1910.

NEW ZEALAND.

DEPARTMENT OF LANDS:

SURVEYS

(ANNUAL REPORT ON).

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

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

SIR,— Department of Lands and Survey, Wellington, 30th April, 1910.

I have the honour to submit herewith the annual report on the survey operations of the Department for the twelve months ended the 31st March, 1910.

I have, &c.,

JOHN STRAUCHON,

Surveyor-General.

The Right Hon. Sir Joseph G. Ward, P.C., K.C.M.G., Minister of Lands.

REPORT.

The output by the field staff for the year is summarized below, but the complete details for the different districts will be found in the attached tables and reports of the several Chief Surveyors in charge.

The total cost of the surveyors and their parties amounted to £72,988, which is about £1,920 in excess of that of the previous year. This is accounted for chiefly by the increased urgency of demands for ordinary settlement surveys and also through the necessity for employment of additional surveyors, &c., on the subdivision of the Otago Central pastoral runs.

The following is a summary of the principal work completed during the past year :—

Class of Work.	Area.	Cost per Acre.	Total Cost.
	Acres.		£ s. d.
Minor triangulation	207,515	1·57d.	1,356 10 0
Topographical, for selection as unsurveyed ..	130,404	3·91d.	2,126 14 1
Rural and suburban, by staff	294,422	2·00s.	29,551 2 7
Rural and suburban, by licensed surveyors ..	25,706	1·61s.	2,076 12 5
Rural and suburban, by licensed surveyors, cost not available	7,651	..	..
Town	430 (468 sections)	22·82s. per section	534 0 6
Native Land Court, by staff	42,233	17·16d.	3,019 19 11
Native Land Court, by licensed surveyors	190,960	..	..
Maori Land Board	85,983	16·87d.	6,044 10 0
Gold-mining, by staff	2,603	4·34s.	564 17 9
Gold-mining, by licensed surveyors	3,914	..	..
Roads and railways	265 miles	£21·49 per mile	5,704 16 3

The work returned as completed under the various classes shows a considerable increase in area over last year's return.

TRIANGULATION.

Two hundred and seven thousand five hundred and fifteen acres have been completed in the Auckland, Nelson, Otago, and Southland Districts.

Reference has been made in previous reports to the pressing need for a secondary triangulation to control and bring into harmony the different groups of practically uncontrolled minor work, with their different standards of length, &c. With this object in view, a start has been made with the measurement of suitable base-lines, &c. In the Wellington District, the Wairarapa base-line of some eight miles in length has been completed ; while the measurement of another, the Eltham–Okaiawa base-line, about ten miles in length, has been begun in the Taranaki District, and this work I hope to considerably extend during the coming year.

SETTLEMENT SURVEYS.

The survey of 327,779 acres into 1,257 sections averaging 260 acres has been completed during the year, but if the subdivision of Native lands under the Maori Land Boards for the purpose of leasing to the public and comprising 85,983 acres, be added, the surveys executed for settlement purposes total 413,762 acres, in 1,464 sections.

The Auckland District takes the lead in this class of work with 73,786 acres of sectionized Crown land and 73,755 acres of Maori Land Board subdivisions ; Wellington District returns 57,105 acres of Crown lands, and 10,062 acres of Maori Land Board subdivisions ; Nelson has 58,554 acres of Crown land ; Hawke's Bay has 41,116 acres of Crown land, and 2,166 acres for Maori Land Boards ; Canterbury has 30,327 acres of Crown land subdivisions ; while the remaining districts contribute 66,891 acres of ordinary settlement surveys.

In addition to the above, the survey of an area of some 681,000 acres representing the subdivision of six large pastoral runs has been completed in the field, and sale lithographs prepared.

The figures estimated to represent the area of settlement surveys, &c., in the hands of the staff surveyors at the close of the year were 1,354,048 acres.

Subsequent detailed information, however, caused this total to be altered to one of 1,339,856 acres, which includes an area of 747 acres of town subdivisions. Out of this total an area of 822,679 acres of settlement land has been completed in the field, but the finished plans have not

been sent in. Out of the 747 acres, an area of some 530 acres has been completed in the field but not yet mapped.

The unsurveyed selections of Crown land are still greatly in arrear, especially in the Nelson District, where they amount to about 126,710 acres, of which the survey of about 25,000 acres has been completed in the field. It is hoped to materially reduce these arrears during the coming season by the employment of additional staff and contract surveyors.

Native Surveys.

During the year 319,176 acres were surveyed, comprising 233,193 acres of Native Land Court, and 85,983 acres of Maori Land Board, distributed in the four North Island districts of Auckland, Hawke's Bay, Taranaki, and Wellington. Of the 233,193 acres 42,233 acres were surveyed by staff surveyors, while 190,960 acres were surveyed by licensed surveyors, 130,650 acres of which were paid for by the Native owners.

Of the 85,983 acres, 70,321 acres were surveyed by the staff surveyors (34,153 acres being provisional work) and 15,662 acres by licensed surveyors.

The survey of Native lands now in progress amount to 213,472 acres, of which 16,445 acres have been completed in the field, and practically also the outline survey of D'Urville Island, 40,469 acres, but the subdivision-lines have yet to be run, and a few triangles to observe over the lower end and connecting it to the mainland.

Gold-mining Surveys.

One hundred and twenty-three sections have been surveyed during the year, comprising 6,517 acres: Auckland, 56; Nelson, 11; Otago, 42; and Southland, 14.

Standard Surveys.

The work coming under this head has been under the supervision of Mr. J. Langmuir, who has associated with him Mr. H. M. Kensington. That of Auckland City and suburbs has been pushed on as fast as possible, and a great amount of extra work has been entailed through the necessity for replacing standard blocks that had been disturbed through alteration in the permanent levels of various street-lines, &c. In addition to this, examination was made on the ground and estimates prepared of the probable cost of making standard surveys of practically all the suburbs around the City of Auckland, approximating 100 miles of streets and roads. The survey of Rotorua has been completed by Mr. Kensington, while that of Takapuna, also in his hands, is expected to be finished in two week's time.

Inspection of Surveys.

In April of last year, Messrs. Langmuir, Climie, and Allom were appointed Inspectors of Surveys and attached to the Head Office staff, although for convenience of work they continued to reside in their respective districts of Auckland, Wellington, and Canterbury.

During the year a considerable number of field inspection have been made throughout the Dominion of both staff and private surveyors' work. Most of these have proved very satisfactory, but a few (about half a dozen) have been found very faulty indeed, and further action may yet have to be taken in connection therewith.

The great urgency for subdivision by certain fixed dates of runs, land-for-settlements blocks, &c., also the continuation of city standard surveys and the measurement of base-line for extension of the secondary triangulation, has occupied a good deal of the Inspector's time, and prevented as many field inspections being made as otherwise would have been the case; but I trust during the coming season to devote more attention to this very necessary and important work.

Our regular inspecting staff is, however, very small, and as there is sure to be, and, indeed now is, a very great deal of survey-work to be done for opening-up of Crown and Native lands, more especially in the Auckland District, it may be necessary to appoint one of the senior District Surveyors to act as Inspecting Surveyor for the southern portion of the Auckland District in place of Mr. Haszard, who was transferred to Christchurch.

Mr. District-Surveyor Wheeler acts as Inspecting Surveyor for the northern portion of the Auckland District, and has recently had to attend to portions of the south also.

In cases of special urgency the Chief Surveyors have been authorized to employ one of their senior District Surveyors, when they can be spared, to make field inspections.

Tidal Survey.

For some time negotiations have been in progress with the Marine Department, for this Department to undertake the harmonic analysis of the tides of the Dominion and the calculation of tide-tables for insertion in the New Zealand Nautical Almanac.

In October an important communication was received from the Lords Commissioners of the Admiralty showing the great convenience it would be to H.M. ships and also to the mercantile marine to have Indian and Colonial Tide-tables included in the Admiralty Tide-tables, and asking for advance proofs of the Tide-tables of New Zealand ports. The Government at once acceded to the suggestion of the Admiralty and arrangements were made to put the work in hand. The Tidal Abacus of Sir G. H. Darwin, F.R.S., was obtained, as well as a supply of the computation forms to use with it. And orders were placed for a Mercedes adding-machine, an arithmotype or printing Brunsviga calculating-machine, and harmonic analysers (1) designed by Professor O. Henrici, (2) designed by Dr. O. Mader. With this equipment it is expected that much quicker progress than is usual will be made with the analysis and prediction of the tides.

There are now in operation, with continuous records, automatic tide-gauges at Auckland, Wellington (for a description of the Wellington tide-gauge see Transactions of the New Zealand Institute, Vol xli, 1908, p. 407), Lyttelton, Port Chalmers, Dunedin, Bluff, Westport, and Greymouth; while at Napier and Wanganui the records are irregular owing to exposed positions of the gauges. At many of the other ports fixed gauges are in use, and it is hoped that at many of these ports as well as at some of the outlying islands automatic tide-gauges will be established, so as to provide data for future investigations of this important subject.

Attached to the report is a diagram drawn from the records of the Wellington tide-gauge (belonging to the Wellington Harbour Board) for the period November, 1907, to April, 1908; and also showing the total miles and direction of the wind per day, readings of barometer, and dates of phases, apogees, and perigees of the moon, with the corresponding declinations.

In another part of the report will be found some interesting plates reproduced from excellent photographs taken by Mr. H. E. Girdlestone, of the Wellington field staff, to whom I am indebted. They depict scenes in the vicinity of the summits of Mounts Ruapehu, Tongariro, and Ngauruhoe, and give in very clear detail views of that wonderful region of thermal activity combined with alpine grandeur, which has of late been brought, owing to the completion of the North Island Main Trunk Railway, within easy reach of all.

Operations for 1910-11.

The work in hand for the staff during the coming year amounts to over a million and a quarter acres, in addition to areas likely to come in from time to time during the season, and probably approximating 190,000 acres—2,839 square miles of minor and secondary triangulation, and 270 miles of road-surveys. Full details of above will be found in the various Chief Surveyors' reports (see Appendix No. 1).

There will also be some 213,472 acres of Native lands to be dealt with, and, as recent legislation has cast upon this Department the duty and responsibility for the conduct of all Native-land surveys, no doubt a good deal of this work will have to be let by contract, as our present staff will be unable to keep pace with requirements.

The extension of the Standard Survey in the chief towns will be steadily pushed on as opportunity offers.

Mr. H. McCardell, Acting Chief Draughtsman at the Head Office, reports as follows for the year 1909–10:—

The routine duties appertaining to this office have been carried out satisfactorily.

The following plans have been completed for photo-lithography: The Boroughs of Wanganui, Hastings, Westport, Tauranga, Waipawa, and Waipukurau Town District, also six sheets showing the boundary between the Canterbury and Westland Land Districts.

The map of the Chatham Islands has at last been completed, and a new edition published, after a thorough revision by Mr. A. Shand, a well-known resident of the Islands, to whom the thanks of the Department are due.

A portion of the South Island showing additional magnetic stations was also drawn for the annual report.

During the year 192 townships (both private and Government) were examined, reported on, and when satisfactory, recommended for the approval of His Excellency the Governor, under section 16 of the Land Act, 1908.

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(1) Philosophical Magazine for July, 1894, p. 110.
(2) Elektrotechnischen Zeitschrift, 1909, Heft 39; Zeitschrift für Instrumentenkunde, Januar, 1910.

The index county maps of the Dominion on the mile-to-an-inch scale have been kept up to date. Several have been replaced by new editions having been issued.

Maps were printed and issued of the Counties of Buller, Inangahua, Murchison, Collingwood, Cheviot, Mackenzie, Waipa, Levels, and parts of Selwyn, Ashburton, and the northern portion of Westland.

New editions of the following survey districts were printed and issued: Kauroo, Rakaia, Teviotdale, Waikari, Papakaio, Moeraki, Linkwater, Tennyson, Tongoio, Waitapu, Grey, Paritutu, Lammerlaw, Hedgehope, Belmont, Rankleburn, Silverpeak, Hawkdun, Tuapeka East, Maruwenua, Hall, Hurst, Mairaki, Selwyn, and New River Hundred.

The number of tracings drawn during the year exceeded 700, and there were considerably over 500 lithographs, maps, and tracings mounted.

During the session of 1909 four new counties were created—viz., Tawera, Waimairi, Wairewa, and Waipara—thereby necessitating a new edition of the county maps on a scale of sixteen miles to an inch. These were printed and published in colour.

Among other duties performed by the draughting staff, there were 130 descriptions made, bands tested for both staff and private surveyors (11 5-chain bands and 12 1-chain), 30 Proclamations prepared and gazetted under the Local Bodies' Loans Act, 1908, 5 Proclamations prepared and gazetted under the New Zealand State-guaranteed Advances Act, 1909. Plans drawn on deeds, 33.

Land-tenure maps of the following counties on a scale of one mile to an inch were also coloured for the use of the Hamilton Survey Office: Thames, Ohinemuri, Waikato, Piako, Matamata, Tauranga, West Taupo, Waipa, Raglan, Kawhia, Awakino, and Waitomo.

Two complete sets of registration districts in the Dominion were prepared, in addition to 40 separate districts for the Registrar-General.

For the Local Bills Committee of the House of Representatives, 33 schedules of Bills and 47 plans were examined and certified to.

A map of Wellington City and suburbs on a scale of 5 chains to an inch has been put in hand, similar to the one of Dunedin and Suburbs published some time ago. The revision of Auckland Sheet No. 4 is also being undertaken, and will be ready during the year.

One most important work for the ensuing year will be the preparation of the census maps (probably two sets) for the enumerators after the Dominion has been divided into districts by the Registrar-General; and, as on each map the boundaries of counties, ridings, road districts (with subdivisions), boroughs, town districts, electoral districts, &c., have to be shown, the work entailed thereby will be considerable, and will probably require the services of extra draughtsmen.

During my temporary charge, since October, 1909, I have to thank all the officers for the assistance given me.

Mr. C. E. Adams, Chief Computer, reports as follows for the quarter January–March, 1910:—

An index map has been compiled of the triangulation between the Wairarapa and Taranaki Bases, as a preliminary to the adjustment of the triangulation, and as soon as the results of the Taranaki Base are available this important work will be actively put in hand.

In order to check a recent Board of Trade Notice to Mariners, the latitude and longitude of the Akaroa Lighthouse and of the leading-light on the Akaroa new wharf have been calculated in terms of Geodetic Station, Mount Pleasant, and of Mount Cook Initial Station, at Wellington. The adopted longitude for Mount Cook Initial Station is 11 h. 39 m. 6·52 s. (= 174° 46′ 37·80″) east of Greenwich*, while the observed latitude of Mount Pleasant is 43° 35′ 23″ south.† The resulting positions are,—Akaroa Lighthouse, lat. 43° 53′ 26·1″ S.; long. 172° 58′ 43·5″ E.: leading-light, Akaroa new wharf, lat. 43° 48′ 34·4″ S.; long. 172° 57′ 32″ E.

A large amount of preparatory investigations has been done on the harmonic analysis and prediction of the tides; and this opportunity is gladly taken to acknowledge the great kindness and valuable help received from Sir G. H. Darwin, F.R.S., Cambridge; J. Eccles, Esq., M.A., Superintendent, Survey of India, Trigonometrical Branch; Thomas Wright, Esq., Sussex; O. H. Tittmann, Esq., Superintendent, United States Coast and Geodetic Survey; Dr. Bell Dawson, Director, Tidal Survey, Ottawa; Dr. Glazebrook, Director, National Physical Laboratory, Teddington, England; Dr. C. Börgen, Kaiserliches Observatorium, Wilhelmshaven (whose death, I regret to say, has since been reported); P. H. Cowell, Esq., F.R.S., Royal Observatory, Greenwich; Dr. G. Wegemann, Kiel; all of whom have been most kind in supplying advice and information on this difficult subject.

* See report of the Department of Lands and Survey for 1901–2, p. 89. † See report of the Department of Lands and Survey for 1883–84, p. v.

APPENDICES.

APPENDIX I.—SURVEYS.

AUCKLAND.

SURVEYS.—The gross area of all classes of surveys completed this year by staff and private surveyors was 261,332 acres, together with 260 miles of roads and railways.

Minor Trig.—An area of 52,551 acres was completed in Opotiki and Raglan Counties, at the rate of 2·68d. per acre. The work was necessary for settlement surveys and road-deviations.

Rural and Suburban.—The surveys of 67,542 acres into 215 sections by staff and contract surveyors at a cost of 1·99s. per acre, and 6,244 acres into 64 sections by private surveyors, the cost of which is not available; the surveys being for subdivisions of Crown leases, the cost being borne by them. The closures of the work done by the staff were very good, the total number of closures being 161 for 356 miles; mean error per mile on meridian, 0·557 links; perpendicular, 0·644 links.

Native Land Surveys.—The total area surveyed during the year was 188,823 acres, divided into 473 subdivisions, and made up as follow:—Native Land Court: 4,993 acres, with 18 subdivisions, were completed by staff surveyors; 60,310 acres, with 125 subdivisions, by licensed surveyors; while 49,765 acres were completed by private surveyors, the costs of which are not available. Maori Land Board: 58,093 acres, with 157 subdivisions, were completed by staff surveyors; while 15,662 acres, with 29 subdivisions, were completed by licensed surveyors.

Other Work.—This comprises a great variety of work—viz., survey of sites for schools, &c., repairs to trig. stations, redefining old boundaries, exploration reports on Crown land, attending Maori Land Board, and supervising surveys for improved-farm settlements.

Inspections.—Fifty-two inspections were made by Messrs. Wheeler, Haszard, and T. K. Thompson. Most of the surveys were found to be fully up to the required standard, but I regret that in four cases the inspections showed the work to be very unsatisfactory. At present Mr. Wheeler is the only Inspector in this district, Mr. Haszard having been transferred to Christchurch. Owing to the large area of the district and the volume of survey-work being done, it is absolutely necessary that another Inspector should be appointed.

Road-surveys.—116·6 miles were surveyed at a cost of £25·06 per mile.

Mining Surveys.—Thirty-five claims were surveyed, representing a total area of 2,603 acres. The balance of 21 claims were old surveys reapplied for, which had to be examined, but for which no vouchers were received.

Proposed Operations.—Twenty-one surveyors. The staff have the survey of 244,377 acres in hand: of this total, 142,774 acres are Crown lands, 81,931 acres are Native Land Court surveys, and 19,372 acres are for Maori Land Boards. The roads have been located and the sections schemed out for 11,512 acres for the Tokerau Maori Land Board; the sectional survey will be done by contract surveyors. In addition to the above total, the survey of 6,192 acres of Crown lands near Waihi Borough will be put in hand at once. The localities of the larger areas of Crown lands are as follows: Hokianga County, 4,150 acres; Whangaroa County, 2,000 acres; Whangarei County, 5,100 acres; Hobson County, 5,400 acres; Opotiki County, 20,000 acres; Rotorua County, 10,103 acres; East Taupo County, 8,536 acres; Waitomo County, 5,945 acres. In addition to the above, instructions will be issued for the survey of about 24,800 acres, West Taupo County; and in spring the survey of about 4,000 acres in Awakino County will be taken in hand. I also propose to locate roads and scheme out sections for 6,925 acres in Waitomo County for the Maniapoto-Tuwharetoa Maori Land Board; the sectional survey to be done by contract surveyors.

Contract Surveys.—8,122 acres of Crown land, being portion of Te Akau B Block, in Raglan County, is under sectional survey.

Office-work.—Plans examined: 126 plans, of 240 Crown sections, totalling 76,582 acres; 82 Native Land Court plans, of 170 subdivisions, totalling 32,314 acres; 178 mining plans, totalling 11,236 acres; 39 residence-sites (for Warden), 69 sections, 27 acres; 275 Land Transfer plans, area 29,274 acres, average area of sections 106½ acres; 192 plans of roads taken and closed, total mileage being 254 miles 14 chains; 7 plans of land taken for railway-mileage, 6 miles 44 chains; 21 plans for Proclamation, area 1,887 acres. The total number of plans checked of all classes was 920, being the work of 84 surveyors. 1,430 tracings were made for poster, surveyors, selectors, and others. Six Native Land Courts were attended, and £123 7s. 11d., on 10 blocks, was collected at the Courts: total amount for liens collected during the year was £1,446 17s. 5d. Twenty-four charging orders were obtained, for £697 19s. 5d. One hundred and thirty-three applications for authority to survey were forwarded to Head Office, and 130 authorities were issued here. Four candidates were examined in the astronomical part of the Licensed Surveyors' Examination. One hundred and ninety-nine chains were tested. There were applications to Head Office for Government loans of a total amount of £15,032, over 50,345 acres. 3,567 plans were indorsed on certificate of titles, leases, and Native Land Court orders, &c. 1,831 plans were indorsed by Mr. A. B. Harding, of the Land Transfer Office. Fees collected, £176 17s. 4d. The work in this office is still increasing, and extra assistance is urgently required to overtake the arrears of work.

Accounts.—The Accountant reports that the number of vouchers passed through the books during the year amounted to 2,087, representing an expenditure of £45,682 17s. 2d. On his Imprest Account, 1,262 vouchers requiring payment were made by 1,811 cheques, totalling £16,225 9s. 10d., and the amount imprested by the Paymaster-General was £17,300. In his official account 892 cheques were issued, for the sum of £15,339 2s. 5d. The average number of men on survey parties requiring payment was ninety-six per month, and on timber parties nine.

Transfers.—I was transferred on the 1st July—and assumed my duties as Commissioner of Crown Lands and Chief Surveyor—from Christchurch to this office, Mr. Strauchon being promoted to Wellington as Surveyor-General. One District Surveyor was promoted to Christchurch as Chief Draughtsman; 2 staff surveyors and 1 draughtsman were retired on pensions, and the services of a temporary surveyor were dispensed with; 3 surveyors and one draughtsman were transferred from the Public Works Department, and 2 draughtsmen from the Geological Department; and 1 draughtsman was transferred from the Napier District Office.

Conclusion.—My cordial thanks are due to the various officers, field and office staff, who have so willingly and assiduously carried out their several duties.

ERIC C. GOLD SMITH,
Chief Surveyor.

HAWKE'S BAY.

Minor Triangulation.—No work of this nature has been executed during the year. It is, however, most desirable that a check over the existing triangulation in the Poverty Bay portion of this district should be established, either by measuring a long base on the Poverty Bay flat and extending a series of major triangles from it to Hicks Bay, near the East Cape, or by measuring four shorter ones at Poverty Bay, Tolago, Waiapu, and Te Araroa. The original base was measured on the Poverty Bay flat, and the unit of length so obtained was carried through a series of minor triangles right up to the East Cape without any check measurement. It is supposed that some imperfect observations were made about the middle of the work, and hence the necessity for a check of some kind. So long as this uncertainty prevails it is difficult to exercise an efficient check over settlement surveys, and for that reason I should like to see the work undertaken at an early date.

Standard Surveys.—Nothing done during the year. Owing to the incomplete state of the Standard Survey of Gisborne much time is spent by the Department in checking town surveys, besides which private surveyors and their clients are put to unfair expense whenever measurements require to be made. Some years ago Mr. Stephenson Smith began this work, but was obliged to leave it incomplete. The result is that surveyors can never ascertain what are the correct offsets from the standard lines to the sides of the streets without doing an unusual amount of work on both sides of the section they are employed to survey. I beg to recommend for your consideration that this work should be completed, first by measuring offsets from Mr. Smith's lines to all the buildings and other landmarks, and then, after their correct positions have been thus determined, by putting in permanent stones or corner blocks in the most convenient positions at a uniform distance from the sides of the streets. If the Inspecting Surveyor was authorized to continue the Standard Survey I have no doubt he would be able to do some of the offsetting from Mr. Smith's lines at times when he is not occupied with his ordinary departmental duties. The 5-chain standard authorized to be laid down at Gisborne has not yet been completed, owing to the time occupied in getting suitable blocks. These are now in hand, and it is proposed to finish it at an early date. A similar standard is required in Napier.

Rural and Suburban.—The plans of 41,116 acres, comprising 116 sections, have been completed, and that area is consequently returned under this heading at an average cost of 1·68s. per acre. This includes 4,557 acres by Mr. T. Brook, 21,919 acres by Mr. Farnie, 5,238 acres by Mr. Roddick, and 9,402 by Mr. Cagney. In addition to these Messrs. Brook and Cagney have completed the field-work of the Clydebank Estate, 9,710 acres; Mr. Walshe, Tongoio Estate, 8,540 acres; and Mr. Ward, 8,400 acres, part of the Ruahine Forest Reserve, resumed for settlement, and other small areas, but which are not able to be returned under this heading.

Native Land Surveys.—26,545 acres, comprising 80 sections, have been completed and the plans received. This includes the subdivision of the Mohaka Block by Mr. Hughes, 24,379 acres; and 2,166 acres, part of the Mangapoike Block, by Mr. Cagney, for the Tairawhiti Maori Land Board. Mr. Brook has also nearly completed the subdivisional survey of the Paeroa No. 2 Block, and Mr. Hughes of the Hinewhaki and Ngamotu Blocks for the same Maori Board.

Other Work.—This includes the Land Officer's proportion of the cost of administering the Gisborne Office, Mr. A. G. Smith's road party for three months in the Tahora Block, and the cost of all the miscellaneous inspections and surveys that could not well be returned under any other heading. During the three months he was employed Mr. Smith explored the Tahora Block of 48,000 acres, and located the best routes for about twenty miles of road to open it up. Unfortunately, at the end of that time ill health compelled him to retire from the service, and I had no one available to take his place, so the work had to be postponed until next summer.

Inspections.—During the current year the whole staff has been so much occupied with urgent settlement surveys that little has been done in this very necessary branch of departmental work. Mr. Bullard has made seven inspections, and reports the work he examined as fairly satisfactory, also that all requisitions for amendment were willingly complied with. I note with satisfaction that your own Inspectors will visit the district from time to time and test the work of the different surveyors. I have already supplied Mr. Inspector Climie with particulars of three surveys here, and when Mr. Brook is at liberty I proposed to let him make some other inspections also.

Road-surveys.—About 45 miles have been laid off by Messrs. Farnie, Roddick, Hughes, and Cagney; but, the plans of only 2¼ miles having been completed, they alone are returned this season at a cost of £10·30 per mile.

Proposed Operations, 1910–11.—Mr. Brook will complete the survey of the Paeroa No. 2 Block, 1,850 acres, the subdivision of the Omahu No. 2 Block, 2,500 acres, for the Native Land Court, besides other surveys that will probably be required for settlement and the Maori Land Board. He will also make some inspections. Mr. Farnie will complete the subdivision of the Huiarua Block, of 7,750 acres, also subdivide Run 48, containing 3,148 acres, into smaller sections; he will then be available for the Tahora Block of 48,000 acres or any more urgent surveys that may be required. Mr. Roddick will complete the subdivisional survey of Run 47, 19,649 acres, of which 14,000 acres is already completed in the field. He will then be available for the Tahora Block or more urgent surveys which I anticipate the passing of the Native Land Act, 1909, will bring to this Department. Mr. Hughes is to be transferred to the Auckland Land District. Mr. Walshe will complete the survey of the Pohokura Block of 40,000 acres. Mr. Cagney will subdivide the Tutaekuri No. 2 Block, 12,150 acres, for the Maori Land Board. Mr. Ward will complete the survey of Tamaki No. 4, 1,800 acres, and other miscellaneous surveys that may be required.

Office-work.—Mr. H. G. Price, Chief Draughtsman, reports as follows: "During the year 378 plans have been examined and approved (an increase of 25 on the previous year) representing an area of 201,192 acres. These, divided up in their several classes, are as follow: Land Transfer, 168 plans, 934 lots, 54,770 acres; Native Land Court, 85 plans, 286 lots, 64,497 acres; Public Works plans, 71 plans, 157 lots, 1,101 acres; departmental, 54 plans, 279 lots, 80,824 acres. In addition to the above, 573 instruments of title, such as transfers, leases, mortgages, &c., have been examined and reported on; 560 tracings have been prepared for surveyors, settlers, local bodies, and other Departments; plans have been indorsed on 1,678 certificates of title, 355 warrants, and 711 leases and Court orders. Twenty-five tracings for sale posters have been prepared, and a tracing for photo-lithography of the Borough of Wairoa is just completed. One hundred and sixty plans have been mounted and repaired. The present staff is kept busy with the current work, and an additional draughtsman is required, whose whole time could be devoted to bringing the block sheets up to date."

Miscellaneous.—Under this heading I have to report the following changes in the staff: On Mr. Trent's superannuation in May I was appointed Commissioner of Crown Lands and Chief Surveyor, and Mr. G. H. Bullard took my place as Land Officer and Inspecting Surveyor at Gisborne. I am pleased to be able to record that the Chief Draughtsman, Mr. Price, resumed his duties on the 20th September, after a tedious illness and painful operation, since which he has regained his health in a remarkable manner. In this connection I wish to express my appreciation of the able assistance rendered me by Mr. Thomson, Chief Clerk, and Mr. Cane, Land Transfer Draughtsman, in attending to Mr. Price's duties during the time he was incapacitated.

Conclusion.—In conclusion I desire to place on record my appreciation of the manner in which the whole field and office staff has assisted me in the conduct of the business of this land district.

T. N. Brodrick,
Chief Surveyor.

TARANAKI.

The gross area surveyed by staff and private surveyors during the year under the various headings represents a return of 55,142 acres, together with 7·98 miles of road and railway.

Minor Triangulation.—Although no triangulation surveys are returned this year, an area of 39,000 acres of subsidiary trig. work is nearing completion, and important work has been carried out in preparing a new ten-mile base-line for measurement in connection with the major triangulation of the Dominion.

Rural and Suburban.—The operations in this class amount to 39,461 acres, in 162 sections, all of which is situated in rough forest country. Of this, 19,670 acres consists of the final survey of ordinary settlement lands at an average cost of 2·65s. per acre, and 19,791 acres, containing 108 subdivisions, preliminary surveys, covering the Tangitu Improved-farm Settlement, &c., the average cost of which works out at 14·22d. per acre.

Native Land Court Surveys.—No work in this class was completed by the staff, but 14 blocks, comprising 15,681 acres, were surveyed by private surveyors during the year.

Other Work.—The expenditure under this head amounts to £1,176 11s. 10d., made up by cost for exploration, grading, and inspection of roads in the Mapara, Tangitu, Ohura, and Taurakawa Survey Districts; inspection and reporting on blocks for landless men; improvements on small grazing-runs, &c.; also a preliminary survey and preparation for the measurement of the new ten-mile base-line in Ngaire and Waimate Survey Districts, construction of pack and swag tracks, partial survey of portion of Wanganui River, as well as the general miscellaneous field-work.

Inspections.—The usual inspections have been made over survey-work in progress during the year.

Roads and Railways.—Under this head, 7·98 miles were completed at a cost of £182 4s., or £22·83 per mile.

Land Transfer.—There were 113 plans, with 142 traverse sheets, checked and approved, covering 124 sections and subdivisions, of an area of 9,306 acres 3 roods 18·03 perches.

Titles.—The plans placed on instruments of title of all kinds were 1,644, and 380 copies of leases and licenses were prepared.

Proposed Operations, 1910–11.—A staff of three permanent, with cadet, and two temporary surveyors and a licensed assistant, are at present engaged upon sectional work along the eastern and north-eastern boundaries of the district, in the valley of the Wanganui River, and in close proximity to the Main Trunk Railway. The total area covered by these operations amounts to 91,590 acres, 72,590 acres of which is new work in Ohura, Rangi, Heao, Mahoe, Taurakawa, and Omara Survey Districts, the balance being the completion of final survey over some 19,000 acres of provisional work carried out during the year in connection with the urgent measures taken in placing the unemployed upon the land. Private surveyors, under contract with and under the supervision of this Department, are also carrying out the subdivisional survey over 17,177 acres in the Mapara and Tangitu Survey Districts for the Maniapoto-Tuwharetoa Maori Land Board. In addition to the above, there is an area of 30,000 acres in the Mimi, Waro, Omara, and Momahaki Survey Districts, over which partial surveys have been made, but further work on these blocks had to be suspended pending the completion of more urgent surveys for unemployed, &c. The work above enumerated will more than keep the present staff fully employed during the coming year.

Office-work: Examination of Plans.—The total number of plans checked under all heads in the ordinary survey branch was 95, with 367 traverse sheets. These covered 524 sections, of a total area of 102,892 acres 3 roods 1 perch, and 84 miles 62 chains of roads taken or closed, and railway land plans. Settlement surveys of Crown lands were represented by 15 plans, containing 177 subdivisions, of a total area of 46,007 acres and 5 perches; trigonometrical, 3 plans, covering 36,300 acres; 27 plans, defining 83 miles 62 chains of roads taken or closed; 1 plan, of 1 mile of railway land plans; 17 Native Land Court plans, of 15,758 acres 2 roods 31 perches, in 18 subdivisions; 24 miscellaneous plans, of 198 subdivisions, containing 2,580 acres 3 roods 1 perch; 6 office compilations, of 2,186 acres 3 roods 24 perches and 36 subdivisions; and 2 township plans, of 59 acres 1 rood 20 perches, in 95 sections.

Compilations.—Twelve drawings and tracings were prepared for photo-lithography; 5 new Crown grant and 2 road record maps, together with 8 block sheets, were compiled.

Miscellaneous.—The usual demands made on the office staff were attended to. These comprise supplying information to the general public; data to the staff for execution of surveys; information for local bodies and other Departments, &c.; 119 tracings were made for the Valuer-General, 105 for Crown selectors, and 95 for gazetting. All recording on block sheets, record, reserve, index, and other maps has been kept up to date. Twenty-five applications for authority to survey Native blocks were received and dealt with during the year.

FRANCIS SIMPSON,
Chief Surveyor.

WELLINGTON.

Secondary Triangulation.—One officer, Mr. Lowe, was engaged upon this work, which is illustrated by a diagram in last year's report. The measurement of the principal base was completed by Mr. Langmuir, having been previously ranged, prepared, and marked out by Mr. Lowe early in the year, and the methods and results of that measurement are, I understand, to form the subject of a special publication, to which I need not further refer here. The stations observed lie at the southern end of the district across the backbone range between the strait and the plains, and the weather-conditions have been most inconstant and variable. The results of Mr. Lowe's observations, made with a 10 in. Everest, have nevertheless been most satisfactory in their mutual agreement and remarkably uniform in their character, clearly evidencing excellent work and matured and experienced methods. Mr. Lowe handed over this work to Mr. Mountfort at the end of February, in order to take charge of the computing branch of this office, which was without a qualified surveyor.

Town Standard Surveys.—Mr. Climie has laid down standard marks in the Boroughs of Hunterville and Levin as a beginning in each, and has verified and amended existing surveys of this kind in Palmerston North, Wanganui, and other places where street-alterations have rendered it necessary. An inspection of all the standard marks in the city and suburban boroughs of Hutt and Petone has been made, and the work of correcting the numerous displacements and alterations is now in hand. An extension of these surveys to Upper Hutt is in contemplation. The plans of the revision of the Standard Survey, City of Wellington, were completed during the year.

Rural and Suburban.—The chief surveys completed in this class have been the special improved-farm lots, which three surveyors, Messrs. Strachan, Stevenson, and Lindsay, with two assistants, began and finished, amounting to some 10,600 acres, being surveyed into lots under 200 acres; an area of 10,062 acres was subdivided by one surveyor for the Maori Land Boards leasehold selections; a number of the Scenery Commissioners' recommendations have been surveyed, in area about 5,420 acres; while out of the settlement survey of the Rangitatau Block, near Waitotara, quite a new class of work fell to Mr. Greville's charge in the unemployed-relief works of felling the bush upon the block; some 2,000 acres were felled by about 130 men, and a most satisfactory burn and grassing have followed. Mr. Greville's successful management of this exceptional and exacting work, and his supervision of this body of men is deserving of special notice. The traverse closures of the work done by the staff surveyors is 0·558 links per mile on meridian, and 0·599 links on perpendicular.

Topographical for Selection.—Under this head I have placed the preliminary work by four surveyors, Messrs. Girdlestone, Stewart, Johnston, and Campbell, in the South Waimarino Block, which enabled some 35,000 acres to be placed in the market for selection during the year.

Town Surveys.—Nothing of great importance has been done in this line, but four new townships have been laid out near the Main Trunk line, comprising 267 sections, many of which, including extensions of existing towns, have been sold.

Native Land Court Surveys.—The Urewera Block, lying on the slopes of our highest mountain, Ruapehu, is the principal item in this class, but there have been also forty-four blocks surveyed by private surveyors for Court purposes. An incidental result of great interest professionally was brought out by Mr. Mountfort's traverses on the high altitudes of Ruapehu. The triangulation lengths, of course, all spring from measurements as at sea-level, consequently measurements over the surface at so much higher levels, four or five thousand feet, show differences so large as to require the application of corrections for altitude in order to enable comparison and closure on triangulation distances and positions.

Other Work.—There is always a long list of small surveys scattered about the district waiting, year after year, for attention. A number of these were squeezed between the more important works and completed, and in addition all sorts of miscellaneous reports, subdivisional schemes, estimates, odd peggings, inspections, &c., fall under this head, and, although all very necessary in their way, do not make much appearance, yet take a considerable time to do.

Inspections.—Mr. Climie during the year was transferred to the Head Office staff, with the duties of this important branch. He has inspected five staff and seventeen private surveyors, and, taken as a whole, the work of both staff and private surveyors has been good.

Roads, Railways, &c.—The North Island Main Trunk Railway land-plans surveys, amounting to 36 miles, with the neighbouring roads, have been executed by Mr. Johnston, and form the principal part of the work done under this heading. The balance consists of 13·5 miles executed by three other surveyors.

Proposed Operations, 1910–11.—Five surveyors, Messrs. Greville, Girdlestone, Stewart, Johnston and Campbell, are now concentrated in the South Waimarino Block, of 96,040 acres, which is the largest area of Crown lands in one block left in this district, of settlement country. Mr. Stevenson will be occupied with Maori Land Board surveys; Mr. Mountfort on secondary triangulation; another surveyor on Scenery Reserve surveys; and two on Crown settlement surveys in the Pohangina and Akitio districts, and some minor work.

Office-work.

During the year the indoor staff has been largely decreased by promotions and exchanges to other districts, as well as retirements on superannuation, &c. Prominent amongst these have been Messrs. J. W. Davis, J. S. Welch, F. A. Thompson, and C. E. Adams, all able men and very hard indeed to replace, although in some instances others have taken their places and are doing excellent work. Notwithstanding that the staff has been so weakened, good results have been obtained, the record, so far as can be tabulated being as follows:—

Examination of Plans.—One hundred and seventy-eight plans were received under all heads, and 198 were approved, covering 97,598 acres of sectional work. Statutory plans: 121 received, 117 approved. Land Transfer: 275 plans were examined, and 205 passed, not including those on transfers. 2,883 dealings were examined, and 4,974 plans put on certificates of title, and the index plans were brought up to date.

Compilations.—Thirty-five tracings for photo-lithography were made, 2 new Crown-grant record maps, one block sheet, and 34 plans, and all approved plans were placed on the record maps; there being no arrears in this work.

Native Land Court Work.—Forty-four new surveys were received; 61 plans were examined; and a total of 71 surveys of blocks, with 293 subdivisions, of an area of 65,204 acres, were made by private surveyors; while staff surveyors made surveys of three blocks, of 26,000 acres, in 48 subdivisions, and plans were compiled of 30 blocks, 73 subdivisions, of an area of 60,763 acres. Crown survey liens to the amount of £705 4s. 6d. were paid; 56 Maori Land Board leases were prepared; 428 orders and certificates were prepared; 163 nominations for survey passed through; and an area of 105,204 acres was dealt with and subdivided by Native Land Court.

General.—Over 1,100 tracings were made; 140 plans were recorded; 100 additions to plans and 151 miscellaneous plans were made; and 11 plans, 77 tracings, 116 lithos, and 308 miscellaneous were mounted. Work done for other Departments, local bodies, &c., amounted to £874.

Miscellaneous.—A number of duties are included in the daily work of the staff which cannot be tabulated, in the way of attendance on the public and the continuous supply of information from maps and records and relating to land and title boundaries, maps, &c.

Conclusion.—In conclusion, again I wish to record my appreciation of the co-operation of my officers, both field and staff, during the year.

James Mackenzie,
Chief Surveyor.

NELSON.

Minor Triangulation.—The work under this heading consists of subsidiary triangulation used to check and control sectional surveys. Area executed, 37,750 acres, at an average cost of 1·02d. per acre.

Standard Surveys.—A revision of the Standard Survey of the City of Nelson is urgently needed. The present survey, executed many years ago, is very defective both in bearings and distances, and many of the blocks have been disturbed and in some cases removed in the execution of road-formation and drainage-works. Standard traverses of some of the main roads are also required where the lands are being subdivided and brought under the Land Transfer Act.

Rural and Suburban.—Under this class of work the plans of 58,554 acres, in 190 sections, at an average cost of 2·03s. per acre, have been returned. Of this area 43,819 acres were executed by staff

surveyors, of which 32,000 acres were situated in blocks opened by sale poster in fairly large sections, and balance consists of scattered areas. Of the above total, 14,735 acres was executed in the Big Bush Block by contract at 1·34s. per acre. The work is all situated in hilly heavy forest country, and a great deal of it very rough and inaccessible. The blocks opened during the year contained 35,000 acres, of which 14,000 acres were selected.

Topographical, for Selection.—29,253 acres is returned under this heading at a cost of 3·58d. per acre. Of this area 27,860 acres is provisional survey for preparation of sale map, while the balance is a proposed scheme of subdivision of applications.

Field Inspections.—It has been impossible to spare a surveyor from the staff to execute this class of work, and my own time has been too fully occupied to make any inspections personally. Only one inspection has been made of which details have been returned. Another inspection of a township survey has been made, but no details yet forwarded. It has now been arranged for an Inspecting Surveyor from the Head Office to make all necessary inspections at an early date.

Other Work.—Various duties are placed in this class which cannot come under any of the headings in the general return, and consist chiefly of reports, inspections, checking plans, minor surveys, and work done for other Departments.

Roads, &c.—17·44 miles of roads were laid off, at a cost of £17·20 per mile. These were short pieces of road to give access to Crown lands. In some cases the lines had to be located and graded in difficult country.

Gold-mining Surveys.—No surveys of this class were executed by staff surveyors. Six mining surveys, containing 495 acres, in 11 sections, were returned by contract surveyors.

Land Transfer Office.—The Land Transfer Draughtsman reports that 67 survey plans have been passed, 47 examined and returned, 142 deeds passed, 384 diagrams placed on 192 certificates of title, 160 plans draughted, and 224 plans examined and issued. Arrears, 12 certificates of title in duplicate.

Proposed Operations, 1910–11.—The work in the hands of the surveyors consists of 470 square miles of minor trig., of which the field-work is nearly completed. One hundred and forty-seven square miles of this is in connection with the survey of D'Urville Island, and this work, together with the defining of the subdivisional boundaries, requires completing at an early date, as the lessees are anxious to fell the bush and fence the boundaries. The balance of the trig. work, which is chiefly in the Maruia Valley, to control the sectional surveys, is completed in the field. An area of 69,210 acres is in the hands of the surveyors, of which approximately 25,000 acres are completed in the field. The unallotted applications number 134, and contain an area of 57,500 acres. These arrears, though approximate, are located as follows: 11,000 acres in the Warwick and Rappahannock Blocks, 20,000 acres in the Buller and Inangahua Counties, and the balance in smaller areas scattered throughout the district. A surveyor has recently been stationed in the Buller County, and arrangements are being made to let contracts in this and also the Inangahua County in order to reduce the arrears which have accumulated during the past year. It is also proposed to let a contract for the Wangamoa Block of 5,000 to 6,000 acres. The surveyors at present employed will be kept steadily at settlement surveys, and, with the help of the contract surveyors as well as the services of another young energetic surveyor, should soon cause the arrears in this work to be materially reduced.

The blocks it is proposed to offer for selection this coming year are the Howard Block, 20,735 acres; the Extension Maruia North Block, 1,248 acres; the Matiri Extension Block, 8,000 acres; and the Waimea Block, 5,000 acres.

Office-work.—Fifty-three certificates of title in lieu of Crown grants (in triplicate) were examined and issued, 169 tracings examined, 55 reports furnished, 9 survey plans and compiled plans examined, and 59 leases, &c., for warrants examined. There are 5 certificates of title in lieu of Crown grants (in triplicate) to issue. Forty-eight plans, containing an area of 40,552 acres, in 147 sections, were examined. Mining surveys—6 plans, 495 acres, in 11 sections. Thirty-five road plans, 4 railway plans, and 6 subsidiary triangulation. Traverse sheets checked, 352. Diagrams were placed on 117 Crown titles (by contract) in quadruplicate, 58 in triplicate, 77 in duplicate, and 4 singly; and on certificates of title in lieu of Crown grant, in triplicate, 53: total number of diagrams, 959. There are in arrear Crown titles in quadruplicate, 16, in triplicate, 16, and in duplicate 9: total, 41. Photo-lithographic tracings were prepared of three large blocks of land opened for settlement, and also for those areas that were reopened for selection after surrender or cancellation. Counter-maps were prepared for the Westport and Reefton offices, tracings and data for surveyors, working-tracings for settlers, for Valuation and other Departments. Tracings for a county map of Takaka are not yet completed, and one is also required of the Waimea County. The lithographs of the Buller, Inangahua, Murchison, and Collingwood Counties are a great convenience. Tracings for a new map of the Nelson City are well forward. Several new selection maps are urgently required, but owing to the stress of current work cannot be yet taken in hand. The rough register of the plans in the safe is now complete, and requires copying into the index-books. The indexing of the rebound Crown grants is now in progress.

ROBT. T. SADD,
Chief Surveyor.

MARLBOROUGH.

Triangulation; Topographical.—Neither triangulation nor topographical surveys have been performed in this district last year; but a little topographical survey for selection before survey has been completed in the Wakamarina Survey District, but not sufficiently elaborate to appear as a separate item.

Rural and Suburban.—14,062 acres of rural and suburban surveys have been finished, at an avearge cost of 1·69s. per acre. This, although very high, is slightly below last year's result; but I hope to show far better results next year, when many of the blocks now unfinished will be completed. The whole of this class of work is heavy-bush-covered hill country, and the work has been much retarded by wet weather, and also by the difficult boundary-lines of the Forest Preservation Reserves, gazetted on paper lines running over all the ridges and streams.

Road, Railway, &c., Surveys.—19·9 miles of this class of survey have been completed at an average cost of £23·99 per mile. Much of this road-survey is in rough timber country, and includes exploration, grading, traverse, and rough engineering survey, to enable an estimate of cost of its construction to be made.

Other Work.—Under this heading is included 10¼ miles of standard survey in the Town of Picton; 13 miles of Standard Traverse in the Town of Blenheim and neighbourhood, and many other services set forth more fully in Table 47. The standard work at Picton has proved very costly, owing to the absence of any previous reliable data to go upon, and the rough nature of many of the streets. Survey of 2,820 acres of compass survey for milling areas and about 14¾ miles of boundaries of State forest has been completed. It is anticipated that the survey operations in this district, with our present staff, will result in bringing in between 35,000 and 40,000 acres of land for selection: this includes two or three small grazing-runs; some small pastoral runs; and the balance, renewable-lease lands, chiefly bush, hilly forest up the Pelorus River and its branches.

F. Stephenson Smith,
Chief Surveyor.

WESTLAND.

Standard Revision Survey.—A distance of 3 miles in the Town of Greymouth was surveyed by Mr. Robinson at a total cost of £100, or £33·33 per mile, in order to adjust pressing land transactions.

Rural and Suburban Surveys.—The total work completed under this heading is 13,391 acres, subdivided into 145 sections, at a total cost of £2,054 3s. 10d., or an average of 3·07s. per acre for the above area. District Surveyor Wilson surveyed 979 acres into 14 sections at a total cost of £282 0s. 10d., or 5·76s. per acre, the work being in heavy bush country, with scattered areas involving much travelling and moving camp. District Surveyor Morison surveyed 2,600 acres, chiefly in Taramakau Valley, into 13 sections, at a total cost of £509 16s. 1d., or 3·92s. per acre, the work being surrounded by troublesome old surveys and prior claims, and often in dense bush. Assistant Surveyor Harrop surveyed 3,688 acres into 84 sections, at a total cost of £571 3s., or 3·10s. per acre, being scattered surveys in dense bush, chiefly in Kanieri, Greymouth, and Cobden Survey Districts. Assistant Surveyor Cunningham surveyed altogether 4,340 acres into 20 sections, at a total cost of £425 9s., or 1·96s. per acre. Most of these surveys, being in bush and swamp country, were executed under unfavourable conditions of weather and South Westland floods. Assistant Surveyor Robinson surveyed 1,784 acres into 14 sections, at a total cost of £265 14s. 11d., or 2·98s. per acre, being principally scattered surveys amidst bush country in Taramakau Valley and Inchbonnie. Small scattered areas, heavy and rugged bush, broken weather, and uncertainty of connecting surveys militate very generally against expedition of work.

Topographical for Selection.—Under this head is returned a total area of 36,200 acres, at a total cost of £381 14s. 2d., or 2·53d. per acre, comprising various pastoral runs and prospective selections, timber locations, &c. Of the above area, Mr. Wilson contributed 2,000 acres, Mr. Morison 19,000 acres, Mr. Harrop 5,200 acres, and Mr. Cunningham 10,000 acres.

Town Surveys.—One hundred and fifteen lots, of a total area of 46·25 acres, have been surveyed, at a total cost of £151 18s. 9d., or an average of 26·42s. per lot.

Other Work.—The return under this head amounts to £322 7s. 5d.

Road Surveys.—A total length of 11½ miles is returned under this head, at a total cost of £126 10s. 4d., or at the rate of £11 per mile.

Proposed Operations, 1910–11.—The above heading comprises (1) completion of work in progress, more especially Moana Block, near Lake Brunner, and sections at Wanganui, Poerua Block, and in Waiho Survey District, about 9,000 acres; (2) selections arising from time to time, including those at Seventeen-mile Beach, in Waiwhero Survey District, various areas in Waimea and Hohonu Survey Districts and in Grey Valley—area about 2,000 acres. The need is felt of extension of standard work in the Towns of Greymouth, Cobden, and Hokitika, in order to facilitate office and field check on Land Transfer plans. It is proposed to assign this work to Mr. Wilson.

Office-work.—During the year 126 plans have been received, of which 33 were Land Transfer plans, 4 mining plans, 15 statutory plans, and 74 relating to land selection. Two 40-chain district maps and 13 application maps have been drawn. Sixteen tracings have been made for photo-lithography. 1,055 tracings have been supplied for general returns, surveyors' data, and for information of settlers. 1,281 plans have been placed on titles as follows: Of Crown leases, &c., a total of 1,093 copies were prepared either in duplicate, triplicate, or quadruplicate; of Land Transfer titles, 184 copies of plans have been placed on deeds, and plans of 40 transfers under the Act have been examined; 100 lithos and maps have been mounted. Numerous reference maps have been prepared, relating to special subjects. Of Land Transfer record maps 8 sheets have been prepared on 50-link scale of the Town of Greymouth, in order to deal with minute and pressing subdivisions. In August last the office moved into new buildings, thereby necessitating a complete rearrangement of all maps and records; and, consequently thereon, a more thorough system of plan record, examination, and indexing has been instituted.

Office-work in Progress.—This comprises the following: A photo-lithographic tracing of Jackson's Bay portion of the Westland County is well in hand. Further Land Transfer record plans of Greymouth and Hokitika are being continued. Forty-chain district maps of the busier portions of Grey County have been started. The work of indexing, cross-indexing, registering, labelling, thoroughly

examining, compiling, and recording is steadily progressing. It is hoped to make during the ensuing year a more extended use than heretofore of blue-print and photo-lithography, and to persevere with the construction of key and index maps, thereby aiding economy and efficiency both in field and office work.

Changes of Staff.—At the end of May last Mr. G. J. Roberts, after having been for nearly thirty-seven years ably identified with every phase of departmental work, was constrained to retire through ill health, at which date I succeeded him as Commissioner of Crown Lands and Chief Surveyor for Westland. Mr. Skeet was promoted to the charge of Southland, and was succeeded as Chief Draughtsman in July by Mr. F. A. Thompson. At the end of February Mr. W. F. Robinson resigned his appointment as Assistant Surveyor, having been appointed to the staff of Canterbury College, after some five years' capable service in this district. In June Mr. F. J. Harrop, Senior Draughtsman, was transferred to Napier, after nineteen years' good work in Westland. Miss S. M. Montgomerie, of the draughting staff, was transferred from the Nelson staff in May, and about the same time Mr. K. G. Hogan was transferred from the Education Department and appointed draughting cadet here. Mr. Stavely was transferred from Blenheim as draughtsman in June, Mr. Newman, Draughtsman, was transferred to Christchurch in November after some nine years' service here. Mr. Bateman, Draughtsman and Computer, was appointed in November. In August Mr. W. Wilson was transferred as District Surveyor from the Roads Department.

My thanks are due to all the officers, both the field and the indoor staff, for their hearty co-operation in the year's work.

G. H. M. McCLURE,
Chief Surveyor.

CANTERBURY.

Rural and Suburban.—The total area under this heading for the year amounts to 30,327 acres, and consists chiefly of blocks resumed for closer settlement under the Land for Settlements Act—viz., Buddo, Fyvie, Tripp, Clandeboye, Ladbrook, and Hornby Settlements. These were surveyed by Messrs. Allom, Young, Davis, and Freeman. The number of sections is 101, and the total cost £1,156 10s. 11d. = 0·76s. per acre. Part of the Tripp Settlement was in high broken country, but the rest of the blocks were level agricultural land.

Town Surveys.—The work under this heading comprises 3·3 acres, in 13 sections, at a cost of 51·14s. per section, being the land cut up for workers' dwellings in Walker Settlement, and two or three small reserves for post-office sites, &c. The high cost is owing to the amount of travelling.

Field Inspection.—Owing to pressure of settlement surveys, only six formal inspections have been made during this year—three by Mr. Allom and three by myself; but, in addition to this, I have been out on several surveys to get a general idea of the work as to pegging, &c., and to advise in reference to boundaries. The general results of the inspections made were satisfactory, but in one instance some amendments were necessary before the work could be passed.

Road Surveys.—These comprise 14·5 miles, at a cost of £14·67 per mile.

Other Work.—The charge under this heading, £102 19s. 11d., is for field inspection, laying down of tide-gauge levels at Lyttelton, and running out boundaries of scenic reserves and miscellaneous reports.

Proposed Operations for 1910–11.—At present there are three Land for Settlements blocks to be cut up, comprising 5,395 acres; a topographical survey of some 2,450 acres of Crown land in the Mount Thomas Survey District; and about 100 acres of reserves in various localities. When the report of the Pastoral Runs Commission has been made and considered, it is probable that a good deal of surveying will be required in the adjustment of new boundaries. These surveys will all be in high broken country, and I do not think it would be advisable to send the surveyors out till at least the end of September. Magnetic traverses on the best fencing-lines would, I consider, answer the purpose required, as the land is of small value. During the winter I propose, as opportunity offers, to put Mr. Allom on the extension of standard traverse lines on some of the main roads radiating from Christchurch. This is very necessary to govern the subdivision coming in under the Land Transfer Act, the triangulation, on account of the plantations and other obstructions, now being of little use. Mr. Allom will also have a certain amount of inspection-work to do.

Office-work.—In the draughting branch, 25 plans, comprising 30,400 acres, and 62 road and railway plans, of a total length of 24½ miles, together with the tabulations, have been examined and passed. Photo-lithographic tracings of Geraldine Township, Ashley, Selwyn, Mackenzie, and Ashburton Counties, also tracings for posters of Walker, Fyvie, Buddo, Clandeboye, Ladbrook, and Tripp Settlements, have been completed and sent to Head Office. On my arrival in Christchurch I put in hand the compilation of county maps on the mile-to-the-inch scale, showing the land tenures up to date, for exhibiting in the passages. Five of these are now complete, and are proving of great convenience to the public, and a saving of time to the draughtsman in charge of the Public Room. The balance of the counties will be dealt with in the same way as opportunity offers. A large amount of miscellaneous work has been done in the preparation of tracings for field data, the Pastoral Runs Commission, duplicate tracing of standard work for Timaru Borough Council, recording the plans in office records, placing plans on Crown tenants' certificates of title, and other details of office routine. As set out in previous annual returns, there are large arrears in the recording of plans on the Crown-grant record plans, block sheets, &c. I have been trying to have this work put in hand; but, with the limited staff and the exigencies of settlement-work, not much progress has been made. A plan of Greater Christchurch will also be put in hand as soon as I can spare the draughtsman to undertake it.

Changes in Staff.—Mr. McClure, Chief Draughtsman, was promoted to the Chief Surveyorship of Westland, and left for there in June; at the same time I was transferred to this office from Auckland as Acting Chief Surveyor and Chief Draughtsman. Mr. W. Darby, Draughtsman, retired on the 31st March. Miss A. O. Adams and Miss N. Dwyer resigned during the year. Mr. W. F. Newman, Assistant Draughtsman, was transferred to this office from Hokitika in November, and Mr. E. L. Hornibrook joined as temporary draughtsman in August. Mr. Cadet J. C. Young passed into the grade of Assistant Surveyor in September.

Land Transfer Branch.—Mr. Leversedge reports that 324 survey plans have been examined and passed, in addition to the deeds and certificates of title as shown in tabulated statement. This number is slightly less than in the previous year, but represents a very considerable area, owing to the subdivision of several large estates in the vicinity of Timaru and other parts of Canterbury. The work of adding to and renewing the Land Transfer record plans is now very urgent, and I propose putting this in hand as early as possible.

In conclusion, I would beg to tender my thanks to both the field and office staff for their active co-operation in carrying out the duties pertaining to this branch of the Department.

H. D. M. HASZARD,
Acting Chief Surveyor.

OTAGO.

Minor Triangulation.—The plan showing a revision of the triangulation in the District of Otago Peninsula, and that of North Harbour and Blueskin (the field-work of which was finished last year), comprising 104,000 acres, was completed during the year. There are other districts also where revision is necessary.

Rural and Suburban. — Four staff surveyors, one temporary surveyor, and three unlicensed assistants were engaged in the work of subdividing six large pastoral runs into small grazing-runs and small sections: total area, 681,000 acres. The field-work was completed and plotted to enable the sale plans to be prepared, so that the land could be opened for selection before the 1st March, 1910; but, as the working-plans are not finished, the work cannot appear in Table 1, there being no column in that table for "unfinished work." The surveys completed in the field are as follows: D. I. Barron and Y. Booker, Morven Hills, 243,000 acres; S. T. Burton, Kawarau Run, 234,000 acres; D. I. Barron, Northburn Run, 12,000 acres; W. T. Neill, Matakanui Run, 54,000 acres; W. T. Neill, Ida Valley Run, 72,000 acres; D. M. Calder, Linnburn Run, 66,000 acres: total, 681,000 acres. The surveys of Matakanui Settlement, of 1,177 acres, and of several small areas, were completed. Twenty-one sections, with a total area of 614 acres, were surveyed by private surveyors for survey fees deposited by applicants.

Town Surveys.—Six plans of new towns surveyed by private surveyors were examined and approved by His Excellency the Governor.

Roads, Railways, &c.—These surveys were all executed by private surveyors, and details are given under the heading "Office-work."

Mining Surveys.—These surveys were all executed by private surveyors for fees paid by the applicants, the number of sections surveyed being 42, and the area 1,703 acres.

Land Transfer Surveys.—Fifty-three plans, representing an area of 7,244 acres, were examined, approved, and recorded. Table No. 4 shows other work under this heading.

Proposed Operations for the Year.—The work at present in view comprises the cutting-up of about 120,000 acres, at present under pastoral leases, into small grazing-runs and pastoral runs; the subdivision of the areas reserved as settlement blocks on Morven Hills, and Kawarau runs, and some small surveys and inspections which must be done by the staff surveyors. This will occupy the surveyors now at work till called in for the winter, when they will complete the mapping of the run-subdivisions referred to under the heading "Rural and Suburban." In the early summer, should the matter be arranged with the Municipal Council, District Surveyor Neill will be put on the Standard Survey of Dunedin, a much-needed work. Another work urgently required is the revision of the measurements of several base-lines, and the readjustment of the triangulations based thereon. In addition to the above, it is probable that there will be an acquired estate to be subdivided, so that ample work will be found to keep the present staff of surveyors employed for the ensuing year.

Office-work.—Altogether 162 plans were examined, approved, and recorded, the majority being in duplicate, and some in triplicate. Of these, 40 were road plans, 6 railway plans, and 22 plans of Crown lands executed by private surveyors. Other work appears on Tables 3 and 5. The principal work of the year has been in connection with the survey of 681,000 acres of Crown lands, as detailed above, under the heading of "Rural and Suburban." Two draughtsmen were sent from the office staff to assist the field surveyors to plot the work, so that the sale plans could be completed in time to place the land in the market before the 1st March. Altogether 63 sale plans were drawn during the year, some very large, also 2 tracings of Papakaio and Kauroo Districts for photo-lithography. Many lithographs of towns and districts are required, and an effort will be made to have some drawn during next year. Three new county maps were made of Waihemo, Tuapeka, and Waikouaiti, and 360 tracings prepared for the Valuation Department. In the lithograph room 538 forms were printed, 30 books bound, and 1,157 maps mounted, 68 of which were for the Valuation and Public Works Departments. A very large amount of work was done for other Departments, the cost amounting to £488. This year has been an extremely busy one, and it is not possible to give in a short report an adequate idea of the work performed.

E. H. WILMOT,
Chief Surveyor.

SOUTHLAND.

Minor Triangulation.—Two items appear under this head—viz., an area of 7,542 acres in Forest Hill and Hokonui Districts by Mr. Macpherson, and 5,672 acres in Lillburn and Hauroko Districts by Mr. Otway. They were extensions of the existing triangulation, to control blocks of land under survey.

Rural and Suburban.—17,579 acres were executed during the year, in 155 sections, the greater part of which consisted of hilly bush country. Included in this area is the Ermedale Settlement, of 2,748 acres, situated in Jacob's River Hundred, acquired under the Land for Settlements Act. Of the

remaining area, 546 acres represent sawmill areas, the surveys of which were paid for by fees deposited by applicants.

Town Surveys.—Sixteen acres situated in Manapouri and Orepuki Townships were surveyed by Mr. Drury into 18 sections.

Other Works.—These included the traverses of water-races, sludge-channels, tramways, &c., in connection with M.D.L.O. surveys, minor surveys, reports, unfinished work, &c.

Roads and Water-races.—These represent 27·3 miles, nearly all of which were executed by the staff, in connection with blocks of land to be opened for selection.

Gold-mining Surveys.—There were only three of these surveys executed during the year. They were all done by private surveyors, and paid for by the applicants.

Proposed Operations.—On the completion of the block of 800 acres on which he is now engaged, I propose to place Mr. Otway on the subdivision of about 10,000 acres for settlement in Aparima and Jacob's River Hundreds. Mr. Macpherson will probably complete his landless Natives survey in Forest Hill and Hokonui Districts in October next, after which he will be available to assist in the cutting-up of the 10,000-acre block above referred to. Mr. Falkiner will be engaged during the whole of the current year in his subdivision for landless Natives of 14,700 acres in Waimumu and Lindhurst Hundreds. Mr. Drury will have finished his survey of 4,000 acres in Blocks V and VII, Longwood, about the end of July, and then will take up a further area contiguous. There are 18,000 acres for landless Natives in Stewart Island to be undertaken, which will require the services of two extra surveyors. There are other areas withdrawn from State forest, and some isolated areas that would keep another surveyor fully employed. In South Riverton a revision survey is required of the various Land Transfer subdivisions, to endeavour to reconcile the many known discrepancies in respect to the position of the roads and sections. For many years this particular corner of Southland has caused a great deal of trouble to every one.

Office-work.—During the year 72 ordinary survey-plans, representing 20,116 acres, were examined and approved, and also 20 sheets of railway-land plans. Twenty-nine photo-lithographic tracings for sale plans were made, 332 working-tracings, and 504 miscellaneous tracings. Two new Crown-grant record maps were compiled, and current work placed on existing maps, and 3 new application maps drawn. Many more of these require to be done, which work is being attended to as opportunity occurs. Twenty-four local bodies' schedules were prepared in duplicate, and 264 maps, lithographs, and tracings were mounted. In the Land Transfer branch, 75 plans, covering an area of 4,355 acres, were exmained and passed. By instructions from Head Office, a new map of the Dominion is being prepared in this office by Mr. Deverell, who has entered on his labour with enthusiasm; and, in the hands of one of his large experience as a draughtsman and artist, the result will no doubt be a very fine map. It is intended to represent the Dominion as it now is, with its cities, boroughs, and many small towns linked together by railways and roads. It will be issued in four sheets. The islands that are attached to the Dominion will also be shown. The scale fixed by the Home Government for the maps of India and the Dominion of Canada has been adopted, and I am pleased to state that the work is now well advanced, although the map may not be ready for the photo-lithographer till near the end of the present year. As has been pointed out on more than one occasion, another experienced draughtsman is much needed in this office to bring up the arrears. Many of the record maps are worn and dilapidated, necessitating new maps. Some of the county maps also require to be renewed, and fresh drawings made of several survey districts and towns, the lithographs of which are out of date. The compilation of new Land Transfer record maps has also had to remain in abeyance owing to the press of current work. One of the cadets, having completed his office course, was transferred to the field during the year. I have to thank the Chief Draughtsman and other officers for their faithful attention to their duties, and for the assistance given to me coming here a complete stranger.

H. M. Skeet,
Chief Surveyor.

APPENDIX II.

THE MAGNETIC OBSERVATORY AND THE MAGNETIC SURVEY.

During the past year the work of the Observatory has been successfully carried out in its various branches. The Adie magnetographs have been kept in thorough working-order, and an unbroken series of magnetograms has been obtained. It was found necessary to readjust all the three instruments, on account of the gradual slowaging of the working magnets and the accumulated secular change of the magnetic elements bringing the registration too near the edge of the magnetograms. This was successfully accomplished. A fresh determination of the sensitiveness of the horizontal force and vertical force magnetographs gave values within 3 per cent. of the values obtained previously. The usual absolute observations of magnetic declination, dip, and horizontal force necessary for evaluating the magnetic curves were made throughout the year. All the magnetograms and seismograms obtained during the year have been developed and annotated up to date.

A number of magnetograms showing the curves obtained on the most disturbed days are reproduced herewith. The vertical ordinates on these curves have the following scale-values :—

Declination curve	1 mm. = 3′.
Horizontal force curve	1 mm. = 0·00012 c.g.s.
Vertical force curve	1 mm. = 0·00010 c.g.s.

The great magnetic storm of the 25th November, 1909, began at Christchurch at 11.42 a.m. Greenwich time with a sudden increase of the easterly declination of about 4′. A simultaneous sudden

increase of the horizontal magnetic force of about 254γ was recorded, with a simultaneous increase in the vertical component of the field of about 3γ, followed, however, immediately by a much larger decrease of 10γ. The oscillations in the value of the vertical component were very irregular, and for some part of the time of duration of the storm the recording light spot was carried off the recording-paper. The maximum value of the vertical component recorded during the storm was only 20γ above normal at 16 h. 55 m., and the storm ceased at about 21 h. 30 m., lasting about ten hours.

In the case of the horizontal force, a maximum value 414γ above normal was recorded at 12 h. 30 m. Greenwich time, the force then diminishing 652γ, or 0·00652 c.g.s. unit, in the course of an hour, the recording spot being then carried off the paper.

The total range of the changes in declination during the storm was slightly over 1°·5, a marked maximum being recorded just after 13 h. and others occurring between 16 h. 40 m. and 18 h. 30 m.

During the disturbance the average value of the declination was greater than normal, of the horizontal component probably less than normal, and of the vertical component also less than normal, pointing to an average disturbing magnetic force (at Christchurch) directed (somewhat downward) to the west of south. The low value of the horizontal component persisted throughout the following day.

Milne Seismograph No. 16.

This instrument has been kept in satisfactory working throughout the year, and a number of the most important seismograms obtained are reproduced herewith.

Records were obtained of eighty-seven earthquakes during the year, about the average number recorded per annum.

The earthquake recorded here on the 12th June, 1909, commencing at 20 h. 25·5 m. Greenwich time, was also recorded at Sydney and Perth Observatories, and all three seismograms are given herein. It is evident from a comparison of the Sydney and Christchurch records that the origin of this quake was equidistant from these two places. The almost perfect agreement between the Sydney and Christchurch times of the various phases of the records is very striking. At Christchurch the beginning occurred at 20 h. 25·5 m., the commencement of larger waves at 20 h. 28·1 m., and the maximum motion at 20 h. 34·3 m. Greenwich time. At Sydney these occurred at 20 h. 25·8 m., 20 h. 28·2 m., and and 20 h. 34·3 m. Greenwich time respectively. It is evident that in this case the times of occurrence of the different phases of motion were not influenced by any differing local geological perculiarities, the short, medium, and long waves reaching both places simultaneously, within the limits of observational error. The longer waves evidently travelled from the origin along a path almost entirely overlain by ocean. A comparison of the three records shows that the earthquake origin, about 23° distant from Sydney and Christchurch, was under the ocean a few hundred miles to the south of the Royal Company Islands.

The only records obtained of earthquakes felt in New Zealand were those of the 12th November, 1909, felt at Wellington, and that of the 29th March, two slight shocks being then felt at Christchurch.

For the Milne seismograph a new recording apparatus has been ordered from the makers. This will give a much more open time-scale, and yield records of a much more modern type. It has also been decided to instal gas at the Observatory, which will be conducive to even better working of the self-recorders.

A table of earthquakes recorded during the year is appended.

Vector Diagrams of Mean Horizontal Disturbing Forces at Christchurch.

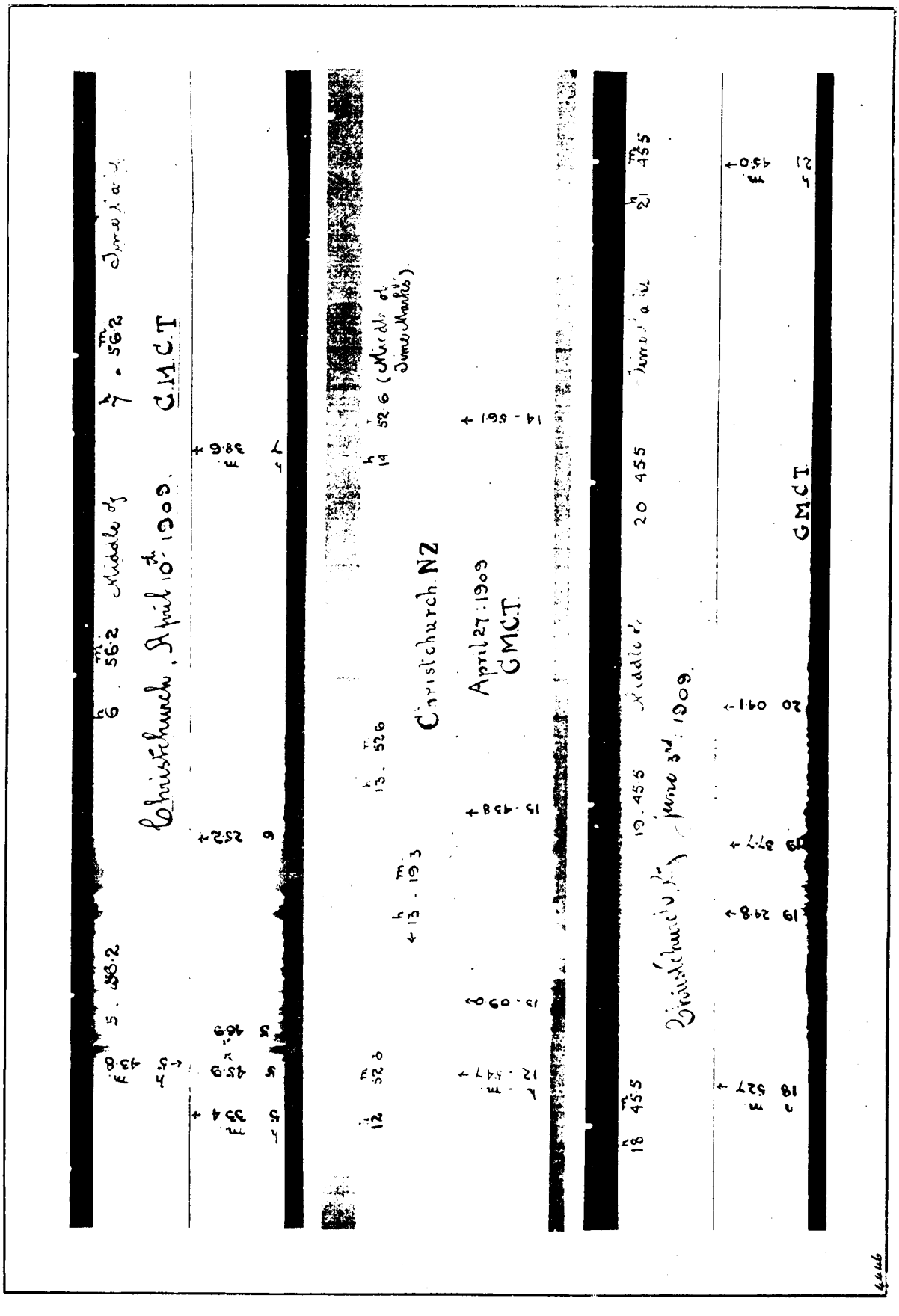
There are appended to this report four Vector diagrams illustrating the changes that occur in the direction and magnitude of the mean diurnal horizontal disturbing forces, as deduced from the magnetograms for 1902, 1903, and 1904. The curves are drawn for the mean day from all days for the three years, the first curve being for the summer months of November, December, January, and February for the combined three years. The second diagram is the corresponding curve for the four equinoctial months of March, April, September, and October. The third is for the winter months—May, June, July, and August. The fourth is for the year.

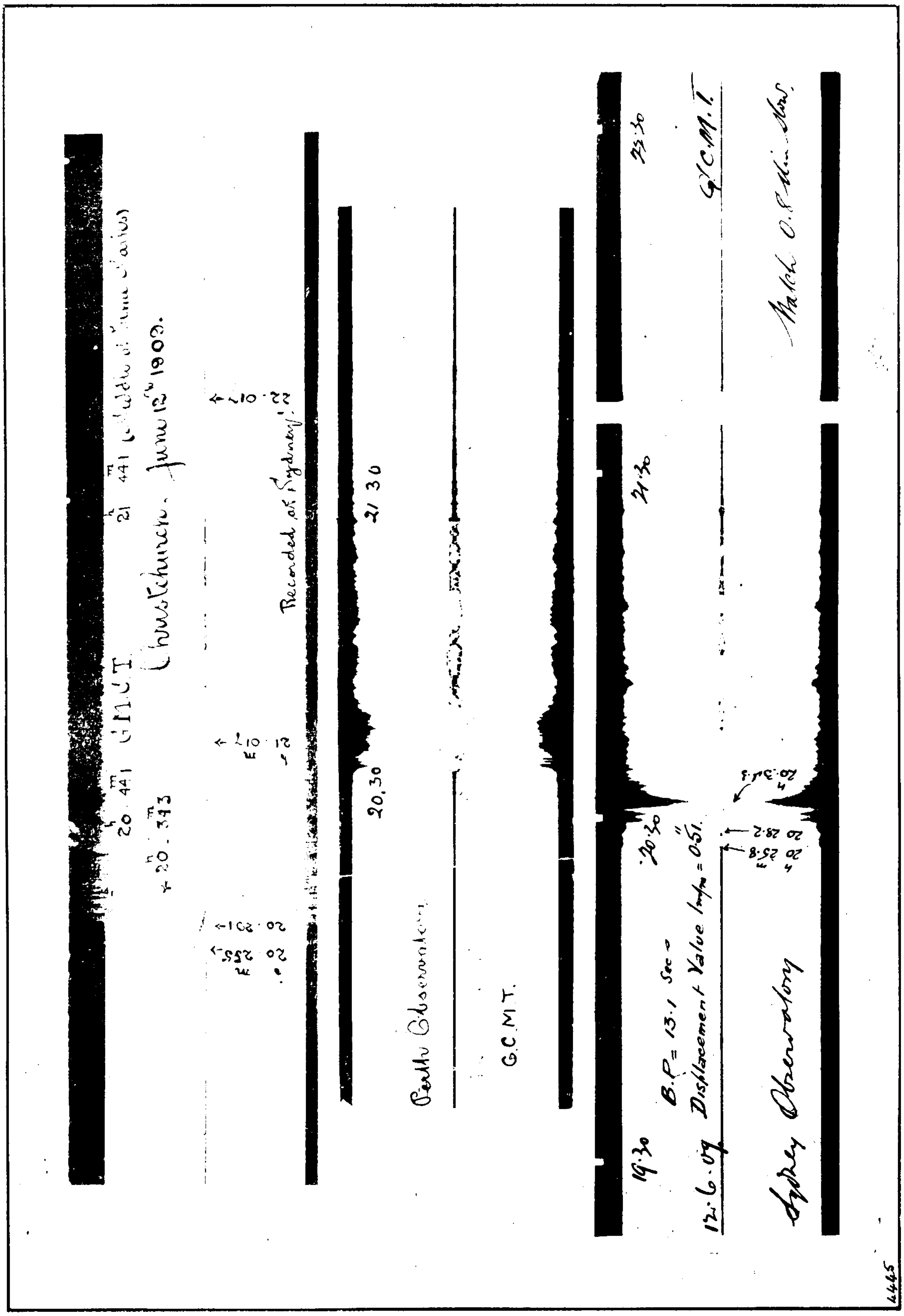
The curves are affected with diurnal non-cyclic inequality, but as this is of small magnitude, the effect is slight. They are drawn from the hourly values for Greenwich civil hours, as obtained from the magnetograms for those years, and only one stormy day of very excessive disturbance—viz., the 31st October, 1903—has been omitted. Investigation showed that the exclusion of other disturbed days did not materially affect the diagrams. The period covered is practically that of the period of antarctic research of the "Discovery" and other expeditions, and the diagrams will prove of much interest in connection with the study of the published magnetic results of those expeditions.

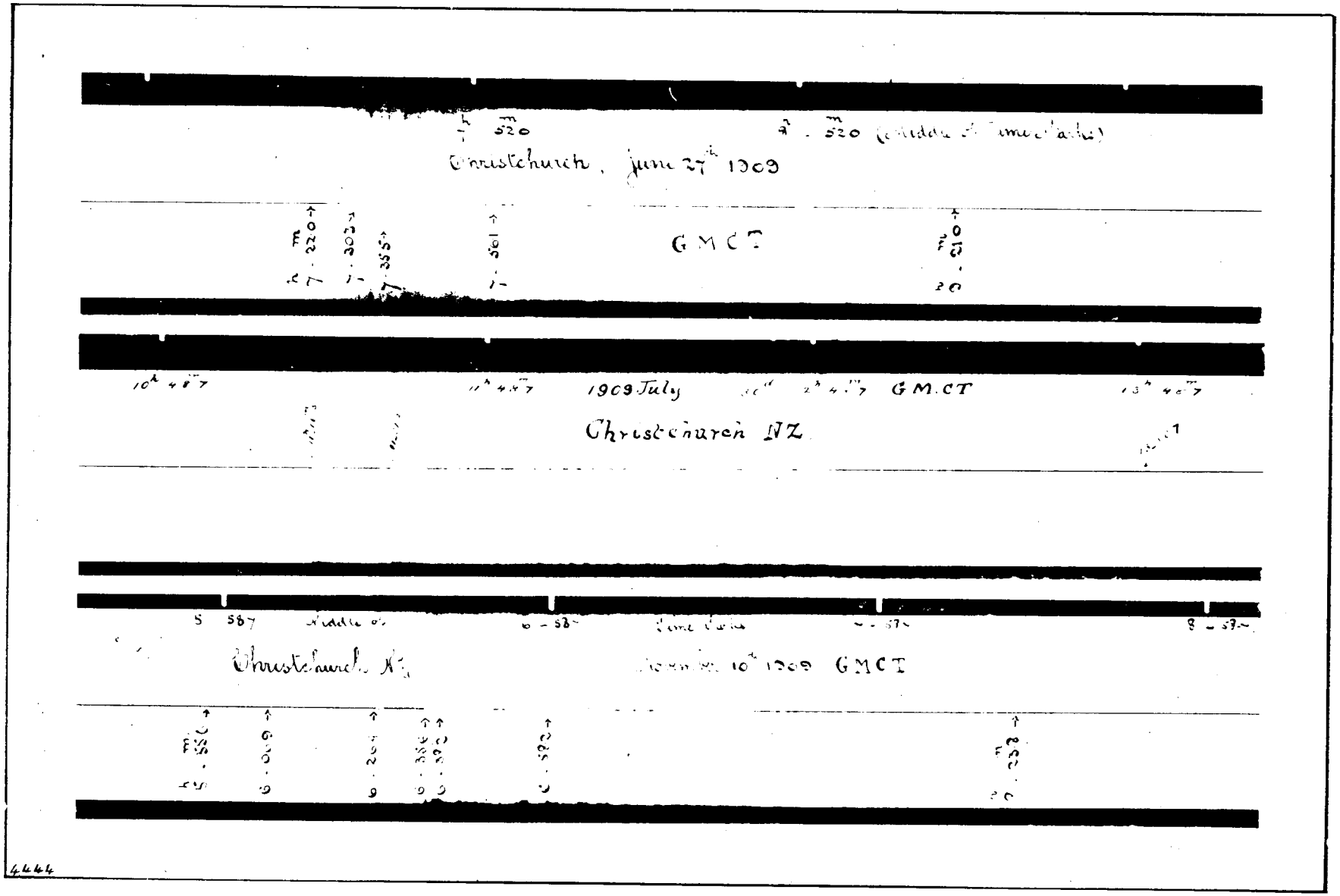
The diagrams are all drawn to the same scale, the line W.–E. or N.–S. being taken as 20γ, or 0·00020 c.g.s. unit, and the origin is taken at the point of bisection of these mutually perpendicular lines. Greenwich civil hours are indicated by the spots in the curve, numberd 0 to 23 (hours), and the magnitude and direction of the horizontal disturbing force at any time in the day is given by the straight line drawn from the origin to that point of the curve corresponding to the given time.

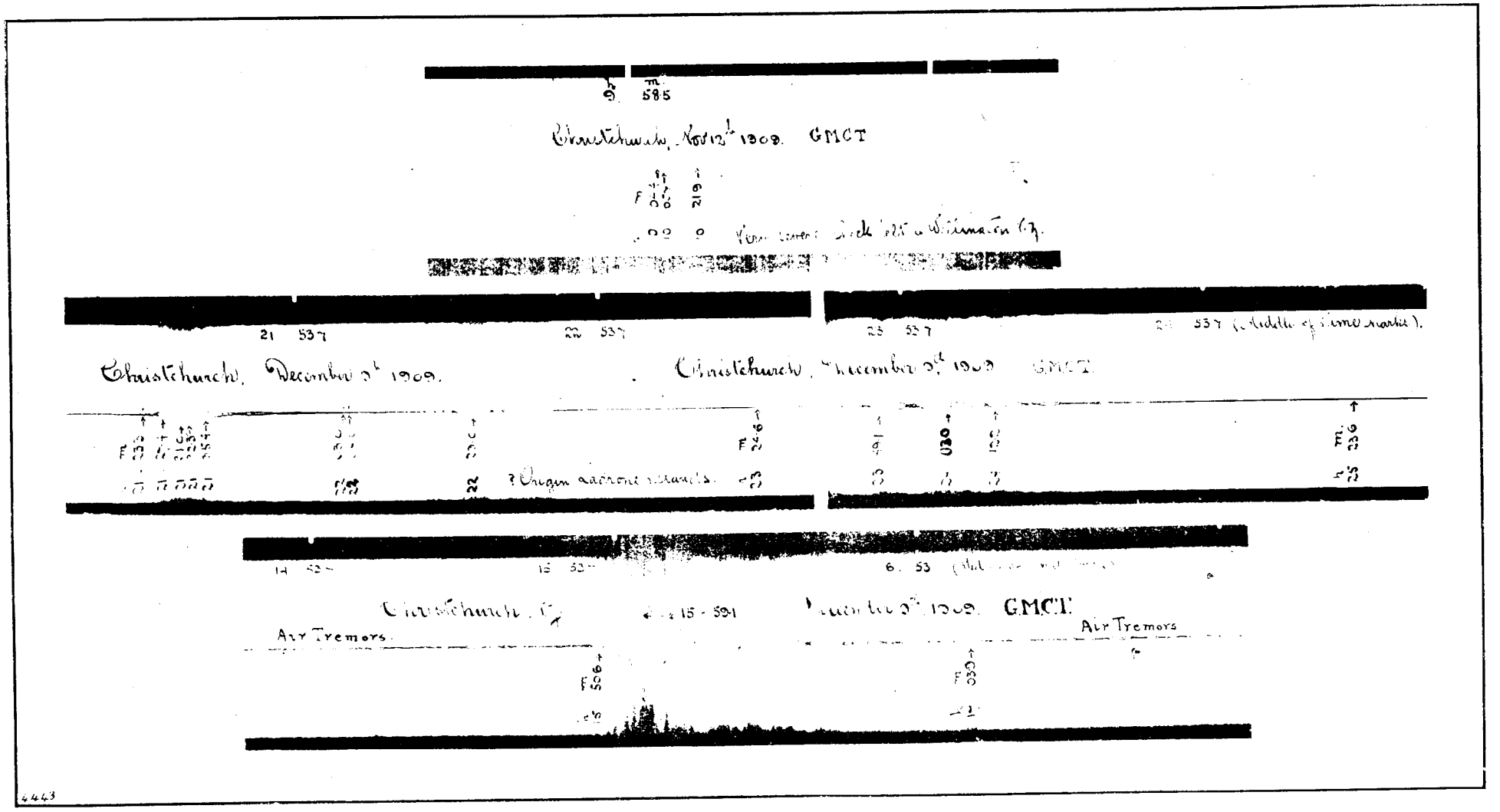
It is evident from the curves that the maximum westerly horizontal disturbing force occurs here in summer at 21 h., and in winter at 23 h., Greenwich time, or at 8.30 a.m. New Zealand time and 10.30 a.m. New Zealand time respectively; while the maximum easterly occurs at 3 h. in summer and somewhat later in winter—that is, at 2.30 p.m. New Zealand time in summer, and 2.50 p.m. New Zealand time in winter. These maxima occur during the equinoctial months at the hours of 9.30 a.m. and 2.30 p.m. respectively.

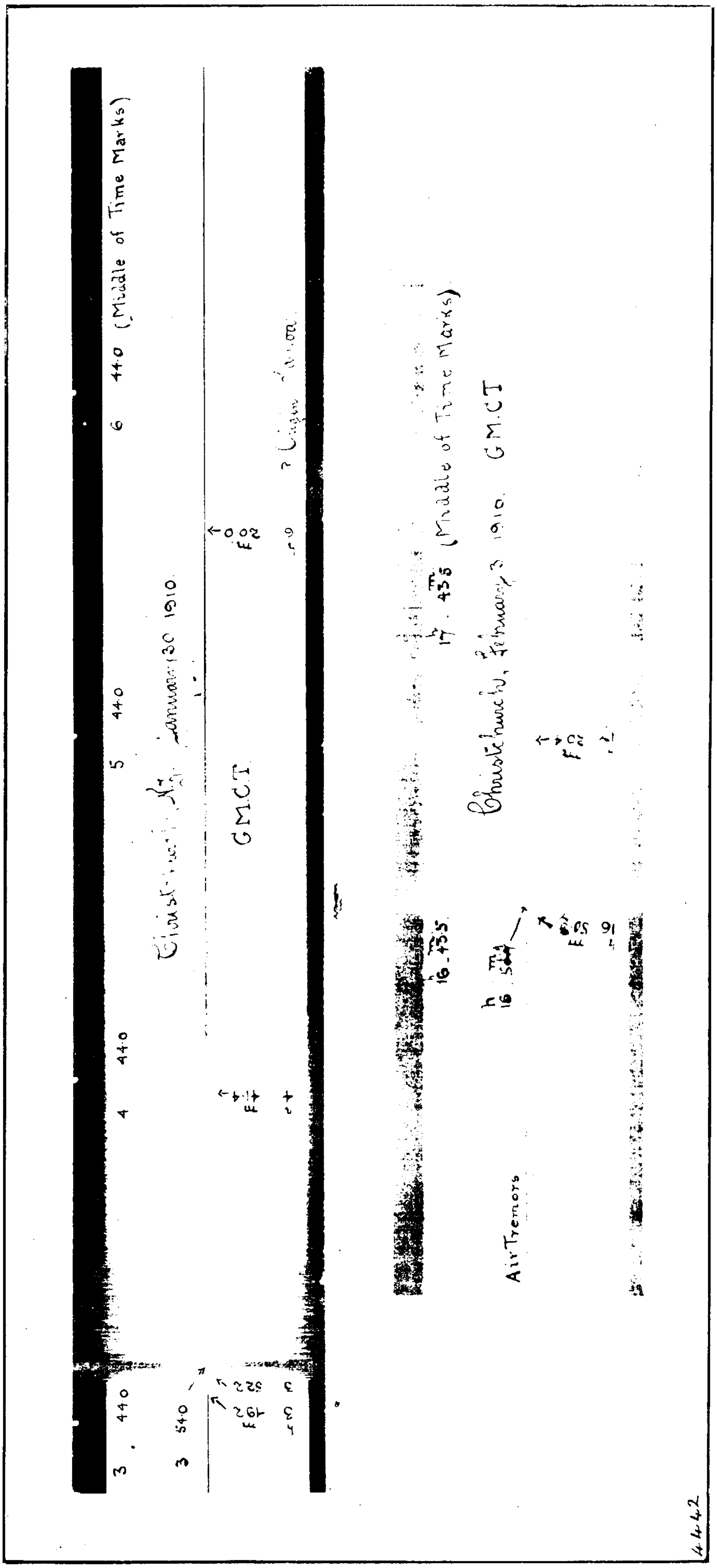
It is noteworthy that the change of seasons practically only affects the time of the maximum westerly disturbing force, which occurs here in the mornings, and leaves the time of the afternoon maximum easterly practically unaltered.

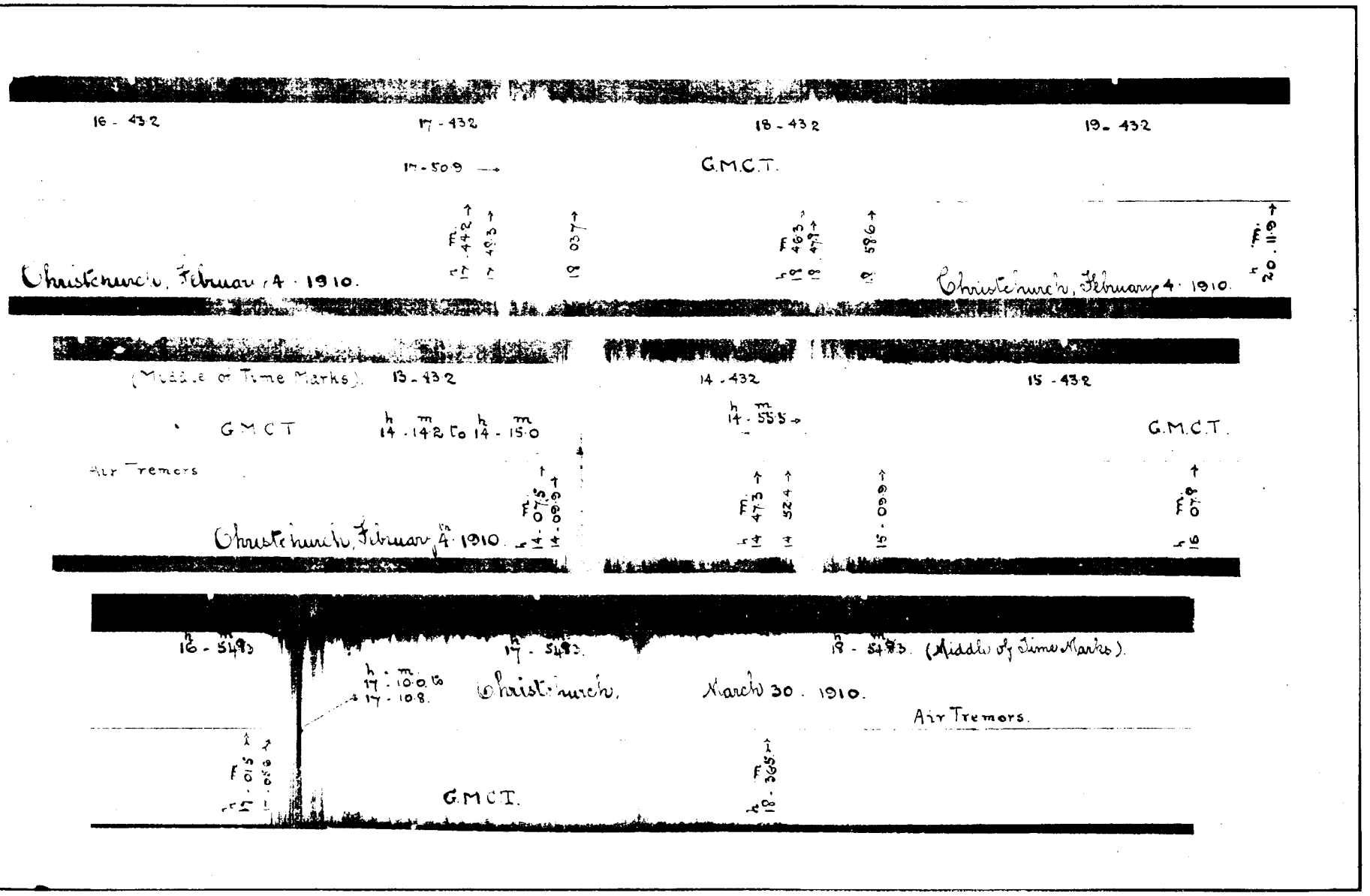

Christchurch, April 10th 1909. G.M.C.T
Christchurch N.Z.
April 27: 1909
G.M.C.T
Christchurch (N.Z.) June 3rd 1909.
G.M.C.T


G.M.T.
Christchurch. June 12th 1909.
Recorded at Sydney.
Perth Observatory
G.C.M.T.
Sydney Observatory
G.C.M.T.
4445


Christchurch, June 27th 1909
GMCT
1909 July
Christchurch NZ
GMCT


585
Christchurch, Nov 12th 1909. GMCT
Christchurch, December 2nd 1909.
Christchurch, December 2nd 1909. GMCT.
Air Tremors.
Air Tremors.
4443


(Middle of Time Marks)
GMCT
(Middle of Time Marks)
GMCT
Air Tremors
4442


16 - 432
17 - 432
18 - 432
19 - 432
17 - 509
G.M.C.T.
Christchurch, February 4 · 1910.
Christchurch, February 4 · 1910.
(Middle of Time Marks). 13 - 432
14 - 432
15 - 432
G M C T
14 - 142
14 - 150
14 - 555
G.M.C.T.
Air Tremors
Christchurch, February 4 · 1910.
16 - 549
17 - 549
18 - 549 (Middle of Time Marks).
17 - 100
17 - 108
Christchurch, March 30 · 1910.
Air Tremors.
G.M.C.T.

4441

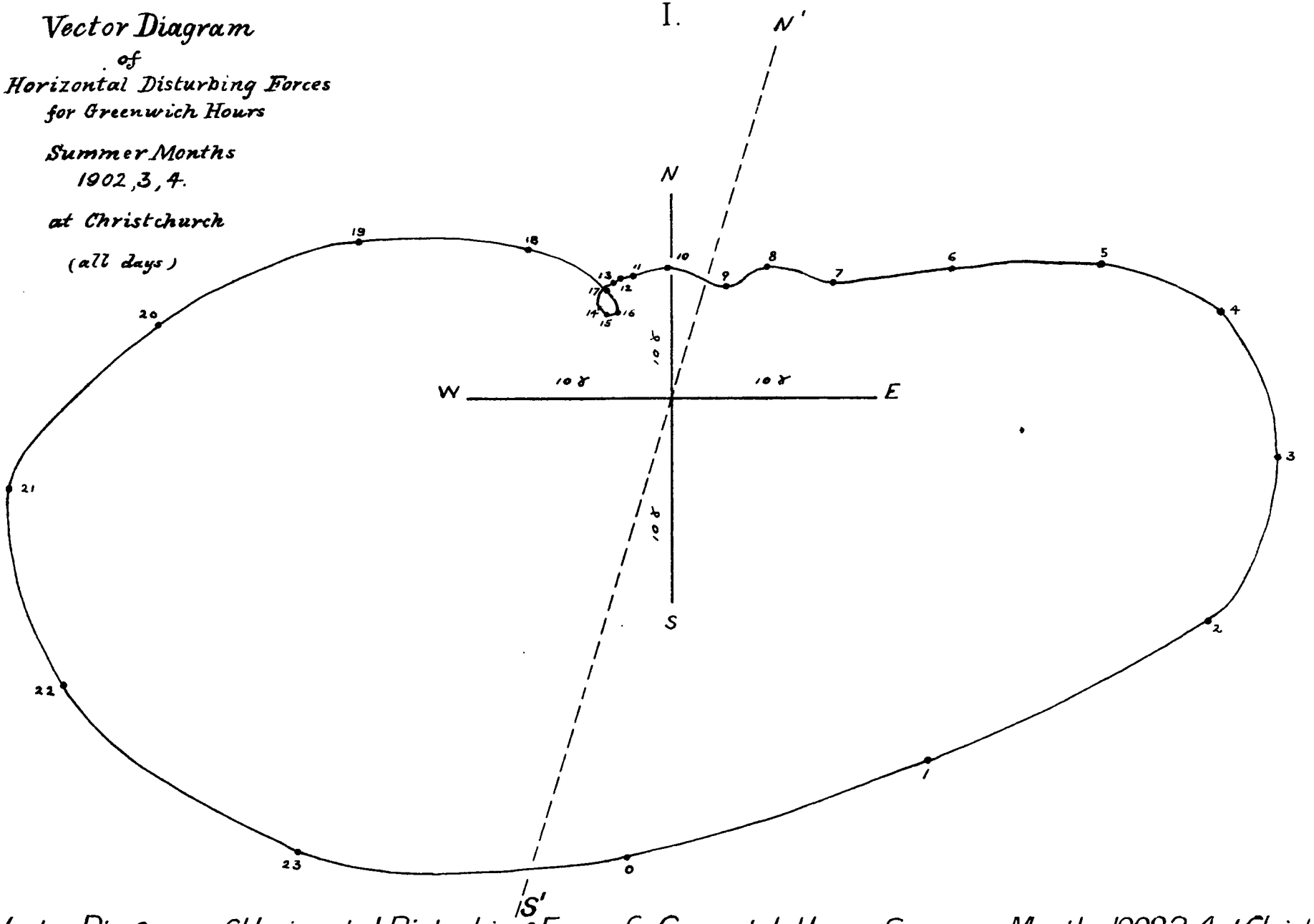
I.

Vector Diagram
of
Horizontal Disturbing Forces
for Greenwich Hours

Summer Months
1902, 3, 4.

at Christchurch

(all days)

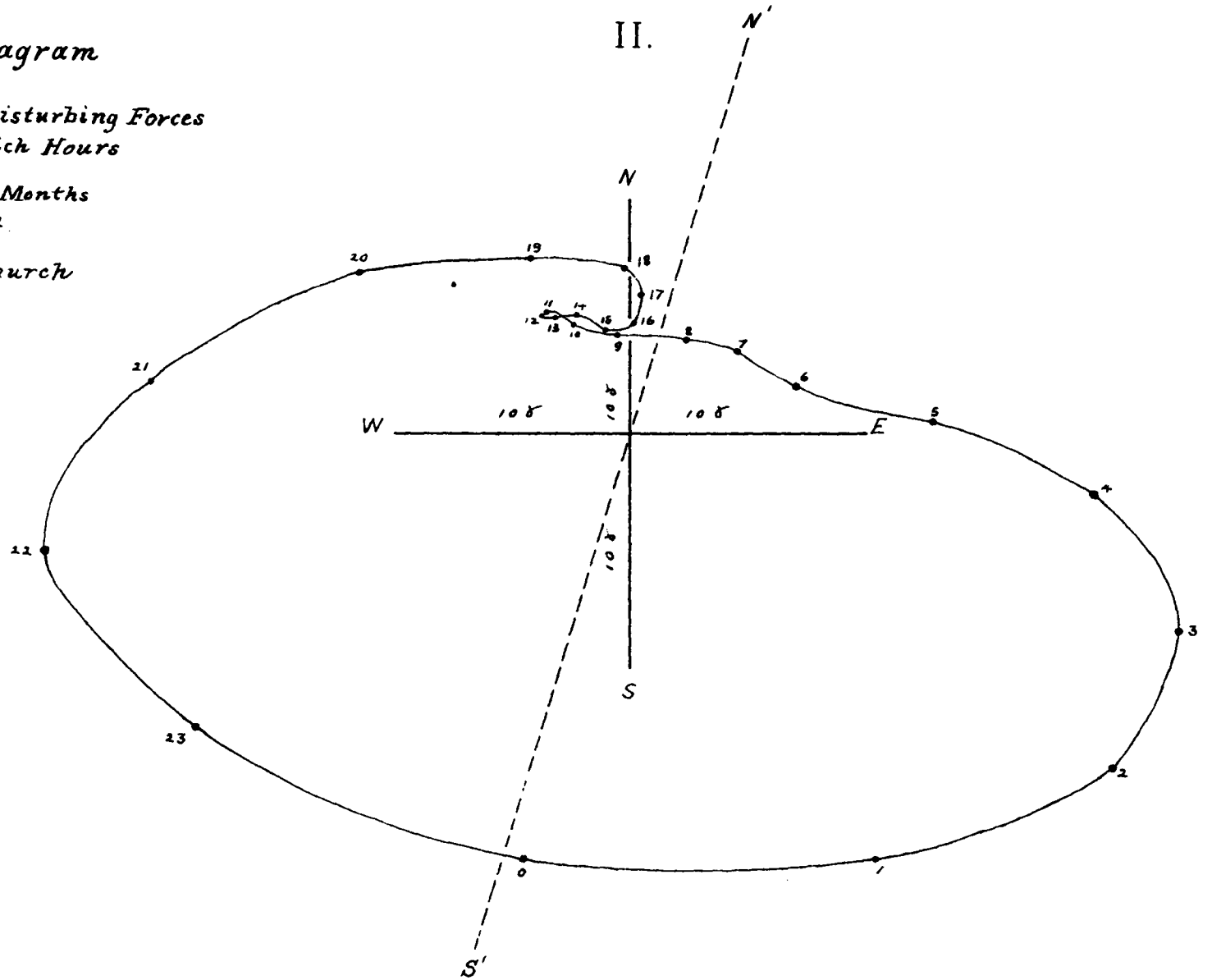


Vector Diagram of Horizontal Disturbing Forces for Greenwich Hours, Summer Months, 1902-3-4 at Christchurch.
(all days)

Vector Diagram
of
Horizontal Disturbing Forces
for Greenwich Hours

Equinoctial Months
1902, 3, 4

at Christchurch

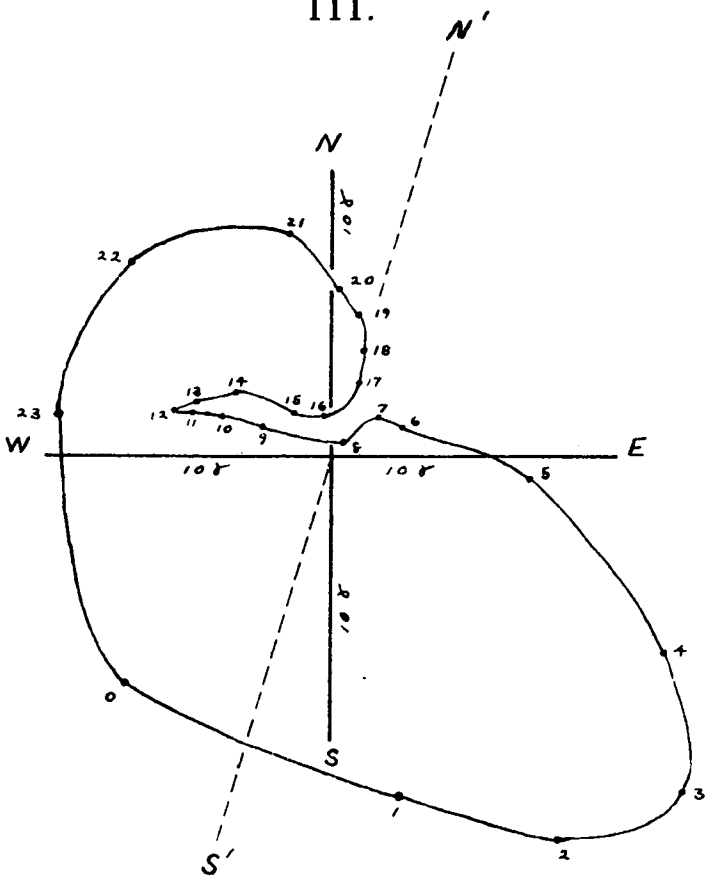


Vector Diagram of Horizontal Disturbing Forces for Greenwich Hours, Equinoctial Months, 1902-3-4 at Christchurch.

Vector Diagram
of
Horizontal Disturbing Forces
for Greenwich Hours

Winter Months
1902, 3, 4.

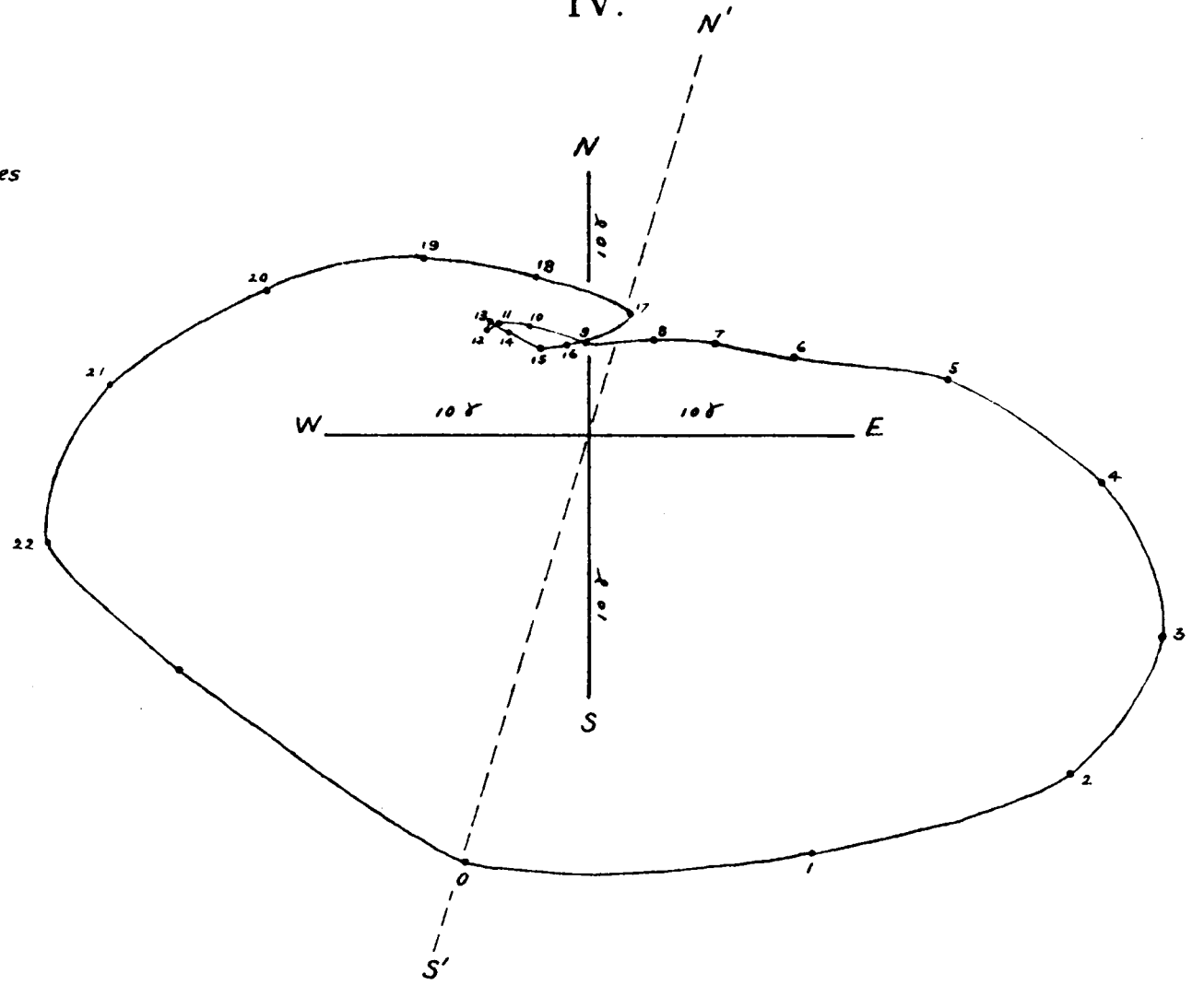
at Christchurch.



Vector Diagram of Horizontal Disturbing Forces for Greenwich Hours, Winter Months, 1902-3-4 at Christchurch

Vector Diagram
of
Horizontal Disturbing Forces
for Greenwich Hours

Year
1902, 3, 4.



Vector Diagram of Horizontal Disturbing Forces for Greenwich Hours. Years 1902-3-4

1500-7.10-436.

The maximum southerly horizontal disturbing force is seen to occur in summer at 23 h. 30 m. Greenwich or 11 a.m. New Zealand time during the mean equinoctial month at 12 noon New Zealand time, and in winter at 1.30 p.m. New Zealand time.

A subsidiary maximum westerly disturbing force occurs in summer at 13 h. 40 m. Greenwich or 1.10 a.m. New Zealand time in the mean equinoctial month, and in winter this occurs at 12 h. Greenwich or 11.30 p.m. New Zealand time.

During the equinoctial months the variation of northerly disturbing force between 8 h. and 16 h. Greenwich (7.30 p.m. and 3.30 a.m. New Zealand time) is seen to be very small. There is evidently a very marked difference between the curve for the night hours, the small but decided loop then occurring in summer becoming in the mean winter month a very marked invagination. The nocturnal variation of the easterly disturbing force, indeed, becomes in winter relatively very large, especially during the late night hours, and bears a much greater ratio to the variation in the daylight hours than it bears in the mean summer month, while this ratio is of an intermediate value in the equinoctial month. As might be expected, the curve for the mean equinoctial month bears a very general resemblance to the curve for the mean month of the year, but it is larger, and encloses a greater area, which points to a non-uniform progressive change in the amplitudes of the diurnal variations between summer and winter, either in spring or in autumn, or in both, and this may perhaps turn out to be accompanied by and connected with a similar want of uniformity in the rate of change of the absolute values of the magnetic elements during the year. The variations occurring in the early morning hours are characterized in summer by being largely in the northern component, and in winter in the easterly component. During the equinoctial month, the curve is seen to be very approximately symmetrical, about an E.–W. axis, between the daylight hours of 12.30 p.m. to 5 p.m. New Zealand time (1 h. to 5 h. 30 m. Greenwich), and also between the hours of 20 to 23½ Greenwich or 7.30 to 11 a.m. New Zealand time. The effect of the irregular variation occurring outside these intervals is, however, to render the two axes of symmetry non-coincident although parallel, the morning axis of symmetry being to the northward of the afternoon axis, which possibly indicates that non-cyclic change with which these curves are affected may be looked for as occurring outside the above intervals.

The mean values of the magnetic elements for the three years considered are as under :—

——	Declination E.	Horizontal Magnetic Force.	Vertical Force.	Inclination S.
1902	16° 15·1′	0·22694	0·55277	67° 40·8′
1903	16° 18·3′	0·22669	0·55286	67° 42·3′
1904	16° 21·8′	0·22644	0·55307	67° 44·1′
		Changes per Annum.		
1902-3	+ 3·2′	— 0·00025	+ 0·00009	+ 1·5′
1903-4	+ 3·5′	— 0·00025	+ 0·00021	+ 1·8′
Means	+ 3·35′	— 0·00025	+ 0·00015	+ 1·65′

Through the courtesy of the Royal Society, a copy of the volume embodying the magnetic observations made in connection with the British National Antarctic Expedition of 1902–4 has been received. In it a very considerable importance is given to the share this Observatory took in the concerted programme of observations, and due appreciation is expressed of the action of the Government in affording the use of the Observatory to the scientific members of the expedition for their work while in Christchurch.

Thanks are due to Dr. Chree, F.R.S., for his kindness in superintending the publication of the results, and for his thorough discussion of them.

It is understood that for his forthcoming expedition Captain Scott is also arranging a programme for magnetic work, besides the other scientific work to be undertaken. The expedition will sail from Lyttelton in the "Terra Nova," and all facilities will be afforded as previously by this Observatory for their preliminary magnetic work.

An account of the magnetic work undertaken in the Sub-Antarctic Islands during the scientific expedition of 1907 to those islands is published in "The Sub-Antarctic Islands of New Zealand," recently published by the Canterbury Philosophical Institute, towards the expense of which publication a very considerable grant was made by the Government.

Further progress has been made with the discussion of the Magnetic Survey. It was hoped to obtain a series of magnetic observations at the Kermadec Islands this summer, but it proved impossible to get there since the g.s.s. "Hinemoa" did not this year visit those islands, and there was no accommodation for passengers on the Government training ship "Amokura," which made the annual inspection in her stead. A future opportunity will be taken in order to get these observations.

It is expected that the discussion of the field observations will be complete, and the survey ready for publication, by the middle of 1911.

The usual regular meteorological observations were made throughout the year.

In conclusion, I have to thank the various private individuals, observatories, and other institutions that have kindly forwarded their publications to this Observatory during the past year.

I would also express my indebtedness to my assistant, Mr. B. V. Pemberton, for his invaluable assistance during the year.

HENRY F. SKEY, B.Sc.,
Officer in charge of Observatory.

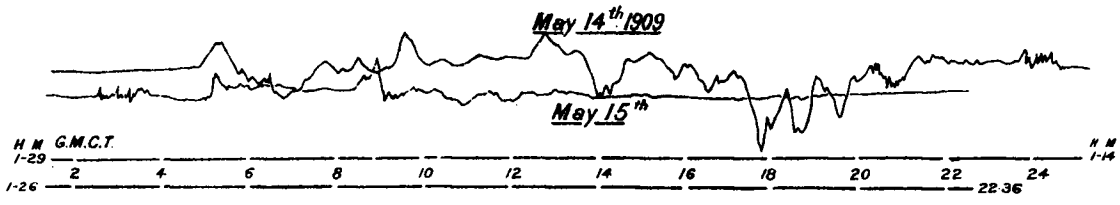
Records of Milne Seismograph No. 16, at Christchurch.

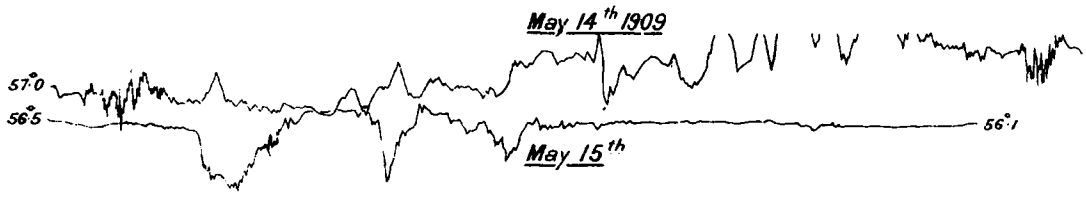
Latitude: 43° 31′ 50″ S. Longitude: 172° 37′ 18″ E. Time employed: Greenwich Mean Civil Time.

Time: G.M.C.T., as stated above. P.T. = Preliminary tremors less than 2 mm. complete range; A.T. = After-tremors less than 2 mm. complete range; B.E. = Beginning and end of vibrations not less than 2 mm.; Amp. = Half-range in millimeters.

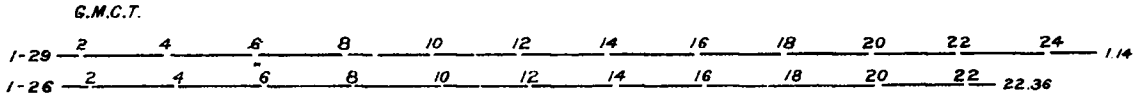
Date.	P.T. from	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. till	B.P.	Remarks.
				April, 1909.					
	H. m.	H. m.	H. m.	H. m.	Mm.	H. m.	H. m.	Secs.	
10	5 38·4	5 43·8	5 45·9	and 5 46·9	6·0	6 25·2	7 38·6	15·5	
12	1 14·3	1 18·5	1 22·6	..	3·95	1 37·1	2 43·3	..	
22	7 14·8	..	7 15·8	..	0·2	..	7 42·2	..	
27	12 54·7	13 09·0	13 19·3	..	6·8	13 43·8	14 56·1	..	
				May, 1909.					
2	7 06·1	7 12·3	7 15·4	..	1·9	7 17·5	8 30·9	..	
2	..	..	15 24·4	..	..	..	..	..	Very slight.
2	18 20·3	18 25·4	18 29·6	..	2·5	18 34·2	19 17·2	..	
11	Indefinite	..	13 21·7	..	1·75	..	Indefinite	..	In middle of air tremors.
12	0 57·2	..	1 19·3	..	0·3	..	1 52·4	..	
17	8 20·2	..	8 31·0	..	0·9	..	9 56·9	..	
24	7 13·4	..	7 17·0	..	0·5	..	7 25·8	..	
25	4 59·7	..	5 27·6	..	1·1	..	6 08·0	..	
30	Indefinite	21 35·9	21 37·9	..	2·9	21 47·2	22 44·6	..	P.T. obscured by air tremors.
				June, 1909.					
8	18 52·7	19 24·8	19 37·7	..	2·2	20 04·1	21 45·0	..	
			6 11·8	..	..	..	..	..	
			6 39·7	..	0·7	..	..	..	
8	6 09·7	..	6 55·2	..	..	..	..	..	
			7 13·9	..	..	..	Indefinite	..	A.T. obscured by air tremors.
9	0 51·0	..	..	..	..	..	1 55·0	..	Very small; maximum at beginning.
12	20 25·5	20 29·1	20 34·3	..	7·5	21 01·7	22 01·7	..	
14	7 31·1	..	7 38·4	..	0·4	..	7 53·4	..	
15	1 19·8	..	..	..	..	..	2 00·1	..	Thickening merely.
26	9 35·6	..	9 36·6	..	0·1	..	9 39·7	..	
27	7 22·0	7 30·3	7 35·5	..	4·7	7 56·1	9 21·0	..	
28	Indefinite	..	15 29·0	..	0·7	..	Indefinite	..	P.T. and A.T. obscured by air tremors.
				July, 1909.					
1	13 03·7	..	13 10·9	..	0·3	..	13 31·6	..	
2	6 25·9	..	6 28·5	..	0·1	..	6 57·0	..	
5	Indefinite	..	17 55·3	..	3·5	..	Indefinite	..	P.T. and A.T. obscured by air tremors.
			13 42·8	13 58·9	0·4	..	..	..	
10	13 40·3	..	14 11·3	..	..	..	14 13·4	..	
26	22 06·6	..	22 08·1	..	..	..	22 22·1	..	Slight thickening.
27	4 34·5	..	4 36·1	..	0·2	..	5 03·5	..	
30	11 16·5	..	11 16·5	and 11 31·2	0·8	..	13 50·7	..	First maximum at beginning of quake. (?) Origin, Mexico
				August, 1909.					
4	6 18·3	..	6 20·4	..	0·1	..	6 24·5	..	
6	5 46·0	..	5 49·1	..	0·4	..	5 57·4	..	
10	6 56·1	..	7 01·2	..	0·25	..	7 17·8	..	
13	12 19·7	..	12 21·7	..	0·25	..	12 25·9	..	
16	7 54·6	..	8 17·7	..	0·4	..	8 36·6	..	
18	0 35·4	0 46·2	0 56·4	..	3·9	1 05·7	2 04·6	..	In progress while attending to instrument.
29	28 59·5	..	..	..	..	..	25 33·4	..	Thickening of line.
				September, 1909.					
8	8 11·2	..	8 18·4	..	0·35	..	8 29·7	..	
25	12 29·6	..	12 32·7	..	0·5	..	12 44·0	..	
				October, 1909.					
3	1 28·8	..	..	..	..	..	3 44·2	..	Thickenings.
4	13 53·2	..	14 07·0	..	0·9	..	Indefinite	..	A.T. obscured by air tremors.
21	0 45·5	..	..	..	..	..	1 40·4	..	Thickenings.
23	Indefinite	..	21 28·9	..	..	..	21 56·6	..	P.T. obscured by air tremors.
27	1 32·3	..	1 33·3	..	0·35	..	2 08·5	..	
30	10 33·8	..	11 02·0	..	0·9	..	Indefinite	..	A.T. obscured by air tremors.

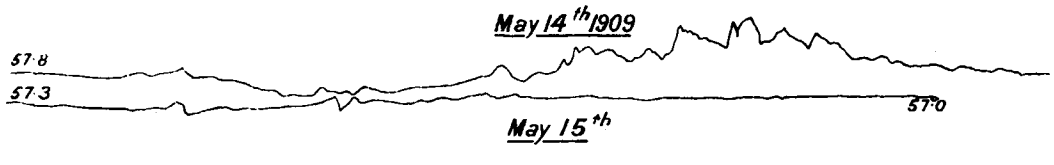
— Dec. Chch. —



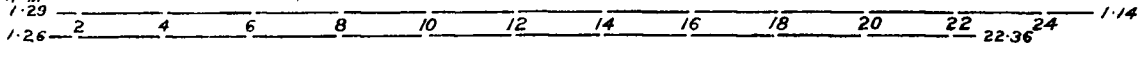


— H.F. Chch. —





— V. F. Chch. —



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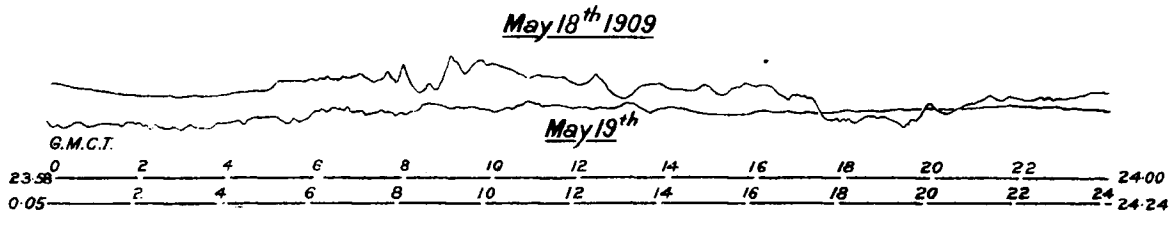
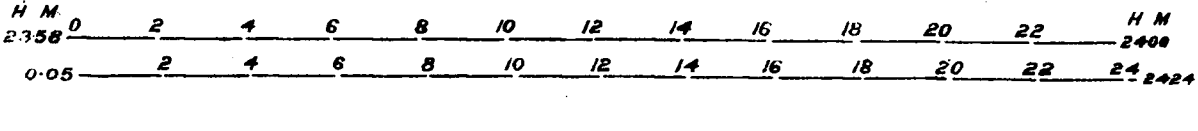
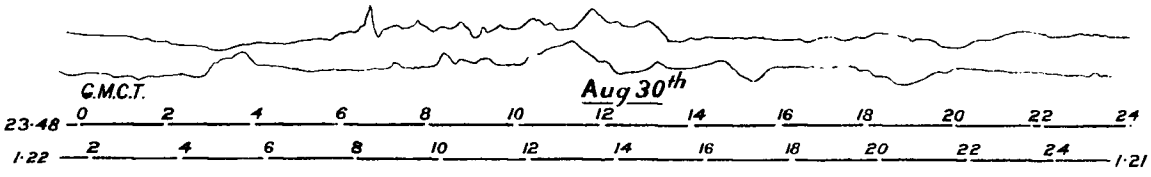


— H.F. Chch. —



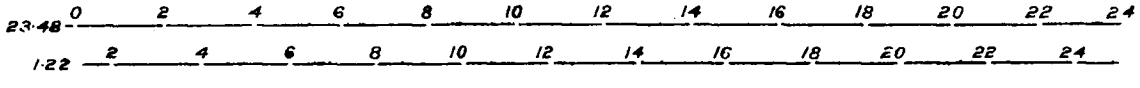
—Dec. Chch.—

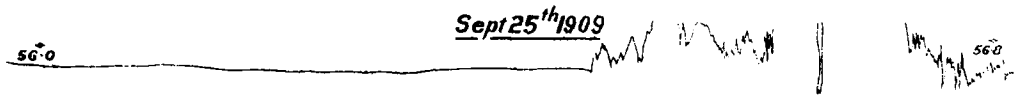
August 29th 1909



August 29th 1909

—H.F. Chch.—





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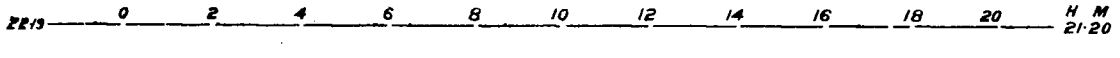

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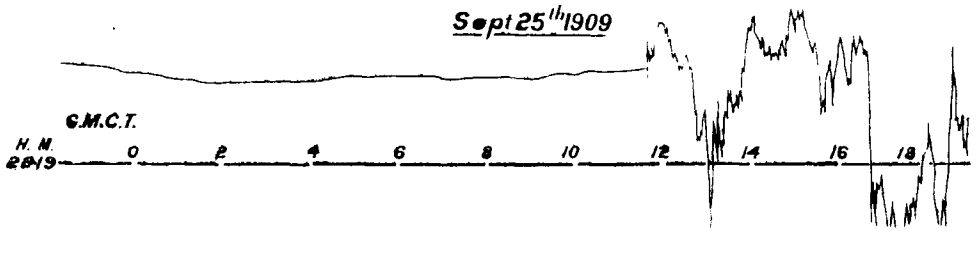

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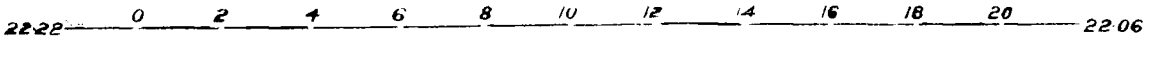

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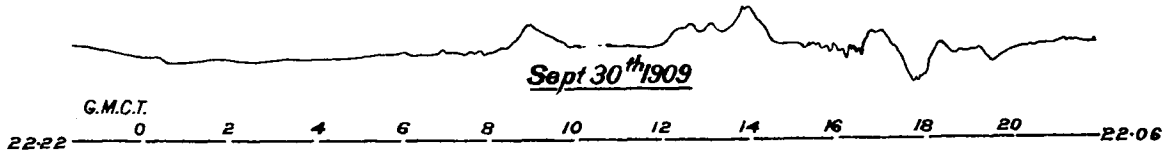

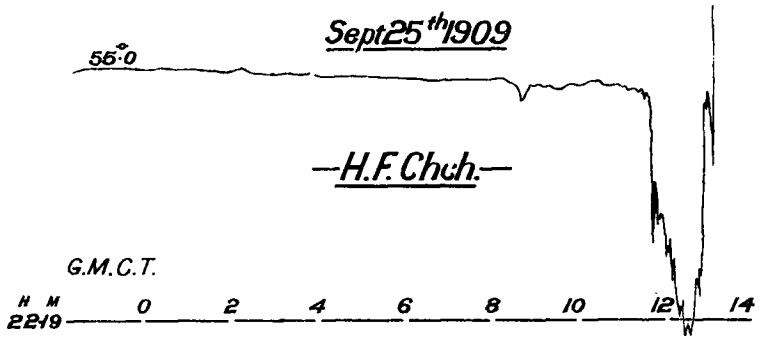

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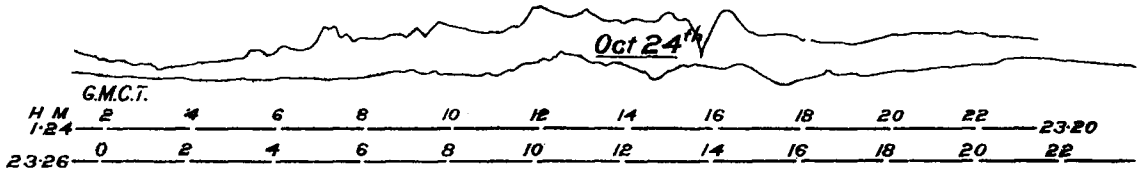
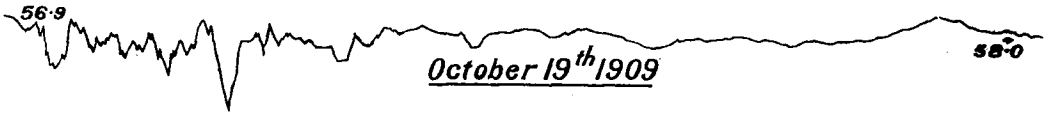
Oct 23rd 1909





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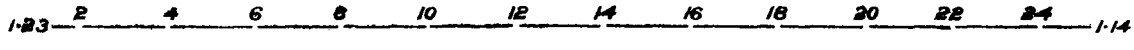

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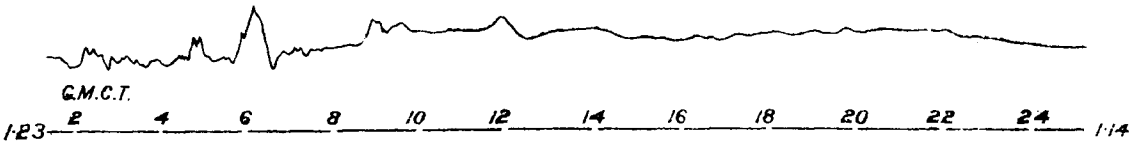
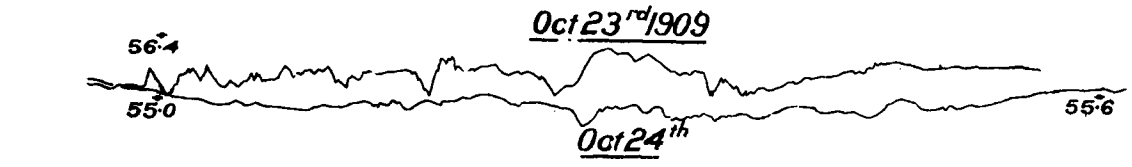
Oct 19th 1909





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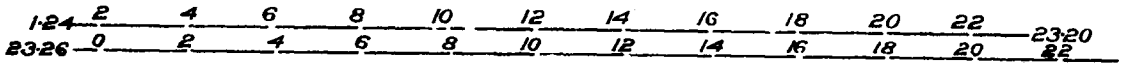
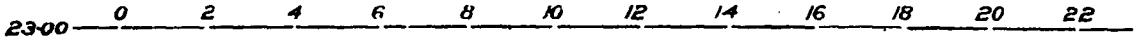


—H.F. Chch.—



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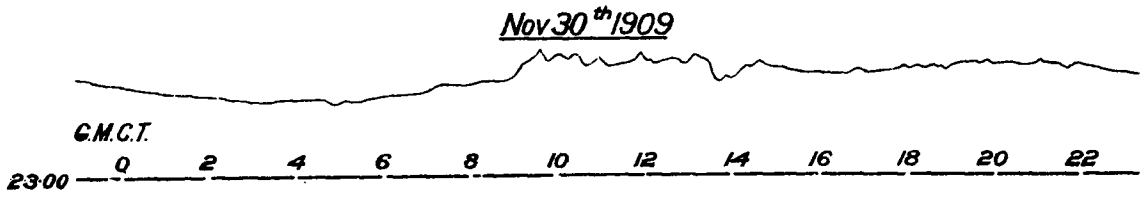

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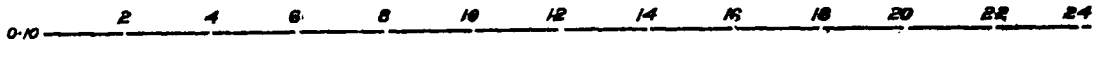
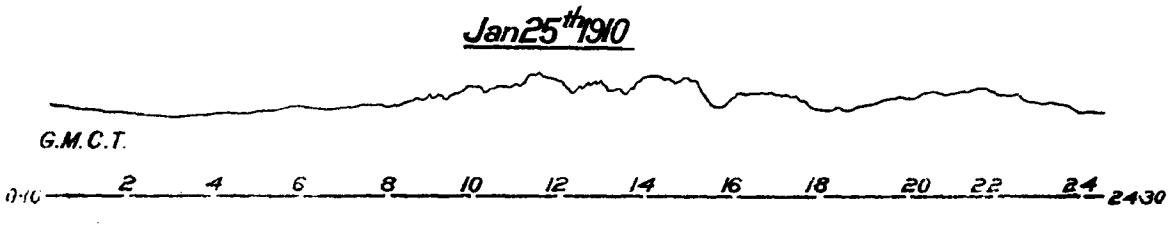
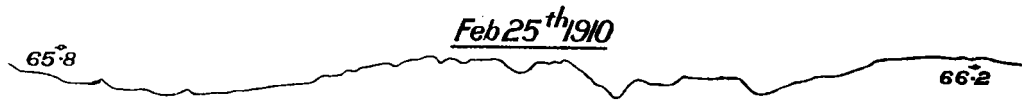


—Dec Chch—





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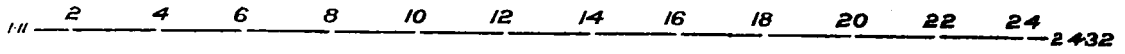

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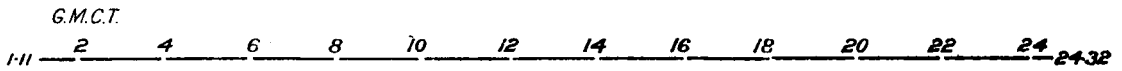
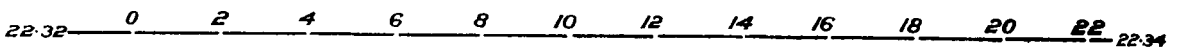
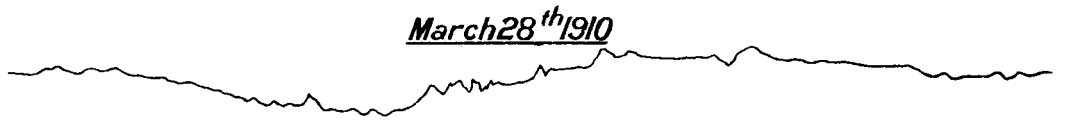


March 28th 1910

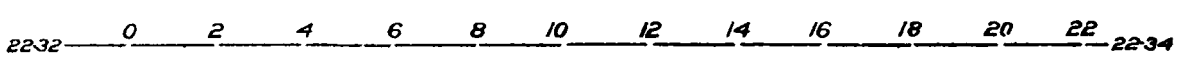
G.M.C.T.

—H.F. Chch—





—V.F. Chch—



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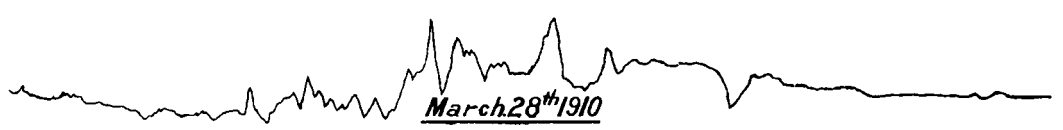
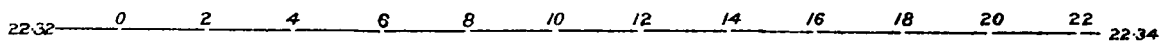




1500.710.432

RECORDS OF MILNE SEISMOGRAPH No. 16, AT CHRISTCHURCH—*continued.*

Date.	P.T. from	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. till	B.P.	Remarks.
				NOVEMBER, 1909.					
3	6 19·0	6 23·9	6 25·4	..	3·25	6 29·6	7 34·7	..	
10	5 55·6	..	..	..	..	..	6 06·9	..	Thickening of line.
10	6 26·4	6 35·6	6 38·2	..	1·4	6 58·2	8 23·8	..	
12	10 04·4	..	10 05·7	..	1·0	..	10 21·9	..	Very severe shock; felt in Wellington, New Zealand.
14	9 47·3	..	9 49·7	..	0·15	..	9 54·5	..	
27	21 19·1	..	..	..	..	..	21 47·3	..	Slight thickening. Possibly air tremors.
27	..	..	22 23·2	..	..	..	..	..	
28	1 07·8	1 14·5	1 15·6	..	1·6	1 27·9	2 32·0	..	
28	8 28·3	..	8 34·0	..	0·5	..	8 59·1	..	Preceded and followed by minute air tremors.
				DECEMBER, 1909.					
	H. m.	H. m.	H. m.	H. m.	Mm.	H. m.	H m.	Secs.	
3	3 25·0	..	3 33·3	3 34·8	0·9	..	4 04·5	..	
8	9 17·6	9 23·8	9 25·8	..	2·1	9 28·4	10 18·6	..	
9	Indefinite	15 50·6	15 59·1	..	5·75	17 03·9	Indefinite	..	P.T. and A.T. obscured by air tremors.
9	21 23·3	21 27·4	21 31·0 and	21 32·3	2·0	21 35·4	22 03·0	..	(?) Origin, Ladrone Island.
9	22 04·0	..	22 29·0	..	1·0	..	23 24·9	..	(?) Origin, Ladrone Island.
9	Indefinite	23 49·1	24 03·0	..	1·4	24 12·2	25 23·6	..	(?) Origin, Ladrone Island. P.T. began while attending to instrument.
22	Indefinite	13 01·3	13 02·8	..	5·9	13 32·0	Indefinite	..	Preceded and followed by air tremors.
23	19 30·2	..	19 36·4	..	2·3	..	20 32·8	..	
23	22 32·3	..	22 45·1	..	1·0	..	23 30·7	..	
28	Indefinite	..	19 56·5	..	1·0	..	Indefinite	15·5	In middle of air tremors.
				JANUARY, 1910.					
10	Indefinite	..	19 27·8	..	0·3	..	Indefinite	..	P.T. and A.T. obscured by air tremors.
13	0 22·2	..	0 34·6	..	0·45	..	1 06·6	..	
15	Indefinite	..	10 58·1	..	0·65	..	Indefinite	..	P.T. and A.T. obscured by air tremors.
15	22 52·9	..	..	..	..	..	23 12·6	..	Thickening of line.
19	15 01·1	15 07·7	15 09·3	..	1·5	15 14·3	16 22·6	..	
29	5 03·7	..	5 11·9	..	1·0	..	6 04·7	..	
30	3 49·2	3 52·2	3 54·0	..	17·0+	4 41·4	6 20·0	..	(?) Origin, Samoa.
				FEBRUARY, 1910.					
3	9 57·9	..	10 05·8	..	0·75	..	10 24·5	..	
3	Indefinite	16 50·7	16 51·9	..	17·0+	17 20·4	Indefinite	..	P.T. and A.T. obscured by air tremors.
4	14 07·5	14 09·9	14 14·2	14 15·0	17·0+	14 47·3	Indefinite	..	A.T. obscured by following quake.
4	Indefinite	14 52·4	14 55·5	..	5·0±	15 09·9	16 07·8	..	P.T. obscured by preceding quake.
4	17 44·2	17 48·3	17 50·9	..	2·75	18 03·7	Indefinite	..	A.T. obscured by following quake.
4	Indefinite	18 46·3	18 47·8	..	1·4	18 58·6	20 11·9	..	P.T. obscured by preceding quake.
6	2 13·7	..	2 15·2	..	0·25	..	2 25·0	..	
6	4 41·5	..	4 45·1	..	0·2	..	4 51·2	..	
6	7 16·2	..	..	..	..	..	7 36·8	..	Thickening of line.
7	23 03·2	..	23 04·7	..	0·1	..	23 13·5	..	
13	10 04·9	..	10 08·5	..	0·45	..	10 39·2	..	
15	1 27·1	..	1 31·2	..	0·25	..	1 58·4	..	
				MARCH, 1910.					
1	11 37·8	..	11 44·0	..	0·5	..	12 52·3	..	
29	..	..	8 48·9	..	0·25	..	..	..	Sharp and sudden. Felt at Christchurch.
29	..	..	8 50·4	..	0·15	..	..	..	
30	17 01·5	17 05·6	17 10·0	17 10·8	17·0+	18 36·5	Indefinite	..	A.T. obscured by air tremors.
30	23 59·4	..	24 02·7	..	0·4	..	24 27·1	..	
31	5 37·2	..	5 40·9	..	0·2	..	5 51·2	..	

APPENDIX III.—SECONDARY TRIANGULATION.

MEASUREMENT OF THE WAIRARAPA BASE-LINE.

[By J. Langmuir, Inspecting Surveyor.]

Having been detailed to measure the first base-line in connection with the proposed scheme of secondary triangulation of the Dominion, I have been requested by Mr. T. Humphries, who was the Surveyor-General when the work was done, to write a description of the apparatus used and methods followed in the work.

A considerable amount of literature on the subject of base-measurements has appeared during the last few years, dealing with refined work in various parts of the world, notably the United States of America, South Africa, Rhodesia, Egypt, &c. It might have been expected that before this a standard design of apparatus would have been evolved, suitable for any country and type of measurement required, but such does not appear to be the case; and in submitting this description of methods and apparatus used I do not assume any superiority over similar apparatus used in other places, but simply claim that it has sufficiently satisfied expectations in the results attained.

Before proceeding to details, it is desirable to give a general description of the position and topographical features of the line, with the climatic difficulties of the locality. The latter were very marked, the high and frequent winds being the most disturbing element, and no doubt have had more or less influence on some of the sectional results. The Wairarapa district is generally acknowledged to be the most windy in New Zealand, and, although the work was carried out in what has been considered the most favourable season of the year, still the locality amply maintained its character in this respect, and much time was lost in waiting for suitable weather.

Geographical Position of Base.

The south end of the base is Trig. Station Bidwill, the position of which is approximately S. lat. 41° 12′ 30″ and E. long. 175° 24′.

Selection of Base.

The base was selected by Mr. H. J. Lowe, District Surveyor, in December, 1908, and was finally examined, and approved by the Surveyor-General, on the 20th January, 1909.

In deciding on the position, the following requirements were considered to be essential:—

(1.) That this, the first base, should be as near the south end of the triangulation as possible.

(2.) That it should be so placed as to render extension from it as simple and perfect as possible. As regards this requirement, it is rarely that such natural conditions exist as have in this case lent themselves for the almost perfect geometrical figures of expansion from the base, forming an ideal base net (see Fig. No. 1).

(3.) That it should avoid if possible all obstacles of any nature whatever that would interfere with direct measurements.

Acknowledgment should be made here to the ready courtesy with which Mr. Lowe was met by those settlers through whose properties the line runs, and their prompt consent to the insertion of the necessary marks on the line, clearing the same, and permission to camp where suitable. Especial thanks were due to the late Mr. J. Williams, Kaiwaiwai, for the privilege of camping near his homestead, and other appreciated favours.

The line selected starts from a point about three-quarters of a mile south-west along the railway-line from the Woodside Station on the Wellington-to-Napier Railway-line, and, running on a bearing of about 176° 46′, intersects in parts closely occupied country; forty-one barb-wire fences being crossed during the course of the measurements. (See Fig. No. 2.) The longitudinal section of the base also shown in Fig. No. 2 generally indicates its profile, but it may further be mentioned that sections 1, 2, and 3 are of a very shingly nature, there being in many places little or no soil overlying the loose stones, which increased the difficulties of setting up both theodolite and measuring-tripod. Sections 4 and 5 are mostly free from shingle, and are good measuring-country. Section 6 is a surface-dry swamp, but the subsoil to a depth of 6 ft. in places consists of soft peat, through which, down to the solid, heavy stakes of sawn timber, 5 in. by 4 in., were driven, to provide stable supports for both theodolite and tripod legs. Sections 7 and 8 are good measuring-ground, but section 9 is for the greater part irregular, with steep rising and falling grades, in some cases approaching to 15° of inclination; and owing to the prevalence of wind it was found absolutely necessary to closely follow the undulations of the country with the measurements. Great care was, however, taken in observing the vertical angles: where these were large eight readings were taken with the instrument in direct and reversed positions, particular attention being paid to the bubble-readings.

It should be explained here that the reason for introducing this section into the line at all was the great desirability of having the base directly connected to "Bidwill," one of the main stations of the triangulation, and for the extension of the latter eastwards. A quite satisfactory base in itself could have been obtained near the one chosen, and about 50 chains shorter, but the improvement in the facilities of expansion attached to the longer base was considered to be of such importance as to outweigh any difficulties inherent to the measurement of section 9.

It is very satisfactory, therefore, to be in a position to say that, judging from the residuals alone of the four measures of section 9, the results of the measurements of this section will be quite as good as those of the measurement of the more level portions of the line. (See Table of Measurements No. 1.)

It may be argued that to depart from established precedent, and attempt by the vertical-angle method to measure a base-line with such steep grades as have been introduced into this one, would simply be to court complete disaster; and, were it not that the writer had had a good deal of experience in standard surveys, where often, to "close" circuits or for other reasons, much steeper grades than any on this line were faced in this way with most satisfactory results, no such attempt would probably have been made in this case. It must be admitted that there are risks attached to the method, and some of these risks increase rapidly with increases in the inclinations observed. The reference plane for angle observations is itself not a stable one, as it depends wholly on the accuracy of the level-bubble; but, notwithstanding the apparent difficulties, it was nevertheless felt, in the light of past experience, that the advantages of the method, when practised with the required care, more than counterbalanced the risks; and I think that this confidence has been fully justified by the results obtained. It must always be kept in mind that any vertical angle measured in this method is pivoted directly on the axis of the vertical arc, to which all lineal measurements are also referred; that no intermediate processes are introduced to obtain the angle; and that errors caused by refraction are very small, and largely compensating in action.

When eight readings are taken, the average error per angle will probably not be more than 3". (See Fig. No. 3 for a diagram of an actual test carried out to check the readings of vertical angles.)

As a further check, however, on the direct measures of section 9, an auxiliary base of about 114½ chains was measured on the plain.

The measurement of this auxiliary base was made with all the accuracy of that of the main base-line, there being only two cases in it where the angles of inclination exceeded half a degree, one of about 2½° on a length of 3 chains, and the other of about 1¼° on a length of 262 links.

Details of the four measurements are given on Table No. 1.

One side of the triangle off this base is coincident with section 9, but about 1 chain shorter, and, as all the angles were measured with a 10 in. Everest theodolite, the measure of section 9 thus verified is very satisfactory. Mean value of the four direct measurements, reduced to sea-level, is 7151·6126 links, and the value derived from triangle off the auxiliary base is 7151·6225 links, or a difference of 0·0099 link, or 1 part in 716,000. (See Fig. No. 4.)

Marking. — The terminal marks at each end of the base were constructed as follows: Holes 4 ft. 6 in. in depth from the ground-surface, by 2 ft. 6 in. square, were sunk. In the bottom of these, 12 in. of 3-to-1 concrete was placed. On the top of the concrete, blocks of Malmsbury bluestone, 12 in. long by 8 in. square, were bedded as concealed marks, and surrounded with concrete to their surfaces. The centres of the stones are marked by brass circular plugs, 3 in. by ½ in., run in with lead, their centres again being further marked by a $\frac{1}{16}$ in. hole, drilled ¼ in. in depth, which final centre is in each case the true terminal mark of the base-line. On the tops of these stones, for surface marks, galvanized trig. tubes 2 in. in diameter by 2 ft. 6 in. long, with footplates, were placed, and 6 in. of clay was well rammed round them. On the top of the rammed clay concrete was placed to the ground-surface, care being taken throughout that the tubes were kept centred over the stone marks, the actual surface-marks being ¼ in. holes drilled in the brass plugs riveted into the tops of the tubes. Small removable plugs with fine centre points, fitting into the ¼ in. holes, gave true points for starting and finishing the measuring on. (See Fig. No. 5.)

Intermediate Marks.—The line was broken up into nine sections by the placing of eight intermediate marks, constructed of trig. tubes, with brass plugs in their tops having fine centre holes, each tube being bedded and packed in concrete.

Apparatus.

The apparatus consists of the following:—

First: Two 5-chain (330 ft. or 100·5821 metres) nickel-steel (Invar) tapes, ⅛ in. (3·175 mm.) by $\frac{1}{50}$ in. (0·508 mm.) thick. Modulus of elasticity supplied by the makers = 20,900,000 lb. per square inch. Coefficient of expansion supplied by the makers = 0·00000016 per degree Fahr. Weight = 0·61558 lb. per chain-length.

Second: One 5-chain Invar tape, ¼ in. (6·35 mm.) wide by $\frac{1}{50}$ in. (0·508 mm.) thick. Modulus of elasticity supplied by the makers = 20,900,000 lb. per square inch. Coefficient of expansion supplied by the makers = 0·00000016 per degree Fahr. Weight = 1·18027 lb. per chain-length. Adopted sag on 50 links = 0·0031 link with 15 lb. tension.

This tape was only used for one measurement of sections 1 and 2, as it was found to be too susceptible to the action of the wind.

As the elastic extension of the ⅛ in. tapes was found frequently by experiment, this value of 0·001844 link per pound pull per chain-length was adopted.

The horizontal sag on 50 links of ⅛ in. unsupported tape under a tension of 15 lb. was found experimentally to be 0·0008 link, and this was the value used throughout the computations, covering work done under this tension. When, towards the end of the work, owing to the weakening of the balance, the nominal tension of 15 lb. was not the real tension, the sag on 50 links or other length of unsupported tape altered accordingly, and was computed by the formula $S = \frac{lw^2}{24t^2}$

Third: A 5 in. transit theodolite, having a vertical circle reading to 20", with a specially divided brass scale attached to the end of the horizontal axis of the vertical limb. (See Fig. No. 6.) This brass scale carries a sliding steel scale divided to 0·001 of a link, which can be made to coincide with any of the tenth-of-a-link spaces on the brass scale.

In using the scales with the tape coming from the left as the instrument is faced, the *link-reading* is always that of the mark on the tape, immediately to the *left* of the zero. If this link-mark is *on the*

scale to the left of zero, then the full reading will be, say, 60·2855, the 5 in the fourth place being read by estimation on the sliding steel scale, and a strong magnifying glass being always used. If the link-mark is on the scale, but to the right of the zero, then the reading will be, say, 59·7145, the parts of the link in this case being read from the right end of the scale, the 59-link mark being then the first to the left. If the tape comes from the right, the method of reading is relatively the same, and, though the scale-figures will be upside down, there will be no difficulty in reading them.

All the tapes are graduated by fine engraved lines drawn right across on the material of the tape itself. As, however, these lines are frequently not precisely at right angles to the length of the tapes, it follows that the graduations on the one edge are not in accord with those on the other; but each edge presents the features of a separate tape, and was treated as such, and standardized accordingly. At each end of the tapes 1 chain-length is graduated to links. The tapes are numbered 01, 02, and 03, the ends are marked A and B, and the two edges of each tape are also distinguished by the letters A and B, all engraved on brass sleeves soldered to the tapes. In using the tapes, of course, the great number of the measurements are of approximate 5-chain lengths, sometimes a little more, sometimes a little less, but whether greater or lesser, the small excess or deficiency from the full chain was measured altogether on the scale attached to the theodolite. Owing to obstacles, however, there are a few irregular lengths on sections 3 to 8, and on section 9 the greater part of the measurements are irregular. To minimize errors in the odd link-values, each link was separately tested on a link-comparator, laid down from an Invar standard link-bar specially supplied by W. F. Stanley, London, and a schedule of the plus and minus link-values made. Subsequently the two half-chain lengths of each graduated link-tape were tested against one another, and their values obtained in terms of the value of the whole chain-length in each case. These were compared with the sums of the plus and minus link corrections in the schedule, which latter were then adjusted in accordance therewith. The corrections to the direct comparison-values in the schedules never exceeded 2 in the fourth place of decimals of a link, and frequently were less than 1.

For comparison of links and adjustment of values see Table No. 2.

Fourth: Three measuring-tripods. These are made of galvanized-iron tubing $\frac{7}{8}$ in. in diameter, with sliding adjustment gun-metal tops, with a further fine centring movement, obtained by two pairs of opposing screws. (See Fig. No. 7.)

Fifth: Measuring-stand. The measuring-stand consists practically of a $\frac{3}{4}$ in. steel shaft rising from a weighted iron frame, and carrying a slow-motion screw for making the contacts of rear end of tapes with the engraved initial-mark on the gun-metal tops of tripods. The frame of the slow-motion screw has a sliding movement up or down the shaft, and also separate horizontal and inclination movements, so that when all are brought into service the contacts can be made readily and with precision for the usual heights of tripods (about 3 ft. 6 in.), and on any grade. (See Fig. No. 8 for details, and No. 9 for stand in use.)

Sixth: Straining-apparatus. Referring to Fig. No. 10: One end of the tension-wire D is first hooked on to the frame of the pulley attached to the stayed shaft, which is always placed on the line being measured. The other end of the wire is then passed under the upper pulley on the galvanized-iron rod A, which pulley is also placed on the line to be measured, then over the pulley, and carried down above the first part of the wire to the ground pulley again, which it passes over and under, to be clamped to the slow-motion screw in the tension-frame E run down near to the ground-level. The balance K is attached to a rider which circulates round the axis of the upper pulley, just clearing its rim. When the balance is therefore clamped to a tape, say, roughly, in a horizontal position, the other end of the tape being rigidly fixed to the measuring-stand, a position of mechanical equilibrium and low tension is set up in the tape and tension-gear. This tension is rapidly increased by raising the tension-frame, which slides on the galvanized rod A, the action naturally being to lengthen the distance between the low pulley and the tension-frame, which can only be accomplished under the circumstances by a corresponding shortening of the distance between the upper and lower pulleys. As the low pulley cannot move, the upper one must; the result being, as it is pulled back, strain is applied to the balance, and the required tension obtained, first rapidly by the sliding movement of the frame upwards, and then accurately by the slow-motion screw.

Seventh: Spring balance. A Salter's spring balance of German silver, circular make, and about 3 in. long, was used for putting the required pull on tapes. This balance was compared at every test of the tapes on the comparator with a standard balance, by means of the known elastic extension of the tapes used in the work.

Eighth: Support-stands. These are made of cast iron, their essential workmanship consisting of a universal joint, to the upper surface of which a blue-gum rod 6 ft. to 7 ft. in length is attached. Sliding up and down on the rods are spring-steel supports with knife-edges, on which the tapes rest when in use. (See Fig. No. 11.)

Ranging.

The ranging of the line, and the insertion of the terminal and intermediate marks, were carried out by Mr. H. J. Lowe, a preliminary measurement being also made to break the line up as far as possible into 5-chain lengths. On section 9, however, this practice had to be departed from owing to the irregularities of the section and the necessity of closely following the grades of the country to avoid the action of the wind on the tapes.

Standard of Length.

The only standard of length for comparator purposes in the Dominion at present is the 100 Imperial links steel tape No. 1, in the Head Office of the Lands and Survey Department, Wellington. This tape, $\frac{1}{4}$ in. by $\frac{1}{50}$ in., was tested by the Standards Department of the Board of Trade, London, in 1903, and its value given under certificate, as being the true Imperial standard length of 100 links at 62° Fahr., and under a tension of 15 lb. The coefficient of expanison for temperature and the modulus of elasticity were not given. The temperature coefficient adopted is 0·00000625 per degree Fahr.

A copy of the certificate which covers the Standard Tape No. 1, and spring balance used with it when laying down comparators, is given below.

Copy of Certificate.

No. 319. Dated 18th June, 1903.

This is to certify that twelve standard subdivided steel measures, riband form, each graduated at 66 feet or 100 links, 150 links and 100 feet, for the Lands and Survey Department of New Zealand (together with twelve spring balances for use therewith), have been compared with and verified by the Imperial Standards in the custody of the Board of Trade, and have been stamped as correct. The ribands were tested when subjected to a pull of 15 lb. at the temperature of 62° Fahrenheit, or 16·666° Centigrade, such temperature being measured in terms of the standard thermometers of the Board of Trade reduced to the hydrogen scale.

The errors of these twelve measures, or differences from Imperial Standard at 62° Fahrenheit are shown on the back of this certificate. H. J. CHANEY,

Board of Trade, Standards Department. Superintendent of Weights and Measures.

Measure No.	100 Feet.	99 Feet or 150 Links.	66 Feet or 100 Links.
	Inch.	Inch.	Inch.
1	+ 0·024	+ 0·014	± 0·000
2	+ 0·029	+ 0·016	− 0·002
3	+ 0·035	+ 0·025	− 0·010
4	+ 0·029	+ 0·013	+ 0·001
5	+ 0·030	+ 0·020	+ 0·006
6	+ 0·030	+ 0·030	− 0·003
7	+ 0·026	+ 0·013	− 0·005
8	+ 0·035	+ 0·020	− 0·007
9	+ 0·035	+ 0·020	+ 0·003
10	+ 0·038	+ 0·021	+ 0·005
11	+ 0·005	− 0·005	− 0·013
12	+ 0·015	+ 0·015	− 0·004

The signs + and − denote too long and too short respectively.

The subdivisions have been found to have no error greater than ± 0·015 inch on each link (the breadth of each defining-line being nearly 0·006 inch).

18th June, 1903. H. J. C.

Comparators.

After some consideration—seeing that the 100-link steel tape was the one and only reference standard available, it was deemed preferable to lay down temporary comparators where and whenever necessary and most convenient along the line, instead of one fixed comparator. This means that in every case where the differences of the tape from standard have been obtained for computation purposes, they are the results of comparisons with two different comparators, the precise instrumental and other conditions being of equal value for each determination. This method of standardizing naturally leads to an apparent greater discordance of results; but in the final means for any section, or for the whole base, there will be a closer approximation to truth than if one fixed comparator had been used.

In laying down a comparator, two tripods are erected 100 links apart, and always in the shade. At the recording end the tripod-head is mounted as shown in Fig. No. 7; at the other end the recording-scale D is not necessary, the rear contact-mark being the outer end of a finely engraved line on the gun-metal top itself, abreast of the capstan screw C, on which the tape rests when in use. The standard reference steel tape lying on its supports—5 links apart—with its rear-end contact-mark brought into coincidence with the mark on tripod, then the zero mark of the fine scale clamped on the tripod-head at the other end is brought into coincidence with the contact-mark on the tape at that end, careful temperature-readings being made simultaneously on two standardized thermometers placed at 33 links from either end of tape, with their bulbs just touching the tapes. (See Fig. No. 12.)

The procedure of recording is as follows:—

Determination of Length of Tapes.—Comparator.

Standard steel comparator tape No. 1 is Imperial standard length of 100 links at		62° F.
Temperature by thermometer No. 263	50·3° F.	
,, ,, No. 264	50°	
Mean		50·15
Difference		11·85 F.

The adopted coefficient of expansion for steel tapes = 0·00000625, which multiplied by 11·85 = 0·0074 links, or, the standard laid down is this amount short of truth, being 99·9926 links.

The above are the actual figures in the laying-down of a comparator, and Table 3 is a record of the comparison of two Invar tapes with it.

Thermometers Nos. 263 and 264 were tested in 1907 at the National Physical Laboratory, Kew, and found to be correct from 32° by 10° intervals to 92°, verified unmounted, and hanging in a vertical position.

At all comparisons they were used under the same conditions.

The results given in the last column of Table 3 are those ready for computation, in conjunction with those of the previous or following tests, as the case may be. Table 4 gives such a combination.

As a spring balance was used for applying the tension of 15 lb. during the measurement of the base, the same balance was used at the comparator tests, but one set of comparisons was made with the certificated standard balance, the results of which were compared with those of the working-balance, the true pull of which, having the known elastic extension of the working-tape, was thus obtained. Of course, as the same balance was used at the comparisons as was later used at the actual measurements of the base, no corrections were required as long as the differences between the standard and working balances were small; but for sections 8 and 9, and the auxiliary base, varying sag, &c., corrections were necessary as the pull of the working-balance weakened.

When evidence of the weakening of the spring balance became apparent, the comparisons were made with extra care in the following manner:—

Sixth Test.—Comparisons to determine the Value of Working-balance No. 1.

Comparisons of each chain-length of $\frac{1}{8}$ in. Invar tape No. 02 under a tension of,—

Chain-length No.	First: Standard Balance, 15 lb., True.	Second: Working-balance No. 1, 15 lb., Nominal.	Differences.
	Links.	Links.	Links.
1	+ ·0039	+ ·0039	·0000
2	− ·0024	− ·0029	− ·0005
3	− ·0033	− ·0036	− ·0003
4	− ·0035	− ·0039	− ·0004
5	+ ·0057	+ ·0053	− ·0004
6	+ ·0055	+ ·0052	− ·0003
7	− ·0035	− ·0041	− ·0006
8	− ·0031	− ·0034	− ·0003
9	− ·0026	− ·0028	− ·0002
10	+ ·0042	+ ·0038	− ·0004
Mean difference	..	..	− ·00034

The differences given in the last column are equivalent to the differences of pull between the standard and working balances, and

$$\frac{\text{Mean difference per chain-length}}{\text{Elastic extension per pound pull per chain-length}} = \text{difference in pull of balance;}$$

$$\text{equals } \frac{\cdot00034}{\cdot00184} = \cdot1842 \text{ lb.}$$

The actual figures taken for the pull of working-balance at the sixth test were 0·185 lb. less than 15 lb.
At the fifth test were .. .. 0·090 lb. ,,

0·275 lb.

And the mean = ... 0·1375 lb.

The working-balance was pulling less than 15 lb. for all measurements between the fifth and sixth tests.

To avoid possible temperature-errors, as long as pure steel tapes are used for laying down comparators it will be desirable that they should be laid down when the temperature is as nearly as possible 62° Fahr., the standard temperature of the reference tape, and this was done whenever practicable.

Field Measurements.

At the base measurements the *personnel* was as follows: One contact-observer at the rear end, which position Mr. H. J. Lowe occupied for the latter half of the measurements; one scale-reader and recorder at the theodolite or forward end; one tape and tension adjuster at the forward end; and three men for lining in supports, placing tapes properly on supports, and assisting to carry tapes forward.

When starting actual measurements after the necessary comparator tests have been made, the first matter to be attended to is the adjustment of the rear tripod contact-mark over the terminal point of the line, or other starting-point for the day. To do this the theodolite is carefully centred over a fine brass tack in a substantial peg, which has previously been fixed at right angles to the line, and about 15 links from it. A tripod is at the same time being centred by plummet over the base mark, every care being taken that it is made as rigid as possible. The base point is then intersected by the wires of the theodolite, and a vertical plane ranged out to the tripod-head, where a fine needle-point mark is made on a lead insertion in the gun-metal at E, Fig. 7. The instrument is reversed, and the operation repeated: if there is any discord with the first point, the mean position is taken, the telescope clamped to it, and the contact-mark on the tripod-head is then adjusted to correspond. When closing down for the day this operation is reversed, the contact-mark on the finishing tripod being then depressed,

and fixed on a strip of lead tacked to the top of a stout peg driven about 2 ft. into the ground, and having its top countersunk two or three inches. All such pegs are protected from injury by carefully covering them until the measurement of the section is completed. As soon as the starting-tripod is fixed ready for measuring, the theodolite is centred over the peg at the forward end of the first measure to be made, the telescope being on the average about 5 ft. above the ground, and the angle of inclination taken to the contact-mark on tripod, whose average height is about 3 ft. 6 in. above the ground, both verniers being read, face right and face left. When the grades are steep eight readings are taken. Immediately the inclinations are booked, the support-stands—50 links apart—are ranged into line, and the spring supports placed on the grade between the horizontal axis of theodolite and contact-mark on the tripod.

In ranging in the support-stands, as the tripod and theodolite are both centred on the base-line itself, but the actual measure to be made is the line between the contact-mark on the tripod-head and the outer end of the axis of the vertical arc of theodolite, which point is 0·372 link from the true base-line, it follows that the support-rods must be placed on a line parallel to the measure being made, and at a distance of about $1\frac{1}{2}$ in. therefrom. That is, the rod of stand (1) in Fig. No. 13 is placed to the left of the optical line AC, so that this line will pass through about the centre of the space between the shaft of the support-stand and the wing of steel support sliding on the rod. Stand No. 2 is placed nearer to the optical line, and so on until stand No. 5 is exactly on the line AC. From this point the stands pass to the right of the optical line, until stand No. 9 is about the same distance to the right of AC as stand No. 1 was to the left.

The operation is perhaps more difficult to understand from description than to perform, as in practice the stands are placed rapidly in their correct positions, and the steel slides run up or down the rods, and placed on the grade-line between B and C.

The corrections for the eccentricity of the line measured are obtained by inspection from a table computed for the purpose.

Tape No. 02 is then lifted and placed on the supports, and it is carefully watched to see that the tape is lying flat, without twists, throughout. The observer at the rear-end tripod then clamps the tape, B end, on to the adjusting-screw of the measuring-stand (A and C, Fig. No. 8), and signals so by whistle, when the tape is at once pulled taut, and clamped to the balance on the tension gear (F, Fig. No. 9, and K, Fig. No. 10). The sliding frame E, Fig. No. 10, carrying a slow-motion screw, is then run up from the bottom of rod A until the required tension is nearly on, when it is made exact by the slow-motion screw. "All ready" is signalled, then the rear contact is made perfect, and the position of the graduation-mark on the A end of tape passing the scale is read, and repeated several times, the tape being lifted from the supports and dropped again between each reading. The last reading of the series booked is made by the tension-adjuster, as a check. Temperature-readings are taken at both ends of the tape, but, as the coefficient of expansion of the Invar (nickel-steel) from which the tapes are made is very small, being, as supplied by the makers, 0·00000016 per degree Fahr., there is no necessity for the same degree of accuracy as is required when steel tapes are used.

Tape No. 02 is then replaced by Tape No. 03, with which another measure is made in the same manner as already described. As soon as completed both tapes are lifted by the four men, and carried forward to the next length to be measured. While the first measurement is being made, one man is erecting the next tripod forward on the line, so as to be ready for the measurement of the second length. In this case the A end of tape is at the tripod, and the B end at the scale, so that alternately throughout the measurements the A and B ends are read at the scale.

One now well-known peculiarity of the nickel-steel tapes (Invar) is their property of contraction with use, especially when new. This difficulty necessitates frequent comparisons, and, as the comparators have to be laid down with a pure-steel tape, it is sometimes difficult to obtain suitable positions in the shade. In some localities it would be imperative to have portable artificial shade, and I think this will have to be provided for in the measurements of some of the other proposed bases. A comparison of the values for the several chain-lengths in column 9, Table No. 3, of the fifth test, there given, with the corresponding values under the sixth test will give an idea of the changes in length which take place. These changes are not at all regular, and for this reason the tests with the standard comparator should be as frequent as possible. If there are facilities for doing so at the end of every mile or thereabout of measurement, then such test should be made if the finest results are desired.

Sections 1 to 4, owing chiefly to the changes in the tape-lengths, were measured six times each, due weight being given to each measure in the final results for the sections. Sections 5 to 9 were measured four times each. The total mileage of the $8\frac{1}{10}$-mile main base-line measurement, inclusive of all repetitions, is 40 miles 1762 links, and of the auxiliary base (which was measured four times) 5 miles 5855 links, and together 45 miles 7617 links.

As a proposed check on the measurements crossing the four gullies shown on section 9 in Fig. No. 2, direct measurements were made with the tape unsupported throughout, the longest measurement thus taken being 429 links. Although calm weather was taken advantage of for this work, the results are far from being satisfactory, and have been abandoned.

Table No. 1 gives the final results of the measurements.

The length of the base, reduced to sea-level, is 64776·6572 links $\pm$ 0·0219 link ($\pm$ 0·34μ), or 1 part in 2,962,000. This length may be subject to slight correction when the length of the steel band has been checked again.

Observations for the probable error in laying down a comparator, as well as specimen pages of field and computation books, are appended.

I have to express my thanks to Mr. C. E. Adams, Chief Computer, Head Office, for the great interest and trouble he has taken in verifying the final results of the measurements, and computing the probable errors attached to each.

TABLE NO. 1.—RESULTS OF MEASUREMENT, WAIRARAPA BASE, WELLINGTON.

No. of Section.	No. of Measurement.	No. of Tape.	Date, 1909.	Direction.	Temperature-range.	Weather.	Individual Measurements.	Weights.	Weighted Means.	Residuals (Weighted Means, Measurements).	Reduction to Sea-level.	Length at Sea-level.	Probable Error.	Remarks.
					Deg. Fah.		Links.		Links.	Links.	Links.	Links.	Links.	
1	1	01/B	Mar. 25 ..	N.–S.	71–78	Fine, with light breeze	7498·3261	3	22494·9783	— ·0384				Woodside Trig. Station at north end of base.
	2	03/B	„ 25 ..	N.–S.	72–90	Ditto	7498·2832	1	7498·2832	+ ·0045				
	3	02/A	„ 24 ..	S.–N.	64–75	Fine	7498·3195	1	7498·3195	— ·0318				
	4	03/A	„ 24 ..	S.–N.	62–76	„	7498·2616	1	7498·2616	+ ·0261				
	5	02/A	April 15 ..	S.–N.	52–76	„	7498·2933	5	37491·4665	— ·0056				Old river-shingle, lightly covered with soil.
	6	03/A	„ 15 ..	S.–N.	54–74	„	7498·2588	5	37491·2940	+ ·0289				
								16	119972·6031					
									7498·2877	..	0·0957	7498·1920	± 0·0077	
2	1	01/B	Mar. 26 ..	N.–S.	72–85	Fair; too much wind for 01 tape	7197·5246	3	21592·5738	— ·0214				
	2	03/B	„ 26 ..	N.–S.	72–85	Ditto	7197·5069	1	7197·5069	— ·0037				
	3	02/A	„ 22 ..	S.–N.	70–83	Fine, with light wind	7197·5387	1	7197·5387	— ·0355				
	4	03/A	„ 22 ..	S.–N.	71–83	Ditto	7197·4811	1	7197·4811	+ ·0221				
	5	02/A	April 14 ..	S.–N.	59–62	Fine, with easterly wind	7197·5100	5	35987·5500	— ·0068				Old river-shingle, lightly covered with soil.
	6	03/A	„ 14 ..	S.–N.	57–63	Ditto	7197·4802	5	35987·4010	+ ·0231				
								16	115160·0515					
									7197·5032	..	0·0776	7197·4256	± 0·0058	
3	1	02/B	Mar. 30 ..	N.–S.	55–64	Fine, with light wind	6016·0100	1	6016·0100	+ ·0193				
	2	03/B	„ 30 ..	N.–S.	56–63	Ditto	6016·0114	1	6016·0114	+ ·0179				
	3	02/A	April 8 ..	S.–N.	58–79	Fine, calm ..	6016·0338	1	6016·0338	— ·0045				
	4	03/A	„ 8 ..	S.–N.	59–79	„ „ ..	6015·9966	1	6015·9966	+ ·0327				
	5	02/B	„ 16 ..	N.–S.	50–75	„ „ ..	6016·0394	3	18048·1182	— ·0101				Old river-shingle, lightly covered with soil.
	6	03/B	„ 16 ..	N.–S.	52–74	„ „ ..	6016·0411	3	18048·1233	— ·0118				
								10	60160·2933					
									6016·0293	..	0·0562	6015·9731	± 0·0048	

4	1	02/B	Mar. 31 to April 1	N.–S.	59–73	Part fine, and heavy rain	10614·8825	1	10614·8825	+ ·0391				
	2	03/B		N.–S.	57–76		10614·8755	1	10614·8755	+ ·0461				
	3	02/A	April 1, 7	S.–N.	62–79	Part blowy, unsatisfactory, and part calm	10614·9299	1	10614·9299	— ·0083				
	4	03/A		S.–N.	60–79		10614·8716	1	10614·8716	+ ·0500				
	5	02/B	April 17 to	N.–S.	52–64	Wind stopped measurement on 17th	10614·9445	3	31844·8335	— ·0229				Good base-measuring country.
	6	03/B	April 19	N.–S.	52–62	Fair	10614·9410	3	31844·8230	— ·0194				
								10	106149·2160					
									10614·9216	..	0·0803	10614·8413	±0·0090	
5	1	02/B	April 19 ..	N.–S.	58–74	Fair and calm ..	6360·3677	1	6360·3677	+ ·0120				
	2	03/B	„ 20 ..	N.–S.	57–72	„ ..	6360·3627	1	6360·3627	+ ·0170				
	3	02/A	„ 21 ..	S.–N.	66–70	„ ..	6360·3986	1	6360·3986	— ·0189				
	4	03/A	„ 21 ..	S.–N.	65–69	„ ..	6360·3897	1	6360·3897	— ·0100				Good measuring-country.
								4	1·5187					
									6360·3797	..	0·0376	6360·3421	± 0·0072	
6	1	02/B	May 3, 4	N.–S.	62–69	Blowy on 3rd ..	8265·3362	1	8265·3362	+ ·0280				
	2	03/B		N.–S.	62–70	Calm on 4th ..	8265·3313	1	8265·3313	+ ·0329				
	3	02/A	May 1 ..	S.–N.	56–77	Fair, calm ..	8265·4040	1	8265·4040	— ·0398				
	4	03/A	„ 1 ..	S.–N.	54–77	„ „ ..	8265·3854	1	8265·3854	— ·0212				This section is mostly a surface-dry swamp, very elastic. Heavy stakes had to be driven 5 ft. and 6 ft. to give stable supports for tripods and theodolite.
								4	1·4569					
									8265·3642	..	0·0392	8265·3250	± 0·0122	
7	1	02/B	May 4, 5	N.–S.	55–66	Fine, calm ..	5676·4094	1	5676·4094	+ ·0143				
	2	03/B		N.–S.	56–68	„ „ ..	5676·4016	1	5676·4016	+ ·0221				
	3	02/A	April 29 ..	S.–N.	55–64	Good breeze ..	5676·4491	1	5676·4491	— ·0254				
	4	03/A	„ 29 ..	S.–N.	55–64	„ ..	5676·4349	1	5676·4349	— ·0112				Good base-measuring ground.
								4	1·6950					
									5676·4237	..	0·0276	5676·3961	± 0·0074	
8	1	02/B	May 5 ..	N.–S.	55–71	Fine, calm ..	5896·4408	1	5896·4408	+ ·0006				
	2	03/B	„ 6 ..	N.–S.	56–69	„ „ ..	5896·4409	1	5896·4409	+ ·0005				
	3	02/A	„ 6 ..	S.–N.	57–67	Fine and calm to blowy & showery	5896·4454	1	5896·4454	— ·0040				
	4	03/A	„ 7 ..	S.–N.	57–66		5896·4386	1	5896·4386	+ ·0028				Good measuring-ground.
								4	1·7657					
									5896·4414	..	0·0282	5896·4132	± 0·0010	

TABLE No. 1.—RESULTS OF MEASUREMENT, WAIRARAPA BASE, WELLINGTON—*continued*.

No. of Section.	No. of Measurement.	No. of Tape.	Date, 1909.	Direction.	Temperature-range.	Weather.	Individual Measurements.	Weights.	Weighted Means.	Residuals (Weighted Means, Measurements).	Reduction to Sea-level.	Length at Sea-level.	Probable Error.	Remarks.
					Deg. Fah.		Links.		Links.	Links.	Links.	Links.	Links.	
9	1	02/B	May 8–17	N.–S.	51–66	Slight wind and fair	7251·8340	1	7251·8340	— ·0120				The greater part of this section is irregular, with steep rising and falling grades, in some cases approaching 15° of inclination. The results show that even with such inclinations, good work can be done if sufficient care is taken, chiefly with the vertical angles. See also Fig. 4 for the computed value of this section. As far as can be ascertained, the grades on this section are the steepest that have been measured on any base of this nature.
	2	03/B		N.–S.	51–66		7251·8308	1	7251·8308	— ·0088				
	3	02/A	May 17–21	S.–N.	49–62	Ditto	7251·8224	1	7251·8224	— ·0004				
	4	03/A		S.–N.	49–63	,, ...	7251·8009	1	7251·8009	+ ·0211				
								4	3·2881					
									7251·8220	..	0·0732	7251·7488	± 0·0050	Bidwill Trig. Station at south end of base.
					Sum of weighted means of sections ..			..	64777·1728	..	0·5156	64776·6572	± 0·0219	
*	1	02/B	May 25–27	Going S.W.	48–62	Fair, with slight wind	11463·7571	1	11463·7571	— ·02555				
	2	03/B	,,	Ditto	47–62	Ditto	11463·7521	1	11463·7521	— ·02055				
	3	02/A	May 27–29	Going N.E.	43–65	,, ...	11463·7032	1	11463·7032	+ ·02835				
	4	03/A	,,	Ditto	43–65	,, ...	11463·7138	1	11463·7138	+ ·01775				
								4	45854·9262					
									11463·73155	..	0·04384	11463·6877	± 0·0091	

* Auxiliary base.

TABLE NO. 2.—DETERMINATION OF LENGTHS OF LINKS.

$\frac{1}{8}$ in. Invar Tape No. 03 : A end, B edge.

Links.	Difference from Standard.	Corrections to 50 Links.	Corrected Difference from Standard.	Compounded Difference from Standard.	Links.	Difference from Standard.	Corrections to 50 Links.	Corrected Difference from Standard.	Compounded Difference from Standard.
									— ·0053
1	— ·0013	..	— ·0013	— ·0013	51	+ ·0008	— ·0001	+ ·0007	— ·0046
2	— ·0003	..	— ·0003	— ·0016	52	— ·0007	..	— ·0007	— ·0053
3	+ ·0003	..	+ ·0003	— ·0013	53	+ ·0002	— ·0001	+ ·0001	— ·0052
4	·0000	— ·0001	— ·0001	— ·0014	54	— ·0003	— ·0001	— ·0004	— ·0056
5	+ ·0008	..	+ ·0008	— ·0006	55	— ·0002	— ·0001	— ·0003	— ·0059
6	— ·0007	..	— ·0007	— ·0013	56	+ ·0005	— ·0001	+ ·0004	— ·0055
7	+ ·0001	— ·0001	·0000	— ·0013	57	— ·0002	— ·0001	— ·0003	— ·0058
8	+ ·0001	— ·0001	.0000	— ·0013	58	+ ·0006	— ·0001	+ ·0005	— ·0053
9	+ ·0003	..	+ ·0003	— ·0010	59	·0000	— ·0001	— ·0001	— ·0054
10	+ ·0002	..	+ ·0002	— ·0008	60	—·0004	— ·0001	— ·0005	— ·0059
11	— ·0002	..	— ·0002	— ·0010	61	·0000	— ·0001	— ·0001	— ·0060
12	— ·0001	— ·0001	— ·0002	— ·0012	62	·0000	— ·0001	— ·0001	— ·0061
13	+ ·0001	— ·0001	·0000	— ·0012	63	+ ·0002	..	+ ·0002	— ·0059
14	— ·0005	..	— ·0005	— ·0017	64	— ·0002	..	— ·0002	— ·0061
15	+ ·0008	..	+ ·0008	— ·0009	65	— ·0001	— ·0001	— ·0002	— ·0063
16	— ·0004	..	— ·0004	— ·0013	66	·0000	— ·0001	— ·0001	— ·0064
17	+ ·0001	..	+ ·0001	— ·0012	67	·0000	— ·0001	— ·0001	— ·0065
18	·0000	— ·0001	— ·0001	— ·0013	68	— ·0003	..	— ·0003	— ·0068
19	— ·0002	..	— ·0002	— ·0015	69	+ ·0004	— ·0001	+ ·0003	— ·0065
20	+ ·0001	— ·0001	·0000	— ·0015	70	·0000	— ·0001	— ·0001	— ·0066
21	— ·0001	— ·0001	— ·0002	— ·0017	71	·0000	— ·0001	— ·0001	— ·0067
22	— ·0004	..	— ·0004	— ·0021	72	— ·0001	— ·0001	— ·0002	— ·0069
23	+ ·0004	..	+ ·0004	— ·0017	73	+ ·0002	— ·0001	+ ·0001	— ·0068
24	— ·0002	..	— ·0002	— ·0019	74	+ ·0002	— ·0001	+ ·0001	— ·0067
25	+ ·0002	..	+ ·0002	— ·0017	75	— ·0002	— ·0001	— ·0003	— ·0070
26	— ·0012	..	— ·0012	— ·0029	76	+ ·0003	..	+ ·0003	— ·0067
27	+ ·0013	..	+ ·0013	— ·0016	77	·0000	— ·0001	— ·0001	— ·0068
28	+ ·0003	..	+ ·0003	— ·0013	78	— ·0003	— ·0001	— ·0004	— ·0072
29	— ·0004	..	— ·0004	— ·0017	79	+ ·0002	— ·0001	+ ·0001	— ·0071
30	·0000	— ·0001	— ·0001	— ·0018	80	+ ·0006	— ·0001	+ ·0005	— ·0066
31	+ ·0003	..	+ ·0003	— ·0015	81	— ·0004	— ·0001	— ·0005	— ·0071
32	— ·0001	— ·0001	— ·0002	— ·0017	82	+ ·0010	— ·0001	+ ·0009	— ·0062
33	— ·0003	..	— ·0003	— ·0020	83	+ ·0004	— ·0001	+ ·0003	— ·0059
34	·0000	— ·0001	— ·0001	— ·0021	84	— ·0006	..	— ·0006	— ·0065
35	·0000	— ·0001	— ·0001	— ·0022	85	— ·0001	— ·0001	— ·0002	— ·0167
36	— ·0001	— ·0001	— ·0002	— ·0024	86	+ ·0005	— ·0001	+ ·0004	— ·0063
37	·0000	— ·0001	— ·0001	— ·0025	87	·0000	— ·0001	— ·0001	— ·0064
38	— ·0005	..	— ·0005	— ·0030	88	+ ·0004	— ·0001	+ ·0003	— ·0061
39	+ ·0001	— ·0001	·0000	— ·0030	89	— ·0002	..	— ·0002	— ·0063
40	— ·0001	— ·0001	— ·0002	— ·0032	90	+ ·0010	— ·0001	+ ·0009	— ·0054
41	— ·0003	..	— ·0003	— ·0035	91	— ·0021	..	— ·0021	— ·0075
42	— ·0002	..	— ·0002	— ·0037	92	+ ·0016	— ·0001	+ ·0015	— ·0060
43	·0000	— ·0001	— ·0001	— ·0038	93	+ ·0003	— ·0001	+ ·0002	— ·0058
44	— ·0003	..	— ·0003	— ·0041	94	— ·0002	..	— ·0002	— ·0060
45	— ·0003	..	— ·0003	— ·0044	95	— ·0003	..	— ·0003	— ·0063
46	— ·0001	— ·0001	— ·0002	— ·0046	96	·0000	— ·0001	— ·0001	— ·0064
47	— ·0006	..	— ·0006	— ·0052	97	+ ·0004	— ·0001	+ ·0003	— ·0061
48	— ·0003	..	— ·0003	— ·0055	98	— ·0002	..	— ·0002	— ·0063
49	+ ·0005	..	+ ·0005	— ·0050	99	·0000	— ·0001	— ·0001	— ·0064
50	— ·0003	..	— ·0003	— ·0053	100	— ·0003	— ·0001	— ·0004	— ·0068
	— ·0095					— ·0074			
	+ ·0060					+ ·0098			
	— ·0035					+ ·0024			
	— ·0053	= true value from Table 5.				— ·0015	= true value from Table 5.		
	— ·0018	to distribute.				— ·0039	to distribute.		

TABLE No. 3.—DETERMINATION OF LENGTHS OF TAPES.

⅛ in. Invar Tape No. 02.

Fifth Test.

1	Tape. 2	Comparison. 3	Temperature. 4	Temperature-correction to 62° Fahr. 5	Corrected Comparison. 6	Value of Comparator with Imperial Standard. 7	True Comparison of Tape with Imperial Standard. 8	Differences from Imperial Standard at 62° Fahr. 9	Differences from Standard compounded for Computation. 10
A end, A edge ..	1	+ ·0018	51	+ ·0002	+ ·0120	+ 99·9926	100·0046	+ ·0046	+ ·0046
	2	+ ·0047	51	+ ·0002	+ ·0049	+ 99·9926	99·9975	— ·0025	+ ·0021
	3	+ ·0044	51	+ ·0002	+ ·0046	+ 99·9926	99·9972	— ·0028	— ·0007
	4	+ ·0039	51	+ ·0002	+ ·0041	+ 99·9926	99·9967	— ·0033	— ·0040
	5	+ ·0130	51	+ ·0002	+ ·0132	+ 99·9926	100·0058	+ ·0058	+ ·0018
A end, B edge ..	1	+ ·0116	50	+ ·0002	+ ·0118	+ 99·9926	100·0044	+ ·0044	+ ·0044
	2	+ ·0050	50	+ ·0002	+ ·0052	+ 99·9926	99·9978	— ·0022	+ ·0022
	3	+ ·0041	50	+ ·0002	+ ·0043	+ 99·9926	99·9969	— ·0031	— ·0009
	4	+ ·0035	50	+ ·0002	+ ·0037	+ 99·9926	99·9963	— ·0037	— ·0046
	5	+ ·0130	50	+ ·0002	+ ·0132	+ 99·9926	100·0058	+ ·0058	+ ·0012
B end, A edge ..	1	+ ·0130	51	+ ·0002	+ ·0132	+ 99·9926	100·0058	+ ·0058	+ ·0058
	2	+ ·0039	51	+ ·0002	+ ·0041	+ 99·9926	99·9967	— ·0033	+ ·0025
	3	+ ·0044	51	+ ·0002	+ ·0046	+ 99·9926	99·9972	— ·0028	— ·0003
	4	+ ·0047	51	+ ·0002	+ ·0049	+ 99·9926	99·9975	— ·0025	— ·0028
	5	+ ·0118	51	+ ·0002	+ ·0120	+ 99·9926	100·0046	+ ·0046	+ ·0018
B end, B edge ..	1	+ ·0130	51	+ ·0002	+ ·0132	+ 99·9926	100·0058	+ ·0058	+ ·0058
	2	+ ·0035	50	+ ·0002	+ ·0037	+ 99·9926	99·9963	— ·0037	+ ·0021
	3	+ ·0041	50	+ ·0002	+ ·0043	+ 99·9926	99·9969	— ·0031	— ·0010
	4	+ ·0050	50	+ ·0002	+ ·0052	+ 99·9926	99·9978	— ·0022	— ·0032
	5	+ ·0116	50	+ ·0002	+ ·0118	+ 99·9926	100·0044	+ ·0044	+ ·0012

Sixth Test.

A end, A edge ..	1	+ ·0026	63	± ·0000	+ ·0026	+ 100·0012	100·0038	+ ·0038	+ ·0038
	2	— ·0040	63	± ·0000	— ·0040	+ 100·0012	99·9972	— ·0028	+ ·0010
	3	— ·0046	63	± ·0000	— ·0046	+ 100·0012	99·9966	— ·0034	— ·0024
	4	— ·0053	63	± ·0000	— ·0053	+ 100·0012	99·9959	— ·0041	— ·0065
	5	+ ·0040	63	± ·0000	+ ·0040	+ 100·0012	100·0052	+ ·0052	— ·0013
A end, B edge ..	1	+ ·0027	64	± ·0000	+ ·0027	+ 100·0012	100·0039	+ ·0039	+ ·0039
	2	— ·0041	63	± ·0000	— ·0041	+ 100·0012	99·9971	— ·0029	+ ·0010
	3	— ·0048	63	± ·0000	— ·0048	+ 100·0012	99·9964	— ·0036	— ·0026
	4	— ·0051	63	± ·0000	— ·0051	+ 100·0012	99·9961	— ·0039	— ·0065
	5	+ ·0041	63	± ·0000	+ ·0041	+ 100·0012	100·0053	+ ·0053	— ·0012
B end, A edge ..	1	+ ·0040	63	± ·0000	+ ·0040	+ 100·0012	100·0052	+ ·0052	+ ·0052
	2	— ·0053	63	± ·0000	— ·0053	+ 100·0012	99·9959	— ·0041	+ ·0011
	3	— ·0046	63	± ·0000	— ·0046	+ 100·0012	99·9966	— ·0034	— ·0023
	4	— ·0040	63	± ·0000	— ·0040	+ 100·0012	99·9972	— ·0028	— ·0051
	5	+ ·0026	63	± ·0000	+ ·0026	+ 100·0012	100·0038	+ ·0038	— ·0013
B end, B edge ..	1	+ ·0041	63	± ·0000	+ ·0041	+ 100·0012	100·0053	+ ·0053	+ ·0053
	2	— ·0051	63	± ·0000	— ·0051	+ 100·0012	99·9961	— ·0039	+ ·0014
	3	— ·0048	63	± ·0000	— ·0048	+ 100·0012	99·9964	— ·0036	— ·0022
	4	— ·0041	63	± ·0000	— ·0041	+ 100·0012	99·9971	— ·0029	— ·0051
	5	+ ·0027	63	± ·0000	+ ·0027	+ 100·0012	100·0039	+ ·0039	— ·0012

TABLE No. 4.—COMBINATION OF STANDARD-TAPE LENGTHS FOR COMPUTATION.

⅛ in. Invar Tape No. 02.

Fifth Test.	Sixth Test.	Means.
A end, A edge.		
1 = + ·0046	1 = + ·0038	1 = + ·0042
2 = + ·0021	2 = + ·0010	2 = + ·0015
3 = — ·0007	3 = — ·0024	3 = — ·0016
4 = — ·0040	4 = — ·0065	4 = — ·0053
5 = + ·0018	5 = — ·0013	5 = + ·0002
B end, A edge.		
1 = + ·0058	1 = + ·0052	1 = + ·0055
2 = + ·0025	2 = + ·0011	2 = + ·0018
3 = — ·0003	3 = — ·0023	3 = — ·0013
4 = — ·0028	4 = — ·0051	4 = — ·0040
5 = + ·0018	5 = — ·0013	5 = + ·0002

TABLE NO. 5.—COMPARISON OF HALF-CHAIN LENGTHS.

½ in. Invar Tape No. 03. A end, B edge.

Name of Half-chain.	Difference in Length.	True Value of 100 Links.	True Value of each Half-chain.	Difference from 50 Links.
0–50 links	·0	99·9932	49·9947	− ·0053
51–100 „	+ ·0037		49·9985	− ·0015

OBSERVATIONS FOR THE PROBABLE ERROR IN LAYING DOWN A COMPARATOR.

Imperial Standard Steel Reference Tape is standard at 62°
Temperature by thermometer No. 263 = 59°
„ „ „ No. 264 = 59

Mean temperature 59

Difference .. .. 3°

Coefficient of expansion adopted = 0·00000625, which multiplied by 3 = 0·001875 link; and the true length of comparator = 100·0000 − 0·0019 = 99·9981 links.

Continued comparisons of same steel reference tape with the above comparator value 99·9981, each comparison being carried out in the same manner as if a new comparator was being established :—

First Set.

J. Langmuir reading scale; H. M. Kensington making contact, rear end.

NOTE.—Perfect open-air conditions taken as 7; then the conditions for observations Nos. 1 to 5 will be 5.

				Deg. Fahr.
1. (*a*.) Tape is long =	+ ·0003	Thermometer	263 at	59·1
			264 „	59·0
(*b*.) „ =	+ ·0001	„	263 „	59·1
			264 „	59·0
Means ..	+ ·0002	Thermometer	at	59·05
2. (*a*.) Tape is long =	+ ·0002	Thermometer	263 at	59·1
			264 „	59
(*b*.) =	+ ·0002	„	263 „	59
			264 „	59
Means =	+ ·0002	Thermometer	at	59·025
3. (*a*.) Tape is long =	+ ·0014	Thermometer	263 at	60·1
			264 „	60·0
(*b*.) =	+ ·0015	„	263 „	60·1
			264 „	60·1
Means ..	+ ·00145	Thermometer	at	60·075
4. (*a*.) Tape is long =	+ ·0009	Thermometer	263 at	60
			264 „	60
(*b*.) =	+ ·0009	„	263 „	59·5
			264 „	60·1
Means ..	+ ·0009	Thermometer	at	59·90
5. (*a*.) Tape is long =	+ ·0013	Thermometer	263 at	59·8
			264 „	60·1
(*b*.) „ =	+ ·0014	„	263 „	60·0
			264 „	60·1
Means =	+ ·00135	Thermometer	at	60·0

Imperial Steel Tape.		Comparisons.		Temperature Fahr. Deg.	Temperature Corrections to 62°.		Corrected Comparisons.	Value of Comparator from above.		Values of subsequent Comparators with Imperial Standard.	Residuals. Mean − Values.
1	=	+ ·0002	at	59·050	+ ·0019	=	+ ·0021	+ 99·9981	=	100·0002	+ ·00022
2	=	+ ·0002	„	59·025	+ ·0019	=	+ ·0021	+ 99·9981	=	100·0002	+ ·00022
3	=	+ ·00145	„	60·075	+ ·0012	=	+ ·00265	+ 99·9981	=	100·00075	— ·00033
4	=	+ ·0009	„	59·900	+ ·0013	=	+ ·0022	+ 99·9981	=	100·0003	+ ·00012
5	=	+ ·00135	„	60·000	+ ·0012	=	+ ·00255	+ 99·9981	=	100·00065	— ·00023
										5/·00210	
				Mean		..	..	..	..	·00042	

Continued comparisons of steel reference tape with the comparator value 99·9981, each comparison being a new establishment of comparator :—

Second Set.

H. M. Kensington reading scale ; J. Langmuir making contact at rear end.

NOTE.—Perfect open-air conditions taken as 7 ; then the conditions for observations Nos. 6 to 10 will be 6.

				Deg. Fahr.
6. (*a.*) Tape is long	= + ·0007	Thermometer	263 at	59·5
			264 „	59·2
(*b.*) „	= + ·0005	„	263 „	59·0
			264 „	58·9
Means ..	+ ·0006	Thermometer	at	59·15
7. (*a.*) Tape is long	= + ·0007	Thermometer	263 at	59·0
			264 „	59·0
(*b.*) „	= + ·0010	„	263 „	59·20
			264 „	59·50
Means	= + ·00085	Thermometer	at	59·175
8. (*a.*) Tape is long	= + ·0015	Thermometer	263 at	59·7
			264 „	59·2
(*b.*) „	= + ·0017	„	263 „	60·0
			264 „	60·0
Means	= + ·0016	Thermometer	at	59·725
9. (*a.*) Tape is long	= + ·0016	Thermometer	263 at	60
			264 „	60
(*b.*) „	= + ·0018	„	263 „	60
			264 „	60
Means	= + ·0017	Thermometer	at	60
10. (*a.*) Tape is long	= + ·0016	Thermometer	263 at	60·2
			264 „	60·0
(*b.*) „	= + ·0017	„	263 „	60·2
			264 „	60·0
Means	= + ·00165	Thermometer	at	60·1

Imperial Steel Tape.		Comparisons.		Temperature Fahr. Deg.	Temperature Corrections to 62°.		Corrected Comparisons.	Value of Comparator from above.		Values of subsequent Comparators with Imperial Standard.		Residuals.
1	=	+ ·0006	at	59·150	+ ·0018	=	+ ·0024	+ 99·9981	=	100·0005	=	+ ·00038
2	=	+ ·00085	„	59·175	+ ·0018	=	+ ·00265	+ 99·9981	=	100·00075	=	+ ·00013
3	=	+ ·0016	„	59·725	+ ·0014	=	+ ·0030	+ 99·9981	=	100·0011	=	— ·00022
4	=	+ ·0017	„	60·000	+ ·0013	=	+ ·0030	+ 99·9981	=	100·0011	=	— ·00022
5	=	+ ·00165	„	60·100	+ ·0012	=	+ ·00285	+ 99·9981	=	100·00095	=	— ·00007
										5/·0044		
				Mean ..		..	..	..	..	·00088		

SPECIMEN PAGE OF FIELD-BOOK.

NOTE.—All roman figures below represent the actual field-notes of six measurements. Figures in italic are means for computation, and final reduced distances.

Station.	Inclination.			Temperature.	Measured Distance.	Reduced Distance.	Total Distance.	Remarks.
	°	′	″	°				
⅄ El. ...	0	16	20	62	140·3195	...		
		16	00	60	·3202	...		
		12	10	...	·3200	...		
		12	50	...	·3205	...		
El. ...	*0*	*14*	*20*	...	*140·3201*	*140·3112*		
		57	00	51	·9271	...		
⅄ El. ...	2	57	00	51	499·9275	...		
		56	40	...	·9271	...		
		56	40	...	·9271	...		
		53	50	...	...	...		
		53	30	...	...	...		
		53	40	...	...	...		
		53	40	...	...	...		
El. ...	*2*	*55*	*15*	...	*499·9272*	*499·2609*		
		32	50	56	400·1380	...		
		32	40	56	·1382	...		
D ...	2	29	20	...	·1383	...		
^ ...		30	00	...	·1375	...		
					·1370			
D ...	*2*	*31*	*12*	...	*400·1378*	*399·7325*		
	4	58	30	...	...	...		
	4	58	00	...	...	...		
	4	58	20	...	·9729	...		
	4	58	20	57	499·9725	...		
	5	02	20	57	·9730	...		
⅄ El. ...		01	40	...	·9728	...		
		01	40	...	...	...		
		02	20	...	...	...		
El. ...	*5*	*00*	*09*	...	*499·9728*	*498·0531*		
		26	00	...	...	...		
		26	00	...	...	...		
		25	50	...	...	..		
		26	10	...	·1349	...		
^ D ...	7	22	00	57	372·1350	...		
		22	50	59	·1351	...		
		22	10	...	·1347	...		
		22	40	...	...	...		
D ..	*7*	*24*	*12*	...	*372·1349*	*369·0152*		
⅄ El. ...	0	17	20	57	99·8875	...		
		17	00	...	·8872	...		
		14	00	...	·8873	...		
		13	40	...	·8873	...		
El. ...	*0*	*15*	*30*	...	*99·8873*	*99·8861*		
O								O Bidwill Trig. Station.

^ *Section 9.*—Third measurement of base-line from Secondary Trig. Station, Bidwill, to Tube No. viii. ⅛ in. Invar tape No. 02: A end, A edge. Working-balance No. 1. Weather fine.—May 17, 1909.

Specimen Page of Computing-book.

Section 9.—No. 3 Measurement.—¼ in. Invar Tape No. 02: A end, A edge.

Between the 8th and 9th Tests.—Differences from Standard.

A end, A edge.	B end, A edge.
1 = + ·0028	1 = + ·0037
2 = — ·0013	2 = — ·0013
3 = — ·0059	3 = — ·0059
4 = — ·0109	4 = — ·0100
5 = — ·0072	5 = — ·0072

Temp. Coeff. = ·00000016
Bal. = 14·6464 lb.
Sag. on 50 = — ·00092
W = ·61558 lb. per ch.

Differences from Standard, Odd Distances.

A end, A edge.	B end, A edge.
0 = + ·0028	0 = + ·00375
1 = — ·0041	1 = — ·00505
2 = — ·00865	2 = — ·00960
3 = — ·01370	3 = — ·01370
4 = — ·00995	4 = — ·01090

Field-book. No.	Page.	Stations.	Observed Temperature.	Corrections. Temperature Corrections.	Differ. from Stand.	Alignment.	Sag.	Mean Tension.	Total Corrections.	Measured Distances corrected.	Corrected Distances and Inclinations.	Logs and Cosines.	Reduced Distances.	Totals.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	26	Bid-will ⊙	57	— ·0001	+ ·0028	— ·0007	— ·0018	—	+ ·0002	99·8873 + ·0002 A	99·8871 El. 0° 15′ 30″	4 1·9995090 9·9999956 1·9995050	99·8861	
			58	— ·0002	— ·0098 — ·0137 + ·0039	— ·0002 1/22 =	— ·0064 — ·0001 — ·0065 × ·98 — ·0064	— ·0001	— ·0176	372·1349 — ·0176 B	372·1173 D. 7° 24′ 12″	85 2·5706713 9·9963644 2·5670442	369·0152	
			57	— ·0004	— ·0072	— ·0001 =	— ·0092 × ·99 — ·0091	+ ·0013	— ·0155	499·9728 — ·0155 A	499·9573 El. 5° 00′ 09″	64 2·6989266 9·9983426 2·6972756	498·0531	
			56	— ·0004	— ·0100	— ·0002	— ·0074	— ·0004	— ·0184	400·1378 — ·0184 B	400·1194 D. 2° 31′ 12″	102 2·6021794 9·9995798 2·6017694	399·7325	
	27		51	— ·0009	— ·0072	— ·0001	— ·0092	+ ·0007	— ·0167	499·9272 — ·0167 A	499·9105 El. 2° 55′ 15″	4 2·6988918 9·9994354 2·6983276	499·2609	
	28		61	—	— ·0048 — ·0041 — ·0007	— ·0006 1/40 =	— ·0018 — ·0005 — ·0023	—	— ·0077	140·3201 — ·0077 A	140·3124 El. 0° 14′ 20″	74 2·1470886 9·9999962 2·1470922	140·3112	

Notes.

1. In the heading, name of tape, end and edge, the end stated as "A" means that this end is always leading in the direction of the measurement for the section.

2. The letters "A" and "B" in column 11 indicate the end of tape in use for the particular measurement.

3. All "differences from standard" are computed to a temperature of 62°.

4. Temperature-corrections are taken out of a table by inspection.

5. "Differences from Standard": When the measurements are nominally full chains, the differences from standard are taken out of the proper column in the tables given in the heading to the left. When the measurements are odd, as 372·1349, the difference for the 3 chains first taken out of the table and proper column in the heading to the right, as — ·0137, and the difference for the odd links from a specially prepared link-value table as + ·0039.

6. Alignment: This correction also from a table is made to correct the small error introduced by the line measured being at one end out of the base alignment. (See Fig. No. 13.)

7. Sag: As the tape is supported on knife-edges every 50 links, the corrections for sag are made on the basis of the number of 50-link lengths in the measurement. When there are shorter lengths requiring corrections, and a large number of them as in section 9, then these corrections are most rapidly taken out by the formula, log. of sag $= \frac{\text{log. sag for 50 links}}{\text{log. } 50^3}$ + log of distance^3, the first term being a constant for the measurement.

8. Mean tension: This correction is due to the position of the constant tension of 15 lb., whether at the upper or lower end of the particular measure. It is rapidly taken out by inspection from graphic scales, one giving the correction first to the tension for degree of slope, and the other for the elastic extension of the tape equivalent to the first-obtained correction. The final correction is + when the tension is at the lower end, and — when at the upper.

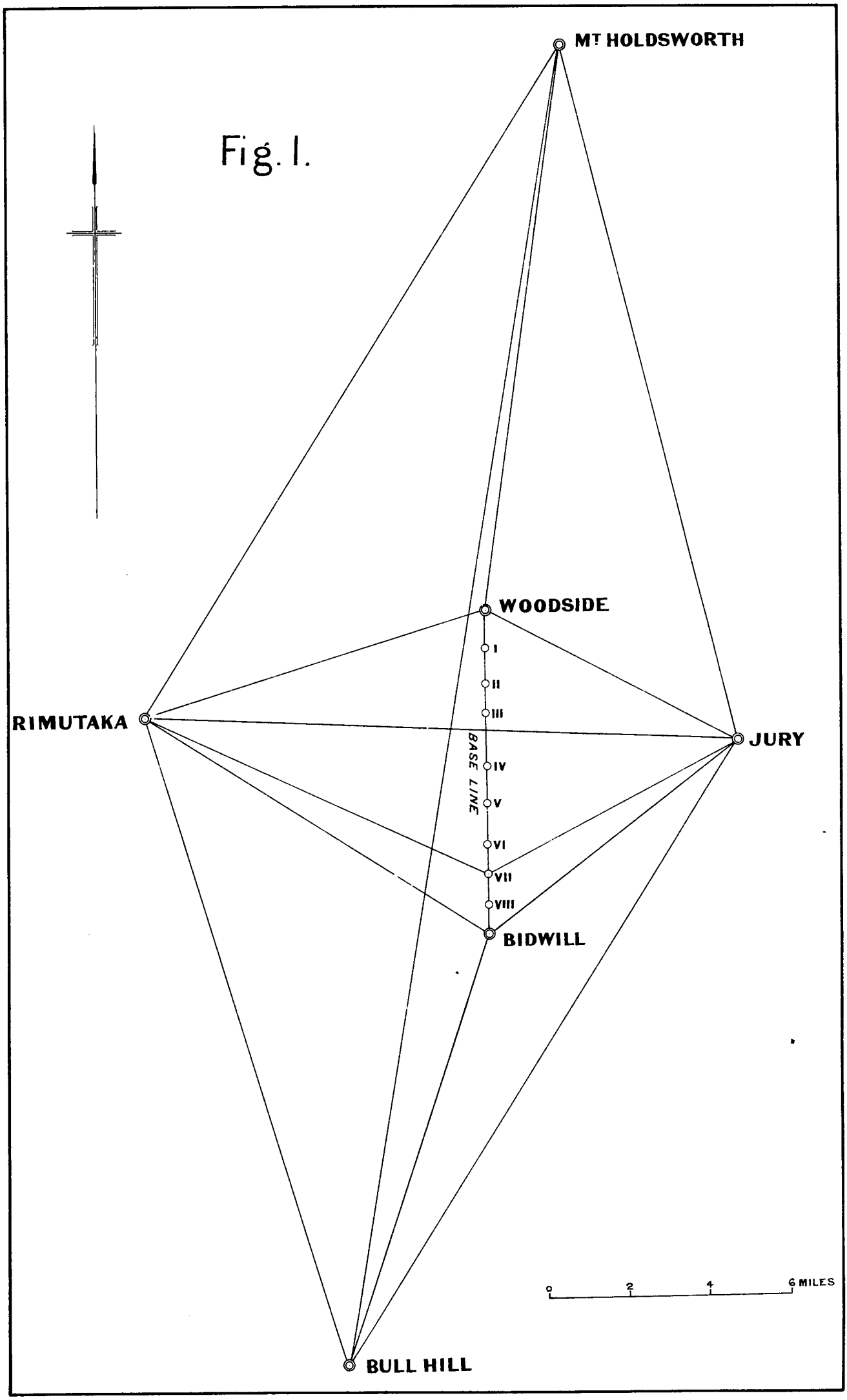


Fig. 1.
MT HOLDSWORTH
WOODSIDE
I
II
III
BASE LINE
IV
V
VI
VII
VIII
RIMUTAKA
JURY
BIDWILL
BULL HILL
0
2
4
6 MILES

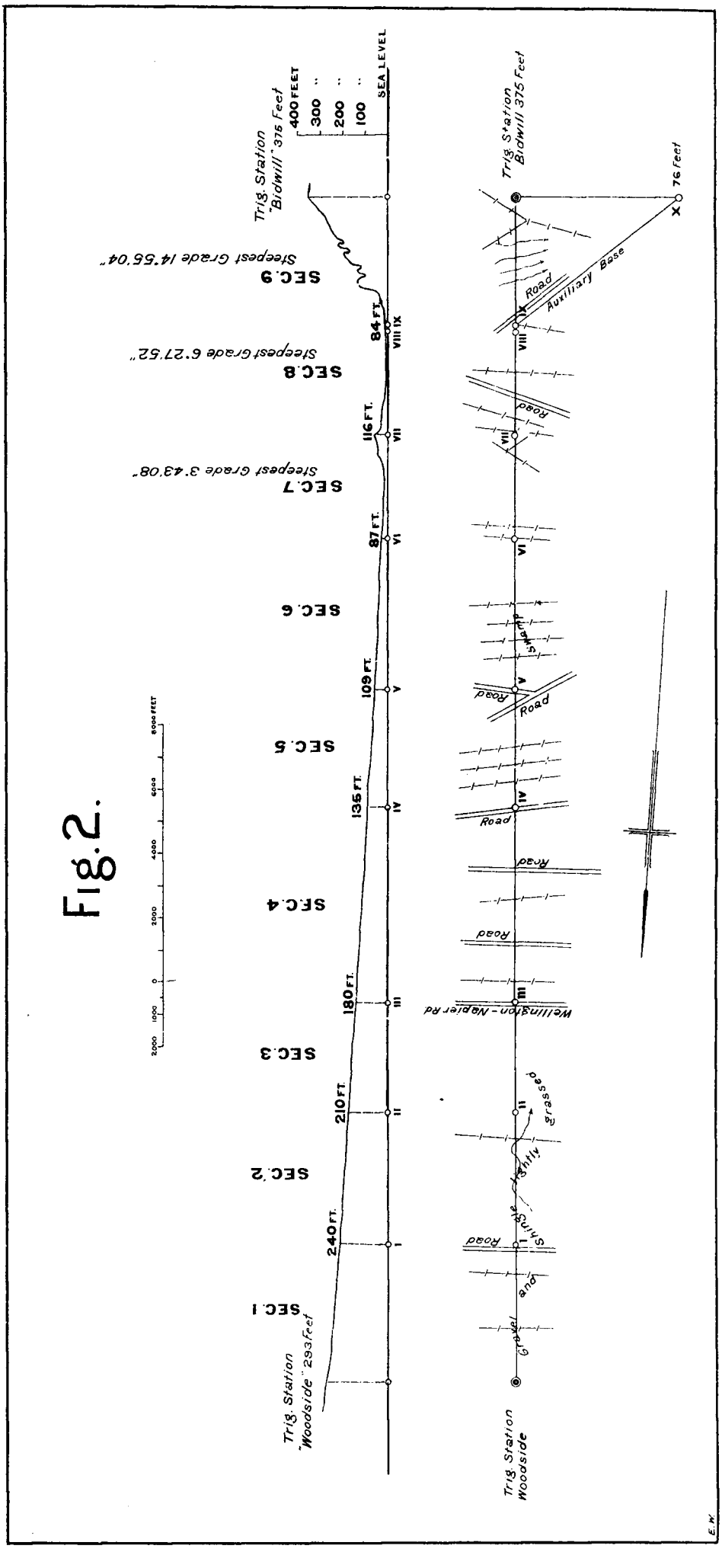
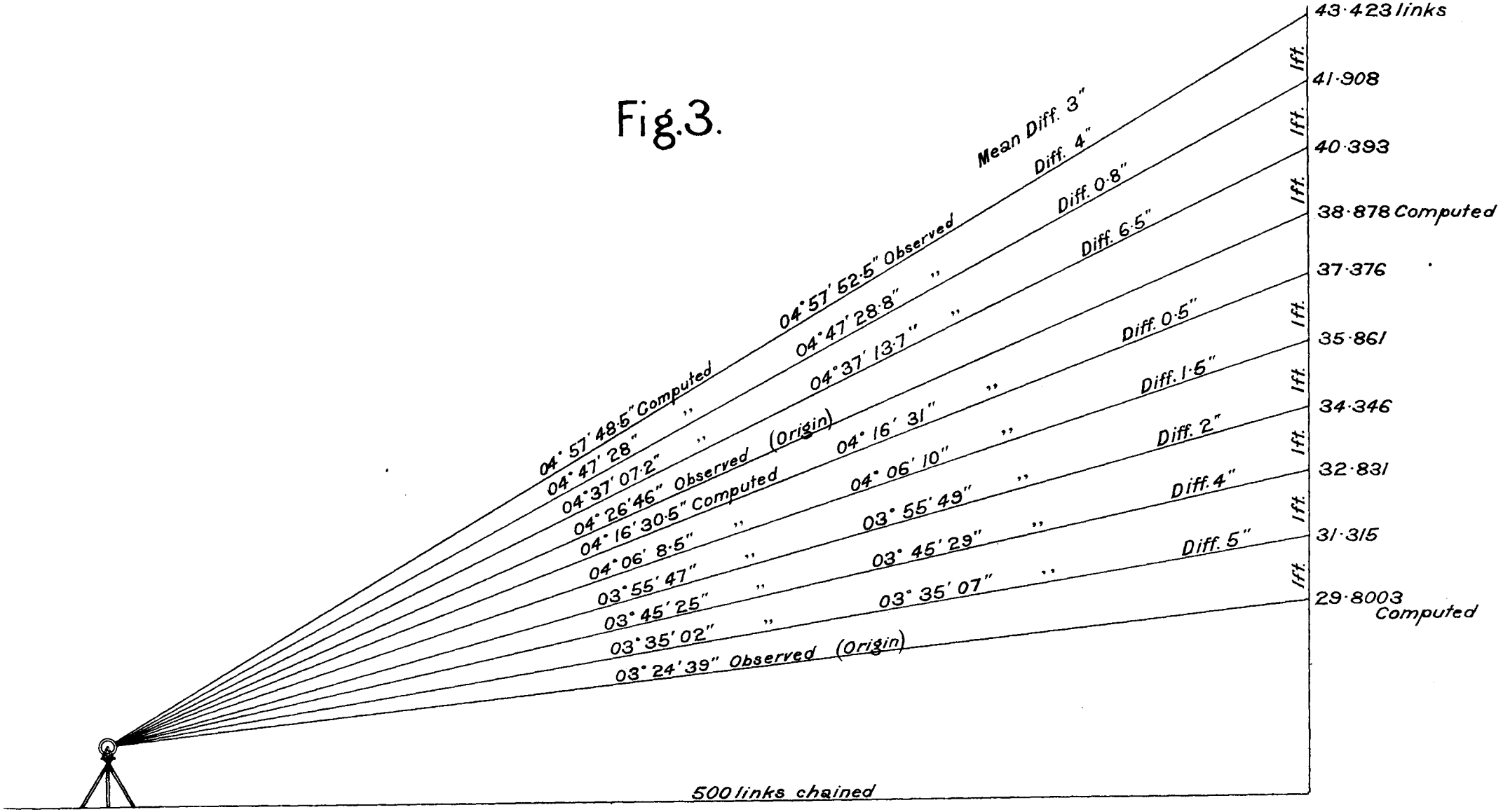

Trig. Station "Bidwill" 375 Feet
SEA LEVEL
400 FEET
300 " "
200 " "
100 " "
Steepest Grade 14°56'04"
SEC. 9
Steepest Grade 6°27'52"
SEC. 8
Steepest Grade 3°43'08"
SEC. 7
SEC. 6
SEC. 5
SEC. 4
SEC. 3
SEC. 2
SEC. 1
84 FT.
116 FT.
87 FT.
109 FT.
135 FT.
180 FT.
210 FT.
240 FT.
VIII IX
VII
VI
V
IV
III
II
I
Trig. Station "Woodside" 293 Feet
Trig. Station Bidwill 375 Feet
76 Feet
Auxiliary Base Road
Road
Swamp
Road
Road
Road
Road
Wellington - Napier Rd
Shingle and gravel Road
grassed
Trig. Station Woodside
E.W.

Fig. 2.

Fig.3.


04° 57' 48·5" Computed
04° 47' 28" "
04° 37' 07·2" "
04° 26' 46" Observed (Origin)
04° 16' 30·5" Computed
04° 06' 8·5" "
03° 55' 47" "
03° 45' 25" "
03° 35' 02" "
03° 24' 39" Observed (Origin)
04° 57' 52·5" Observed
04° 47' 28·8" "
04° 37' 13·7" "
04° 16' 31" "
04° 06' 10" "
03° 55' 49" "
03° 45' 29" "
03° 35' 07" "
Mean Diff. 3"
Diff. 4"
Diff. 0·8"
Diff. 6·5"
Diff. 0·5"
Diff. 1·5"
Diff. 2"
Diff. 4"
Diff. 5"
1ft.
1ft.
1ft.
1ft.
1ft.
1ft.
1ft.
1ft.
43·423 links
41·908
40·393
38·878 Computed
37·376
35·861
34·346
32·831
31·315
29·8003 Computed
500 links chained

C—14.

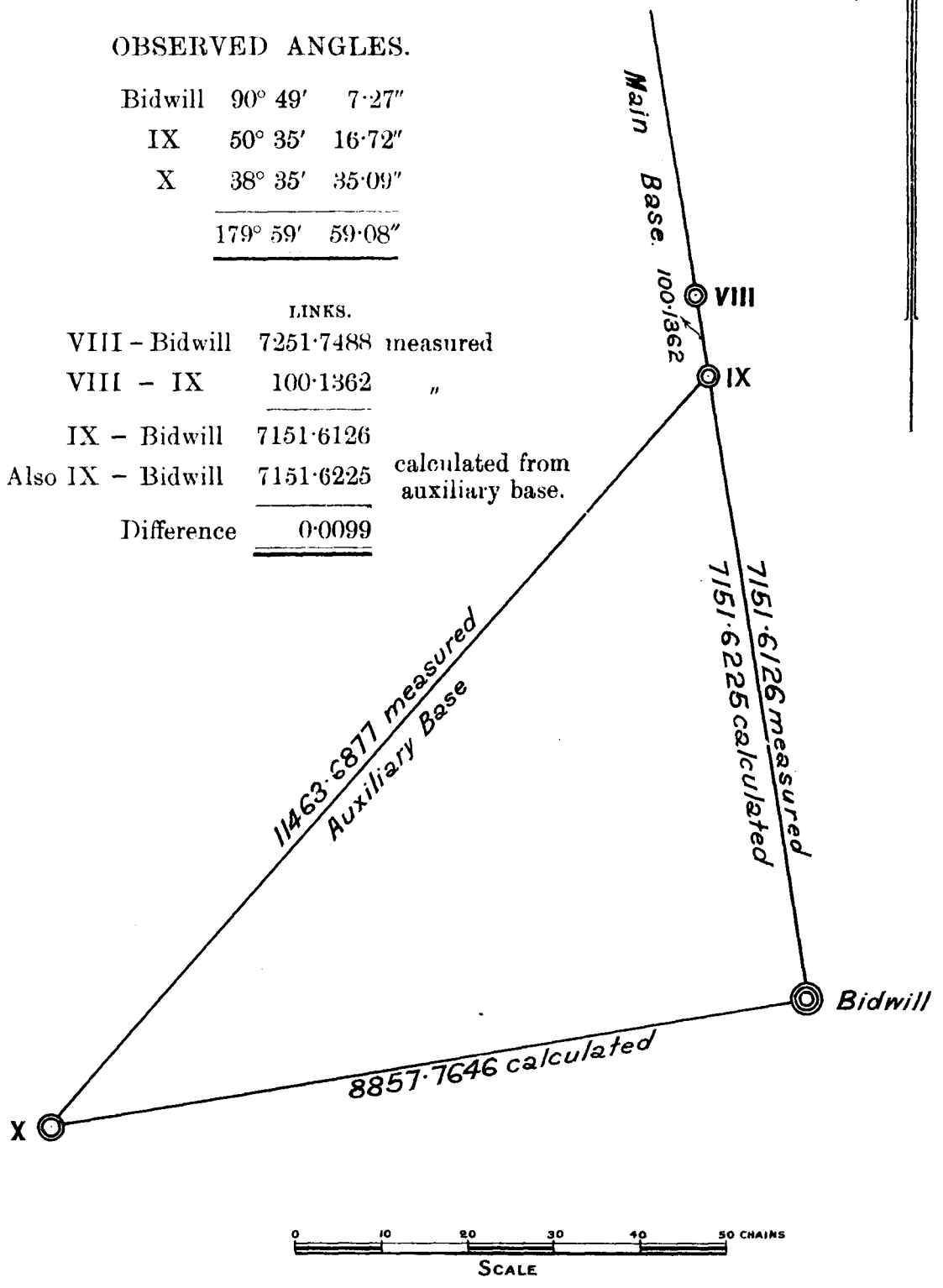
Fig. 4.

Diagram showing Auxiliary Base and Triangle Check on the direct Measurement of Section No. 9.

OBSERVED ANGLES.

Bidwill	90° 49′	7·27″
IX	50° 35′	16·72″
X	38° 35′	35·09″
	179° 59′	59·08″

	LINKS.	
VIII – Bidwill	7251·7488	measured
VIII – IX	100·1362	„
IX – Bidwill	7151·6126	
Also IX – Bidwill	7151·6225	calculated from auxiliary base.
Difference	0·0099	



Note.—Angles observed by Mr. H. J. Lowe, District Surveyor, using a 10 in. Everest Theodolite.

Fig. 5.

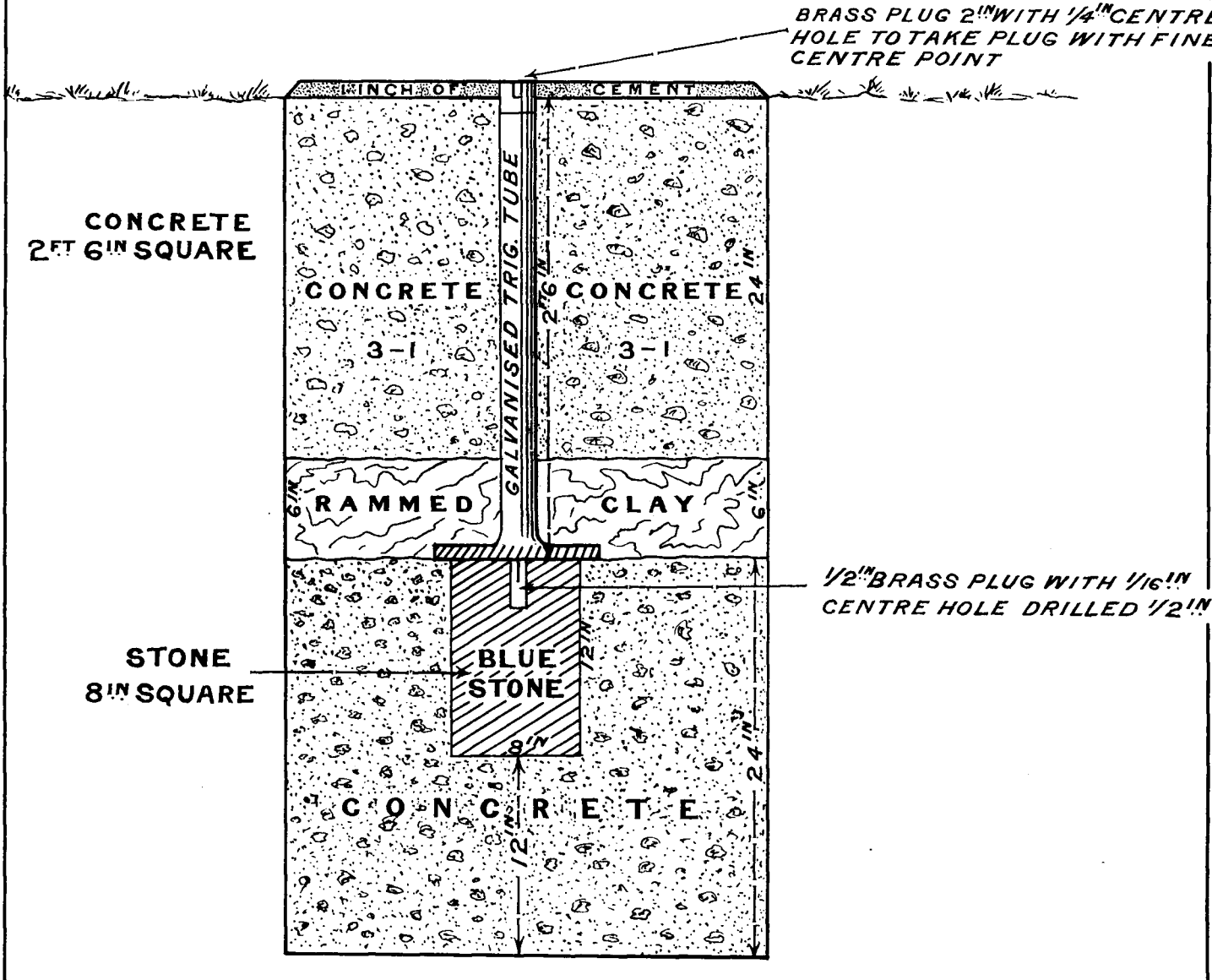
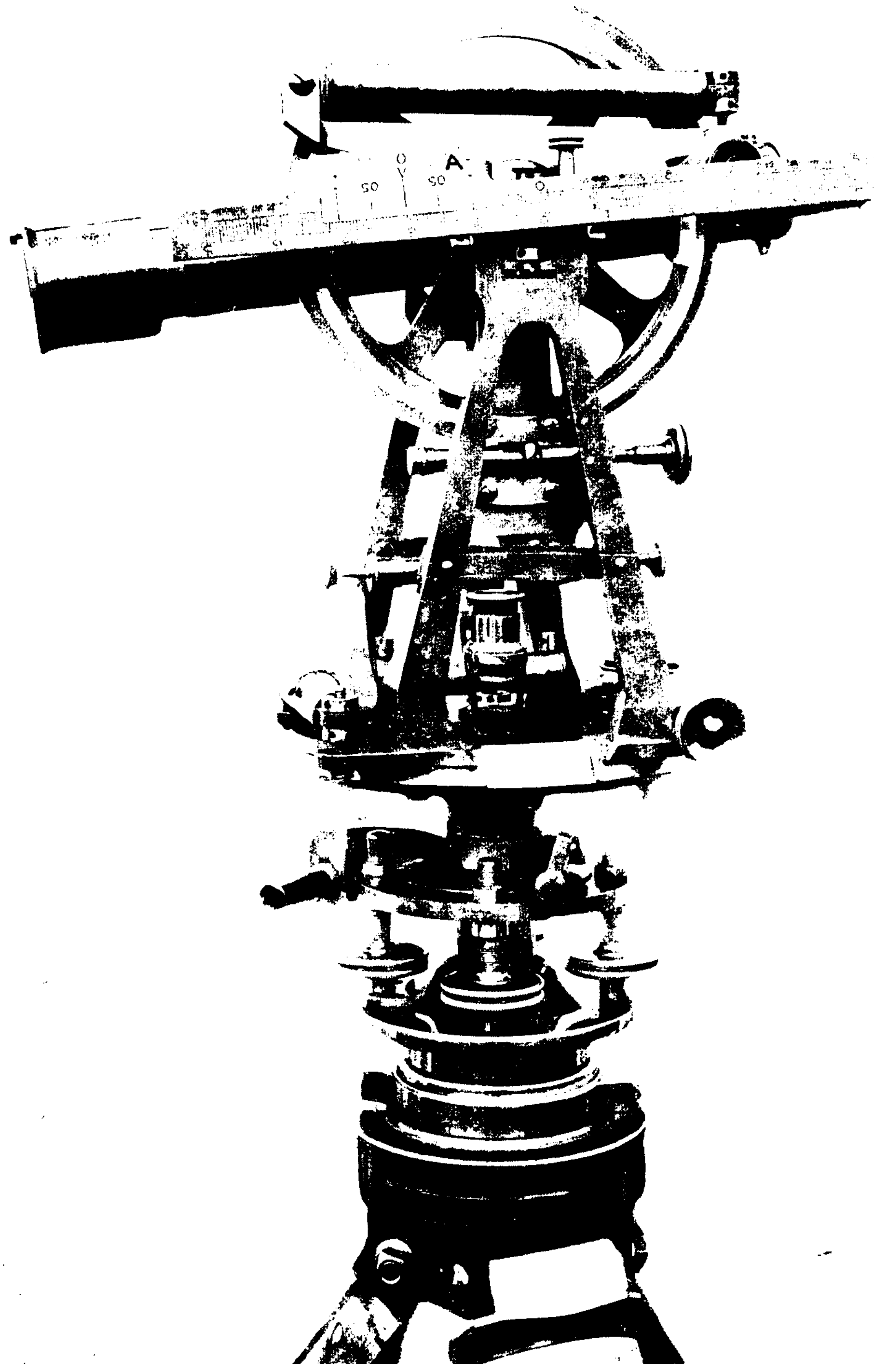

BRASS PLUG 2IN WITH 1/4IN CENTRE HOLE TO TAKE PLUG WITH FINE CENTRE POINT
1 INCH OF CEMENT
CONCRETE 2FT 6IN SQUARE
CONCRETE 3-1
GALVANISED TRIG. TUBE
2FT 6 IN
CONCRETE 3-1
24 IN
6 IN
RAMMED
CLAY
6 IN
1/2IN BRASS PLUG WITH 1/16IN CENTRE HOLE DRILLED 1/2IN
STONE 8IN SQUARE
BLUE STONE
12 IN
8 IN
CONCRETE
12 IN
24 IN

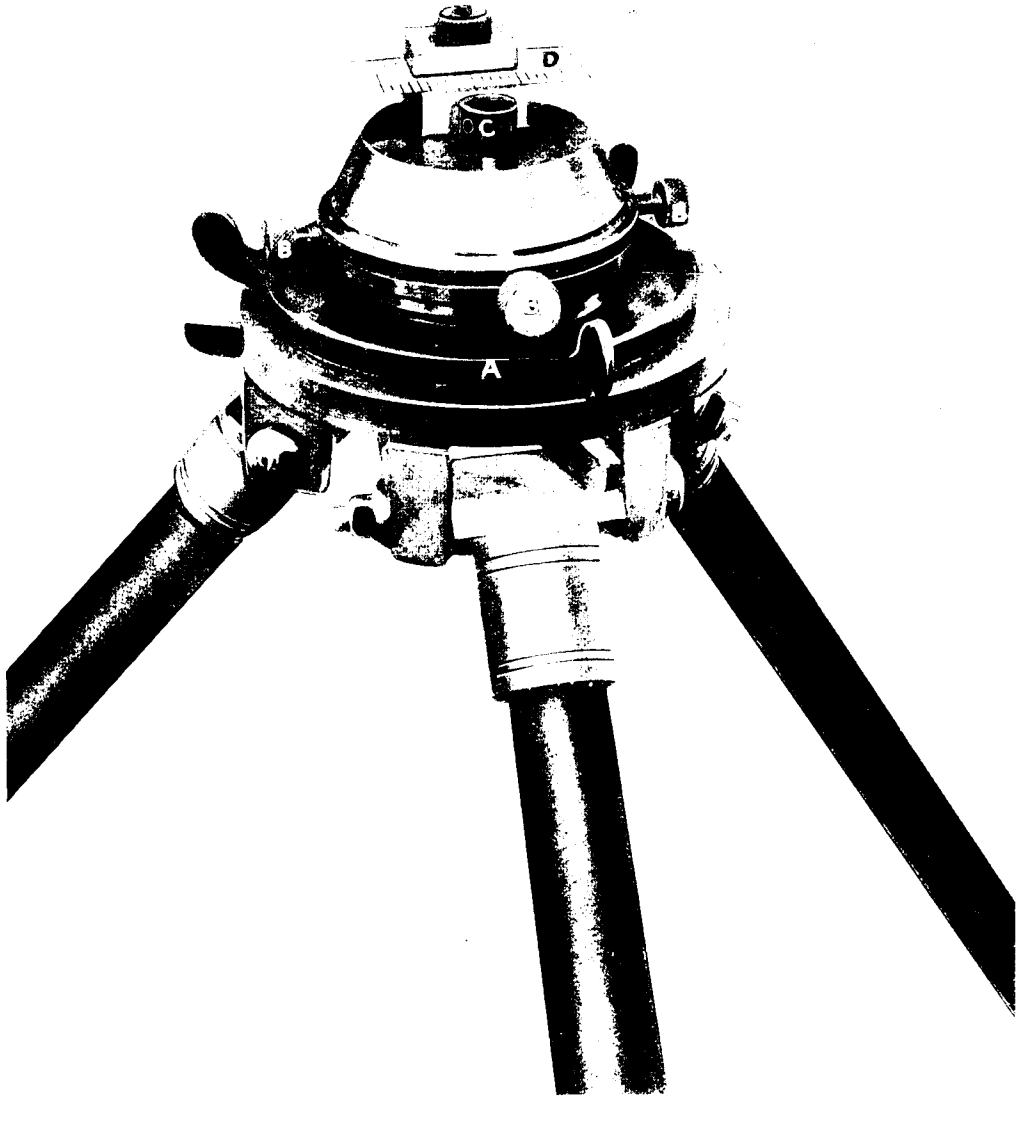
Fig. No. 6



Five inch Troughton and Simms Transit Theodolite (Vertical Arc divided to 20 seconds), with Chain [illegible] scale attached.

A. Steel scale divided to 0.001 [illegible] tenth of a link on the [illegible] scale.
B. Brass scale divided [illegible]

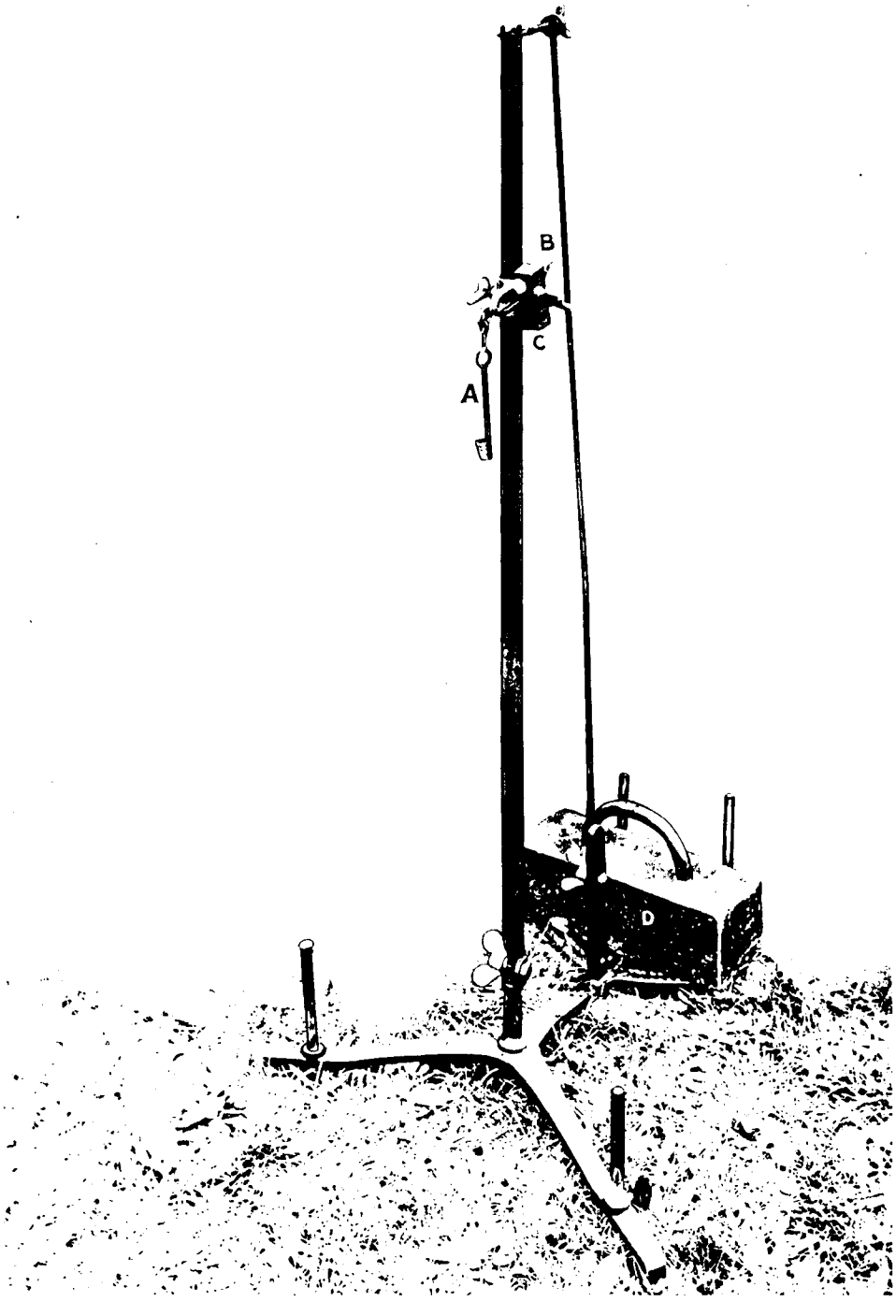
FIG. NO. 7.



MEASURING TRIPOD.

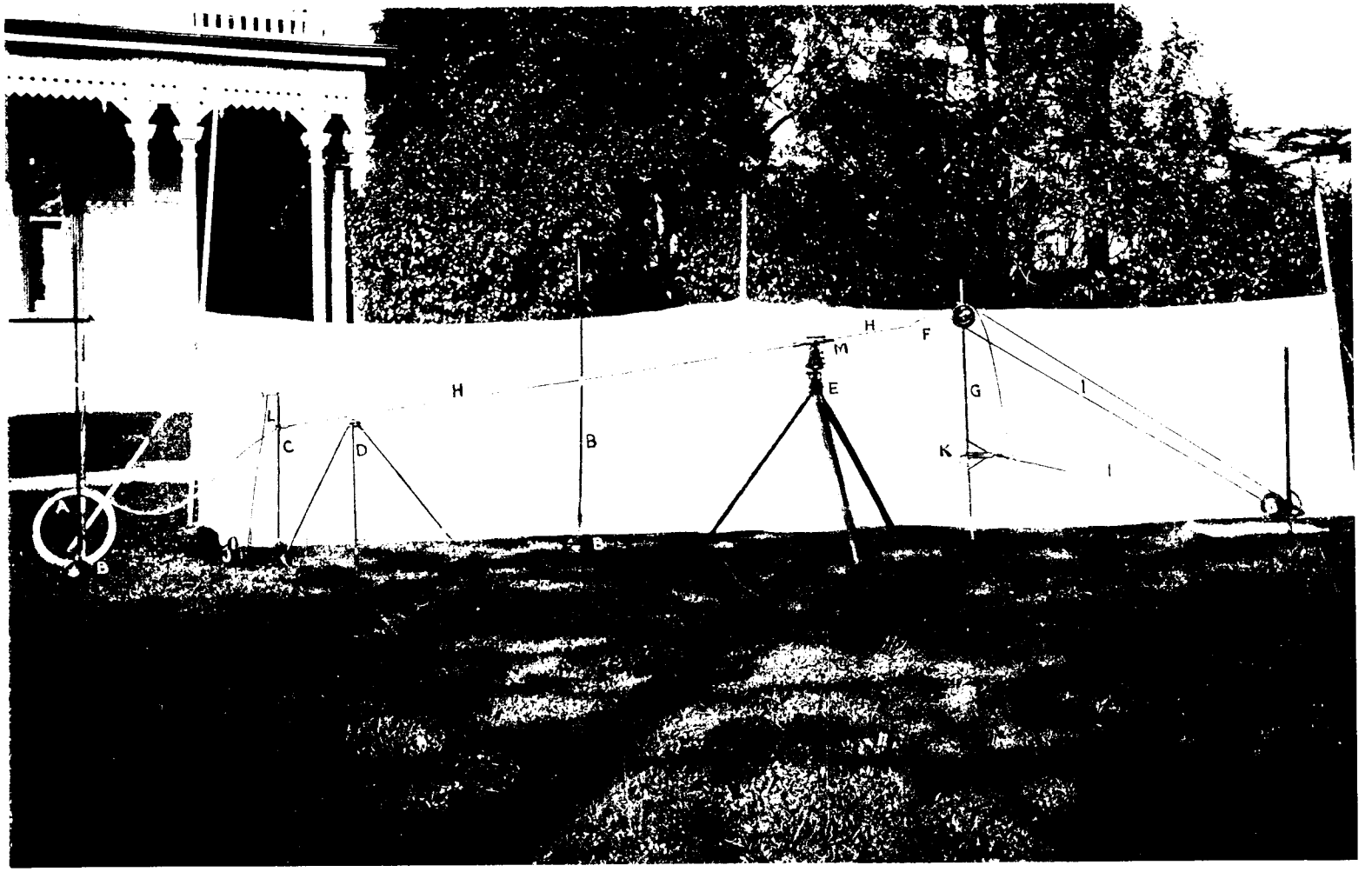
A. Sliding adjustment for approximate centring.
B. Slow motion opposing screws for fine adjustment.
C. Capstan screw supporting tape when in use.
D. Steel scale divided to 0·001 link. Used when standardizing tapes.
E. Inset of lead.

FIG. NO. 8.



MEASURING-STAND.

A. Littlejohn's brass chain grip, with swivel loop.
B. Slow-motion screw.
C. Gun-metal adjustable frame, with slow motion screw.
D. Weight.



General View of Base-measuring Apparatus set up ready for use.

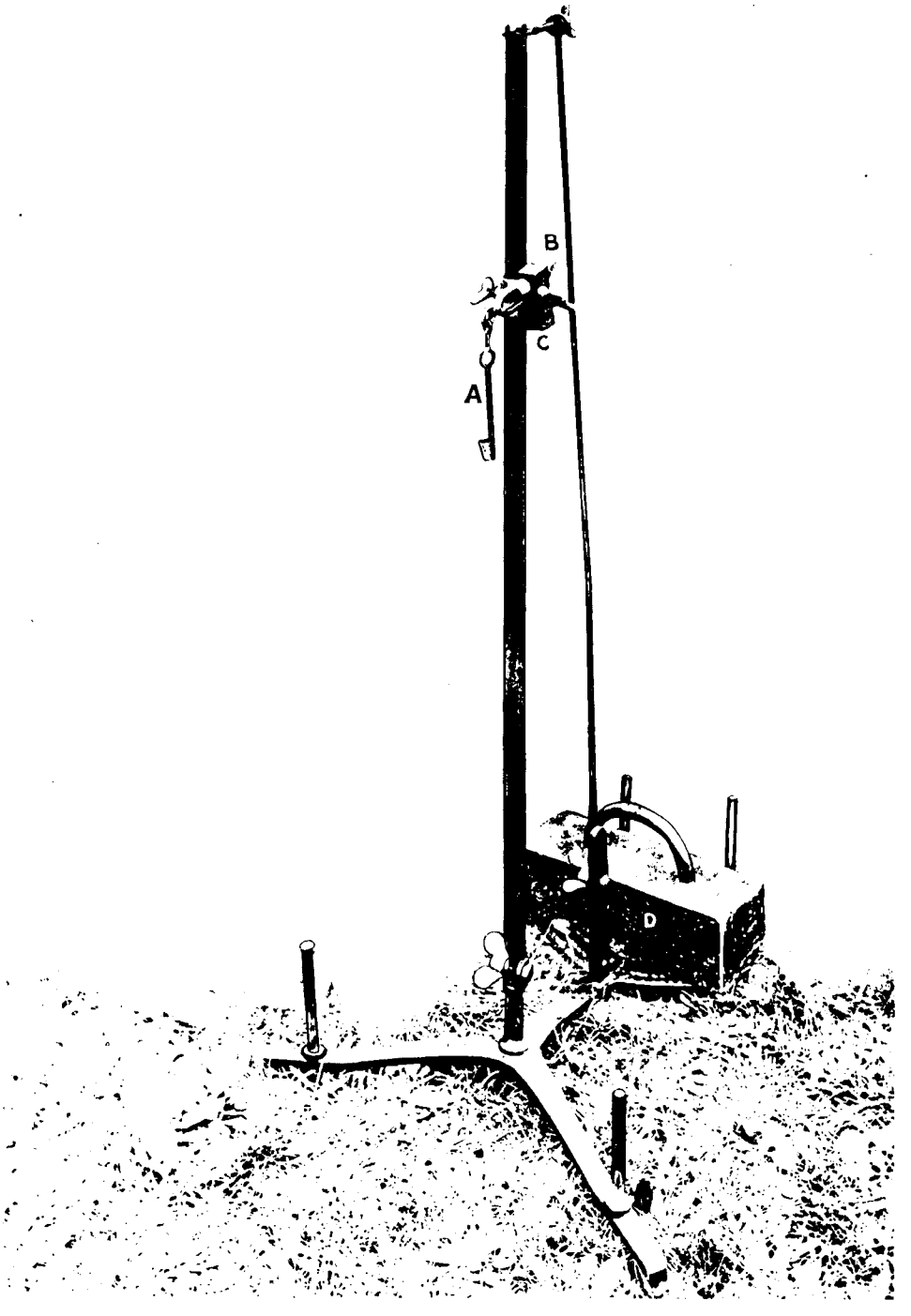
A. Tape-winder. Steel-wire frame, covered with stout leather, 18 in. inside diameter.
B. Cast-iron universal-jointed support-stands (Crabs). (For details see Fig. No. 11.)
C. Measuring-stand. (For details see Fig. No. 8.)
D. Measuring-tripod. Galvanized-iron tube legs, gun-metal top. (For details see Fig. No. 7.)
E. Five-inch Troughton and Simms transit theodolite, with brass and steel reading-scales attached to the vertical arc. (For details see Fig. No. 6.)
F. Spring balance.
G. Tension-gear. (For details see Fig. No. 10.)
H. Tape.
I. Tension-wires.
J. Weight.
K. Winch-handle of slow-motion screw of tension-gear.
L. Slow-motion screw of chaining-stand.
M. Scale attached to axis of vertical arc of theodolite.

When measurements are being made in the field, the observer at the scale stands abreast of the theodolite and reads the position of the graduated mark on the tape where it passes the scale M or A clearly shown in Fig. No. 6, always using a strong magnifying-glass.

The observer at the rear end, or tripod D, stands abreast of the tripod and makes the contact of the rear graduated tape-mark with the zero-mark on the tripod-head (see Fig. No. 7) by means of the slow-motion screw at L or B in Fig. No. 8. The fine scale on tripod is only in the position shown when the tape is on the comparator.

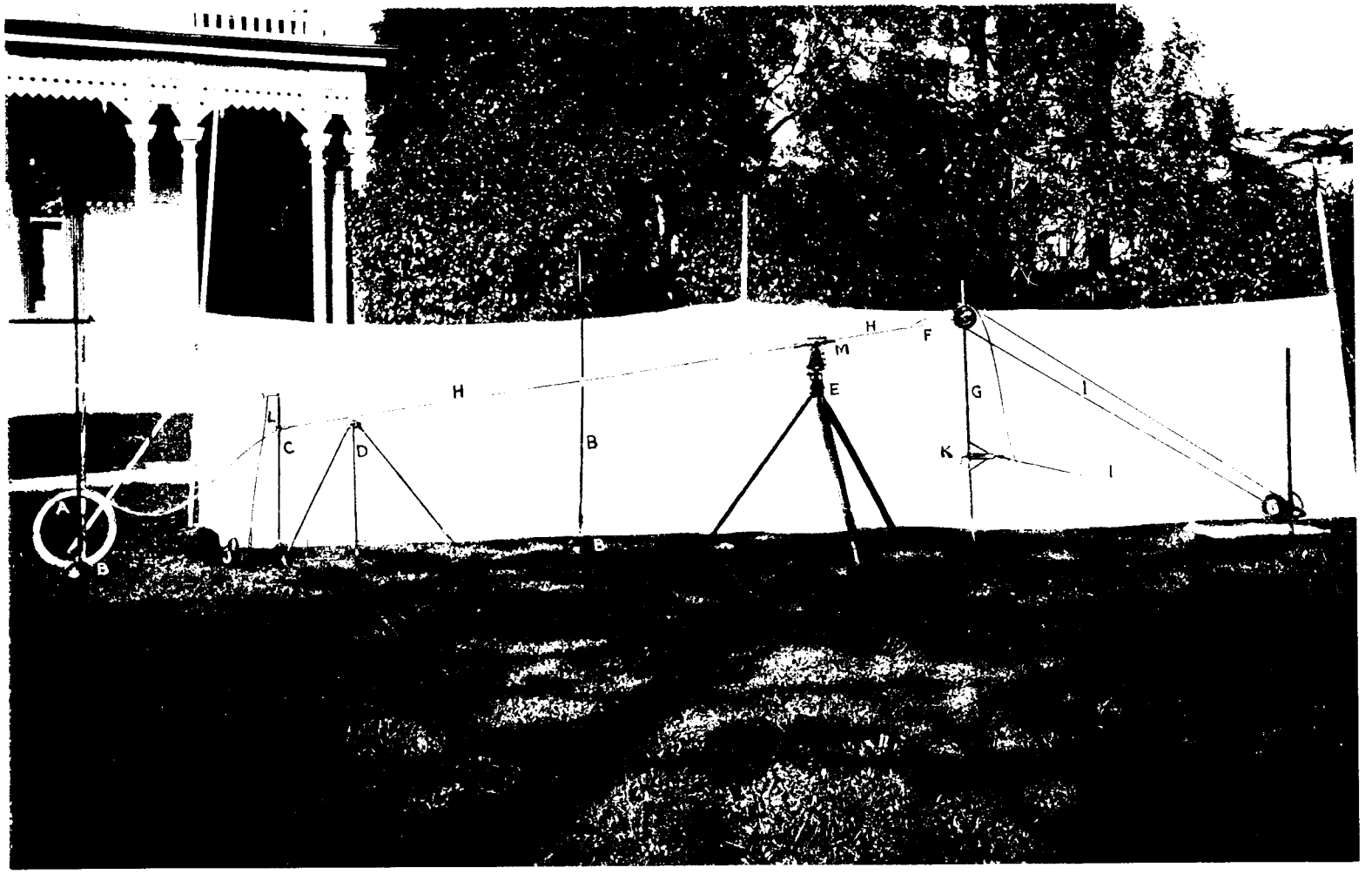
The tension-recorder stands abreast of F and keeps the index-mark of the balance true by means of the winch-handle K of the slow-motion tension screw.

FIG. No. 8.



MEASURING-STAND.

A. Littlejohn's brass chain grip, with swivel loop.
B. Slow-motion screw.
C. Gun-metal adjustable frame, with slow-motion screw.
D. Weight.



General View of Base-measuring Apparatus set up ready for use.

A. Tape-winder. Steel-wire frame, covered with stout leather, 18 in. inside diameter.
B. Cast-iron universal-jointed support-stands (Crabs). (For details see Fig. No. 11.)
C. Measuring-stand. (For details see Fig. No. 8.)
D. Measuring-tripod. Galvanized-iron tube legs, gun-metal top. (For details see Fig. No. 7.)
E. Five-inch Troughton and Simms transit theodolite, with brass and steel reading-scales attached to the vertical arc. (For details see Fig. No. 6.)
F. Spring balance.
G. Tension-gear. (For details see Fig. No. 10.)
H. Tape.
I. Tension-wires.
J. Weight.
K. Winch-handle of slow-motion screw of tension-gear.
L. Slow-motion screw of chaining-stand.
M. Scale attached to axis of vertical arc of theodolite.

When measurements are being made in the field, the observer at the scale stands abreast of the theodolite and reads the position of the graduated mark on the tape where it passes the scale M or A clearly shown in Fig. No. 6, always using a strong magnifying-glass.

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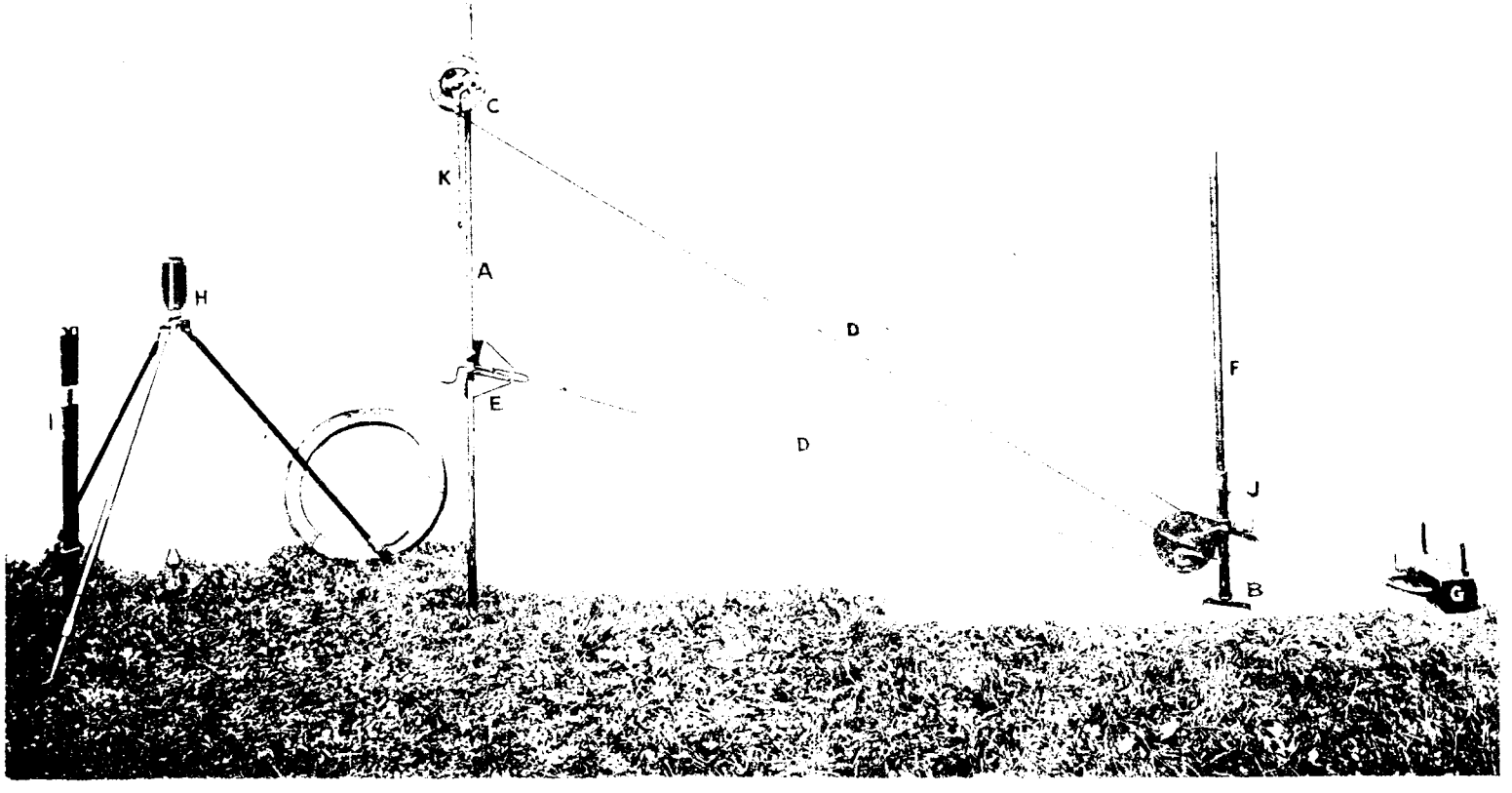
The tension-recorder stands abreast of F and keeps the index-mark of the balance true by means of the winch-handle K of the slow-motion tension screw.



TENSION APPARATUS.

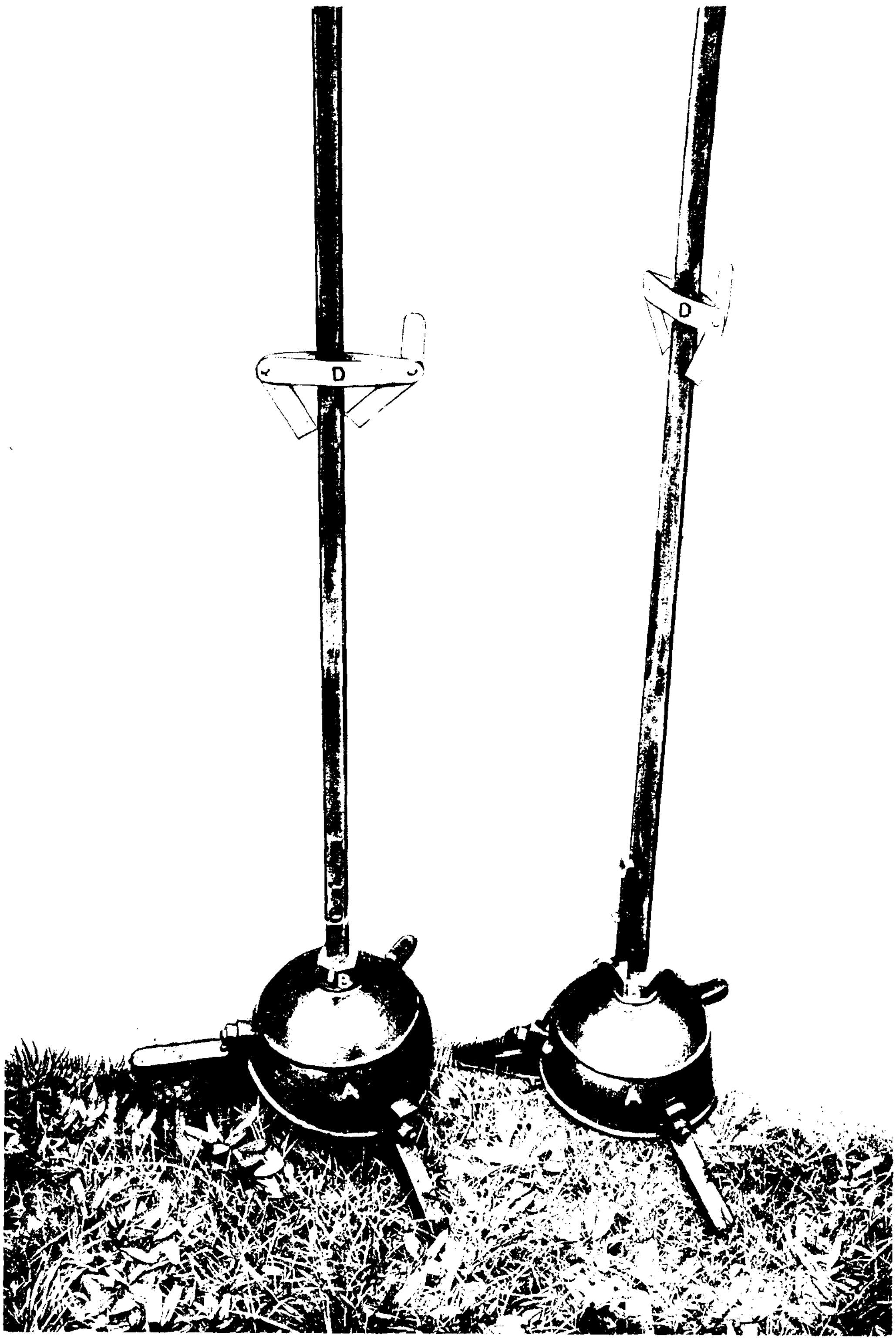
A. Three quarter inch galvanized iron rod.
B. Foot stand for stay-pulley.
C. Pulleys.
D. Tension wires.
E. Tension-frame and screw, for slow motion. Approximate strain put on by sliding frame up or down rod.
F. Stay pole.
G. Stay-weight.
H. Tripod with signal attachment for angular rod.
I. Extensions for legs of tripod.
K. Balance with grip attached.

FIG. NO. 10.

C. IA.

C. 1A

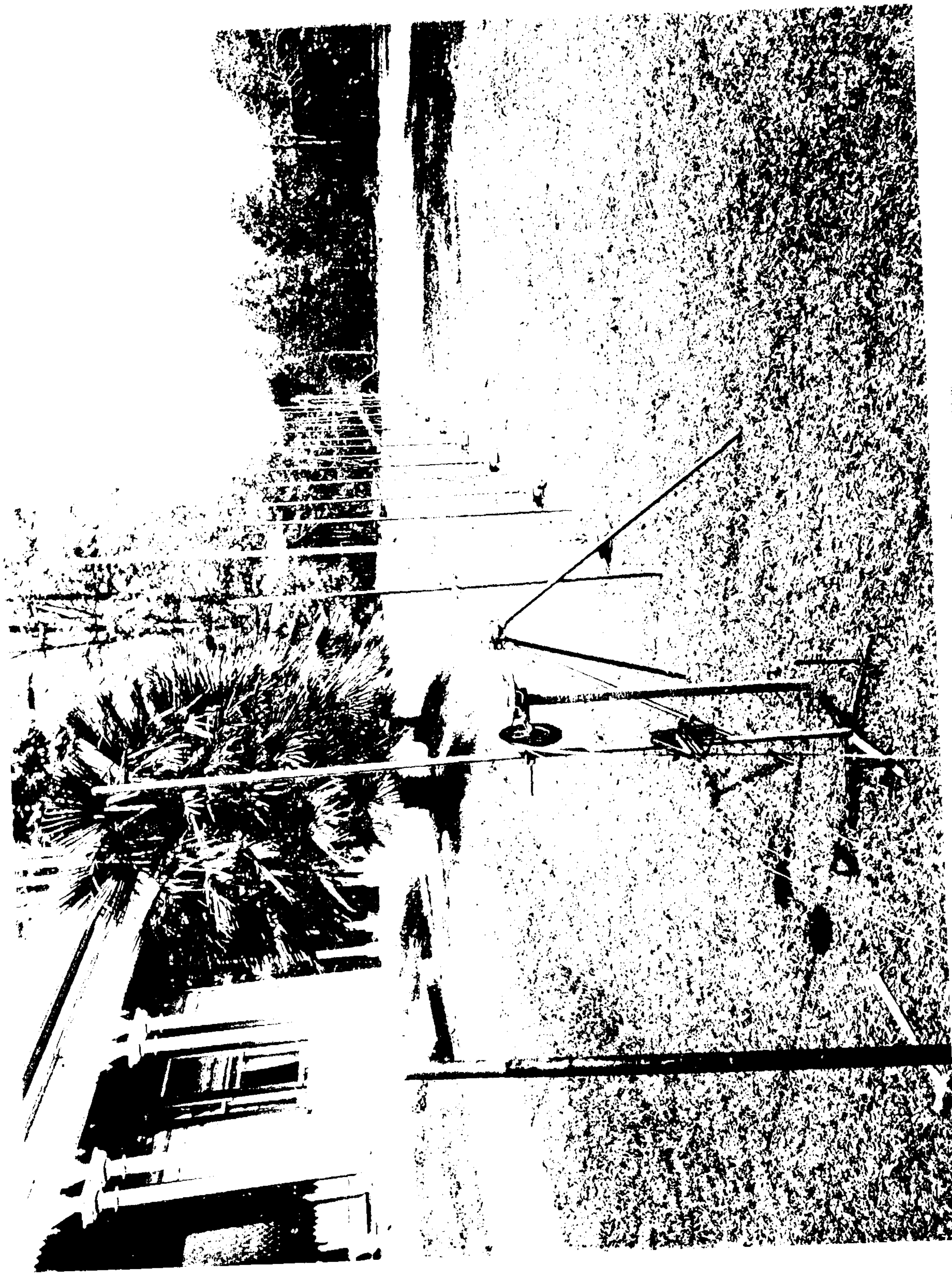
FIG. No. 11.



SUPPORT STANDS.

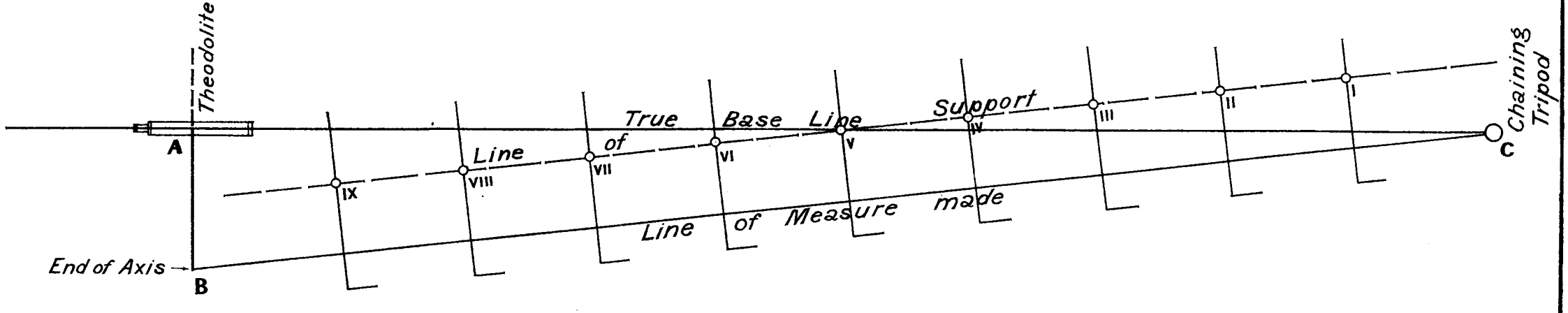
A. Cast iron universal jointed seats.
B. Brass collar clamping nut.
C. Bluegum rods, 6 ft. to 7 ft. long.
D. Steel spring sliding supports.

Fig. No. 12.



Comparator set up with Supports 5 Links apart.

Fig. 13.


Theodolite
A
True Base Line
Support
Line of
Line of Measure made
End of Axis
B
C
Chaining Tripod
I
II
III
IV
V
VI
VII
VIII
IX

APPENDIX IV.

REPORT OF THE SURVEYORS' BOARD.

THE Board, acting in conjunction with the Australian Surveyors' Boards, conducted examinations of candidates for surveyors' licenses in September, 1909, and March, 1910.

At the September examination twenty candidates sat, and of these Mr. John Norris, Public Works Department, Otira, and Mr. George Arthur Bridges, Timaru, passed the examination; while Mr. John Cawte Young, Lands and Survey Department, Christchurch; Mr. Robert Stanley Finch, Whangarei; and Mr. Stanley Parkinson, Auckland, who had previously passed in some of the subjects, completed their examinations.

At the March examination there were fourteen candidates, of whom the following completed their examinations: Mr. Robert Black, Wellington; Mr. Arthur Hastings Bridge, Christchurch; Mr. John Berry Cuthbert, Napier; and Mr. Henry Godfrey, Port Levy. The Board issued certificates of competency and licenses to the successful candidates.

Licenses were also issued to Mr. H. Vickerman, who had passed the September, 1905, examination with credit, and to Mr. G. H. A. Purchas, Mr. A. W. D. Bell, Mr. C. B. R. Turner, and Mr. J. Mouat, who held qualifications entitling them thereto.

Letters of recommendation to the Australian Boards were issued in favour of Mr. J. G. MacGibbon, Mr. D. A. Crawford, Mr. W. Loudon, Mr. T. G. Lilliecrona, and Mr. G. P. Middleton, to enable them to obtain licenses in Australia.

The deaths of the following licensed surveyors were reported: J. S. Browning, T. W. Downes, F. H. Geisow, W. G. Murray, C. F. R. Neumann, G. F. Richardson, and W. Tole.

The late Hon. G. F. Richardson, who died at Wellington on the 23rd October, 1909, was an original member of the Board, and up to the last took an active interest in its work, and represented it at a number of conferences of Surveyors' Boards in Australia: at the first meeting of the Board held after his death appreciative references were made by the chairman and members, and the following resolution was carried: "That this Board respectfully desires to convey to Mrs. Richardson and family its deep sympathy with her and them in their recent sad bereavement, and it further directs that an entry shall be made in the minutes of the Board recording its sense of the irreparable loss it also has sustained through the death of the late Hon. George Frederick Richardson, one of its oldest and most respected members, a man of wide and varied experience, of deep thought and keen observation, a most genial, considerate, and courteous gentleman, and one who took a deep interest in all matters connected with surveying and its cognate subjects, and who was generally looked up to and revered throughout the Dominion as one of the Grand Old Men of the profession."

To fill the extraordinary vacancy caused by the death of the Hon. G. F. Richardson, the Board nominated Mr. Hubert Sladden, Wellington, to hold office until the end of the year.

The Board for 1910 consists of Mr. J. Strauchon, Surveyor-General, *ex officio*; Mr. T. Humphries, Wellington, and Mr. E. C. Gold Smith, Chief Surveyor, Auckland, nominated by the Minister of Lands; Mr. C. H. Bridge, Christchurch, and Mr. H. Sladden, Wellington, nominated by the Council of the Surveyors' Institute. At the first meeting of the Board Mr. J. Strauchon was unanimously elected Chairman.

The list of licensed surveyors as at the 1st January, 1910, now numbering 445, was published in the *Gazette* on the 27th January, and copies were supplied to surveyors on application.

During the year Survey Regulation No. 67 was amended, and regulations providing for payment of fees and travelling-allowances of members of the Board were gazetted.

The examination-papers for the March examination were prepared by this Board, and copies were supplied to each of the six Australian Boards for use in their examinations.

The Conference Recess Committee, Sydney, forwarded suggestions as to the proposed Conference of Surveyors-General in London on Reciprocity in Survey Licenses and on other professional subjects, and invited the Board's views on the proposed representation thereat. The Board considered, and resolved that the proposal to send only two Australian representatives seemed inadequate to deal with the large and important questions involved, and that on this account it is desirable to defer the Conference in London in order to secure complete representation from Australia and New Zealand.

One case of alleged breach of the Act by a licensed surveyor was reported to the Board, but upon investigation the evidence was not considered sufficient to enable the Board to take any action. An application for reinstatement from a surveyor whose license was suspended was fully reconsidered; but the Board did not see its way to depart from its original resolution.

The Board held six meetings, and appointed a committee of three members to deal with routine matters between Board meetings. The committee held six meetings during the year.

JOHN STRAUCHON, Chairman.
Wellington, 31st March, 1910. C. E. ADAMS, Secretary.

Table 1.—Return of Field-work executed by the Staff and Contract Surveyors from 1st April, 1909, to 31st March, 1910.

Land District.	Minor Triangulation.		Topographical Survey for Selection as "Unsurveyed Land."		Rural and Suburban.			Town Section Survey.			Native Land Survey.			Gold-mining Survey.			Roads, Railways, and Water-race		Other Work.	Total Cost of Surveyors and Parties from 1st April, 1909, to 31st March, 1910.
	Acres.	Cost per Acre.	Acres.	Cost per Acre.	Acres.	No. of Sections.	Cost per Acre.	Acres.	No. of Sections.	Cost of Sections.	Acres.	No. of Secs. or Divs.	Cost per Acre.	Acres.	No. of Sections.	Cost per Acre.	Miles.	Cost per Mile.	Cost.	
		d.		d.			s.			s.			d.			s.		£	£ s. d.	£ s. d.
Auckland	52,551	2·68	9,996	3·24	67,542	215	1·99	45	55	32·45	(a)65,303 (b)73,755	143 186	13·50 ..	2,603	35	4·34	116·6	25·06	3,291 6 3	25,291 6 1
Hawke's Bay ..	..	..	..	..	41,116	116	1·68	..	..	..	(a)24,379 (b) 2,166	75 5	21·11 8·76	..	..	..	2·25	10·30	869 11 1	5,879 12 5
Taranaki	..	..	19,791	14·22	19,670	54	2·65	..	..	..	..	..	..	..	..	..	7·98	22·83	1,176 11 10	6,940 4 9
Wellington	..	..	35.164	4·00	57,105	155	2·17	319·5	267	18·24	(a)12,861 (b)10,062	12 16	11·51 35·39	..	..	..	49·5	18·35	2,826 14 4	12,563 17 7
Nelson	37,750	1·02	29,253	3·58	58,554	190	2·03	..	..	..	..	..	..	..	..	..	17·44	17·20	317 1 9	8,867 1 10
Marlborough	..	..	..	..	14,062	33	1·69	..	..	..	..	..	..	..	..	..	19·9	23·99	1,425 0 1	3,851 3 6
Westland	..	..	36,200	2·53	13,391	145	3·07	46·25	115	26·42	..	..	..	..	..	..	11·5	11·00	322 7 5	3,718 19 8
Canterbury	..	..	..	..	30,347	101	0·76	3·3	13	51·14	..	..	..	..	..	..	14·5	14·67	102 19 11	1,411 19 1
Otago	104,000	1·18	..	..	1,575	8	1·62	..	..	..	..	..	..	..	..	..	..	..	154 3 1	796 9 1
Southland	13,214	1·70	..	..	16,786	148	2·54	16·0	18	17·78	..	..	..	..	..	..	25·8	21·41	611 12 2	3,667 15 4
Means and totals	207,515	1·57	130,404	3·91	320,128	1,165	1·97	430·05	468	22·82	188,526	437	15·88	2,603	35	4·34	265·47	21·49	11,097 7 11	72,988 9 4
Licensed surveyors (paid by applicants) ..					7,651	92	..	..	..	..	130,650	452	..	3,914	88	..	1·5	..		
Totals					327,779	1,257	..	..	..	..	319,176	889	..	6,517	123	..	266·97	..		

(a) Native Land Court. (b) Maori Land Board.

Table 2.—Return showing Surveyors employed and the Work on Hand on 1st April, 1910.

Chief Surveyors.	Surveyors employed.		Work on Hand.						
	Staff.	Temporary.	Land District.	Trig.	Settlement.	Town.	Native Land Survey.	Roads, &c.	Topography.
				Sq. Mi.	Acres.	Acres.	Acres.	Miles.	Acres.
E. C. Gold Smith	26	3	Auckland ..	29	142,774	300	101,303	166	..
T. N. Brodrick ..	7	1	Hawke's Bay	..	98,180	..	16,100	47	..
F. Simpson ..	3	2	Taranaki ..	..	91,590	..	..	..	..
J. Mackenzie ..	15	1	Wellington ..	2,340	103,040	427	30,900	11	..
R. T. Sadd ..	6	3	Nelson ..	470	69,210	..	40,469	14	..
F. Stephenson Smith ..	2	3	Marlborough	..	44,334	20	..	30	..
G. H. M. McClure	4	..	Westland ..	..	11,000	..	..	2	..
H. D. M. Haszard (Acting)	2	..	Canterbury ..	..	5,395	..	..	..	2,450
E. H. Wilmot ..	4	..	Otago ..	..	768,400	..	..	..	..
H. M. Skeet ..	2	2	Southland ..	..	5,186	..	24,700	..	..
Totals ..	71	15	..	2,839	1,339,109	747	213,472	270	2,450

Table 3. — Plans placed on Crown Grants and other Instruments of Title from the Crown from 1st April, 1909, to 31st March, 1910.

District.	Number.					Cost.		
	Singly.	In Duplicate.	In Triplicate.	In Quadruplicate	Total Copies.	£	s.	d.
Auckland	20	269	527	249	3,135	161	17	6
Hawke's Bay ..	3	92	96	59	711	53	8	3
Taranaki	6	15	150	49	682	61	7	8
Wellington	3	66	808	72	2,847	142	7	0
Nelson	4	77	111	117	959	116	16	6
Marlborough ..	5	18	75	3	278	64	1	8
Westland	..	319	49	77	1,093	60	0	0
Canterbury	39	63	15	63	462	85	7	7
Otago	..	52	146	..	542	109	0	0
Southland	241	62	345	13	1,452	99	17	4
Totals	321	1,033	2,322	702	12,161	954	3	6

Table 4. — Work done under the Land Transfer Act, &c., from 1st April, 1909, to 31st March, 1910.

District.	No. of Plans passed.	Deeds and other Instruments passed.	Number of Plans placed on Certificates of Title.				Miscellaneous Plans drawn or compiled.	Cost.		
			Singly.	In Duplicate.	In Triplicate.	In Quadruplicate.		£	s.	d.
Auckland ..	275	1,792	19	1,810	2	..	22	240	0	0
Hawke's Bay ..	168	573	2	838	117	1	25	513	2	9
Taranaki ..	113	..	3	475	3	..	..	244	6	6
Wellington ..	205	2,883	4,974	..	..	..	182	1,381	1	9
Nelson ..	67	142	..	192	..	..	..	156	6	4
Marlborough ..	24	..	..	64	4	..	..	40	12	0
Westland ..	33	40	..	59	22	..	..	65	5	1
Canterbury ..	324	2,253	16	872	5	..	18	1,214	18	5
Otago ..	53	1,378	6	793	3	.	..	319	6	11
Southland ..	75	14	11	480	8	..	..	300	0	0
Totals ..	1,337	9,075	5,031	5,583	164	1	247	4,474	19	9

Table 5. — LITHOGRAPHS and PHOTOGRAPHS printed and sold, from 1st April, 1909, to 31st March, 1910.

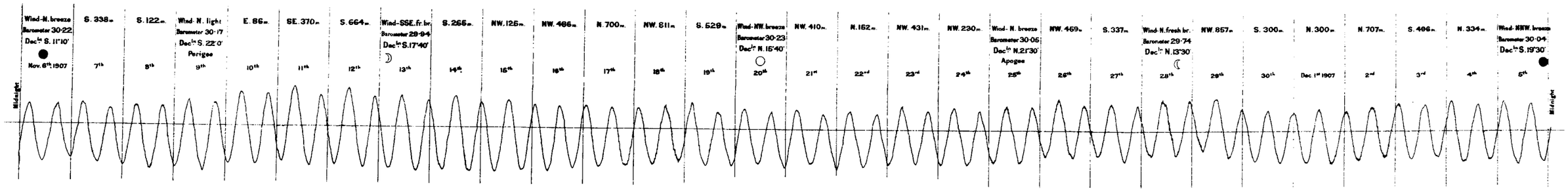
District.	Number of Lithographs printed.	Number of Photographs printed.	Amount of Fees received from Sale of Maps and Lithographs.
			£ s. d.
Auckland	4,400	..	129 19 9
Hawke's Bay	..	..	45 12 6
Taranaki	1,000	..	48 6 5
Wellington	..	..	46 13 0
Nelson	..	..	20 5 8
Marlborough	..	..	20 9 7
Westland	..	..	..
Canterbury	600	..	41 16 5
Otago	538	..	80 8 8
Southland	..	..	27 13 11
Totals	6,538	..	461 5 11

Approximate Cost of Paper.—Preparation, not given; printing (1,500 copies, including maps, &c.), £131 10s.

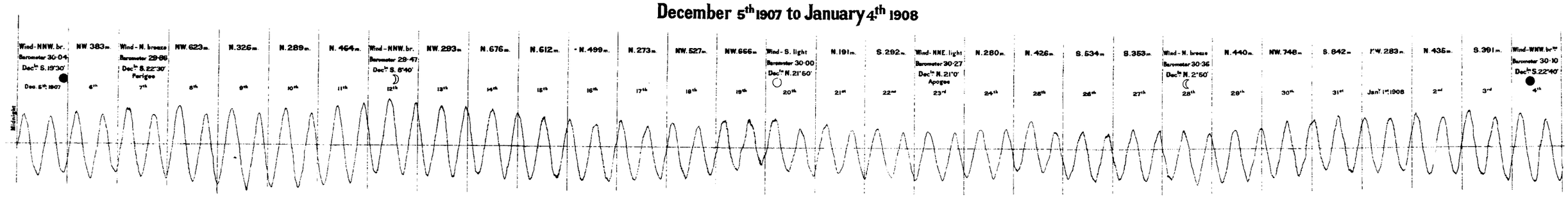
By Authority: JOHN MACKAY, Government Printer, Wellington.—1910.

Price 2s.]

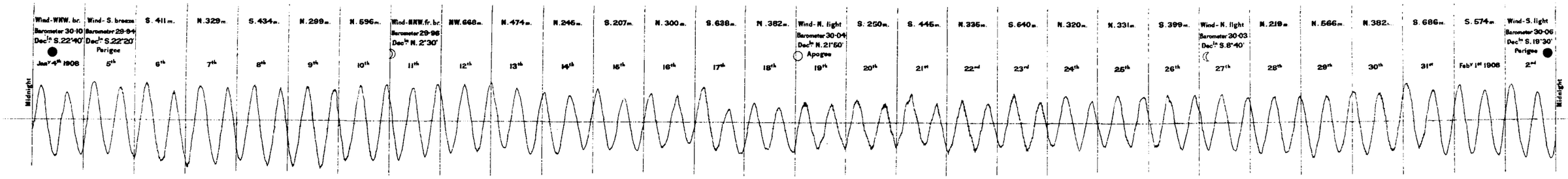
November 6th to December 5th 1907



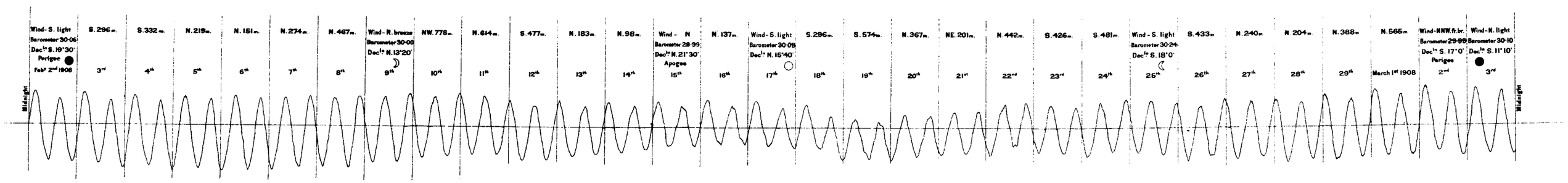
December 5th 1907 to January 4th 1908



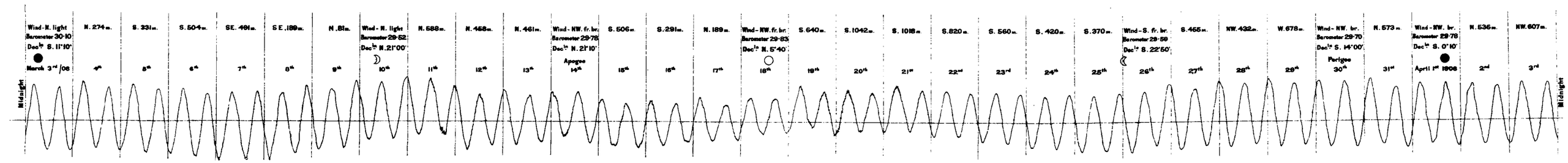
January 4th to February 2nd 1908



February 2nd to March 3rd 1908



March 3rd to April 3rd 1908

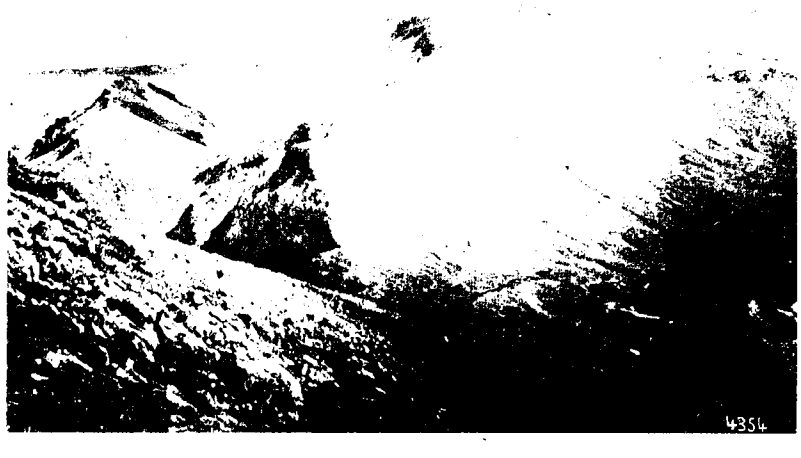


Vertical Scale

Note -- Vertical lines represent Midnight

1890-710-538.

TIDAL CURVES AT WELLINGTON.


4354

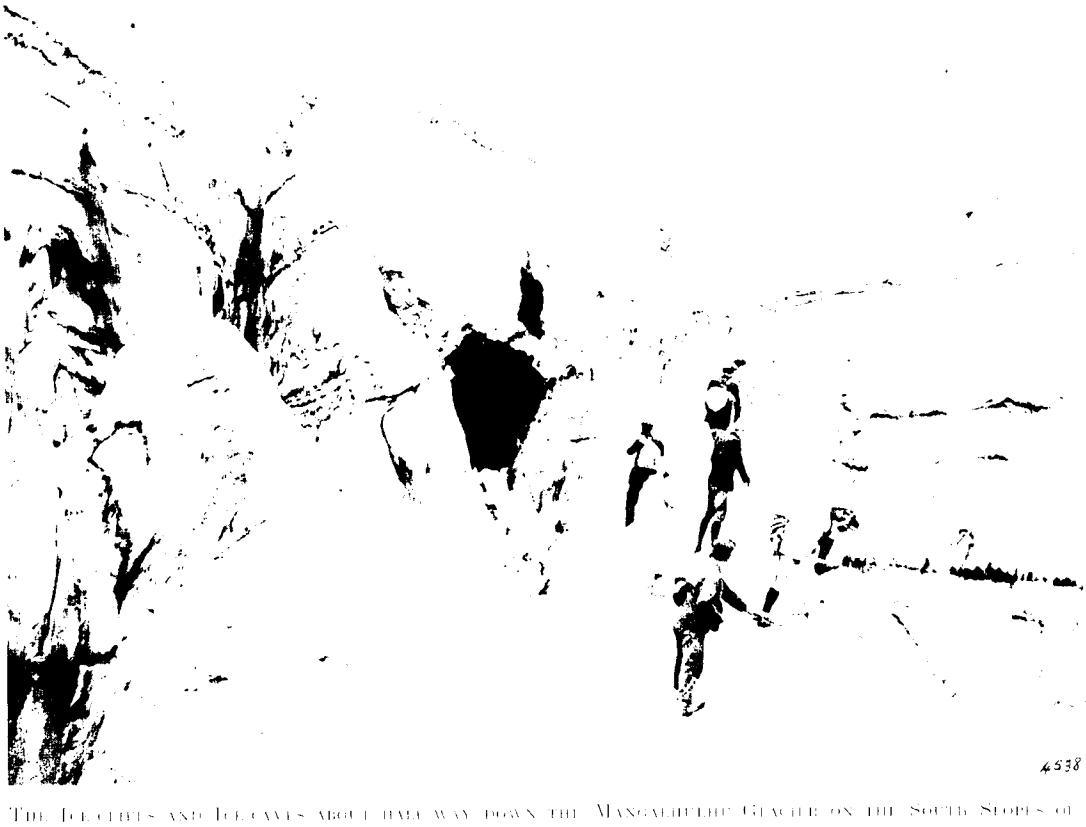
2. General View taken from the North Peak (Te Heu Heu Peak), looking South.

In the distance the sharp rocky peak (Little Matterhorn) shows up. Ruapehu Peak, the highest, shows in the centre of the picture to the top. The central crater-lake is hidden through the ice-cliffs which surround it. On the left can be seen the top of the much-crevassed Wangaehu Glacier.

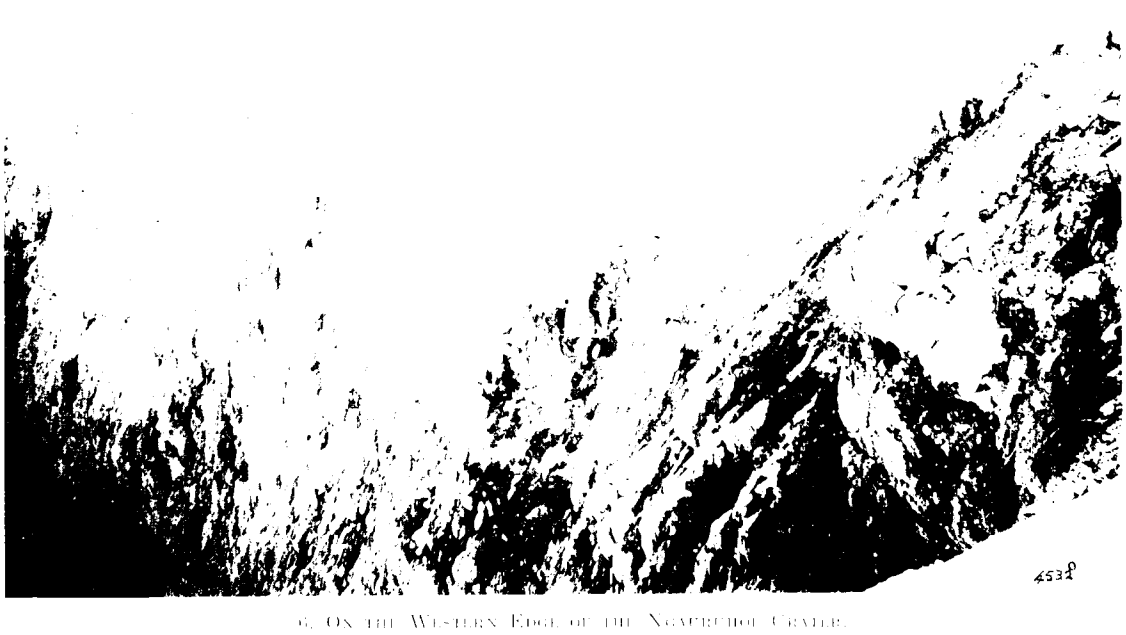
3. The Summit of Pare-te-tai-tonga Peak, Mount Ruapehu.
The appearance at Christmas time

1. Pare te Tai tonga Peak, showing the Top of the Ice cliffs, 200 ft. high, which surround the Crater lake.

These cliffs are undermined by the warm water of the lake, and large blocks are continually breaking off, and the crevasses seem to show that there is a gradual movement of the ice towards the lake. This photo was taken at Easter time, and presents quite a different aspect to No. 3.

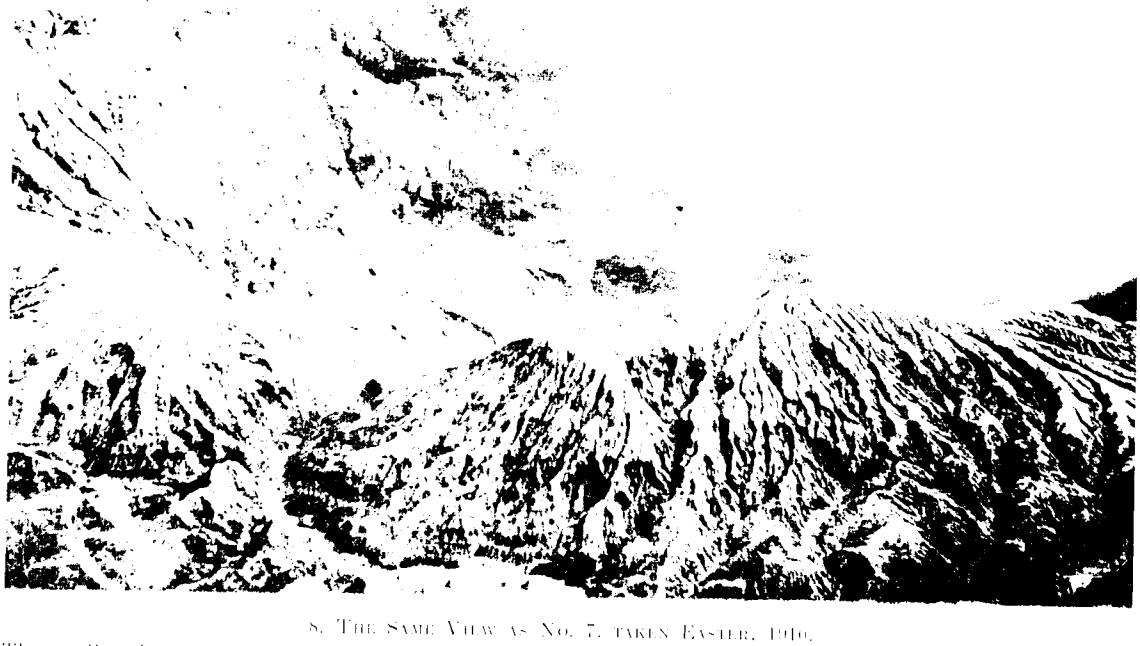


5. The Ice-cliffs and Ice-caves about half-way down the Mangaehehe Glacier on the South Slopes of Ruapehu.
This is one of the sights of the Rangataua route.



6. On the Western Edge of the Ngauruhoe Crater.
The figures are standing on what is known as Castle Rock, and there is a perpendicular drop of about 600 ft. underneath.

7. The Great Chasm, Ngauruhoe Crater, which was the Vicent Eruption, Easter, 1909.
Photo taken Christmas, 1908. Castle Rock can be seen at the left side of the crater. The white patches are snow.



8. The Same View as No. 7, taken Easter, 1910.
The small rock to the left of Castle Rock has disappeared. A good deal more mud has been thrown out and deposited inside the outer crater. As this view was taken three months later in the year than No. 7, all trace of snow has disappeared.

T. HUMPHRIES
Surveyor General

NORTH ISLAND
(TE IKA-A-MAUI)
NEW ZEALAND

Scale of English Miles

Reference

Reference to State of Public Surveys.

Meridional circuit
Minor Triangulation
Section Survey under check
Section Survey built

RAOUL or SUNDAY Is

MACAULEY Is

CURTIS Is

L'ESPERANCE Rk

KERMADEC ISLANDS

COOK ISLANDS

TASMAN SEA

Mercury Bay
Bay of Plenty
Hawke Bay
South Taranaki Bight
Tasman Bay
Golden Bay
D'Urville I.
Karamea Bight
Cloudy Bay
Cook Strait
MIDDLE ISLAND
SOUTH PACIFIC OCEAN
TE MOANA-NUI-A-KIWA

172 173 174 175 176 177 178 East Longitude
34 35 36 37 38 39 40 South Latitude

T. HUMPHRIES
Surveyor-General

SOUTH ISLAND
(TE WAI-POUNAMU)
NEW ZEALAND

Scale of English Miles

Reference

Cities
Boroughs
Towns and villages
Railways and stations
Roads
Boundaries of Land Districts
Projection - Rectangular Tangential

Meridional Circuit
Minor Triangulation
Section Survey under check
Section Survey built

Golden Bay
Tasman Bay
Karamea Bight
Pegasus Bay
Banks Peninsula
Canterbury Bight
South Latitude
Stewart Island

T A S M A N S E A

S O U T H P A C I F I C

(TE MOANA-NUI-A-KIWA)

O C E A N

AUCKLAND 1/6

CAMPBELL 1/6

(REKOHU or WHARE-KAURI)
CHATHAM ISLANDS

167° 168° 169° 170 East Longitude 171° 172° 173° 174°

By Authority: John Mackay, Government Printer.