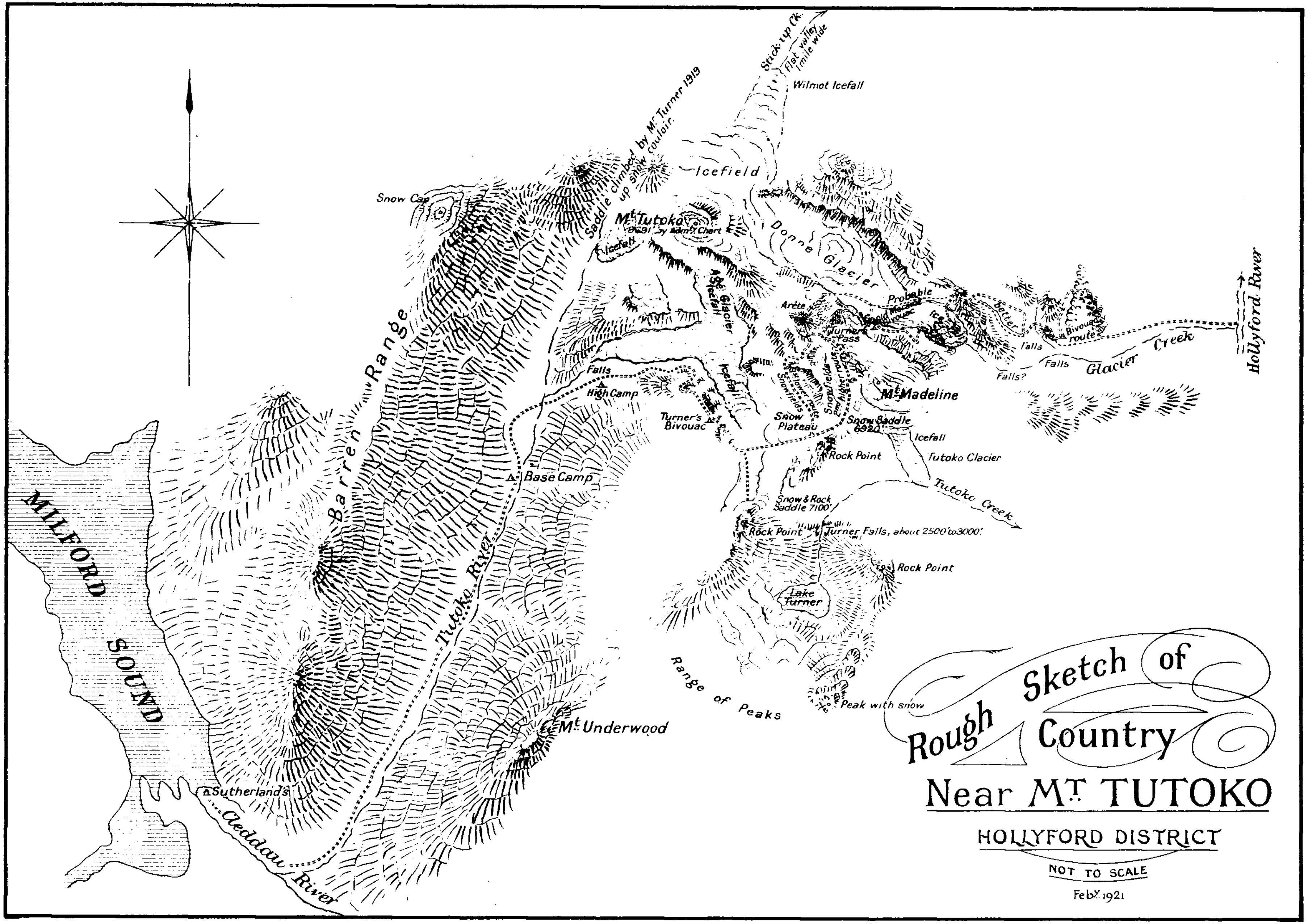
Earthquake Reports.

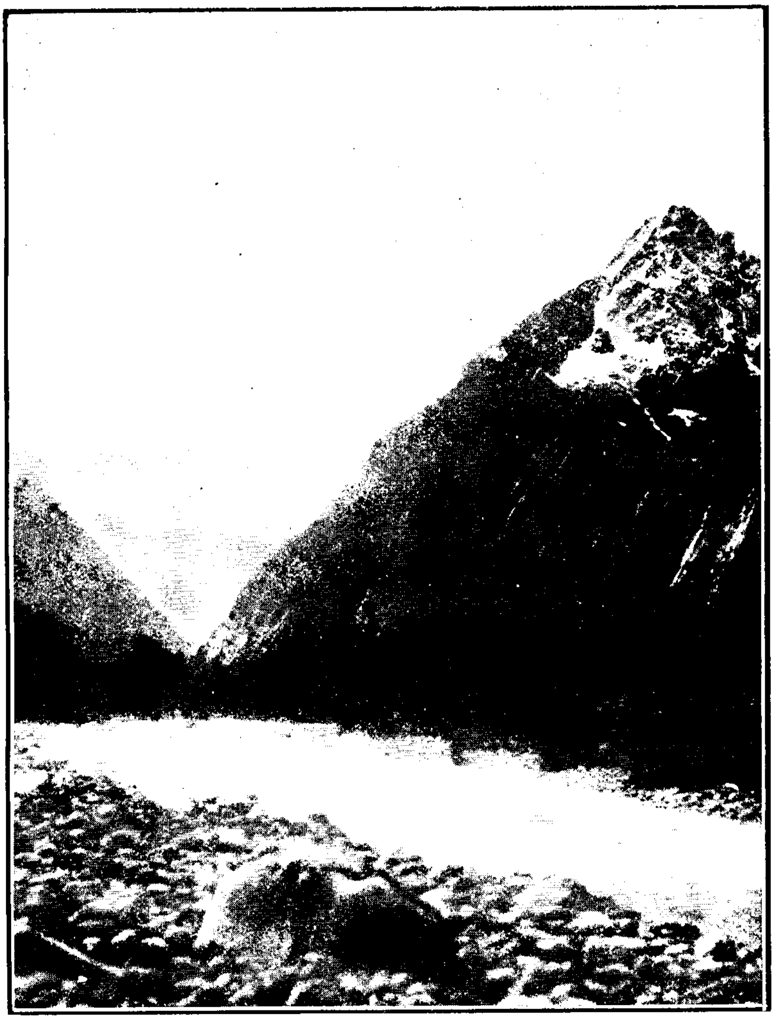
Time is Greenwich civil mean time; it is given in hours, minutes, and seconds. 0h. or 24h. = midnight.

No.	Date.	Character.	Phase.	Time. G.C.M.T.	Boom Period.	Amplitude. A_e.	Remarks.
	1920.			H. M. S.	S.	MM.	
1	Jan., 1	..	P	3 10 48	..	..	Slight microseisms in evidence.
			M	3 14 18	16	0·2	
2	,, 1	..	P	12 21 18	..	..	
				12 21 36	..	..	
				12 23 12	..	..	
			L	12 24 12	..	..	
			M	12 25 06	..	4·0	
			M	12 41 12	16	2·4	
3	,, 11	..	P	3 02 54	..	..	
			M	3 04 54	16	0·4	? Microseism.
4	,, 22	..	P	21 30 24	..	..	? S.
				21 32 48	..	..	? SR_1.
				21 35 18	..	..	
			L	21 36 00	..	..	
			M	21 40 30	13	2·0	
5	,, 29	..	? SR	21 50 24	..	..	
			L	21 54 18	..	..	
			M	21 58 24	13	1·4	
6	,, 29	..	S	19 46 24	..	..	Slight microseisms evident.
			SR_2	19 48 24	..	..	
			L	19 50 12	..	..	
			M	19 53 00	13	1·0	
7	Feb., 3	..	PR_1?	03 36 00	..	..	
			S	03 43 42	..	..	
			L	04 13 48	..	..	
			M	04 17 30	..	0·2	
8	,, 3	..	L	12 32 00	..	..	Slight microseisms evident.
			M	12 37 30	..	1·5	

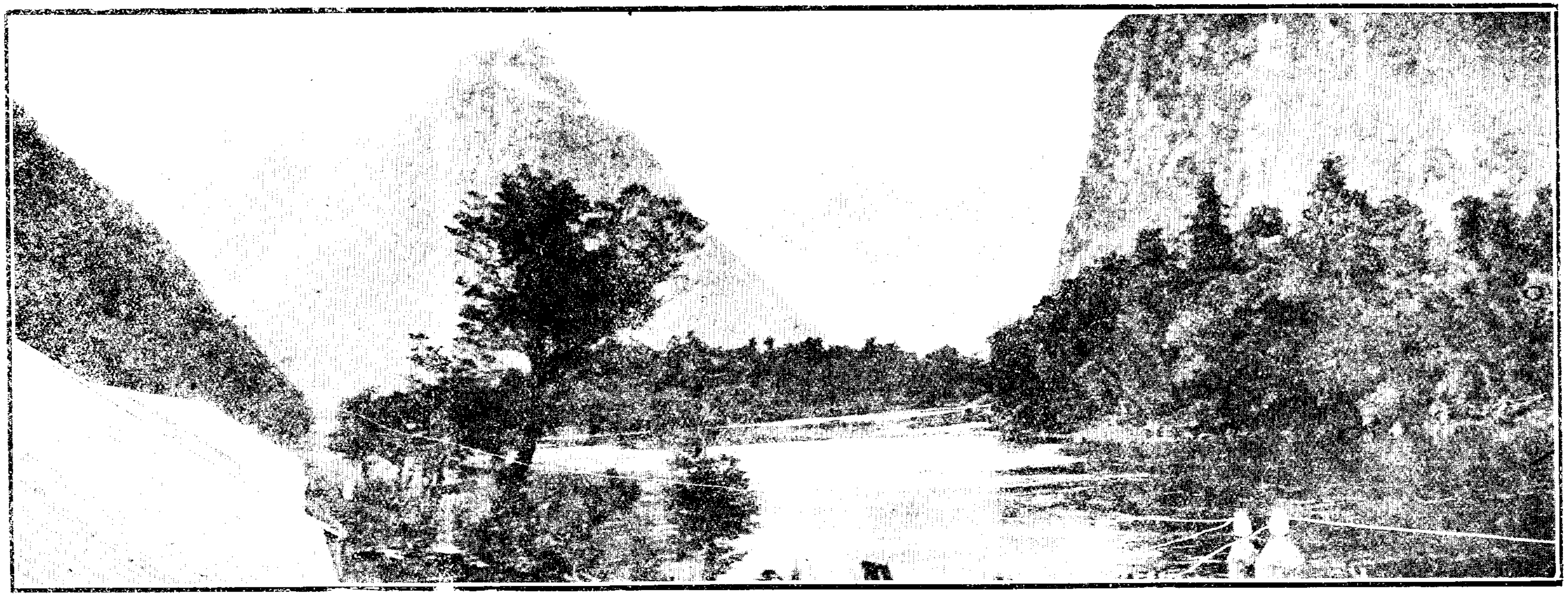
EARTHQUAKE REPORTS—*continued*.

No.	Date.	Character.	Phase.	Time. G.C.M.T.	Boom Period.	Amplitude. Ae.	Remarks.
	1920.			H. M. S.	S.	MM.	
9	Feb. 10	..	S	9 24 42	..	..	
			SR_1 ?	9 27 00	..	..	
			L	9 30 06	..	..	
			M	9 32 30	..	2·6	
10	„ 12	..	L	9 03 36	..	0·6	Microseisms commenced earlier.
			M	9 07 30	..	..	
11	„ 27	..	PR_1	7 16 30	..	..	
			S	7 21 00	..	..	
			L	7 25 00	..	..	
			M	7 27 24	..	1·5	
12	„ 27	..	S	10 45 00	15	..	
			L	10 49 00	..	..	
			M	10 51 24	..	1·0	
13	Mar. 20	*u*	SR_1 ?	18 50 18	..	..	In middle of microseisms.
			SR_2 ?	18 53 12	..	..	
			L	18 59 00	..	..	
			M	19 06 00	15	3·0	
14	April 2	..	RR_1	0 14 18	..	..	
			S	0 18 42	..	..	
			L	0 26 42	..	..	
			M	0 30 00	16	1·1	
15	May 7	*r*	P	21 43 48	..	..	△ 18° ±.
			L	21 48 42	..	..	
			M	21 53 30	16	5·0	
16	„ 10	*u*	PR_1	18 58 48	..	..	
			S	19 06 00	..	..	
			L	19 23 48	..	..	
			M	19 25 00	16	1·3	
17	„ 13	..	P	01 57 06	..	..	△ 50° ±.
			S ?	02 04 12	..	..	
			SR_1	02 08 00	..	..	
			L	02 12 42	..	..	
			M	02 22 54	16	4·0	
18	„ 20	*r*	P ?	07 34 00	..	..	Microseisms running.
			S ?	07 37 30	..	..	
			L	07 40 12	..	..	
			M	07 44 00	16	5·5	
19	June 5	*u*	P	4 34 00	..	..	
			S	4 44 24	..	..	
			L	4 59 12	..	..	
			M	5 05 12	15	1·0	
20	„ 9	..	P	11 40 30	..	..	
			S ?	11 48 00	..	..	
			L	11 56 18	..	..	
			M	12 06 00	15	0·8	
21	July 2	..	S ?	18 52 54	..	..	
			SR_1 ?	18 56 12	..	..	
			L	19 01 16	..	..	
			M	19 03 36	15	0·9	
22	„ 2	..	PR_1 ?	21 47 00	..	..	
			S ?	21 54 30	..	..	
			L	22 13 00	..	..	
			M	22 25 30	15	1·0	
23	„ 6	..	P	3 07 54	..	..	
			S	3 12 36	..	..	
			L	3 14 45	..	..	
			M	3 20 00	15	2·1	
24	„ 6	..	P	05 04 18	..	..	
			S	05 07 48	..	..	
			L	05 09 50	..	..	
			M	05 11 54	15	0·7	
25	Aug. 15	*r*	P	8 25 12	..	..	
			S	8 30 06	..	..	
			L	8 33 50	..	..	
			M	8 42 42	15	2·1	
26	„ 29	*r*	S	10 59 12	..	..	
			SR_1 ?	11 01 40	..	..	
			L	11 03 36	..	..	
			M	11 06 24	15	0·9	
27	Sept. 8	..	S ?	1 50 20	..	..	
			SR_1	1 52 24	..	..	
			L	1 56 40	..	..	
			M	2 02 00	15	5·0	△ 38° ±.
28	„ 9	*r*	PR ?	19 11 48	..	..	Microseisms running.
			S ?	19 16 54	..	..	
			L	19 22 00	..	..	
			M	19 25 30	15	2·0	
..	„ 20	..	P	14 44 36	16	..	Large oscillations continued for 20 minutes after L_1, on the record
			L	14 48 42	..	..	
			M	14 56 00	..	12·0	
..	„ 21	*r*	P	02 40 06	16	..	
			S	02 44 12	..	..	
			SR_1	02 45 36	..	..	
			L	02 47 36	..	..	
			M	02 50 12	..	2·5	


Rough Sketch of Country
Near Mt. TUTOKO
HOLLYFORD DISTRICT
NOT TO SCALE
Feby. 1921
Hollyford River
Glacier Creek
Falls
Falls?
Bivouac
route
Better
Probable
Stick up Ck.
Flat valley
1 mile wide
Wilmot Icefall
Icefield
Saddle climbed by Mr. Turner 1919
up snow couloir.
Mt. Tutoko
9691' by Admty. Chart
Icefall
Donne Glacier
Arête
Turner's Pass
Age Glacier
Icefall
Snowfields
Snow Plateau
Mt. Madeline
Snow Saddle
6920'
Icefall
Tutoko Glacier
Tutoko Creek
Rock Point
Snow & Rock
Saddle 7100'
Rock Point
Turner Falls, about 2500' to 3000'
Rock Point
Lake Turner
Peak with snow
Range of Peaks
Falls
High Camp
Turner's Bivouac
Base Camp
Snow Cap
Barren Range
Tutoko River
Mt. Underwood
Sutherland's
Cleddau River
MILFORD SOUND



TRUE TUTOKO PEAK, LOOKING NORTH FROM MIDDLE TUTOKO VALLEY.



Sandfly Point, End of Milford Sound Track.

Turner's Fifth Camp: First Crossing from Tutoko to Hollyford Valley.

True Tutoko, from Madeline (formerly Tutoko).

From Foot of Snow Plateau.

TWO LEAPS OF THE NEW WATERFALL (ESTIMATED AT 3,000 FT.).

(Foreground rock cuts off one third.)

TRUE TUTOKO, FROM ABOUT 6,000 FT.

EARTHQUAKE REPORTS—*continued.*

No.	Date.	Character.	Phase.	Time. G.C.M.T.	Boom Period.	Amplitude. Ae.	Remarks.
	1920.			H. M. S.	S.	MM.	
..	Nov. 6	..	P ?	21 23 06	15	..	
			L	21 24 36	..	..	
			M	21 25 48	..	..	
..	„ 11	..	P ?	11 08 24	..	..	
			L ?	11 13 48	..	..	
			M	11 16 00	..	0·5	
			M	11 26 00	..	0·5	
..	Dec. 10	r	P	04 59 18	..	..	
			S	05 08 00	..	..	
			SR_1	05 12 48	..	..	
			L	05 23 00	..	..	
			M	05 44 30	16	3·0	
..	„ 13	r	P	03 50 06	16	..	
			S	03 56 30	..	..	
			SR_1	04 00 12	..	..	
			L	04 04 42	..	..	
			M	04 06 06	..	1·0	Δ 47° ±.
..	„ 16	r	P	12 24 24	15	..	
			S	12 30 48	..	..	
			L	12 48 30	..	..	
			M	13 14 42	..	4·7	

APPENDIX III.

EXPLORATIONS ABOUT MOUNT TUTOKO.

THE Darran Mountains, lying between the head of Milford Sound and the valley of the Hollyford River, are shown on the Department's maps as an unexplored region, some isolated points therein having received a provisional fixing during the course of explorations made in neighbouring districts.

Mr. S. Turner, F.R.G.S., the well-known mountaineering enthusiast, has devoted several seasons to climbing in this little-known region, discovering a very large new fall and a lake, and finding reasons to believe that a peak hitherto shown as Tutoko on the maps was not the highest in the vicinity, and that the name (which belongs to the highest) should be transferred to another peak some two miles north-west, which is apparently that shown on the original Admiralty chart as 9,691 ft.

Desirous of locating his discoveries and settling the doubt as to the identification of Mount Tutoko, Mr. Turner applied to the Department for the services of a surveyor for reconnaissance work, and Mr. D. Macpherson eventually was allowed to accompany Mr. Turner in February, 1921.

Unfortunately, owing to several untoward circumstances, the amount of survey work accomplished was insufficient to effect the primary objects of the trip, but the observations and photographs made seem to an outsider to strengthen Mr. Turner's conclusions as to Mount Tutoko, though Mr. Macpherson is not convinced of this. The fogs and mist, while they did not hinder the roar of a very large fall being carried to the ears of the explorers, did prevent any determination or estimation of its size, which previous observers consider to rival the famous Sutherland Falls.

The country climbed is very difficult, and at one time fears were entertained for the safety of the party, which found itself unable to return by the way it had gone out, and was obliged to make a most difficult trip, pushing over largely unknown glacier and ice country, down into the Hollyford Valley, thus crossing quite over the mountain-range and making five days' travel on three days' provisions, eventually getting out to Martin's Bay. The delay due to this experience was a considerable factor in preventing sufficient reconnaissance survey being done, as it was necessary to return again to Lake Te Anau—an immense detour—whence the trip would have to be begun again to get back to the mountains, and Mr. Macpherson did not return.

The very interesting photographs reproduced here, kindly lent by Mr. Turner for the purpose, give a good idea of the country, but the accompanying map, drawn from Mr. Macpherson's sketches and Mr. Turner's descriptions and bearings, can only be considered as an eye-sketch owing to lack of proper intersecting bearings, &c. Two of these photographs are of especial interest as showing the unknown country surrounding the disputed Tutoko peaks. That of Turner's Pass shows both peaks; that to the right, now named Madeline, is that which is suggested as being really the peak at present called Tutoko on the maps, while the far-off mountain on the left is the higher new peak, probably the real Tutoko. The next photograph is taken from the top of Madeline (the snow-covered foreground), in a north-westerly direction across Turner's Pass to the real Tutoko, some two miles and a half distant. This view shows to the right the newly found icefield lying round Tutoko, and sending down one glacier to the left (south) into the Tutoko Valley, one to the north-east towards Stick-up Creek and Lake McKerrow, and another one along the flanks of Tutoko and Madeline south-east into the Hollyford Valley, and over and along which the party, after crossing Turner's Pass, descended into the Hollyford Valley.

Approximate Cost of Paper.—Preparation, not given; printing 750 copies (including diagrams, &c.), £67 10s.

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