SESSION II.
1923.
NEW ZEALAND.

DEPARTMENT OF LANDS AND SURVEY.

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, 1st July, 1923.

I have the honour to present herewith the report on survey operations for the year ended 31st March, 1923.

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

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

REPORT.

The demands on the Department for the year ended 31st March, 1923, have again been heavy, although the acreage surveyed shows a slight shrinkage as compared with last year's returns. Of the fifty-four surveyors employed, thirty-eight were staff and sixteen contract; while apart from these a number of cadets and assistants were employed.

The attached 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 344,635 acres is shown as completed work, as compared with 370,082 acres for last year; and under the heading of "Native-land Surveys" the area shows a decrease from 258,067 acres to 244,043 acres.

The average cost per acre of rural surveys has decreased from 1s. 10d. to 1s. 6d., and the average cost per acre of Native-land surveys shows a similar decrease from 2s. 1d. to 1s. 8d. as compared with the prices ruling last year. These figures show that the work is being done at a reasonable price.

TABLE A.

Class of Work.	Area, &c.	Average Cost.	Total Cost.
	Acres.		£ s. d.
Triangulation, by staff surveyors	31,546	2·615d.	343 16 0
Rural surveys, by staff surveyors	335,566	1·54s.	25,898 17 7
Rural surveys, by licensed surveyors	9,069	2·50s.	1,132 19 2
Village and suburban, by staff surveyors ..	1,401·21	14·00s.	980 14 10
Village and suburban, by licensed surveyors ..	0·21	Special	12 12 0
Town, by staff surveyors	355·88	64·03s.	1,139 6 10
Town, by licensed surveyors	1·456	Special	44 11 0
Native Land Court, by staff surveyors	29,462·37	1·375s.	2,025 13 7
Native Land Court, by licensed surveyors ..	214,580·80	1·73s.	18,530 10 9
Coal- and gold-mining areas, paid by applicants ..	560·0	..	..
Sawmill areas, &c., paid by applicants	..	..	..
	Miles.	Per Mile.	
Roads, by staff surveyors	291·24	£49·52	14,421 4 10
Roads, by licensed surveyors	7·03	£28·37	199 8 8

TABLE B.

Land District.	Rural Surveys.	Native-land Surveys.
	Acres.	Acres.
North Auckland	16,524	10,129
Auckland	90,627	142,333
Hawke's Bay	6,284	53,913
Taranaki	17,559	7,665
Wellington	5,699	27,946·37
Marlborough	2,711	1,362
Nelson	5,921	..
Westland	7,972	..
Canterbury	2,665	601
Otago	126,673	82
Southland	62,000	11·8
Totals	344,635	244,043·17

MINOR TRIANGULATION.

An area of 31,546 acres, at a cost of 2·6d. per acre, is shown under this heading. The whole of the work was undertaken to control the settlement surveys in Auckland, Taranaki, and Marlborough Districts.

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 thus shown being 344,635 acres, while the remainder includes village and suburban and town lands, totalling 1,754 acres.

NATIVE-LAND SURVEYS.

An area of 244,043 acres was completed during the year under report by staff and contract surveyors. Table A shows that areas of 29,462 acres and 214,581 acres were surveyed by staff surveyors and contract surveyors respectively. The area surveyed in each land district is shown in Table B.

GOLD- AND COAL-MINING SURVEYS.

An area of 560 acres is shown under this head. The surveys were made by private surveyors, and the fees paid by the applicant.

GEODETIC TRIANGULATION.

An examination on the ground of the triangulation scheme covering the Urewera country has been completed, and most of the signals have been erected on the stations, comprising a net of triangles extending from the Kaingaroa Plains base-line to the coast in the north and east directions.

STANDARD SURVEYS.

The extension of the standard survey of Palmerston North was completed by Mr. C. A. Mountfort, District Surveyor, with the assistance of Mr. A C. Haase, surveyor, who was acting under his supervision in order to gain experience and receive training in work of this class. Mr. Mountfort also returns seventy-two miles of standard traverse of main roads in the vicinity of Feilding at a very moderate cost per mile. The system of measurement and the apparatus and instruments used by Mr. Mountfort is the subject of an illustrated report appended hereto.

The standard survey of Gisborne was resumed by Mr. H. M. Kensington, District Surveyor, early in the year, and the field-work is nearly completed. An examination of the traverse closures shows that the high degree of precision necessary in standard work is being maintained.

TOPOGRAPHICAL SURVEY.

Operations were commenced in Nelson District by one topographer to map an area in Motueka and Waimea Survey District, on which the Cawthron Institute is conducting a soil-survey and experimenting in afforestation. The field-work of forty-four square miles has been completed.

INSPECTIONS.

Inspections have been made during the year under review by the Chief Draughtsmen and staff surveyors of surveys under the Land Transfer Act executed by surveyors in private practice. The work inspected has generally been found satisfactory, but sufficient discrepancies have been disclosed by the Inspectors to warrant increasing the number of inspections in order to ensure that an adequate check is being maintained on the field operations of the staff and surveyors in private practice or on contract surveys.

TIDAL SURVEY.

The work for the past year comprised a fresh analysis for each of the ports of Wellington, Bluff, Dunedin, and Westport. The constants derived therefrom, combined with previous determined values of the constants of these ports and the mean constants for Auckland and Lyttelton, are shown in Table C below.

Table C.

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

Tide Symbol.	Auckland. A_0 = 5·74 ft.		Bluff. A_0 = 5·38 ft.		Dunedin. A_0 = 3·23 ft.		Lyttelton. A_0 = 3·20 ft.		Wellington. A_0 = 2·93 ft.		Westport. A_0 = 5·00 ft.	
	H.	K.	H.	K.	H.	K.	H.	K.	H.	K.	H.	K.
Short Period.	Ft.	°	Ft.	°	Ft.	°	Ft.	°	Ft.	°	Ft.	°
S1	0·010	17·35	0·009	94·60	0·015	14·41	0·035	31·91	0·003	331·06	0·011	69·61
S2	0·595	265·12	0·503	49·35	0·245	129·50	0·179	143·04	0·100	334·84	0·970	332·02
S4	0·020	334·01	0·010	225·12	0·007	318·52	0·009	202·78	0·004	207·87	0·008	49·18
S6	0·003	55·73	0·006	167·65	0·003	115·92	0·015	344·95	0·005	310·03	0·006	329·28
M1	0·011	144·69	0·013	119·06	0·010	108·52	0·010	99·40	0·007	0·39	0·016	86·66
M2	3·805	204·90	2·859	35·81	2·485	122·39	2·879	125·63	1·600	137·23	3·754	304·17
M3	0·038	199·10	0·010	272·60	0·016	262·98	0·016	112·80	0·024	175·36	0·021	210·07
M4	0·108	128·64	0·092	226·85	0·261	177·75	0·016	80·19	0·037	258·61	0·060	43·83
M6	0·024	309·52	0·087	79·41	0·072	357·87	0·022	68·96	0·014	90·98	0·026	36·73
O1	0·055	140·10	0·114	73·47	0·088	72·39	0·088	61·46	0·105	35·34	0·093	47·64
K1	0·235	168·27	0·059	116·06	0·074	90·24	0·148	82·58	0·084	81·79	0·074	184·13
K2	0·142	252·93	0·132	47·40	0·091	122·50	0 054	102·88	0·045	351·44	0·264	329·53
P1	0·075	165·26	0·023	105·71	0·023	94·68	0·051	112·04	0·032	74·67	0·024	130·32
J1	0·015	203·86	0·006	218·54	0·004	78·86	0·007	146·39	0·007	141·00	0·014	232·09
Q1	0·012	65·42	0·028	42·72	0·028	76·62	0·021	43·38	0·037	24·64	0·037	31·52
L2	0·171	202·92	0·106	32·24	0·155	102·59	0·088	148·45	0·048	124·43	0·089	280·34
N2	0·793	172·38	0·647	16·85	0·537	104·34	0·663	95·31	0·405	101·66	0·753	288·29
ν2	0·190	197·96	0·135	59·31	0·099	114·97	0·148	122·05	0·122	130·26	0·179	322·85
μ2	0·103	172·63	0·062	5·86	0·029	46·38	0·091	59·29	0·072	90·40	0·126	283·59
T2	0·067	293·47	0·021	94·47	0·017	231·08	0·030	219·85	0·036	283·24	0·048	11·68
(MS)4	0·180	195·00	0·080	1·53	0·108	140·91	0·102	123·98	0·035	134·53	0·103	297·37
(2SM)2	0·064	303·96	0·043	121·14	0·046	8·44	0·066	25·99	0·033	352·71	0·079	202·28
R2	0·023	214·72	0·014	121·64	0·014	198·62	0·013	150·12	0·015	132·60	0·041	236·31
Long Period.												
Mm	0·083	184·66	0·048	262·34	0·056	69·33	0·048	137·29	0·065	303·88	0·028	150·48
Mf	0·044	252·09	0·066	180·11	0·068	184·30	0·063	183·39	0·043	175·37	0·046	330·87
MSf	0·054	181·63	0·064	324·28	0·089	137·64	0·129	156·38	0·083	71·66	0·066	132·63
Sa	0·223	46·05	0·097	41·93	0·135	267·26	0·097	246·56	0·088	301·59	0·101	100·39
Ssa	0·065	113·05	0·110	90·56	0·073	104·27	0·085	139·91	0·086	153·27	0·124	109·27

An analysis of one year's observations of the observed times of the swinging of the light-ship at the Bluff to the flood and ebb tide was performed, with the results that the light-ship swings to the flood 27m. after low water, and to the ebb 21m. after high water, respectively, at Bluff Harbour Wharf. These values are in agreement with the hitherto published results in the "New Zealand Nautical Almanac."

A comparison of the predicted times of high water and low water as published in the tide-tables for the year 1921 with the actual values obtained from the automatic tide-gauge is given in Tables 1 to 3 in the report of Mr. E. J. Williams, Tide-computer (appended) for the ports of Auckland, Wellington, Bluff, and Westport.

The error in the times and heights of high and low water are of the same order as those shown in all tide-tables computed by the method of harmonic analysis, and the tide-tables are considered satisfactory for the purposes of navigation.

Two new tide-gauges, on the same pattern as that operating at Wellington, were manufactured locally by Messrs. Littlejohn and Son. One is installed at Lyttelton and the other at Dunedin, replacing the very old and unreliable gauges hitherto in use at these ports The new gauges are performing satisfactorily.

The mean high-water mark has been determined from the record of the year 1921 for the following places. The readings on the tide-gauges of the mean high-water marks are: Auckland, 9·73 ft.; Wellington, 4·64 ft.; Bluff, 8·27 ft.; Westport, 8·60 ft. These readings are for practical use in defining high-water marks along the foreshore.

The tide-tables for the year 1924 were received in Wellington from the Director, National Physical Laboratory, Teddington, on the 20th September, 1922.

Advice was received from the Hydrographer to the Admiralty at the end of May, 1922, that the Tidal Department at the Laboratory was closed and the tide-predicting machine transferred to India. The Director of the Laboratory had, however, run off the curves to enable him to supply predictions for 1924 and 1925. The Government then authorized the Hydrographer to make arrangements for the prediction of the tide-tables for six New Zealand ports for 1926 and onward. The exchange of the New Zealand tide-tables with other responsible national authority requiring them for inclusion in published tide-tables, in accordance with the recommendations of the International Hydrographic Conference, 1919, is contemplated by the Hydrographer. The New Zealand predictions have therefore been placed at his disposal for exchange purposes, which will be of great advantage to the Dominion in having the New Zealand tide-tables published abroad, and will lead to the inclusion of predictions from more foreign parts in the Admiralty Tide-tables.

My thanks are due to the Hydrographer for the advice and assistance given by him in connection with the arrangement for a supply of the New Zealand predictions from Messrs. Roberts and Son, Broadstairs.

The details of the tidal work are more fully dealt with in the report by Mr. E. J. Williams, Tide-computer, appended hereto.

MAGNETIC OBSERVATORY.

During the year the work of the Magnetic Observatory at Christchurch and the substation 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.

The magnetographs have continued in regular operation throughout the year, and the base values of the curves were determined by absolute observations of declinations, dip, and horizontal force, usually taken once a month. The results of the absolute observations and of certain meteorological observations have appeared month by month in the monthly report of the Director.

Mr. D. G. Coleman, of the Department of Terrestrial Magnetism, Carnegie Institute of Washington, visited the Dominion in March and April, 1922. He was making observations for secular change in the Pacific islands and Australia. He reobserved the magnetic elements at several stations in New Zealand where Mr. W. C. Parkinson, of the Carnegie Institution, had made similar determinations in 1916. When the results of Mr. Coleman's observations are published valuable information regarding the change in the magnetic elements will be known, and the secular change in declination can be made use of for correcting the magnetic variation shown on the charts of the coast.

A distinguished scientist, Dr. L. A. Bauer, Director of the Department of Research in Terrestrial Magnetism, Carnegie Institution of Washington, visited Wellington in July last on his return journey from the meeting of the International Geodetic and Geophysical Union held at Rome in May, 1922. He submitted the following resolutions passed by the International Section of Terrestrial Magnetism and Electricity at the Rome meeting, 9th May, 1922, for the information of the Government:—

(*a.*) That the steps already taken by the New Zealand Government regarding the continuation of the Apia Observatory in Samoa are highly commended, and it is hoped that the New Zealand Government may find it possible to provide for the continued activities of the Observatory.

(*b.*) That every magnetic observatory publish annually the monthly and annual mean values of the magnetic elements observed during the preceding year, for the purpose of the mutual exchange of such results.

(*c.*) That the organizations responsible for the various magnetic services be urged to make prompt publication of their data as completely as circumstances permit.

Dr. Bauer also kindly undertook to include a summary of the state of the New Zealand magnetic survey, and the work done at the Christchurch Observatory, in the report of the International Geodetic Union, and supplied valuable information regarding instruments and methods of observing and recording results in use in his Department. My thanks are due to him for these, and the keen interest he took in all matters pertaining to the magnetic work being done in this Dominion.

In addition to the current work of the year being satisfactorily performed, the arrears in connection with the measurement of the records between the years 1906 and 1913 are being steadily overtaken, and the record of the declination curve for the year 1911 has also been measured during the year under report.

The mean annual values of the magnetic elements as far as they are available are given in Table D following:—

TABLE D.

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.	Hourly Values: 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 ..	16 31·1	..	..	..	..	..	..	..	..
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	+2·9	0·22261	−20	0·55525	+03	68 09·2	+1·10	†1920–21
1921 ..	17 04·6	+3·7	0·22241	−24	0·55528	−21	68 10·3	+0·90	†1921–22
1922 ..	17 08·3	..	0·22217	..	0·55507	..	68 11·2	..	†1922–23

* Mean hourly values published in *New Zealand Journal of Science and Technology*. † Special publication.

A list of the earthquakes recorded at Christchurch during the year by Milne seismograph No. 16 is contained in the Director's report.

Seismic activity was pronounced during the year 1922 in this Dominion, particularly in the districts north-east of Lake Taupo, where a great number of local shocks were felt. The most notable of the thirty-eight shocks recorded at Christchurch was that which occurred off the Chilian coast on the 11th November. I had the privilege of witnessing the record of this earthquake on the instruments of the Riverview Observatory at Sydney. The destructive shock which took place at North Canterbury on the 25th December is not recorded, as the seismograph was immediately thrown out of adjustment by the first waves of the shock. A map of the area affected by the North Canterbury shock is in course of preparation.

A study of earthquakes is very important to a country contemplating hydro-electric or irrigation schemes, as valuable information will be obtained as to the conditions in their vicinity.

The Director of the United States Coast Survey, in his annual report for 1922, referring to the value of seismological investigations, states : " These involve the life and security of great numbers of people and the safety of vast property. If through ignorance of conditions a great dam were placed across an active fault it would be completely destroyed by a major earthquake."

Proposed Operations for the Year 1923-24.

Geodetic Triangulation.—The field-work of this survey will be conducted by Mr. A. C. Haase, surveyor. The observations will be made by means of an 8 in. geodetic theodolite at the stations of the scheme on which signals have been erected, and when the observations of a sufficient number of triangles have been completed an analysis of the results will be made to test whether the 8 in. theodolite is sufficiently powerful to give satisfactory closures.

Standard Surveys.—Mr. H. M. Kensington, District Surveyor, will complete the standard survey of Gisborne early in the year, after which he will attend to reinstatement of a number of blocks in the City of Auckland, and then take up the standard survey of Hamilton. Rural standard traverses will be continued, during periods of slackness in the settlement work, in the vicinity of Christchurch by Mr. F. H. Waters, District Surveyor, and in the Clutha district in Otago by Mr. S. T. Burton, District Surveyor. Standard surveys are asked for by various local bodies, and those at Whangarei, Invercargill, Dunedin, and Cobden will be undertaken as soon as trained surveyors are available.

Settlement Surveys.—The work may be summarized as follows : 373,383 acres rural survey, 330,826 acres Native-land survey, 274 miles road survey, 44½ acres town survey, and 156 square miles minor triangulation. The details of the field-work are shown in Table 4.

Topographical Survey.—One topographer will continue the work in Nelson District to provide maps which will assist the officers of the Cawthron Institute in the soil-survey being conducted by them. A complete party will commence operations in the vicinity of Rotorua and survey the thermal region.

Miscellaneous.—In addition to the above-mentioned works, there is the customary inspection of surveys, the work of computing the tide-tables, measuring the curves of the magnetic elements, the preparation of geodetic tables, and the drawing and compilation of the maps for publication.

General.

Proclamation of Roads, &c.—A number of applications for the proclamation of road-lines laid off by the Native Land Court pursuant to sections 48, 49, 50, and 52 of the Native Land Amendment Act, 1913, were dealt with during the year under review. The statutory notices were duly served on the local authority of the district in terms of section 15 of the Native Land Amendment Act, 1914, and in the large majority of cases no objections were raised to the proclamation of the roads. The statutory provisions referred to are proving very useful in providing legal access to Native and other lands hitherto without road facilities.

Under the Land for Settlements Act, 1908 (section 80), the old road-lines traversing recently acquired estates and not required in connection with the subdivision thereof were duly closed and incorporated in the area available for disposal.

Under the Land Transfer Act a large number of warrants for the issue of titles were duly certified to in terms of section 13 of the Act, and in addition several applications to bring land under the Act were examined and approved in terms of section 19.

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.

Table 1.—Return of Field-work executed by Head Office Staff from 1st April, 1922, to 31st March, 1922.

Land District.	Standard Surveys.				Rural Standard Surveys.				Primary Triangulation.		Other Work.
	Completed.		In Progress.		Completed.		In Progress.		Completed.	In Progress.	
	Miles.	Total Cost.	Miles.	Total Cost.	Miles.	Total Cost.	Miles.	Total Cost.			
		£		£ s. d.		£		£	Acres.	Cost.	£
Auckland ..	..	..	..	..	..	..	..	..	..	£1,533 14 8	140 5 8
									Secondary	Triangulation.	
Wellington	..	..	..	..	72	2,000	..	..	148,000	£816 16 4	127 5 4
Hawke's Bay	..	..	..	3,004 6 4	..	..	..	..	..	..	..

Table 2.—Return of Field-work executed by the Staff and Contract Surveyors on Lands administered by Lands and Survey Department, from 1st April, 1922, to 31st March, 1923.

District.	Minor Triangulations.			Topographical Survey for Selection as Unsurveyed Land.			Rural.			Village and Suburban.				Town Section Survey.				Roads, Railways, and Water-races.			Other Work.	Total Cost of Completed Work from 1st April, 1922, to 31st March, 1923.
	Acres.	Cost per Acre.	Total Cost.	Acres.	Cost per Acre.	Total Cost.	Acres.	Cost per Acre.	Total Cost.	Acres.	No. of Sections.	Cost per Acre.	Total Cost.	Acres.	No. of Sections.	Cost of Sections.	Total Cost.	Miles.	Cost per Mile.	Total Cost.	Cost.	
		d.	£ s. d.		s.	£ s. d.		s.	£ s. d.			s.	£ s. d.			s.	£ s. d.		£	£ s. d.	£ s. d.	£ s. d.
N. Auckland	..	..	..	6,583	0·79	258 15 4	16,520	3·91	3,231 17 7	701·37	64	5·74	201 9 10	150·12	184	22·8	209 15 6	10·09	28·34	285 19 0	1,541 1 5	5,728 18 8
Auckland ..	8,504	0·86	73 16 0	..	..	..	90,627	1·88	8,509 17 6	108·0	21	19·09	103 2 0	9·75	3	157·22	23 11 8	165·5	62·52	10,348 1 4	4,331 1 2	23,389 9 8
Taranaki ..	..	..	..	1,452	0·65	47 6 8	17,559	6·27	5,506 5 5	..	..	..	..	96·0	72	102·8	370 0 2	8·5	44·08	374 13 7	179 10 11	6,477 16 9
Hawke's Bay	..	..	..	20,490	0·02	25 0 0	6,284	1·99	625 15 0	..	..	..	..	5·0	1	110·00	5 10 0	5·25	26·95	141 10 4	130 12 0	928 7 4
Wellington ..	..	..	..	..	..	..	5,699	4·86	1,386 1 5	50	26	36·98	92 9 0	3·71	21	30·95	32 10 0	25·0	45·4	1,134 1 2	421 17 1	3,066 18 8
Marlborough	23,042	2·8	270 0 0	..	..	..	2,711	1·17	154 12 7	..	..	..	..	..	..	..	..	10·1	30·5	309 3 3	101 18 7	835 14 5
Nelson ..	..	..	..	..	..	..	5,759	3·98	1,146 0 2	233·00	11	17·3	201 8 0	7·0	27	18·51	25 0 0	1·75	24·0	42 0 0	143 9 7	1,557 17 9
Westland ..	..	..	..	..	..	..	7,972	5·38	2,145 14 10	299·83	21	23·6	354 6 0	76·0	113	72·5	409 12 0	6·5	36·0	234 0 0	15 0 0	3,158 12 10
Canterbury ..	..	..	..	..	..	..	2,665	2·5	333 2 6	..	..	..	..	..	..	..	..	50·0	23·0	1,150 0 0	85 0 0	1,568 2 6
Otago ..	..	..	..	..	..	..	126,673	0·44	2,786 14 1	..	..	..	..	2·3	18	58·0	52 0 0	1·08	49·5	53 10 0	230 5 4	3,122 9 5
Southland ..	..	..	..	..	..	..	62,000	0·36	1,128 10 8	..	..	..	..	..	..	..	..	..	..	..	9 0 0	1,137 10 8
Totals ..	31,546	2·61	343 16 0	28,525	0·23	331 2 0	344,469	1·56	26,954 11 9	1,392·20	143	13·69	952 14 10	349·88	439	81·46	1,127 19 4	283·77	49·55	14,072 18 8	7,188 16 1	50,971 18 8

Table 3.—Return of Field-work executed by Staff and Contract Surveyors on Lands administered by other Departments from 1st April, 1922, to 31st March, 1923.

District.	Rural.			Village and Suburban.				Town Section Survey.				Native-land Survey.				Gold-mining Survey.			Roads, Railways, and Water-races.			Other Works.	Total Cost of Completed Work from 1st April, 1922, to 31st March, 1923.
	Acres.	Cost per Acre.	Total Cost.	Acres.	Number of Sections.	Cost per Acre.	Total Cost.	Acres.	Number of Sections.	Cost of Sections.	Total Cost.	Acres.	Number of Sections or Divisions.	Cost per Acre.	Total Cost.	Acres.	Number of Sections.	Cost per Acre.	Miles.	Cost per Mile.	Total Cost.	Cost.	
		s.	£ s. d.			s.	£ s. d.			s.	£ s. d.			s.	£ s. d.					£	£ s. d.	£ s. d.	£ s. d.
North Auckland ..	4	63·0	12 12 0	..	..	..	..	..	..	..	..	10,129·0	231	3·48	1,762 0 3	..	..	..	..	..	..	..	1,774 12 3
Auckland	..	..	..	..	..	..	..	..	..	..	..	142,333·0	..	1·18	8,388 18 10	..	..	..	..	..	..	..	8,388 18 10
Taranaki	..	..	..	..	..	..	..	..	..	..	..	7,665·0	79	2·42	926 13 0	..	..	..	..	..	..	..	926 13 0
Hawke's Bay ..	..	..	..	0·21	1	1143·88	12 12 0	1·46	4	222·75	44 11 0	53,913·0	436	1·86	5,024 4 6	..	..	..	..	..	..	..	5,081 7 6
Wellington	..	..	..	9·0	3	62·22	28 0 0	..	..	..	..	27,946·4	247	2·91	4,065 6 11	..	..	..	14·5	37·7	546 17 10	12 0 0	4,652 4 9
Marlborough ..	..	..	..	..	..	..	..	..	..	..	..	1,362·0	4	2·25	149 16 0	..	..	..	..	..	..	26 10 0	176 6 0
Nelson	162	8·02	65 0 0	..	..	..	..	6·0	13	17·46	11 7 0	..	..	..	..	480	6	..	..	..	..	..	76 7 0
Westland	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Canterbury	..	..	..	..	..	..	..	..	..	..	..	601·0	17	4·13	124 2 0	..	..	..	..	..	..	..	124 2 0
Otago	..	..	..	..	..	..	..	..	..	..	..	82·0	15	20·73	85 0 0	80	1	..	..	..	..	..	85 0 0
Southland	..	..	..	..	..	..	..	..	..	..	..	11·8	4	51·14	30 2 10	..	..	..	..	..	..	..	30 2 10
Totals ..	166	9·35	77 12 0	9·21	4	88·17	40 12 0	7·46	17	65·77	55 18 0	244,043·2	1,033	1·68	20,556 4 4	560	7	..	14·5	37·7	546 17 10	38 10 0	21,315 14 2

Table 4.—Return showing Surveyors employed and the Work on Hand on 1st April, 1923.

Names of Chief Surveyors.	Surveyors employed.			Work on Hand.						
	Staff.	Temporary.	Contract.	District.	Settlement.	Native Blocks, &c.	Roads, &c.	Towns.	Triangulation.	Standard Traverse.
					Acres.		Miles.	Acres.	Sq. Miles.	
R. P. Greville ..	5	..	..	N. Auckland	25,793	..	9	0·5	..	..
H. M. Skeet ..	17	..	..	Auckland ..	191,422	65,335	170·5	..	..	..
V. I. Blake ..	2	..	1	Gisborne ..	..	18,268	..	..	..	..
W. F. Marsh ..	..	..	2	Hawke's Bay	..	111,000	..	..	..	..
H. J. Lowe ..	2	..	5	Taranaki ..	22,669	3,555	6·0	..	150	..
Thomas Brook ..	3	..	7	Wellington ..	..	131,230	17·5	..	..	..
J. Cook ..	1	..	1	Marlborough	..	980	..	..	..	..
H. D. McKellar ..	2	..	..	Nelson ..	1,037	..	0·63	29·0	..	..
W. T. Morpeth ..	2	..	1	Westland ..	60,402	326	3·0	15·0	..	..
G. H. Bullard ..	1	..	..	Canterbury..	800	..	50·0	..	..	..
R. T. Sadd ..	2	..	..	Otago ..	57,260	132	17·0	..	6	..
R. S. Galbraith ..	1	..	..	Southland ..	14,000	..	..	..	..	..
Totals ..	38	..	16		373,383	330,826	273·75	44·5	156	..

Table 5.—Principal Classes of Office-work done from 1st April, 1922, to 31st March, 1923.

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	390	676	604	..	781	..	7	69	..	93 0 6
Auckland	634	9,920	2,269	4,940*	1,302	..	..	43	..	206 14 11
Hawke's Bay	95	1,678	948	945	331	..	4	6	..	23 19 6
Taranaki	111	1,190	1,162	2,191	342	616	..	5	..	77 9 10
Wellington	516	5,430	544	4,524	782	..	..	15	..	36 3 11
Marlborough	126	305	60	115	81	30	7	5	..	33 2 9
Nelson	362	606	10	261	138	..	5	28	..	42 3 4
Westland	152	153	24	..	76	176	..	..	..	73 5 6
Canterbury	221	4,118	58	2,531	369	231	..	6	..	135 4 7
Otago	494	1,500	37	295	187	500	7	15	..	85 11 8
Southland	97	988	92	505	109	..	5	9	..	48 13 10
Totals	3,198	26,564	5,808	16,307	4,498	1,553	35	201	..	955 10 4
Head Office	..	..	..	..	..	..	..	..	..	271 9 3
										1,226 19 7

* These figures include a North Auckland quota.

APPENDIX I.

(a.) HEAD OFFICE DRAUGHTING BRANCH.

Publication of Maps.

During the year the Department paid £1,893 9s. 6d. for the printing of maps, not including sale plans and accessory or illustrative maps. For this sum 134 standard maps were issued, being either new maps or reissues, and being at the rate of 2·6 maps per week. In last year's report it was shown that a rate of three per week is required to keep map stock merely level without beginning on the large number of new maps as yet undrawn but badly required. That report also showed that we were falling behind at the rate of two maps per week, and the above figures show that we are still falling behind. As a matter of fact, at the rate of three per week the year ends with a stack of eighty-odd maps—thirty weeks' work on hand with fresh work coming in all the time equal to the full output, so that arrears are increasing. The printing of maps under present conditions is a "bottle-neck," congesting all the avenues of work.

The revenue in cash derived from the sale of maps during the year was £817, while the various Departments of Government used £1,000 worth of maps. If it were possible to print all the maps which the staff can turn out, and which are sorely needed, and to use improved methods of production and sale, the revenue should be easily doubled. There are indications that private printing firms are beginning to wake up to the existence of an unsatisfied market, all the maps for sale in booksellers shops are local or outside publications, not Government.

Only one notable map was published during the year—the long-delayed topographical map of Dunedin with contours. The promised City of Auckland sheet is still in proof stage.

An attempt has been made to issue specimen maps, especially of topographical drawing, for the guidance of student draughtsmen, but these are still in the before-mentioned "bottle."

"Town" plans coming in for the approval of the Minister keep up their number. A very marked feature of this work, however, is the agitation caused by the demand for reserves for public purposes where the circumstances require such provision. In the majority of cases this is met at once, more than is asked for being given voluntarily; in other cases, however, a great deal of protest has been made, up to the length of a test case in Court, in which the power to require these reserves has been fully maintained.

Legislation to amend procedures and render them more flexible and efficient has been prepared for a considerable time, but has not been accepted by the Government, new law on the policy aspect of the question being considered desirable.

Draughtsmen's Examination.

This examination was held in July, thirteen candidates sitting; two passed in advanced computations, two in second-grade computations, and two in second-grade draughting. The purpose of this examination and the conditions under which it is prepared and held require attention and organization. It is primarily intended to encourage draughtsmen and computers to fit themselves for higher and better-paid work, and to be a substitute for the Matriculation Examination in grading from class to class. The preparation of the papers and subsequent assessment of the results—a very considerable and ungrateful task—is left to two or three officers wholly after hours—officers who as time goes on are in the nature of things more and more removed from first-hand touch with the minutiæ and details dealt with. The best system undoubtedly would be that an Inspector of the technical branches, in consequent close touch with all the details and able to set and examine papers unhampered by attention to other work for all the working-hours of the day, should be mainly responsible. Improvements could be made also in the methods—the black-and-white plan, for instance, should be of the same locality for all candidates, and they should also be enabled to make these plans in daylight hours.

Other Work.

The cost of descriptions, maps, and other kinds of work done at Head Office for other Departments amounted to £669.

(b.) REPORT BY E. J. WILLIAMS, TIDE-COMPUTER.

Computation and Reduction of Observations.

During the year under report the tidal curves of the self-registering tide-gauge records of the standard ports of Wellington, Bluff, and Westport have been reduced by harmonic analysis. The tidal constants deduced from the above reductions are shown in Table C.

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 agreement 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 year of analysis as to the best result.

Errors in Predictions.

The predicted times and heights for high and low water for the year 1921 as given in the tide-tables have been compared against the actual values obtained from the self-registering tide-gauge records of the standard ports of Auckland, Wellington, Bluff, and Westport. The object of the comparisons was to test the accuracy of the predictions. The results compare favourably with the comparisons between actuals and predictions at Indian ports, published by the Tidal Branch of the Survey of India; these comparisons being derived from predictions based upon harmonic constants evaluated by the same method of reducing tidal observations, by harmonic analysis, as that adopted in New Zealand.

The actual heights of high and low water as obtained from the self-registering tide-gauge records have been corrected for barometric pressure at Auckland, Wellington, and Bluff. Barograph records were not available for the Port of Westport. The errors of the predictions thus determined are tabulated in the three tables herewith appended.

No. 1.—*Percentages and Amounts of the Errors in the Predicted Times of High Water and Low Water at Four Standard Ports for the Year 1921.*

Port.	Number of Comparisons between Actual and Predicted Values.	Errors not exceeding 15 Minutes.	Errors over 15 Minutes and under 30 Minutes.	Errors over 30 Minutes and under 45 Minutes.	Errors over 45 Minutes.
		HIGH WATER.			
		%	%	%	%
Auckland	705	80	17	3	0
Wellington	705	89	9	2	0
Bluff	695	90	10	0	0
Westport	683	80	15	4	1
		LOW WATER.			
Auckland	705	87	12	1	0
Wellington	705	84	13	3	0
Bluff	694	82	17	1	0
Westport	684	86	13	1	0

No. 2.—*Percentages and Amounts of the Errors in the Predicted Heights of High Water and Low Water at Four Standard Ports for the Year 1921.*

Port.	Number of Comparisons between Actual and Predicted Values.	Mean Range of Spring Tides in Feet.	Errors not exceeding 6 in.	Errors over 6 in. and under 12 in.	Errors over 12 in.
		HIGH WATER.			
			%	%	%
Auckland	705	8·8	82	18	0
Wellington	705	3·4	95	5	0
Bluff	695	8·0	86	14	0
Westport	682	9·5	72	24	4
		LOW WATER.			
Auckland	705	8·8	80	19	1
Wellington	705	3·4	96	4	0
Bluff	694	8·0	70	27	3
Westport	685	9·5	71	23	6

No. 3.—*Table of Average Errors in the Predicted Times and Heights of High and Low Water at Four Standard Ports for the Year 1921.*

Port.	Mean Range of Spring Tides in Feet.	Average Errors.					
		Of Time in Minutes.		Of Height in Terms of the Range.		Of Height in Inches.	
		H.W.	L.W.	H.W.	L.W.	H.W.	L.W.
Auckland	8·8	11	9	0·037	0·039	4	4
Wellington	3·4	9	9	0·066	0·068	3	3
Bluff	8·0	8	9	0·043	0·058	4	6
Westport	9·5	10	9	0·049	0·051	6	6
General mean ..	..	10	9	0·049	0·054	4	5

APPENDIX II.

SURVEYORS' BOARD.

THE examinations in September, 1922, and March, 1923, were held as usual. For the former thirty-three candidates sat, being sixteen new and seventeen completing. Of these, four new and six completing passed. At the March examination twenty-six sat, being six new and twenty completing, of whom one new and eleven completing passed, adding twenty-one to the list of New Zealand licensed surveyors, the statutory list of whom showed at 31st December 490 members, there having been twelve deaths during the year.

Several matters made the year important in the Board's history, notably the passing of the amending legislation referred to in last year's report, and the consequent completion of new regulations for the conduct of surveys.

The personnel of the Board suffered change. Mr. Humphries, Government nominee and former Surveyor-General, who has been upon the Board for seventeen years, and its oldest member, retired; and also Mr. H. Sladden, Institute nominee, also with a long connection with the Board, retired; both members, having been very active in the work of the Board, will be greatly missed. In their places Mr. G. H. Bullard, Chief Surveyor, Canterbury, was nominated by the Government, and Mr. S. T. Seddon, M.C., of Wellington, was nominated by the Institute.

A most important event was the conference of all the reciprocating Boards of Australia and New Zealand at Melbourne in October, 1922, attended by the Surveyor-General as delegate from New Zealand. At this conference the position of the profession and status of the examination were reviewed, and a number of matters were considered, resulting in changes of practice and procedure of a distinctly evolutionary character, since detailed generally in *Gazette* notice of the 3rd May, 1923. New regulations for examination, uniform for all the States and New Zealand, are now in preparation. The chief features of the changes are the increase of the apprenticeship period to four years, and the increased emphasis on the engineering element of surveying by making it compulsory.

W. T. NEILL, Chairman.
M. CROMPTON-SMITH, Secretary.

APPENDIX III.

MAGNETIC OBSERVATORY, CHRISTCHURCH.

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

DURING the year 1922 the work of magnetic, seismological, and meteorological observation has proceeded as usual, and the resulting mean values of the magnetic elements for Christchurch determined from the magnetograms are as follows:—

	Mean Value, 1922.	Change since 1921.	Change from 1920 to 1921.
Magnetic declination (east)	17° 08·3′	+3·7	+2·9
Magnetic horizontal force..	0·22217	−24 γ	−20 γ
Magnetic inclination (south)	68° 11·2′	+0·9′	+1·1′
Northerly component	0·21230	−30 γ	−24 γ
Easterly component	0·06547	+16 γ	+13 γ
Vertical component	0·55507	−21 γ	+03 γ
Total magnetic force	0·59802	−14 γ	−04 γ

At the end of the year building operations were commenced near the Adie magnetograph house, and since the 31st December, 1922, the curves yielded by the Easterhagen magnetographs at Amberley have alone been measured for hourly values of declination, horizontal magnetic force, and vertical magnetic force. The measurements made are mean ordinates over the hour centring at the Greenwich civil hour. When a large disturbance prevails the curves are planimetered and the mean hourly ordinate thus determined. Smooth curves are measured for mean ordinates over the hour on the method adopted by the United States Coast and Geodetic Survey observatories, and it is evident that a very high degree of accurracy is obtained.

The plan of measurement adopted for curves up to the end of 1922 has been to measure ordinates at the Greenwich hour, yielding an instantaneous value at the hour. The new plan gives an average for the hour, centring about the same times of day as the instantaneous hourly values hitherto published, so that in diurnal analysis all phase angles and amplitudes can be made directly comparable, always being corrected to the true instantaneous ordinates.

The amplitudes and phase angles of the first four diurnal harmonic components for the summer, equinoctial, and winter months of the year 1922 are given below, for horizontal magnetic force.

The usual horizontal vector diagrams, and average curves of diurnal D and H for months and seasons, and monthly range diagrams, are published herewith.

Milne seismograph No. 16 has been kept in operation, and a list of records for the year is appended.

The usual meteorological observations at 9.30 a.m. and noon and 5 p.m. were taken, as in previous years.

The data for hourly H and D values for 1911 are nearing completion, and will be published this year.

Seasonal Diurnal Variation of H, 1922.
(Coefficients of the first four terms.)

—		P_1.	A_1.		P_2.	A_2.		P_3.	A_3.		P_4.	A_4.	
		γ	°	′	γ	°	′	γ	°	′	γ	°	′
Four summer months	..	13·43	291	37	8·86	299	32	4·52	303	43	0·35	276	55
Four equinoctial months	..	9·78	257	00	4·94	275	19	3·14	285	34	0·59	248	43
Four winter months	..	7·30	208	55	3·01	224	19	1·97	202	42	1·17	186	19

The summer months taken are January, February, November, December; equinoctial months taken are March, April, September, October; winter months taken are May, June, July, August. As regards the amplitudes of these harmonics, a general seasonal graduation shows itself in the first three terms, the amplitude being greatest in summer-time; but in P_4 the reverse is the case, the amplitude being greatest in winter and very small in summer; but there seems no reason to doubt that it is well determined, so that some significance attaches to its phase angle differing by very approximately 90° between summer and winter. Significant also is the fact that in the third and fourth components the winter phase angle is $\frac{2}{3}$ of the summer angle phase, very nearly. In A_2 the summer angle is practically $\frac{4}{3}$ of the winter value, so that in these harmonics the summer angle is $\frac{4}{3}$ of the winter angle for A_2 and $\frac{3}{2}$ of the winter angle for A_4 and A_3.

There seems to be more evidence than usual of the non-independence of the harmonic constituents. This may be looked upon as worthy of consideration, and perhaps attributable to our latitude. The origin of the averages must be remembered, for the summer data are the means for two intervals of two months each, separated by ten months; for the equinoctial data the separation is six months; for the winter data, really two months; and the mean values from the three means is this year appreciably different, being—

H, summer months..	0·222209 C.G.S.
H, equinoctial	0·222125
H, winter	0·222162
Year	0·222165

The winter value is very near the arithmetical mean for the year.

Coefficients of the First Four Terms in Fourier Series, of the Main Seasonal Diurnal Variation, for Year 1922 and for Greenwich Civil Mean Day, at Christchurch, N.Z.

—		P_1.	A_1.		P_2.	A_2.		P_3.	A_3.		P_4.	A_4.	
Magnetic Horizontal Force (unit 1γ).													
			°	′		°	′		°	′		°	′
Four summer months	..	13·43	291	37	8·86	299	32	4·52	303	43	0·35	262	57
Four equinoctial months	..	9·78	257	00	4·94	275	19	3·14	285	34	0·55	272	14
Four winter months	..	7·30	208	55	3·01	224	19	1·97	202	42	1·17	186	19
Year ..	..	8·61	261	51	5·02	282	23	5·84	334	06	0·57	226	16
Magnetic Declination: (unit 1′).													
Four summer months	..	2·59	14	09	2·19	357	48	0·20	22	39	0·16	43	45
Four equinoctial months	..	1·28	35	23	1·83	339	46	0·79	347	58	0·25	332	12
Four winter months	..	5·06	170	54	0·97	328	54	0·43	338	16	0·27	289	15
Year ..	..	1·36	32	01	1·63	345	33	0·84	00	33	0·17	329	06

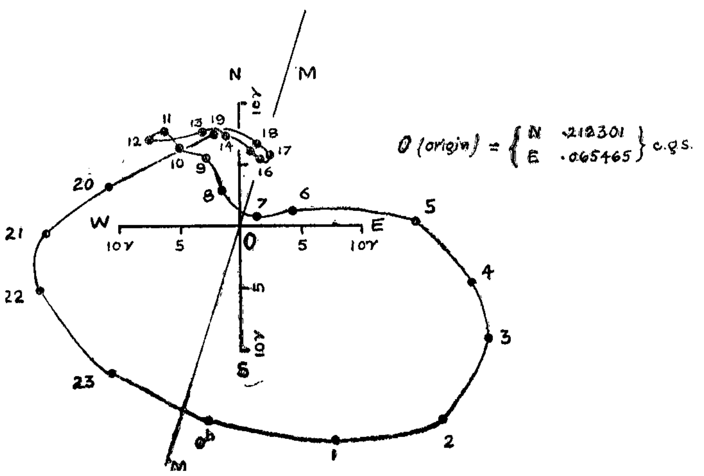
The phase angles are as at 0h. G.C.M.T.

The four summer months comprise January, February, November, December; the equinoctial months, March, April, September, October; and the four winter months, May, June, July, August.

In the horizontal force it is noticeable that the amplitude of the diurnal wave P_1 in summer seems to determine all the amplitudes during the equinoctial months; and in the same way the amplitude of the diurnal wave in equinox seems to determine all the amplitudes in the winter months. This is possibly dependent upon the consideration that the amplitude of P_1 depends upon a generally effective cause. Such cause may be expected to have an effect upon the amplitude of the constituent waves P_1, P_2, P_3, P_4 in the ratio 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$. And taking the resolved equinoctial amplitudes in H, we find $9·78 + \frac{1}{2}(4·94) + \frac{1}{3}(3·14) + \frac{1}{4}(0·55) = 9·78 + 2·47 + 1·05 + 0·14 = 13·44r$, which is the value of P_1 in summer. Similarly, for the winter months, in H, we find $7·30 + \frac{1}{2}(3·01) + \frac{1}{3}(1·97)$

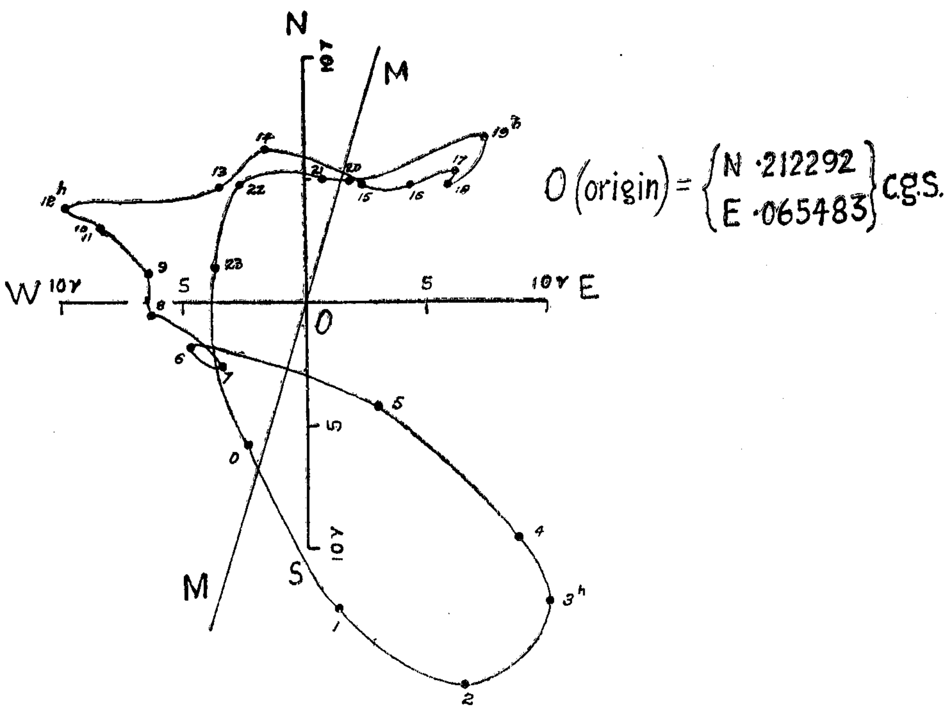
$+ \frac{1}{4} (1 \cdot 17) = 7 \cdot 30 + 1 \cdot 51 + 0 \cdot 66 + 0 \cdot 29 = 9 \cdot 76 \gamma$, which is, within the range of arithmetical error, the value of P_1 for equinoctial months. It must be remembered that the summer data is from two intervals of two months each, ten months apart; and that the two equinoctical intervals are six months apart, and really the two winter intervals two months apart, and this division is important.

In magnetic declination the outstanding feature is the large range in the diurnal wave P_1 in winter. In the summer months A_1 and A_2 are not greatly different, but in the winter months they differ by about 158°, so that the phase difference of diurnal and semidiurnal effect changes by 175° between the two seasons, and this accounts for a large part of the difference between summer and winter vector diagrams of the diurnal horizontal disturbing forces.

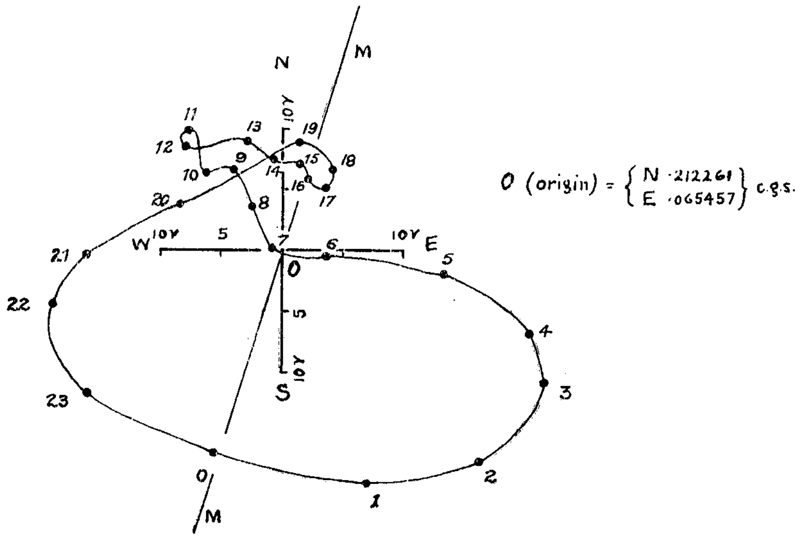


VECTOR DIAGRAM: MEAN DIURNAL HORIZONTAL DISTURBING FORCES, FOR YEAR 1922 (ALL DAYS) AT CHRISTCHURCH.

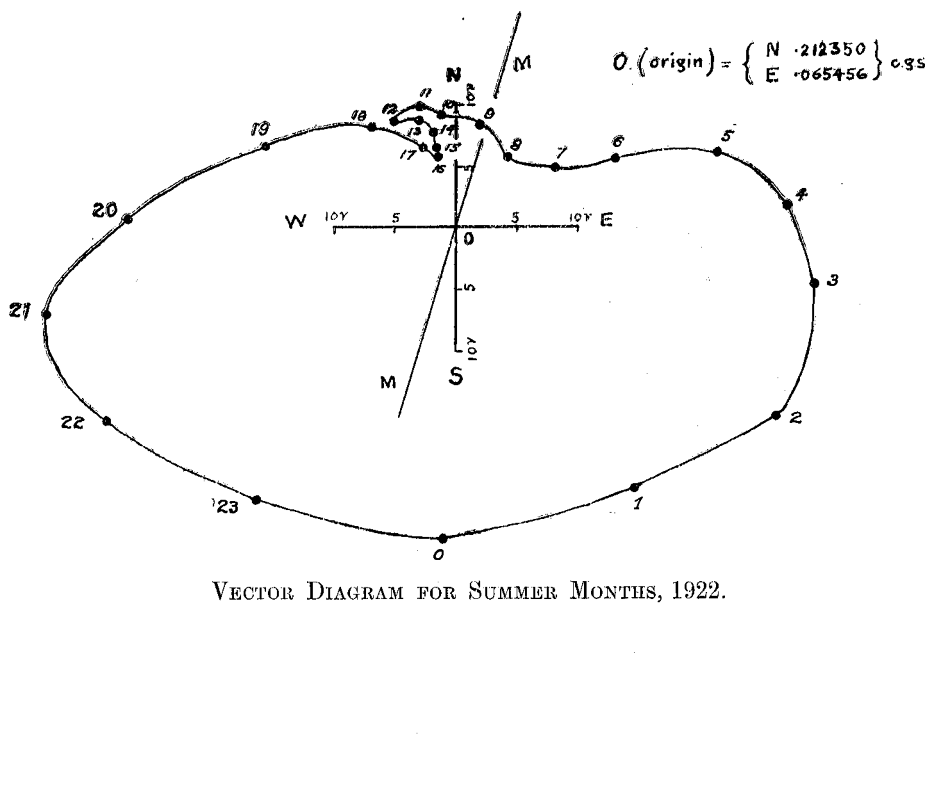
Greenwich hours indicated: NS = geographical meridian. MM = magnetic meridian.



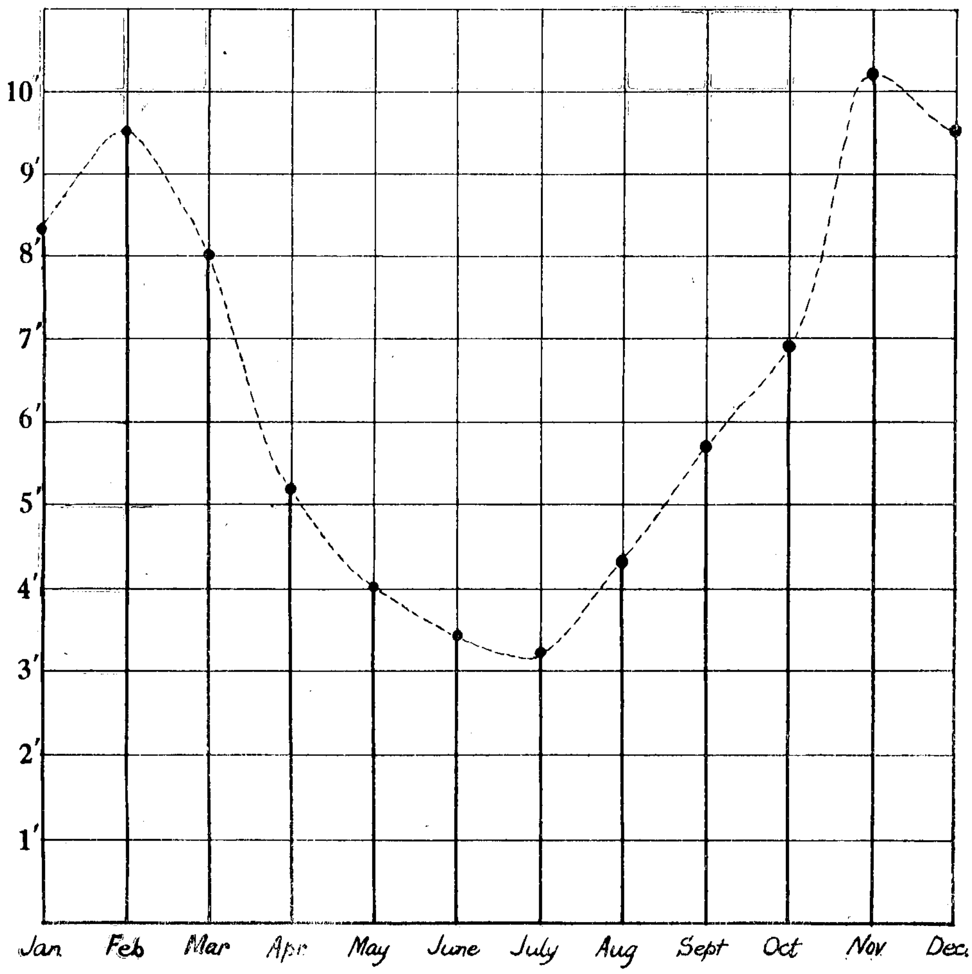
VECTOR DIAGRAM FOR WINTER MONTHS, 1922.



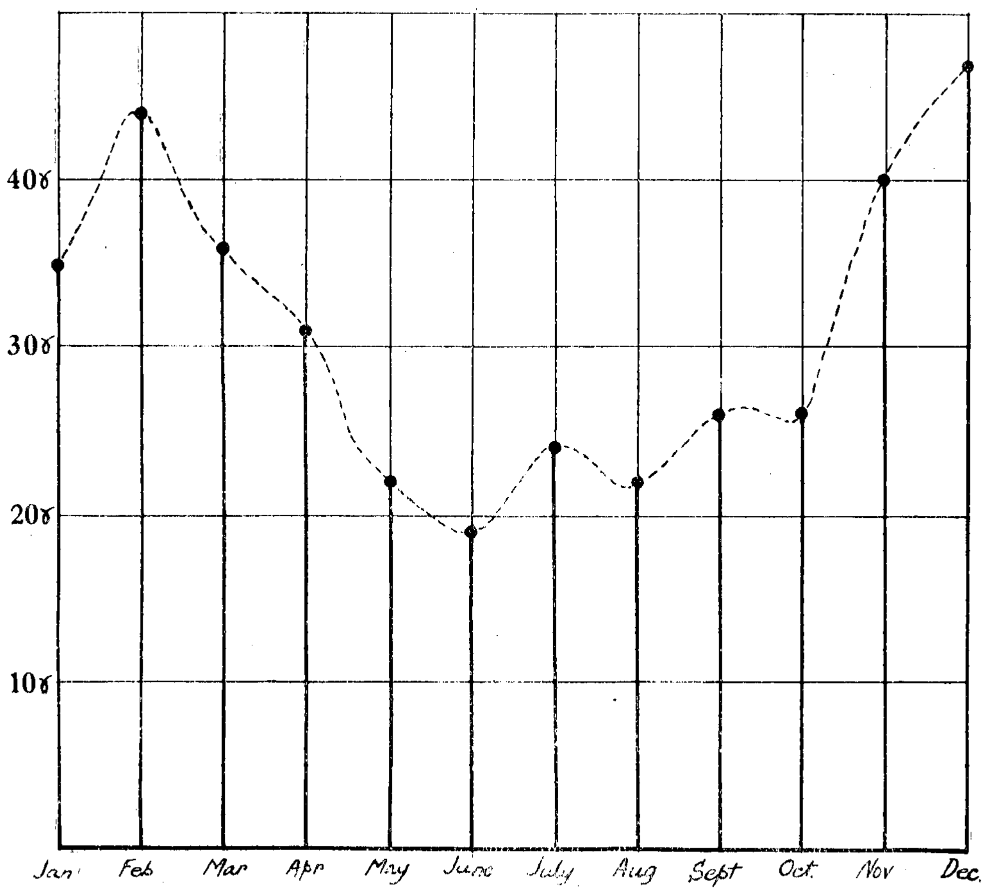
Vector Diagram for Equinoctial Months, 1922.



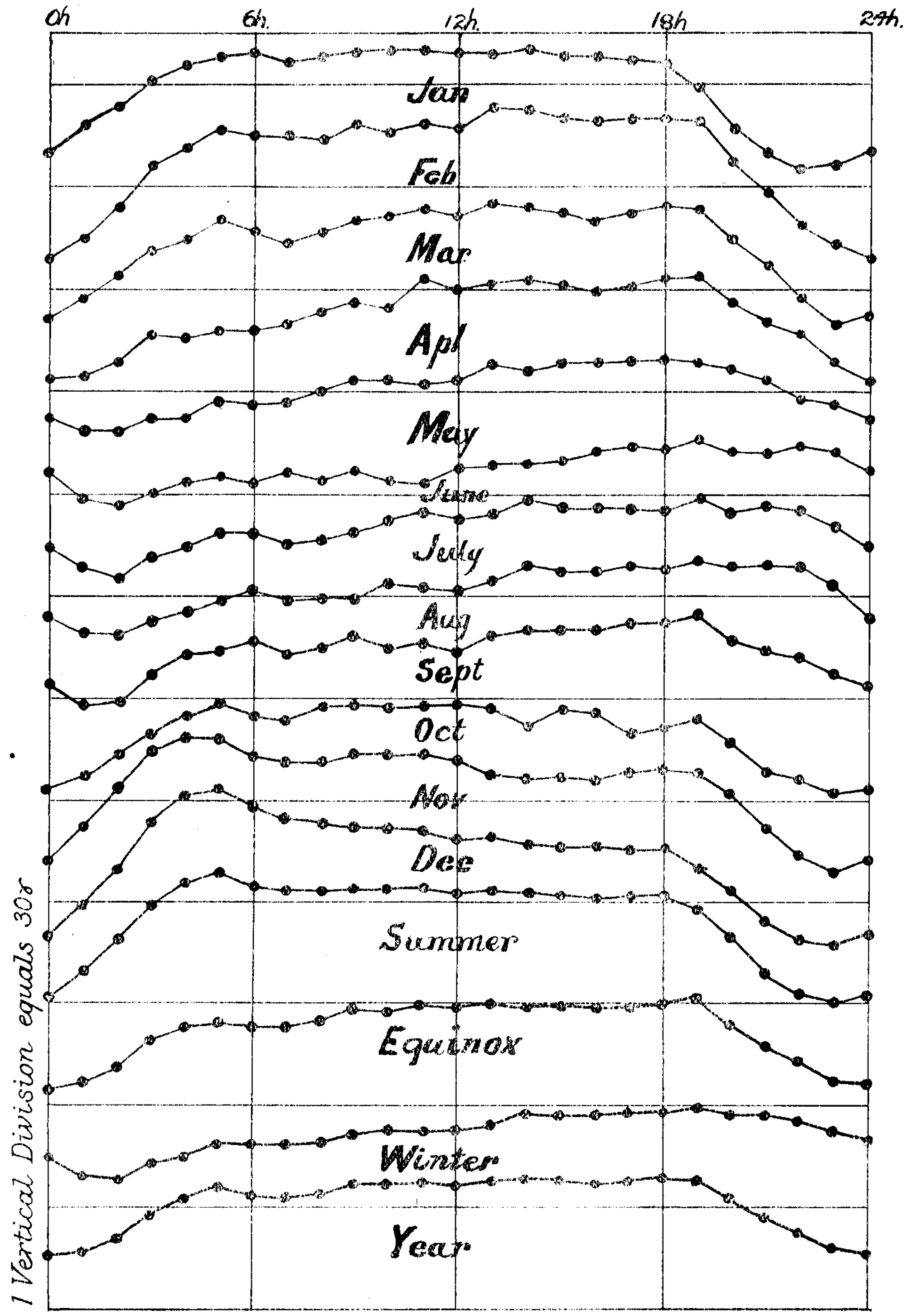
Vector Diagram for Summer Months, 1922.



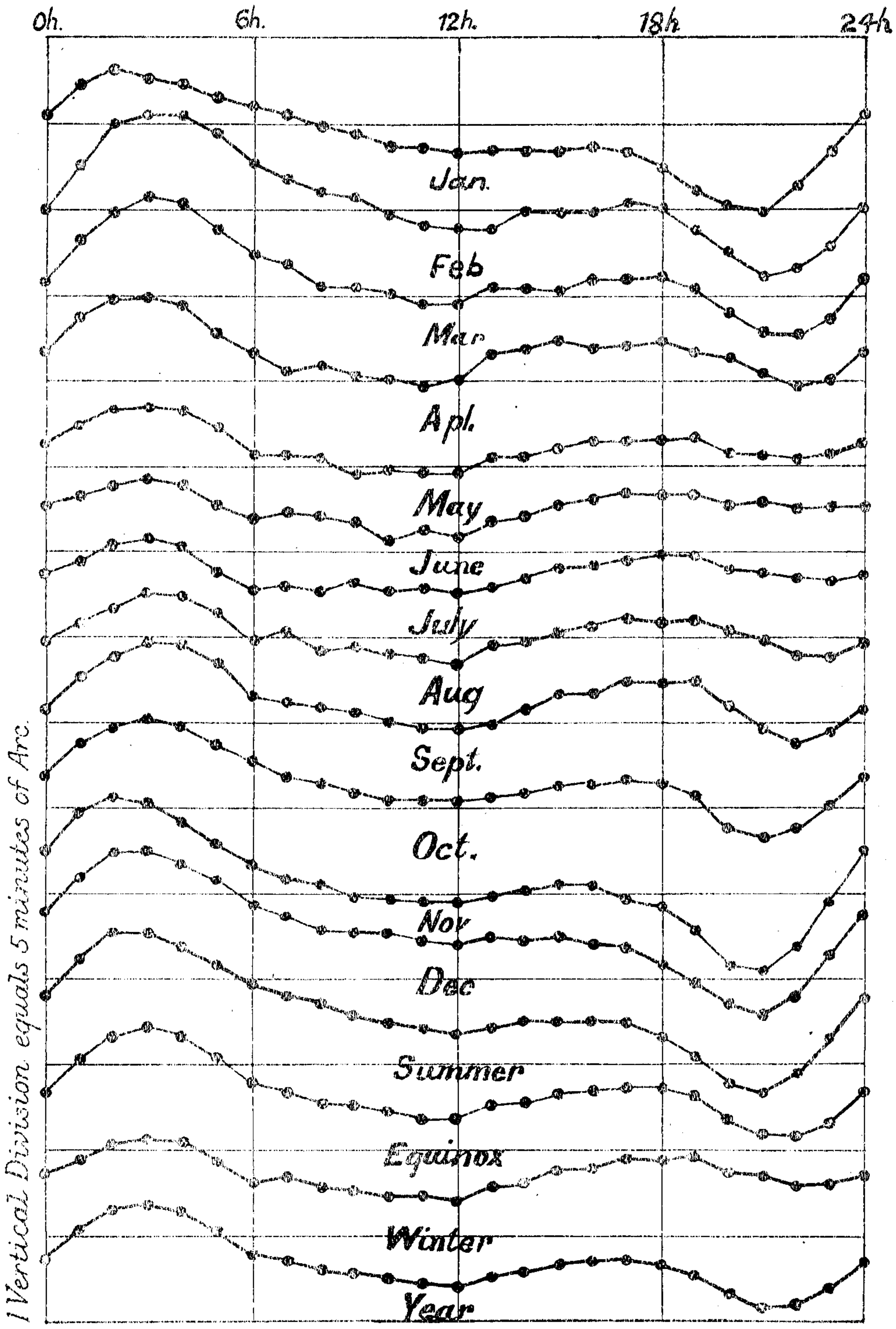
MEAN DIURNAL RANGE OF DECLINATION AT CHRISTCHURCH FOR 1922.



MEAN DIURNAL RANGE OF HORIZONTAL FORCE AT CHRISTCHURCH, 1922.



MEAN DIURNAL HORIZONTAL FORCE, 1922.



MEAN DIURNAL DECLINATION FOR 1922.

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 .. .. Long waves passing along the major arc of the great circle through the epicentrum and the observatory.

   (Repeats of L or L_1 after a circuit or circuits of the earth are noted in the "Remarks.")
   - M .. .. Greatest motion in the chief phase.
   - M_1 .. .. Maximum of the L_1 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): (μ = 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, 0h. or 24h. = 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 (latitude and longitude): Lat. S. 43° 31′ 48″. Long. E. 172° 37′ 13″ (11h. 30m. 28·9s.).
     Its height (in metres and in feet) above mean sea-level: 8 m. (25 ft.).
   - (*b*.) The kind of seismograph: Milne seismograph No. 16.
     How installed (E.-W., N.-S., or vertical): Boom N.-S.
     Natural period (in seconds): 16 ±.
     Magnification: 6.
     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. Ae.	Remarks.
	1922.			H. M. S.	S.	MM.	
1	Jan., 1	*r*	S?	19 59 00	15	..	
			L	20 02 18	..	..	
			M	20 05 00	..	10·0	Duration, 1h.+.
2	„ 3	*r*	P	8 04 24	..	..	
			S?	8 07 12	..	..	
			L	8 08 24	..	..	
			M	8 10 42	..	1·2	Duration, 25m.
3	„ 19	*u*	PR_1?	22 09 24	..	..	
			S?	22 14 00	..	..	
			SR_1	22 17 42	..	..	
			L	22 21 24	..	..	
			M	22 32 36	..	10·5	Duration, 2h.
4	„ 22	*r*	S?	3 33 54	..	..	
			SR_1	3 36 12	..	..	
			L	3 39 48	..	..	
			M	3 45 42	..	4·2	Duration, 2h.
5	„ 22	*r*	S?	20 56 24	..	..	
			SR_1	20 58 36	..	..	
			L	21 00 24	..	..	
			M_1	21 03 48	..	..	
			M_2	21 05 42	..	..	
6	„ 31	*u*	P?	13 42 12	..	..	
				13 44 42	..	..	
				13 50 12	..	..	
				13 52 54	..	..	
			L	14 04 00	..	..	
			M	14 17 36	15	5·5	Duration, 2h.+.

EARTHQUAKE REPORTS—*continued.*

No.	Date.	Character.	Phase.	Time. G.C.M.T.	Boom Period.	Amplitude. Ae.	Remarks.
	1922.			H. M. S.	S.	MM.	
7	Feb., 20	*r*	S ?	7 50 24	..	..	
			SR_1	7 55 06	..	..	
			SR_2	7 56 42	..	..	
			L	8 00 42	..	..	
			M	8 04 18	..	1·6	
8	,, 20	..	L	16 05 54	..	..	
			M	16 10 00	..	1·6	In midst of microseisms.
9	Mar., 7	*r*	P	17 00 42	..	..	
			S ?	17 05 06	..	..	
			L	17 11 48	..	..	
			M	17 15 00	..	1·5	Duration, 30m.
10	,, 10	*r*	P	18 01 54	..	..	
			L	18 05 24	..	..	
			M	18 08 24	..	2·0	Duration, 1h.+.
11	,, 12	*r*	P	12 30 48	..	..	
			L	12 34 06	..	..	
			M	12 36 12	..	3·5	Duration, 1h.+.
12	,, 26	*r*	P	13 33 12	..	..	
			S	13 39 12	..	..	
			L	13 42 48	..	..	
			M	13 48 00	..	3·0	Duration, 1h. 30m.
13	,, 28	*r*	P	4 09 48	..	..	
			S	4 14 06	..	..	
			L	4 22 12	..	..	
			M	4 23 36	..	1·3	Duration, 1h. 20m.
14	April 5	*r*	P	10 08 42	15	..	
			S	10 14 00	..	..	
			SR	10 18 48	..	..	
			L	10 21 06	..	..	
			M	10 42 36	..	3·0	
15	,, 28	*v*	P	6 39 54	..	..	
			S	6 40 54	..	..	
			L	6 42 00	..	..	
			M	6 43 36	..	2·8	Duration, 30m.+.
16	May 1	*r*	P	11 26 42	..	..	
			L	11 30 54	..	..	
			M	11 31 54	..	2·0	
17	,, 11	..	..	09 20 54	..	..	? microseism.
18	,, 11	*V*	P	09 24 00	..	..	
			L	09 25 30	..	..	
			M_2	09 32 30	..	4	M_1 not defined.
19	,, 12	*r*	S	17 49 24	..	..	
			L	17 50 30	..	..	
			M	17 53 18	..	10	
20	May 13	*r*	SR ?	3 23 12	..	..	
			L	3 27 00	..	..	
			M	3 28 12	..	..	
21	,, 14	*u*	eL	8 17 48	..	..	
			M	8 20 48	..	0·4	
22	,, 17	*u*	S ?	6 35 54	..	..	
			L	6 40 00	..	..	
			M	6 42 42	15	1·0	
23	June 24	*V*	P	21 43 24	16	..	
			L	21 44 24	..	..	
			M	21 46 30	..	1·1	
24	July 13	*V*	P	1 20 24	..	..	
			L	1 24 06	..	..	
			M	1 25 00	..	1·4	Duration, 35m.±.
25	,, 14	*V*	P	3 58 18	..	..	
			S	3 58 54	..	..	
			L	3 59 30	..	..	
			M	4 02 12	..	0·9	Duration, 40m.
26	,, 15	*V*	P ?	20 46 30	..	..	
			L	20 46 48	..	..	
			M	20 48 12	..	0·5	Duration, 22m.
27	,, 17	*V*	P	4 22 00	..	..	
			L	4 23 06	..	..	
			M	4 23 36	..	0·6	Duration, 13m.
28	,, 18	*r*	eL	9 00 30	..	..	
			M	9 04 36	..	0·4	
29	Aug. 16	*d*	P	13 19 12	..	..	RF3.
			M	13 19 18	..	1·5	Ae actual, 0·25 mm.
30	Nov. 11	*u*	P	4 45 12	..	..	O off Chilian coast (89°±).
			PR_1	4 49 18	..	..	P distinctly emergent, becoming more *i* after 30 seconds. A change of period after 90 seconds caused a larger instrumental range (evidencing more regular periodicity in the P waves) of 1·5 mm. The S phase commencing at 4h. 55m. 54s. was also followed by a large instrumental amplitude of 16 mm. 2 minutes after commencement. Instrumental amplitude continued large for over 2 hours. Followed by microseisms for 13 hours.
			S	4 55 54	..	..	
			SR_1	5 02 48	..	..	
			L	5 14 24	..	..	
			M	5 16 06	15	23	PR_2 seems not to exist in the record, and SR_2 is not definite.

EARTHQUAKE REPORTS—*continued*.

No.	Date.	Character.	Phase.	Time. G.C.M.T.	Boom Period.	Amplitude. Ae.	Remarks.
	1922.			H. M. S.	S.	MM.	
31	Dec. 3	r	S	0 24 18	..	..	
			L	0 27 24	..	..	
			M	0 29 12	..	1·6	Duration, 15m.
32	„ 5	r	L	7 34 18	..	..	
			M	7 36 24	..	0·6	Duration, 20m.
33	„ 14	..	PR_1	23 15 00	..	..	
			S	23 19 36	..	..	
			SR_1	23 22 24	..	..	
			SR_2	23 24 24	..	..	
			L_1	23 27 24	..	..	O = 47°±.
			M_1	23 28 54	..	4·2	Duration, about 70m.
			M_2	23 31 36	..	6·5	Microseisms not running.
			L_2	23 36 48	..	..	
34	„ 24	..	..	21 14 42	..	..	Minute sudden displacement of boom to E., through about 0·1 mm.
35	„ 24	..	..	21 29 36	..	..	Ditto. These occur at the end of nocturnal microseisms.
36	„ 25	..	PS_1	3 33 00	17	..	R.F.7-8. Origin North Canterbury, where widespread damage to chimneys especially occurred, most marked at Cheviot and Waikari, respectively 58 miles N.E. and 40 miles N. of the Observatory. Damage slight in Christchurch. The seismograph was immediately thrown out of adjustment by the shock.
37	„ 25	..	..	21 05 18	..	..	Very minute displacement of boom to E., less sudden than on 24th, at end of nocturnal microseisms.
38	„ 31	..	SR_1	7 36 24	17	..	
			SR_2	7 43 54	..	..	
			L	8 05 24	..	..	
			M_1	8 08 06	..	0·9	
			M_2	8 12 00	..	0·7	
			M_3	8 17 00	..	1·0	
			M_4	8 20 54	..	0·5	
			M_5	8 28 42	..	0·6	
			M_6	8 33 42	..	0·7	

APPENDIX IV.

STANDARD SURVEYS.

MR. C. A. MOUNTFORT having now retired on superannuation the following notes by him on certain points in his methods and apparatus used on standard surveys are published in order to preserve a record of the character and degree of precision aimed at. The notes, which do not profess to be a complete essay, refer generally to his methods on the standard surveys of Nelson, Wanganui, Palmerston North, Feilding, and Napier, and rural surveys near Hastings–Napier, and Feilding–Palmerston North.

NOTES.

(See figures.)

In ranging lines I have found the following to be a good method where you cannot see from end to end but can see from the middle both ways. I generally get as near one end as I can see the other from. I first set up on 2,* set on 4, and reverse to 1, repeat the operation until I am exactly in line, drive peg a short distance off and put in tack; reverse and put in a second tack and take the mean, drawing into line a second time before putting in second tack. Now shift to 3, set on 1, and pull in line with 4, putting in peg and meaning as before. Now set up at centre and pull in line, setting on 1 and reversing on 4, put in peg, and reverse. Remove signals from 1 and 4, put up smaller ones at 2 and 3 at centre, pull in line with these direct and reversed, mean with former, set up signal at mean centre. Start at 1 and put pegs in line, shifting from peg to peg. If correct, tack on peg 2 ought to be struck; proceed in a similar manner starting from peg 4. My method of putting pegs in line is this: Peg is driven in line by holding up bar 8 to 10 chains off on the line. Steel rod is then driven off to one side of peg, its cross-arm being over peg; man then stoops down, chalks his plumb-string, and faces me, slipping the string along until I give him signal to mark, when he lets string slide down until plumb strikes peg so that the point of the plumb marks the peg, where he drives tack, and tries it two or three times, he making scratch on tack at mean line. I now shift on to this point, and he moves on, repeating the operation. Where there is a similar road, parallel and a short distance off, it can be treated in a similar manner. Chain across twice at each end and in the centre; if the centre-line distance

* See Fig. 2.

comes short the tacks can be shifted half or a quarter of the error each if all or half is attributed to the range, both tacks being moved out or in, in which case the remaining pegs would have to be gone over again, starting from each end and working towards the centre with instrument, bar across arm, and plumb-bob. When 2 and 3 are visible from opposite ends it is best to put signal at 3 and start at 1 and put pegs in line until centre is reached. Set up at 4, set up signal at 2, and put pegs in line until centre is again reached. Where the mean standard lines of two streets do not differ more than 3 minutes and the cross-roads are not more than 10 or 12 chains apart it is best to increase one 1½ minutes and decrease the other a similar amount to make them parallel. The offsets can be varied between the different cross-roads to keep sides of roads parallel.

We next come to the method of rendering rods and sighting-tripods visible. I have found the following to be good. An ordinary flagpole is used, which must have no white about it, to which a short cross-arm is attached by a screw and washer which allows it to revolve, a diamond-shaped piece of double-thickness black and red cloth well sewn together and hemmed round the edges, to each corner of which is sewn a small brass ring. In using, the cross-arm is turned at right angles to the pole and the cloth screen hooked on to small hooks; when not in use the screen is unhooked and the cross-arm lies flat along the pole. It can be secured in this position by rolling the screen round it, or a piece of cord can be fastened to one end of the cross-arm to tie it to the pole with, and the screen removed. A hole is made in the ground behind the sighting-tripod, and the screen-pole driven in, or it can be attached to a tripod if a hole cannot be made in the road. The top of sighting-rods should be quite flat and not round, so that they present an even appearance against the screen, and no flags should be attached to them.

Chaining, and Sighting-tripod.—Top of tripod with sighting-vane inserted, which is flat brass with a round stem. The vane is black on one side and white on the other, to suit different backgrounds. It has three vanes of different sizes, to be used at different distances from 15 up to 70 or 80 chains. With screen behind it the tripod makes a good signal to observe to. It has a shifting head, and is levelled by laying a short level on upper circular plate. It clamps with ball and socket, has a shifting head, and is so constructed that the spindle can be rocked from side to side without affecting the plumb-bob. When used for chaining the sighting-vane is removed and a short spindle is inserted in its place, projecting above the main spindle only about ⅛ in. with a fine mark in its centre to chain to.

Under 10 or 15 chains the sight generally used is a steel rod and cross-bar driven into the ground, and a plumb-bob with well-chalked string hung on to it and adjusted exactly over the station-mark, a dark background being placed behind it. I have often used one of the sighting-tripods in a similar manner, placing it over the station with one of its legs in the line on the side farthest from the instrument—this leaves the side nearest open; then tie on black screen, on farthest side, and the plumb-string is clearly visible at 20 chains off.

Rural Standard Survey is carried out much in the same manner, but only the main lines are chained—no parallel offset lines are laid out. If the ground is smooth and flat a 5-chain ⅛ band marked at every link can be used: this is very convenient, as it allows of offsets being taken at any point that may be required. These offsets are generally taken with a 1-chain ⅜ in. figured steel band wound on a special drum which winds up rapidly; the right angle can be estimated by unwinding the band a few links beyond the measuring-band and estimating the right angles on both sides of it. By this method chaining and offsetting are carried out at the same time. This method of chaining requires at least three men. In rough ground the above-mentioned method cannot be used. I then chain from instrument to table, using just over 6 chains each stretch with the $\frac{1}{16}$ in. band, which is supported at centre by a pole driven into the ground in line and a bradawl stuck in at the height to give a uniform grade, the vertical angle having first been observed direct and reversed. An offset can now be taken from instrument chaining-table and centre-pole. If intermediate offsets are required pegs can be driven in on line, measured to, and bearings and distances taken to the required points. I generally use two different $\frac{1}{16}$ in. bands, chain with one band and check chain with the other. With one I use a constant strain and correct for sag. With the other I use a varying strain according to the amount hanging. In this case the strain is 10 lb. when laid flat on the ground and working up to 15·5 lb. with 6 chains hanging. Both methods appear to be equally accurate, the latter being the easier on the band, as the shorter the stretch the lighter the strain.

In both town and rural standard surveys a separate field-book is kept to enter the offsets in, the distances at which they are taken being copied out of the chainage-book as they are taken; these distances are always the actual ones affected by slope, &c., but when required reference to the chainage-book will give the corresponding reduced distances. When the centre of the band comes higher than the centre-pole, an extra square rod sliding through a block like a carpenter's gauge is placed on the top of the pole in the ground, and when at the proper height is clamped, the wire resting in a fork.

In this kind of work I generally set out a given offset from both sides of the road, using any existing pegs, boundaries, buildings, &c., putting up ranging-poles at each, from which I strike a mean line, and put in a peg at each end to hold the line. I generally peg two or three lines in this manner, and then get the intersections. I sometimes stretch a cord across from the opposite corners of the road and insert two pegs under it about a yard apart, to cover the standard lines. I then stretch a string between these pegs and get the intersections with the standard lines. It often happens that they do not intersect the cross-line at the same point, in which case they must be eased in to a common point. It is well to set the instrument up on this point and see that the half-angle strikes the opposite corners. If not, any alteration that can be made to improve matters must be effected. It will sometimes happen that in making one side of the road better the other is made worse. It is then best to leave the intersection alone. If both can be improved it is well to still further amend the standard lines until the best mean is obtained, care being taken to see which line can be shifted most with the least encroachment to the occupation.

It is best to keep a preliminary field-book for the above, keeping it in diagram form, showing direction of lines, intersections, and all small pegs put in to hold lines; mean offset to sides of roads, and enough offsets to find intersection pegs. When the above has been completed of a few lines, the blocks are carted out and put in.

The bearings are taken with a 5 in. or 6 in. micrometer instrument with an extra powerful telecope (my 5 in. micrometer has a telescope with a focal length of 12 in., and $1\frac{1}{2}$ in. object-glass). The amount of time devoted to this work must vary with the class of work. In rural standard surveys I generally take a round of eight readings at each block, and sometimes observe inner angle, starting at 360° and shift to 90°; this gives four readings. I then observe the outer angle in the same manner, and if the sum of the two angles does not differ more than 2 or 3 seconds from the 360° I consider that sufficient for rural standard surveys. At important corners where check-shots are taken to trigs., &c., I often take the reading by means of eight readings, also included angle by means of eight readings and mean results.

One very important point in laying out standard traverses for towns is to get true right angles. In a town of 100 chains square, or thereabouts, if two roads cross at right angles near the centre, a good plan is to observe the right angles with an ordinary Vernier instrument reading to 20 in., and put in four pegs; obtain the distances to these pegs from centre-peg by rough measurement; now repeat the angles eight times and divide the result by 8, and the difference of each angle from 90° in seconds reduced to fractions of a link can be set off at each peg, and gives angles very close to the truth. Now observe the angles over again by different methods with a micrometer instrument. Care should be taken that the signals are perfectly flat and well shown up by screens behind them. No calico should be attached to the signals. In case these are the main streets of a town it is well to observe them morning and evening, or on two different days, or half one day and half another time, according to light, so as to get the angles within a second. Once the main lines are exactly determined the others will not give much trouble.

An important point is the standard blocks and covers. The covers often stick and are hard to remove; they should always be well greased before being put on. The trouble is, surveyors working with only one man cannot carry all the tools required. In my opinion a visible mark which does not attract attention, but which could be readily found, even if not quite so accurate, would be better than having men set up over the centre of the cover to save time of opening, when hard to open, taking it for granted that the centre of the cover represents the centre of the block. This I know has often been done. I think the following would be quite accurate enough for all practical purposes: The covers are generally made nearly 2 ft. square and have from 8 in. to 10 in. opening. Being of this size, when once rammed and set they take great force to shift them—ten times what a block or pipe does, and are practically immovable. The ironwork is supposed to be carefully made, the opening true to $\frac{1}{10}$ in. A skeleton lid is made having a small hole exactly in its centre, the size of a small plummet, string. When a cover is being put on, the skeleton lid is put on and the plummet string passed through the small hole and the cover shifted until the plumb-bob is exactly over the centre of the block, care being taken to see that it maintains this position while the cover is firmly rammed. When finished the skeleton cover is removed and the ordinary lid put on the opening. The ordinary lid has $\frac{1}{4}$ in. hole in it drilled $\frac{1}{2}$ in. in depth exactly in its centre. The hole in the cover would be exactly over the centre of the block, and its use would never cause an error of more than 0·01 link. It would be quick in use and cause no danger to traffic. An inspecting officer could test the blocks from time to time, by raising the lid with proper tools, inserting the skeleton cover and testing the block with plumb-bob, which would show if any movement had taken place. The above might fail in streets paved with wooden blocks, but a yard of tar macadam put round each cover, the wooden blocks having first been removed, might prevent those remaining shifting either cover or block.

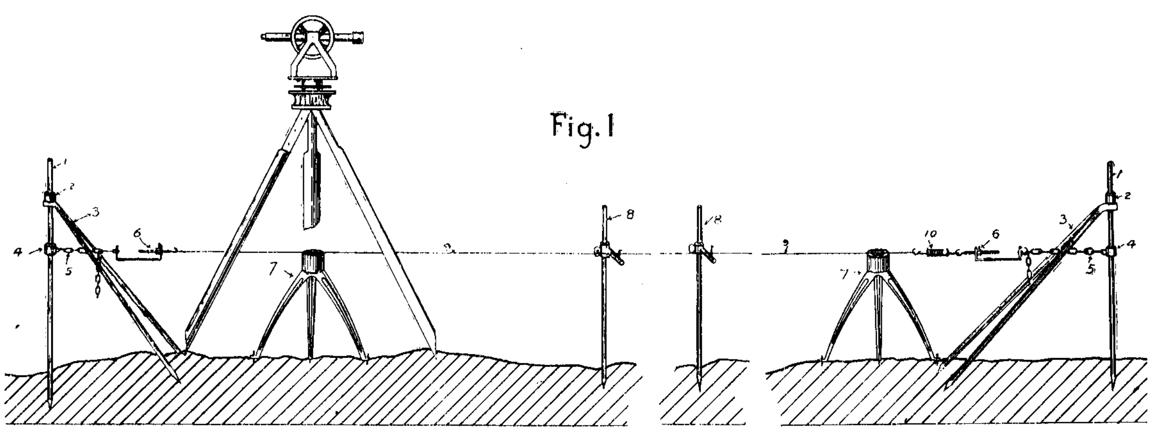


FIG. 1.—METHOD OF CHAINING: STANDARD SURVEY.

1. Steel chaining-rod.
2. Fixed collar.
3. Forked prop (see Fig. 8 for detail of head).
4. Sliding-collar to adjust measuring-band to height of table (7).
5. Brass chain to which adjusting-screw is hooked.
6. Adjusting-screw.
7. Chaining-table (see Fig. 7).
8. Steel supports with adjustable arms and spring clips. These supports are placed 50 links apart for $\frac{1}{4}$ in. band and 100 links apart for $\frac{1}{8}$ in. band.
9. Steel band, $\frac{1}{8}$ in. or $\frac{1}{4}$ in.
10. Spring balance.

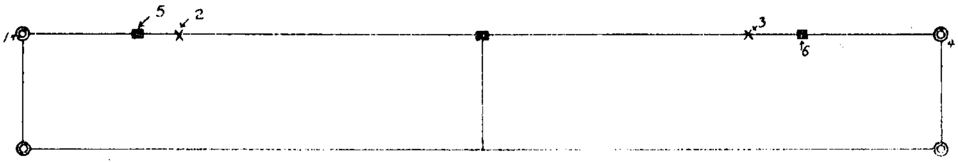
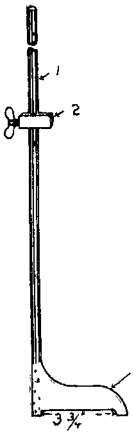
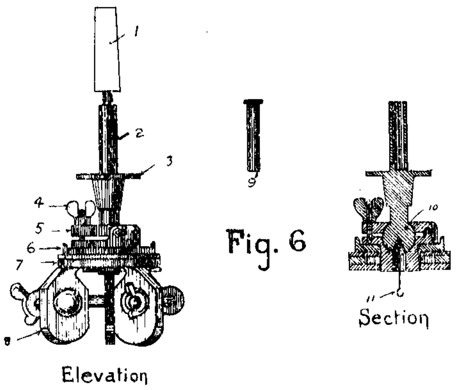
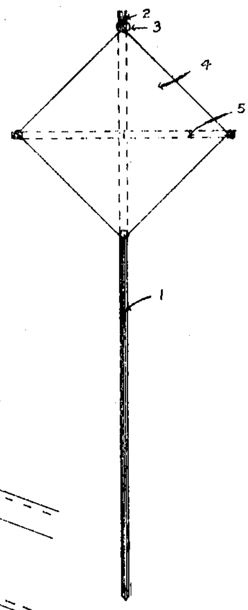


FIG. 2.—RANGING BETWEEN TWO BLOCKS NOT INTERVISIBLE.

1, 4. Standard blocks.
2. Position of first set-up.
3. Position of second set-up.
5, 6. Pegs on line.







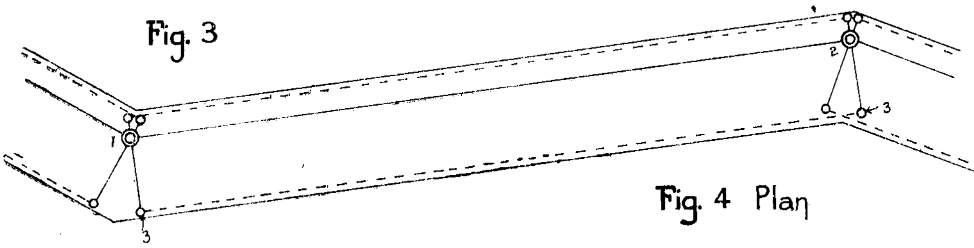


FIG. 3.—GRADE-ROD TO ENABLE ANGLES OF ELEVATION AND DEPRESSION BETWEEN TABLES TO BE READ.

1. Rod about 5 ft. long.
2. Sighting-signal, adjustable to height of instrument.
3. Brass foot to stand on top of chaining-table.

FIG. 4.—SHOWING LAYING-OUT OF OFFSET LINES IN TOWNS.

1, 2. Standard blocks.
3. Offset pegs at right angles to standard lines, the lines between being parallel to standard lines and as nearly as possible 5 links from line of occupation.

NOTE.—The standard lines are measured first, and offset pegs put in. These lines are then measured as carefully as the main lines and offsets taken. Three measurements are thus obtained for each standard line without check chainage. Occupation-points are taken with 10 links offset rod.

FIG. 5.—BACKGROUND FOR SIGHTING-VANE.

1. Flagpole.
2. Hook.
3. Brass rings sewn on black-cloth screen.
4. Diamond-shaped black-cloth screen.
5. Cross-arm pivoted in centre to flagpole.

FIG. 6.—CHAINING, AND SIGHTING-TRIPOD HEAD.

1. Sighting-vane (may be replaced by 9).
2. Socket for above.
3. Horizontal plate on which level is placed.
4. Clamping-screw for ball.
5. Clamping-plate for ball.
6. Clamping-screw for shifting-head.
7. Shifting-head.
8. Lugs with bolts and nuts to attach to tripod-legs.
9. Chaining-plug (in place of vane).
10. Ball cut out to receive plummet-string hook from centre.
11. Plummet-string hook.

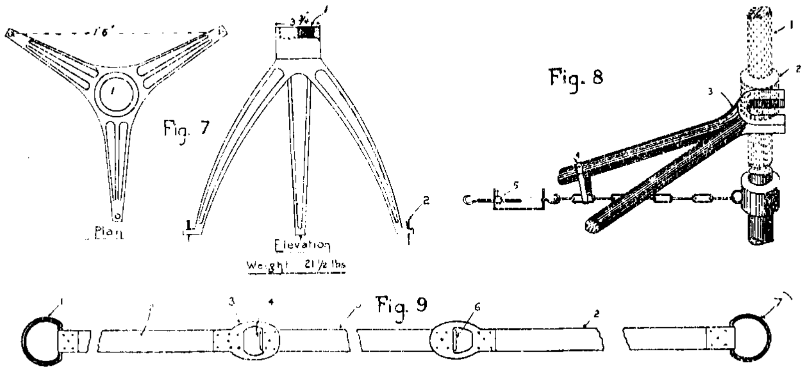


FIG. 7.—CHAINING-TABLE.

1. Lead filling to receive scratch-marking end of band.
2. Steel spike to be driven into ground by hammer.

FIG. 8.—DETAIL SHOWING LOCKING OF FORKED PROP AND CHAINING-ROD.

1. Steel chaining-rod.
2. Fixed collar.
3. Head of forked prop.
4. Strap for pulling band into true alignment.
5. Adjusting-screw.

NOTE.—The chaining-rod is placed vertically and in alignment; the prop is pushed under fixed collar on rod, and the rod hammered in, tightening the prop. If the band when hooked on and strained is not exactly in alignment, a strap is passed around one leg of prop and the band drawn to the required side.

FIG. 9.—END MARKS OF BAND.

1. Brass ring to be hooked to adjusting-screw.
2. Steel band about 1 ft. in length.
3. Brass connection.
4. Zero mark—end of tape slightly rounded to adjust to mark on lead top of chaining-table.
5. Steel band, ¼ in. or ⅛ in., 3 chains in length.
6. End mark of tape, straight edge projecting beyond brass connection, to enable fine line to be scratched with needle on leaden top of chaining-table.
7. Brass ring to be hooked to spring balance.

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