1915.
NEW ZEALAND.

DEPARTMENT OF LANDS AND SURVEY:

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,— 29th June, 1915.

I have the honour herewith to present the report on survey operations for the year ended 31st March, 1915.

I have, &c.,
E. H. WILMOT, Surveyor-General.

The Right Hon. W. F. Massey, P.C., Minister of Lands.

REPORT.

In framing this report I purpose making it as concise as possible, and shall therefore present general aspects of the work performed during the year, leaving details to be found in the various tables and appendices accompanying.

The volume of work performed is rather less than that of last year. This is due, in the case of the regular staff, in large measure to the fact that no fewer than seven surveyors and five survey cadets enlisted and went to the front. Another factor has been the weather, which during the past year has been exceptionally boisterous, thus militating against survey operations. In consequence of this, also, the cost per acre of surveys has somewhat advanced on last year's figures, but is still quite satisfactory.

A summary of the work performed during the year is given in the following tables:—

TABLE A.

Class of Work.	Area.	Cost per Acre.	Total Cost.
	Acres.		£ s. d.
Triangulation, by staff surveyors	146,443	1·70d.	1,034 15 4
Topographical, by staff surveyors..	218,101	2·32d.	2,109 2 7
Rural, by staff surveyors	430,562	1·97s.	42,316 17 4
Rural, by licensed surveyors	20,050	2·57s.	2,579 17 9
Rural, by licensed surveyors (cost not available) ..	12,862	..	..
Village and suburban, by staff surveyors	5,514	7·11s.	1,961 11 1
Town, by staff surveyors	105*	23·67s.†	300 13 11
Town, by licensed surveyors	104‡	22·35s.†	34 13 0
Native Land Court, by staff surveyors	102,080	15·22d.	6,475 13 6
Native Land Court, by licensed surveyors	383,735	16·87d.	26,988 3 3
Native Land Court, by licensed surveyors (costs paid by applicants)	31,008	..	..
Gold-mining, by staff surveyors	98	9·75s.	47 16 0
Gold-mining, by licensed surveyors (costs paid by applicants)	2,275	..	..
Roads, by staff surveyors	233 miles	£22·16§	5,162 14 2
Roads, by licensed surveyors	24 "	£29·46§	707 3 4
Roads, by licensed surveyors (costs not available) ..	15 "	..	..

* In 254 sections. † Per section. ‡ In thirty-one sections. § Per mile.

TABLE B.

District.	Rural Surveys.	Native Land Court Surveys.
	Acres.	Acres.
Auckland	151,517	280,507
Hawke's Bay	50,086	100,770
Wellington	34,499	86,993
Taranaki	35,302	44,950
Nelson	113,445	159
Marlborough..	11,735	1,308
Westland	9,555	..
Canterbury	8,576	186
Otago	9,585	534
Southland	39,173	1,416
Totals	463,473	516,823

TRIANGULATION.

Very slow progress has been made with this work, on which there has been only one observer, and, owing to illness and bad weather, his efforts have been somewhat spasmodic. As is pointed out in Mr. Langmuir's report (see appendix), if this work is to make satisfactory progress the staff of observers must be increased. It is hoped that this coming year this work, which is an important one, will be pushed on with vigour on the lines suggested in his report, Owing to lack of staff and the demands of settlement surveys, minor triangulation has been restricted to that required for the control of these surveys; and revision of old minor triangulation, which it was intended to have carried out during the year, has had to be abandoned, though such revision in several districts is urgently required. An endeavour will be made to make progress in this direction next season.

Standard Surveys.

Owing to the want of specially trained surveyors and apparatus there has not been the amount of work accomplished that I had desired. The principal items of field-work were the continuation of the standard surveys in the suburbs of Auckland, and in Dunedin. The Auckland work has been executed by Mr. H. M. Kensington, under the direction of Mr. Langmuir, Inspector of Surveys, while Mr. Neill has continued the Dunedin work. The plan-work in each case has been kept going, though from lack of staff that of Auckland is falling into arrear. The principal work done by Mr. C. A. Mountfort has been the plans of Wanganui, Gonville, and Nelson, the bulk of the field-work of which he completed last year. Just before the close of the year Mr. Climie started a standard survey of Vogeltown. All the surveyors have maintained the high standard of accuracy which has always been aimed at in this class of survey.

An inspection of the detailed report on his year's work by Mr. Kensington shows that much of his time has been occupied in reinstating blocks, and remarking them after they have been built up or lowered. This has been rendered necessary on account of the alteration of the street-levels by the local bodies, who therefore pay for the reinstatement. In connection with this, and the appreciation of these standard surveys by local bodies, Mr. Langmuir makes some interesting remarks in his report, which appears as an appendix to this report.

Settlement Surveys.

Under the heading of "Rural Surveys," in Table A, 463,473 acres are returned as having been surveyed during the year. Table B shows the apportionment into the various districts. The average cost of this class of survey for the past year works out at 2s. per acre.

Native Surveys.

During the year staff surveyors completed the survey of 102,080 acres, while 414,743 acres were surveyed by licensed surveyors. Table B shows the allocation of these acreages between the various districts.

Gold-mining Surveys.

Thirty-one applications were surveyed, aggregating 2,373 acres, the largest area (1,142 acres, in nine holdings) being in Westland. The average cost of these surveys is not obtainable, owing to the fees having been paid by the applicants.

Inspections.

The inspections made from time to time by Chief Surveyors and Inspecting Surveyors show that the work of the surveyors in general is good, though there are exceptions which emphasize the necessity for systematic inspections.

Proposed Operations, 1915–16.

At the close of the year there were in the hands of staff surveyors 1,324,034 acres of settlement land (including village and suburban), and 191,943 acres of Native land; while in the hands of private surveyors there were respectively 10,835 acres and 449,268 acres. The distribution of this is shown in Table 4. Of this a considerable amount of fixed work has been completed, and before the end of June a large area will be ready for the completion of the plans. As usual, where advisable owing to weather-conditions, &c., staff surveyors will be called in for the months of July and August, and will during these months complete their plan-work. Owing to enlistments the field staff has been considerably depleted, and if the usual amount of Crown land and land for settlements is available this year for survey, more use must be made of the contract system; and it is probable that there will be no difficulty in placing contracts satisfactorily, as, owing to the war, private surveyors are finding work rather slack.

There is, as I pointed out in last year's report, an urgent need of standard surveys both in town and country. This work can be done satisfactorily only by having a specially trained staff with the proper appliances. This I hope to be able to arrange for during the coming year. In the meantime the standard surveys of Auckland, Dunedin, and probably Napier, and some of the smaller boroughs, will be carried on by the present staff, while the standard survey and revision of original survey of Vogeltown will be continued by Mr. Climie.

The secondary triangulation and revision of parts of the major and minor triangulations must be pushed on, but, as I have stated, it cannot be done unless the field staff working under Mr. Langmuir's direction is much increased. I hope it will be possible to effect this also.

Draughting Staff.

In his report (see appendix) the Chief Draughtsman calls attention to the time lost owing to protracted sick-leave granted to several officers, which has told against the output of work, and hampered the process of reorganization which is being carried out. A perusal of the report gives an idea of the variety of work performed by the Head Office staff. Special features of this year's work are the publishing of maps of the war areas in Europe, the issue of a new form of protractor sheet for Land Transfer plans, and the completion of maps of New Zealand on scales of ten miles and one millionth, which it is expected will be published at an early date.

Attention is called to the large amount of work required to be done to bring publication maps up to date, which work demands an increase of draughting staff.

Surveyors' Board.

The work of the year presented no unusual features. At the September examination fifteen candidates sat, of whom five completed the examination, having previously passed in some subjects; and at the March sitting eleven candidates sat, of whom one passed the whole examination and three completed and passed.

The Secretary, Mr. C. E. Adams, resigned in December, and left for the Lick Observatory, California, where he is to spend a year on leave studying in connection with his work as Government Astronomer. Mr. M. C. Smith was appointed Secretary to the Board in Mr. Adams's place.

The Board records with regret the death during the year of the following surveyors: Messrs. H. Baker, J. O. Barnard, P. Bedlington, G. B. Beere, J. L. Dickie, L. Simpson, W. C. Spencer, J. Stewart, and H. Trent.

Tidal Survey.

From March to December, 1914, the work was carried out under the direction of Mr. C. E. Adams, Chief Computer. In January, 1915, Mr. Adams left for America, and since then the work has been carried on by Messrs. J. J. Hay and T. G. Gillespie.

The work has comprised the predictions, from harmonic tidal constants already obtained, of the times and heights of high and low waters for the Ports of Auckland and Wellington, 1916. Predictions for Wellington, 1917, are nearing completion.

During the year further investigations were made into an improved method of harmonic analysis. About three months were taken up in this, and some valuable work was done. On the completion of the predictions for Auckland, 1917, this investigation will again be taken up, and if the new method of analysis is found to be more practicable it will be used in preference to that of Sir George Darwin's.

A start has been made on a new harmonic analysis for Wellington. The hourly heights for about the first three months have been measured from the gauge-sheets supplied by the Wellington Harbour Board. These measurements have been done in duplicate, and checked. This work will also be continued on the completion of the predictions for Auckland, 1917.

Magnetic Observatory.

At Christchurch the usual work of the observatory has been carried on with efficiency by Mr. Skey, whose report, with its illustrative diagrams and seismic records, may be found among the appendices.

Hector Observatory.

The observing for time and time-signalling have gone on as usual at the observatory. Mr. Adams, Chief Computer, who acted as Government Astronomer, left at the beginning of this year to take up a fellowship at Lick Observatory, and since his departure a well-known amateur astronomer from Canterbury, Mr. Westland, has taken charge of the work.

Obituary.

During the past twelve months, though there has been much sickness, I have only to record the death of one officer, Mr. John Dickie, by which the Department lost the services of a zealous and efficient officer. At the time of his death he was in the position of Land Transfer Draughtsman at Invercargill, which position he had held with credit for some years.

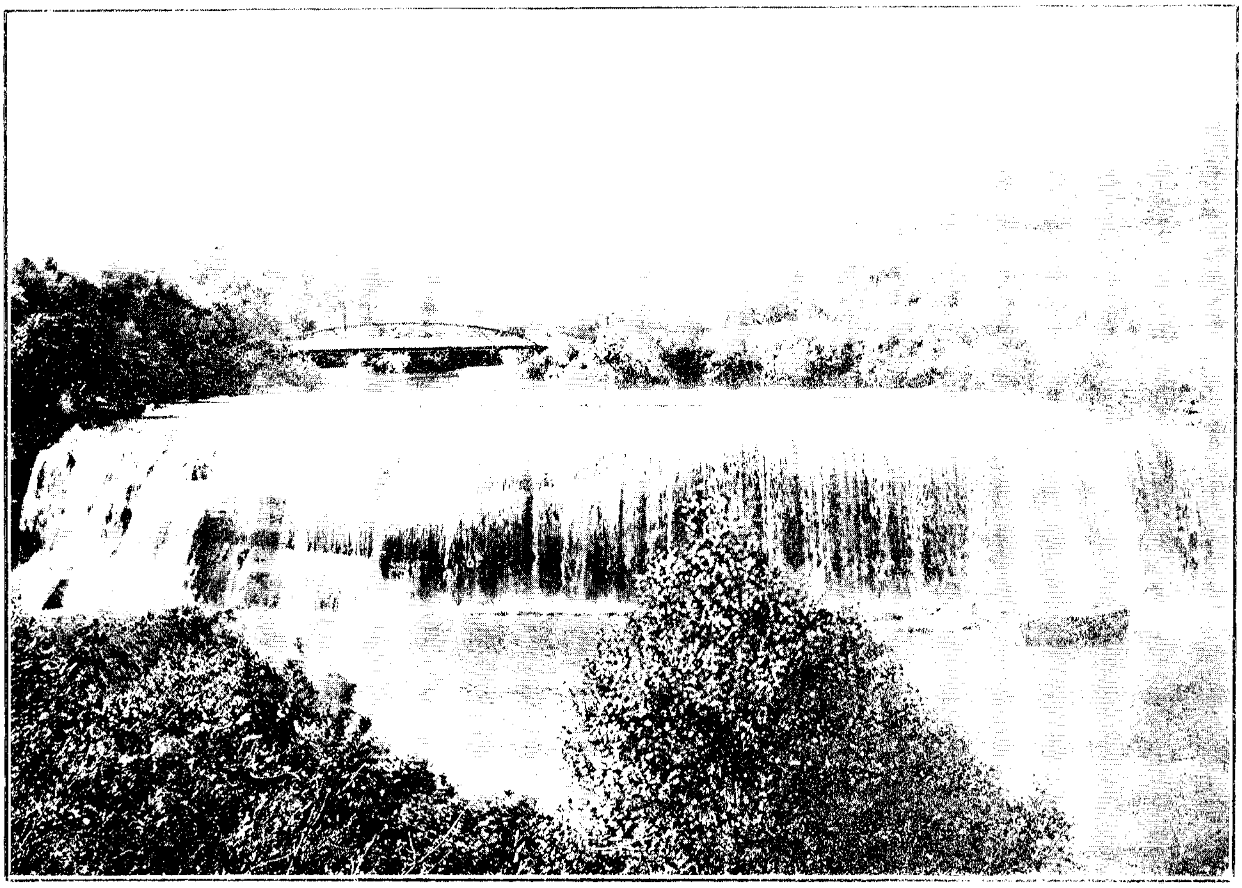
There passed away, however, two retired officers, Mr. Horace Baker and Mr Henry Trent, each of whom at the time of his retirement was holding the position of Chief Surveyor. The former had held the position also of Commissioner of Crown Lands, while the latter, starting as a cadet in 1863, had risen through the various grades to the joint position of Commissioner of Crown Lands and Chief Surveyor.

I have also to record the death of Mr. W. C. Spencer, a private surveyor, who at one time was on the staff, serving both in the field and office.

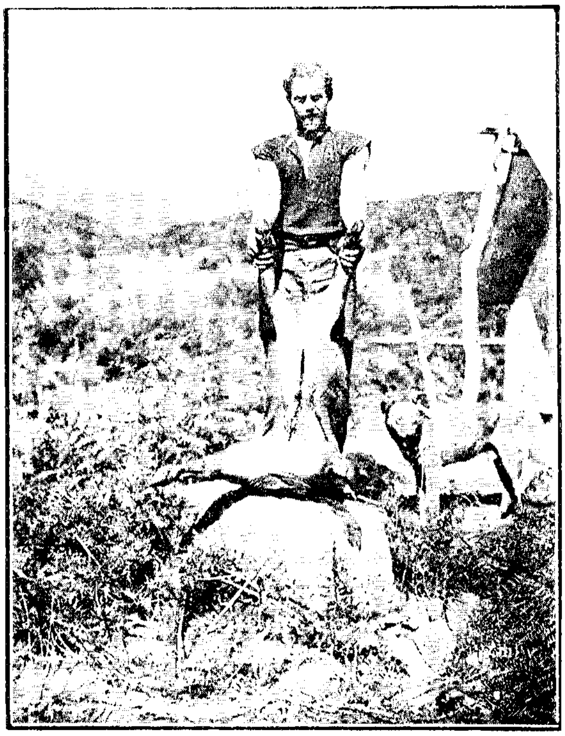
Conclusion.

I cannot conclude this report without paying a tribute of praise to those officers—young men with "all the world before them"—who have nobly decided to serve their country, giving their lives it may be, in this time of its trial. Their names and positions are as follows: Staff surveyors—V. Blake, W. M. Gray, G. Pirrit, S. T. Seddon, F. W. Watson, W. B. de L. Willis; temporary surveyor—W. S. Thomson; survey cadets—R. F. Burgess, L. W. B. Hall, T. R. Hancock, N. A. Middlemas, L. J. Poff; draughtsmen—G. J. B. Cairnie, T. S. Couch, E. H. Ingram, C. L. Purdie, H. B. Randrup; draughting cadets—F. Coleman, R. J. Cornwall, F. H. Hudson, H. L. Wake, and E. H. Whiting. All honour to them!

The enlistment of these officers, and the unusual amount of sick-leave granted to officers during the past year—several of these have had to undergo serious operations—has resulted in the Head Office and several of the district offices having to work short-handed, and I have now pleasure in recording my appreciation of the way in which, under these difficulties, officers in general have kept the work going.



Waterfall, Wharekopae River, Poverty Bay



INCIDENTS OF SURVEY LIFE.

WILD PORK. SWAGGING CAMP.

P. R. Wilkinson, photos.

NATIVE PIGEON ON ROADSIDE, WESTLAND.

E. Richardson, photo.

APPENDICES.

APPENDIX I.—SURVEYS.

AUCKLAND.

Minor Triangulation.—55,160 acres by three staff surveyors is all the work done under this heading.

Topographical.—The only survey made was of a small grazing-run in Rotorua County, of 6,200 acres.

Rural.—The staff surveyed 127,849 acres, a large increase on last year's return, the principal areas being in Urutawa, Waiawa, and Kawhia districts. 23,668 acres were surveyed by private surveyors, being largely subdivisions of land held under lease from the Crown, and land selected as "unsurveyed."

Village and Suburban.—The staff surveyed 4,335 acres in 257 sections, comprising principally fruit farms at Waerenga, Henderson, and near Wade.

Town Section Survey.—The 15 acres in 55 subdivisions by a staff surveyor under this heading is of workers' homes at Otahuhu, and 7 acres in 23 subdivisions by a contract surveyor is of an education reserve at Remuera.

Native Land Survey.—The staff surveyed 75,242 acres (a large increase), chiefly in the Rotorua, Opotiki, and Kawhia Counties. Contract surveyors, 205,265 acres, in 1,173 subdivisions, which is a considerable less area than last year, but the average size of the subdivisions is much smaller.

Gold-mining Survey.—Only 5 claims, of a total area of 355 acres, have been surveyed by private surveyors.

Roads, &c.—The staff have this year surveyed nearly double the length of last year, doing 113 miles scattered over the district; 26 miles were also surveyed by private surveyors.

Other Work.—The usual miscellaneous surveys, inspections, reports, &c., are included under this heading.

Inspections.—About the usual number of survey inspections were made, the work examined being found to be generally satisfactory. One of the chief obstacles surveyors have to contend with now is the difficulty in re-establishing old surveys, and the question of marking all important corners with more durable material than wood should be raised.

Contract Surveys.—Fifty-four contract surveyors have on hand 1,985 acres of Crown land, 285,067 acres of Native land, and 19 miles of road.

Office-work.—The Land Transfer Branch examined and approved 771 plans, comprising 106,409 acres, in 5,257 allotments, 1,274 traverse sheets were examined, 170 plans were recorded, 161 tracings prepared, 23 plans compiled. At the Land Transfer Office 3,454 plans were endorsed on certificates of titles and 30 plans prepared; 51 plans not yet checked remain in office, the average number of plans received per month being about 60.

Native Land Survey Branch: 264 authorities were issued for an area of 318,912 acres; 3 road surveys also were authorized for a mileage of 10 miles; 414 plans were received for an area of 376,283 acres in 1,681 subdivisions; 427 plans were examined and approval for an area of 322,999 acres in 1,703 subdivisions; 66 ordinary compilations were made, and 38 plans compiled under section 60 of the Native Land Amendment Act, 1913; 142 plans are now under examination, and 40 remain untouched; 2,141 schedules of costs were checked for the sum of £21,935; 3,182 endorsements were made on Court orders and other instruments of title; 9 Native Land Courts were attended, £894 being collected, 434 charging-orders obtained representing charges amounting to £7,345, and 191 acres 2 roods taken in lieu of mortgages; £15,712 2s. 11d. was collected for survey liens; 414 lithos and tracings were mounted, 249 tracings made for field data, &c., 217 tracings being made for the Valuation Department. This branch is practically self-supporting, the cost of examination, compiled plans, &c., being added to the cost of survey, and recovered in the usual way.

Statutory Plans and Roads Legalization Branch: 282 plans were examined and approved, taking and closing 343 miles of road; 618 acres of reserves for various purposes, and taking 41¼ miles for railways; 11 plans were compiled; 208 tracings made and 75 plans entered on records; 336 new plans were received during the year, and 292 remain unchecked. Through sick, annual, special, and territorial leave, 150 days were lost during the year; alterations of rooms in building also hampered the work about three months.

Computing Branch: 219 settlement plans examined and approved; 5 mining and 6 residence sites plans for Warden approved, of a total area of 142,792 acres, in 630 sections; 579 traverse and 36 triangle sheets examined; 419 chain lengths of surveyors' steel tapes were tested and certificates for same issued. 974 tracings for various purposes prepared. Loan proposals over 15 blocks, of 124,978 acres, for £31,915, were prepared. New trig. lithos compiled and revised for lithograph of 21 survey districts; 248 plans remain unchecked. An exceptionally large number of plans (262) was received during the year; the average for some time past has been under 200.

General: 5,056 plans were endorsed on Crown grants, &c. The total number of plans examined and approved was 1,710; plans compiled, 138; tracings, &c., made, 2,300. Fees collected, £190 16s. 6d.

Proposed Operations, 1915–16.—Twenty-five staff surveyors have on hand 302,816 acres of Crown land, 105,208 acres of Native land, 228½ miles of road, and 101 acres of town surveys. In addition to the above, the larger areas of Crown land and new purchases proposed to be surveyed for selection are as follows, arranged in counties: Mangonui, 9,700 acres, national endowment; Hokianga, 5,800 acres (1,000 acres national endowment); Whangaroa, 2,800 acres (1,500 acres national endowment); Whangarei, 1,000 acres; Rodney, 700 acres; Waitemata, 1,600 acres (300 acres national endowment); Franklin, 2,300 acres (300 acres national endowment); Waitomo, 500 acres; Awakino, 12,600 acres; Waikato, 3,000 acres, national endowment; Tauranga, 5,000 acres; Piako, 3,000 acres, national endowment; Ohinemuri, 5,000 acres; Thames, 8,000 acres; Coromandel, 6,000 acres.

Accounts.—There has been a large increase in the work of the Accounts Branch this year.

Transfers, &c.—The field staff has been reduced during the year by the transfer of Mr. A. H. Vickerman, District Surveyor, to be officer in charge of the Roads Branch; by Mr. R. P. Greville's (Inspecting Surveyor) appointment to Superintendent of Kauri-gum Surveys; Mr. H. F. Edgecumbe, District Surveyor, to triangulation-work, under Mr. Langmuir. Messrs. W. B. de L. Willis, F. W. Watson, and G. Pirrit, Assistant Surveyors, joined the Expeditionary Force; Survey Cadets N. A. Middlemas, L. J. Poff, and L. W. B. Hall also joined the same Force. Messrs. H. T. Mitchell and G. A. Hathaway resigned; Mr. D. I. Barron transferred to office; Mr. V. I. Blake transferred to Land Transfer Draughtsman, Gisborne. Mr. A. A. Seaton has been absent all the year on sick-leave, and has since died. Messrs. Burnley, Leeds, E. V. Blake, and Surveyor's Assistant Olsen have been engaged since January on surveys of kauri-gum land under the direction of Mr. Greville. The only additions to the survey staff have been Messrs. P. V. Norman and R. M. McIver (temporary). Messrs. G. J. B. Cairnie, H. B. Randrup, F. Coleman, and M. Haworth, of the office staff, joined the Expeditionary Force. The appointment and transfer of cadets and temporary draughtsmen have increased the office staff by ten during the year, but in most branches there are still arrears of work. With the rearrangement of the rooms and contemplated additions to the staff of officers to be specially trained as draughtsmen, it is confidently expected the trouble of arrears that have been banking up so long will almost disappear in the next year, or two years at the most.

During the year a superannuated officer, in the person of Mr. W. C. C. Spencer, passed away. Mr. Spencer had many years of faithful service in the field and office to his credit, during which time he made friends with all whom he came in contact.

Conclusion.—The work of the office for the last year has been much interfered with by the continual changes of staff and the structural alterations of the building. I have to specially thank all officers for their good work and strong efforts during a very arduous and troublesome year.

H. M. Skeet,
Chief Surveyor.

HAWKE'S BAY.

Minor Triangulation.—The proposal mentioned in the report for last year for the extension of the major triangulation into this district from the Auckland side was abandoned owing to the large area of settlement surveys requiring attention and the lack of staff to take on this particular work. This extension of the triangulation is urgently required for the reason that the present minor trig. work is generally of a low standard, and, being based apparently on several different measurements, is incapable of being brought into harmony without revision on thoroughly reliable and sound lines. Only a very small area of this class of work was executed during the year, the work being done for purpose of controlling sectional surveys in the Porangahau district.

Topographical Survey for Selection.—Although only 12,781 acres, at a cost of 1·93d. per acre, of this class of work has been returned as completed during the year, a large amount of useful topographical survey has been done in connection with rural and Native surveys carried out by staff surveyors in different parts of the district. Included in these may be mentioned Kaiwaka, Matakuhia, and Marangairoa Blocks; also on various blocks of which field operations are complete but plans not sent in. The area returned is a careful magnetic topographical survey of Mangamaire and part of the Whawhakanga Blocks, being subdivided for settlement purposes. The permanent survey of this block is now nearly complete.

Rural.—During the year an area of 50,086 acres, at a cost of 1·27s. per acre, was executed, the cost per acre of the previous year being 1·57s. The principal blocks subdivided for settlement were: Kaiwaka (14,483 acres), divided into 5 small grazing-runs; Otawhao (5,045 acres), into 46 sections; Matakuhia (6,589 acres), into 2 small grazing-runs; and two blocks under Land for Settlements Act—Gwavas and Springhill Settlements—containing 12,281 acres, and divided into 31 sections. The balance of the area returned is made up of more or less small areas in different parts of the district. In every instance the operations have been carried out in open country, with the exception of Mr. Gray's Matakuhia Block, on which there was a large amount of cutting through heavy bush in rough country, this fact accounting for his cost being somewhat higher than the other surveyors' costs.

Town.—During the year 34 acres of this class was divided into 63 sections, at a cost of 26·09s. per section, for the purpose of workers' dwellings, known as Pakowhai and Lomas Settlements, and situated near Hastings; engineering survey of longitudinal sections was done in connection with the latter settlement.

Village and Suburban.—During the year 311 acres of this class of work was divided into 44 allotments, at a cost of 18·43s. per acre. The area is made up of 50 acres known as "Gray's Bush," Te Puia suburbs, and 50 acres at Clive, near Napier. The cost per acre last year under this heading was 3·17s., but the area in that instance was fairly large, and provided 4 allotments only.

Roads.—During the year 30·10 miles of this class of work was done, at a cost of £18·26 per mile, as against £21·64 per mile in the previous year, the principal lengths being 9 miles, Maraehara Valley Road, and 6 miles, part of Te Pohue - Tutira Road, surveyed in connection with exchanges on Kaiwaka Block, the balance being for more or less short lengths in different parts of the district.

Native Surveys.—The total area surveyed during the year amounted to 100,770 acres, in 501 subdivisions. Of this area the staff completed 26,443 acres into 43 allotments, at a cost of 11·29d. per acre, as against 22·33d. per acre last year. These surveys were made up principally of the Marangairoa 1C and 1D at East Cape and Mangawhariki Blocks. Private surveyors completed 74,327 acres, containing 458 allotments, scattered over the whole land district, at a cost of 16·24d. per acre, as compared with 21·96d. per acre for the previous year.

Field Inspections.—Thirteen Land Transfer and 6 Native Land Court inspections were carried out during the year, as against 23 in the previous year, principally by Mr. Brook, the results, generally speaking, being satisfactory. Inspection of the work of staff surveyors was also carried out by Mr. Brook. Detailed reports of these inspections have already been forwarded to you.

Work in Progress.—Actual operations are being carried out on the Mangamaire and Whawhakanga Blocks (12,481 acres), situated about 69 miles from Napier (this work is now nearly complete); Manawa-angiangi Block (11,551 acres), revision survey in the same locality is nearing completion; Te Pohue - Tutira Road, 14 miles, field-work complete; Heru-a-tureia Block (3,990 acres), about 44 miles from Napier, field-work just completed; Maungaharuru E.R. (7,750 acres), in same locality, field-work completed; Wharerauraukau Native Land Court survey (3,310 acres), in same locality, field-work just commenced; Wharekahika Block (Native Land Court survey), 42,000 acres, at East Cape, field-work to be completed in June; Waipaoa Block (8,785 acres), situated about 95 miles from Napier, on which a large amount of field-work was done prior to the last winter recess, the work being then left in abeyance, but Mr. Walshe is again on the ground rounding off the work done by Mr. Thompson and himself with a view to completion before the winter recess; Omahaki Block (15,710 acres), situated about 50 miles from Napier, field-work completed; and Timahanga No. 1 and Waipaoa 5A, 5B, and 5C, Native Land Court surveys, containing 23,789 acres, field-work is nearly completed. Mapping of all the above work is advanced as far as is practicable. With the exception of Native Land Court surveys mentioned, the work is being done on blocks proposed to be opened for selection at an early date. Private surveyors have 45,764 acres on requisitions from the Native Land Court under survey.

Proposed Operations.—After completing work in progress staff surveyors will carry out subdivisional and other operations as follows: Tahora Block, of 49,000 acres, situated about 50 miles west of Gisborne; Te Putere Block, 8,000 acres, situated about 60 miles in a northerly direction from Napier; Pastoral Run No. 11, 11,000 acres, situated about 60 miles from Napier in a north-westerly direction; Pastoral Runs Nos. 13 and 14, containing 32,659 acres, situated in the same locality; Mangaorapa No. 1 and Porangahau 1B No. 4, containing about 12,783 acres, situated near to coast, about 70 miles from Napier, in a southerly direction.

Other Work.—This consists of miscellaneous departmental duties; inspection of roads, &c., for other Departments; schemes of proposed subdivisions of land for settlement; reports on blocks proposed to be acquired by the Crown; standard survey-work in Towns of Hastings, Dannevirke, Otane; reports on exchanges; reports on roads to be opened and closed; checking of Crown plans during the winter recess; assisting with arrears in plan-work during winter recess; examination of unlicensed assistants.

Office-work.—Land Transfer Branch: During the year 246 plans, consisting of 1,271 allotments, and containing 62,064 acres, were received; 256 plans, consisting of 1,501 allotments, and containing 49,661 acres, were approved; 354 sheets of co-ordinates have been examined and filed

Computing Branch: During the year 35 Crown plans, consisting of 139 allotments, and containing 51,431 acres, were received; 38 Crown plans, consisting of 235 allotments, and containing 63,151 acres, were approved; 152 Native plans, consisting of 465 allotments, and containing 100,770 acres, were received during the year; 187 Native plans, consisting of 550 allotments, and containing 84,702 acres, were approved; 145 Public Works and local bodies' plans, consisting of 1,195 allotments, were received; 143 plans, consisting of 924 allotments, were approved; 600 sheets of co-ordinates have been examined and filed.

Fees collected for protractor sheets, miscellaneous tracings, sale of lithographs, &c., amounted to £63 9s. 1d. Miscellaneous plans compiled in office, 20.

Tracings, lithographs coloured, &c.: 27 tracings were made for sale-poster purposes, and 1,984 were made for various purposes—settlers' tracings, tracings for Valuer-General, field data tracings, and tracings for gazetting purposes. 540 lithographs for various purposes were coloured.

District lithographs: Owing to the great amount of routine work requiring attention, practically nothing has been done in this section, although the Tautane district is nearly complete, and a start made with Porangahau. When time permits this work will be pushed on. It is an urgent necessity in this district, the only lithographs available being the county maps, and these are being revised to fill the gap in the meantime. A four-mile map showing survey-district boundaries is getting well on to completion.

General.—It will be observed that the volume of work has been maintained during the year, and that survey operations have been carried out at an all-round decreased cost. During the year

Messrs. Gray and Thompson, of the field staff, left with the Expeditionary Force. The work and costs of these two officers has been taken over by Mr. Walshe until such time as opportunity offers for a reallocation of the work.

Mr. Roddick, District Surveyor, attached to the Gisborne office, has been transferred from the field to the office staff, after a long and arduous term in the field, a change which failing health made necessary.

Owing to serious ill health the Chief Draughtsman, Mr. H. Mackay, has been absent on sick-leave for some time, Mr. F. Carrington, of New Plymouth, fulfilling his duties meanwhile.

The recent acquisition of Native lands and the negotiations now proceeding for the purchase of similar blocks along the route of the Napier–Gisborne Railway, and in other parts of the district, will make large demands on the depleted field staff during the coming year.

In conclusion, I wish to tender my thanks to the staff, both field and office, for the active and loyal way in which they have carried out their duties, and generally for their most willing help and co-operation during the year.

W. H. Skinner,
Chief Surveyor.

TARANAKI.

Minor Triangulation.—No work of this nature has been done during the past year, but a scheme of triangles to control some 150 square miles of the Lower Mokau and Mohakatino basins has been prepared, and the work should be undertaken during 1915–16, as it is urgently needed to check work in hand properly and make a better connection in the triangulation itself.

Standard Surveys.—No true standard work has been done in this district for many years, and a revision and extension of earlier work in Hawera, Stratford, and Patea is urgently needed, as well as a standard survey of main roads from Eltham to Opunake and around the mountain to control the new railway route and the numerous Land Transfer surveys that are expected there. In carrying out his inspections in the places named the office surveyor has had to do a lot of work that can be utilized in connection with a complete standard survey. Now that local bodies are scarifying the roads and laying down tarred and suchlike surfaces, it is stated to be very difficult for surveyors to find and use old marks (placed as they often are in the middle of the road). To avoid damaging these new road-surfaces is one reason why standard surveys are so much needed.

Topographical Surveys for Selection.—Under this heading an area of only 856 acres was completed, and this was for the Land Purchase Board.

Rural.—An area of 35,302 acres is returned under this head, the greater part of which is situated in very rough forest country, where the rainfall is heavy and continuous and location of roads difficult. An additional area of 11,000 acres has been completed in the field, but plans are not yet ready.

Village and Suburban.—258 acres, in 75 lots, were surveyed in the Aria Township Reserve, but as plans have not yet reached me this must appear in next year's return.

Town Section Survey.—An area of 5·35 acres, comprising 8 lots, was surveyed in the Town of Ohura for general Government purposes.

Native Land Court Surveys.—The total area of Native land surveyed during the year amounted to 14,950 acres, the whole of the work with one exception (when a staff surveyor was employed on an area near his main camp) being completed by private surveyors. Of the 57,538 acres returned as under survey last year, 37 plans, of 35,462 acres, have been received and 20 approved. A total area of 60,498 acres is now under survey, which I expect to be completed during the coming year. Some of this work is for the subdivision of areas previously surveyed.

Maori Land Board Surveys.—The subdivisional survey of Mohakatino Parininihi 1D East, containing 4,425 acres, placed in the hands of a staff surveyor (being close to his main camp), has been completed in the field, but as the plans are not in it must be returned next year.

Roads.—In this class 25½ miles are returned by the staff and two contract surveyors, while the field-work of 20 more miles has been completed.

Inspections.—Seven inspections were made during the year, six of Land Transfer surveys by Mr. Sole, and one of a Native survey by Mr. District Surveyor Wilson. Three of these inspections were the work of a surveyor of the old school, and, although not wilfully incorrect, they showed careless and slipshod work and want of up-to-date methods and proper searching for old marks.

Other Work.—The expenditure under this heading amounts to £188 16s. 1d., and includes the inspections mentioned, repairs to trigs., and various miscellaneous isolated surveys of small areas, where travelling-expenses were proportionately heavy.

Chainage Closures.—The mean of all closures by the staff, mostly in rough-bush country, gave an average of 1 link per mile.

Office-work.—The total number of plans checked under all heads in the General Computing Branch was 153. Of these, Crown settlement surveys were represented by 39 plans, covering 58,399 acres in 171 sections; Native Land Court surveys by 41 plans, of 22,422 acres in 59 sections; road and railway surveys for Proclamation, &c., by 37 plans, covering 56 miles. The balance of 36 plans comprised trigonometrical and miscellaneous surveys. Three candidates sat for examination as authorized assistants; one passed at his first sitting and one at his second.

Land Transfer: In this branch 92 plans, with 213 traverse sheets, were checked and approved, covering 303 lots, of a total area of 7,869 acres. Land Transfer record plans are badly needed here, but I had no one available for this work (the Land Transfer Draughtsman being also Crown-grant draughtsman), all being required to keep pace with incoming urgent work.

Titles: The plans placed on instruments of title of all kinds were 1,485, and 577 copies of leases and licenses were prepared, all by the office staff.

Compilations: For photo-lithography 12 large drawings and tracings were prepared. The new survey-district lithos of Mapara and Tangitu were also completed, while those of Ohura, Heao, and Mahoe were sent for and brought up to date. The Rangi and Piopiotea West districts will soon be completed, when we shall be in a position to issue proper county maps of Ohura, Waitomo, and Whangamomona, all of which are urgently required by other Departments and the public.

Miscellaneous: The usual demands made on the office staff were attended to, comprising the supplying of information to the general public; tracings for Rangers and selectors, and diagrams and tracings to illustrate letters to Head Office, and others; also numerous tracings for Proclamation purposes and taking roads under the Native Land Act. Over 45 complete sets of field data, averaging more than three to the set, were supplied checked to the staff and contract surveyors, while 198 tracings of West Coast Settlement Reserves leases were furnished to the Public Trust Office for revaluation purposes. For the Valuer-General 161 tracings were prepared, 84 of Land Transfer plans and 77 of Native blocks, while the total of the other miscellaneous tracings mentioned above amounted to 198. All recording on existing block-sheets, Crown grant, 40-chain record maps, reserve, index, and wall maps was kept well up to date, but I had no one to spare to prepare the many new maps that are urgently required.

Native Land Court work: Two hundred and ten plans have been endorsed for attachment to Native Land Court orders by the Native Land Draughtsmen, and forwarded to the Registrar, covering an area of 44,043 acres; and 130 Native Land Court plans have been forwarded for the Court's use. The survey-costs, including cost of the examination of plans and interest due, collected for ordinary Native land surveys, amounted to £550 11s. 3d. Tracings and field data for Native surveys have been prepared and supplied when asked for. Owing to the isolated position of the New Plymouth office with regard to the Native Land Court officials, solicitors, and surveyors, a great deal of extra correspondence and supply of data is required from this office, the outward correspondence relating to Native surveys requiring some 650 letters being drafted. Twenty-one vouchers, covering 92 subdivisions, for payment to surveyors have been prepared in this branch and sent on to the Accountant for checking and payment. Whenever necessary an officer has attended the sittings of the Native Land Court for the purpose of collecting survey fees, obtaining charging-orders, &c., and the usual detail work rendered necessary has been carried out.

Proposed Operations for 1915–16.—A staff of three permanent surveyors, with one cadet and one temporary surveyor, are at present engaged upon settlement surveys along the eastern, north-eastern, and north-western boundaries of this land district, and by the end of next year I expect to have the northern end of the district cleaned up. The total area to be covered by these operations amounts to 56,000 acres, of which some 11,000 acres and 20 miles of access road through Native land are completed in the field and partly mapped, leaving 35,000 acres of new country on hand for the coming season 1915–16, situated in the Survey Districts of Aria, Totoro, Mimi, Waro, Pahi, Tangitu, Rangi, and Pouatu; and the cadet above mentioned having now passed, it is proposed to allot him an additional 10,000 acres in the Waro Block, explored by Mr. Larkin but left unfinished by him.

Changes of Staff.—In August last two cadets—one field and one draughting (Messrs. Hancock and Hudson)—joined the Expeditionary Force, and we now expect to lose Mr. Saxton (keeper of the safe) in July on superannuation. Mr. Laing, District Surveyor, retired from the field last May, and joined the office staff in lieu of Mr. W. F. Gordon, who retired on pension; whilst Mr. Larkin resigned and left the Department in June. Early in February Mr. Carrington, Chief Computer, was sent to Napier as Acting Chief Draughtsman there; Mr. Laing took over his work here, and we have been short-handed ever since.

Although there has been a falling-off lately in the Land Transfer and Native work, which latter must decrease from now, we are shortly expecting quantities of complicated railway land plans from the four contracts now under survey; there will also be some amount of work with the subdivisions of the valuable West Coast Settlement Reserves, and I am therefore of opinion that the draughting and computing staff wants strengthening. This, though a small, is a very busy and valuable district. Although in most parts a fairly dry season, my surveyors in Mimi, Waro, and Pouatu Survey Districts have had very heavy rainfalls.

In conclusion, I wish to record my appreciation of the willing and competent assistance rendered by the whole staff.

G. H. BULLARD,
Chief Surveyor.

WELLINGTON.

Triangulation.—No work of this class has been undertaken during the past year by this office.

Standard Survey.—No work under this heading has been returned, but Mr. J. D. Climie, of Head Office staff, is at present engaged upon some intricate work adjacent to the City of Wellington. There are several localities in which standard traverses must soon be made, but no urgency is necessary, and what is to be done may easily await the convenience of the Department.

Topographical Survey.—Field-work and plans of about 90,000 acres of Native land near Taupo were completed by Mr. Blake, and should prove of great assistance to the Native Department in the determination of individual interests. Of this area, some 80,000 acres are within the boundaries of the Auckland Province.

Rural.—Under this head an area of 34,499 acres has been returned, of which 9,439 acres, forming the Poroporo Settlement, was thrown open for selection towards the end of the previous year. The Falloon Settlement, containing 1,035 acres, was settled during the year, and of the remaining area about 2,300 acres will shortly be available for settlement. About 20,220 acres of the Waimarino Block have been completed, but it is probable that certain constructive road-works may precede the actual settlement. At the present time four staff surveyors have in hand the subdivision of about 26,670 acres, the greater portion of which should be ready for settlement early in the coming year.

Village and Suburban Surveys.—This head returns 302 acres, of which some 26 acres will be used as homestead-sites for sections in the Waimarino, and the balance, being sections of from 1 to 10 acres near Kakahi and Ohakune, will be offered shortly.

Town Surveys.—The return is comparatively small, and represents an addition of about 39 sections, aggregating 17 acres, to the present Town of Raurimu.

Native Land Court Surveys.—The total area of surveys returned during the year under the authority of the Native Land Court amounted to 86,993 acres, and was all accounted for by private surveyors at schedule rates. An area of 58,022 acres is in hand for the coming year, authorities having been issued to private surveyors.

Roads.—The roads returned are independent of settlement surveys, but have been laid off in two instances to provide access to Crown land and for a deviation in the remaining case.

Other Work.—The main body of settlement survey is surrounded by a fringe of small surveys, reports, inspections, &c., usually undertaken in the winter recess, and which cannot be conveniently classified under main headings.

Proposed Survey Operations.—Our staff surveyor will go on with the subdivision of the Waimarino A Block, of about 14,850 acres, and, as the complexities which surrounded this block have, I believe, been satisfactorily disposed of by the Native Land Court, I am in hopes that this year will see the completion of the survey. Three staff surveyors will continue the present work in hand of about 26,670 acres in the Whirinaki, Retaruke, Ruahine, and Gorge Survey Districts, and thence proceed with such surveys as may be necessary. The services of one of the staff surveyors will be required for some time to assist in unravelling the intricacies of the Putiki Native Reserve near Wanganui, a reserve which has earned an unenviable notoriety in respect to its titles, which, however, through recent legislation are in a fair way to be rectified.

Examination of Plans.—The number of plans approved during the year was 548, of which 241 were for the Land Transfer Department, 107 for the General Staff Branch, 112 for the Native Branch, and 88 for the Statutory Plans Branch, and in most cases the examination is conducive to a large and varied amount of investigation and correspondence. The new plans in the General Branch covered 33,860 acres, embracing 168 sections, and in the Native surveys 94,531 acres, comprising 384 subdivisions.

Land Transfer.—In addition to the 241 plans approved, the branch also examined 52 applications, 1,431 transfers, 211 leases, 84 mortgages, 202 Native Land Court orders, 32 Orders in Council, 56 Proclamations, 412 new and balance certificates, and 23 other dealings, besides placing 3,987 diagrams on certificates of title. New and improved sectional indices are now near completion, and 83 index tracings with plan references have been compiled, which, though only a portion of what is required very much, will be of great convenience to the office and the public.

Native Land Court.—Under this heading a large volume of work passes; 112 authorities, representing 345 partitions aggregating 63,966 acres, have been issued; 431 charging-orders representing costs of survey amounting to £7,886 13s. 11d. have been made, and 300 releases of liens, representing £4,700 0s. 1d., have been sent to Registrar; plans have been endorsed on 691 partitions and other Court orders; and with the additional work of checking costs and attending to the despatch of plans to the various Courts, the staff has been kept busy. The total area of surveys approved during the year was 94,531 acres.

General Draughting.—Satisfactory progress has been made in this branch, despite the general depression which has been caused by the great Continental strife. Irrespective of the very large amount of miscellaneous work from all transactions affecting land, the following actions may be mentioned: The preparation of 19 new plans, the compilation of 9 district maps and of 70 tracings for photo-lithography, together with 1,235 tracings for various purposes, and 1,358 diagrams were placed on instruments. This branch of the staff has suffered many losses and changes during the year owing to the war and departmental adjustments, the net result being that at the present time we are four officers short of what we begun with—viz., two belonging to the field and two to the office. We shall also certainly lose Mr. Lamason on the 22nd April, but we hope to get Mr. Crawford back from the Head Office, and to be allowed to retain the services of Messrs. Freeman and De Castro until some of those who joined the Expeditionary Forces return. Now that Mr. Climie is about to retire I need a District Surveyor in Wellington to inspect surveys, to survey blocks near at hand, do scattered surveys, and put in the rest of his time in this office. The details of the changes mentioned above are as follow: In order to fill gaps and overtake the arrears of work mentioned in my last annual report, four computing draughtsmen were temporarily engaged—viz., Messrs. W. F. Burgess, Lamason, Freeman, and De Castro; Messrs. Blake (Assistant Surveyor), C. L. Purdie (Computing Draughtsman), R. F. Burgess (field cadet), and E. H. Whiting (cadet) joined the Expeditionary Force; Mr. J. R. Strachan, District Surveyor, who had been at work in this office for the previous twelve months, was transferred to Nelson; Mr. Roe was transferred to another district, and Mr. Crawford is lent to the Head Office; Mr. T. A. L. J. Armstrong was here for a short time, but has now gone to another district; the work for which Mr. Burgess was temporarily engaged being completed, he left the service last December; Mr. J. R. H. Thorp, draughting cadet, joined us on the 3rd June, 1914, but two months later was lent to the Defence Department, and has only recently returned to his duties here. The above being the position regarding the staff, I must further remark that there has been a diminution of the work in this branch, especially during the earlier months of the war, and so far as I can foresee the present staff can cope with what there is likely to be during the next twelve months.

I have to report my satisfaction with the efficient manner in which the Chief Draughtsman and other officers have performed their duties.

T. N. BRODRICK,
Chief Surveyor.

NELSON.

Triangulation.—Under this heading 90,000 acres were completed during the year, including 50,000 acres of revision survey in Oparara district; the major part of the balance—namely, 36,000 acres—was in the Rotoroa district. The average cost is 1·9d. per acre, including that of the revision.

Topographical Survey for Selection.—34,000 acres, at an average cost of 4·3d., was completed, the main portion, 29,000 acres, being in the Waitakere district.

Rural.—113,445 acres, mostly heavy-bush country, were completed during the year under this heading, the low average cost, 1·6s., considering the weather experienced, being accounted for by several very large areas being included. Eleven staff surveyors, with two unlicensed assistants, were employed in the early part of the year (April to August), but only six surveyors from September to March. One contract surveyor was employed intermittently during the year.

Town Surveys.—Only two areas were dealt with under this heading.

Native Land Court Surveys.—159 acres were subdivided under this heading into eight lots, at a cost of 7·01s. per acre, by a contract surveyor.

Road Surveys.—Twenty-eight miles were surveyed, at an average cost of about £26 per mile, which is reasonable considering the rough nature of the ground and the very wet season experienced in the locality of these surveys.

Office-work.—Computing Branch: 176 plans were examined and approved, in connection with which there were 849 traverse sheets. These plans comprise 117 sectional plans, dealing with an area of 165,056 acres; 39 road plans; 10 mining plans; and balance miscellaneous.

Land Transfer Branch: In this branch 77 plans and 105 traverse sheets were checked and approved, covering an area of 5,432 acres; 364 diagrams were placed on certificates of title, and 149 deeds and other instruments were approved. The Valuation Department was supplied with 27 tracings of deposited plans and 176 tracings from certificates of title. Fees collected for the sale of lithographs, protractor sheets, &c., amounted to £25 6s.

Proposed Operations for 1915–16.—Next year the present staff will be fully employed in settlement survey on the Okari Block, Waitakere Survey District; Rotoroa Block, Rotoroa Survey District; Tutaki Survey District; Oparara, Oparara Survey District; Block at Little Wanganui, Kongahu Survey District; and in surveying numerous applications for unsurveyed land in various parts of the land district.

Office-work.—The office staff, which remains at a minimum strength, has been further depleted at times owing to the illness of several officers, two of them for a lengthy period.

Changes of Staff.—During the year Mr. F. E. Greenfield, Chief Draughtsman, was transferred to Christchurch in a similar capacity, and was succeeded by Mr. A. D. Burns. Mr. W. A. Curtis, Land Transfer Draughtsman, retired on superannuation after forty years' service in the district, and was succeeded by Mr. J. R. Strachan, District Surveyor, from the Wellington District. During the interval of six months between the time of Mr. Curtis leaving and Mr. Strachan's appointment the position of Land Transfer Draughtsman was held by Mr. P. A. Dalziell, of this office. Mr. J. D. Thomson, District Surveyor, was appointed Chief Draughtsman in Blenheim. Mr. Seddon, Assistant Surveyor, and Mr. Whiting, draughting cadet, joined the Expeditionary Force. Messrs. Armit and Waters, Assistant Surveyors, and Messrs. Hemphill and Sutton, unlicensed assistants, were transferred to Otago.

I desire to place on record my appreciation of the long and faithful service rendered by Mr. W. S. Curtis, who during the year retired from the position of Land Transfer Draughtsman to take up that of censor. During a period of forty years Mr. Curtis showed a diligent, accurate, and exemplary discharge of his duties.

I desire also to thank the officers, both of the office and field staffs, for their services, and in a special degree the late Chief Draughtsman, Mr. Greenfield, and the present Chief Draughtsman, Mr. Burns.

F. A. THOMPSON,
Chief Surveyor.

MARLBOROUGH.

Triangulation.—A small amount only of subsidiary triangulation necessary in connection with rural surveys was done.

Topographical Survey for Selection.—An area of 51,000 acres, known as "Stronvar Run," adjoining Hillersden Settlement, has been returned under this heading. The land is described generally as high, rough, barren country.

Rural.—Under this heading an area of 11,735 acres is returned at a cost of 1·06s. per acre, and included in this area is the Wither Settlement survey. An area of 27,464 acres, being Land Transfer survey of Kekerangu Run, has been separated from work done in connection with departmental settlement operations.

Town and Village.—Under "Towns," 66 sections, including Hillersden, Wairau Valley, and Golden Bar, containing 23 acres, were surveyed, at a cost of 15·76s. per section. Under "Village," 23 sections, containing 196 acres, were surveyed, at a cost of 2·64s. per acre.

Roads and Railways.—Okoha-Endeavour Inlet Road, Gore Survey District (4 miles), is the only work done under this heading.

Gold-mines Surveys.—Nil.

Native Land Surveys.—An area of 1,308 acres was subdivided into 8 sections by private surveyors at schedule rates.

Other Work.—The expenditure under this heading represents the cost of 6 small isolated surveys by Mr. Hunt, amounting to 26 acres, and a quarter-mile of road-surveys, costing £51 13s.; 6 inspection surveys, £18 12s. 6d.; subdivision of block of Crown land, Wakamarina district, £17; and resurvey of Hapuku River land, £6 15s. 3d., were executed by office staff.

Traverse Closures.—The mean closing errors in 10 circuits, with a length of 25 miles—389 stations—are 0·79 and 1·29. The work is all in hilly country, rough in places.

Proposed Operations for 1915–16.—The settlement surveys throughout the season will be in the Wakamarina and Tennyson districts, where Mr. Hunt has in hand a block of 6,570 acres and 1,025 acres of scattered applications. In anticipation of the forest reserve in the Upper Opouri Valley (at present being milled by the Marlborough Sawmilling Company) being cut out, Mr. Hunt will then proceed with the survey of a block of about 4,000 acres, for which there are numerous inquiries, so that when the reservation is uplifted the land can be immediately disposed of.

Office-work.—Examination of plans, &c.: The total number of plans received in the ordinary Survey Branch was 48, with 71 traverse sheets, comprising 15 departmental plans, containing an area of 62,900 acres; 2 Native Land Court surveys, with an area of 1,306 acres; 14 computed plans; 7 tracings prepared for photo-lithography; 285 tracings made; 17 plans of road-surveys; 293 diagrams placed on Crown leases.

Land Transfer Branch: 41 plans and 110 traverse sheets were received, covering an area of 61,240 acres; 495 diagrams placed on certificates of title.

Changes in Staff.—Mr. Burns, Chief Draughtsman, was promoted to a similar position in Nelson, and Mr. Thomson, District Surveyor, Nelson, was appointed in his place. Mr. Couch, draughtsman, joined the Expeditionary Force in August.

I have to thank the staff for their co-operation and assistance at all times.

H. G. Price,
Chief Surveyor.

WESTLAND.

Minor Triangulation.—I have nothing to report under this heading during the past year.

Topographical Survey.—Comprises 6,450 acres in Waimea and Ahaura Survey Districts preparatory to settlement-work.

Rural Surveys.—Amount to 9,555 acres in 48 sections, mostly selected in isolated positions, under the special regulations for Westland and Karamea. This class of work entails heavy expense in moving camp, though I try to minimize it as much as possible by holding up surveys till several can be done in one district.

Village and Suburban.—Amount to 284 acres in 18 sections, being small area taken up under Part VIII, &c., of the Land Act.

Road Survey.—Comprise seven miles, at a cost of £15·23 per mile. These roads were laid off to give access to isolated sections.

Gold-mining Surveys.—Comprise 1,142 acres, in 9 areas, the cost of which was borne by the applicants.

Survey Inspections.—Several inspections have been made by myself personally, and I am glad to state that the result showed that the works had generally been carried out well up to the regulations.

Proposed Course of Operations for the coming Year.—Since Mr. Harrop came into the office my field staff has been two below the normal, and I have not yet been able to do anything in connection with the Bruce Bay surveys. On my list awaiting survey there are about 22,000 acres, and this will be augmented by fresh applications during the current year. It is therefore essential that the field staff should be strengthened. I would also recommend that Mr. Morison should be provided with a cadet, to be trained in the particular class of work in this district.

Other Work.—Amounts to £72, details of which are given in the schedule; it includes miscellaneous reports and inspections on flood damage, &c.

Office-work.—At the beginning of the year there was a shortage in the draughting staff, which was increased by the departure of Mr. E. A. Ingram, who joined the Expeditionary Force in August, and the absence through severe illness of Mr. Staveley for half the year.

The total number of plans received for examination was 93, with 225 traverse sheets, comprising—Crown surveys, 50; Land Transfer, 20; mining, 8; and plans for local bodies, &c., 15.

There were 584 diagrams placed on deeds, comprising 306 on Crown leases and 278 on Land Transfer titles. 302 tracings of all descriptions were made, including those for survey data, and 267 lithographs were coloured; in all, 38 photo-lithographic tracings were prepared, representing 16,200 acres of land for settlement and 647,600 acres of pastoral runs. Nine compiled plans were made and 4 plans of surveys executed by the Chief Draughtsman during the year. Tracings and descriptions for *Gazette* notices have been prepared, while the usual routine work of recording, cross-indexing, mounting plans, &c., is well up to date. The Crown-grant maps of the Town of Cobden have been brought up to date, but there are considerable arrears of this class of work, also of block sheets and Land Transfer record maps, which the present staff are not able to overtake.

Changes in Staff.—Mr. A. N. Harrop, District Surveyor, was promoted to be Chief Draughtsman in this office in May, 1914, since which he has been very assiduous in mastering the details of his new work. Mr. Armstrong, Draughtsman, was transferred to the Wellington office, and Cadet Norris was appointed in his place.

My cordial thanks are due to both the field and office staff for their efficient co-operation in the various duties allotted to them.

H. D. M. HASZARD,
Chief Surveyor.

CANTERBURY.

Triangulation.—No work of this nature has been done during the year.

Topography.—The 16,334 acres of topography returned represents preliminary surveys of various estates acquired.

Rural.—Under this heading only 8,381 acres has been completed by the staff, comprising Finlay Downs, Teschemaker, Hillboro, and Copland Settlements, &c. In addition, the survey of Glenmark (about 11,400 acres) was almost completed.

Village and Suburban.—There were no surveys of this description.

Town Section Surveys.—Only about 10 acres, subdivided into 21 lots, for workers' homes at Waimate was executed during the year.

Roads.—About 13 miles of standard survey on the Canterbury Plains, near Rangiora, represents the bulk of the return under this heading.

Gold-mining Surveys.—There were none.

Coal-mining Surveys.—One mining claim of 1,000 acres was surveyed by contract, and paid for by the applicant.

Native Land Court Surveys.—Altogether there were 80 subdivisions, comprising 186 acres, all done by contract surveyors, and mostly paid for by the owners concerned.

Survey Inspections.—During the year 4 field inspections of Land Transfer surveys have been made, and in 2 cases the result fully justified the expenditure.

Other Work.—Consists of inspections, reports, road deviations, drainage, and water schemes, miscellaneous surveys, &c.

Proposed Operations for 1915–16.—This work will comprise the subdivision of Lees Valley Block, being Runs 145 and 145A, in conjunction with the adjoining freeholds recently acquired (36,200 acres in all); the survey of Glenmark Settlement (11,400 acres), and any new estates that may be acquired; the continuation of the standard survey of the Canterbury Plains; the survey of an extension of the Summit Road, over the Port Hills; and various small surveys in different parts of the district.

Land Transfer.—During the year 281 plans have been examined and approved, embracing 51,195 acres; 2,231 transfers, leases, Proclamations, &c., have been dealt with; diagrams (in duplicate) have been endorsed on 1,709 certificates of title, all the copies having been made in the office.

Office-work.—During the year 24 Public Works plans, 29 road plans, 4 land-for-settlements plans, and 31 miscellaneous plans have been examined and approved. Isomagnetic charts in connection with the recent magnetic survey of the Dominion by Dr. Farr have been prepared for reproduction, but these are not all completed. The acquisition of Finlay Downs, Teschemaker, and Glenmark Settlements has entailed a large amount of office-work.

Changes in the Staff.—Owing to a variety of causes there have been a large number of changes in the personnel of the staff. Mr. H. G. Price, Chief Draughtsman, was promoted to the position of Commissioner of Crown Lands and Chief Surveyor at Blenheim, and was succeeded here by Mr. F. E. Greenfield, formerly Chief Draughtsman at Nelson; Messrs. D. McDonald, Crown Lands Ranger, and R. J. Cornwall, cadet, have joined the Expeditionary Forces; Mr. S. H. Sapsford, clerk, was transferred to the Defence Department at Wellington; Mr. A. E. Rosanowski, clerk, to the Head Office; Messrs. S. P. Day and C. D. Gaudin, cadets, to the Audit and local Government Life Insurance Departments respectively; and Miss Sapsford, typiste, to the Public Works Department at Wellington. Mr. J. G. Nilson, from the Head Office, was appointed Clerk to the Receiver, and Misses Brake and Eslick joined the staff as typistes, and Messrs. Nightingale and King as cadets.

In conclusion, I desire to record my appreciation of the hearty co-operation of the staff, both field and office.

C. R. POLLEN,
Chief Surveyor.

OTAGO.

Minor Triangulation and Topographical.—No work of this nature was done during the last year.

Rural.—A large amount of work has been carried out, consisting of the subdivision of the Omarama Runs, Waitahuna Settlements No. 1 and No. 2, and Bellamy Settlement, and a number of small spotting surveys. Mr. Burton has been engaged on this work during the whole of the year, and Messrs. Richmond, Armit, and Waters, together with three unauthorized assistants, during part of the year. Mr. Burton returns 8,735 acres as completed, the work of the rest of the staff being carried forward to next year, as, owing to pressure of work, it has been impossible to complete the plans. In addition to the foregoing, 600 acres for fruit farms was done under contract by Mr. R. S. Allan, and 248 acres carried out by private surveyors, the cost being defrayed by settlers.

Village and Suburban.—Mr. W. T. Neill returns an area of 13 acres at Balclutha, being an area laid off as a rifle range.

Standard Survey.—The standard survey of the City of Dunedin has been continued during the year by Mr. W. T. Neill, District Surveyor, who reports 25 miles of traversing in the North-east Valley, including permanent blocks as completed, and in Roslyn 15 miles is traversed and about half the blocks finished. The defective and faulty surveys originally made in these portions of the city require careful examination, and are a source of considerable expenditure, which was unforeseen and not allowed for in the estimated cost of this work.

Town Surveys.—Mr. S. T. Burton returns one small area in the Town of Lawrence, and 97 acres in the Town of Alexandra was subdivided into fruit farms under contract by Mr. R. S. Allan.

Mining Surveys.—The area surveyed for gold-mining purposes was 237 acres, divided into 8 sections, the whole of the work being undertaken by private surveyors for the fees.

Roads and Railways, &c.—Under this heading 27 plans for various statutory purposes were examined and approved.

Native.—An area of 534 acres, being a portion of the Waikouaiti Native Reserve, was subdivided into 25 allotments under contract by Mr. N. Paterson.

Land Transfer.—One hundred plans were examined and approved, comprising an area of 11,167 acres, including 5 plans of towns approved by the Minister in accordance with the provisions of the Land Laws Amendment Acts; 639 deeds were examined and 1,315 diagrams were put on certificates of title.

Proposed Operations for the Year.—Mr. W. T. Neill, District Surveyor, will continue the standard survey of the City of Dunedin, also subdivision Maia Settlement for workers' homes and field inspections; and Mr. S. T. Burton has in hand a number of spotting surveys, and about 7,500 acres of fruit and settlement farms on Earnscleugh, also the subdivision of the Galloway Run, 120,000 acres; Mr. W. D. Armit, the completion of his work on Omarama Run and Bellamy Settlement, and the subdivision of 2,170 acres of Maraeweka Estate, acquired under the Land for Settlements Act; and Mr. F. H. Waters has the completion of his Omarama work, and the subdivision of the Benmore Runs, 374,000 acres in all.

Office-work.—During the year the following plans were examined: Settlement, 42; mining, 5, statutory, 27; Native, 2; Land Transfer, 100: making a total of 176. The number of diagrams placed on various instruments of title was 962 in the Survey Office and 1,315 in the Land Transfer Office, 2,277 in all. A new 40-chain map of the Cromwell district was drawn for lithography, and similar maps of Skipper's Creek, Earnslaw, and Strath Taieri districts were revised and brought up to date. In all, 46 plans were prepared for photo-litho sale posters, including Waitahuna Settlements Nos. 1 and 2, Omarama Runs, and Bellamy Settlement. The Land Transfer record map of Port Chalmers was completed, and two new block maps prepared for the Land Office. The work of revision of the Valuation Department's maps is still proceeding as opportunity occurs, and the major portion of one Draughtsman's time has been taken up on the Dunedin standard plans, several of which have been copied for the City Corporation. Tracings of various kinds to the number of 982 were made, and the usual diagrams put on Ranger's field-books as needed. The Printer reports the printing of 1,450 litho plans and forms; 1,158 maps were mounted, in addition to bookbinding and such work as is necessary to keep the various plan portfolios in a state of good repair.

In conclusion, I have pleasure in reporting that during this busy year the surveyors in the field and the officers of the draughting staff have carried out their duties in an efficient manner, and wish to record my appreciation of their hearty co-operation in the work of settlement.

ROBT. T. SADD,
Chief Surveyor.

SOUTHLAND.

Minor Triangulation.—No work of this nature has been done during the past year.

Rural.—Of 39,173 acres returned under this heading, 36,689 acres in 54 sections were surveyed by the staff at an average cost of 1·26s. per acre, about 8,000 acres consisting of hilly bush country and the remainder of hilly open land. Contract surveyors completed an area of 2,110 acres in 14 sections at a cost of 2·11s. per acre, made up of 154 acres, Invercargill Rifle Range, surveyed for Defence Department, and 1,956 acres, sawmill areas in various parts of the land district. The balance, 374 acres, consists of 4 coal leases in Wairio Survey District, and 1 school-site in New River Hundred, surveyed by licensed surveyors and paid for by the applicants.

Village and Suburban.—Under this heading 72·1 acres in 21 sections are returned by the staff at an average cost of 18·34s. per acre, situated in the Town of Woodend and in Waikawa, Hokonui, and Wakaia Survey Districts; and there are also 14·5 acres in 2 sections, paid for by applicants, which were surveyed by licensed surveyors.

Town Section Surveys.—These comprise 0·25 acres in 2 sections, surveyed by Mr. C. Otway, in the City of Invercargill, at a total cost of £2 5s., being a subdivision of an educational endowment section; and 0·44 acres, also educational land, in the City of Invercargill, surveyed by Mr. G. L. Cuthbertson and paid for direct by applicants.

Native Land Court Surveys.—A subdivision of Ruapuke Nos. 2 and 4 Blocks, Ruapuke Island, 1,416 acres, in 17 sections, was surveyed by Mr. P. B. Macdonald, at a cost of 34·13d. per acre, including the survey of roads necessary for access.

Gold-mining Surveys.—One special claim of 100 acres, surveyed by Mr. T. S. Miller, in Block VII, Longwood Survey District, and paid for by the applicants, appears under this heading.

Roads, Railways, and Water-races.—A total of 18·94 miles is returned in this class, 8·65 miles having been executed by the staff surveyors in connection with access to Crown lands, at a cost of £18·39 per mile; and 10·29 miles by licensed surveyors, consisting principally of road deviations surveyed for County Councils, &c., and paid for by them. Costs not available.

Other Work.—Expenditure under this heading includes revision and street-alignment surveys; redefining boundaries; engineering surveys in connection with protective works Beaumont Settlement, Silver Stream Channel improvement, Taieri Survey District, and Hedgehope University-endowment drainage scheme; traverse to define river-encroachment, Beaumont Settlement; reports on sections, inspections, &c.; also completion of large block for landless Natives in Waimumu Hundred, a considerable proportion of the pegging and line-cutting having been left unfinished owing to a proposal, since abandoned, to reserve the land for the Mataura waterworks.

Inspections.—Five Land Transfer surveys in the Borough of Invercargill were inspected by Mr. R. S. Galbraith, Chief Draughtsman, during the year, with generally satisfactory results. These include surveys by practically all the surveyors who sent in Land Transfer surveys during the year.

Traverse Closures.—94·6 miles of traverses, representing 15 separate surrounds returned by staff surveyors, show that a very high standard of accuracy has been maintained, the closing errors averaging only 0·35 links on the meridian and 0·21 links on the perpendicular per mile.

Proposed Operations.—Mr. C. Otway will be engaged during the coming year in the survey and subdivision of a large bush block of Crown land in Lillburn Survey District (15,000 acres), a portion of which will, it is hoped, be ready for settlement by March next. Mr. D. Macpherson has at present in hand a small block of about 300 acres in Oreti Hundred which he expects to finish by the end of April. He will then undertake the defining of a number of uncut section-boundaries in Blocks V and VII, Aparima Hundred, and afterwards subdivide a block of some 2,500 acres in Block XIX, Jacob's River Hundred. Mr. N. L. Falkiner is at present engaged on the survey of 1,460 acres of Crown land in Otara Survey District, and when this is completed he will undertake the survey and subdivision for settlement of two small blocks of Crown land, containing about 700 acres, in Oteramika Hundred, being some recently-cut-out sawmill areas.

General.—I would like to draw attention to the fact that practically the whole of the districts of Eyre, Eyre North, Eyreside, Black Hill, Lincoln, and Takitimo require a triangulation and topographical survey, as the only information available is a reconnaissance survey made in 1857. I consider that the work is imperative, and would recommend that an additional surveyor be provided to commence the survey in the coming spring.

Office-work.—During the year 11 new application-maps and 2 new index-maps have been prepared to replace those worn out, 1 working-plan which was becoming illegible was redrawn, and 4 index-maps have been compiled to show the state of the roads in the land district—*i.e.*, formed, gravelled, &c. One of these maps which has already been brought up to date has proved most useful, and it is hoped to add the necessary information to the other three during the coming year. Four district lithographic maps were revised—viz., Taringatura Survey District (2 sheets), Campbelltown and Waimumu Hundreds, and a new drawing of Longwood Survey District is almost completed, also the revision of a number of other maps is well in hand. Fifty-one ordinary survey plans comprising 39,147 acres, 31 statutory plans principally of roads taken and closed, and 8 plans of new towns for Governor's approval were checked and approved; 751 diagrams were endorsed on Crown grants and other instruments of title; 52 lithographic tracings for sale plans; 501 miscellaneous tracings and 201 working-tracings were prepared; 6 new maps of ridings were prepared and 1 revised, and 79 Land Transfer and deeds plans were traced for Valuation Department; 20 local bodies' schedules were prepared in duplicate, and 226 maps of various descriptions mounted; 3 maps in triplicate were prepared for Justice Department in connection with three Supreme Court cases, and maps of Waimatuku River District and tracings of Taieri drainage scheme were made for Government Drainage Engineer. Mr. Deverell has been altogether engaged during the year in the preparation of the lithographic map of Otago Land District which he commenced in January, 1914, and which is now nearing completion.

Land Transfer.—Seventy-nine plans, representing 3,075 acres, were checked and approved, 964 diagrams placed on certificates of title, and 472 deeds and other instruments of title examined and passed.

Changes of Staff.—During the year there have been considerable changes in the personnel of the staff, and I regret to have to record the death, on the 12th November last, of Mr. J. L. Dickie, who was for many years Land Transfer Draughtsman here, and who was a most capable and painstaking officer. Mr. O. G. Goldsmith has since been appointed Land Transfer Draughtsman, and as his promotion left the position of Computer vacant, he has, up to the present, in so far as possible, attended to the duties of both positions. Mr. A. Macfarlane, Receiver of Land Revenue, was promoted to be Chief Clerk at Nelson; Mr. L. Hay, field cadet, was transferred to the Otago Land District; and Mr. J. Southern, draughting cadet, resigned.

In conclusion, I wish to thank the officers of both field and office staff for their efficient assistance and co-operation in the work of the past year.

G. H. M. McClure,
Chief Surveyor.

APPENDIX II.

HEAD OFFICE DRAUGHTING STAFF.

ONE feature of the past year has been the amount of time lost by the absence on sick-leave of several members of the staff for unusually long periods, which has had a detrimental effect on the output. Other and unusual features have been the preparation of maps of the war areas in Europe; and the preparation of examination-papers and details for a draughtsman's examination, for which, however, no candidate sat. Owing to the absence of the Chief Computer on leave at the Lick Observatory, California, the duties of Secretary to the Surveyors' Board were taken over by the Chief Draughtsman. The completion of new fittings has made possible the proper indexing of records as soon as clerical assistance is available; and an investigation of the state of the publications generally has enabled the volume of work of that nature required to be done to be grasped, and it is very considerable. Of the 125 counties in New Zealand, 33 remain still to be drawn and published, while a large part of those published are marked "Provisional." Of the 997 survey districts, 553 are unpublished still, and no definite plan of completing this, probably the most useful publication of the Department, is yet properly in action. There are also probably well over a thousand small centres of population, towns and villages, of which maps would be useful but are not drawn.

Revision and redrawing of the 4-mile sheets of the North Island is in progress, but there is still a good deal to be done to the large map of Wellington. The new map of New Zealand, after the outbreak of war, was put aside; it requires, however, but two or three days' work to bring it to completion.

A new protractor was plotted by co-ordinatograph and put to stone during the year, and is of rectangular shape, giving greater clearness. The work of standardizing drawing-papers is so far advanced in that some 200 samples from the best makers are in hand for selection of suitable grades and characters for departmental work and records. Colours and other materials likewise are receiving attention, and it will be possible, it is hoped, shortly to issue a list of standard draughting materials of unexceptionable character from which to order supplies.

A large amount of miscellaneous work passes through this branch in the preparation of tracings, descriptions, maps, and similar matters for other Departments and the legislative; and index-maps of all parts of New Zealand are kept up and available for consultation by all branches.

Two sheets of the international map subdivisions were compiled as an experiment from the mile lithographs and reduced to the standard natural scale of $\frac{1}{125000}$, but were not very satisfactory, and a further sheet required will be controlled by plotted points.

Seventeen schedules for the Local Bills Committee were examined and certified to, 185 plans of towns were examined and prepared for statutory approval, 103 drawings were photo-lithographed, 176 technical descriptions were written, 9 surveyors' bands were tested, 70 plans of registration districts and 37 loan-blocks maps were made. Large numbers of maps were mounted and lithographs disposed of, and all the town plans were traced, and many miscellaneous tracings and maps were made, while all the land transactions of the Department were brought up on the county maps.

M. C. SMITH,
Chief Draughtsman.

Table 1.—RETURN OF FIELD-WORK EXECUTED BY HEAD OFFICE STAFF.

Land District.	*Secondary Triangulation.		Minor Triangulation.		Town Standard Surveys.		Rural Standard Surveys		Inspections.		Other Work.
									No. of Surveyors.		
	Area.	Cost per Acre.	Area.	Total Cost.	Miles.	Cost per Mile.	Miles.	Cost per Mile.	Staff.	Private.	
				£		£		£			£ s. d.
Auckland ..	Carried	forward	..	..	23	39·75	..	..	..	..	1,096 7 4
Wellington ..	Carried	forward	..	135	Carri	ed forwa	rd	..	..	18	696 2 3
Nelson ..	..	..	..	..	37	41·00	..	..	..	..	..
Totals ..	..	..	..	135	60	80·75	..	..	..	18	1,792 9 7

* A large area of triangulation as shown on litograph is in progress in the field.

Table 2.—RETURN OF FIELD-WORK EXECUTED BY STAFF AND CONTRACT SURVEYORS ON LANDS ADMINISTERED BY LANDS AND SURVEY DEPARTMENT.

Land District	Minor Triangulations.		Topography.		Rural.		Village and Suburban.			Town.			Roads, &c.		Other Work.	Total Cost of Surveyor and Party from 1st April, 1914, to 31st March, 1915.
	Acres.	Cost per Acre.	Acres.	Cost per Acre.	Acres.	Cost per Acre.	Acres.	No. of Sections.	Cost per Acre.	Acres.	No. of Sections.	Cost per Acre.	Miles.	Cost per Mile.	Cos .	
		d.		d.		s.			s.			s.		£	£ s. d.	£ s. d.
Auckland	55,160	1·13	6,200	6·97	139,472	2·32	4,335	257	5·46	22	78	19·03	134·75	22·83	4,009 17 8	38,398 7 11
Hawke's Bay	1,000	7·52	12,781	1·93	50,086	1·27	311	44	18·43	34	63	48·30	30·10	18·26	726 14 2	12,889 6 11
Taranaki	..	..	856	4·24	33,085	2·70	..	..	..	5	8	36·42	23·47	26·44	86 4 0	4,484 12 9
Wellington	..	..	90,000	1·44	34,499	3·33	302	104	17·70	17	39	26·60	5·07	32·78	228 0 4	3,535 6 3
Nelson..	90,283	1·97	34,480	4·31	113,445	1·60	..	..	..	2	5	33·08	27·92	26·00	938 3 6	8,196 9 8
Marlborough	..	..	51,000	2·02	11,735	1·06	196	23	2·64	23	66	15·76	4·00	32·02	75 8 3	1,274 2 5
Westland	..	..	6,450	2·34	9,555	3·23	284	18	8·50	..	..	..	7·00	15·23	72 3 1	2,001 8 0
Canterbury	..	..	16,334	2·35	8,381	1·78	..	..	..	10	21	32·08	14 25	20·14	300 5 1	2,332 2 4
Otago	..	..	..	..	9,337	1·47	..	..	..	97	9	50·93	..	..	1,253 3 1	1,890 0 10
Southland	..	..	..	..	36,689	1·26	72	21	18·34	0·25	2	22·50	8·65	18·39	873 4 3	3,569 2 10
Means and totals	146,443	1·70	218,101	2·32	446,284	2·00	5,500	467	7·09	210·25	291	23·51	255·21	22·80	8,563 3 5	78,571 9 11
Licensed surveyors (paid by applicants)	..	..	..	..	12,667	..	145	2	..	0·44	2	..	14 07	..	..	..
Totals	..	..	..	..	458,951	..	5,645	469	..	210·69	293	..	269·28	..	..	..

Table 3.—Return of Field-work executed by Staff and Contract Surveyors on Lands administered by other Departments.

Land District.	Minor Triangulation.		Topography.		Rural.		Village and Suburban.			Town.			Roads, &c.		Native-land Survey.			Gold-mining.			Other Work
	Acres.	Cost per Acre.	Acres.	Cost per Acre.	Acres.	Cost per Acre.	Acres.	No. of Sections.	Cost per Acre.	Acres.	No. of Sections.	Cost per Section.	Miles.	Cost per Mile.	Acres.	No. of Sub-divisions.	Cost per Acre.	Acres.	No. of Sections.	Cost per Acre.	
						s.			s.					£			d.			s.	£ s. d.
Auckland	..	..	..	..	..	..	..	..	..	..	..	..	..	..	251,441	1,232	16·58	..	..	..	..
Hawke's Bay	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100,770	501	14·94	..	..	..	250 19 4
Taranaki	..	..	..	..	*2,217	2·72	..	..	..	..	..	..	2·09	23·91	44,950	53	14·46	..	..	..	102 12 1
Wellington	..	..	..	..	..	..	..	..	..	..	..	..	..	..	85,237	402	18·67	..	..	..	..
Nelson	..	..	..	..	..	..	..	..	..	..	..	..	..	..	159	8	84·26	98	4	9·75	..
Marlborough	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1,308	8	25·68	..	..	..	18 12 6
Westland	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Canterbury	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	443 8 0
Otago	..	..	..	..	..	..	*12·9	..	17·00	..	..	..	..	..	534	25	33·03	..	..	..	..
Southland	..	..	..	..	*2,110	2·11	..	..	..	..	..	..	..	..	1,416	17	34·18	..	..	..	11 1 11
Means and totals	..	..	..	..	4,327	2·42	12·9	..	17·00	..	..	..	2·09	23·91	485,815	2,246	16·53	98	4	9·75	826 13 10
Licensed surveyors (paid by applicants)					27,464	..	..	..	..	..	..	..	..	..	31,008	250	..	2,275	26	..	..
Totals					31,791	..	..	..	..	..	..	..	..	..	516,823	2,496	..	2,373	30	..	..

* Includes scenic reserves, sawmill areas, and other reserves.

Table 4.—RETURN SHOWING SURVEYORS EMPLOYED AND THE WORK ON HAND ON 1ST APRIL, 1915.

Chief Surveyors.	Surveyors employed.			Work on Hand.					
	Staff.	Temporary.	Contract.	Land District.	Trig.	Settlement.	Town.	Native Land Survey.	Roads.
					Sq. Mls.	Acres.	Acres.	Acres.	Miles.
H. M. Skeet ..	15	8	54	Auckland ..	..	304,801	101·0	390,275	247·5
W. H. Skinner ..	9	1	..	Hawke's Bay	..	106,690	0·1	113,141	22·25
G. H. Bullard ..	4	..	6	Taranaki ..	42	56,034	258·0	64,923	23·0
T. N. Brodrick ..	4	..	..	Wellington ..	..	26,670	..	72,872	..
F. A. Thompson ..	4	2	2	Nelson ..	..	115,640	..	..	..
H. G. Price ..	..	1	..	Marlborough	..	7,645	1·0	..	..
H. D. M. Haszard	2	..	..	Westland ..	..	2,190	..	..	..
C. R. Pollen ..	2	1	..	Canterbury ..	..	47,300	..	..	41·0
R. T. Sadd ..	4	..	..	Otago ..	..	651,100	..	..	..
G. H. M. McClure	3	..	..	Southland ..	..	16,799	..	..	7·0
Total staff surveyors	47	13	62	..	42	1,334,869	360·1	641,211	340·75

Table 5.—WORK DONE UNDER THE LAND TRANSFER ACT, ETC., FROM THE 1ST APRIL, 1914, TO THE 31ST MARCH, 1915.

District.	Plans placed on Instrument of Title.			Deeds and other Instruments passed.	Plans examined, &c.	Deeds or other Instruments, &c.	Maps drawn.		Lithos published.	Lithos sold.
	Leases and Licenses.	Freehold.	Miscellaneous.				Hand Publication.	Sale Plans.		
										£ s. d.
Auckland	1,964	3,092	3,078	3,647	1,710	..	..	182	3,600	190 16 6
Hawke's Bay	407	2,166	1,072	748	618	407	..	27	..	39 15 6
Taranaki	577	908	210	20	245	577	3	12	..	17 19 2
Wellington	580	4,745	711	2,557	548	880	9	70	..	8 10 6
Nelson	254	464	26	149	253	204	2	12	..	25 6 0
Marlborough	293	495	18	..	102	290	..	7	..	25 17 3
Westland	285	104	195	27	93	292	17	21	..	6 1 7
Canterbury	268	3,493	64	2,231	369	..	..	18	..	29 9 0
Otago	765	1,512	..	639	176	962	4	46	1,450	72 8 11
Southland	486	1,228	1	472	161	606	4	52	..	53 14 9
Totals	5,879	18,207	5,375	10,490	4,275	4,218	39	447	5,050	469 19 2

APPENDIX III.—WELLINGTON CITY TRIANGULATION.

DURING the year Mr. J. D. Climie, Inspector of Surveys, completed a small triangulation survey covering the City of Wellington, the primary purpose of which was to connect Mount Cook Initial Station, the origin of latitude and longitude for New Zealand, with the Dominion Astronomical Observatory known as the Hector Observatory.

Advantage was taken of this work to tie together the earlier determination of meridian and standards of length, so as to provide reliable facts to enable comparisons of old and new survey-work to be made in future work when required, and also to form the connecting-link between the new secondary triangulation and the observatory and initial and city and suburban standard surveys. Mr. Climie has done this work most thoroughly, and has ascertained and brought together in a form convenient for record and reference a quantity of data which have hitherto been scattered through many separate records. Copies of his report and plan follow.

TRIANGULATION ETC., IN CONNECTION WITH THE MOUNT COOK, HECTOR, AND WELLINGTON OBSERVATORIES.

I am handing in herewith a plan, 30 in. by 30 in., showing the observations I have made to connect the new observatory (Hector Observatory) at Kelburn with the Mount Cook Initial Station, also the connection with the old Wellington Observatory together with the connections with the standard survey. There is shown on the drawing the work done by Messrs. McKerrow and Marchant in 1877, and that by Mr. C. W. Adams in 1883. Altogether there are fourteen diagrams (drawn to various scales) in explanation of all the work that has been done in determining the true meridians at Mount Cook and Wellington Observatories. I have taken much trouble in obtaining all the data that are available at this and the District Office, so that the plan should be a reliable record for easy reference in the future.

The following is an explanation of each diagram —

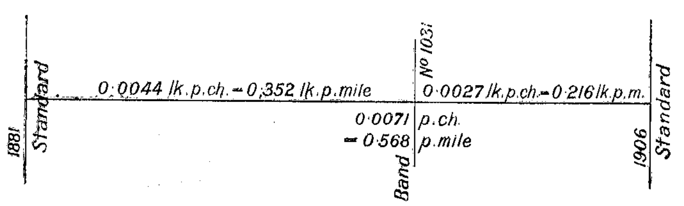
Diagram No. 1.—The triangulation, which is drawn to a scale of 30 chains to an inch, shows the result of the seventy-four rounds of bearings which have been taken at twenty-two different trig. points. The initial bearing for triangulation is Mount Victoria (flagstaff) to Kaukau (349° 11′ 58·8″), which was determined by Messrs. McKerrow and Marchant in 1877. Their origin was Kaukau to Mount Cook, which was astronomically determined at Mount Cook by Mr. McKerrow. I have extended this meridian from Mount Victoria to North Lamp, and thence to the true meridian passing through Mount Cook to Island Bay, which was astronomically determined by Mr. C. W. Adams in 1883, and by this extension have ascertained the difference between Messrs. McKerrow and Adams's true meridian at Mount Cook to be 2·3 seconds only, and at the old Wellington Observatory (Seddon Monument at cemetery—Henry Jackson's determination) 3 seconds. Therefore the three observed meridians by Messrs. McKerrow, Adams, and Jackson are in agreement as follows :—

Mr. McKerrow's	.. ..	360° 00′ 00″.	Date, 1877.
Mr. Adams's ..	.. ..	360° 00′ 02·3″.	Date, 1883.
Mr. Jackson's ..	.. ..	359° 59′ 57″.	Date, 1870.*

The standard of length adopted by me is that of the city standard survey of 1881, corrected by deducting 0·568 link per mile, which reduces it to the new Imperial standard. The correction of 0·568 link per mile is arrived at as follows (see F. Bk. 2487, p. 5, District Office) :—

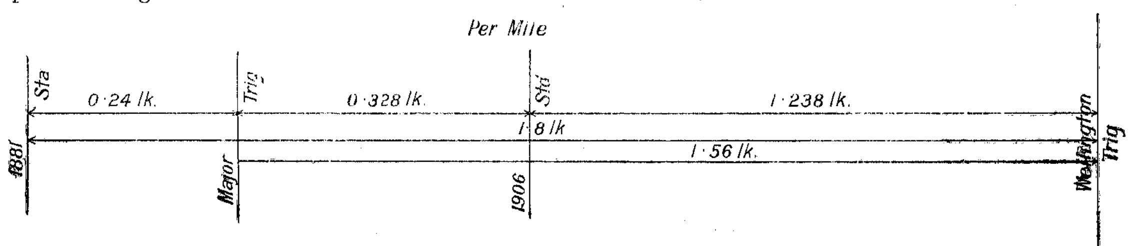
(1.) The 3-chain ¼ in. band No. 1031 used on the verification city survey in 1906 was, after a series of tests with the Imperial band, found to be 0·008 links short, which is equal to 0·0027 links per chain.

(2.) This 3-chain ¼ in. band was compared with the 1-chain ¾ in. band used for the 1881 survey and found to be longer by 0·0126 link; and by comparison with the Pirie Street base-line laid down with the 1881 band was 0·0146 link long. These, summarized, are as follows: 0·0126 link by ¾ in. band; 0·0126 link by ¾ in. band (added for weight); 0·0146 link by Pirie Street base. Mean, 0·0133 = 0·0044 of a link per chain. This is equal to 0·352 link per mile, by which the 3-chain band is longer than the 1906 Imperial standard. These results may be put in diagram form thus :—



That is, 0·0027 + 0·352 = 0·568 link, the total correction per mile to be deducted from the 1881 standard survey trig. distances to bring them into terms of the present chain-standard (Imperial).

The 1881 standard of length (city standard survey) was shorter than the adjacent triangulation by 1·8 links per mile (see Captain Hewitt on city standard survey, District Office file 10123/60). Comparison of the base adopted for the major work along the Tararua Range with the Wellington Trig.: distances show that this is 1·56 links less per mile than the major base, thus showing that the 1881 standard survey base is shorter than the major trig. base by 0·24 link per mile. All these results put in a diagram are :—



In computing my work I have accepted the lengths of my 1881 city triangulation (less 0·568 link per mile) of sides Mount Victoria - Kaiwarra, Mount Victoria - No. 1 Trig., Mount Victoria - Mount Albert, and Mount Victoria - Ohiro. These lengths were computed from the Pirie and Riddiford standard base-lines by Captain Hewitt in 1881, and are sides of polygons corrected in the usual way for seconds correction.

The instrument used, excepting for the sets taken with the 8 in. micrometer, was my 5½ in. Cooke micrometer with a 40-diameter eye-piece, which has given excellent results.

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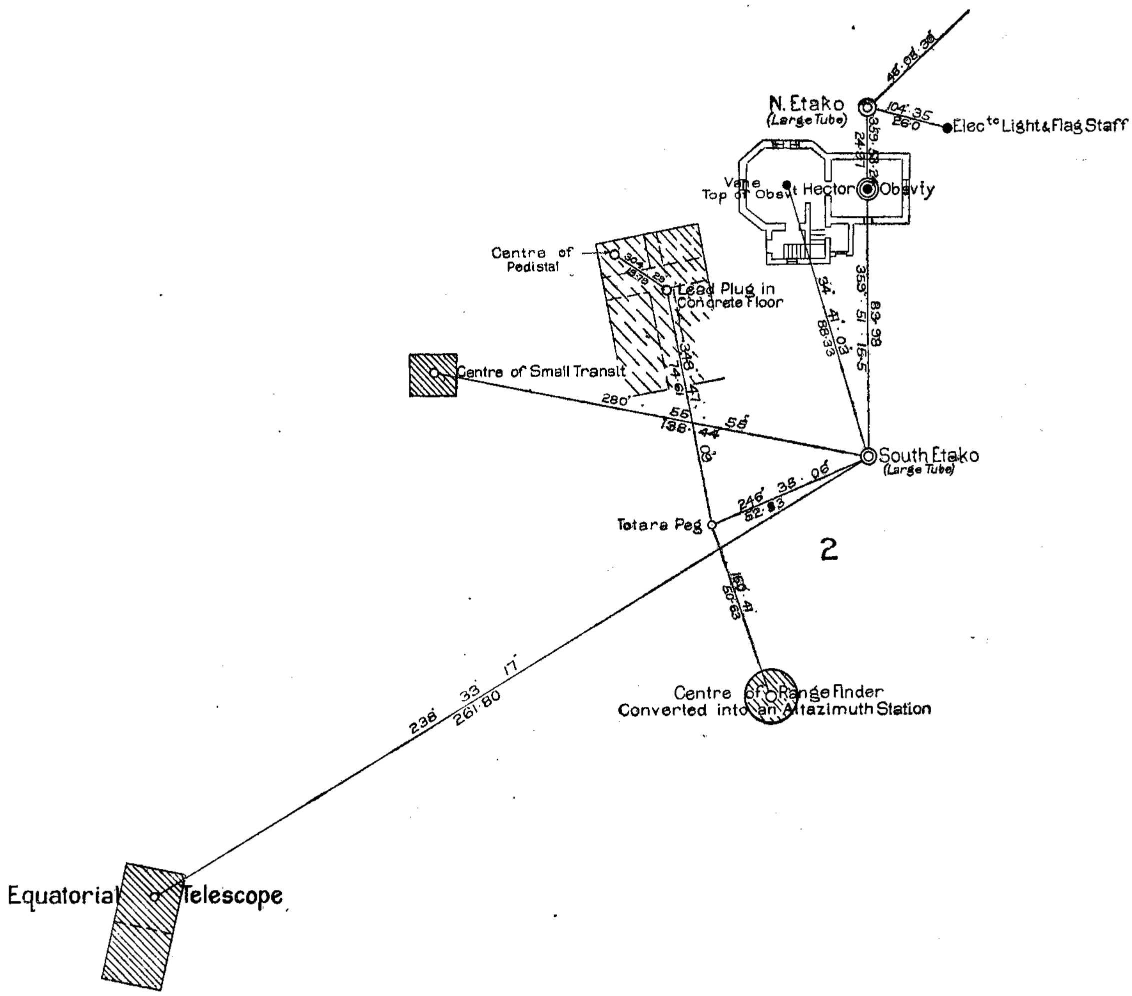
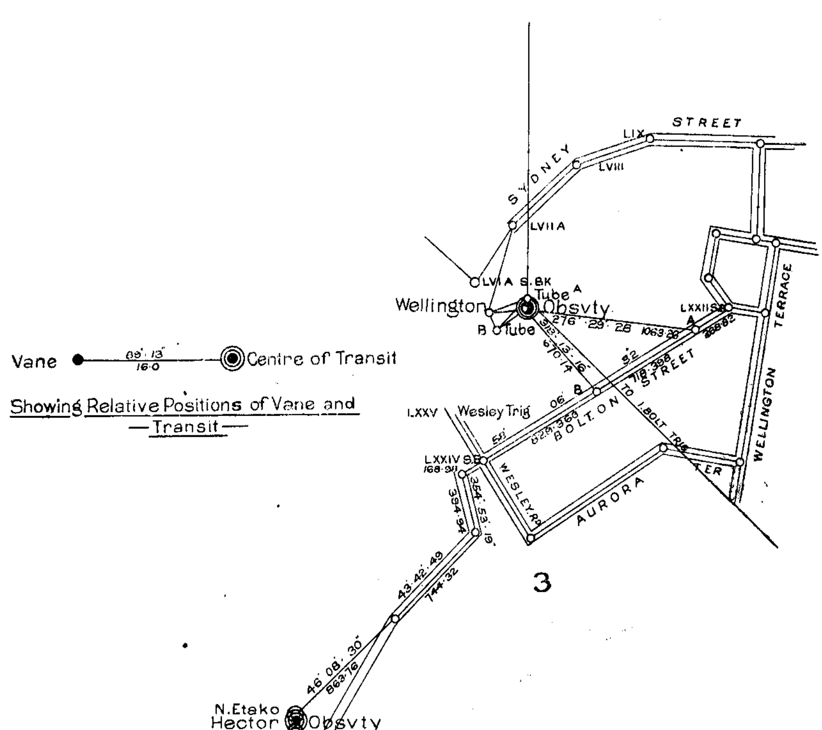
* Mr. Thomas King, F.R.A.S., formerly time-observer, writes :—

"In reply to your note of to-day, I am sorry to say that I am unable to give you the date on which the meridian-mark for the old time-service observatory in the cemetery was placed in position on the Tinakori Range. The observatory was built in 1869, and in January, 1870, the work of the time-service was transferred to it from the small transit-house which stood on part of the ground which is now the site of the General Post Office, Customhouse Quay.

"I have heard the late Sir James Hector say that the meridian-mark was erected under his personal direction, and I gathered that the necessary observations were taken by himself or by the late Archdeacon Stock, my predecessor in charge of the observatory. The late Mr. Henry Jackson may, of course, have had something to do with the placing of this mark; but I have always understood that Mr. Jackson's astronomical work was done at the Hutt, in a small observatory erected there for longitude-determination purposes."

The average error for twenty-one triangles closed is 3·5 seconds. The smoke and haze of the city was a cause of much delay and trouble, preventing obtaining even better results.





Diagrams Nos. 2 and 3 show the connection of the Wellington and Hector Observatories with the standard survey and each other.

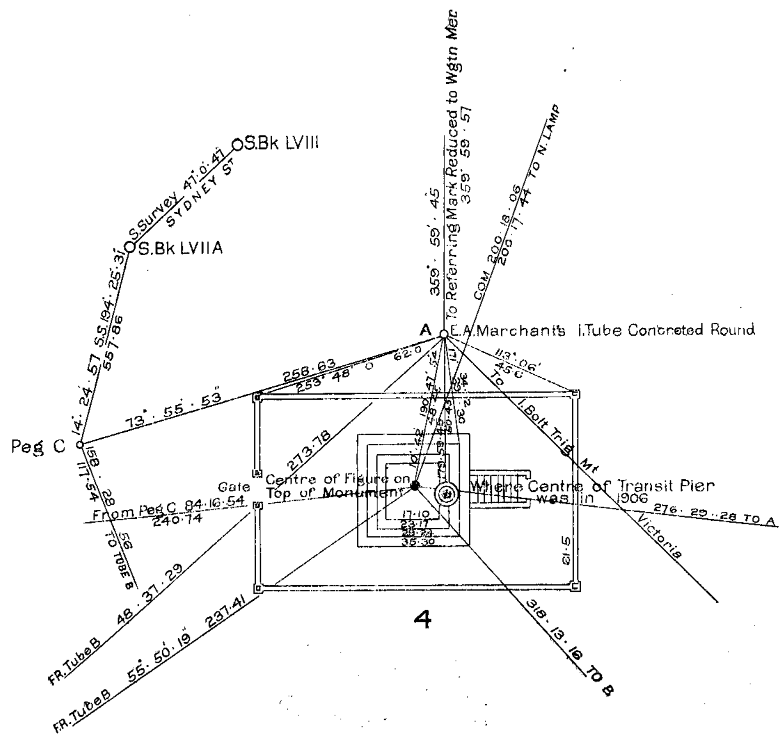
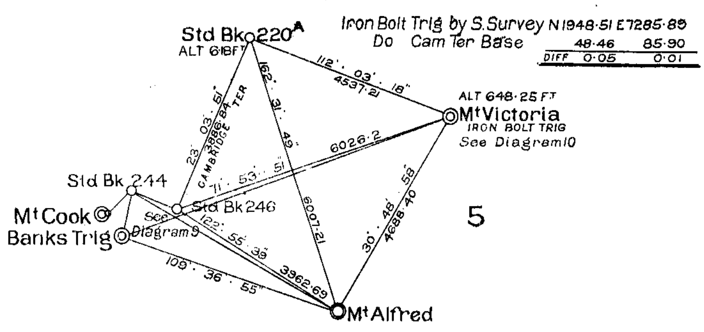


Diagram No. 4 shows the connection of the old Wellington Observatory with the standard survey in Sydney Street and Bolton Street, also the position of the Seddon Monument with reference to the situation of the transit pier in 1906.



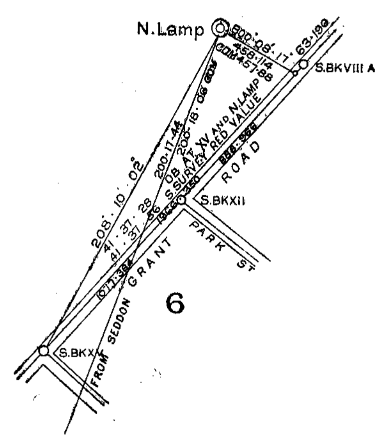


Diagram No. 5 shows the standard survey traverse line in Cambridge Terrace adopted as a base-line for connections with Victoria Flagstaff. This was done to check the distance between Mount Cook and Flagstaff, also to obtain the correct altitude of the latter by connecting with the bench-mark close to Block 220A.

The differences made in the co-ordinates at Mount Victoria Flagstaff were—North, 0·05 link; east, 0·01 link; and in altitude, 0·25 ft. from my values in 1881.

Diagram No. 6 shows connection of North Lamp with the standard survey.

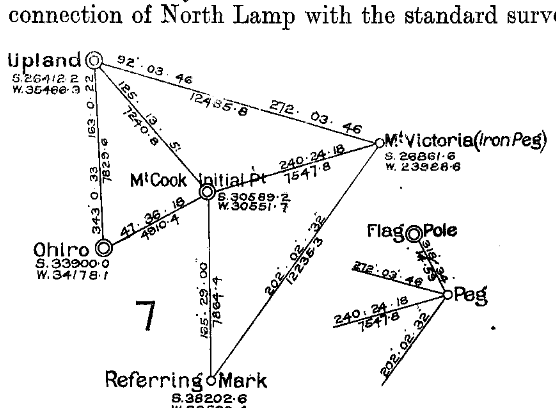


Diagram No. 7 shows the triangulation by which the position of Mount Cook Observatory was fixed by J. W. A. Marchant, January, 1877. On this diagram there is a note showing how the variation of 14° 31′ 27·5″ was arrived at, which has to be added to Jackson's original triangulation (which was on a magnetic meridian) to reduce it to the true meridian of Mount Cook.

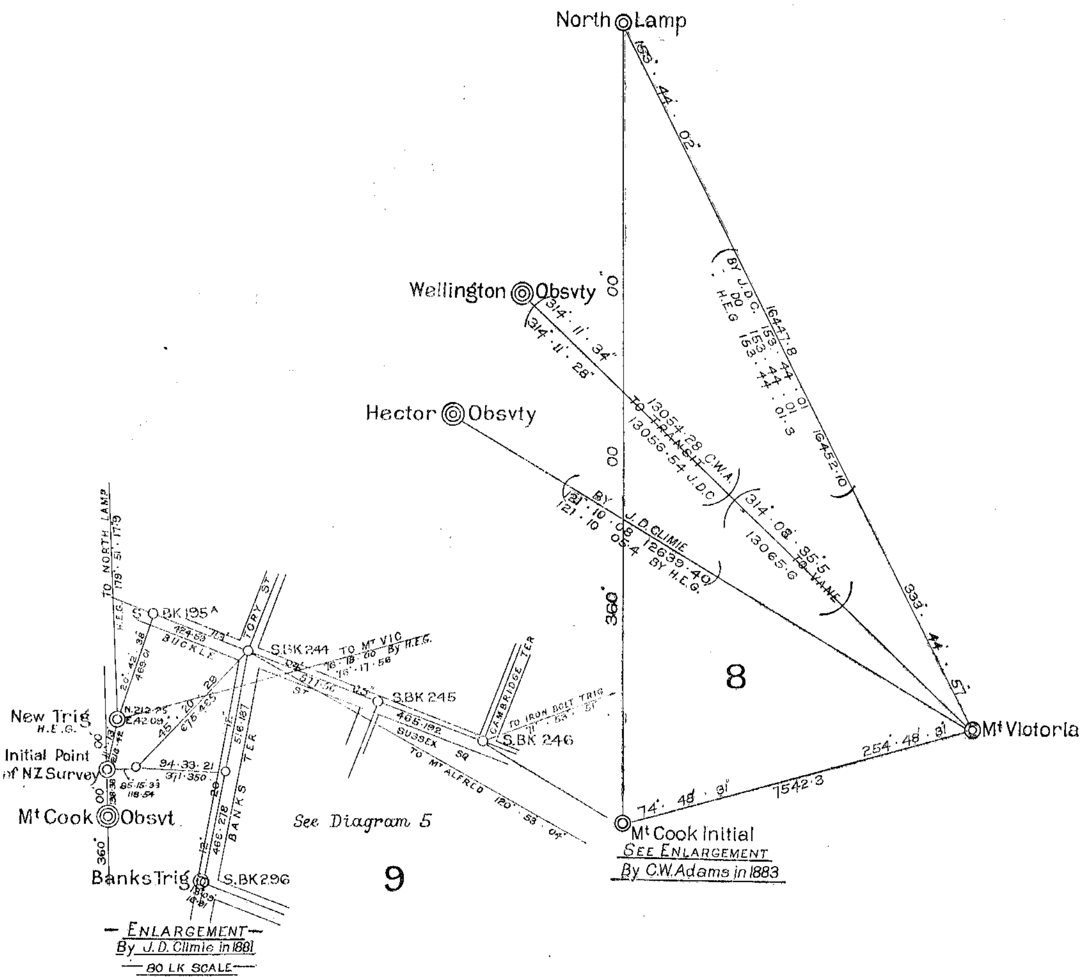
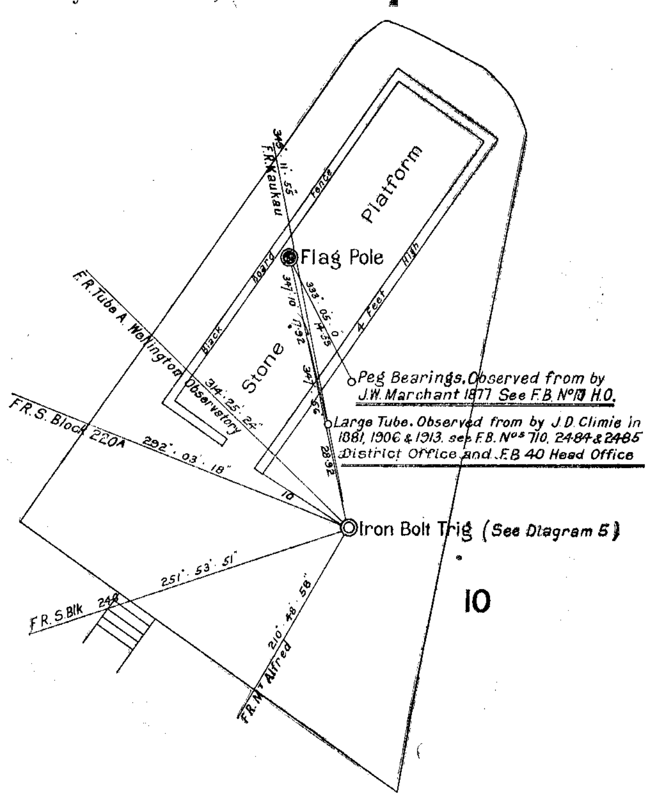


Diagram No. 8 shows connection by C. W. Adams in 1883 of Mount Cook Initial with standard survey and with triangulation, with some additions made by me showing bearings and distances connecting it with the Wellington and Hector Observatories.

Diagram No. 9 shows connection of Mount Cook Initial and Observatory with the standard survey by me in 1881, and also shows Mr. Girdlestone's new Mount Cook Trig. Station (fixed 1914).



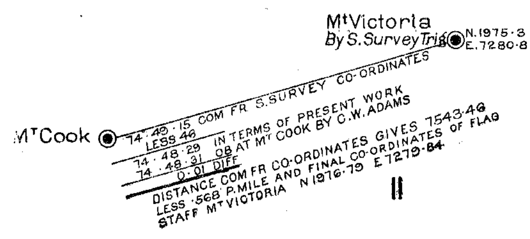


Diagram No. 10.—Plan of Mount Victoria, showing position of—(1) Peg observed from by Mr. Marchant in 1877; (2) the large tube observed from by me in 1881, 1906, and 1914; (3) iron bolt trig. (concreted in) to which the Cambridge Terrace base-line is connected (see Diagram 5).

Diagram No. 11 shows how bearing and distance of Mount Cook – Mount Victoria are determined for use in my present work.

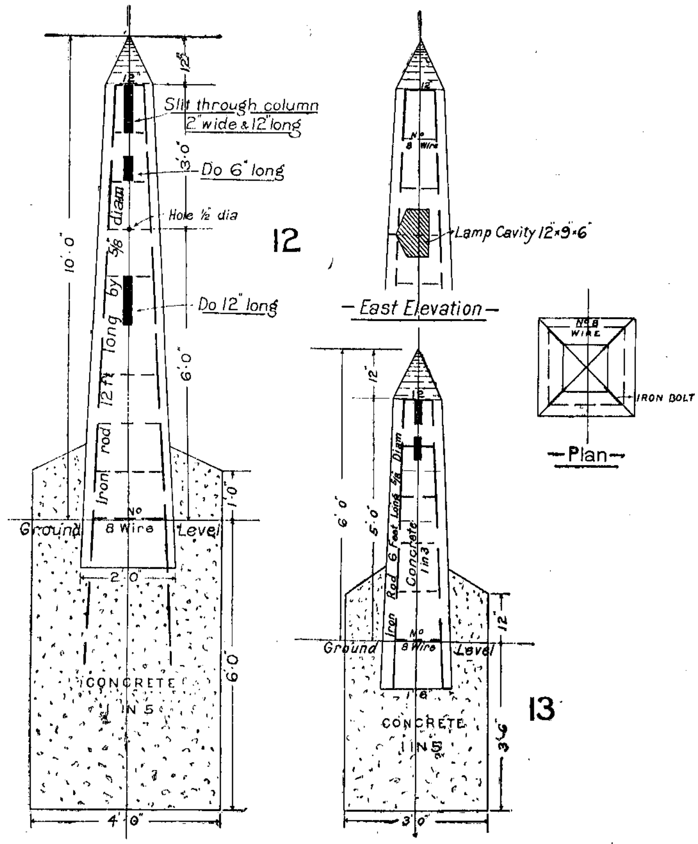


Diagram No. 12 shows a design for south-meridian mark.
Diagram No. 13 shows a design for north-meridian mark.

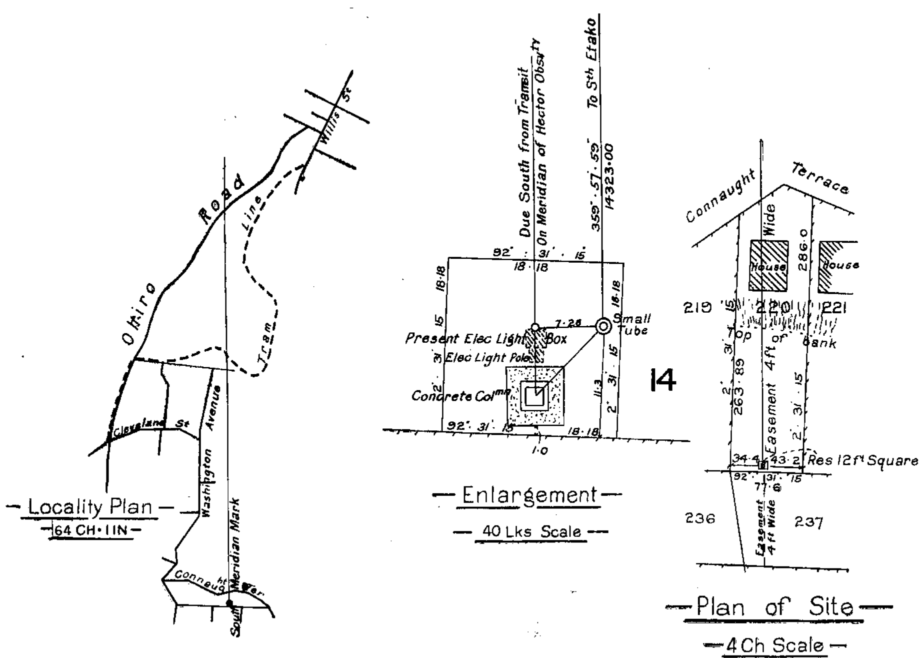
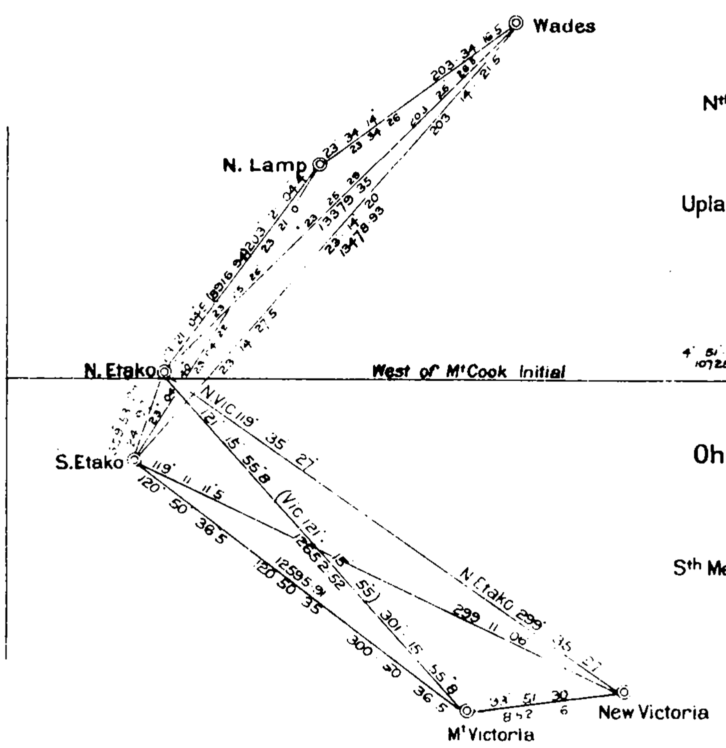


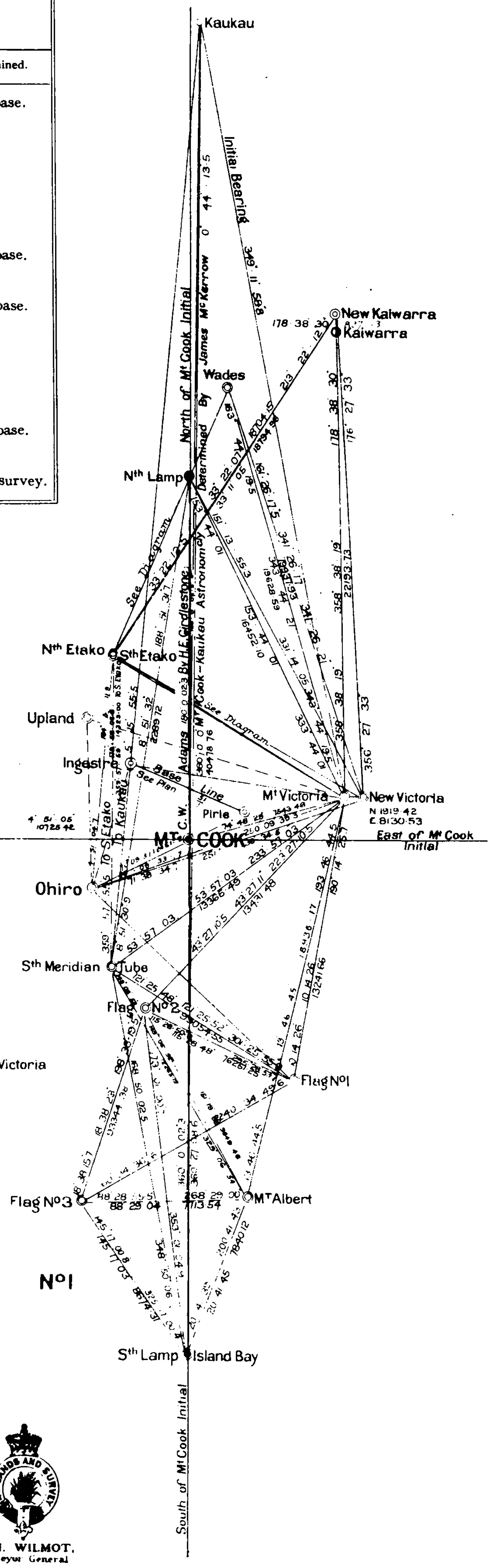
Diagram No. 14 shows the reserve at the south-meridian mark, and locality plan for finding same. F. Book No. 40 contains all the observations, and has been returned to the safe.

J. D. CLIMIE,
Inspector of Surveys.

TABLE of DISTANCES in LINKS on the Meridian and Perpendicular from Initial Station at Mt. COOK.

Name of Station.	Meridian.	Perpendicular.	How determined.
Mt. Victoria.. ..	N. 1,976·79	E. 7,279·84	Pirie St. base.
New Kaiwarra ..	N. 24,164·25	E. 6,752·55	„
Wades	N. 20,820·17	E. 1,783·67	4 values.
North Lamp ..	N. 16,730·14	W. 0·99	5 „
North Etako ..	N. 8,543·49	W. 3,535·20	5 „
South „ ..	N. 8,434·55	W. 3,534·69	5 „
Ohiro	S. 2,252·45	W. 4,441·74	Pirie St. base.
S. Mer. Tube ..	S. 5,888·50	W. 3,526·32	2 values.
Flag No. 1	S. 11,053·94	E. 4,925·72	Pirie St. base.
Mt. Albert	S. 16,414·42	E. 2,769·66	„
Flag No. 2	S. 7,773·63	W. 1,957·75	2 values
„ 3	S. 16,618·45	W. 4,941·18	2 „
Island Bay	S. 23,748·62	W. 1·08	3 „
Iron Bolt, Victoria ..	N. 1,948·51	E. 7,285·89	Pirie St. base.
Hector Observatory ..	N. 8,518·50	W. 3,535·03	6 values.
Well'gton „ ..	N. 11,077·90	W. 2,081·94	Standard survey.





NOTE.—*The Initial Bearing* for this triangulation is Mt. Victoria to Kaukau, 349° 11′ 58·8″, observed by McKerrow and Marchant in 1877; their initial bearing was Kaukau to Mt. Cook, which was astronomically determined at Mt. Cook by James McKerrow. The true meridian passing through Mt. Cook to North Lamp and Island Bay was astronomically determined by C. W. Adams in 1883.

The Standard of Length is that of the City Standard Survey of 1881, less ·568 lk. per mile, to reduce to the New Imperial Standard.

E. H. WILMOT,
Surveyor General

Triangulation by J.D.Climie 1914

SHOWING DATA IN CONNECTION WITH WELLINGTON, HECTOR, AND MT COOK OBSERVATORIES

CITY OF WELLINGTON

—Scale of Chains—

30 20 10 0 30 60 90 120 150

A.C.Watt 1915

APPENDIX IV.—WELLINGTON STANDARD SURVEY.

Mr. J. D. Climie, Inspector of Surveys, contributes the following remarks upon the closures obtained by him in his recent revision of his earlier 1881 (first) standard survey of the streets of Wellington:—

In the revision of the Wellington standard survey made by me in 1881 the following thirty-five circuits have been completed. Total length, twenty-three miles, embracing all the hilly portion of the city; average length of circuit, 52·6 chains. Error, 0·055 link north and south, and 0·067 link east and west, equal per mile to 0·084 link north and south and 0·102 link east and west.

The closures of the traverses to the triangulation (which was specially made in 1881 to a measured base in Pirie Street) are generally very good, indicating that the triangulation and standard of length are in agreement, and that Gale's system of traverse corrections gives satisfactory results. Apparently the position of Banks trig. is slightly in error, causing the rather larger differences in traverses affected by that position.

Revision Survey of Wellington Standard, 1906.

Schedule of Standard Circuits computed by Messrs. Heenan and Hocking.

No. of Circuit.	Name of Circuit.	Length.	Errors.	
			N. and S.	E. and W.
		Chains.		
1	Cotterville Street and Featherston Terrace	23	0·05	0·01
2	Hobson Street, Tinakori Road, Thorndon Quay, and Davis Street	80	0·00	0·31
3	Fitzherbert Terrace, Hobson, Muturoa, Pipitea, and Murphy Streets	61	0·06	0·06
4	Tinakori Road, Hill, Molesworth, and Hawkestone Streets	68	0·10	0·11
5	Lambton Quay, Hunter, Featherston, and Customhouse Streets	16	0·00	0·04
6	May Street Circuit	29	0·10	0·03
7	Murphy, Pipitea, and Molesworth Streets	41	0·03	0·07
8	Tinakori Road, Hobson Street, and Fitzherbert Terrace ..	34	0·02	0·01
9	Tinakori Road, Hawkestone, Molesworth, and May Streets	47	0·10	0·01
10	Bolton Street, Wellington Terrace, and Aurora Terrace ..	51	0·19	0·04
11	Thompson, Nairn, and Webb Streets	45	0·05	0·01
12	Thorndon Quay, Mulgrave, Muturoa, and Davis Streets ..	60	0·06	0·08
13	Sydney Street and Hill Street Circuit	84	0·03	0·01
14	Ballance, Featherston, and Taylor Streets Circuit ..	36	0·09	0·05
15	Lambton Quay, Bunny, and Ballance Streets Circuit ..	42	0·01	0·04
16	Grey, Customhouse Streets, and Lambton Quay Circuit ..	30	0·02	0·04
17	Mowbray, Bowen, Bolton Streets, and Wellington Terrace	15	0·04	0·00
18	Sydney and Bowen Streets Circuit	35	0·12	0·01
19	Boulcott, Willis, Dixon Streets, and Wellington Terrace ..	68	0·10	0·00
20	Woodward and Bowen Streets, Wellington Terrace, and Lambton Quay	49	0·00	0·02
21	Manners, Cuba, Dixon, and Willis Streets Circuit ..	38	0·02	0·05
22	Farish, Manners, and Old Customhouse Streets ..	19	0·00	0·04
23	Clyde Quay and Oriental Bay Circuit	102	0·01	0·24
24	Roxburgh Street Circuit	44	0·03	0·14
25	Taranaki, Buckle Streets, Banks Terrace, Howard and Wallace Streets	93	0·13	0·12
26	Thompson, Webb, Taranaki, and Hankey Streets ..	68	0·15	0·22
27	Wright, Hargreaves, Wallace Streets, and New Road ..	51	0·01	0·09
28	Howard, Crawford, New Road, and Wallace Streets ..	36	0·07	0·13
29	Hall and Revans Streets and Adelaide Road	45	0·05	0·01
30	Crawford, John, Drummond Streets, and Adelaide Road ..	33	0·03	0·02
31	Adelaide Road, Stokes, Rintoul, and Hall Streets ..	58	0·08	0·03
32	Riddiford, Russell, Waripori, and Rintoul Streets ..	92	0·02	0·10
33	Stokes, Rintoul, Luxford Streets, and Adelaide Road ..	84	0·06	0·05
34	Hill, Molesworth, Hawkestone Streets, and Tinakori Road	68	0·10	0·12
35	Wellington Terrace, Woodward Street, Lambton Quay, Willis, and Boulcott Streets Circuit	94	0·01	0·04
	Totals	23 m. 2 ch.	1·94	2·350

For thirty-five circuits the average is—Length, 52·6 chains. Errors—N. and S., 0·055; E. and W., 0·067 = per mile, N. and S. 0·084, and E. and W. 0·102; and the largest errors, 0·19 N. and S. in 51 chains, and 0·31 E. and W. in 80 chains.

APPENDIX V.

A TRIP ACROSS THE TARARUA RANGES FROM GREYTOWN TO OTAKI.

[By H. E. Girdlestone, F.R.G.S., District Surveyor.]

(Note.—For a description of the routes over the Tararua Range from Levin and Masterton (Mount Holdsworth), with map, see Appendix VII, Report of Department of Lands and Survey, 1910–11, p. 35.)

Attention is drawn to the Tararua Ranges from time to time by accounts in the newspapers of different parties which have succeeded in crossing over the Mount Hector Track. Owing to the absence of information, and particularly of a good map of the locality, few people realize that within easy distance of Wellington there is an outing which should become one of their most popular holiday trips. Mount Hector is particularly interesting to Wellington people, as this is the peak that stands out so clearly, snow-clad on fine winter days, away up at the head of the Hutt Valley.

The track committee on the Wairarapa side has been working steadily for some time past, and a good pack-track has been cut through the bush right on to the open tops, while huts are in course of erection, which should simplify the journey considerably. It is possible to make the trip from Greytown to Otaki in two days, providing the weather is clear along the main range, but to do so it is necessary to push ahead all the time, and half the pleasure of the outing is lost. To avoid disappointment it is well to have a few extra days in hand—there are some lovely spots to explore—and if the mist comes on when you have reached the high camps you are prepared to wait for the opportunity to push ahead, instead of having to return disgusted. The bush portion of the journey can be traversed at any time, but it is absolutely necessary to have clear weather along the tops in order to follow the main range. In this respect the Tararuas are rather unkind, as the north-westerly wind, which is the prevailing one, almost invariably brings up the mist. Numbers of people have got up as far as the bush-line and then had to return owing to the mist and because their time was limited.

I had made two previous attempts last year when the weather compelled a return, so this Easter I set out with two companions, having a longer time at my disposal, and was fortunate enough to get almost ideal weather after the first day. I carried a camera and barometer, and made notes on my way through with a view to making a map of the route, and herewith give the following account of our experiences, which should serve as a guide to future climbers:—

We left Wellington by the 4.25 p.m. train on the Thursday, having with us an alpine tent, sleeping-bags, change of clothes, oilskin cape, "tucker," an alpine cooker, and a slasher. In order to lighten our load we travelled up in walking-costume of heavy boots, putties, short pants, grey-flannel shirt, and light coat, and caused a good deal of amusement as we marched down to Lambton Station.

We arrived at Woodside about 8.15, adjusted our swags, and set out for Basset's hut. Most parties prefer to go on to Greytown by train and drive out to Basset's hut early next morning, but as it was a clear moonlight night, and we had been over the route before, we decided to push on that night.

Leaving the station we walked along the railway-line for a few chains till we struck the Waiohine Valley Road, turned to the left, and then a few chains farther on took the right-hand turning, passed through a gate, and saw two roads ahead. The one continuing straight ahead runs to a settler's homestead, but the one veering to the left is our route. This road runs along a stony flat, up a short rise, through a gate, along another flat past Jackson's homestead on the left, down a terrace with the Waiohine River roaring alongside, and through a gate on to a low grass flat. After proceeding along this flat for a few chains a small stream is met with, and Basset's hut is discerned on the left about 4 chains from the road.

We could not help comparing our journey up in the bright moonlight with a former attempt in the dark, when we scrambled along nearly losing one another, almost tumbled into the Waiohine River, passed Basset's hut, and then came back and struck matches for ten minutes before we located it.

We took fifty minutes to come from the station, and as we neared the hut noticed two horses feeding in boxes, and approached with some misgivings as to its being occupied. We had our tent, but as it was now after 9 p.m. we hoped to be saved the necessity of pitching. Pushing open the door, a pile of pack-saddles, stores, and other gear denoted that the track packers were making use of it, though probably they had gone out for the holidays.

We soon made ourselves at home, and, getting out the alpine cooker, had tea on in a few minutes. This cooker is worthy of a passing description. It consists of a small flat lamp burning methylated spirits, a wind-screen, two pots, a frying-pan which can be used as a lid to the pots, and a detachable handle that fits everything, the whole outfit being made of aluminium, and fitting together into a very compact light parcel. These are in use in the Mount Cook district, and can be obtained from A. and W. McCarthy, of Dunedin.

Where wood is plentiful down in the low camps the value of this cooker is not very apparent, but away up along the high tops it is delightful to be able to squat down alongside one of the many beautiful tarns and boil the billy or have some soup without the necessity of scouring the range for firewood.

We turned in hoping for a nice fine morning, but during the night the wind arose and the rain came on, necessitating a rearrangement of positions owing to a hole in the corner of the roof.

Friday turned out a miserable day—a howling gale with rain—so we decided to stay where we were. We added to the larder by gathering mushrooms, and kept ourselves amused by playing quoits with some old maul-rings which we found in the whare, and also having an eel-hunt in the adjoining stream, with fisherman's luck.

At midday two men landed up in a gig, and we found them to be stalkers who were going over to try their luck in the Tauherenikau Valley, which was being opened for the first time. They decided to stay the night as the weather was still bad, and we had some very interesting accounts of deer-stalking adventures in different parts of the Wairarapa around the fire that evening.

Saturday morning found the sun shining brightly with the clouds lifting off the ranges, and our spirits rose accordingly. It did not take us long to have a dip in the stream, get breakfast over, and fix up our swags. The deer-stalkers were packing their gear on the horses, so leaving them to go up the road and follow the horse-track, we cut across the corner and made for the steep zigzag which showed up on the spur above us. This steep pinch is a real good pipe-opener, and on reaching the top we were glad of a spell to get our second wind. The barometer showed a rise of 890 ft. from the hut. Here we got the first view of the Wairarapa plains which was beginning to spread out below us. Ahead of us the track rose much more easily, and our next spell on the edge of the green bush showed 600 ft. rise and one hour's journey from the hut. Looking to the north the Waiohine River shone like a streak of silver in the sunlight with Mount Holdsworth as a background, below which the saddle, where the mountain-house is located, showed out very clearly. Away to the west Mount Reeves stood out as a bare brown patch amongst the surrounding green. The back ranges were becoming clearer, and our spirits rose as the mist floated away from each peak. The track is well cut through the bush, and, being along the top of the ridge, is fairly dry and good walking. The bush is principally birch, and this accounts for the absence of bird-life, a stray fantail or a tomtit being all that we saw.

After a stretch of half an hour's bush travelling we came out suddenly on to a small open rocky knob, 2,210 ft. altitude, or 350 ft. above the edge of the bush, where a good view was obtained of the ridge ahead. Another half an hour's bush track brought us to another rocky knob in the open, where our deer-stalking friends caught up and passed us with their horses; altitude, 2,485 ft. The ridge ahead for some distance is open and runs out level, and this was very much welcomed after our long climb from the Waiohine River. Just where the track takes to the bush again there is an old camp, where water is within easy reach down to the right.

Another twenty minutes up a steeper grade and we had reached Mount Reeves, altitude 2,949 ft., after two hours and fifty minutes' journey from the hut. Here we had a good spell, and made a start on the prunes and chocolate, which we had kept in a handy position. Mount Reeves commands a splendid view of the Wairarapa, from Rangitumau Hill above Masterton right down to Palliser Bay. The different towns are easily picked up, and the topography of the district shows up like a map. Our interest was more centred on the country towards Mount Hector. Away down below us we got a glimpse of the Tauherenikau River, and beyond it could identify the ridge up which the track goes over Bull Mound and on to Omega and Alpha, besides the main range to Hector.

On our last trip we got no farther than the Tauherenikau River, and the weather was so thick the whole time that we did not even get one glimpse of the country.

It looked a tremendous drop down into the Tauherenikau, and it is rather disheartening to think that after climbing up to Mount Reeves from the Waiohine the same thing has to be done over again from the Tauherenikau to Omega. There is a good leading ridge from Mount Reeves to Mount Hector over Cone Trig., which would have avoided the big drop into the Tauherenikau, but the track committee reckoned that the ridge was too rough for a horse-track. However, it would not take much to cut a walking-track along it, and it would be a good dry route for foot traffic only, whereas the horse-track is always bound to be a bit muddy.

There is a long burnt spur running out from Mount Reeves in the direction of the Tauherenikau, and it is the intention of the committee to use this spur for the horse-track, as it is much more direct than the present route. The spurs running in several directions from Mount Reeves are rather confusing in a fog, and notice should be taken of the tin direction-pointers.

Continuing our journey we followed the ridge along a fairly level grade for about twenty minutes, and then worked away to the left and started the long drop, as we thought, to the river. After a short down grade the track ran out level, and then up slightly on to a knob, then down again, another piece of level going, and up slightly on to another knob. We knew we had a big drop in front of us, but still the track kept out level until finally we reached what seemed to be the end of the spur, with a big drop ahead. I read the barometer, and working it out later found that this drop was 1,320 ft.

Down we went, and the lower we got the muddier we found the track. Pack-horses do not take long to churn up the ground on these steep portions, coming down with all feet together, sliding half the time.

We slid about just as much as the horses, with our swags on our backs upsetting our balance. At last we heard the sound of the river, and, crossing a small creek, came out on to Mr. Workmann's camp on the Tauherenikau River bed. Whilst we boiled the billy Mr. Workmann, who is doing contract work for the committee, gave us a short description of the track ahead. He mentioned that the track was to be deviated and brought direct from Mount Reeves to the Tauherenikau River, meeting it just where the spur across the river leads up to Omega. A hut was being erected up under Alpha, and another one was to be built in the Tauherenikau. This should be a favourite spot in time to come, as here the river rushes down between shingle-beds and small clearings, with steep bush-clad spurs towering up on both sides, and altogether is a charming spot.

We sat in the sun smoking and having a real good spell, enjoying the surroundings and the yarn with Mr. Workmann—but not the sandflies—until we realized that we still had some distance to go and time was getting along.

It had taken us just an hour to come from Reeves, and in that time we had lost 1,830 ft. of our morning's climb, so we knew we had a good pull ahead to make up. Saying goodbye to our deer-stalking friends, who were camping close by, we shouldered our swags and were once more on the trail. We went down the river-bank for about 20 chains, first through a small grass clearing and then through the bush track, and then came out on the river-bed.

Several parties have had some trouble picking up the track ahead at this point, but we were well informed, and immediately on striking the river-bed we kept our eyes open for signs on the other side. We soon located an opening in the birch-trees, with a small notice tacked up to an adjoining tree. The river was too deep to cross dry-footed, so one of our party took off his boots and carried the others across. This looked so comical that the camera fiend took a record.

Starting up the other side we found that all reports about the track were true. It was a stiff pull and no mistake, and to make things worse, the recent packing had made the track muddy. Our boots became clogged and made the going very heavy. Up we went with numerous spells, occasionally glancing at the barometer to see how we were faring. At last, at an altitude of 3,320 ft., or 2,200 ft. above the Tauherenikau, we came out on to an open rocky knob, where we were able to enjoy a good view after an hour and three-quarters climb. The peep down the Tauherenikau was particularly fine. Mount Reeves stood out plainly on the other side, and we had the satisfaction of knowing that we had more than caught up what we had lost in height before lunch. The much-discussed Cone Ridge stood out right in front of us, with Mount Holdsworth away beyond.

Our swags were beginning to feel heavy, but the barometer gave us a good deal of hope by showing us that Omega was only about 350 ft. above us. The back ranges were wonderfully clear, and we only hoped that we would get such another day on the morrow.

Pushing onward again, we climbed up a steep pinch and came out on to the flat swampy top known as Bull Mound. Here the horse-track turns down to the left to avoid the bog. We had been advised to keep along the open top and pick up the track again farther on, as it was better walking. Peeping out amongst the bog we saw the first of the pretty gentian mountain-flowers which are so noticeable along the Hector Ridge. The top is fairly clear, with a few small patches of scrub, and when we came to a harder surface we picked up the horse-track again, and soon the smell of burnt birch denoted a camp-site somewhere in the vicinity. Sure enough, in a little cosy corner, we struck the tent belonging to the men who were erecting the hut under Alpha. We debated whether to boil the billy here, but the afternoon was drawing on and we still had some distance to go. However, we had some chocolate and biscuits, and shouldered our swags again.

The ridge rises a little, still open along the top to a rocky knoll. We thought at first that this was Omega Trig., but decided afterwards that Omega was the scrubby knob a little distance ahead, which appeared a little higher in altitude. After leaving the rocky knoll the track makes over to the right of the spur, cuts into the scrub, and drops down into a well-defined saddle 350 ft. below in the direction of Alpha.

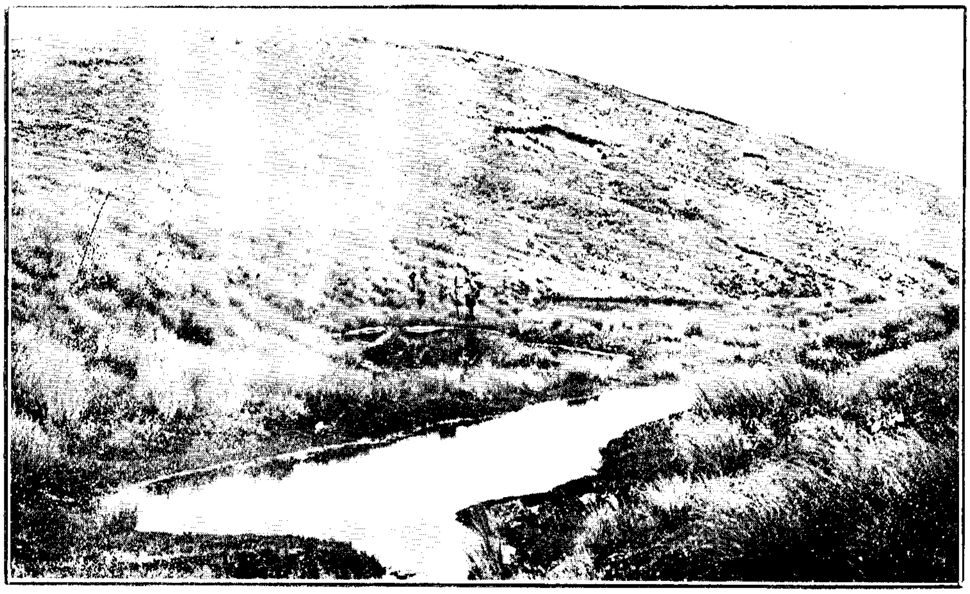
We were now on the main range, as the summit runs from Rimutaka over Mount Marchant to Omega, and then takes a big bend to the west to Alpha and on to Mount Hector. From the saddle there is a sharp rise up a zigzag, which the men who were making the track named "Hell's Gates." We were getting tired, and did not wonder at the name after we had climbed the 595 ft. to the top. Down the other side the grade is much easier, and we could see Alpha standing out ahead of us, with our proposed camping-place inside the edge of the bush below. The sight of the end of our long day's journey cheered us up, and we commenced to step it out, singing at the tops of our voices, when we suddenly ran into the hut-builders returning to their camp under Omega, and we shut up like rat-traps. We had a yarn with them, and then dropped gradually down to a flat saddle 365 ft. lower than the knob we had just passed over, and then started an easy climb towards Alpha. A short distance ahead chips on the track denoted the site of the hut, which was only just commenced, and five minutes later we came to an open space in the scrubby bush, where a couple of old tent-poles and the charred logs of an old fire told us that we had at last reached our camping-spot.

It had taken us three hours and fifty minutes from the Tauherenikau River. It was just 6 o'clock, with the atmosphere almost down to freezing, betokening with the clear sky a frosty night. Whilst two of the party pitched the tent, the other went for water. The best place is about three minutes' walk up the track, just outside the bush on the right. There is a small watercourse which appears dry, but a search discovers a little pool under an overhanging flax-bush. It did not take us long to get the tent pitched, as it was slung on a rope, but it was nearly dark by the time we had cut the scrub for the bunk.

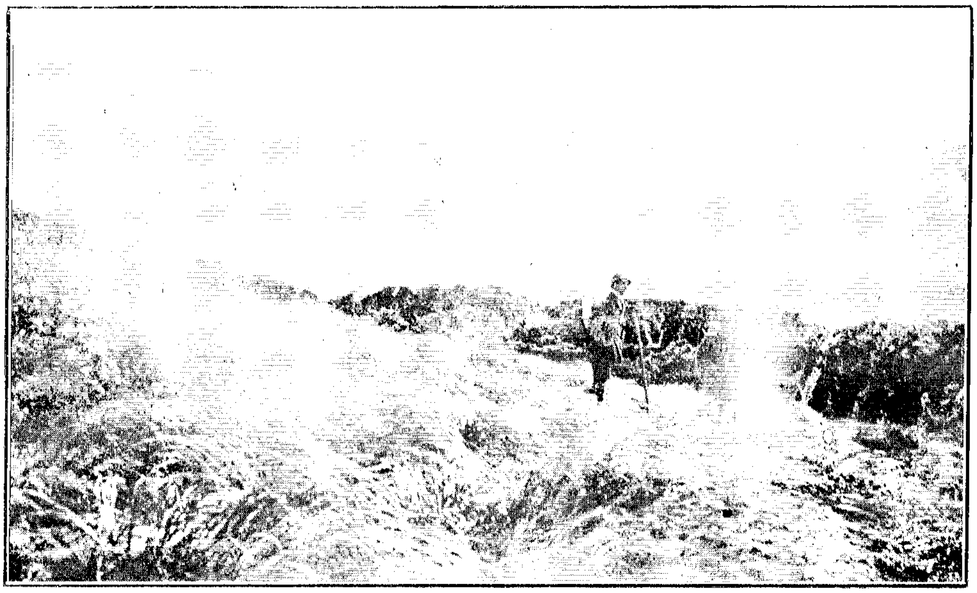
The beauty of the alpine cooker now asserted itself, for we tied the tent-door, sat on our swags, and had a three-course dinner in no time. It also warmed up the tent and made things very comfortable. After we had finished tea we lit our pipes and strolled around in the moonlight gathering odd bits of dead timber. After a good deal of coaxing we managed to get a fire going, and sat toasting our toes and yarning over the day's journey.

It was a perfect night outside, but very chilly; not a cloud in the sky, and a full moon lighting up the landscape with most glorious effects. We turned in early and slept soundly for about five hours. Then the cold awakened us, and each one tried to persuade the others to get up and replenish the fire. As the man that got up stood a good chance of losing his blankets, no move was made.

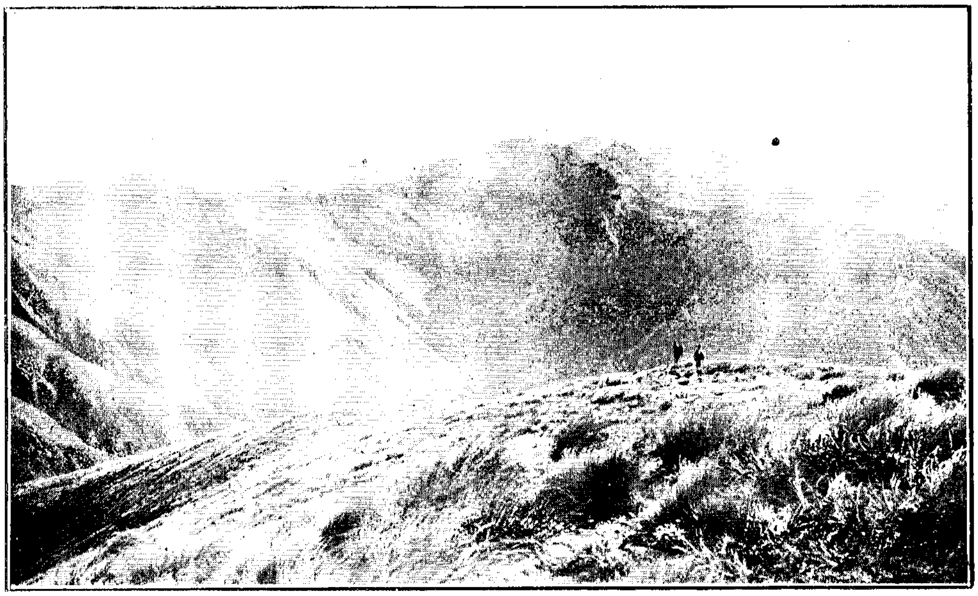
We dozed off and on at intervals until daylight, when a puff of wind on the tent brought us all to attention. Northerly breeze—this meant mist on the ranges. We rose and had a look around. Northerly breeze all right, with mist creeping through the range just south of Mount Holdsworth: we must be away at once.



MOUNTAIN TARN ALONG MAIN RANGE.

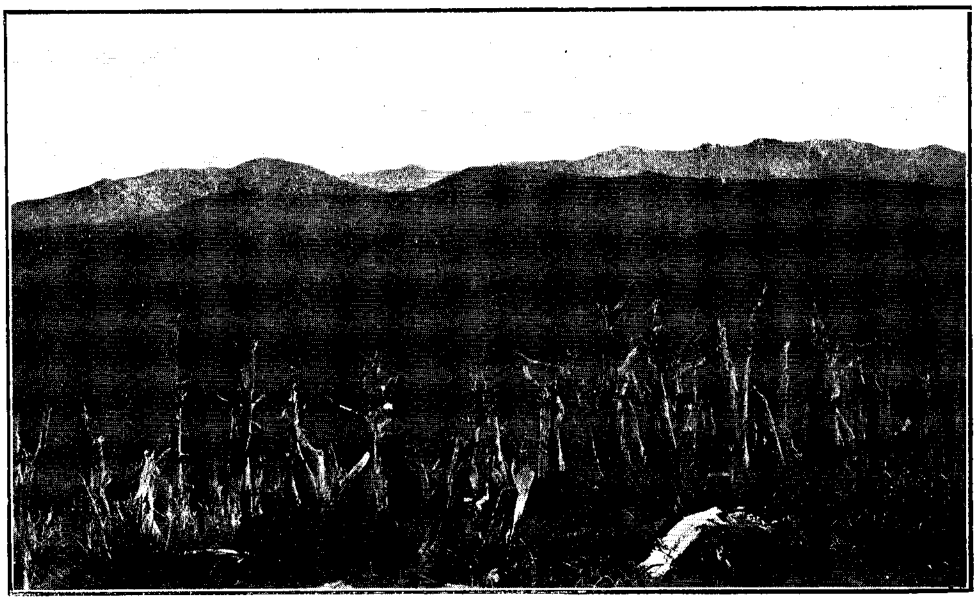


THE EDGE OF THE BUSH BELOW ALPHA.

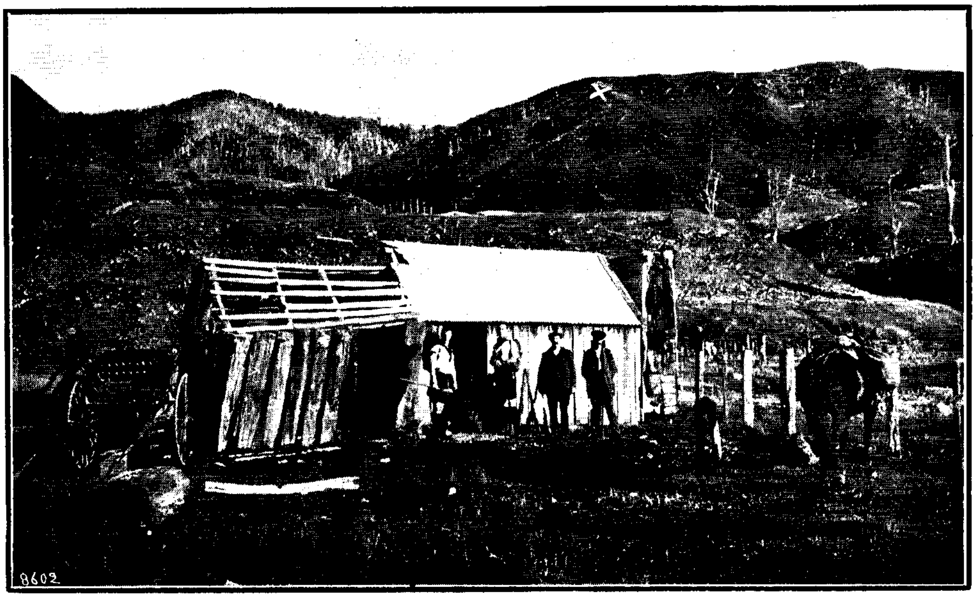


LOOKING TOWARDS MOUNT HECTOR FROM ALPHA.

H. E. Girdlestone, photos.



Looking towards Mount Hector from Mount Reeves.

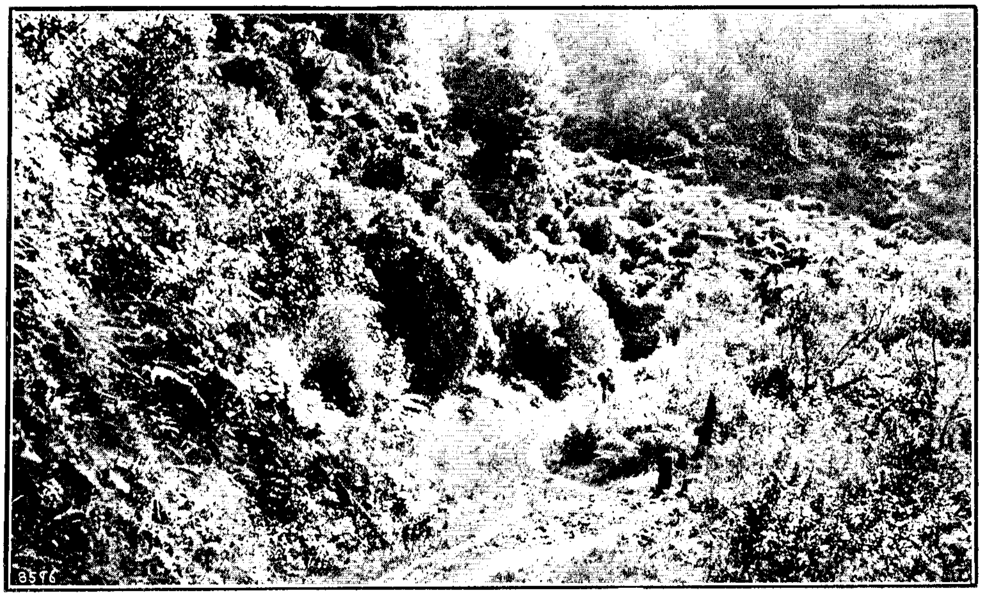


Basset's Hut, with Spur up which Track commences.

View from Hell's Gates Zigzag. Mount Holdsworth in the Distance.

H. E. Girdlestone, photos.]

Crossing the Tauherenikau River.



The Bush above the Otaki Forks.

A Bunch of Gentians.

H. E. Girdlestone, photos.

We watched the sun rise over the Maungarakis, away on the far side of the Wairarapa flats, and kept an anxious eye on Mount Hector for signs of mist whilst we were cooking breakfast. We soon packed up our gear, and shortly after 8 a.m. were on our way to Alpha. It was a glorious morning; the ground was hard with frost, and the atmosphere was most exhilarating.

A few minutes brought us to the edge of the bush, and it was most interesting to notice how the limbs of the stunted birch-trees were clothed with moss right to the very tips. Long icicles hung down from a damp bank, and the snow-grass glistened in the sunlight as if covered with diamonds.

In half an hour we were on the summit of Alpha, 720 ft. above our camp, and stopped to admire the most beautiful panoramas spread out before us. All the principal features of the Wairarapa were spread out like a map, with the sea showing up away in the distance. Wellington appeared no distance away looking right down the Hutt Valley. Kapiti Island stood out in bold relief, with the South Island beyond. The coast-line from Otaki north could be easily discerned curving around and disappearing in the distance towards Wanganui. It was too hazy to the north to discern Mount Egmont or Mount Ruapehu, although the main range as far as Mount Dundas stood out very clearly in the morning light. Looking to the south the main spur leading down over Quoin to the Otaki Forks showed out very distinctly, and one of our party, who had made the trip from Kaitoke the previous year, was able to point out the route he had followed on that occasion.

We could have spent some time drinking in the view, but all the time we were watching Mount Hector with anxious eyes. Leaving Alpha we dropped 360 ft. to a saddle, and on the way down came across the first patches of the interesting edelweiss which is so much beloved by alpine climbers. The botanist is in his glory rambling along the mountain-tops, as every step brings into view some interesting alpine growth.

A little farther ahead we came to the first of the tarns which are such a feature along the top of the Tararuas. A steady climb ahead for some time and a turn to the west brought us to a prominent knob, from which a long high ridge branches off towards Renata and Kapakapanui, one hour and twenty-five minutes' journey from camp. This knob is 40 ft. higher than Alpha, but so far is not named. The ridge ahead veers around sharply to the north, forming an easy-sloping semicircular curve, which has the appearance of a large dress-circle.

Mist was now beginning to collect around the top of Hector, so we plugged steadily ahead through the snow-grass, passed over a small knob, and dropped slightly to a saddle 700 ft. lower than Hector. We brought out the emergency rations of prunes and chocolate, and each keeping a prune-stone in his mouth to suck, we made up a narrow ridge to another prominent knob, where we found ourselves in the mist. From this point a long spur runs out in a south-easterly direction into the head of the Tauherenikau River, and is one of the places where a party coming from Hector to Alpha would be likely to go wrong in a mist. The other place is the ridge leading to Renata, where there is also a change in the general direction of the main ridge, with a long spur running out. We could follow the main ridge without much difficulty, as we were rising all the time.

The track committee intend at some future date to pare a line through the tussocks over these knobs to act as a guide; and this should be most useful to any parties caught in the mist on the way along the ridge.

The barometer showed we were not far below Hector, and by and by a round knob loomed up through the mist like a gigantic beehive. We scrambled up, thinking we had reached Hector, but discovered no cairn, so we dropped down the other side and saw another beehive ahead; scrambled up this to find we were again disappointed, and immediately ahead we scaled a third beehive. This was getting monotonous, so we looked at the barometer and discovered we still had about 150 ft. to ascend. Finally, we saw a bigger mound ahead showing dimly through the mist, and a few minutes later reached the cairn—three hours' tramp from our camp.

We could not see more than a few chains ahead, so only stopped long enough to put our names on a piece of paper and insert it in a bottle which contained many others.

A lift in the mist showed us a tarn in a basin to the north, so we descended and found the tarn was really a spring situated in a basin alongside a prominent rock. The alpine cooker soon had some tomato-soup and fried whitebait ready, and we sat down to enjoy our lunch. We were just about on the lower level of the mist, and as we were having our meal it kept lifting up and down like a curtain, giving us most charming views of the main range north, with Mount Holdsworth, Mitre Peak, Mount Dundas, and Mount Crawford showing out more prominently amongst a mass of broken ridges. The mist still covered the top of Hector, and seemed to keep to the basin at the head of the streams running down into the Waiotauru River.

We had a good spell, enjoying our smoke, spread out on the snow-grass in the sunshine. This would be a glorious spot for a hut, though the absence of firewood would necessitate parties bringing a cooker of some description.

There is another tarn on the south side of Hector, to the east of the ridge before the first beehive from Hector is reached, which we passed in the mist, where several parties have camped and put the night in on their journey through. Our spring is 500 ft. below Hector, almost directly north, a little higher than the saddle between it and the west peak, and a bit to the right. There are also other tarns quite handy to the ridge just below the saddle on each side.

As we packed up our things again after lunch the mist lifted, and we could see the west peak standing out ahead. Sidling round to the saddle 555 ft. below Hector, we ascended the west peak, and found that it was only 155 ft. lower than the trig.

For some distance ahead the ridge, which is still the main Tararua Range, widens out, dropping suddenly on the west and running out in easy basins on the east, with a succession of tarns nestling amongst the snow-grass. We thoroughly enjoyed this part of the journey, rambling along in the sunshine admiring the beautiful gentians which were growing everywhere in great profusion, and locating the different peaks along the ranges on either side.

Coming to the end of the easy country, we could see Dennan away below, with Tabletop just ahead hiding the ridge down to the Otaki Forks. Before we commenced the steep descent we made a detour up to a knob on the right to get a view of the main range north, which we leave behind here after following it from Omega. A glorious view up the Otaki River rewarded us, and also a very interesting one along the range itself. It was rather unfortunate that a fogged plate spoilt the photo taken from this point, as it was a very interesting one from a topographical point of view. The barometer height, 4,700 ft., coincided with a former reading recorded.

Coming down from Hector in thick weather it would be rather difficult to keep to the ridge leading down to Dennan, as it drops fairly steeply ahead, and other spurs run out north towards the Otaki River. All the way down we passed through a regular garden of gentians, and collected a small bunch, which we photographed on the spot.

There is a saddle, 3,860 ft. altitude, a drop of 840 ft. from the last knob just before Dennan is reached, and then a short rise of 150 ft. to the trig.—two hours fifteen minutes' easy going from Hector. This climb over the trig. can be dodged by scrambling round the side, but nothing much is gained, as the scrub is fairly thick.

On Dennan there is a small cairn of stones, and a board with "Mt. Crawford" carved in large letters thereon. This is an error, as Mount Crawford is a much higher peak away to the north on the main range.

The sun by this time was well over to the west, and lit up the Otaki River and the sea-coast in a charming manner. From Dennan a long spur runs down towards the Waiotauru River to the left, which would have to be borne in mind in thick weather. Our route lay in the direction of the Forks, down a short steep ridge to an easy flat-topped one covered with beds of astelia, mutton-bird scrub, and snow-grass about the height of the knees. There is an old camping-spot here, with water a short distance to the left, which would make a good site for a whare.

We met with a couple of Wellington boys who had camped on the edge of the bush below Tabletop the previous evening, and were having a ramble up the ridge. Tabletop is a short rise ahead, 3,450 ft. altitude, and about thirty minutes' journey from Dennan. From here the bush ridge leading down to the Forks shows out very plainly. A drop of 290 ft. through thick scrub, where a narrow worn track makes the going much easier, brought us to the end of the bush ten minutes later. There is a good track cut through the bush right down to the Forks. The ridge drops steadily, barring a couple of short rises up to small knobs, stunted trees give way to taller trees, the moss-covered trunks and banks of kidney-ferns are left behind, mixed timber is met with, and after fifty minutes' steady travelling an old camp-site is reached, where a sign-board indicates water in a handy position. A barometer reading showed that we had dropped 1,480 ft. from the edge of the bush.

The afternoon was drawing on, so after a short spell we continued on down through bush country for some distance, passed an old bushfelling camp, and came suddenly out on to a new burn. The country to the left has been felled, and we scrambled over tree-trunks in and out amongst the stumps until we came out on to older-grassed land, and saw the Forks about a mile below. We kept to the spur for some distance, and then made over to the left towards the Waiotauru River, which we reached after one hour fifty minutes' journey from the edge of the bush below Tabletop, and four hours and a half from Hector.

We forded the river, and selected a camp-site just above a deep pool on the bank on the other side. In half an hour we had enjoyed a swim, pitched camp, and were sitting in front of a good fire watching the tea cooking. Our provisions had lasted out well, so we were able to enjoy a really good meal. Compared to our bivouac camp under Alpha the previous evening, this camp was luxury, and we sat before the fire toasting our toes and yarning about the day's experiences until well into the night.

We had an easy journey to Otaki for the Monday, so took things very easily. After a fine swim and breakfast we sat in the sun for some time on the river-bank, and did not make a start until 10.40 a.m. The weather still continued fine, and we congratulated ourselves on our good fortune. From our camp-site we made straight up on to the good metalled dray-road which leads to Otaki. There is some very pretty bush scenery just before the junction of the Waiotauru and the Otaki is reached, which justified the camera being brought into play. Right in the corner, between the rivers, is the site of Judd's hut, known to former climbers, but recently a new building has been erected. A suspension bridge crosses the Waiotauru River immediately above.

We read the barometer on the road above the junction, making it 370 ft. altitude; and saying goodbye to the ranges we started out along the metalled road for Otaki at 11.10 a.m. We were feeling in splendid trim, and stepped it out gaily, admiring the many charming peeps of the Otaki Gorge on our way along. We reached the Waihoanga Bridge in an hour and a half, and boiled the billy for lunch.

The dray-road to Otaki keeps to the left of the river until the railway is reached, and does not cross the river until a short distance from the station. We intended to go via the Waihoanga Road, the other side of the river, which is only a horse-track for half of the distance, but is much shorter.

After lunch we crossed the bridge, turned to the left, and followed a dray-road for a short distance, leaving it where it turned sharply up a rise to the right. We passed through a gate straight ahead, and skirted round under a terrace and down to the edge of the river-bed, following the horse-track. Then we rose up the side of a steep bluff through pretty bits of scenery, and down again to a flat where the horse-track merges into a good metalled road.

As we passed a wool-shed we saw a settler busy with sheep. Noticing our swags he guessed that we had come over the ranges, and when he found that his surmise was correct he asked us into his residence and treated us most hospitably. We bade him adieu, and, cutting out the remainder of the distance in good time, arrived at the Otaki Station in one hour thirty-five minutes' walking from the Waihoanga Bridge. We had a wash and a change, and caught the 5 p.m. train for Wellington, thoroughly satisfied with our Easter holiday trip.

Carrying a swag right through might seem rather a strenuous task for many, but we were in good form and used to the game. A much easier way would be to drive out from Greytown to Basset's hut, arrange for a pack-horse to carry swags to Alpha, walk along the ridge and down to the Forks, and have a trap ready there to drive to Otaki. However, the weather-conditions have a good deal to do with the trip, and might prevent any definite arrangements being carried out. The best plan is to camp high up and be prepared to wait for the right weather for the trip along the range. Half the beauty of the outing lies in the glorious views obtained. Nothing is to be gained by trying to push through in the mist, and the party stands a good chance of being lost on the way.

It took us about five hours to go from Alpha to Dennan, so there is some chance of parties being overtaken by mist on their way through. In such cases lines pared through the tussock over knobs where blind spurs run out would be of great assistance. Later on, when all the huts are erected, the route should become well known to Wellington people.

As the crow flies, the distance from Greytown to Otaki Station is about twenty-three miles; Greytown to Woodside is three miles; Woodside to Basset's, two miles and a half; from Basset's hut to the Otaki Forks is about twenty miles by the track; Otaki Forks to Otaki Station, twelve miles by Hautere Road and about ten by the Waihoanga Road.

Distances in rough country are very deceiving, and a much better indication is given by the times taken. The following is a list of the times taken by our party between the main points, remembering that we swagged everything right through: Woodside to Basset's, 50 minutes; Basset's to Mount Reeves, 2 hours 50 minutes; Mount Reeves to Tauherenikau River, 1 hour; Tauherenikau to Omega, 2 hours 15 minutes; Omega to camp near Alpha, 1 hour 35 minutes; camp to Alpha Trig., 30 minutes; Alpha to Mount Hector, 2 hours 30 minutes; Mount Hector to Dennan, 2 hours; Dennan to edge of bush, 40 minutes; bush to Waiotauru River, 1 hour 50 minutes; Forks to Waihoanga Bridge, 1 hour 30 minutes; bridge to Otaki Station, 1 hour 35 minutes: total, 19 hours 5 minutes.

There is a splendid paper on the botany of the Tararuas, which also describes the route from Kaitoke, by Mr. B. C. Aston, F.I.C., F.G.S., which is to be found in the "Transactions of the New Zealand Institute," Vol. xlii, 1909.

APPENDIX VI.

EIGHT-INCH TRANSIT THEODOLITE.

Mr. H. E. Girdlestone, who is using one of the 8 in. transit theodolites by Troughton and Simms, No. 219, on the new secondary triangulation, has put on record his method of reading the micrometers to show the error of run and corrections; and also a description of the vertical circle of the instrument with its reading, setting, and level corrections. These are published here to render them accessible to other observers and to investigators of the results achieved in this particular triangulation. A description, with illustrations, is also given of the breakwind which Mr. Girdlestone uses while at work.

Wind-screen used on Secondary Triangulation.

The following is a description of the wind-screen used in secondary trig. stations in the Wellington District, photos of which appear in this report. It is simple to erect, light to carry, will stand a good breeze, and has proved very effective throughout the work. Four bamboo poles are stuck in the ground to form a square of 6 ft. sides. The tops are connected with a rope, and then each pole is stayed out in two directions with ropes attached with rings to iron spikes driven in the ground. Four other bamboo poles are lashed about 4½ ft. from the ground around the square. A canvas screen, 4 ft. 6 in. high and 24 ft. long, is put round the poles and drawn taut by short ropes running through eyelet-holes at intervals around the top and bottom. Above the canvas the calico blinds are tied to the uprights, the bottom of the blinds being just below the top of the canvas. These blinds run on cords top and bottom, six separate pieces pinned together with safety-pins forming one side. The top piece is a calico square fastened in the centre to a rope running diagonally across between the top of the uprights, and the corners tied down just below the tops of the blinds. In breezy weather the top piece can also be pinned at intervals to the blinds.

In observing, the blinds are left unpinned in the directions of the surrounding stations, and are drawn apart whilst sighting, and immediately closed again when the object has been intersected. When the wind and sun are from the same direction only two of the blinds will be required.

Most of the signals are of wood, bolted down to four posts. These nuts can be unscrewed, and the signal is not too heavy to shift temporarily aside. This enables the wind-screen to be properly erected, when the light for reading is then much better than under the wooden tripods, and there is more room to work. Some of the signals are permanently fixed, and in these cases the canvas and blinds are adjusted to fit round the struts.

As only one observer is doing the work in each district, the signal being moved aside does not interfere with the work.

When the wind is fairly strong extra bamboo poles can be placed at mid-distance between the uprights and stayed out. It is really surprising what the screen will stand, seeing that it is such an apparently light construction.

CORRECTION FOR RUNS OF MICROMETERS, 8 IN. TRANSIT THEODOLITE.

In observing for secondary triangulation purposes with the 8 in. micrometer theodolite I have been recording the reading of the parallel wires of the micrometer on both back and forward divisions on the horizontal plate. At the end of each set I have shown the mean runs of each micrometer for the period of observation. These means will vary from time to time according to the changes in temperature. At the present time the error of the B micrometer is about 1 second, and the A micrometer about 2 seconds, the mean being 1·5 seconds. The greatest correction for runs will be half the total error, so that at the present time the correction would be about 0·75 second.

Although the 8 in. theodolite is divided to seconds on the micrometer screw-head, it is difficult to guarantee any single reading to 1 second, so that the correction for run would be beyond the powers of the instrument. By showing the mean runs for each period of observation it can be seen at a glance whether the micrometers are in good adjustment. As long as the mean error is less than 2 seconds (giving the greatest correction less than 1 second) I do not think it should be considered, from a practical point of view.

In case the increase in the mean error of the runs makes it necessary to apply a correction, I herewith give my method of reading, with examples of the application of the correction.

The horizontal plate of the 8 in. theodolite is graduated to 5-minute intervals; the comb in the micrometer gives the extra minutes, and the graduated screw-head the seconds. The micrometers are placed opposite one another at right angles to the telescope, and there is an extra microscope for reading the degrees and minutes, placed close to one side of the telescope. As the microscopes reverse the field of view the degree-figures on the plate and division-lines are engraved upside down, so that on looking through they are seen right side up, the numbers increasing from left to right. In reading the comb of the micrometers the number of notches between the zero-line and the first division on the plate to the left indicate the number of minutes by which the zero-line has passed, providing that the instrument is in adjustment. By turning the graduated screw-head of the micrometer to give an increasing reading, the parallel wires travel from right to left. In observing it has been my practice to bring the parallel wires beyond the division-mark to the right, come carefully back and intersect, note the seconds, then screw on in the same direction until the left-hand division is intersected, and again note the seconds. Both readings are thus taken with the parallel wires working from right to left.

When I first began observing with this instrument I called the first reading the "back" reading and the second one the "forward." This is an error, as, owing to the microscopes reversing the field of view, the numbers on the plate increase from left to right, so that the left-hand division should be called the "back" reading. However, in order to keep the work in the field-book consistent I am still recording as I commenced. The corrections will therefore require a little alteration from the usual rule. In all my observations *b* refers to the right-hand reading, and *f* to the left.

Example I. (See Diagram.)

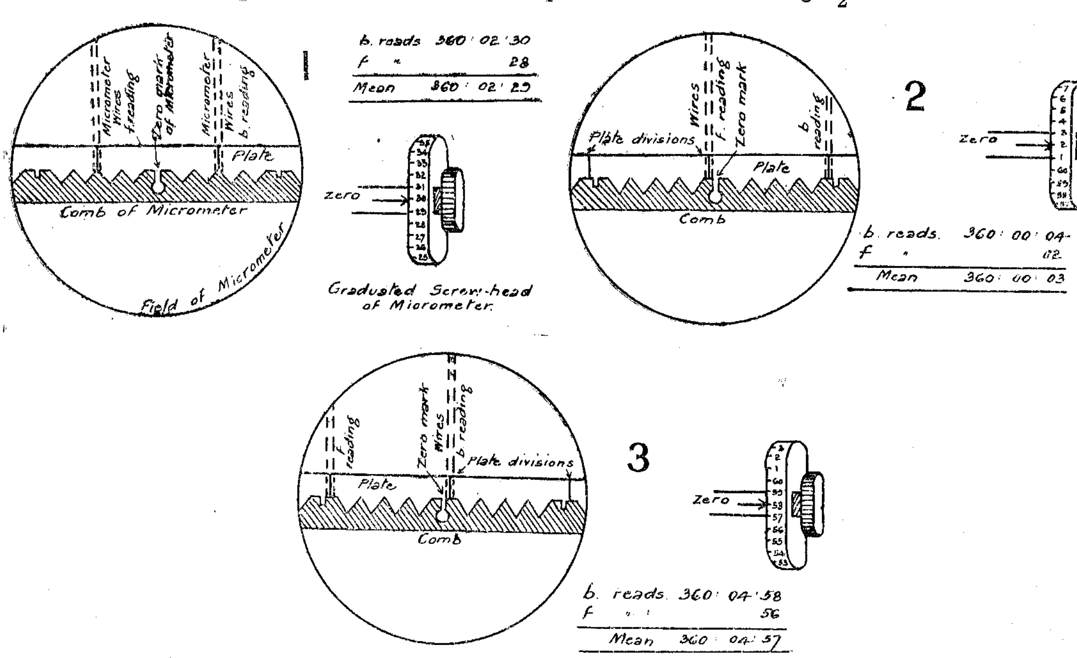
Zero-line coming midway between the divisions on the plate.

Let *b* read	360° 02′ 30″
and *f* read	28
Error in run	— 2″

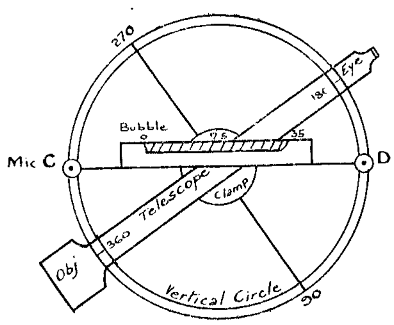
Here the actual reading of the interval, instead of being five complete turns, is 2 seconds short.

As the zero-line is midway between the divisions the correction to each reading will be the same —that is, half the total run. To increase the interval reading, the corrections will be + 1″ to the forward figures and — 1″ to the back figures (since it is working opposite to the way the divisions on the screw-head are numbered).

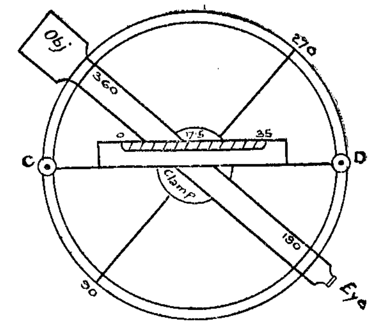
Corrected reading = 360° 02′ 29″, which is equal to the mean reading $\frac{b+f}{2}$ = 360° 02′ 29″.



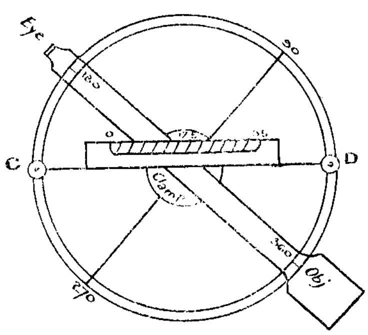
DIAGRAMS TO ILLUSTRATE MICROMETER READINGS OF 8 IN. TRANSIT THEODOLITE.



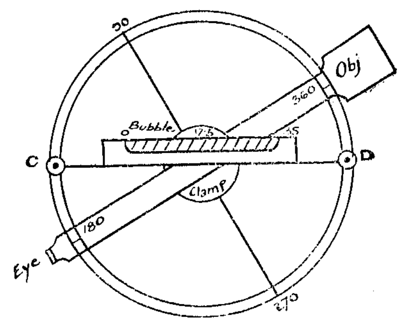
FACE LEFT, DEPRESSION.



FACE LEFT, ELEVATION.



FACE RIGHT, DEPRESSION.



FACE RIGHT, ELEVATION.

VERTICAL CIRCLE OF MICROMETER THEODOLITE No. 219.

NOTE.—In the above diagrams the circle is shown as fixed in one position, but it can be moved to any position by unscrewing the clamp and turning the circle by hand.

Example II. (See Diagram.)

Zero-line almost coinciding with the left division-mark.

Let b read	360° 00′ 04″
and f read	02
Error in run..	— 2″

Here the whole run must be applied to the b reading. The interval is again 2 seconds short of five complete turns, and must be increased, giving a correction g —2 to the b reading (since it is read backwards against the screw-head numbering).

Corrected figures : $b = 360° \; 00' \; 04'' - 2'' = 360° \; 00' \; 02''$

$f =$ 02 — 0 = 360 00 02.

Correction to the mean reading $\frac{b+f}{2}$ would be half the total run : 360° 00′ 03″ — 1″ = 360° 00′ 02″.

Example III. (See Diagram.)

Zero-line almost coinciding with the right-hand division-mark.

Let b read	360° 04′ 58″
and f read	56″
Error in run	— 2″

Again the interval reading is short of the five complete turns, but this time the whole run has to be applied to the f reading.

A plus correction to the actual figures will increase the interval reading :—

Corrected readings : $b = 360° \; 04' \; 58'' + 0'' = 360° \; 04' \; 58''$

$f =$ 56 + 2 = 58.

The correction to mean reading $\frac{b+f}{2}$ will be + 1″ : 360° 04′ 57″ + 1″ = 360° 04′ 58″.

From the preceding examples it will be seen that the corrections to the mean reading $\frac{b+f}{2}$ for run vary from 0, when the zero-line of the micrometer is midway between the division-marks (*i.e.*, at reading 2′ 30″), to half the total run when at extreme ends with opposite signs. Any intermediate reading can be corrected relative to the zero-line of the micrometer. When f reading is less than b the correction to $\frac{b+f}{2}$ will be minus from 0′ to 2′ 30″ and plus from 2′ 30″ to 5′. When f is more than b the signs will be reversed.

To simplify matters the corrections can be put in tabular form.

Example from F.B. 34, p. 19.

Mean error in run for mic. B	.. .. .. =	0·62″
Mean run for mic. A	.. .. =	2·30
Sum	.. .. =	2·92
Total mean run	.. .. =	1·46
Extreme correction = half run	.. .. .. =	0·73

This 0·73″ is distributed over two and a half revolutions of the micrometer screw-head = 150″, since when the zero-line comes at mid-interval there is 0 correction.

A change of 0·1″ of run-correction is equal to $\frac{150}{\cdot 73}$ = 20·5″ of the screw-head reading.

Table.

Limits for 0·1 Run-correction.	Run-correction.	Limits for 0·1 Run-correction.
	— ·7″ +	
0′ 16·8″		4′ 43·2″
	— ·6 +	
0 37·3		4 22·7
	— ·5 +	
0 57·8		4 02·2
	— ·4 +	
1 18·3		3 41·7
	— ·3 +	
1 38·8		3 21·2
	— ·2 +	
1 59·3		3 00·7
	— ·1 +	
2 19·8		2 40·2
	— ·0 +	
2 30·0		2 30·0

Working from 2′ 30″, adding and subtracting half 20·5″ gives figures 2′ 40·2″ and 2′ 19·8″; and from these figures, adding and subtracting the full 20·5″ gives the remainder of the figures for the table.

Since the *f* readings are less than the *b* readings, the sign is + from 2′ 30″ to 5′ 00″, and — from 2′ 30″ to 0′.

In using the table it is not necessary to correct every individual reading, but the figures may be grouped into sets of face left and right readings, and the corrections applied to the means.

Taking the first four columns F.B. 34, page 19, and grouping the face left and right readings, gives the following results :—

Mark.	Face.	Mic.	*b*.	*f*.	*b* — *f* = *r*.	Mean $\frac{b+f}{2}$	Run-correction.	Corrected Means.
Brooklyn ..	L	B	360° 00′ 07″	08				
		A	02	00				
	R	B	11	10				
		A	11	10				
			360 00 07·7	07·0	0·7	7·3	— 0·7	360 00 07·0
Wadestown ..	L	B	203 15 10	08				
		A	09	06				
	R	B	17	17				
		A	12	10				
			203 15 12·0	10·2	1·8	11·1	— 0·7	203 15 10·4
Belmont ..	L	B	218 30 26	26				
		A	30	28				
	R	B	34	34				
		A	30	27				
			218 30 30·0	28·7	1·3	29·3	— 0·6	218 30 28·7
Somes ..	L	B	251 44 30	30				
		A	33	31				
	R	B	36	35				
		A	30	27				
			251 44 32·2	30·7	1·5	31·4	+ 0·6	251 44 32·0

To trig. Brooklyn the mean bearing is 360° 00′ 07·3″. Looking up the table we see that 0′ 07·3″ comes between 0 and 0′ 16·8″, so the run-correction is — 0·7″, giving final mean as 360° 00′ 07·0″. Similarly, to Somes the mean is 251° 44′ 31·4″. Looking up the table we see that 4′ 31·4″ comes between 4′ 22·7″ and 4′ 43·2″, and the run-correction is + ·6, giving final mean as 251° 44′ 32·0″.

The run-corrections can thus be made for any position of the zero-line of the micrometer.

Vertical Angles with the 8 in. Transit.

The vertical circle of the 8 in. micrometer theodolite which is being used on the secondary-triangulation work is somewhat different from the usual pattern, and consequently requires different rules for obtaining vertical angles and applying the level-corrections. The circle is graduated continuously from 0° to 360°, in the reverse direction to that in which the hands of a clock move. It is not rigidly attached to the telescopic axis, but can be moved round and clamped in any position, similarly to the horizontal plate. The level is attached to the micrometers, and is divided continuously from left to right, from 0 to 35 divisions. Both level and micrometers are fixed to one of the standards of the instrument, and there are no clip-screws.

To obtain a vertical angle the following method is adopted, no matter in what position the circle is clamped: Level the instrument and take face-left and then face-right readings to the object, booking both C and D micrometers. Add 180° to the mean of the face-right readings, and take the difference between this and the mean of the face-left readings. The result will be double the vertical angle to the object. If the face-left figures are the greater, then the angle will be an elevation; and if less, then it will be a depression.

Example I.—Vertical Observations at Kaukau.

Face.	Mic.	Somes Island Apex.	E.	O.	Centre $\frac{E+O}{2}$	Correction.	Belmont Apex.	E.	O.	Centre $\frac{E+O}{2}$	Correction.
L	C	0° 03′ 07″	29·5	6·0	*17·75*	*— 1·4*	2° 43′ 35″	30·0	6·0	*18·0*	*— 2·9*
	D	03 02					43 30				
R	C	185 20 21	6·5	30·5	*18·5*	*— 5·7*	182 39 55	6·0	30·0	*18·0*	*— 2·9*
	D	19 31					39 07				
		Dep. 2 38 25·75				*— 2·15*	*Elev. 0 02 00·75*				*0*

In working out the vertical angle I adopt the following method:—

Example II.

	Somes.	Belmont.	
1. Mean of face left	0° 03′ 04·5″	2° 43′ 32·5″	
2. Mean of face right plus 180° ..	5 19 56·0	2 39 31·0	
3. Difference	5 16 51·5	0 04 01·5	
4. Half difference	2 38 25·75	0 02 00·75	= Vertical angle.
5. Sum of half difference and lesser of face left or right ..	2 41 30·25	2 41 31·75	= True level reading.
6. Sum of lines 4 and 5.. ..	5 19 56·0	2 43 32·5	= Checks with lines 1 or 2 above.

Line 4 gives the vertical angle, and as the face-left readings are less than the face-right readings to Somes, the angle is a depression. To Belmont the face-left readings are greater, so the angle is an elevation.

Line 5 gives the true-level reading, and these figures should come out approximately the same for all objects observed to, right through one set. Should it be desired to set the telescope to point true level, all that is necessary is to set the mean of the C and D micrometers to this reading if face left, or to reading + 180° if face right.

Line 6 checks the working in a similar manner to taking out the half-angles when side-pegging a road.

To take another set, unclamp the circle, leaving the telescope clamped on Somes Island signal, and turn the circle by hand until the reading is 45° 03′. Reclamp the circle, and proceed as before.

Example III.

Face.	Mic.	Somes Island Apex.	E.	O.	Centre $\frac{E+O}{2}$	Correction.	Belmont Apex.	E.	O.	Centre $\frac{E+O}{2}$	Correction.
L	C	45° 03′ 21″	29·5	5·5	*17·5*	*0*	47° 43′ 41″	29	5	*17·0*	*+ 2·9*
	D	03 10					43 30				
R	C	230 20 25	5·0	29	*17·0*	*+2·9*	227 40 03	5·5	29·5	*17·5*	*0*
	D	19 33					39 11				
		Dep. 2 38 21·7				*+1·4*	*Elev. 0 01 59·2*				*+ 1·4*

Similar sets can be taken at + 90° and + 135° on original set, and the final mean will be free from errors due to eccentricity of axis. It has been my practice to take four sets at 0, 45° 01′, 90° 02′, and 135° 03′ round the circle. The vertical readings are always taken after 10 a.m. and before 3 p.m. There is sometimes a fair difference in the angles, due to refraction, but the mean of four sets taken on different days should be the best obtainable.

Level-corrections.

The level is divided from left to right from 0 to 35 divisions, so that when the instrument is face left the larger figures are at the eye end; and when face right, at the object end.

The sum of the eye and object bubble readings divided by 2 gives the position of the centre of the bubble. If this coincides with 17·5, the centre division of the scale, there will be no level-correction, but, if not, then the following rule has to be followed:—

If $\frac{E+O}{2}$ comes less than 17·5, then the correction is a plus to the actual circle reading on the circle, whether the instrument is face left or face right; if more than 17·5, then the correction will be a minus to the actual circle reading.

To get the value of one division of the level scale I took a number of readings all round the circle by the usual method of slightly altering the level of the instrument and noting the differences by micrometer and level readings. This worked out at 5·73 seconds, although the Kew certificate which came out with the instrument gave the value as 8 seconds. Adopting my figures, I made out the following table to simplify the working:—

Example IV.

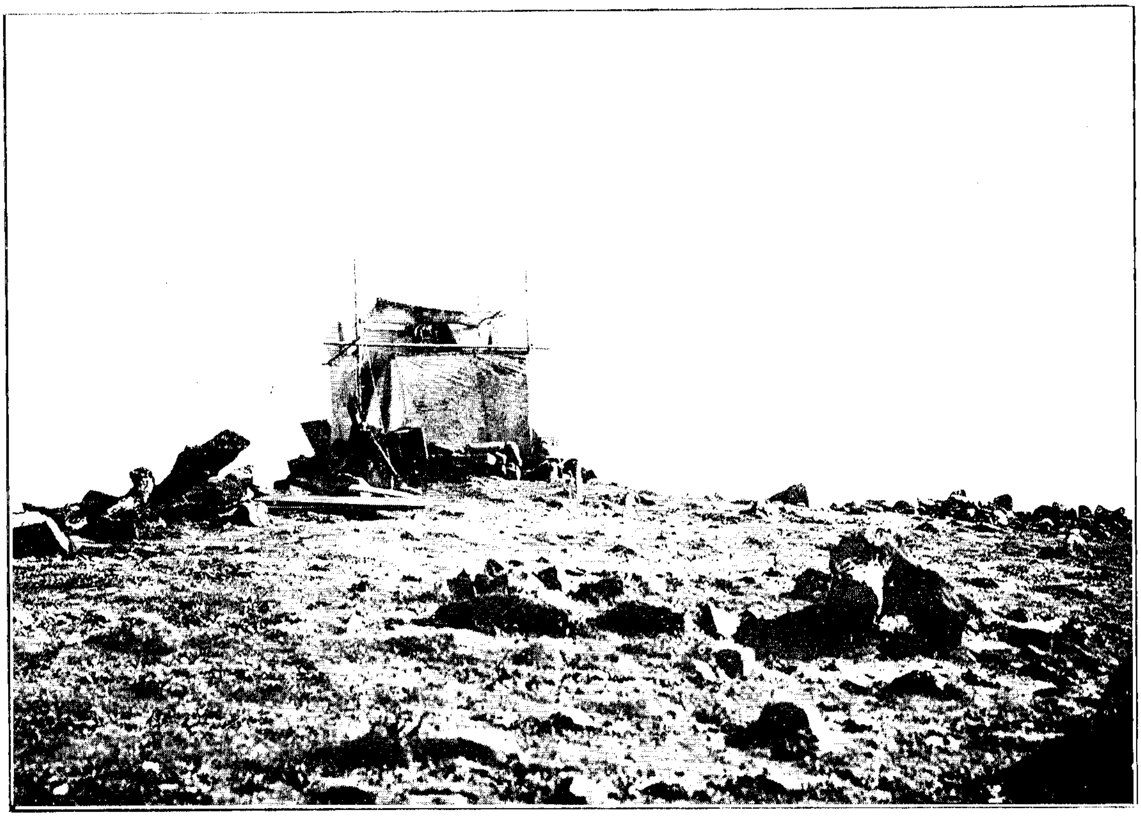
$\frac{E+O}{2}$	Seconds Correction.
15·50	*+11·46*
15·75	*+10·03*
16·00	*+ 8·59*
16·25	*+ 7·16*
16·50	*+ 5·73*
16·75	*+ 4·30*
17·00	*+ 2·86*
17·25	*+ 1·43*
17·50	*0·00*
17·75	*− 1·43*
18·00	*− 2·86*
18·25	*− 4·30*
18·50	*− 5·73*
18·75	*− 7·16*
19·00	*− 8·59*
19·25	*−10·03*
19·50	*−11·46*

In Examples I and III, to get the level-corrections, work out the value $\frac{E+O}{2}$ and look up the table in Example IV, keeping an eye on the sign. This correction can be applied to the actual circle-readings before working out the vertical angle, and then the result would be the true vertical angle free of level-error. For instance, take Example II: the figures would be, to Somes,—

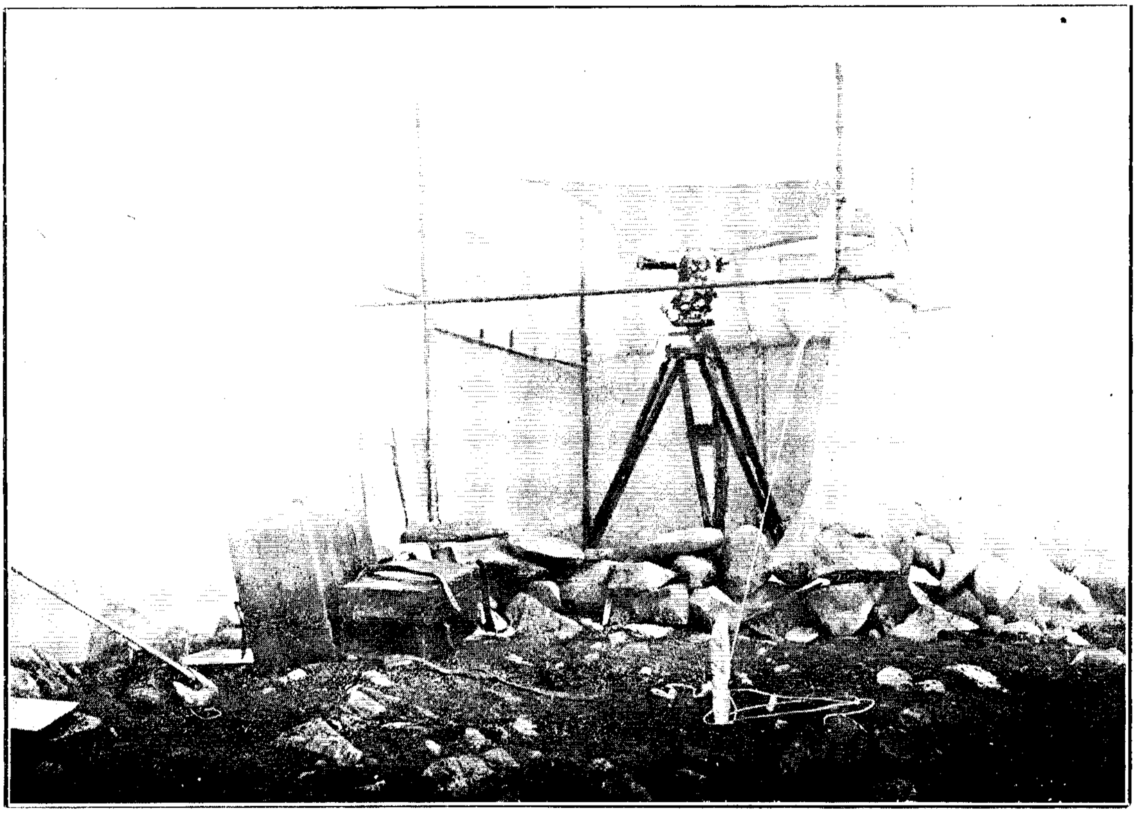
Face left	0° 03′ 04·5″ − *1·4* =	0°	03′	03·1″
Face right	5 19 56·0 − *5·7* =	5	19	50·3
		5	16	47·2
True vertical angle =		2	38	23·6
		2	41	26·7
		5	19	50·3

My own method is to take out the angle as in Example II and apply the correction to angle afterwards. To do this the following rule must be remembered: Change the sign of the correction opposite the lesser of the face-left or face-right readings; take the algebraical sum of the two corrections, and divide by 2. Thus in example we have $\frac{-5{\cdot}7+1{\cdot}4}{2} = -2{\cdot}15$. This gives for the final angle 2° 38′ 25·75″ − 2·15 = 2° 38′ 23·6″, which is the same as by method shown above.

In obtaining the final vertical angle from the different sets I put down the angles with their corrections for level-error alongside and take the mean.

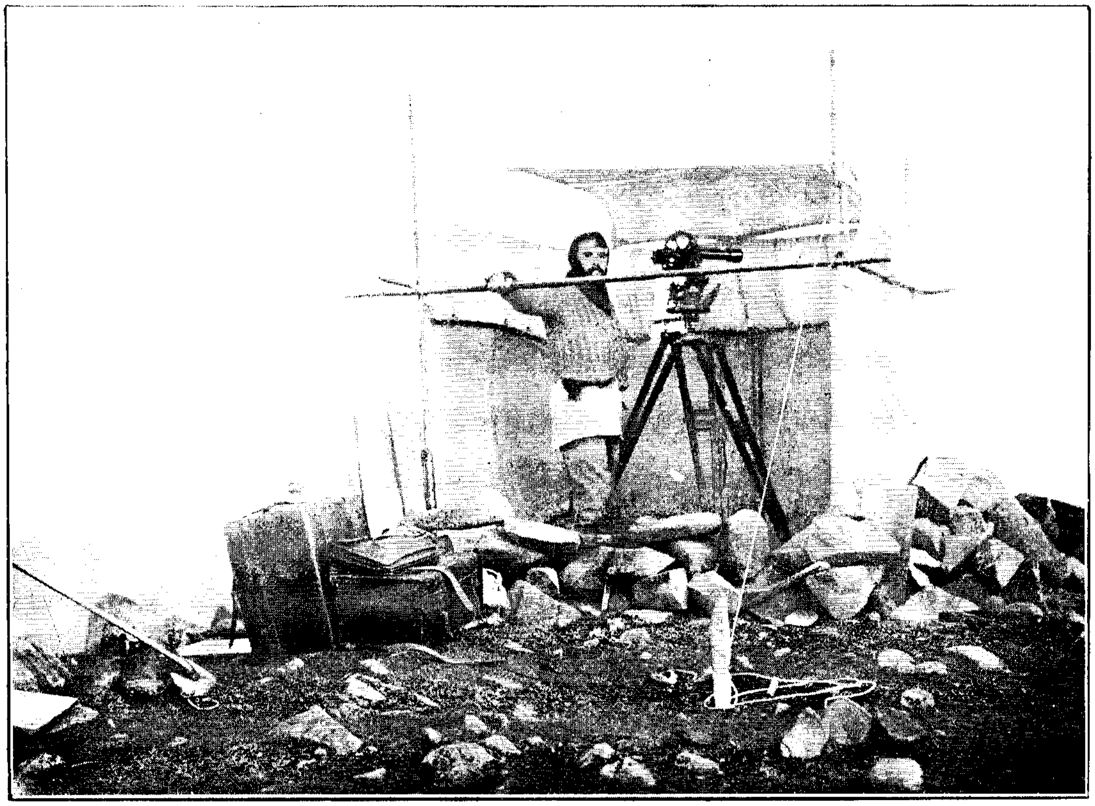


General View of Break-wind.

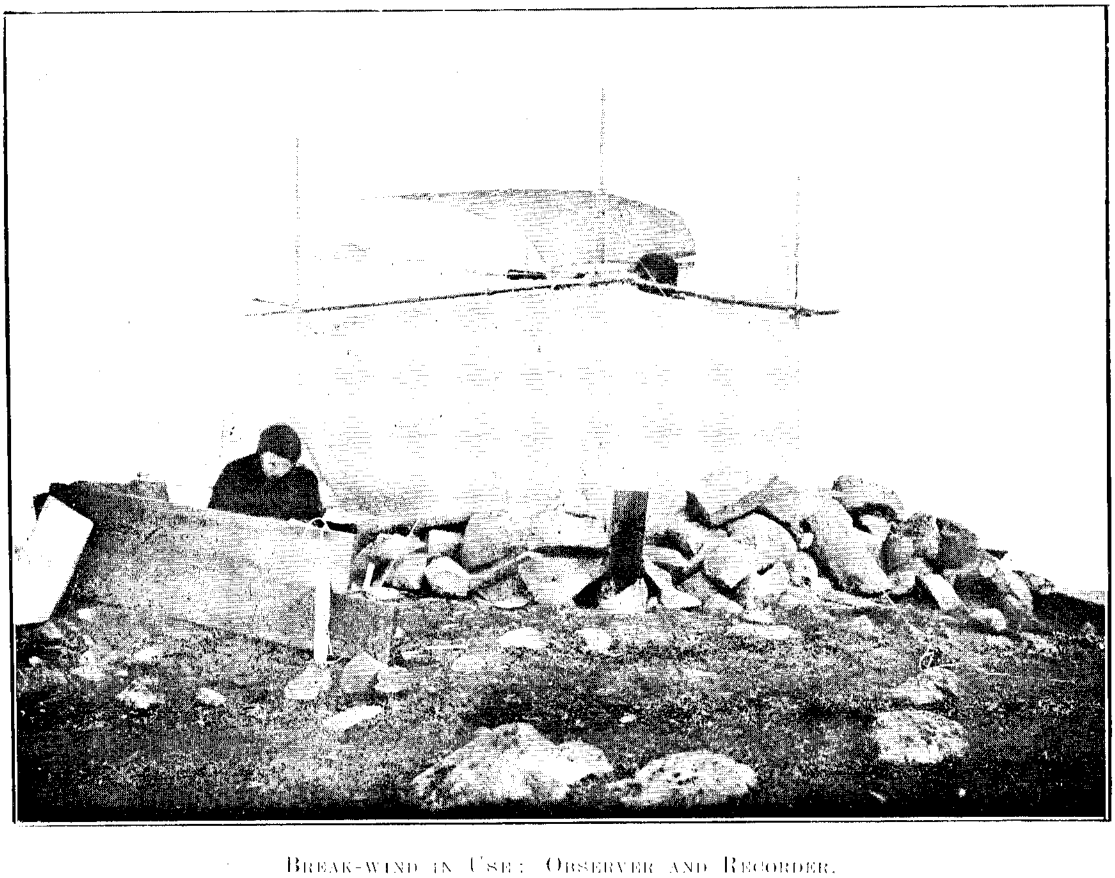


Showing Break-wind and Instrument.

M. C. Smith, photos.]



Break-wind and Observer.



Break-wind in Use: Observer and Recorder.

M. C. Smith, photos.

Example V.

At Kaukau.

Circle set at	Somes Island.	Level-correction.
	Dep.	
0	*2° 38′ 25·7″*	*− 2·1*
45	*2 38 21·7*	*+ 1·4*
90	*2 38 11·2*	*− 1·4*
135	*2 38 20·7*	*+ 2·9*
Sum	**79·3**	**+ 0·8**
Final vertical angle ..	**2 38 19·8**	**+ 0·2**

In keeping my field-book I show by different colours the actual figures read as printed above in roman, the means of different sets and level-corrections in italic, and the final means of the sets in antique.

The height of the axis of the instrument and different parts of the signal are noted as each trig. station is visited.

In Example V above, the figures taken with circle set at 90 differ from the other results. This is due to refraction, which is proved by observations to other signals taken at the same time. At every trig. station I get variations, up to about 10 seconds, even though the observations are taken at the same time of the day, so I spread the observations over a number of days and take the mean of the lot. It is not often that three out of the four sets agree so closely as in the example given.

APPENDIX VII.

REPORT ON THE MAGNETIC OBSERVATORY.

As in previous years, the regular observational work of the Observatory has been thoroughly carried out, and this year two years' magnetic curves have been measured at hourly intervals. Towards the end of 1914 a temporary assistant was appointed (Mr. H. S. Richards), who had been previously employed here. His services were specially employed on the work of computation of the curve-measurements made from the 1905 magnetograms, &c., and tabulation of the hourly values therefor. I have to congratulate Mr. Richards, who is a graduate of the New Zealand University, upon his selection as Rhodes Scholar for the year, and to wish him success in his studies at Oxford. I wish also to recognize the valuable services of Mr. T. Maben throughout the year.

Every effort has been made to secure accuracy in the published tables by checking wherever possible, and any errors that have escaped detection must be very small, and are certainly very few. In no case can they appreciably affect even the mean for a single day.

A number of diagrams are attached to this report, and some remarks thereon are given below under separate headings.

Meteorological observations have been made twice daily, and three times on week-days, at times 9.30 a.m., 12 noon, and 5 p.m. These have been published daily for public information, and a monthly synopsis furnished to the Meteorological Department, which has kindly offered a meteorological equipment for the Amberley sub-station when it is in operation. A self-recording rain-gauge, or pluviograph, has been installed here, as it is useful in obtaining the rate of rainfall, and it is further proposed to obtain an evaporimeter. The recording barograph and thermograph have been in continuous operation.

ADIE MAGNETOGRAPHS.

During the year these have been kept in continuous operation, and the resulting magnetograms have been developed and measured. The usual absolute observations for the determination of base-line values have been duly made. The magnetograms have been measured at hourly intervals, and the measurements converted, base-line values and temperature corrections applied, and the results tabulated for magnetic declination (D) and horizontal magnetic force (HF).

These tables are published herewith, and a glance will show that very satisfactory registration has been obtained. The few gaps in the tables are due to lamp-failure in all cases but the 1st January, part of which day's register of D and HF was lost through the failure of a holding-clip in the recording mechanism. On the 27th January the HF recording-lamp failed for the first part of the day, but a mean for thirty whole days was still obtained. In a similar way the record of HF for the 14th December was lost, this being the only day's record of HF entirely missing. In D no day's record is entirely missing, the only loss being the last fourteen hours of the 1st January.

The mean values for the year of the magnetic elements are as follows:—

Magnetic declination, east	16° 44·84′
Horizontal magnetic force	0·224130 c.g.s. unit.
Inclination	67° 59·8′ S.
Northerly component of force	0·214626 c.g.s. unit.
Easterly ,,	0·064584 c.g.s. unit.
Vertical ,,	0·55465 c.g.s. unit.
Total magnetic force	0·59822 c.g.s. unit.

Milne Seismograph No. 16.

A table of forty-two earthquakes recorded by this instrument is appended, and four of the principal seismograms are reproduced herewith. Records of some of the more distant earthquakes were not obtained, their effect here being too slight, although they were of a character to do damage at places near their origin. The instrument was working well throughout the year, and a controlling value of the the boom period was obtained almost daily.

Vector Diagrams of Diurnal Horizontal Disturbing Forces for Seasons.

These diagrams are drawn from the mean values of N (northerly component of forces) and E (easterly component), computed from the monthly means of horizontal force and declination for Greenwich mean civil hours. They exhibit clearly the mean diurnal ranges for various Greenwich hours in N and E.

The radius vector drawn from E to the curve at any given hour represents in direction and magnitude the horizontal disturbing component of force at the given hour. The scale marked on the axes is applicable also to the radii vectores in deducing the disturbing-force equivalent.

The diagram for the year 1914 exhibits a very general similarity to that published already for the year 1913 (see annual report, 1913–14). In both cases 0 h. comes on the geographical south meridian, and 8 h. just slightly to the west of the geographical north meridian. Even the nocturnal loop from 8 h. to 16 h. is remarkably similar in the two years in every respect. This seems to indicate that the inclusion of stormy days has not affected the value of the diagrams as showing the characteristics of diurnal variation. Slow changes in this diagram may, however, probably be expected in after-years.

The diagram for summer months is also generally similar for the two years 1913–14, but in the 1914 diagram the nocturnal loop exhibits a slightly increased change of E between 14 h. and 16 h., the loop clearly opening. The small but pronounced increase of E from 12 h. to 13 h. still persists, and is of approximately the same extent. Between 5 h. and 9 h. the rate of change in E is not altered, but the variation of N becomes much smoother for 1914.

The vector diagram for equinoctial months (1914) exhibits minor changes as compared with that for the previous year. With regard to daylight hours, the most noticeable change is that 0 h. on the curve has moved away from the geographical south meridian. The time of occurrence of the least horizontal force has evidently moved slightly ahead, and this is even noticeable to a slight extent in the diagram for the year.

The nocturnal loop in the equinoctial 1914 diagram exhibits greater smoothness, and, in fact, has opened out and become a simple invagination owing to the 12 h., 13 h., and 15 h. N values now becoming greater than the N values for 9 h., 10 h., and 11 h. However, the general variation occurring between 8 h. and 15 h. is still shown to be an increase of force to the north-west from 8 h. to 11 h. and a decrease from the north-west from 11 h. to 15 h., a phenomenon also exhibited in the mean diagram for the year.

In the winter diagram is noticed the greatest difference with the previous year's diagram. The general shape is the same, and the large amount of diurnal change in N occurring from 23 h. to 0 h. (24 h.) persists. The variation from 16 h. to 20 h. also seems to be similar. The diminished rate of variation of N between 0 h. and 1 h., and its increase from 1 h. to 2 h., are shown in the incurving at 1 h. The nocturnal loop becomes more irregular, and in the curves for both years it may be suspected of being somewhat influenced by the occurrence of magnetic storms, the effect of which may even be systematic over a close group of four months together; for it must be remembered that the other three diagrams each embrace more time than this one, the summer and equinoctial diagrams being each taken over two periods separated by these four winter months. The consideration of the mean winter variation over a number of years may be expected to disclose the origin of the apparent irregularity of the night variations in winter.

The nocturnal loop in winter occurs between 7 h. and 15 h., and, strangely enough, is as large or larger than that in the equinoctial diagrams or in the year diagrams.

It is plainly evident from the diagrams that the rule is, in summer, greater day variations and less night variations; in winter, less day variations and greater night variations. In summer the hours 11 h. to 15 h. are characterized by large variation in N and small variation in E. In winter these hours are characterized by a small variation in N and a large variation in E.

Comparing the winter diagrams for the mean of years 1902, 1903, 1904, with 1913 and 1914, it appears that, relatively, the early morning range in H, as from 16 h. to 23 h., has been gradually assuming a large proportion to the afternoon range, as from 0 h. to 5 h.

Mean Monthly Curves of Diurnal Change, 1914, with Seasonal Curves.

These curves are shown plotted for declination and for horizontal magnetic force. They are of the same character as those for 1913, and those for declination call for little comment; indeed, their resemblance to the declination curves for 1913 is startling, when one considers that all days are included, stormy or calm. The declination curve for July, 1914, is evidently not so smooth as the one for 1913, printed in the previous report, and the same remark applies to the July curves for horizontal force. This want of smoothness has made itself evident to some slight extent in the mean winter vector diagram of horizontal disturbing forces. The tendency to an invagination of the curve at 19 h. in the mean winter curve still persists, and this slight effect not being masked gives one confidence in the reliability of the mean winter curves and the deduced winter vector diagram. In the corresponding H diagram also a slight peak persists at 20 h.

In 1914 the February curve in H ends with a downward trend from 23 h. to 24 h., whereas in 1913 the trend is upward between these hours, corresponding in appearance rather with the termination of the 1914 January H curve. In HF also, in February, 1914, a decrease is shown from 0 h. to 1 h., whereas in 1913 an increase is shown in February between those hours, as has happened in January in both years.

In May, June, and July, from 0 h. to 1 h. G, the decrease of H shown in the 1913 curves has diminished in the 1914 curves It was small for May, 1913, and has become a slight increase of H in May, 1914.

Curves of Mean Diurnal Ranges.

These two diagrams show the mean daily amount of change of declination, and of horizontal magnetic force, for each month of the years 1913, 1914. For convenience in reading off values the ordinates of the 1914 curves are drawn in.

The diagrams are instructive, showing clearly the great difference in diurnal range between summer and winter, and the continuity of this phenomenon from year to year. The curves for the two years roughly approximate to each other, more especially the two declination-range curves. The minimum mean diurnal range of declination occurs in June, and the maximum in December, or at the depth of winter and the height of summer respectively.

In the HF curve, however, it is remarkable that the minimum range seems to occur in May, with a secondary minimum in July and a third in September. It will be interesting to find whether this phenomenon will persist in future years, for if it persists it will show May, July, and September are less stormy months than June and August in horizontal force, although in regard to declination the coincidence of the two curves at the June ordinate seem to indicate a probable "quietness" in June in declination. It requires many years' results, however, to yield reliable evidence upon such questions, and it requires consideration not of declination and HF ranges, but of force-ranges in the N, E, and V components.

The large peak in HF range for November, 1914, indicated in the diagram is possibly due to greater storminess in November, 1914, than usual, combined with a less than usual degree of storminess in December, 1914.

The general agreement of the curves for the two years is very satisfactory, and would not be evident unless the instruments were functioning well.

Magnetograms reproduced.

Twelve magnetograms are reproduced, showing records for twenty-four days. Some of these are shown simply as examples of stormy days during the year; others are typical examples, showing remarkable features not confined to these days.

HF, 21st and 22nd February: Two almost "calm" days. The mean value for the 21st is 0·22423. On the 21st the curve is that of an undisturbed day, but the 22nd shows a sudden commencement of disturbance just before 12 h.; the HF has been lower than on the 21st for the preceding six hours, and the sudden increase, though it tends immediately to diminish, persists for several hours afterwards, gradually diminishing. The mean for the day is 0·22421, very slightly lower than the mean for the month. Shortly after 14 h. on the same day a similar sudden stop in the opposite direction is noted, followed by a uniform increase of force, and similar phenomena recur in a less marked degree at 17 h. to 18 h.

Dec., 3rd and 4th March: These exhibit the occurrence of pronounced peaks of minimum declination occurring within some few minutes at the same hour on successive days.

Dec., 6th and 7th April; HF, 6th and 7th April: The most stormy day of the year, involving a range of about ½° of declination, and 100 γ in horizontal force. This storm commences and ends in a gradual manner. The rapid change of compass-direction, over more than ¼° in about a quarter of an hour, occurring at 16½ h., is especially remarkable.

Dec., 8th and 9th April: Remarkable peaks of small declination occur between 5 h. and 9 h. on the 8th April, followed seven hours after by a sudden considerable increase of declination, which gradually disappears in the course of a few hours.

Dec., 5th and 6th July: On the 5th July a large sudden decrease of declination occurs, which gradually disappears in the course of three hours. It is possible that a displacement in this direction is annulled more rapidly than in the case of a sudden increase of declination.

Dec., 29th and 30th July: On the 29th is apparent a storm of comparatively short duration, with a large range for most of the time in one direction. On the 30th another sharp commencement of a disturbed period, commencing with a phenomenon similar to that on the 5th July.

Dec., HF, 2nd and 3rd August: These curves exhibit remarkable sharp peaks. On the 2nd these approximately coincide for D and H, but on the 3rd a rapid diminution of easterly force alone precedes a large increase in both easterly and horizontal force, which attain a maximum at the same time, and thereafter rapidly diminish.

HF, 26th and 27th August: These exhibit, like the December curves for the 3rd and 4th March above, the occurrence of similar large but short disturbances on comparatively calm successive days, at the same hour, and due to solar influence. It would be instructive to compare these periods with the same periods on the magnetograms obtained in the hemisphere illuminated at the time.

HF, 27th and 28th October, 29th and 30th October: These comprise a long stormy period, with two portions of remarkably large amplitude. They may be especially valuable for comparison with the corresponding magnetograms obtained at other observatories.

Magnetic Survey.

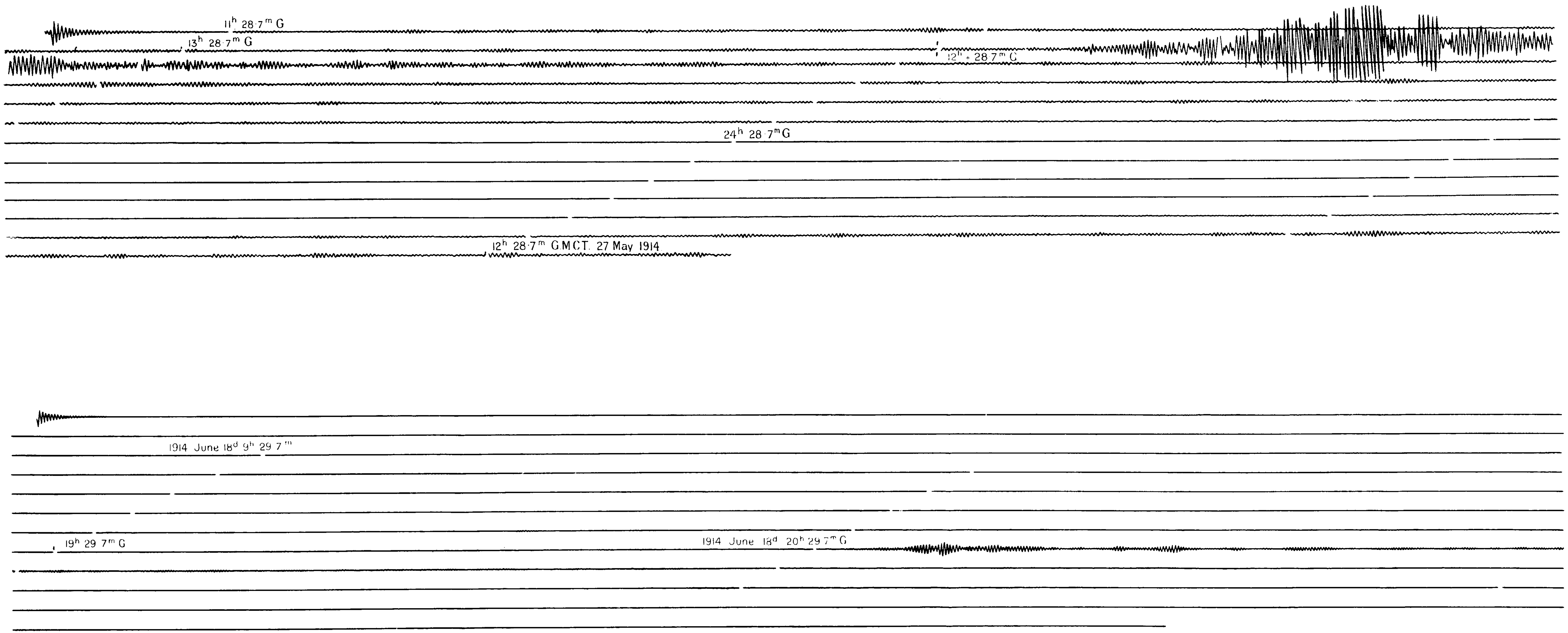
Work upon the discussion of the data obtained is proceeding, and all available older observations made in past years by the Admiralty are being considered with a view to determining the variation of secular change in these regions. In this connection it should be mentioned that next November the Carnegie special ocean magnetic surveying-vessel of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington will visit Lyttelton, and afterwards engage in a south complete circumpolar observational cruise. I should especially like to have the Amberley sub-station equipped sufficiently to regularly operate during this cruise, and to enable the necessary observations for the standardization of their instruments to be done there. Their sea instruments are of new types, and capable of much greater accuracy than the older instruments used, and their observations will be of especial value in correcting the magnetic variation given upon the charts of these southern seas. It certainly would be of considerable advantage for the ship's observers to be able to carry out standardization in a place beyond the influence of stray earth-currents. A small grant of £200 would be well spent in achieving this end, and enable us to co-operate much more successfully with their work.

It would be of great advantage if a free railway pass between Christchurch and Amberley were issued to the Director of this observatory.

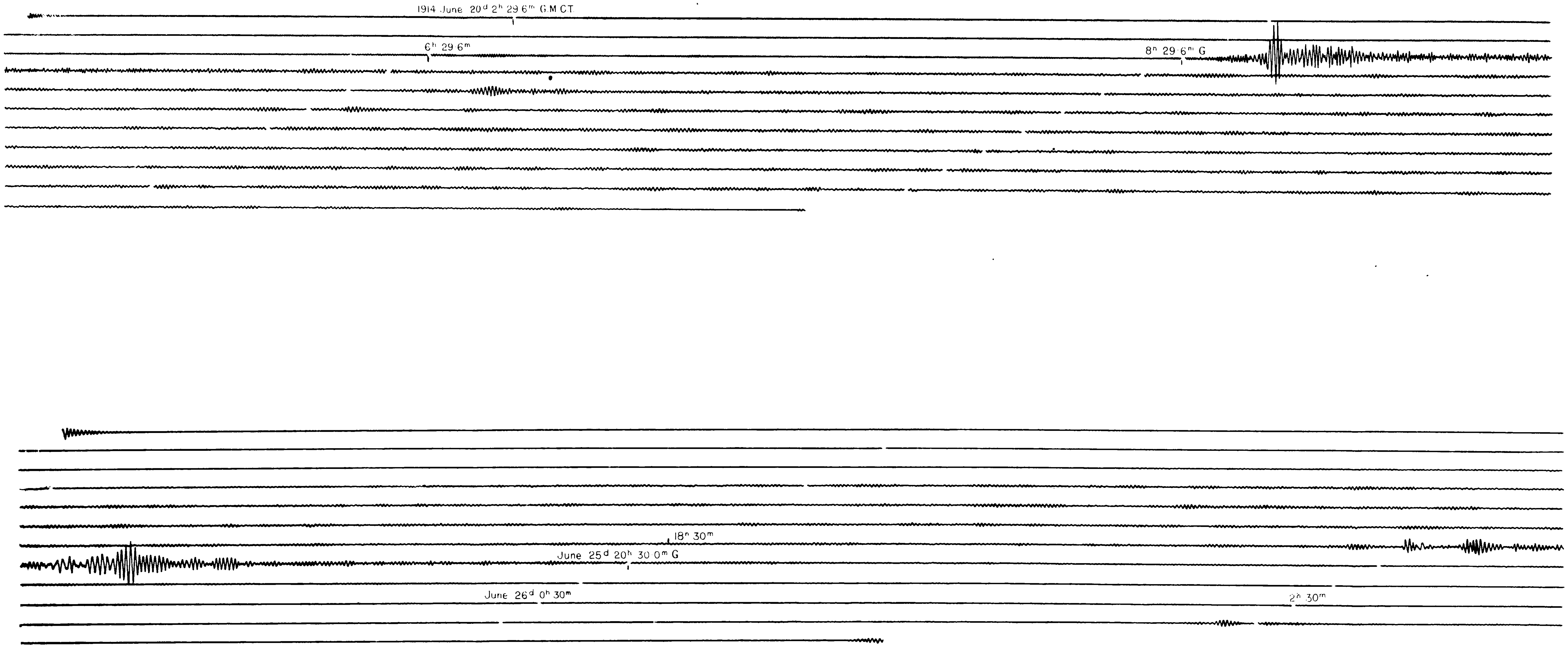
Antarctic.

Permission was kindly given by the Under-Secretary for the use of the integrating curve-measuring machine here in the work of measuring up the splendid series of magnetograms obtained by the Australian Antarctic Expedition in Adélie Land. As Mr. Webb, the magnetic observer to the Expedition, could not afford time enough to do the actual measurement himself, a lady assistant was procured at the expense of the Expedition, and the work of measurement is now far advanced. Mr. Webb, it should be stated, is himself spending his spare time in computations necessary in connection with the final evaluation of the results of the measurement.

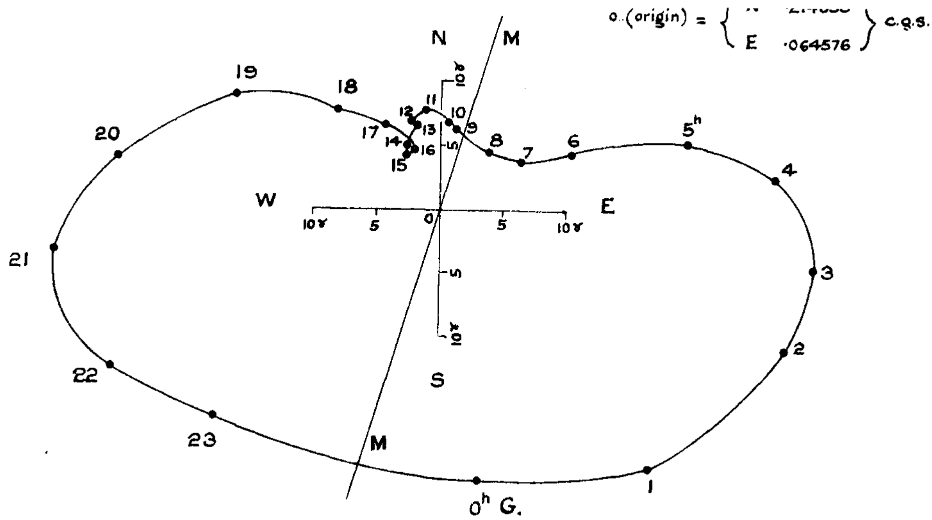
Henry F. Skey, B.Sc.,
Director, Magnetic Observatory, Christchurch.



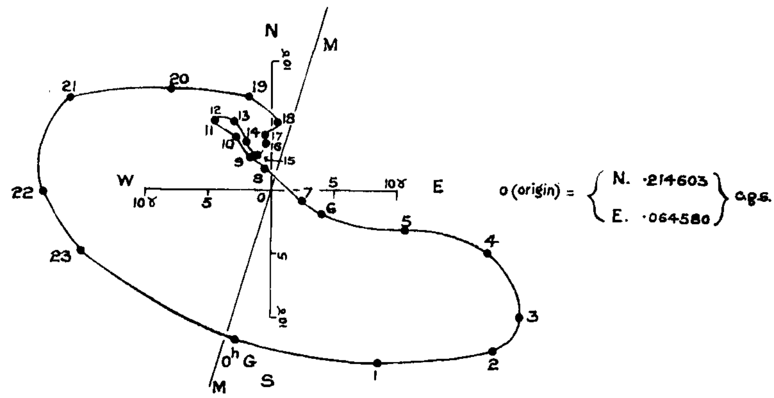
Records by Milne Seismograph No. 16, at Christchurch.—1.



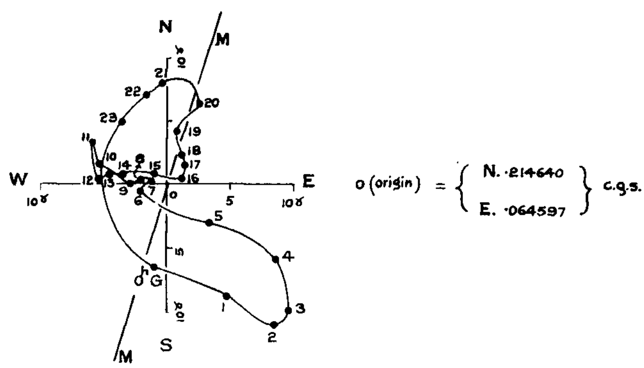
Records by Milne Seismograph No. 16, at Christchurch.—2.



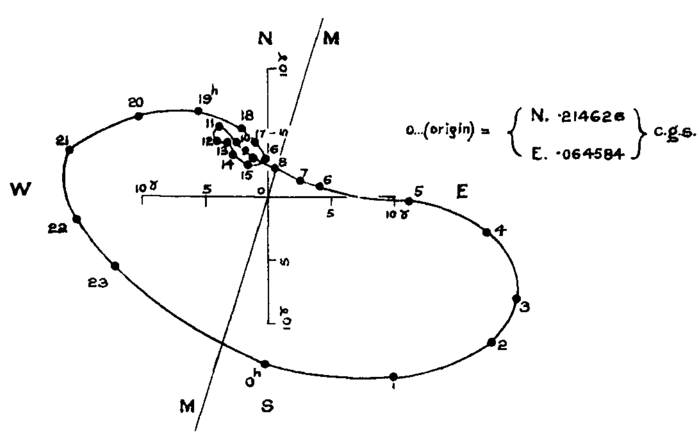
Vector Diagram.
for Summer Months 1914.



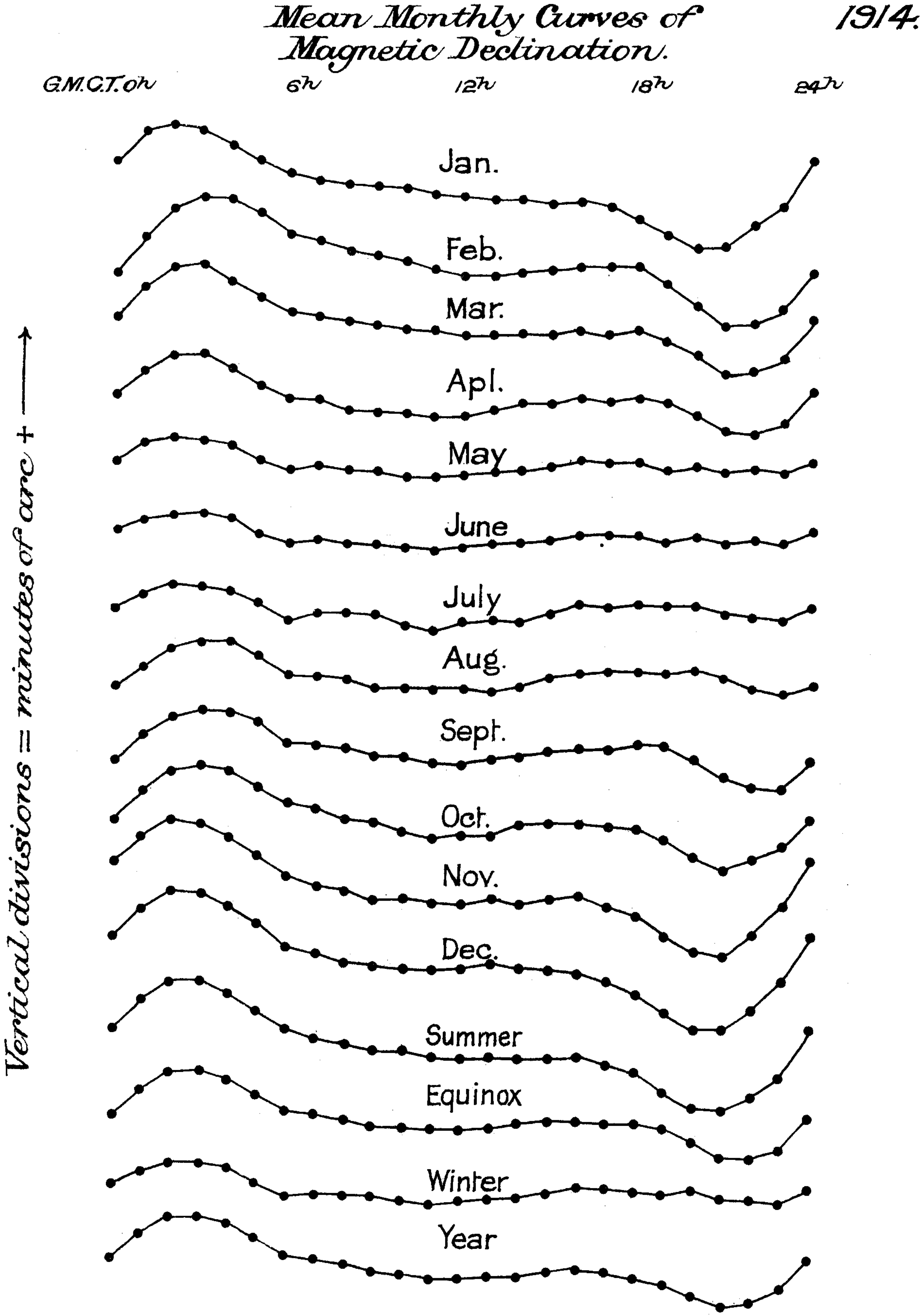
Vector Diagram.
for Equinoctial Months 1914.

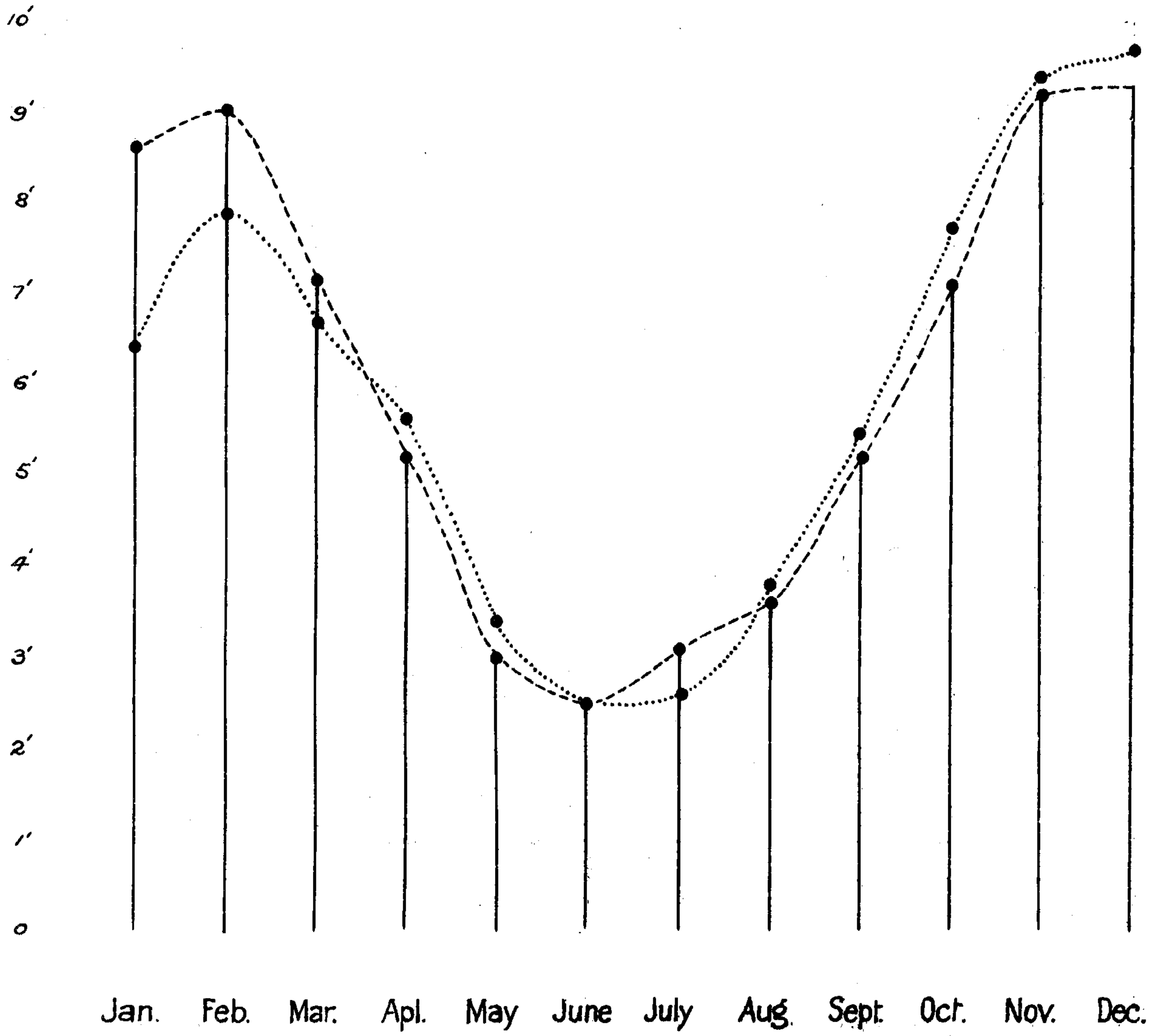


Vector Diagram.
for Winter Months 1914.



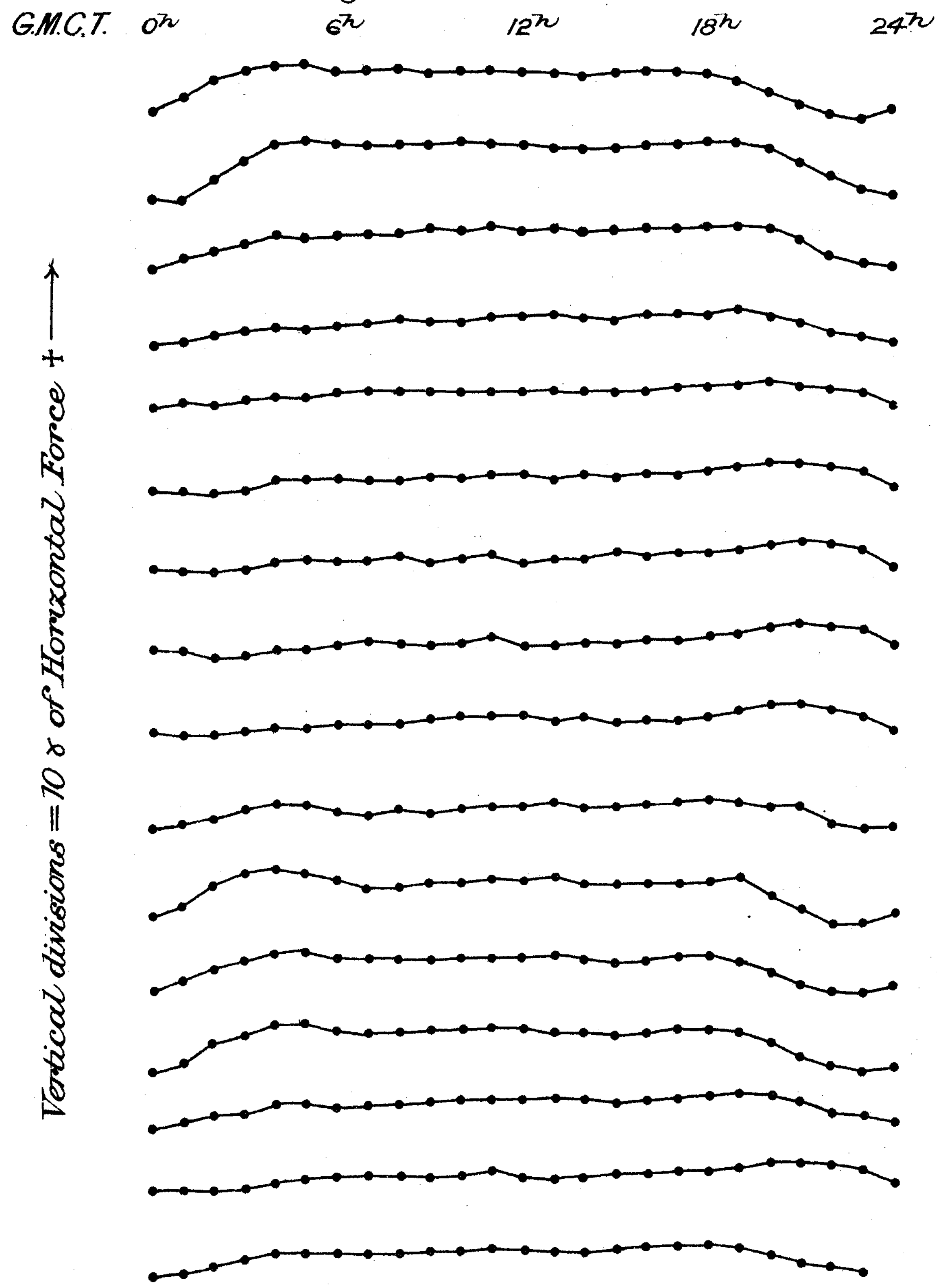
Vector Diagram.
Mean Diurnal Horizontal Disturbing Forces for Year 1914 (all days)
at Christchurch.
(Greenwich Hours indicated) N.S Geographical Meridian.
MM Magnetic Meridian.

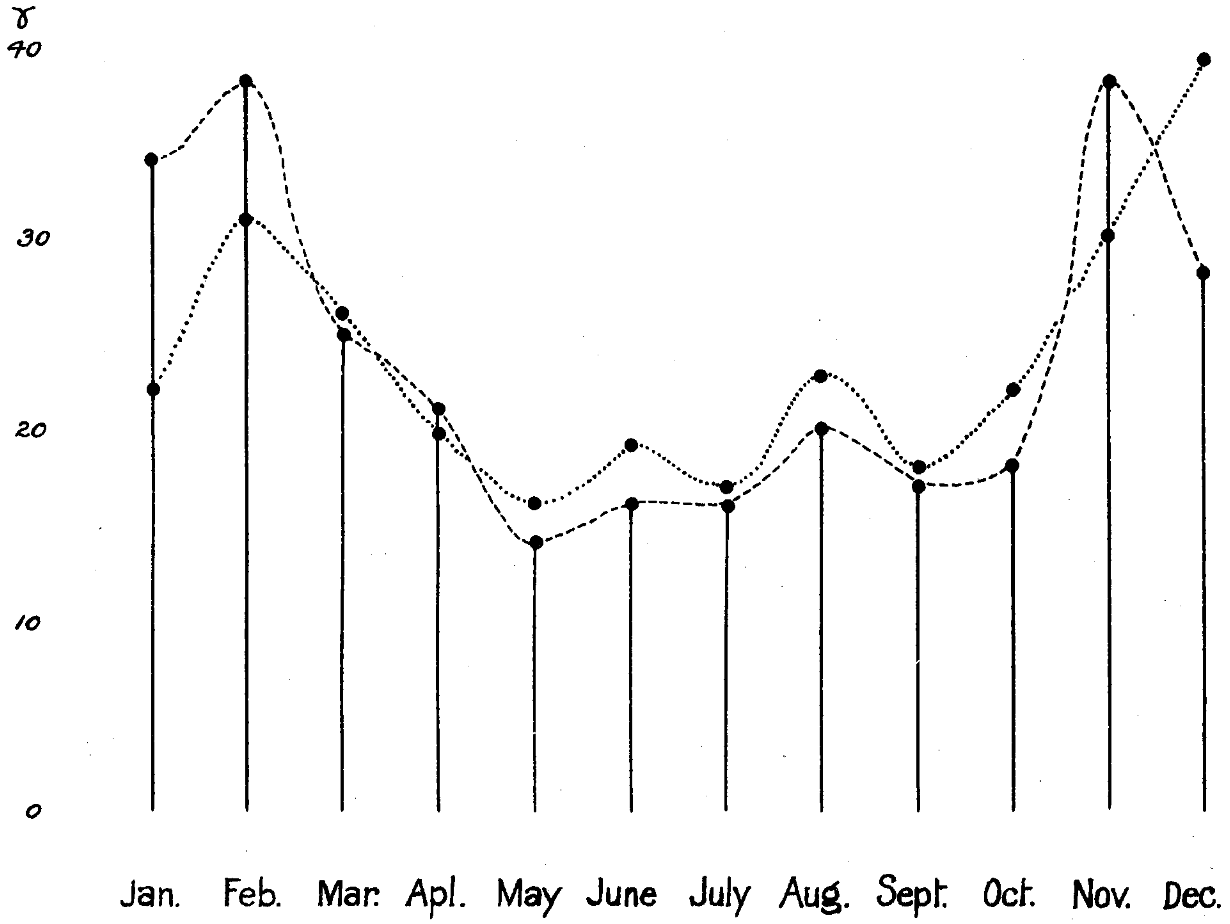

Mean Monthly Curves of Magnetic Declination.
1914.
G.M.C.T. 0h
6h
12h
18h
24h
Vertical divisions = minutes of arc + →
Jan.
Feb.
Mar.
Apl.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Summer
Equinox
Winter
Year



Curve showing
Mean diurnal Range of Declination
at Christchurch
for 1914 thus ------ for 1913 ......

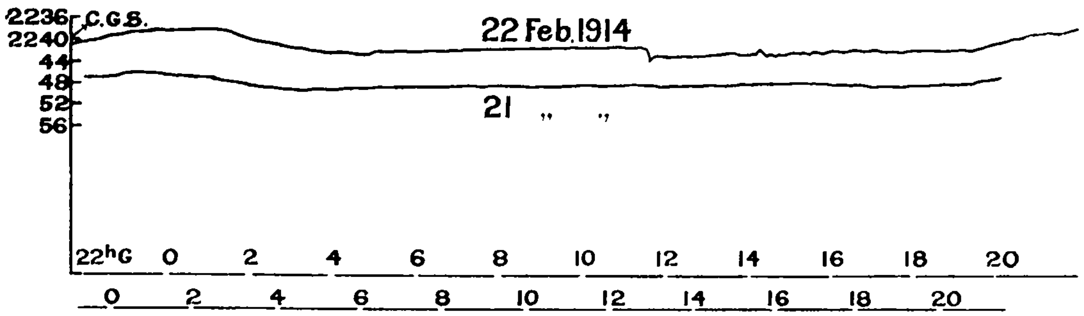
Mean Monthly Curves of Magnetic Horizontal Force. 1914.



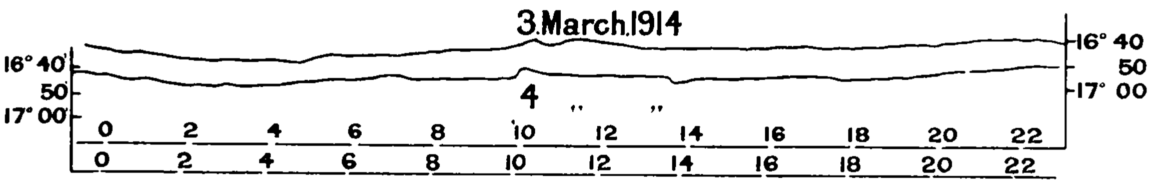


Curve showing
Mean diurnal Range of Horizontal Force
at Christchurch
for 1914 thus ------- for 1913 thus ....

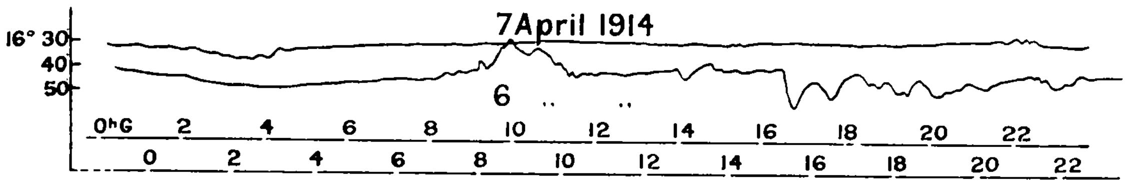
H.F.Chch



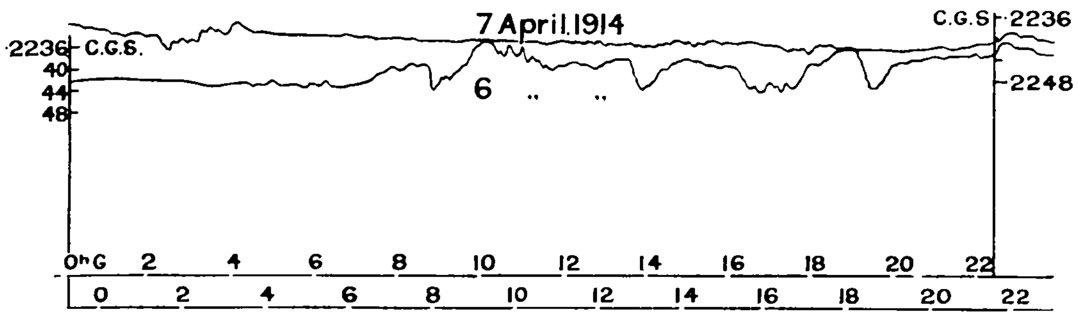
Dec.Chch



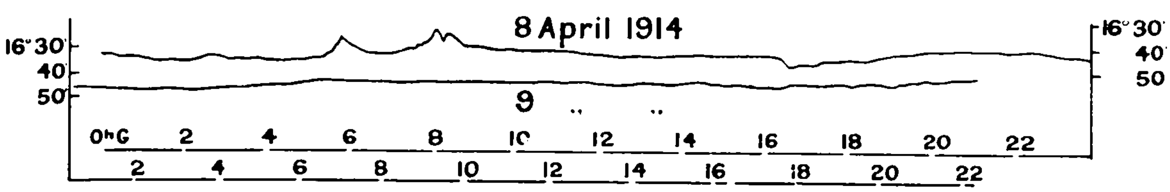
Dec. Chch



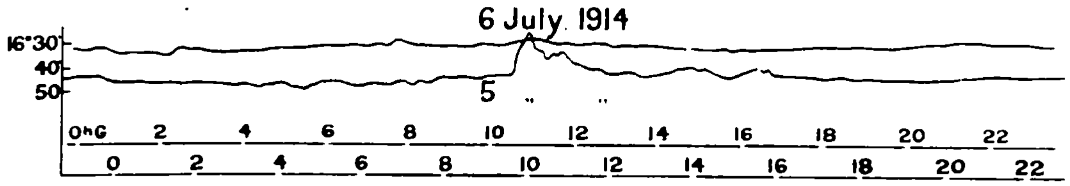
H.F.Chch



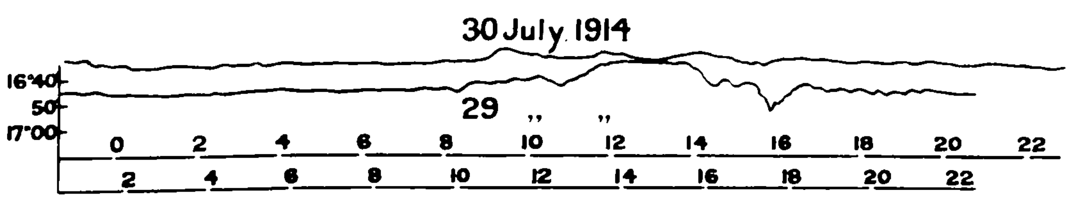
Dec Chch



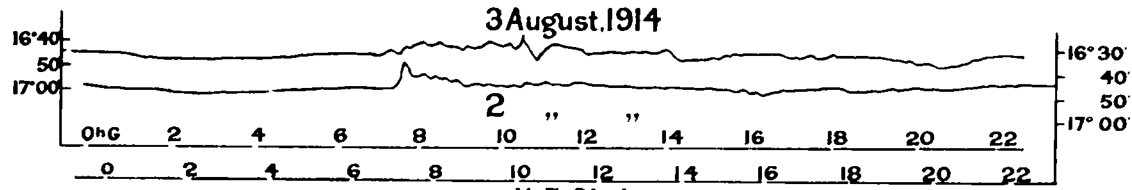
Dec. Chch



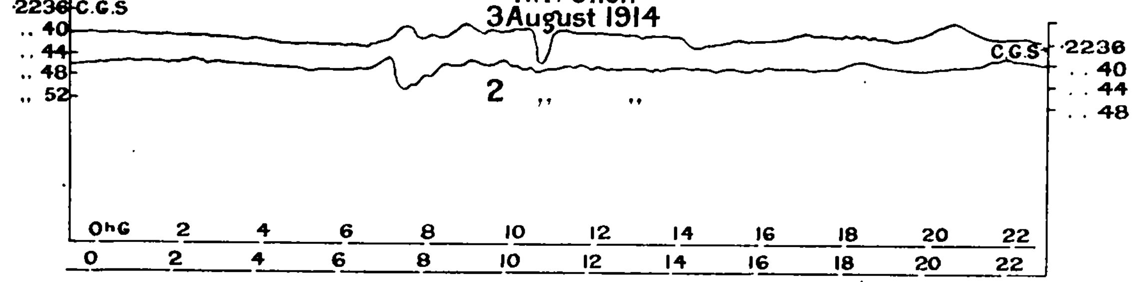
Dec Chch



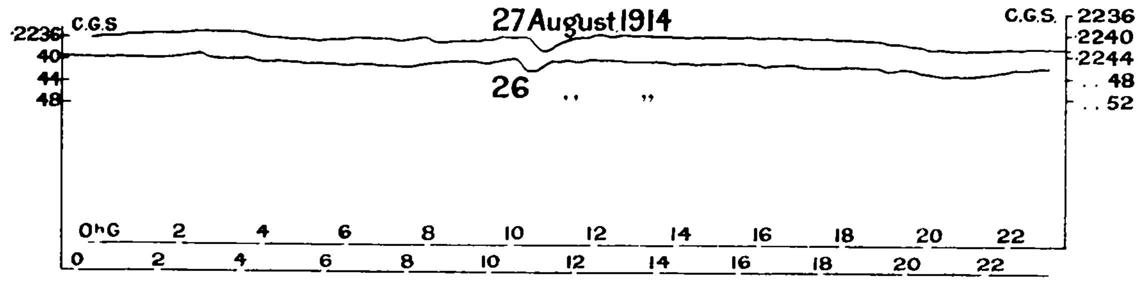
Dec Chch



H.F. Chch



H.F.Chch



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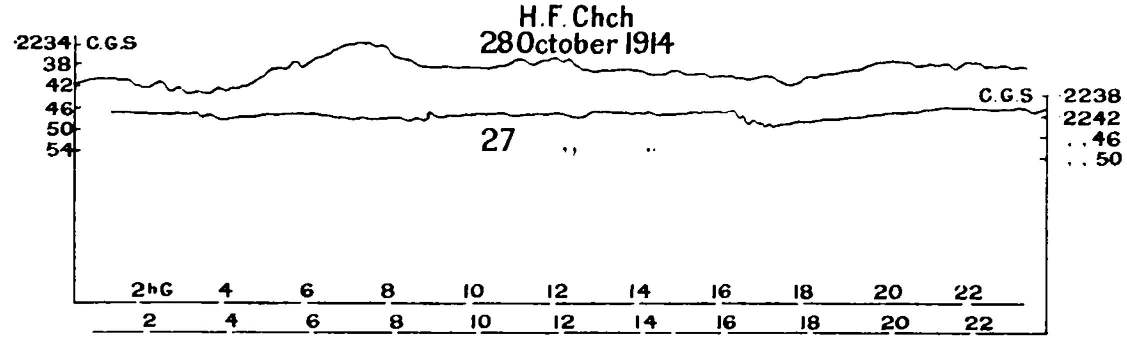

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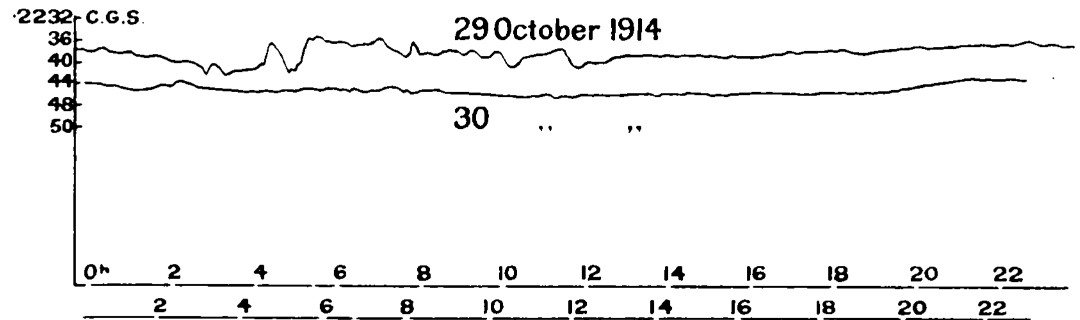


Records of Milne Seismograph No. 16, at Christchurch.

Latitude, 43° 31′ 50″ S.; longitude, 172° 38′ 9″ E.; time employed, Greenwich civil time.

Date.	Commencement.	Maxima.	Maxima Amplitude.	Duration.	Remarks.
1914.	H. M.	H. M.	Millimetres.	H. M.	
April 9 ..	3 46·1	3 50·1	3·1	..	B.P. 17 seconds.
		3 51·1	3·0	..	
		3 52·1	2·9	2 10	
„ 11 ..	16 33·0	16 41·5	10·9	..	First larger motion commences 16 h. 41·7 m.
		16 49·8	19·0	..	
		16 53·6	19·0	..	
		16 54·4	18·9	4 18	
„ 20 ..	14 21 ±	14 30·0	..	..	Duration uncertain; air-tremors in progress.
		14 45·4	..	1+	
„ 23 ..	16 29·1	16 33·9	2·0	..	
		16 35·9	2·0	2 15	
„ 25 ..	7 39·0	7 46·0	1·0	1 8	
May 1 ..	5 36·7	5 42·8	5·1	..	
		5 46·0	3·2	1 22	
„ 8 ..	23 54·0	23 56·0	4·6	0 45	
„ 18 ..	23 55·1	24 6·3	2·0	..	
		24 9·8	2·8	1 0	L.W. commence 24 h. 14·3 m.
„ 26 ..	14 40·2	14 45·2	6·0	..	
		14 50·0	10·0	..	
		14 56·7	24·0	..	
		15 0·8	22·1	..	
		15 2·8	24·0	..	
		15 7·8	18·0	1 15	End uncertain; air-tremors.
„ 29 ..	6 9·0	6 33·5	5·0	..	
		6 37·0	7·0	1 51	L.W. commence 6 h. 45 m.
June 18 ..	20 27·0	20 38·5	2·8	..	
		20 40·0	4·0	..	
		20 44·0	2·1	..	
		20 54·0	2·0	1 30	Duration uncertain.
„ 20 ..	8 30·9	8 37·0	19·5	..	
		8 39·5	7·0	..	
		8 40·4	7·0		
		8 41·4	6·9	..	
		8 42·2	5·9	..	
		8 43·3	6·2	1 0	End uncertain.
„ 20 ..	..	10 41·0	3·0	..	Isolated maximum; amongst air-tremors.
„ 20 ..	23 44·0	23 48·0	7·0	..	
		23 50·2	4·0	3+	End uncertain.
„ 21 ..	8 17·0	8 24·7	1·0	1 0	
„ 25 ..	19 24·3	19 29·4	4·0	..	
		19 35·0	4·6	..	
		19 50·0	23·1	..	
		19 57·5	4·0	1+	End uncertain.
„ 26 ..	3 21·6	3 27·6	1·8	0 20	
„ 26 ..	5 2·0	5 31·0	3·0	1 0	
„ 26 ..	6 7·2	6 10·0	4·0	0 30	Duration uncertain.
July 8 ..	21 18·0	21 34·0	1·0	0 52	Long swelling.
Aug. 4 ..	4 26·0	4 27·5	0·8	0 5	
„ 4 ..	9 7·0	9 13·5	2·0	0 47	
„ 22 ..	6 17·0	6 22·5	0·6	0 30	
„ 22 ..	15 14·5	15 17·8	5·0	..	Duration of large waves 8 m.
Sept. 29 ..	1 30·5	1 31·4	4·0	0 15	Origin N.E. of South Island, New Zealand.
„ 29 ..	1 49·8	1 50·3	0·7	0 4	
Oct. 6 ..	19 18·6	19 20·8	26·5	0 23	Violent motion; in midst of air-tremors.
„ 8 ..	12 13·0	12 23·6	2·4	1 0	End uncertain.
„ 27 ..	4 14·0	4 17·0	0·6	1 7	Irregular waves to 0 h. 36 m. approx.
„ 28 ..	0 19·6	0 21·6	22·0	..	Tokomaru shock: L.W. end at 0 h. 28·1 m
		0 22·8	17·0	..	
Nov. 8 ..	5 8·3	5 10·2	0·7	0 4	End uncertain.
„ 8 ..	11 37·0	11 43·6	2·6	0 25	Duration uncertain.
„ 8 ..	12 14·0	12 16·8	4·0	0 10	„
„ 8 ..	20 24·0	20 26·7	2·0	0 10	„
„ 10 ..	6 36·1	6 41·0	5·0	..	
		6 43·4	7·5	..	
		6 45·0	3·5	1 0	
„ 24 ..	12 8·2	12 9·0	3·0	..	
		12 17·2	5·8	..	
		12 24·0	4·0	1 ±	Air-tremors in progress.
Dec. 20 ..	14 19·9	14 27·7	17·5	..	L.W. commence 14 h. 23·4 m.
		14 36·9	6·3	..	Duration uncertain.
1915.					
Jan. 3 ..	0 3·9	0 11·1	5·0	1 35	L.W. commence 0 h. 7·9 m.
„ 5 ..	14 34·0	14 49·9	4·9	..	
		14 53·0	4·0	1 ±	
„ 5 ..	23 39·0	23 50·0	2·9	..	
		24 8·0	2·8	1 50	
„ 10 ..	23 33·0	23 41·3	1·3	1 20	
Feb. 25 ..	20 40·5	20 48·1	4·9	..	
		20 53·5	2·0	1 55	L.W. commence 20 h. 42·9 m.

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME).

Declination (east of north): 16° + tabular minutes.

Date.		0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean
	1914.																									
January	1 ..	46·2	47·7	47·9	48·4	47·4	46·2	45·2	44·6	44·5	44·4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	2 ..	46·0	47·4	48·6	49·9	49·0	47·3	45·1	44·1	43·9	43·9	44·0	43·7	42·8	43·0	42·3	42·2	42·7	43·2	42·6	39·9	40·4	40·2	41·1	41·1	43·9
,,	3 ..	43·9	45·6	46·9	47·3	48·5	48·4	46·8	45·0	43·7	43·8	43·4	43·0	43·0	42·2	42·8	42·2	42·2	41·8	41·6	40·4	39·4	39·4	40·1	41·0	43·4
,,	4 ..	43·9	45·5	47·2	49·0	48·5	47·2	46·2	45·0	44·5	43·9	43·4	43·3	43·2	43·9	43·1	42·8	42·7	42·4	42·1	41·6	39·4	40·1	41·6	41·6	43·8
,,	5 ..	45·0	46·8	46·6	47·0	46·2	45·1	43·8	43·9	44·6	44·1	44·2	44·1	44·2	43·9	43·7	41·5	41·1	42·2	40·2	40·8	39·9	40·5	41·7	45·5	43·6
,,	6 ..	46·2	46·2	45·6	44·8	44·6	44·2	45·5	45·6	45·4	45·5	44·5	44·2	43·9	43·4	43·2	43·2	42·9	42·8	41·6	41·1	41·3	41·6	43·2	43·4	43·9
,,	7 ..	45·2	45·8	45·6	45·6	45·0	45·0	45·1	45·6	44·9	44·7	44·4	44·4	44·6	41·6	41·1	41·8	41·1	40·1	40·0	39·6	40·1	41·9	43·2	44·6	43·4
,,	8 ..	46·4	46·7	46·6	45·6	45·5	45·0	45·0	46·0	44·5	44·6	44·4	44·2	44·1	43·4	43·3	42·8	42·5	42·2	41·6	40·4	40·3	40·9	43·2	43·2	43·9
,,	9 ..	44·5	46·0	45·7	45·5	46·1	45·8	45·7	45·0	44·6	44·5	43·9	43·3	43·7	43·3	43·2	43·1	43·2	42·5	41·9	41·1	39·6	39·9	42·2	44·1	43·7
,,	10 ..	46·2	46·7	46·7	46·2	46·2	45·9	45·4	44·8	44·5	44·5	44·5	44·1	44·2	43·9	43·4	43·3	43·3	43·0	41·6	40·0	38·8	38·8	40·6	40·6	43·6
,,	11 ..	45·0	47·2	47·6	46·3	45·7	44·9	44·8	44·5	44·0	43·9	43·4	43·3	43·3	43·3	43·3	43·3	43·9	43·3	41·8	39·6	40·5	39·5	41·4	44·5	43·7
,,	12 ..	46·7	49·5	50·2	49·0	47·8	46·2	44·8	42·9	44·1	43·9	44·1	44·1	42·8	42·7	42·8	42·2	42·1	42·2	41·6	40·0	40·0	41·0	43·9	46·7	44·2
,,	13 ..	50·0	51·4	49·4	47·8	46·9	45·8	44·8	44·1	43·9	43·9	44·0	43·7	43·6	45·0	43·9	43·0	42·5	42·1	40·8	39·9	39·4	40·2	43·1	46·7	44·4
,,	14 ..	49·5	50·1	48·1	46·8	46·7	44·2	42·5	42·7	43·4	43·9	43·7	43·9	43·4	43·2	42·8	42·2	42·7	42·2	40·6	39·5	37·6	37·1	39·4	42·2	43·3
,,	15 ..	46·2	48·8	49·4	49·0	47·8	46·6	45·8	45·6	45·2	44·6	44·0	43·3	43·3	42·8	42·8	42·7	42·5	42·2	41·1	41·2	39·4	38·8	40·8	43·9	44·1
,,	16 ..	47·8	49·5	47·9	46·8	46·4	45·7	44·8	43·3	43·8	43·6	43·3	42·8	41·8	42·8	43·3	43·2	43·9	43·2	41·5	40·6	38·8	39·7	41·1	41·1	43·6
,,	17 ..	48·4	51·7	51·2	49·0	46·7	45·7	44·7	44·5	43·9	44·1	42·1	41·4	42·5	43·3	43·3	43·3	43·3	42·8	41·8	40·8	40·5	40·5	40·6	40·6	44·0
,,	18 ..	45·4	48·6	48·4	48·8	46·7	45·7	45·0	44·5	44·5	44·2	44·4	43·3	43·4	43·3	43·3	43·4	43·3	43·4	41·7	41·0	40·5	40·0	40·5	41·1	43·9
,,	19 ..	45·1	47·6	48·4	47·9	45·6	43·9	44·2	44·2	44·2	44·1	43·9	42·3	43·3	42·8	42·8	42·7	43·3	43·0	42·3	41·4	39·7	39·2	40·1	40·1	43·8
,,	20 ..	42·8	44·9	45·7	45·6	45·0	44·7	44·5	43·9	43·9	44·2	44·1	44·0	43·3	43·3	43·2	43·0	43·0	42·2	41·9	41·1	40·5	40·2	40·8	42·1	43·2
,,	21 ..	44·2	47·7	49·3	49·3	47·2	46·2	45·1	44·9	44·7	44·2	43·9	43·6	43·2	43·3	43·4	43·4	42·9	42·8	41·8	41·1	40·0	40·1	40·8	41·6	43·9
,,	22 ..	43·9	46·0	48·4	49·0	46·9	46·2	46·2	46·2	43·3	42·2	43·6	43·6	43·0	43·3	43·1	43·9	43·3	41·8	41·5	41·1	40·3	41·3	43·3	44·2	44·0
,,	23 ..	45·0	46·8	47·9	47·5	47·0	45·8	44·6	44·5	44·4	44·4	43·8	43·7	43·3	43·3	43·3	43·2	43·3	42·8	42·3	41·9	40·6	40·3	41·4	41·6	43·9
,,	24 ..	45·0	48·1	48·2	47·3	46·3	45·0	43·4	43·1	43·2	43·4	43·4	43·2	43·7	43·3	43·3	43·3	43·3	43·2	41·8	40·5	39·2	39·4	41·6	43·3	43·6
,,	25 ..	47·3	50·3	50·6	50·5	49·0	46·8	45·6	45·0	44·2	43·8	43·7	43·9	43·3	43·3	43·3	43·3	43·3	43·2	41·6	40·0	39·3	39·4	41·1	42·8	44·4
,,	26 ..	45·6	48·4	50·0	49·1	47·8	46·2	44·5	43·9	43·1	43·0	43·2	43·1	43·2	43·2	43·3	43·3	43·2	42·8	41·2	40·0	38·9	39·7	41·6	43·8	43·8
,,	27 ..	46·5	50·6	53·0	50·8	48·4	46·0	44·6	44·0	43·9	43·0	43·3	43·2	43·2	43·2	43·2	43·2	43·3	43·3	43·3	42·9	41·6	40·3	39·2	38·8	43·9
,,	28 ..	45·6	47·9	50·0	49·0	47·7	46·2	44·5	43·9	43·4	43·9	43·9	43·3	43·1	41·7	42·2	42·8	43·3	42·2	41·1	39·6	38·7	38·3	40·5	43·2	43·6
,,	29 ..	45·9	49·0	50·6	49·5	47·4	45·8	43·9	44·0	44·4	44·2	44·1	43·9	43·9	43·8	43·3	43·4	43·3	43·3	42·8	41·4	39·4	38·8	40·5	42·8	44·2
,,	30 ..	44·5	45·7	47·0	47·8	47·7	46·6	45·5	44·6	44·4	44·4	44·2	43·9	43·3	43·3	43·7	43·4	43·6	43·3	42·3	40·0	39·1	38·5	39·4	41·6	43·7
,,	31 ..	45·0	47·2	49·2	48·7	47·8	45·7	44·0	43·8	44·4	43·9	44·2	42·4	43·2	43·3	43·3	43·3	43·8	43·8	43·3	41·2	38·8	37·7	39·3	40·5	43·7
Means	..	45·8	47·8	48·3	47·9	46·9	45·8	44·9	44·4	44·2	44·0	43·8	43·5	43·4	43·2	43·1	42·9	43·0	42·6	41·7	40·7	39·7	39·8	41·2	42·6	43·8

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
January 1 ..	403	414	429	436	443	445	435	437	438	438	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, 2 ..	409	419	424	436	454	456	456	449	445	444	442	438	452	444	445	440	440	440	443	437	425	420	408	403	436
,, 3 ..	405	416	425	431	438	437	442	450	441	441	440	439	441	436	433	434	436	437	438	441	436	430	421	419	434
,, 4 ..	410	416	421	436	438	439	446	444	443	438	437	438	436	434	435	436	435	435	434	431	427	436	436	437	434
,, 5 ..	430	414	428	426	429	447	430	443	441	431	436	434	433	436	440	436	433	429	431	422	416	407	410	416	429
,, 6 ..	421	417	427	435	430	434	427	434	434	433	433	433	433	428	430	429	432	431	429	422	414	414	423	427	428
,, 7 ..	418	426	438	438	439	437	444	440	435	436	435	435	434	434	434	434	436	434	431	426	406	402	404	415	430
,, 8 ..	421	439	440	425	427	444	440	440	437	436	439	435	434	434	431	433	432	434	434	427	420	413	414	417	431
,, 9 ..	437	439	438	437	444	449	445	439	435	436	435	435	435	433	433	436	436	434	432	425	416	412	412	413	433
,, 10 ..	419	438	454	451	441	439	438	435	435	435	437	435	435	435	437	438	435	435	436	435	431	423	416	416	435
,, 11 ..	419	436	449	446	442	442	440	437	438	437	436	437	438	434	435	437	438	436	441	441	430	411	405	405	434
,, 12 ..	424	446	446	450	449	442	440	439	443	449	447	444	445	444	442	430	435	437	435	425	411	397	385	384	433
,, 13 ..	400	429	449	458	463	451	453	457	453	453	452	445	447	436	435	450	449	444	442	433	415	396	388	392	437
,, 14 ..	417	433	444	447	448	447	442	446	445	441	443	440	440	440	440	441	444	444	443	434	423	410	407	405	436
,, 15 ..	417	423	432	434	437	440	444	441	446	450	450	447	445	444	440	441	442	443	441	434	430	412	392	393	434
,, 16 ..	399	406	419	426	428	431	429	429	431	437	435	432	427	427	429	431	431	437	430	430	417	408	392	392	423
,, 17 ..	399	416	431	448	449	449	437	440	444	447	443	451	441	437	435	435	437	439	440	435	426	413	405	405	433
,, 18 ..	403	420	437	439	438	437	429	431	433	432	434	437	441	437	436	435	436	439	437	432	425	415	411	411	430
,, 19 ..	411	425	439	440	445	438	432	432	434	434	435	432	432	432	432	432	432	431	431	430	426	423	418	411	430
,, 20 ..	406	413	423	435	439	438	434	434	432	433	432	429	428	431	432	433	433	433	433	432	426	416	402	395	427
,, 21 ..	397	410	431	434	432	430	431	436	437	439	439	437	434	435	433	438	438	440	443	440	438	435	430	425	433
,, 22 ..	411	418	424	427	424	441	439	442	428	430	431	442	428	429	430	435	432	438	423	423	414	402	406	412	426
,, 23 ..	416	428	434	436	429	431	431	431	435	434	434	434	434	435	431	430	430	430	429	425	419	412	404	400	427
,, 24 ..	406	421	431	437	437	436	436	438	434	434	434	435	432	431	432	432	432	434	433	427	418	404	394	394	427
,, 25 ..	416	428	443	450	443	437	435	436	435	433	433	433	433	433	434	434	434	434	434	429	422	413	461	450	436
,, 26 ..	404	414	430	451	454	451	444	443	443	439	441	437	439	439	438	438	439	440	440	432	422	413	403	396	433
,, 27 ..	..	..	..	..	..	..	..	..	..	..	441	441	436	439	437	437	439	441	440	438	428	418	409	401	..
,, 28 ..	401	401	415	433	444	443	446	441	442	441	442	443	443	446	439	439	446	435	432	428	420	408	398	390	430
,, 29 ..	402	418	439	448	450	446	439	434	435	434	434	435	432	431	431	433	432	433	436	433	428	417	402	397	430
,, 30 ..	392	401	415	427	437	444	428	438	442	440	439	438	440	437	432	433	434	436	433	433	428	421	411	408	429
,, 31 ..	403	404	420	435	446	447	446	442	447	447	444	441	442	438	434	434	434	435	434	429	421	414	405	402	431
Means ..	411	421	432	438	441	442	439	439	439	438	438	438	437	436	435	435	436	436	435	431	423	414	409	408	431

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
February 1 ..	43·3	46·0	49·0	50·1	49·5	47·3	45·1	44·1	44·0	43·9	43·9	43·4	43·4	43·3	42·9	43·3	42·9	42·8	42·1	40·6	38·8	37·8	38·3	40·1	43·6
„ 2 ..	44·5	46·0	47·3	47·3	47·7	47·2	45·6	45·0	44·8	44·7	44·6	43·2	42·3	42·2	43·3	44·4	44·5	43·4	43·9	44·4	42·2	40·5	40·6	42·1	44·2
„ 3 ..	44·9	46·4	47·3	48·1	48·4	47·7	46·4	46·2	45·6	45·4	44·4	42·8	42·5	43·3	43·3	43·9	45·0	42·3	42·2	41·2	40·4	40·3	41·1	41·6	44·2
„ 4 ..	43·3	45·7	47·6	47·8	48·4	47·3	45·6	45·0	44·1	42·9	43·9	43·9	43·4	43·3	42·8	42·8	43·3	43·3	43·3	42·3	41·1	40·0	41·9	43·7	44·0
„ 5 ..	45·0	46·7	47·3	46·7	46·0	45·2	44·5	44·7	43·3	42·9	43·4	44·0	43·9	43·3	43·3	43·3	43·2	43·3	43·0	42·9	41·2	40·3	40·2	41·1	43·7
„ 6 ..	43·9	46·0	47·4	47·7	47·6	46·7	45·5	43·3	42·5	43·2	42·8	41·8	39·4	38·3	40·0	40·2	41·2	41·1	42·2	42·2	40·8	39·9	40·2	41·8	42·7
„ 7 ..	44·5	47·3	49·0	48·6	47·8	47·3	45·6	45·1	44·4	43·9	44·5	44·4	43·9	42·3	42·8	43·3	43·9	44·4	43·4	43·2	41·4	40·5	41·1	41·9	44·4
„ 8 ..	43·9	44·8	49·4	49·0	47·8	46·2	44·6	43·9	43·9	43·3	43·3	43·3	43·4	43·3	43·4	43·3	43·3	43·4	43·2	41·8	40·0	39·4	38·5	38·8	43·5
„ 9 ..	41·6	45·1	47·5	47·8	47·3	46·4	45·6	44·6	44·1	43·9	43·4	43·0	43·3	43·2	43·2	43·1	43·3	43·3	42·8	41·6	40·0	38·8	39·4	39·4	43·4
„ 10 ..	44·9	47·9	49·6	49·5	49·0	47·8	46·3	45·1	44·5	44·4	43·9	43·6	43·3	43·4	43·4	43·7	43·7	43·8	43·8	42·8	40·1	38·7	38·3	39·5	44·2
„ 11 ..	41·9	45·4	48·1	48·5	48·3	47·7	45·6	45·4	44·6	44·2	43·8	43·7	43·7	43·0	43·4	44·4	43·9	44·0	43·7	42·2	40·4	39·4	39·3	40·0	43·9
„ 12 ..	43·0	46·2	48·5	48·5	47·6	46·9	45·0	44·8	43·8	43·4	43·6	41·2	42·8	42·8	43·2	42·2	43·3	43·3	42·8	41·1	38·8	36·8	37·1	38·3	43·1
„ 13 ..	40·0	43·0	46·5	48·3	48·6	48·1	46·7	45·8	44·6	43·9	43·6	43·9	43·1	43·3	43·2	43·3	44·4	44·5	43·3	42·3	41·8	37·4	37·0	37·7	43·5
„ 14 ..	40·5	43·4	46·7	48·3	48·4	47·7	46·9	45·7	44·6	44·2	43·4	42·5	42·4	43·2	43·3	43·3	44·5	44·4	44·5	43·2	42·0	40·8	40·1	39·4	43·9
„ 15 ..	41·6	43·8	48·4	50·3	50·4	49·4	48·7	47·3	47·2	44·9	42·8	42·1	40·2	42·2	42·7	43·4	42·8	43·3	43·3	43·0	41·9	40·2	39·9	40·0	44·2
„ 16 ..	40·2	42·8	45·4	46·4	46·7	46·2	44·6	44·2	44·5	44·4	43·8	43·7	43·2	43·3	43·3	43·3	43·3	43·4	44·5	43·2	40·6	39·4	39·4	40·2	43·3
„ 17 ..	41·8	44·5	46·5	47·7	47·8	47·4	45·7	45·1	44·7	44·6	44·4	42·8	42·4	43·3	42·8	42·8	42·7	42·2	42·2	41·0	39·6	38·6	39·0	39·4	43·3
„ 18 ..	42·8	45·1	46·6	47·3	47·6	46·4	45·4	45·1	44·7	44·8	44·6	44·2	43·7	43·6	43·3	42·8	43·4	43·2	42·5	41·2	40·2	40·0	41·0	41·6	43·8
„ 19 ..	43·3	45·2	47·3	48·1	47·8	47·3	45·8	45·4	45·0	44·7	44·4	43·3	43·0	42·1	42·2	42·3	43·3	43·3	43·3	42·2	40·6	38·5	39·3	40·5	43·7
„ 20 ..	41·8	45·6	47·0	48·5	48·4	47·2	46·2	45·1	44·9	44·7	43·9	43·8	43·3	43·3	43·3	43·9	43·3	43·0	43·0	42·3	40·5	39·3	39·2	39·2	43·8
„ 21 ..	41·9	44·9	47·5	47·8	47·8	47·0	45·8	45·0	44·2	44·2	44·2	44·1	43·9	43·4	43·3	43·3	43·3	43·3	43·3	42·9	41·2	39·9	38·8	38·8	43·7
„ 22 ..	43·9	46·0	48·4	49·4	48·4	48·2	46·3	45·6	45·0	44·6	44·2	43·9	43·7	43·4	43·3	42·2	42·3	43·3	42·2	42·2	40·5	41·5	42·2	42·2	44·3
„ 23 ..	45·0	46·3	48·1	49·3	49·0	48·0	46·0	45·0	44·8	44·7	44·4	43·9	43·8	43·4	43·4	43·6	43·3	43·4	43·3	43·0	41·6	39·9	39·8	41·6	44·4
„ 24 ..	45·0	48·7	50·3	50·2	49·1	47·6	46·5	45·7	45·0	44·5	43·8	43·6	43·3	43·4	43·3	43·4	43·3	43·4	43·3	42·2	40·1	37·9	37·4	38·8	44·2
„ 25 ..	41·9	45·0	47·6	47·8	47·3	46·8	45·0	44·8	44·5	44·7	43·8	43·2	43·3	43·4	43·7	43·7	46·0	44·5	43·9	43·3	41·4	40·0	39·2	39·4	43·9
„ 26 ..	43·7	46·2	47·8	48·1	48·4	47·8	46·3	45·4	45·0	44·7	43·4	43·2	42·2	42·9	43·3	43·4	44·4	44·0	43·6	42·5	41·2	39·2	38·8	39·9	44·0
„ 27 ..	43·3	47·2	49·6	49·9	48·4	47·5	46·0	44·8	44·8	44·1	43·8	42·8	42·7	43·3	43·3	43·3	43·4	43·7	43·4	42·8	41·1	39·4	39·1	39·1	44·0
„ 28 ..	41·6	44·5	41·2	48·1	47·3	46·4	45·8	45·2	44·9	44·6	44·1	43·6	42·8	43·3	43·3	43·7	42·7	42·8	42·9	41·6	40·8	39·4	40·5	41·6	43·4
Means ..	43·0	45·6	47·6	48·4	48·1	47·2	45·8	45·1	44·6	44·2	43·9	43·3	42·9	42·9	43·1	43·2	43·5	43·4	43·3	42·3	40·7	39·4	39·5	40·3	43·8

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued*.

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
February 1 ..	393	397	413	425	442	443	437	436	436	437	438	438	437	438	437	438	438	438	443	443	437	427	416	406	431
,, 2 ..	408	414	420	423	443	443	440	434	444	445	444	441	435	431	429	434	443	438	437	440	436	425	415	410	432
,, 3 ..	406	403	418	427	447	448	443	443	443	445	447	443	442	438	438	441	444	442	436	434	429	420	412	404	433
,, 4 ..	398	401	413	413	435	437	427	437	437	443	446	435	433	431	429	430	432	433	435	432	427	421	411	407	431
,, 5 ..	407	416	427	429	434	441	439	438	438	439	438	438	435	435	431	425	429	430	431	431	431	426	412	407	429
,, 6 ..	406	412	421	431	440	441	439	431	406	424	424	421	411	411	413	421	436	435	440	425	414	406	391	380	420
,, 7 ..	380	407	416	420	429	433	430	433	431	428	431	430	430	432	435	428	425	427	430	429	430	418	416	389	423
,, 8 ..	388	394	407	420	416	426	429	426	426	425	426	429	426	428	431	426	426	426	428	425	422	412	404	400	419
,, 9 ..	389	394	405	418	429	437	434	434	435	437	438	438	439	436	435	433	434	434	432	432	424	413	403	401	425
,, 10 ..	398	402	416	435	440	439	435	434	430	432	431	431	428	428	427	428	430	432	432	434	429	419	404	404	426
,, 11 ..	382	396	415	426	433	436	432	424	425	428	432	432	430	430	427	427	429	427	428	429	423	412	399	390	421
,, 12 ..	382	391	410	427	435	432	431	429	428	429	427	429	428	426	426	428	430	433	436	436	432	426	411	398	423
,, 13 ..	387	385	396	414	428	435	433	435	434	434	430	431	430	429	431	426	432	438	434	434	431	422	405	392	423
,, 14 ..	382	378	384	402	420	428	426	428	426	429	429	428	426	426	425	425	433	431	432	436	433	428	415	413	420
,, 15 ..	396	398	405	426	413	425	432	423	430	428	425	424	427	421	421	421	421	420	421	420	421	412	404	402	418
,, 16 ..	390	390	394	399	418	420	423	421	427	427	426	425	423	424	423	426	427	431	429	432	434	423	414	413	419
,, 17 ..	397	400	407	429	445	444	435	433	424	433	429	431	428	428	429	430	440	435	439	440	439	433	422	422	429
,, 18 ..	405	413	420	426	445	426	432	428	433	433	434	435	434	430	427	426	427	425	426	430	425	416	408	404	425
,, 19 ..	404	405	418	430	434	434	430	431	430	433	433	431	423	426	422	420	423	424	424	425	423	419	414	402	423
,, 20 ..	394	394	401	411	423	427	427	430	429	435	436	434	429	427	429	432	429	429	426	428	425	414	407	407	422
,, 21 ..	402	401	405	417	429	433	432	430	429	429	431	430	428	429	427	426	426	426	430	431	430	423	406	393	423
,, 22 ..	389	386	403	418	429	431	426	426	423	424	424	427	438	437	437	435	430	428	430	431	422	404	402	402	421
,, 23 ..	384	393	405	411	414	417	420	422	421	423	424	436	433	432	427	424	424	424	426	424	425	417	405	393	417
,, 24 ..	393	405	421	434	438	442	436	433	434	431	433	428	428	427	426	426	427	427	425	425	422	415	402	383	423
,, 25 ..	380	385	397	410	418	415	422	425	424	425	423	423	420	422	421	421	421	424	428	430	426	419	409	394	416
,, 26 ..	402	407	414	421	428	429	425	426	430	433	434	431	429	430	432	431	435	435	434	432	429	419	407	401	425
,, 27 ..	390	389	396	414	426	432	431	430	428	429	429	430	426	425	425	425	429	425	428	426	423	414	406	404	420
,, 28 ..	392	394	403	412	427	429	430	436	432	435	437	434	436	434	432	434	431	437	437	432	425	408	386	386	422
Means ..	396	395	409	420	431	433	431	431	430	432	432	132	430	429	428	428	430	430	431	431	427	418	408	401	424

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
March 1	42·4	46·2	49·0	49·3	49·2	47·8	46·2	45·5	44·7	43·7	44·2	43·2	39·6	42·3	42·9	43·9	44·5	44·5	43·4	43·9	43·9	41·9	40·5	40·5	44·3
,, 2	45·6	47·5	49·0	49·0	49·0	48·4	46·9	45·8	44·1	43·9	43·9	43·9	43·3	43·4	43·8	43·4	44·4	45·0	45·6	45·6	43·9	42·7	42·4	42·9	45·1
,, 3	45·2	47·3	49·5	49·5	50·2	49·0	47·8	46·4	45·5	45·6	46·7	46·8	46·7	43·4	43·8	43·7	43·9	43·9	43·8	42·7	41·7	40·2	42·8	41·6	45·3
,, 4	44·6	46·2	48·3	48·6	47·4	46·4	45·2	43·4	45·0	45·0	43·8	42·9	43·9	43·8	45·9	43·9	44·0	44·1	44·2	43·3	42·8	40·6	39·4	39·5	44·3
,, 5	42·2	44·9	46·6	46·8	46·7	45·5	44·7	44·6	43·7	44·1	43·4	43·6	43·3	42·9	43·2	42·8	43·4	43·3	43·3	43·3	43·1	41·9	41·8	43·3	43·9
,, 6	42·8	46·3	47·8	48·2	48·7	47·7	44·6	47·0	46·4	45·8	44·8	42·8	41·3	43·7	43·9	43·8	45·6	44·4	43·4	42·9	42·5	41·1	42·2	43·9	44·6
,, 7	45·5	47·6	49·0	50·1	47·6	46·9	45·7	41·3	43·7	44·4	43·7	44·6	44·2	44·6	44·5	44·5	44·6	44·5	44·5	44·4	43·0	41·6	41·6	42·2	44·8
,, 8	45·0	47·0	47·5	47·6	46·2	45·6	45·5	45·0	44·0	42·2	43·3	43·3	43·4	43·3	43·9	44·0	43·9	43·9	43·4	42·9	41·6	40·6	40·0	40·0	43·9
,, 9	45·0	46·8	47·3	47·9	46·2	44·9	44·4	43·9	44·5	44·0	43·8	42·1	42·4	42·0	42·8	43·3	43·3	43·3	43·3	42·4	41·2	40·2	40·4	42·2	43·7
,, 10	44·7	47·3	49·4	48·4	47·2	45·8	45·0	45·0	44·9	45·0	44·1	44·1	44·5	43·9	42·5	43·3	43·9	42·8	43·3	42·8	41·8	41·1	40·5	41·1	44·3
,, 11	43·9	46·0	48·6	49·1	48·2	47·2	46·0	45·0	43·3	43·9	43·4	41·2	42·1	43·2	43·9	43·9	43·7	43·8	43·3	42·2	41·5	41·2	42·1	43·9	44·2
,, 12	47·0	48·6	49·7	49·6	47·3	45·5	43·3	43·9	44·0	42·8	42·3	44·2	43·9	44·2	43·9	44·4	44·5	43·4	44·4	44·5	42·2	40·5	40·4	43·0	44·5
,, 13	45·6	46·4	49·9	49·5	48·3	46·8	43·6	44·2	44·4	44·2	43·2	43·1	43·4	43·3	44·0	43·9	44·0	44·5	44·5	43·4	42·1	40·5	40·4	41·1	44·3
,, 14	44·5	46·6	47·9	48·3	47·3	46·3	45·0	44·9	44·5	44·5	43·9	42·8	44·2	44·0	43·4	43·6	43·9	43·7	43·9	43·1	42·2	40·9	41·1	41·1	44·2
,, 15	46·2	49·0	50·0	49·7	48·5	46·8	45·6	45·5	45·1	44·7	44·5	44·1	44·0	44·5	43·2	43·9	43·3	44·5	48·4	47·4	43·9	41·1	40·0	40·0	45·2
,, 16	43·9	46·4	48·4	49·1	48·2	46·7	45·4	45·6	45·1	44·8	44·4	44·1	43·9	43·3	43·4	43·6	43·8	43·8	43·9	43·3	42·4	40·9	40·6	40·6	44·4
,, 17	43·9	46·7	48·8	49·2	48·5	47·3	45·8	45·6	45·0	45·0	44·2	43·8	43·9	43·9	43·3	43·3	43·3	43·3	43·4	42·8	40·8	40·0	40·5	40·1	44·3
,, 18	43·7	47·0	49·2	49·0	48·3	46·9	45·8	45·8	45·1	44·6	44·5	44·7	44·4	45·6	43·7	44·5	43·4	43·6	43·9	43·1	42·8	41·3	41·3	42·8	44·4
,, 19	43·9	46·0	46·7	47·4	47·3	46·7	45·7	45·8	45·8	45·8	43·1	45·0	44·5	44·4	43·8	43·6	43·4	43·4	43·8	43·4	43·0	41·9	42·3	43·9	44·6
,, 20	44·0	46·7	46·8	47·3	46·7	45·4	45·1	43·6	44·8	44·7	44·5	43·6	43·3	43·8	43·9	44·0	45·0	42·2	44·8	43·3	42·2	41·1	40·9	42·2	44·2
,, 21	45·0	46·7	47·7	47·8	46·3	45·0	44·5	45·0	44·6	44·5	44·2	44·5	44·4	43·9	43·6	43·8	43·3	43·3	43·3	43·3	42·3	41·6	42·1	42·1	44·3
,, 22	43·9	45·1	45·7	46·2	46·2	45·6	45·0	45·2	45·2	44·9	45·0	46·0	44·5	44·5	43·9	44·0	43·9	43·9	43·8	43·3	42·3	42·0	41·6	42·8	44·4
,, 23	44·1	45·9	47·5	47·3	47·0	46·2	45·4	45·7	44·7	45·0	44·8	44·8	44·5	44·5	44·5	44·4	44·5	43·9	43·7	43·3	42·3	41·2	41·6	42·8	44·6
,, 24	45·2	47·8	49·1	48·6	46·6	45·2	44·5	44·6	44·4	44·5	44·6	44·2	44·2	44·5	43·9	43·9	43·9	43·7	43·3	43·2	41·6	40·3	41·1	43·9	44·4
,, 25	49·0	50·4	50·4	50·0	47·8	45·6	45·5	45·0	44·2	41·6	43·8	44·4	43·9	44·4	44·5	44·4	44·2	43·9	43·8	43·9	42·1	41·1	40·6	43·1	44·9
,, 26	46·2	47·8	48·6	48·4	46·7	45·0	44·9	45·0	45·0	43·9	44·2	44·2	44·4	44·5	44·5	44·4	44·0	44·5	44·5	43·9	43·2	42·2	41·4	42·8	44·8
,, 27	43·9	46·0	48·3	49·3	46·7	45·8	44·9	44·8	44·5	44·8	44·5	44·7	44·7	44·6	44·6	44·5	44·5	44·1	44·4	44·2	43·4	42·0	42·2	43·2	44·8
,, 28	46·2	47·7	48·1	47·8	46·7	45·4	45·0	44·8	44·5	44·2	44·4	44·2	44·1	43·9	43·9	43·9	43·9	44·0	43·9	43·8	42·8	42·1	41·2	41·6	44·5
,, 29	47·7	48·0	46·8	45·6	44·9	44·6	44·8	44·5	44·4	44·4	44·5	44·4	44·4	44·4	43·6	43·9	43·9	43·4	43·0	41·6	41·1	42·8	44·0	46·2	44·5
,, 30	48·4	48·4	48·4	48·3	47·2	45·6	45·2	45·6	45·1	45·2	45·2	45·0	44·5	44·5	44·6	44·5	44·5	44·5	44·6	44·5	43·9	42·8	42·1	43·9	45·3
,, 31	45·5	47·9	49·2	48·5	47·8	46·5	45·5	45·6	45·0	44·6	44·5	44·0	44·5	44·1	44·5	44·1	45·2	44·5	44·5	44·2	43·2	42·2	41·9	42·8	45·0
Means ..	45·0	47·0	48·4	48·4	47·4	46·3	45·2	45·0	44·7	44·4	44·2	44·0	43·8	43·9	43·9	43·9	44·1	43·9	44·0	43·5	42·5	41·3	41·3	42·3	44·5

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
March 1	387	392	395	389	398	406	416	419	417	401	416	414	423	420	420	421	425	429	432	428	430	421	410	398	412
,, 2	388	388	373	402	410	403	418	418	413	422	422	425	420	421	422	422	424	421	425	424	422	411	398	388	412
,, 3	381	378	388	410	418	398	401	419	406	416	407	414	414	416	416	416	418	418	419	421	418	408	398	390	408
,, 4	388	388	400	405	405	426	425	412	419	422	418	427	421	419	425	425	423	419	420	423	424	415	388	396	414
,, 5	403	409	401	406	412	417	419	420	418	417	420	419	421	421	423	422	424	425	425	427	426	420	412	406	417
,, 6	405	405	412	416	418	409	423	406	430	440	439	474	433	428	425	423	423	430	422	426	425	420	395	373	421
,, 7	383	385	402	413	409	415	406	414	408	420	431	421	421	418	421	418	417	418	415	420	422	415	401	400	412
,, 8	388	394	404	416	417	415	409	410	410	420	411	414	418	418	415	419	419	419	418	417	420	415	401	401	412
,, 9	398	407	415	424	430	424	419	423	425	426	427	426	427	444	417	419	420	422	422	424	422	413	405	401	420
,, 10	396	403	412	418	425	421	417	419	421	424	430	429	429	432	436	427	435	433	431	434	432	421	413	413	423
,, 11	404	410	421	431	431	424	420	422	429	425	422	427	430	425	421	425	426	428	433	430	423	409	397	397	421
,, 12	392	402	409	414	420	421	415	409	412	411	417	422	420	422	422	424	423	424	422	427	426	417	403	386	415
,, 13	386	398	407	416	423	421	420	425	425	424	420	421	422	421	422	422	423	424	425	434	427	425	411	398	418
,, 14	396	416	409	418	428	430	429	425	423	420	420	419	419	419	421	418	419	421	424	424	420	415	399	397	418
,, 15	395	402	406	410	417	417	416	419	422	423	423	424	423	438	423	425	423	425	427	414	429	424	410	395	418
,, 16	375	380	401	405	412	419	427	428	424	427	424	422	420	419	417	417	418	419	422	424	427	423	415	410	416
,, 17	396	405	413	419	421	425	425	427	429	430	430	427	428	427	425	427	429	430	433	438	447	425	408	408	424
,, 18	403	402	396	408	419	417	418	415	423	424	424	424	422	425	426	427	422	423	425	428	427	426	415	408	419
,, 19	407	411	419	420	432	431	431	437	427	431	441	431	427	427	430	432	424	424	425	425	427	421	411	408	425
,, 20	404	413	416	422	424	421	423	425	430	435	434	436	434	428	423	421	430	426	427	426	425	417	405	402	423
,, 21	415	417	418	421	424	428	427	429	430	433	434	432	429	431	431	432	431	431	430	428	425	421	421	421	427
,, 22	424	423	425	427	428	427	428	427	429	429	428	431	429	431	429	429	431	431	433	430	426	420	416	415	427
,, 23	425	431	433	433	435	438	437	438	440	440	438	436	433	431	431	431	432	432	432	429	426	417	408	405	430
,, 24	414	422	432	435	437	436	432	433	432	432	431	431	433	432	433	433	432	432	435	431	431	419	397	382	427
,, 25	387	409	409	415	421	419	421	421	421	427	427	417	420	421	421	421	421	422	425	421	418	414	408	404	417
,, 26	424	405	414	418	416	410	416	420	421	418	416	418	418	419	419	420	420	421	420	423	422	414	406	401	417
,, 27	404	406	409	416	413	416	418	421	421	424	425	426	425	424	425	425	430	428	425	425	427	422	413	412	420
,, 28	413	415	418	423	427	427	409	411	425	427	424	424	426	419	423	424	424	425	425	426	425	421	417	409	421
,, 29	415	420	423	428	426	426	428	429	427	429	426	426	426	427	427	428	429	429	426	422	415	413	412	422	424
,, 30	432	432	432	433	433	432	432	433	434	435	435	434	432	433	436	429	431	431	433	431	429	426	418	414	431
,, 31	418	421	423	426	428	423	423	424	424	422	419	420	427	422	426	423	417	417	417	422	422	424	417	407	421
Means ..	401	406	411	417	421	421	421	422	423	425	425	426	425	425	424	424	425	425	426	426	425	418	407	402	420

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean
1914.																									
April 1	43·9	45·6	47·7	47·8	47·6	46·4	45·7	44·5	42·8	44·0	43·9	38·3	40·4	39·3	43·9	46·7	42·5	45·6	46·8	46·4	43·7	42·2	41·4	42·8	44·2
,, 2	44·5	45·0	45·6	45·6	45·0	44·4	43·9	43·9	43·9	43·9	43·8	43·9	43·4	43·3	43·4	43·3	43·8	43·4	43·9	43·3	42·8	42·2	41·6	43·3	43·8
,, 3	45·0	46·4	46·2	45·6	44·8	43·9	43·9	44·0	43·9	43·9	43·8	42·5	42·3	43·3	43·7	43·7	44·6	44·5	43·6	43·9	43·3	42·5	41·6	41·6	43·9
,, 4	43·7	45·8	46·7	47·3	46·6	45·0	44·7	44·5	43·9	43·9	43·9	43·9	43·5	43·7	43·6	43·4	43·4	43·3	43·9	43·3	43·4	42·3	42·4	42·8	44·1
,, 5	44·5	46·2	47·3	47·3	46·6	45·0	44·9	44·9	44·5	44·5	42·2	42·2	43·4	43·4	43·4	43·4	43·3	43·8	43·8	43·3	42·8	41·1	40·5	41·1	43·9
,, 6	43·3	44·5	44·9	47·8	47·0	46·2	45·0	44·5	37·6	32·1	39·9	42·2	42·2	44·4	41·1	40·5	55·7	42·1	50·1	51·3	47·3	43·3	47·7	43·3	44·4
,, 7	44·5	45·0	46·7	50·0	49·1	45·6	44·5	44·5	44·5	44·5	43·9	43·3	43·3	43·3	43·3	43·2	43·3	43·3	43·3	43·3	42·8	42·1	41·1	43·9	44·3
,, 8	43·9	45·6	46·2	45·0	46·7	46·0	40·0	43·4	33·2	41·0	42·2	42·2	44·1	44·4	44·5	44·5	44·5	47·9	46·2	43·4	42·2	41·1	42·2	43·3	43·5
,, 9	45·7	46·7	46·8	46·6	45·6	44·6	43·2	43·3	43·3	43·3	43·4	43·4	43·5	43·5	44·4	43·4	43·9	45·0	44·5	43·9	43·9	42·7	41·6	41·6	44·1
,, 10	44·5	45·9	46·7	46·7	45·7	44·6	44·5	41·1	43·3	41·2	43·3	43·3	43·4	43·9	45·6	44·6	43·4	43·3	43·6	43·7	43·3	41·6	41·1	41·1	43·7
,, 11	44·1	45·0	46·6	46·8	46·2	44·9	44·1	44·5	43·9	43·7	42·9	42·3	42·5	43·3	43·9	44·5	44·5	44·5	44·6	43·8	43·8	42·8	41·9	41·9	44·0
,, 12	45·2	46·9	48·4	48·5	46·2	45·8	45·5	45·2	44·1	43·3	42·9	43·6	43·3	43·3	44·5	44·4	43·7	44·5	43·9	43·3	42·8	41·8	41·3	41·3	44·3
,, 13	43·9	46·7	47·3	46·7	46·2	45·7	44·6	44·5	44·1	42·5	43·0	42·8	43·3	44·6	43·9	42·2	44·5	44·4	44·5	43·9	42·5	41·6	41·3	42·2	44·0
,, 14	44·6	47·5	49·0	48·4	46·7	45·6	45·5	45·0	44·8	44·8	44·1	43·9	43·7	43·3	43·9	43·9	43·3	43·9	43·9	43·9	42·9	42·2	42·3	42·3	44·6
,, 15	45·0	46·7	47·7	47·0	46·7	45·9	45·5	45·0	43·9	45·0	44·6	44·0	44·1	43·9	43·3	43·9	44·4	44·1	44·4	43·9	42·8	42·0	41·6	42·2	44·5
,, 16	46·2	47·3	48·3	48·6	47·4	46·4	44·4	45·0	44·5	44·6	44·6	44·2	40·5	44·6	44·0	45·0	43·9	43·9	45·5	45·0	42·9	42·2	42·1	43·7	44·8
,, 17	47·3	47·3	47·2	47·0	46·4	45·4	45·0	44·2	44·4	43·9	43·2	43·6	43·6	43·7	44·4	44·2	44·1	43·9	43·8	43·4	42·2	41·3	41·2	42·5	44·3
,, 18	46·2	46·7	47·8	47·5	46·2	44·8	44·1	44·2	43·7	43·3	43·8	43·3	43·6	43·9	44·5	44·8	44·5	44·5	43·9	43·3	43·2	42·2	42·2	42·2	44·4
,, 19	45·0	47·5	49·0	49·5	47·9	45·0	45·6	44·9	44·8	44·5	43·3	43·7	43·9	43·9	44·4	43·9	44·5	44·5	44·0	43·9	43·3	42·2	41·3	43·3	44·7
,, 20	45·6	48·1	48·3	47·3	46·2	44·9	43·9	44·2	44·0	44·5	44·5	44·1	43·9	44·5	44·2	43·9	44·2	44·1	44·1	43·7	43·8	42·9	42·2	42·8	44·6
,, 21	45·0	46·6	47·5	47·5	45·7	45·0	44·5	44·5	44·2	43·9	43·4	43·3	42·2	43·9	43·9	43·9	43·9	43·9	43·4	43·7	43·3	42·2	42·1	43·3	44·2
,, 22	45·0	47·4	47·3	47·3	46·3	44·9	44·1	44·5	44·5	43·9	43·8	44·2	44·4	44·2	44·2	44·4	44·2	43·9	43·3	43·3	43·2	42·8	42·7	43·3	44·5
,, 23	45·0	46·2	46·9	47·3	46·5	45·1	44·8	44·6	44·1	44·6	44·1	44·5	44·5	44·4	42·8	44·9	45·6	44·5	44·1	45·0	43·7	43·4	44·5	44·5	44·8
,, 24	45·4	46·7	47·5	47·5	46·2	45·1	44·5	43·9	44·6	44·1	43·9	43·6	43·9	43·9	45·1	45·6	45·0	44·5	44·8	45·0	43·9	42·8	42·1	44·2	44·7
,, 25	44·8	46·5	46·5	47·3	45·6	45·0	45·0	45·0	44·1	43·9	43·3	43·3	43·9	44·4	44·5	44·5	44·5	44·5	43·9	43·4	43·4	42·8	42·8	42·8	44·4
,, 26	45·6	47·3	48·2	48·1	46·8	45·6	45·0	45·1	44·9	44·8	44·5	43·9	43·9	43·4	43·1	44·5	44·5	44·4	43·9	43·4	42·4	42·2	41·8	42·5	44·6
,, 27	44·7	46·6	48·2	47·8	46·6	45·8	45·0	45·0	44·7	44·9	44·5	44·4	44·1	44·5	44·5	45·0	44·6	45·6	44·7	44·5	43·3	42·8	42·2	42·8	44·4
,, 28	44·5	46·2	48·4	47·5	46·7	45·5	45·0	44·5	44·5	44·4	43·3	43·3	43·2	43·9	44·4	44·5	45·0	44·5	43·9	43·4	42·3	41·1	41·2	43·2	44·4
,, 29	45·6	46·7	47·7	46·7	45·7	45·0	44·0	43·0	44·5	43·9	43·9	43·9	43·9	43·9	44·5	44·5	44·5	44·5	44·5	43·9	43·3	42·2	42·4	43·4	44·4
,, 30	46·2	46·7	47·0	46·7	45·6	44·6	44·1	44·4	43·9	43·9	43·9	43·7	43·7	43·9	44·5	44·5	44·4	44·4	43·9	43·3	43·3	42·2	42·2	42·2	44·3
Means ..	44·9	46·4	47·3	47·3	46·4	45·2	44·5	44·3	43·6	43·5	43·5	43·3	43·3	43·7	44·0	44·1	44·5	44·3	44·4	44·1	43·3	42·2	42·1	42·7	44·3

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
April 1	408	408	413	406	418	422	419	421	430	420	422	427	414	415	436	406	431	417	426	445	432	426	417	411	420
„ 2	409	415	415	415	416	420	422	426	426	429	428	427	425	430	429	432	427	424	425	425	425	422	418	413	423
„ 3	410	408	416	422	424	425	422	424	426	431	430	434	429	421	419	417	417	422	421	423	425	420	416	411	421
„ 4	403	406	403	410	414	418	416	420	423	423	423	425	422	422	420	422	422	423	423	427	427	425	418	408	418
„ 5	398	401	410	414	419	422	424	426	425	418	417	416	417	417	420	419	419	421	426	429	431	429	425	425	419
„ 6	412	414	417	424	422	429	427	393	434	346	363	388	388	434	377	390	447	395	356	429	373	373	349	380	398
„ 7	368	382	397	402	385	389	392	397	399	405	402	405	403	406	411	404	404	410	423	418	420	414	409	389	401
„ 8	404	401	379	374	382	372	406	387	382	384	389	396	407	405	406	409	408	408	412	410	405	410	385	390	396
„ 9	390	390	403	403	400	398	398	402	405	405	406	411	409	409	410	413	409	410	410	416	413	400	404	404	405
„ 10	415	409	419	419	419	418	416	416	414	416	413	422	415	416	408	409	399	408	409	398	402	400	405	405	411
„ 11	412	417	415	419	416	415	425	413	416	409	413	414	413	412	409	409	412	413	411	406	400	403	408	408	412
„ 12	388	398	408	393	408	403	397	394	399	408	410	412	414	416	421	428	427	427	428	428	414	409	400	392	409
„ 13	382	389	399	405	412	408	395	408	412	412	412	413	413	416	416	417	419	420	419	421	419	413	406	383	409
„ 14	391	399	408	418	419	415	415	422	423	424	420	420	419	419	420	424	422	424	423	423	423	417	410	400	417
„ 15	401	409	412	418	420	419	419	421	423	426	426	425	422	419	421	419	418	418	420	418	422	419	411	411	418
„ 16	411	411	408	405	405	406	405	412	420	424	430	426	434	425	422	421	421	448	425	425	408	419	413	409	418
„ 17	400	400	409	415	403	407	414	417	420	421	419	419	419	419	417	419	419	422	421	421	420	416	417	417	415
„ 18	394	396	404	413	417	421	422	421	424	426	425	422	420	420	418	420	423	423	424	423	419	415	408	401	417
„ 19	411	406	406	401	405	385	408	410	408	410	417	417	420	419	418	418	418	421	421	421	419	408	395	390	410
„ 20	397	402	404	414	417	415	419	422	422	424	424	422	423	424	420	423	422	423	423	425	423	413	405	404	417
„ 21	405	408	409	416	409	412	419	422	421	417	420	418	451	420	424	423	425	424	426	426	426	426	419	417	420
„ 22	412	408	409	416	419	418	416	416	416	421	422	422	420	422	423	423	423	423	427	427	425	420	412	409	419
„ 23	402	405	412	421	426	427	425	427	427	427	425	426	424	428	436	421	421	428	426	428	424	412	405	410	421
„ 24	405	405	407	413	421	422	422	423	425	420	418	423	424	419	424	426	426	427	426	426	428	425	420	410	420
„ 25	402	405	413	415	414	415	414	416	424	424	424	422	425	422	425	424	425	425	426	425	424	418	411	411	419
„ 26	401	403	411	413	416	418	411	411	413	413	416	418	424	422	417	417	417	419	421	422	422	416	414	412	415
„ 27	407	406	417	427	429	427	429	429	431	431	431	431	430	430	430	430	429	429	431	436	429	420	412	400	425
„ 28	402	409	415	417	419	419	415	419	424	419	417	419	422	421	417	417	417	419	422	422	424	417	412	404	417
„ 29	402	407	409	409	413	417	421	421	423	427	427	424	424	422	423	422	424	422	424	427	427	417	409	406	419
„ 30	407	412	417	422	409	414	414	418	425	427	426	425	421	421	421	421	424	423	424	423	423	418	411	406	419
Means ..	402	404	409	412	413	413	414	415	419	416	417	419	420	420	419	418	420	420	420	423	419	415	408	405	415

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
May 1	45·2	46·7	47·3	46·7	45·9	45·0	44·5	44·5	44·4	44·5	43·3	43·9	44·5	44·4	44·5	44·5	44·5	44·5	44·5	43·2	43·3	42·2	42·8	43·3	44·5
,, 2	45·0	46·2	46·7	47·7	47·8	47·8	45·7	45·0	44·5	44·5	44·4	43·3	42·2	43·4	43·9	44·2	44·4	44·4	44·2	43·9	43·4	43·3	43·3	43·3	44·7
,, 3	44·6	46·7	46·8	46·7	45·6	45·0	44·5	44·5	44·2	43·9	43·4	43·4	43·3	43·3	43·4	43·4	43·9	43·9	43·9	43·8	43·4	42·8	43·1	43·9	44·2
,, 4	44·8	45·2	45·6	45·6	45·6	44·6	43·9	43·9	43·9	43·9	43·8	43·9	43·3	43·3	43·4	43·8	43·7	43·9	43·8	43·6	43·9	43·8	43·3	43·4	44·1
,, 5	46·2	46·7	47·3	46·7	45·7	45·0	44·5	44·5	44·6	44·6	44·5	44·4	44·5	43·9	44·5	44·5	44·4	44·4	44·4	43·9	43·3	42·3	42·8	43·3	44·6
,, 6	45·0	45·6	46·7	46·2	45·6	45·0	44·5	44·5	44·5	44·4	43·3	43·3	44·5	44·5	44·5	44·5	44·5	45·0	43·3	43·9	44·4	43·3	43·9	44·5	44·6
,, 7	45·0	46·7	46·7	46·6	46·5	45·6	44·6	44·7	44·5	44·5	43·3	42·2	43·9	43·9	44·5	44·5	44·5	44·5	43·9	43·9	43·3	42·8	43·3	43·3	44·5
,, 8	45·6	46·7	47·3	46·8	46·7	45·2	44·5	44·5	43·9	43·9	43·8	43·0	42·4	44·4	44·5	44·5	44·5	44·5	43·9	43·7	43·3	42·8	43·3	43·3	44·5
,, 9	44·5	45·6	46·2	45·8	45·6	45·0	44·5	44·5	44·4	44·5	43·3	43·9	44·5	44·5	44·6	44·6	44·5	44·5	44·5	44·5	43·4	42·5	42·8	42·8	44·4
,, 10	44·8	46·7	47·3	47·7	47·0	46·2	45·2	45·0	44·6	44·5	44·6	44·5	44·5	44·6	45·0	45·1	45·0	44·5	44·5	44·4	44·0	43·3	43·0	43·3	45·0
,, 11	45·1	47·9	47·9	46·7	46·0	44·9	44·6	44·1	43·9	44·2	44·0	43·3	43·3	43·4	43·9	44·5	44·5	43·9	44·4	43·9	44·4	42·8	42·8	43·9	44·5
,, 12	45·6	47·3	47·8	47·0	46·2	44·9	44·5	44·5	43·9	44·0	43·9	43·7	43·9	43·9	44·5	44·5	44·6	44·5	44·5	44·0	44·5	44·5	44·5	44·4	44·8
,, 13	45·0	46·2	46·2	45·6	45·6	44·8	44·0	44·5	43·9	44·5	43·9	42·2	43·3	43·9	43·9	44·5	44·5	44·5	44·5	44·5	43·9	43·3	44·5	44·8	44·4
,, 14	45·5	46·7	46·7	46·2	45·9	45·6	44·6	44·5	43·9	44·2	44·5	44·5	43·9	43·4	44·5	44·5	44·5	44·5	44·5	44·5	44·5	44·0	44·0	44·5	44·8
,, 15	45·2	45·2	46·2	46·2	45·7	45·0	44·5	44·2	44·0	43·9	44·0	43·3	41·4	41·9	42·8	43·4	43·3	43·9	43·9	44·5	44·5	44·6	44·2	44·5	44·2
,, 16	45·0	46·2	46·7	46·2	46·2	42·9	43·9	43·9	43·7	44·6	42·3	43·0	44·4	43·9	44·5	43·8	44·0	43·9	44·4	44·9	45·0	44·5	43·3	43·3	44·4
,, 17	44·5	45·6	45·5	45·7	46·2	47·8	46·7	46·2	43·4	46·8	44·5	44·2	45·0	45·0	44·5	44·5	44·5	44·5	44·5	44·5	45·0	44·5	44·5	44·1	45·1
,, 18	45·0	46·0	46·2	46·4	45·7	45·4	44·7	45·0	44·7	45·0	44·7	44·5	44·5	44·5	44·6	44·6	44·7	44·6	45·0	45·2	45·6	45·0	45·6	44·9	45·1
,, 19	43·9	45·0	45·6	45·6	45·4	45·0	44·8	45·0	44·7	43·9	43·9	44·1	44·4	44·0	44·0	44·5	44·5	44·5	44·5	44·5	44·4	43·2	42·8	43·3	44·4
,, 20	43·9	45·0	46·3	46·4	45·6	45·0	44·6	44·2	44·4	44·5	44·6	44·7	44·4	44·5	44·5	44·5	44·6	44·6	44·5	44·4	44·2	43·3	43·4	43·9	44·6
,, 21	45·6	47·3	47·9	46·8	46·2	45·0	45·0	45·0	45·0	44·8	44·6	44·6	44·7	43·9	44·5	44·5	45·0	44·5	44·6	44·5	44·6	44·4	44·5	44·9	45·1
,, 22	45·0	47·2	48·4	48·4	46·6	45·6	44·8	44·5	44·4	44·5	44·5	44·5	44·4	45·0	44·7	45·0	45·2	44·8	44·7	44·5	44·4	43·9	43·9	43·9	45·1
,, 23	45·4	47·3	47·8	47·7	46·2	45·0	44·5	44·4	43·3	43·9	45·0	43·9	44·2	44·5	44·5	44·6	44·8	44·7	45·0	44·0	43·9	43·7	43·9	43·8	44·8
,, 24	44·8	46·6	47·6	47·6	47·0	45·2	45·6	44·8	45·0	44·1	44·4	44·4	44·5	44·5	44·5	44·5	44·5	44·5	44·5	44·4	44·4	43·9	43·4	43·9	44·9
,, 25	45·9	47·3	47·3	47·3	46·2	45·1	44·5	44·5	44·5	44·5	44·6	44·6	44·5	44·6	44·8	45·2	45·1	45·0	45·0	43·9	44·6	43·9	44·5	45·5	45·1
,, 26	45·6	46·6	46·7	46·2	45·5	44·5	43·9	43·9	43·9	44·0	44·5	42·8	42·2	41·6	42·8	43·3	48·6	43·3	43·4	44·9	44·5	44·5	45·0	45·0	44·5
,, 27	46·2	46·2	46·7	46·2	45·5	45·0	44·5	44·5	44·5	44·4	44·4	44·5	44·5	44·6	44·7	45·0	45·0	44·9	44·5	44·5	44·4	43·9	43·9	43·9	44·8
,, 28	45·0	45·0	45·6	46·2	45·6	43·9	43·9	44·1	43·9	44·0	44·1	42·8	42·2	43·2	44·2	44·5	45·0	44·5	44·5	44·1	44·1	43·9	44·5	44·5	44·3
,, 29	45·6	45·6	45·5	44·9	44·5	44·5	44·5	44·4	44·5	43·9	43·9	43·9	44·5	44·5	44·5	44·6	45·0	45·0	44·6	44·5	44·5	44·5	44·5	44·4	44·6
,, 30	44·5	45·6	45·5	45·0	45·6	45·0	44·5	44·6	44·5	44·5	44·5	44·5	44·5	44·5	44·5	45·0	45·0	45·4	45·0	45·0	44·6	44·5	44·5	44·5	44·8
,, 31	44·5	45·5	45·6	45·9	45·9	45·6	44·6	44·5	44·5	44·2	43·9	43·2	43·9	43·3	44·5	44·5	44·8	46·7	43·4	44·5	44·9	44·5	44·5	44·5	44·7
Means	45·1	46·3	46·7	46·5	46·0	45·2	44·6	44·5	44·3	44·4	44·1	43·8	43·9	44·0	44·3	44·4	44·7	44·5	44·3	44·3	44·2	43·7	43·8	44·0	44·6

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
May 1	399	403	407	415	419	420	421	422	421	421	425	423	423	418	417	417	419	422	423	425	428	428	423	415	419
,, 2	405	405	405	406	412	406	409	421	419	420	420	427	425	422	422	421	424	426	426	427	426	425	422	420	418
,, 3	411	406	411	413	418	420	422	423	425	423	423	425	429	426	425	422	421	422	426	426	429	427	426	426	422
,, 4	421	416	412	413	419	425	427	431	430	431	431	430	426	425	425	425	425	426	428	430	435	433	430	428	426
,, 5	418	420	425	425	425	430	432	435	431	428	429	429	429	432	429	429	429	434	433	431	433	430	428	423	429
,, 6	418	418	416	416	421	428	430	431	428	426	425	426	427	427	425	427	426	432	437	425	427	426	420	413	425
,, 7	424	420	410	403	398	400	408	420	417	413	413	417	416	416	417	422	419	421	421	424	423	415	421	417	416
,, 8	407	407	409	406	414	421	413	413	411	413	414	420	415	418	420	420	420	421	419	419	418	419	419	418	416
,, 9	412	414	412	417	421	421	425	422	423	424	425	423	423	421	421	421	421	420	423	421	420	418	414	412	420
,, 10	405	405	405	407	410	412	416	423	423	423	423	422	420	425	426	424	427	427	429	429	431	428	422	422	420
,, 11	413	420	425	428	428	429	430	431	433	433	427	425	428	424	421	426	431	431	430	431	428	424	424	416	426
,, 12	409	413	414	419	426	425	425	425	425	425	425	425	425	423	421	422	423	424	426	426	429	429	431	431	424
,, 13	416	421	424	421	418	419	427	428	429	430	427	429	426	425	425	425	426	428	428	428	428	426	424	420	425
,, 14	417	416	419	418	425	427	428	428	427	431	428	427	422	421	421	422	425	427	427	427	427	427	428	424	425
,, 15	421	421	420	424	427	429	425	427	428	424	421	414	413	413	418	415	415	420	425	426	427	419	424	410	421
,, 16	386	396	405	408	415	391	411	419	419	418	408	409	419	417	424	418	416	418	422	418	422	421	421	421	413
,, 17	416	409	404	402	416	394	399	411	387	404	398	411	420	417	412	413	415	416	417	417	421	425	429	425	412
,, 18	417	421	417	425	421	423	427	420	421	421	420	419	418	418	416	416	414	416	418	418	422	425	426	426	420
,, 19	423	413	407	401	401	405	403	407	409	411	413	411	415	415	415	414	415	416	417	417	423	427	423	416	413
,, 20	405	405	407	409	413	415	415	416	419	422	421	421	419	419	418	417	418	423	423	424	426	427	421	416	417
,, 21	405	406	411	412	418	421	420	421	422	424	425	426	425	428	423	423	423	424	427	427	427	420	414	414	420
,, 22	416	416	419	419	422	424	427	427	427	427	427	427	424	428	421	424	420	422	424	424	425	421	419	412	423
,, 23	406	404	408	418	421	421	424	422	423	424	424	424	422	422	422	422	422	422	423	425	428	427	423	413	420
,, 24	413	413	418	419	423	423	415	418	413	407	411	412	412	411	415	414	420	418	421	422	423	423	423	416	417
,, 25	411	414	419	425	427	429	426	426	426	425	425	425	421	421	423	424	426	424	426	431	422	430	421	416	423
,, 26	408	413	412	417	421	420	426	427	421	423	417	409	407	405	409	412	418	425	418	420	425	422	413	420	417
,, 27	418	418	418	422	422	418	418	422	413	425	422	421	418	418	418	419	420	422	422	424	422	420	420	415	420
,, 28	410	410	410	411	418	420	421	422	422	423	422	420	420	415	415	415	418	420	422	425	425	427	430	427	420
,, 29	419	418	418	421	421	421	421	419	418	420	420	420	419	420	420	420	423	423	423	423	425	426	429	424	421
,, 30	417	417	416	434	422	422	424	426	423	424	424	423	423	420	420	420	420	420	424	427	430	430	430	430	424
,, 31	421	416	416	415	419	424	427	431	430	426	424	424	421	428	428	431	426	421	421	434	438	436	428	428	426
Means ..	412	413	414	416	419	419	421	423	421	422	421	421	421	421	420	421	421	423	423	425	426	425	423	420	421

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
June 1	46·3	47·9	50·7	47·4	46·7	45·7	44·7	44·6	44·2	39·4	43·0	44·6	44·3	44·5	45·7	44·9	45·0	45·6	45·1	45·1	44·6	43·4	43·4	44·0	45·0
„ 2	45·1	46·0	46·5	46·3	45·7	45·1	44·6	44·7	44·6	44·6	44·5	43·5	43·7	42·9	44·5	44·6	44·6	44·6	46·3	45·7	45·1	44·7	45·7	45·7	45·0
„ 3	44·6	45·7	46·7	47·4	46·9	46·7	44·6	45·1	44·0	44·6	42·9	43·4	43·0	43·4	43·9	44·0	44·6	44·6	44·6	45·3	45·7	45·1	45·1	45·1	44·5
„ 4	45·7	45·7	46·3	46·3	45·2	44·6	44·0	44·6	44·6	44·5	44·0	44·5	43·4	44·6	44·6	44·6	45·1	44·9	45·1	44·7	44·6	44·0	44·0	44·5	44·3
„ 5	45·1	45·1	46·1	46·3	45·7	44·8	44·0	44·6	44·0	44·0	44·1	44·1	44·2	44·0	44·6	44·6	44·6	45·1	45·1	44·7	44·9	44·6	44·1	44·6	44·7
„ 6	45·0	46·6	46·8	46·6	45·7	44·7	44·5	44·5	44·6	44·6	44·6	44·6	44·6	44·7	44·7	45·3	45·1	45·3	45·1	45·0	45·1	44·6	44·6	44·6	45·1
„ 7	45·7	46·5	47·4	46·8	46·0	45·6	45·7	45·0	44·6	44·6	44·5	44·5	44·0	44·6	44·7	45·1	45·1	44·9	44·6	44·6	44·5	44·5	44·0	43·8	45·1
„ 8	45·1	46·3	46·7	47·3	46·3	45·7	44·6	44·0	44·0	44·6	42·3	43·4	43·4	44·0	44·5	44·6	44·6	45·1	44·5	44·6	45·7	44·0	44·0	44·0	44·7
„ 9	45·7	45·7	46·3	46·3	45·7	44·6	44·1	44·6	44·6	44·0	44·0	44·0	44·5	44·6	44·6	44·6	44·7	44·6	44·6	43·4	44·6	44·0	44·0	44·0	44·7
„ 10	45·7	45·7	45·8	45·7	45·6	44·6	44·0	44·0	44·0	44·0	44·0	44·0	44·0	44·6	44·6	45·6	45·3	45·1	45·9	45·7	44·6	44·6	44·6	44·6	44·8
„ 11	45·1	45·1	45·8	46·3	45·9	44·6	44·2	44·5	44·6	44·6	44·6	44·5	44·2	44·6	44·7	45·1	45·2	45·3	45·1	45·0	45·7	44·5	44·0	44·0	44·9
„ 12	44·6	46·0	46·8	46·8	46·3	44·9	44·5	44·5	44·6	44·6	44·0	43·9	44·0	44·0	44·6	44·6	44·6	44·6	45·3	44·6	44·6	44·0	44·5	44·5	44·8
„ 13	45·7	46·3	46·6	47·1	46·7	45·6	45·1	44·8	44·8	44·1	44·5	44·3	44·8	44·6	44·6	44·7	44·7	44·8	44·7	44·6	44·6	44·6	44·0	44·0	45·0
„ 14	44·2	46·3	46·8	47·4	46·3	45·0	44·7	44·7	44·7	44·6	44·8	44·7	44·2	44·5	44·6	44·7	45·1	44·9	44·8	44·7	44·9	44·6	44·2	44·2	45·0
„ 15	46·3	46·3	46·9	47·0	46·3	45·0	44·6	44·7	44·6	44·6	44·6	44·5	44·6	44·6	44·6	44·7	45·1	44·9	44·9	44·8	44·6	44·5	44·1	43·5	45·0
„ 16	45·7	45·7	45·7	46·3	45·7	44·6	44·0	44·6	44·6	44·6	44·5	44·1	44·1	44·6	44·6	44·6	44·6	44·6	44·6	44·6	44·7	43·8	43·4	43·4	45·2
„ 17	46·3	46·3	46·1	46·0	46·0	45·1	44·7	44·5	44·8	44·7	44·8	44·7	44·7	44·8	45·0	45·0	44·8	44·9	45·0	45·0	44·9	44·8	44·5	44·6	45·1
„ 18	45·8	46·0	46·0	45·7	44·7	44·6	44·5	44·6	44·7	44·7	44·7	44·5	44·6	44·8	44·7	44·7	44·8	44·8	44·9	44·8	44·7	44·6	44·7	45·0	44·9
„ 19	47·4	47·4	47·9	47·4	46·8	46·8	45·6	44·7	44·2	44·6	44·0	44·0	44·5	44·6	44·6	44·8	45·1	45·3	45·1	45·0	45·1	44·9	44·6	45·1	45·4
„ 20	45·7	45·7	45·7	46·3	46·3	45·2	45·1	45·1	44·6	44·5	44·6	44·0	44·5	44·6	44·6	44·6	44·6	44·6	45·0	44·8	44·7	44·6	44·5	43·4	44·9
„ 21	44·6	45·6	45·7	46·3	46·3	45·8	44·8	44·7	44·6	44·6	44·6	44·0	44·5	44·5	44·7	44·7	45·1	45·1	45·1	44·6	44·7	44·5	43·4	43·4	44·8
„ 22	44·6	45·7	46·8	46·7	45·8	45·1	46·6	46·6	44·1	44·2	44·6	43·4	43·5	44·6	44·6	44·7	45·1	45·1	45·0	44·7	44·7	44·6	43·9	43·8	44·8
„ 23	45·7	45·7	46·4	46·7	45·7	45·1	44·5	44·5	44·6	44·6	44·6	44·6	44·6	44·7	44·8	45·0	45·1	45·1	44·9	44·6	44·5	43·5	43·5	43·5	44·9
„ 24	44·0	45·2	45·7	46·3	46·3	45·2	44·6	44·6	44·6	44·6	44·6	44·6	44·6	44·7	44·7	45·1	45·3	45·5	45·1	44·6	44·6	44·0	43·4	43·4	44·8
„ 25	43·4	44·9	45·1	45·1	45·0	45·1	44·9	46·3	44·6	44·0	41·3	42·4	44·0	44·6	41·3	41·2	44·7	44·6	44·6	44·0	44·2	46·8	47·4	47·9	44·5
„ 26	45·3	45·3	45·7	45·7	46·3	46·3	45·1	45·1	44·6	44·0	44·0	44·0	44·1	44·5	44·6	45·1	45·3	45·1	44·6	44·6	44·5	44·0	45·0	44·6	44·9
„ 27	47·9	47·9	48·0	47·9	48·5	45·7	44·0	43·4	44·6	43·3	43·4	40·6	43·1	44·6	44·6	45·1	46·8	45·7	45·1	44·8	45·1	44·0	44·6	44·6	45·1
„ 28	45·7	45·7	47·9	45·1	46·9	44·6	43·4	44·9	44·8	44·0	44·6	44·0	43·4	43·4	45·7	45·1	45·6	45·7	45·9	45·7	45·7	45·7	44·8	45·1	45·1
„ 29	45·1	46·1	46·4	46·8	45·7	45·1	45·0	45·2	42·9	44·0	45·1	45·0	45·7	44·6	44·6	45·0	45·3	45·6	45·1	45·1	45·5	46·3	45·7	45·7	45·3
„ 30	45·1	46·3	46·4	45·8	46·5	43·4	42·3	45·7	45·1	44·6	43·5	44·1	44·6	45·1	45·1	47·4	46·5	45·7	45·6	45·1	44·6	44·3	44·6	44·0	45·1
Means ..	45·4	46·0	46·3	46·5	46·1	45·2	44·6	44·8	44·5	44·5	44·1	44·0	44·2	44·4	44·6	44·8	45·1	45·1	45·0	44·7	44·9	44·5	44·7	44·4	44·9

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
June 1	377	384	340	371	391	389	388	378	383	395	392	393	400	397	397	396	401	401	405	405	408	407	407	407	392
„ 2	398	398	398	400	405	407	407	407	407	409	411	411	408	421	416	406	406	407	406	419	419	411	401	401	407
„ 3	411	409	399	405	405	405	397	404	402	403	405	409	431	414	412	411	413	413	413	418	416	416	412	412	410
„ 4	402	402	400	405	407	417	412	414	416	414	412	415	414	416	414	413	416	417	418	418	420	423	420	418	413
„ 5	398	398	400	398	401	408	408	406	398	399	411	413	420	413	408	411	418	416	418	420	422	423	425	420	410
„ 6	412	410	412	419	419	423	421	419	419	421	419	419	416	416	421	417	417	418	418	418	421	425	423	421	419
„ 7	420	417	420	417	416	416	416	416	421	420	416	416	412	415	413	417	417	419	419	420	429	432	432	429	419
„ 8	417	419	421	418	422	425	418	421	420	415	410	417	408	410	420	420	423	414	414	418	416	418	418	418	418
„ 9	413	413	413	412	413	417	415	415	410	414	413	414	414	415	415	416	418	418	418	420	421	425	425	422	416
„ 10	418	418	418	422	423	428	426	426	423	423	423	422	419	418	418	422	422	422	420	420	425	425	424	418	422
„ 11	411	411	407	406	406	415	418	418	418	418	418	418	418	418	419	422	424	425	424	420	419	422	418	417	417
„ 12	402	402	404	414	418	421	418	421	420	421	421	421	420	417	420	420	418	420	423	427	428	427	423	423	419
„ 13	414	411	411	414	419	423	422	423	421	424	423	421	420	422	422	422	423	423	424	424	424	423	422	422	421
„ 14	414	412	411	412	417	422	422	420	422	420	419	420	422	422	421	420	421	422	423	424	427	429	429	429	421
„ 15	415	417	415	414	420	424	424	424	422	424	424	422	419	419	419	419	419	421	422	423	426	423	425	421	421
„ 16	413	413	412	416	419	419	420	421	421	422	423	423	419	419	421	420	422	423	424	425	428	432	430	424	421
„ 17	414	420	421	423	426	426	427	427	427	426	423	425	423	423	425	423	423	423	424	426	427	428	429	428	424
„ 18	414	419	421	423	424	425	423	423	423	423	423	423	422	423	425	424	423	423	424	426	426	424	422	422	423
„ 19	417	417	421	418	416	403	415	417	419	419	416	417	418	416	416	419	416	420	421	427	432	425	426	417	419
„ 20	423	423	417	416	421	421	417	412	407	414	419	421	418	423	422	419	421	419	423	420	422	427	427	420	420
„ 21	413	409	406	407	410	415	413	417	418	418	419	419	418	419	419	419	421	422	425	426	427	430	428	428	419
„ 22	406	404	403	402	408	411	411	411	414	413	411	414	417	417	418	419	419	420	421	422	424	428	429	421	415
„ 23	412	412	410	407	411	414	416	415	415	416	418	416	416	418	416	416	417	419	419	420	420	422	420	418	416
„ 24	408	406	403	406	417	420	420	420	420	422	422	420	420	420	423	423	424	425	425	427	427	431	432	427	420
„ 25	415	413	422	422	432	428	422	412	399	412	407	416	416	414	414	406	399	399	396	408	409	406	418	415	413
„ 26	412	413	410	408	415	420	424	424	421	421	416	411	416	415	414	414	416	418	420	422	426	425	413	399	416
„ 27	393	393	393	393	398	405	405	403	399	400	403	437	412	410	411	410	414	415	415	417	421	417	417	415	408
„ 28	393	386	391	374	397	398	399	388	412	418	412	407	410	410	413	414	415	419	424	425	419	417	421	415	407
„ 29	409	397	402	408	411	417	417	415	407	409	430	415	430	419	413	411	413	416	419	420	425	417	422	418	415
„ 30	410	405	404	398	405	400	411	416	416	423	426	416	418	414	411	419	416	416	421	422	424	425	424	419	415
Means ..	409	408	407	408	413	415	415	414	414	416	416	417	417	416	417	416	417	418	419	421	423	423	422	419	416

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued*.

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
July 1	45·1	46·8	46·7	45·6	45·1	44·6	44·0	44·6	44·0	44·7	44·6	44·6	44·6	44·6	44·6	44·7	45·1	45·1	45·1	44·8	45·1	44·6	44·6	44·6	44·9
„ 2	46·3	46·3	46·8	46·3	45·6	44·6	44·0	43·5	44·6	44·6	44·6	44·6	44·6	44·6	44·7	44·7	44·9	45·1	45·0	44·6	44·6	44·5	43·5	43·4	44·8
„ 3	45·8	46·7	45·8	45·8	45·7	44·6	44·7	44·0	44·6	44·6	44·6	44·6	44·5	44·5	44·6	44·6	44·7	45·1	45·0	44·7	44·7	44·7	44·6	44·5	44·9
„ 4	44·0	45·1	45·7	46·1	45·7	44·6	44·6	44·6	44·6	44·7	44·6	44·5	44·0	44·6	44·7	45·1	45·1	45·2	45·1	45·0	45·6	45·1	45·1	45·1	44·9
„ 5	45·1	46·8	46·8	47·4	46·8	46·3	47·8	46·8	44·7	44·6	27·7	35·4	43·3	44·6	41·3	45·7	44·0	44·6	46·3	45·7	45·7	44·7	44·6	44·6	44·2
„ 6	44·9	46·3	46·9	45·7	45·7	45·1	44·6	44·6	43·5	44·6	44·0	42·3	44·0	44·5	44·6	45·7	45·7	45·1	45·7	45·1	45·1	44·2	44·0	44·0	44·8
„ 7	45·1	45·6	46·8	46·8	46·1	44·6	44·7	45·1	44·7	42·9	44·5	42·3	44·0	45·0	44·9	45·7	46·8	45·6	45·6	45·1	45·1	44·6	43·4	43·4	44·9
„ 8	45·7	45·7	45·7	45·7	46·3	45·3	44·6	44·6	44·6	44·6	44·6	44·6	44·6	44·9	45·1	45·7	45·7	45·7	45·6	45·1	45·1	44·6	44·6	44·6	45·1
„ 9	44·6	45·1	45·7	45·8	46·8	45·1	44·6	44·7	44·6	44·6	43·8	43·5	43·7	42·3	42·3	44·0	43·8	44·6	44·6	44·6	44·9	44·7	44·6	45·1	44·5
„ 10	47·4	47·9	49·1	47·9	46·3	44·6	44·9	44·8	44·0	44·0	43·4	42·9	41·6	41·4	42·9	44·6	44·9	44·8	45·1	44·8	45·1	44·6	44·6	43·4	44·8
„ 11	44·0	45·9	46·3	46·3	46·3	45·1	44·9	44·8	44·6	44·6	44·5	44·5	44·6	44·6	45·1	45·7	45·6	45·7	45·6	45·1	45·5	44·6	43·4	43·4	45·0
„ 12	44·0	45·6	46·3	46·0	46·7	45·5	44·9	45·1	45·1	44·7	44·6	44·6	44·6	44·6	44·7	45·1	45·1	45·7	45·6	45·3	45·7	44·7	44·0	43·4	45·1
„ 13	44·0	45·1	45·7	45·6	45·8	45·1	44·9	45·7	44·8	44·6	44·3	44·0	44·6	44·6	44·6	44·6	45·1	45·1	44·9	44·9	45·1	45·1	44·6	44·0	44·9
„ 14	44·6	45·7	46·3	45·7	46·3	45·2	44·6	44·6	44·6	44·6	44·8	44·0	44·6	44·6	44·6	44·9	45·1	45·1	45·1	45·1	45·7	44·7	44·7	44·7	45·0
„ 15	45·1	46·3	46·1	46·0	45·8	45·7	45·0	45·1	45·1	45·1	44·6	44·6	44·5	44·5	44·6	44·7	44·7	44·7	45·3	44·6	45·1	44·6	44·2	44·0	45·0
„ 16	44·6	45·3	45·7	45·7	45·1	45·1	44·1	43·1	44·5	44·6	44·6	44·6	44·6	44·6	44·6	44·8	45·3	45·3	45·1	45·1	45·1	44·6	44·6	44·6	44·8
„ 17	45·1	46·5	47·4	47·0	46·3	45·7	44·7	45·1	44·9	44·6	44·6	45·0	45·1	45·1	44·5	45·1	45·0	45·1	45·1	44·7	45·1	44·7	44·7	44·6	45·2
„ 18	44·7	46·3	46·8	46·8	46·3	45·7	45·1	45·1	45·0	45·1	44·6	43·8	42·9	44·0	45·1	45·7	45·7	45·7	45·7	45·7	45·7	45·7	45·1	44·6	45·3
„ 19	45·1	46·3	47·4	47·4	47·1	46·3	45·7	45·7	45·7	45·1	45·1	44·8	44·2	43·4	45·1	45·1	45·7	45·7	45·6	45·1	45·1	44·6	44·6	44·6	45·4
„ 20	45·7	46·7	46·7	46·7	45·7	44·6	45·1	44·7	44·7	44·6	44·0	44·0	43·8	43·4	43·4	44·6	44·6	44·6	44·7	44·6	44·6	44·0	44·0	44·0	44·7
„ 21	45·1	46·4	47·4	46·8	46·8	45·6	45·1	45·1	45·1	44·6	44·0	41·2	44·6	44·6	44·6	44·0	44·6	44·7	45·1	44·7	44·6	44·6	44·6	44·6	44·9
„ 22	46·3	45·8	47·9	47·9	47·4	45·7	45·1	45·1	44·9	45·1	44·6	42·3	43·4	43·4	44·6	45·1	45·7	45·8	45·6	45·1	45·1	45·1	45·6	44·1	45·3
„ 23	44·6	45·8	46·8	47·4	46·3	45·0	43·4	44·6	44·9	44·0	44·6	44·6	44·6	44·6	44·7	45·7	45·7	46·3	45·3	45·1	45·1	45·7	45·7	45·1	45·2
„ 24	44·6	45·1	46·1	46·7	45·7	45·1	44·6	45·1	45·1	44·7	44·6	44·0	44·1	44·0	44·9	45·2	45·7	45·7	45·1	45·1	45·2	45·1	45·6	44·6	45·1
„ 25	44·8	46·0	46·8	47·4	46·7	44·6	27·1	44·0	44·6	44·0	43·9	40·1	44·0	45·7	46·3	45·7	45·7	45·7	45·7	45·7	45·7	45·7	45·7	44·0	44·4
„ 26	44·0	45·1	45·8	47·3	45·7	43·4	45·1	45·1	46·7	43·4	44·0	43·4	46·0	46·0	45·6	45·7	45·7	46·3	45·7	45·7	46·3	45·2	45·1	44·6	45·2
„ 27	45·7	45·7	46·3	45·7	46·3	45·7	45·1	45·1	45·7	45·6	44·0	43·4	44·0	43·5	46·8	44·6	45·7	45·7	45·7	45·7	45·7	44·7	44·6	44·6	45·2
„ 28	44·0	45·1	46·1	46·8	46·5	45·7	42·3	45·7	42·4	45·6	44·5	44·6	44·6	43·4	45·1	46·8	45·7	45·7	45·7	45·1	45·7	45·1	44·0	44·5	45·0
„ 29	44·6	45·1	44·6	46·0	45·8	45·1	44·6	45·1	45·1	44·0	45·7	41·7	39·5	39·3	32·2	32·7	40·1	41·2	46·8	44·6	45·7	44·6	44·6	44·6	43·1
„ 30	46·8	47·4	47·4	46·8	46·8	46·3	46·3	43·4	45·6	45·1	42·5	44·0	42·3	45·1	41·2	44·7	44·6	44·0	44·6	45·1	46·3	45·7	46·8	46·8	45·2
„ 31	46·3	46·8	47·9	45·1	45·7	45·1	41·2	40·6	43·4	44·6	43·4	45·1	44·2	44·6	45·6	45·7	51·2	44·6	44·7	45·7	45·7	44·7	44·6	45·1	45·1
Means ..	45·1	46·0	46·6	46·5	46·2	45·2	44·1	44·7	44·7	44·6	43·8	43·5	44·0	44·1	44·1	44·7	45·3	45·1	45·3	45·2	45·3	44·8	44·7	44·4	44·9

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
July 1	412	411	407	408	417	420	419	419	419	419	422	421	417	417	417	417	423	419	420	422	424	427	427	424	419
„ 2	405	405	407	410	414	418	417	419	419	419	418	419	415	416	417	417	417	419	420	422	424	428	429	424	417
„ 3	417	409	408	411	418	424	424	423	421	417	420	422	423	420	420	421	421	423	424	426	431	435	438	433	422
„ 4	423	418	416	414	418	422	419	419	418	417	419	418	419	418	418	418	419	421	423	423	428	431	431	431	421
„ 5	421	416	435	441	431	408	397	383	391	378	381	396	383	390	398	425	395	388	392	400	407	407	404	404	403
„ 6	394	394	380	402	409	412	411	407	407	406	405	411	404	407	406	407	409	410	412	410	412	414	412	407	406
„ 7	392	392	393	399	407	411	413	413	410	408	410	411	403	406	414	412	415	413	415	416	418	421	423	416	410
„ 8	399	401	401	409	416	421	419	419	417	417	416	415	417	415	416	415	417	417	420	423	424	428	427	420	416
„ 9	408	406	401	405	411	418	417	417	417	415	416	415	412	427	415	417	419	419	420	423	424	420	414	404	415
„ 10	396	394	394	401	401	406	406	405	410	407	407	429	417	417	420	412	413	417	420	417	425	425	420	418	411
„ 11	406	402	402	406	410	408	415	414	415	416	414	414	414	414	414	414	417	418	420	420	422	425	425	425	415
„ 12	410	405	405	406	415	416	420	418	419	418	418	418	415	415	415	418	418	420	420	422	428	425	422	422	417
„ 13	413	411	411	415	420	425	421	414	417	420	421	423	420	417	424	424	419	420	422	423	428	428	429	425	420
„ 14	403	409	406	410	417	425	422	424	424	424	419	419	417	417	415	413	417	418	420	422	428	427	429	423	419
„ 15	419	417	411	414	419	420	417	421	422	422	421	418	416	416	415	415	414	416	421	426	430	437	440	440	421
„ 16	418	421	414	414	413	414	412	413	419	422	422	419	418	418	419	421	423	423	426	428	430	432	435	435	421
„ 17	420	418	419	417	422	423	423	423	422	422	423	422	420	422	420	420	422	423	425	425	430	432	433	427	423
„ 18	420	420	419	421	424	425	425	425	422	422	421	420	415	415	415	420	420	424	429	425	427	432	425	422	422
„ 19	410	409	411	412	414	419	419	416	416	419	418	418	419	414	414	415	414	416	418	418	422	423	423	423	417
„ 20	410	410	413	411	408	410	410	413	411	406	415	410	411	415	413	413	423	416	418	420	426	423	420	418	414
„ 21	410	408	407	408	411	418	417	416	417	415	418	417	420	418	414	429	416	416	421	424	428	431	426	416	418
„ 22	407	404	406	409	419	421	422	422	421	417	404	409	411	413	415	412	412	421	416	419	426	426	423	421	416
„ 23	412	405	410	403	410	415	413	415	415	417	413	415	416	417	418	416	416	415	421	421	424	428	428	421	416
„ 24	416	415	416	416	418	420	416	418	415	416	417	418	417	415	416	417	420	420	424	420	427	412	410	419	417
„ 25	403	403	407	404	410	400	349	390	403	397	403	405	404	404	416	407	408	410	414	414	419	417	414	411	405
„ 26	403	402	385	387	379	402	411	411	432	387	419	407	409	407	407	411	419	411	413	416	418	416	412	412	407
„ 27	410	417	413	398	407	413	416	416	412	404	423	406	408	406	415	415	411	411	412	415	421	429	432	429	414
„ 28	419	410	404	400	396	390	397	392	439	406	400	411	412	409	406	411	402	406	406	408	419	423	413	409	410
„ 29	409	409	411	413	416	413	410	413	409	404	421	413	390	414	419	422	402	437	427	372	380	383	397	390	407
„ 30	380	378	378	392	389	385	390	395	395	385	390	385	391	408	387	406	401	399	403	408	411	403	401	401	394
„ 31	387	401	403	384	395	396	404	410	401	403	415	452	394	399	399	409	409	426	397	394	407	409	412	412	405
Means ..	408	407	406	408	411	413	412	413	415	411	414	415	411	413	413	416	415	417	417	417	421	422	422	419	414

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
August 1	45·8	45·8	46·4	46·9	46·4	45·2	45·1	43·5	45·7	45·2	44·7	43·4	44·6	44·7	45·2	45·8	45·2	46·4	46·4	45·2	45·7	46·4	45·2	44·8	45·4
„ 2	45·8	46·9	47·9	47·5	46·9	46·4	45·7	43·0	41·3	44·6	44·8	44·6	44·7	45·2	45·8	46·4	48·0	45·7	45·8	45·8	45·8	44·8	43·5	43·5	45·4
„ 3	44·7	45·8	47·5	47·9	46·9	45·8	45·2	46·4	41·3	43·4	41·3	45·7	43·9	44·6	43·0	46·4	44·0	46·1	44·9	45·8	48·4	49·7	44·8	44·7	45·3
„ 4	45·1	46·4	48·1	47·6	47·7	46·4	43·5	41·8	42·4	40·7	44·1	44·1	44·8	45·2	45·1	44·8	45·9	46·4	46·0	45·8	45·8	44·7	43·5	44·1	45·0
„ 5	44·1	45·0	46·4	47·9	47·5	45·2	45·0	45·7	45·2	45·2	44·9	44·7	44·7	44·8	45·2	45·4	45·8	45·8	45·8	45·7	45·7	44·7	44·7	44·1	45·4
„ 6	44·1	45·8	48·0	49·2	49·7	48·0	44·7	47·0	46·8	45·2	44·7	44·8	44·7	45·3	45·7	45·8	45·8	48·6	45·8	46·9	46·9	49·0	46·9	46·4	46·5
„ 7	46·4	47·2	49·0	49·3	48·6	46·9	45·8	45·8	45·2	45·8	44·8	45·2	44·8	45·2	43·9	44·8	45·2	45·2	45·2	45·1	45·7	44·7	44·1	44·6	45·8
„ 8	45·2	45·2	45·8	46·9	46·9	46·8	45·8	45·8	45·2	43·5	44·6	44·7	45·2	45·6	45·6	45·8	45·8	46·2	46·4	46·1	46·4	45·8	45·2	45·2	45·7
„ 9	43·5	44·8	47·5	47·5	47·5	46·9	45·8	45·8	45·8	45·2	45·2	44·7	44·8	44·7	44·8	45·8	45·7	45·8	45·7	45·2	45·8	45·1	43·6	43·2	45·4
„ 10	44·1	45·8	47·5	48·0	48·4	47·9	45·8	45·2	45·8	46·4	45·2	44·7	44·6	45·2	45·2	45·8	45·7	45·8	46·0	45·7	45·8	45·4	44·7	44·1	45·8
„ 11	44·6	46·4	48·0	48·0	48·0	47·5	46·4	45·7	45·8	45·8	45·3	43·6	44·7	44·4	44·7	45·3	45·2	45·8	45·8	46·2	46·9	46·6	45·8	45·7	45·9
„ 12	45·2	46·9	47·5	47·9	47·5	46·9	45·8	45·8	45·3	45·2	45·4	45·1	45·0	45·2	45·8	45·8	45·8	45·9	45·8	45·8	45·8	45·2	44·7	44·1	45·8
„ 13	44·7	45·8	46·9	46·9	46·9	45·9	45·8	45·7	45·8	44·8	43·5	43·5	44·7	44·7	44·8	45·2	45·8	45·8	45·8	45·2	45·7	44·2	43·5	43·5	45·2
„ 14	44·6	45·0	45·8	45·4	46·9	46·4	45·8	45·7	45·2	45·2	45·2	43·5	44·1	44·8	43·5	44·7	45·2	45·7	45·2	45·2	45·6	44·7	43·6	43·6	45·0
„ 15	44·7	45·8	46·9	47·9	47·5	46·9	44·7	45·8	44·7	44·7	44·8	44·7	44·7	44·8	44·7	44·8	44·9	45·1	45·2	45·2	45·8	44·7	44·1	44·1	45·3
„ 16	44·7	45·8	46·8	48·0	47·5	46·9	45·7	45·2	45·7	45·7	45·7	45·2	44·7	44·7	44·7	44·7	45·7	45·6	45·2	44·8	45·8	45·0	44·7	44·7	45·5
„ 17	44·7	44·1	46·9	47·6	48·0	47·2	45·8	46·4	45·8	45·2	45·2	44·7	44·1	44·7	44·7	45·2	45·8	45·8	45·7	45·2	44·7	44·0	43·6	43·6	45·4
„ 18	45·8	45·8	46·9	47·8	46·9	46·4	45·3	45·2	45·2	44·7	44·8	42·4	43·6	44·1	44·3	45·8	44·1	44·7	45·1	45·0	45·1	44·6	44·6	44·6	45·1
„ 19	44·8	46·9	48·4	48·5	47·5	46·9	45·8	45·8	45·8	45·7	45·2	45·2	44·7	44·7	44·2	45·1	44·8	45·7	45·8	45·8	45·2	45·0	48·6	46·4	45·9
„ 20	45·8	48·1	49·2	49·7	46·9	48·6	45·8	45·7	45·7	43·3	44·8	45·2	45·1	44·4	42·9	44·6	44·7	45·8	44·8	45·0	47·0	44·6	43·5	43·0	45·6
„ 21	43·5	45·2	46·9	47·9	47·5	46·8	45·3	45·6	45·2	44·8	42·4	44·7	44·7	44·7	43·5	43·6	45·2	45·8	45·4	45·2	45·2	43·9	43·5	43·5	45·0
„ 22	45·2	46·9	48·1	48·1	47·2	45·8	45·2	45·2	45·3	45·2	44·9	45·0	44·7	44·8	45·7	45·2	45·7	45·6	45·7	45·8	45·8	45·2	44·1	43·4	45·6
„ 23	44·7	46·9	48·1	48·1	49·3	45·9	48·0	46·8	45·2	44·3	45·2	44·7	44·1	41·6	43·6	44·7	45·2	44·8	44·8	45·2	45·7	44·7	43·5	43·5	45·4
„ 24	44·7	45·8	46·8	47·1	47·0	46·4	45·7	45·8	45·8	45·8	45·7	45·2	45·2	45·8	45·8	45·8	46·0	46·0	45·8	45·8	46·8	45·8	44·1	43·5	45·8
„ 25	44·1	45·2	45·8	46·8	47·5	46·9	45·8	45·8	45·7	45·2	45·0	44·8	44·8	44·8	44·7	44·7	45·4	45·9	45·8	45·7	45·8	44·7	43·6	43·5	45·3
„ 26	43·5	45·2	46·9	47·5	47·9	46·7	45·7	45·7	45·2	45·2	44·1	43·5	43·0	44·0	44·7	44·8	45·7	45·8	45·8	45·8	45·8	44·8	44·7	44·1	45·3
„ 27	43·5	44·8	46·7	47·1	47·8	46·9	45·4	45·8	45·8	45·8	44·8	45·8	44·7	44·7	45·2	44·8	45·2	45·7	45·7	45·2	45·2	44·6	44·7	43·8	45·4
„ 28	43·5	44·8	45·9	46·5	46·9	46·8	44·3	45·8	45·8	45·8	45·2	44·8	44·7	41·3	43·6	44·6	44·7	45·0	45·8	45·8	45·8	44·8	44·7	43·6	45·0
„ 29	45·2	46·8	46·4	45·0	49·9	48·0	45·9	39·6	44·6	45·2	41·8	42·3	40·7	41·3	44·1	45·2	44·7	45·2	44·7	44·7	44·6	43·8	44·7	43·0	44·5
„ 30	44·1	45·8	46·9	48·0	47·5	45·7	45·8	45·8	45·2	40·7	44·7	44·7	44·7	44·1	45·8	45·8	45·8	45·8	46·4	45·8	45·8	45·2	45·2	44·7	45·4
„ 31	45·7	46·9	48·6	49·1	48·0	46·8	41·3	45·2	45·8	49·0	42·4	43·6	44·7	45·1	44·8	45·2	45·8	45·8	45·7	45·2	44·7	44·1	43·5	43·5	45·0
Means ..	44·7	45·9	47·2	47·7	47·6	46·7	45·4	45·3	45·1	44·6	44·5	44·5	44·5	44·5	44·7	45·2	45·4	45·8	45·6	45·5	45·8	45·2	44·5	44·1	45·4

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
August 1	407	407	401	406	407	409	398	404	407	411	414	441	413	407	408	409	411	405	411	412	401	417	391	413	409
,, 2	407	403	403	403	411	415	415	395	422	402	393	412	407	410	406	413	410	410	406	401	411	406	391	401	406
,, 3	397	401	401	404	409	415	416	406	401	379	389	418	393	396	399	416	405	394	399	404	389	388	401	401	401
,, 4	401	392	388	381	386	400	404	418	413	409	389	395	396	402	399	399	399	402	406	409	415	416	408	409	402
,, 5	398	399	388	390	400	397	405	407	410	412	414	405	408	408	409	408	408	408	408	411	421	426	408	415	407
,, 6	410	397	392	387	383	382	387	387	375	394	404	399	397	404	404	409	409	423	418	407	402	399	404	404	399
,, 7	391	387	385	390	394	394	404	397	400	397	400	394	399	399	409	405	409	409	409	414	421	424	429	429	404
,, 8	412	412	409	410	418	419	418	412	402	399	407	409	409	409	408	408	408	409	413	413	407	409	407	407	410
,, 9	400	400	400	395	402	408	407	411	411	410	409	408	407	408	411	417	415	415	417	417	422	423	423	420	411
,, 10	403	403	396	396	405	413	417	418	410	413	412	418	415	412	412	417	417	417	416	419	422	425	421	413	413
,, 11	405	405	400	399	404	415	409	419	418	414	412	410	412	412	415	416	417	422	417	419	431	430	424	415	414
,, 12	407	410	405	406	406	414	411	414	415	414	415	415	415	412	413	411	414	413	416	415	425	427	432	429	415
,, 13	411	407	407	410	411	418	414	417	404	409	414	414	414	412	412	411	419	419	417	419	429	430	429	424	415
,, 14	411	405	406	410	410	415	414	416	415	417	414	422	407	406	409	407	411	413	415	418	423	429	430	430	415
,, 15	418	413	406	408	406	412	395	410	414	412	415	415	414	415	414	413	412	412	416	418	418	428	430	430	414
,, 16	411	413	413	413	408	411	413	411	415	415	415	417	416	412	409	410	413	415	418	421	429	424	421	424	415
,, 17	416	416	409	400	399	405	408	405	407	411	416	414	411	409	411	412	412	413	416	419	429	438	442	433	415
,, 18	411	411	404	409	416	420	418	418	416	417	412	409	407	412	413	409	408	409	413	413	418	422	422	417	413
,, 19	400	400	401	405	414	416	416	414	410	420	413	413	410	405	409	407	407	405	411	415	423	418	411	403	410
,, 20	406	406	376	386	381	398	408	410	401	403	404	408	406	403	428	403	404	403	406	412	415	421	421	418	405
,, 21	411	405	401	401	405	409	403	405	406	408	413	411	404	411	411	403	408	406	408	413	418	418	420	416	409
,, 22	400	400	396	399	408	411	410	410	409	412	409	408	403	403	409	410	410	412	411	411	415	417	421	417	409
,, 23	404	394	387	391	401	391	401	411	372	399	401	410	408	434	412	417	417	424	420	417	420	421	423	418	408
,, 24	407	402	404	408	410	407	407	411	413	410	411	408	410	412	413	412	413	416	417	420	427	429	420	417	413
,, 25	405	405	411	410	405	384	402	408	412	413	414	413	410	412	413	412	412	420	418	422	422	422	420	420	412
,, 26	399	401	400	394	403	411	412	416	414	408	409	424	405	405	406	409	409	414	419	419	423	432	430	422	412
,, 27	408	398	398	399	403	410	410	413	415	414	411	430	407	406	409	410	409	410	414	419	428	430	431	430	413
,, 28	420	409	403	403	403	409	412	422	422	423	420	421	412	411	410	413	415	414	416	425	426	426	423	423	416
,, 29	412	401	385	404	391	378	398	388	430	399	417	422	401	384	384	391	394	398	399	398	410	407	407	407	400
,, 30	412	411	409	406	405	402	413	416	415	405	400	404	405	405	404	410	409	392	406	414	408	409	412	412	408
,, 31	399	404	403	404	408	411	415	414	414	409	408	410	400	400	400	400	400	399	403	406	415	416	413	408	407
Means ..	406	404	400	401	404	406	408	410	409	408	409	413	407	408	409	409	410	410	412	414	418	420	418	417	410

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
September 1 ..	45·3	47·0	48·0	48·0	47·0	45·9	45·3	45·3	44·8	44·7	43·1	43·2	43·5	44·7	44·8	45·3	45·3	44·8	45·3	44·9	44·8	43·7	43·1	43·1	45·0
,, 2 ..	45·3	45·9	47·0	47·0	46·5	45·9	45·3	45·3	45·3	44·8	44·2	44·2	44·8	45·4	45·9	45·9	45·9	45·8	45·3	45·3	44·8	43·6	42·5	41·9	45·2
,, 3 ..	45·3	45·3	48·0	48·1	48·1	47·6	45·9	45·8	45·8	45·9	45·5	45·3	44·7	44·8	45·3	45·9	45·9	45·9	45·4	44·9	44·2	43·1	42·2	41·9	45·5
,, 4 ..	45·9	45·9	46·5	47·0	47·0	46·9	45·9	45·9	45·7	44·8	44·8	44·2	45·1	44·7	47·0	45·4	44·8	45·8	45·9	45·3	44·9	43·6	43·6	43·1	45·4
,, 5 ..	43·1	45·3	47·3	47·7	47·1	46·5	46·2	45·9	45·9	45·9	44·5	44·2	44·8	43·6	40·3	42·5	42·8	44·8	45·3	45·3	45·3	44·8	43·6	43·7	44·8
,, 6 ..	44·8	46·5	46·5	47·0	48·0	47·6	46·3	43·2	45·1	44·8	43·7	44·8	45·0	45·3	45·3	45·9	45·9	45·9	45·1	45·3	45·3	44·1	43·1	42·5	45·3
,, 7 ..	43·1	44·3	45·9	47·0	45·3	46·2	45·3	45·9	45·3	45·8	45·0	44·8	44·8	44·8	45·3	45·8	45·3	45·8	45·3	45·3	44·8	44·0	42·6	41·9	45·0
,, 8 ..	44·2	45·2	45·9	46·9	47·5	47·6	46·5	46·2	45·9	45·9	45·3	44·8	45·3	45·8	45·9	45·9	45·8	45·9	45·8	45·3	44·8	43·7	43·2	42·5	45·5
,, 9 ..	44·7	46·5	48·0	48·8	49·3	48·7	46·3	45·9	45·8	45·9	44·8	44·2	45·0	44·8	46·9	45·9	45·4	45·9	45·9	44·9	44·7	43·7	43·6	43·6	45·8
,, 10 ..	45·3	47·0	47·6	48·1	47·7	46·5	45·9	45·9	45·3	45·3	45·1	44·7	43·6	43·6	40·3	44·8	45·8	45·5	45·1	45·1	44·9	43·6	42·5	42·5	45·1
,, 11 ..	43·5	45·1	46·5	46·7	47·1	46·5	45·8	45·8	44·9	44·7	44·8	44·8	44·8	44·8	45·3	45·8	45·9	44·8	45·8	44·9	44·2	41·9	41·4	41·4	44·5
,, 12 ..	43·6	45·9	47·6	48·1	47·6	46·5	45·9	45·9	43·7	44·8	44·2	41·4	42·5	43·1	44·3	44·8	45·8	44·8	44·8	44·8	44·5	43·7	43·1	43·1	44·8
,, 13 ..	44·8	47·0	48·7	49·3	48·7	48·1	47·0	46·9	45·9	45·9	45·3	45·2	45·3	45·3	45·3	45·3	45·2	44·9	45·3	45·3	44·2	42·1	41·9	41·9	45·6
,, 14 ..	43·6	45·9	47·0	47·2	47·6	46·6	46·0	45·9	45·8	45·9	45·2	45·2	45·0	44·8	45·3	45·2	45·1	45·0	44·9	44·8	44·2	42·3	41·4	42·5	45·1
,, 15 ..	43·6	45·8	47·6	48·1	48·2	47·6	45·9	45·9	45·9	45·9	45·3	44·9	42·7	44·4	44·8	44·9	44·9	44·8	44·9	44·8	44·3	42·5	41·9	42·5	45·1
,, 16 ..	44·9	47·2	49·1	49·1	48·7	47·3	45·9	45·8	45·9	39·2	43·9	44·9	44·8	44·8	44·7	44·7	44·8	45·9	45·9	45·9	44·8	43·6	42·6	42·6	45·3
,, 17 ..	43·6	45·9	47·6	48·2	48·1	47·1	46·5	46·5	45·9	45·9	45·9	45·3	45·2	44·8	45·9	45·9	45·8	45·3	45·9	44·9	44·8	42·5	41·4	41·4	45·4
,, 18 ..	45·9	47·0	49·3	49·8	48·6	48·7	44·2	45·9	46·0	45·9	45·3	44·7	43·6	45·9	45·8	45·9	45·9	45·9	45·8	45·3	44·2	42·5	41·4	42·5	45·7
,, 19 ..	44·8	46·8	48·1	48·8	48·7	48·0	47·6	44·7	45·4	45·8	45·3	44·7	44·7	44·0	44·9	45·8	45·9	45·9	44·9	44·9	43·6	41·9	41·4	41·4	45·3
,, 20 ..	43·1	44·8	47·0	48·0	47·0	46·9	46·5	45·9	45·3	45·3	45·8	45·2	45·3	43·6	43·6	44·7	45·9	42·6	45·3	45·3	44·1	42·5	41·9	41·9	44·9
,, 21 ..	44·2	46·7	48·1	48·1	48·4	47·6	46·9	46·9	46·3	45·9	45·9	45·3	45·8	45·9	45·8	45·9	45·9	45·9	45·5	44·8	44·2	42·5	41·4	41·4	45·6
,, 22 ..	44·8	47·6	48·7	48·2	47·6	47·0	45·8	45·9	45·8	45·9	45·3	45·3	45·3	45·2	45·1	45·3	45·8	45·3	45·3	44·8	43·7	41·9	41·4	41·9	45·4
,, 23 ..	44·2	47·0	47·6	48·7	49·8	49·8	47·1	47·0	41·8	41·1	44·0	41·9	40·3	42·5	43·6	45·9	46·9	47·0	50·4	52·5	49·3	43·6	42·5	42·6	45·7
,, 24 ..	44·2	45·9	47·6	48·7	48·6	47·0	44·7	40·3	45·3	45·5	44·8	44·2	43·6	43·6	44·8	45·3	45·9	45·9	45·8	45·1	44·8	42·5	42·5	42·6	45·0
,, 25 ..	44·8	45·9	47·1	47·1	47·6	47·0	45·9	45·9	44·8	41·4	43·5	44·7	44·8	44·2	45·9	46·5	45·5	45·3	44·9	44·9	44·8	43·3	43·4	43·4	45·1
,, 26 ..	45·3	46·5	46·9	47·6	47·6	47·0	46·5	45·9	45·9	45·9	45·3	45·3	45·3	45·9	45·9	45·5	45·5	45·5	45·7	45·3	44·8	43·6	43·1	43·1	45·6
,, 27 ..	44·8	45·3	46·5	47·0	47·6	47·0	46·5	45·9	44·8	45·3	45·3	45·8	43·1	44·3	43·0	42·5	45·9	47·0	49·2	52·7	48·1	54·3	51·5	50·4	46·8
,, 28 ..	50·4	49·7	49·3	48·7	47·0	45·3	43·1	44·9	45·3	45·3	44·9	43·6	44·8	44·8	44·8	44·8	44·8	44·8	44·8	43·6	42·6	41·4	40·5	42·5	45·1
,, 29 ..	43·6	44·9	47·0	47·6	48·1	48·0	45·9	45·3	44·2	43·6	43·7	42·5	41·4	42·5	41·4	42·4	42·6	42·5	43·5	43·1	43·1	43·1	43·6	43·6	44·1
,, 30 ..	44·8	46·5	47·6	47·6	47·6	47·1	45·9	45·9	45·9	44·8	42·5	42·6	44·8	45·3	44·9	44·2	46·5	45·3	44·8	45·8	44·8	43·6	43·6	44·1	45·3
Means ..	44·6	46·2	47·5	47·9	47·8	47·2	45·9	45·6	45·3	44·9	44·7	44·4	44·3	44·6	44·7	45·1	45·4	45·3	45·6	45·5	44·7	43·4	42·7	42·8	45·3

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
September 1 ..	403	403	404	405	408	409	410	411	406	402	402	416	402	403	406	407	410	412	412	415	423	423	423	423	410
,, 2 ..	409	406	404	408	414	414	413	416	415	415	415	414	413	414	414	415	415	416	418	424	428	431	424	421	416
,, 3 ..	408	408	411	414	422	421	419	419	423	421	421	419	419	421	417	414	416	417	419	429	426	424	421	419	419
,, 4 ..	409	409	409	410	414	411	414	417	419	418	419	419	419	412	439	426	413	409	412	416	424	424	423	417	417
,, 5 ..	407	403	404	408	413	417	414	412	412	414	436	415	410	435	429	410	414	410	414	415	419	421	423	417	415
,, 6 ..	413	407	398	403	409	408	409	402	401	405	409	404	407	407	410	410	408	414	415	417	423	425	419	407	410
,, 7 ..	406	404	406	404	405	409	409	412	411	415	416	416	417	414	412	414	417	414	417	424	426	426	429	429	415
,, 8 ..	419	415	419	413	412	414	415	415	417	414	412	410	410	411	411	413	414	415	415	423	430	430	429	423	417
,, 9 ..	425	425	423	420	413	386	403	414	415	404	430	399	404	401	411	404	406	406	406	414	415	411	414	411	411
,, 10 ..	399	396	394	401	410	411	416	419	420	422	421	420	429	430	407	403	402	404	411	413	419	416	421	419	413
,, 11 ..	411	402	404	406	408	404	406	406	406	418	408	411	413	409	410	412	411	411	406	411	417	416	412	406	409
,, 12 ..	405	401	400	401	406	413	416	413	421	415	411	409	408	408	401	401	403	402	408	413	415	421	423	416	410
,, 13 ..	409	400	394	392	404	403	411	407	411	413	412	409	410	409	409	412	413	414	416	423	428	429	428	426	412
,, 14 ..	408	406	402	406	408	408	413	414	417	416	412	413	410	410	409	416	412	412	413	413	420	422	425	412	412
,, 15 ..	410	407	405	405	410	411	405	411	417	417	419	414	416	408	412	411	412	412	414	421	423	422	421	411	413
,, 16 ..	406	403	402	401	410	411	415	416	416	410	406	416	413	409	428	408	404	404	411	416	420	413	411	411	411
,, 17 ..	394	395	391	402	409	411	412	410	403	410	412	413	411	415	412	409	408	408	412	416	417	416	418	416	409
,, 18 ..	406	406	400	398	396	391	384	385	396	406	404	401	402	399	403	402	405	405	406	408	412	411	411	404	402
,, 19 ..	402	396	396	400	402	404	401	401	396	400	403	403	403	406	406	408	410	412	411	413	416	418	413	411	405
,, 20 ..	411	408	406	403	406	405	406	410	410	410	409	408	409	419	412	409	418	410	409	417	417	414	412	412	410
,, 21 ..	397	402	407	411	412	414	416	416	417	418	418	417	409	409	410	412	412	414	415	418	420	416	415	415	413
,, 22 ..	398	399	404	410	414	414	414	411	411	414	414	416	416	412	419	416	416	415	421	425	429	428	423	439	416
,, 23 ..	398	400	403	410	418	408	401	389	394	424	449	446	451	405	400	400	405	405	407	402	417	413	403	388	410
,, 24 ..	378	364	375	375	385	393	381	413	402	406	404	399	402	402	399	401	405	407	411	415	415	415	413	413	399
,, 25 ..	401	399	398	394	395	400	405	404	403	409	405	406	404	399	401	407	404	406	411	414	419	418	415	415	406
,, 26 ..	403	397	399	405	410	414	413	413	413	418	420	415	415	410	409	410	414	414	411	418	420	420	421	418	412
,, 27 ..	407	405	405	403	408	418	419	396	381	397	407	412	425	410	411	403	419	398	411	379	350	334	344	344	395
,, 28 ..	348	361	364	368	369	364	365	379	384	387	392	394	397	397	399	397	399	404	403	410	417	417	412	405	389
,, 29 ..	387	389	395	395	405	382	371	370	366	368	376	407	384	386	394	396	392	393	391	393	394	391	395	391	388
,, 30 ..	393	392	378	392	399	396	398	400	400	400	399	397	399	403	405	400	407	401	398	396	403	401	395	388	398
Means ..	402	400	400	401	406	405	406	407	407	410	412	411	411	409	410	408	409	409	411	414	417	417	415	411	409

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
October 1 ..	44·8	47·1	48·8	50·4	49·4	48·2	46·2	46·0	41·5	43·6	44·3	43·6	44·0	42·4	45·5	44·9	44·8	44·9	45·8	46·0	44·9	43·4	43·2	43·8	45·3
„ 2 ..	46·0	47·1	49·2	49·9	49·9	48·2	47·1	45·9	45·6	45·4	45·0	43·7	44·9	45·0	44·9	45·6	46·1	46·6	47·1	46·0	44·3	42·6	41·5	42·6	45·8
„ 3 ..	43·7	46·1	48·8	48·2	48·8	47·9	46·0	46·0	45·0	44·9	45·2	44·9	44·8	44·9	45·4	45·6	45·4	46·0	48·1	46·0	44·9	42·7	42·0	42·0	45·6
„ 4 ..	44·9	47·7	49·0	49·4	48·8	47·2	46·6	46·7	46·0	45·0	43·7	45·4	44·3	45·3	45·9	45·9	46·0	46·0	46·0	45·5	43·7	42·6	42·6	42·9	45·7
„ 5 ..	44·3	46·3	48·2	48·8	48·8	47·8	46·9	46·6	46·6	46·0	45·0	45·4	45·0	45·4	45·9	45·9	45·2	46·0	46·6	46·0	43·7	42·0	42·5	43·2	45·8
„ 6 ..	45·4	47·1	48·3	48·8	48·2	46·6	46·0	46·0	45·4	44·9	46·0	44·3	44·3	44·9	44·9	46·0	46·0	45·0	44·6	43·8	42·6	40·9	42·6	46·0	45·4
„ 7 ..	47·1	48·8	49·8	49·2	48·8	47·1	46·3	45·9	45·4	45·9	45·0	45·4	44·9	44·8	45·4	47·2	46·6	45·3	45·0	44·8	43·4	42·5	43·2	44·9	45·9
„ 8 ..	46·1	47·7	49·1	49·4	48·8	48·1	46·9	46·6	46·0	45·9	45·4	44·9	44·0	44·1	45·0	47·1	45·0	45·1	45·0	44·8	43·6	42·5	43·7	45·4	45·8
„ 9 ..	45·6	47·2	48·8	48·8	47·6	47·0	47·6	45·2	43·6	44·3	45·3	44·9	45·4	45·2	45·3	45·9	44·8	44·9	44·9	44·9	44·3	43·7	45·4	46·0	45·7
„ 10 ..	46·1	47·7	48·0	47·7	47·1	47·0	47·0	46·9	46·6	46·1	44·8	39·8	41·0	42·5	43·7	43·7	43·6	43·7	43·7	44·0	43·7	43·7	44·3	44·3	44·9
„ 11 ..	45·8	47·3	48·6	48·7	48·2	47·0	46·6	46·0	46·0	46·0	47·2	44·3	44·3	44·3	43·7	43·7	43·8	44·9	44·9	44·9	43·5	42·8	43·2	43·7	45·4
„ 12 ..	45·1	46·9	47·8	48·5	47·8	47·4	46·0	46·0	45·4	45·4	44·8	44·6	45·4	43·8	43·7	43·7	44·9	44·9	44·9	44·3	43·5	42·6	43·6	44·3	45·2
„ 13 ..	46·0	47·3	48·2	48·8	48·0	47·0	46·1	45·9	45·4	45·2	43·5	45·2	44·9	44·9	44·9	45·0	45·0	45·2	45·4	45·0	44·3	42·9	42·9	42·6	45·4
„ 14 ..	43·7	45·5	47·8	49·4	48·8	48·1	46·4	46·0	46·0	45·9	45·8	45·4	45·4	44·9	44·9	44·9	44·9	44·9	44·8	44·3	43·2	42·5	42·6	42·6	45·4
„ 15 ..	44·6	46·6	48·2	48·2	48·3	47·3	45·8	45·5	45·8	45·4	44·3	43·6	44·9	44·9	44·8	45·0	44·9	44·3	44·5	44·0	43·2	42·7	43·7	43·7	45·2
„ 16 ..	47·0	49·4	50·5	50·7	49·9	48·7	48·2	47·1	44·9	46·1	45·4	44·8	45·5	45·4	45·1	45·2	45·0	44·9	44·9	43·7	42·4	42·0	42·6	43·2	45·9
„ 17 ..	44·8	47·7	49·7	49·6	49·5	48·6	47·0	46·6	46·2	46·0	40·0	39·9	44·3	44·9	44·8	44·9	45·0	44·9	44·9	44·0	42·6	40·9	42·0	43·2	45·1
„ 18 ..	45·9	47·7	48·6	48·5	48·6	48·2	46·6	46·4	46·3	44·0	43·2	42·6	42·6	43·8	43·1	43·7	43·7	43·8	44·9	43·7	42·7	41·5	42·6	42·8	44·9
„ 19 ..	45·4	47·1	48·5	48·9	48·8	48·5	47·0	46·6	45·4	45·3	45·4	45·3	45·4	45·4	45·3	45·2	44·9	44·9	44·3	42·8	41·5	40·4	41·6	43·2	45·3
„ 20 ..	45·5	47·7	49·3	49·5	49·3	48·2	46·4	46·0	42·2	43·2	44·9	44·9	44·9	45·0	45·2	45·2	45·2	45·0	44·9	43·7	42·0	40·9	40·9	42·6	45·1
„ 21 ..	45·4	48·2	49·6	49·6	49·9	46·0	48·6	47·7	46·0	46·3	46·1	46·0	45·6	44·9	44·9	44·8	49·4	44·9	44·3	44·3	43·3	42·5	42·9	44·3	46·1
„ 22 ..	45·4	47·1	48·1	48·2	47·3	46·6	46·6	45·9	45·4	44·9	45·2	45·9	46·0	44·3	44·9	44·9	44·9	44·9	44·9	43·8	42·9	42·0	42·0	42·6	45·2
„ 23 ..	44·9	46·1	46·6	46·6	47·1	47·1	44·5	45·4	45·4	45·3	44·9	45·0	44·9	44·9	44·9	44·9	44·9	44·9	44·3	43·2	41·8	41·7	42·6	43·7	44·8
„ 24 ..	44·9	45·8	47·2	48·1	48·1	47·0	46·0	45·8	46·0	46·0	45·8	44·9	45·3	45·0	44·9	44·9	45·0	44·9	44·9	43·7	42·7	42·5	43·2	44·3	45·3
„ 25 ..	42·3	44·0	50·9	50·5	49·5	48·8	47·5	46·6	46·4	46·0	46·0	45·9	45·9	45·4	45·4	45·4	45·4	45·4	45·0	45·3	43·1	42·0	43·2	43·7	45·8
„ 26 ..	45·4	47·0	48·3	48·4	47·6	46·9	46·6	46·3	46·2	46·0	45·9	45·0	45·0	44·9	45·2	44·8	44·9	44·9	43·7	42·7	40·9	41·0	42·6	45·0	45·2
„ 27 ..	46·6	47·8	48·2	47·7	47·7	48·2	47·1	46·6	46·6	45·5	45·4	42·6	43·7	43·8	44·9	44·8	44·9	44·9	43·4	41·7	40·9	40·0	40·9	43·2	44·9
„ 28 ..	45·4	47·4	49·6	50·0	52·2	49·4	46·6	48·2	44·3	45·5	44·9	41·0	37·8	41·6	47·0	47·3	44·3	42·9	42·7	42·6	42·3	41·6	42·9	45·0	45·1
„ 29 ..	47·1	49·2	50·5	51·0	52·1	46·6	47·7	48·7	47·1	45·1	38·9	43·3	47·1	45·2	46·0	47·1	45·6	46·0	46·0	43·6	41·7	40·4	42·0	45·0	46·0
„ 30 ..	47·9	49·6	50·5	49·5	48·2	47·2	45·1	45·0	44·5	44·3	44·2	45·1	45·9	45·6	45·4	45·3	44·9	44·9	43·6	42·5	41·2	40·9	42·6	44·3	45·3
„ 31 ..	48·2	49·9	51·0	50·5	48·8	48·1	46·4	46·0	45·5	45·4	45·4	45·3	45·3	46·0	45·6	44·9	44·3	43·8	43·6	42·0	41·8	40·9	43·2	44·9	45·7
Means ..	45·5	47·4	48·9	49·1	48·8	47·6	46·6	46·3	45·4	45·3	44·7	44·3	44·6	44·6	45·1	45·3	45·1	45·0	44·9	44·1	42·9	42·0	42·7	43·8	45·4

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
October 1 ..	398	398	388	385	383	381	393	393	401	388	391	393	395	417	393	408	396	400	399	397	400	399	399	395	395
,, 2 ..	373	370	389	390	386	390	395	397	399	400	399	407	408	415	410	408	406	410	409	413	411	407	406	393	399
,, 3 ..	378	379	384	381	388	402	401	403	402	402	403	402	402	403	404	405	405	400	408	411	406	401	386	381	397
,, 4 ..	367	370	381	390	402	398	383	394	399	400	400	392	399	398	398	400	400	402	403	403	403	398	391	392	394
,, 5 ..	390	392	401	406	414	412	411	407	406	404	401	416	406	403	403	406	409	407	409	411	414	403	391	384	404
,, 6 ..	391	394	400	405	413	410	404	400	411	405	410	406	407	411	407	406	413	416	420	413	412	404	392	388	406
,, 7 ..	399	402	397	399	409	407	394	397	398	400	395	404	421	403	398	394	403	400	405	398	400	398	393	381	400
,, 8 ..	377	381	391	404	407	398	399	402	405	406	402	403	407	406	400	404	404	403	405	405	406	403	403	397	401
,, 9 ..	402	416	413	399	412	404	400	401	396	394	399	404	398	402	400	405	400	400	403	403	407	402	387	382	401
,, 10 ..	395	398	399	405	413	412	409	405	403	406	399	418	409	397	399	395	398	404	400	400	401	397	386	381	401
,, 11 ..	386	389	394	401	397	404	408	406	409	396	395	394	393	393	405	399	398	398	403	403	403	396	394	391	398
,, 12 ..	381	386	389	392	400	400	399	399	394	392	393	399	401	412	404	401	402	403	405	408	411	407	401	398	399
,, 13 ..	391	394	401	409	413	414	407	398	394	389	379	393	399	399	402	401	401	403	406	406	404	399	395	393	400
,, 14 ..	390	389	394	399	405	408	410	410	410	406	408	404	405	410	404	403	404	405	406	409	411	406	401	393	404
,, 15 ..	383	381	390	395	402	407	409	407	407	409	409	416	412	409	407	405	414	407	408	409	409	406	398	398	404
,, 16 ..	395	395	394	394	398	400	395	393	392	399	400	400	403	401	403	401	400	403	403	404	404	401	395	391	399
,, 17 ..	388	389	386	396	406	405	406	406	411	405	423	395	396	399	411	396	396	396	398	399	395	394	387	377	398
,, 18 ..	387	394	400	396	403	399	392	399	401	407	403	401	401	423	400	404	407	405	404	406	403	396	393	393	401
,, 19 ..	390	403	398	409	414	410	405	404	403	405	410	413	414	414	414	416	414	416	418	414	403	394	384	379	406
,, 20 ..	375	379	388	399	412	408	417	405	405	391	397	404	407	407	408	408	410	411	413	411	407	400	394	392	402
,, 21 ..	388	390	399	412	421	402	391	386	364	392	401	402	403	422	411	405	403	410	414	409	406	403	397	394	400
,, 22 ..	392	397	398	407	410	407	402	401	392	397	398	412	413	412	403	403	406	406	408	408	409	404	394	392	403
,, 23 ..	399	393	387	399	401	412	407	399	399	404	401	402	405	405	405	405	403	403	405	405	403	396	391	388	401
,, 24 ..	396	396	400	404	412	411	398	405	403	405	405	405	404	404	403	404	404	405	409	409	408	400	399	397	403
,, 25 ..	394	395	401	405	409	411	407	406	406	406	408	406	405	405	406	404	404	405	410	412	410	406	398	394	405
,, 26 ..	395	396	400	405	410	410	411	412	414	414	415	412	413	415	413	411	411	411	414	418	413	404	402	403	409
,, 27 ..	410	415	418	418	427	422	419	428	426	423	421	425	418	414	416	415	413	440	430	425	418	412	409	410	420
,, 28 ..	417	404	422	423	426	402	379	343	398	382	381	371	363	390	385	383	393	396	403	388	365	372	368	379	389
,, 29 ..	378	381	399	403	380	414	364	359	383	381	399	385	401	387	387	389	390	383	381	381	375	370	371	371	384
,, 30 ..	383	392	386	390	393	395	395	398	400	400	403	406	404	403	402	400	398	397	398	397	393	482	374	374	398
,, 31 ..	388	400	400	404	404	405	405	401	403	406	404	404	406	410	407	406	408	408	411	409	399	390	383	385	402
Means ..	390	392	396	401	405	405	400	399	401	400	402	403	404	406	403	403	404	405	407	406	404	402	392	389	401

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean
1914.																									
November 1 ..	47·1	48·8	50·5	50·3	49·2	48·0	46·9	46·6	46·0	45·4	45·1	44·9	44·3	48·3	42·6	39·8	44·9	47·1	44·3	42·6	41·5	40·4	42·0	44·5	45·5
„ 2 ..	47·7	49·5	50·1	49·5	48·1	47·7	46·0	46·0	43·2	44·4	44·8	44·9	45·9	45·4	46·0	45·4	43·7	44·2	43·7	42·5	41·6	31·2	43·2	46·0	45·4
„ 3 ..	48·3	49·9	50·1	49·5	48·1	47·1	46·0	45·4	45·9	43·8	46·6	43·7	44·3	45·0	44·1	44·9	46·4	45·4	43·1	41·5	40·4	39·8	40·9	44·8	45·2
„ 4 ..	47·2	48·8	50·1	50·1	49·9	49·9	43·1	47·4	46·6	39·8	41·9	44·3	41·9	44·8	44·3	44·9	44·6	44·3	43·7	43·2	41·0	41·3	41·6	43·7	44·9
„ 5 ..	46·6	47·9	49·6	50·1	49·4	46·6	46·6	46·3	45·4	43·1	44·4	45·1	44·3	45·3	44·9	44·9	44·8	44·8	44·3	43·3	42·0	41·7	42·0	43·7	45·3
„ 6 ..	46·0	47·7	49·0	49·4	48·8	48·1	46·4	46·3	46·0	46·3	45·4	44·5	44·9	44·9	45·4	45·2	46·4	45·6	45·1	43·6	41·8	39·9	40·4	42·9	45·4
„ 7 ..	47·7	49·9	51·6	51·0	49·2	48·2	44·9	46·6	44·3	42·5	44·1	43·7	43·7	44·5	44·9	47·1	46·0	44·9	44·1	43·2	41·6	40·4	41·5	43·7	45·4
„ 8 ..	46·4	48·0	49·8	49·9	48·3	47·2	46·6	46·2	45·4	45·2	44·3	44·5	44·9	44·9	44·9	45·0	44·9	44·9	43·8	42·6	41·5	41·5	42·0	43·8	45·3
„ 9 ..	46·6	49·1	49·9	50·9	49·7	48·8	47·6	46·6	46·6	46·2	46·3	45·8	45·6	45·4	45·4	45·4	45·0	44·9	44·3	42·6	40·9	41·4	42·0	44·3	45·9
„ 10 ..	47·0	48·6	49·6	49·4	48·1	47·1	46·6	46·2	45·9	45·5	45·4	45·1	45·0	44·9	45·0	44·9	44·8	43·7	43·0	41·5	40·4	40·4	42·3	45·8	45·3
„ 11 ..	48·8	50·9	52·2	51·8	50·6	49·4	47·7	45·9	46·3	45·0	44·3	44·6	43·2	42·0	39·2	42·6	47·0	43·2	45·3	46·0	44·3	42·0	42·7	44·3	45·8
„ 12 ..	46·4	48·2	49·5	48·8	47·7	46·2	46·1	45·4	45·6	43·8	44·8	44·0	45·4	44·6	44·3	44·3	44·9	44·9	44·3	42·5	41·5	40·5	41·5	41·5	44·9
„ 13 ..	44·3	47·4	49·5	48·8	48·8	47·8	46·6	46·1	45·9	45·9	45·9	45·4	45·4	45·4	45·4	45·4	45·2	45·0	45·4	43·7	42·6	42·0	43·1	43·1	45·6
„ 14 ..	48·0	50·5	51·0	49·8	48·8	48·0	47·0	46·0	45·5	45·4	44·9	43·7	41·8	40·9	41·8	43·4	44·3	43·7	43·7	42·6	42·5	41·5	46·0	48·2	45·4
„ 15 ..	49·4	50·4	50·5	49·5	49·3	48·1	46·6	44·9	46·1	43·8	44·3	45·6	44·9	45·0	45·4	45·0	46·6	45·4	44·9	43·2	42·3	42·0	43·7	46·1	46·0
„ 16 ..	48·8	50·1	50·1	50·0	49·4	47·7	46·6	46·2	45·9	46·0	45·4	45·4	45·9	44·3	44·9	44·9	44·9	43·8	42·6	42·5	40·8	40·9	42·6	45·4	45·6
„ 17 ..	50·8	50·8	50·6	49·4	48·7	48·2	46·1	45·4	45·4	45·5	45·6	45·4	44·6	44·9	47·2	45·9	44·9	44·9	45·5	43·6	43·1	43·3	45·4	47·7	46·4
„ 18 ..	49·9	51·6	51·6	50·4	48·7	47·1	45·4	44·9	44·9	45·0	44·8	44·9	45·4	45·0	44·9	44·8	43·7	43·8	42·6	40·5	40·1	39·8	42·6	46·0	45·4
„ 19 ..	49·9	51·6	52·2	51·6	50·5	48·3	46·6	44·4	45·4	43·8	45·3	44·9	45·1	44·9	46·0	47·2	46·1	46·6	44·3	42·6	41·5	42·0	43·7	46·0	46·3
„ 20 ..	48·3	50·9	51·6	51·6	50·0	48·2	46·6	45·4	45·1	45·0	44·9	44·9	45·9	46·0	46·0	46·0	46·0	45·3	44·3	42·6	40·4	39·8	42·0	44·4	45·9
„ 21 ..	47·4	50·0	51·6	51·6	50·9	49·2	47·1	46·2	46·0	45·9	45·4	43·8	44·9	45·0	45·0	45·9	44·9	44·9	43·7	42·0	41·5	41·5	42·7	44·1	45·9
„ 22 ..	46·6	48·3	49·9	50·5	49·5	48·2	47·1	46·1	46·0	45·9	45·5	45·4	45·3	45·2	45·1	45·0	44·9	44·8	43·7	42·2	40·4	40·5	43·2	45·4	45·6
„ 23 ..	46·3	48·2	50·4	49·5	48·8	47·7	45·5	45·4	45·9	45·9	45·4	45·0	45·0	44·9	44·9	44·9	44·9	43·7	42·7	41·5	41·5	41·5	43·6	46·1	45·4
„ 24 ..	48·1	49·4	49·9	49·4	49·2	48·2	46·6	46·1	46·0	45·4	45·4	45·2	44·9	44·9	44·9	44·9	44·9	44·2	43·2	41·5	41·0	40·9	42·6	42·6	45·4
„ 25 ..	48·2	47·7	48·3	48·9	48·8	47·9	46·4	46·1	46·0	46·0	45·5	45·2	44·9	44·9	44·9	44·9	44·9	44·8	43·7	43·7	43·2	42·0	42·8	44·8	45·6
„ 26 ..	46·6	48·2	49·4	50·5	50·3	48·3	46·6	46·1	46·0	46·0	45·9	45·0	45·0	45·1	45·0	44·9	44·3	43·7	42·0	40·4	42·5	39·3	40·9	45·4	45·3
„ 27 ..	47·7	48·8	51·6	52·8	51·3	49·4	48·2	47·1	47·1	46·6	45·0	43·7	43·8	44·3	46·0	43·8	43·8	43·2	43·2	41·9	40·4	40·5	41·8	43·7	45·7
„ 28 ..	46·0	48·2	48·8	49·4	48·7	48·2	46·6	46·6	44·8	45·4	44·9	44·9	44·8	44·5	44·9	44·9	44·9	44·0	43·5	42·6	42·6	42·6	44·8	45·4	45·5
„ 29 ..	48·2	49·5	49·9	49·9	49·2	48·2	47·0	46·6	44·2	44·3	44·5	43·8	45·4	45·0	44·6	46·0	44·9	43·7	43·1	42·0	40·4	40·4	40·9	41·5	45·1
„ 30 ..	47·1	48·8	49·8	49·4	48·8	48·2	46·7	46·0	45·4	45·4	45·2	45·4	45·4	46·0	47·4	46·6	46·0	44·1	42·6	41·5	40·9	40·9	42·6	43·7	45·6
Means ..	47·6	49·3	50·3	50·1	49·2	48·0	46·5	46·0	45·6	44·9	45·0	44·8	44·7	44·9	44·8	45·0	45·1	44·6	43·8	42·5	41·5	41·1	42·6	44·6	45·5

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
November 1 ..	391	398	405	411	412	410	409	375	373	396	397	402	408	420	417	409	391	393	386	392	374	367	367	372	395
,, 2 ..	382	394	401	409	410	405	399	398	395	395	395	397	398	416	398	404	396	394	397	399	389	382	369	373	396
,, 3 ..	386	397	408	420	422	420	423	390	377	387	414	399	397	402	397	397	394	399	400	403	399	386	376	381	399
,, 4 ..	376	401	409	415	423	440	435	374	376	383	389	411	392	394	389	387	391	389	395	390	385	378	366	361	394
,, 5 ..	376	383	400	403	402	407	402	403	398	401	399	398	401	418	401	392	394	394	397	397	388	385	380	379	396
,, 6 ..	376	385	399	406	407	410	399	400	402	403	404	408	401	399	396	398	398	404	407	403	398	391	376	376	398
,, 7 ..	352	375	393	408	411	415	405	394	402	416	401	402	404	401	401	410	405	409	411	404	401	396	395	370	396
,, 8 ..	377	389	400	405	404	406	406	400	396	394	399	394	395	400	395	396	400	400	404	405	396	387	383	380	396
,, 9 ..	368	375	398	410	417	413	407	403	403	402	402	402	403	401	402	406	404	402	405	406	397	396	387	386	400
,, 10 ..	392	402	409	414	416	412	412	409	414	408	410	407	406	405	406	407	412	415	415	418	407	399	394	389	407
,, 11 ..	387	395	414	433	417	425	417	415	406	404	404	408	407	452	392	375	411	389	389	386	378	378	370	372	401
,, 12 ..	377	385	390	399	398	400	393	390	389	394	393	394	401	398	388	390	388	396	395	402	398	388	381	381	392
,, 13 ..	378	382	388	395	395	396	398	398	401	401	400	400	401	399	397	396	396	396	403	402	392	379	372	372	393
,, 14 ..	375	386	394	403	403	411	402	400	399	399	396	390	394	387	394	392	388	393	398	394	386	371	355	369	391
,, 15 ..	394	406	417	420	412	408	390	388	392	420	396	399	402	401	399	397	402	400	399	395	398	383	371	371	398
,, 16 ..	388	405	410	415	418	405	410	408	409	413	413	415	412	420	408	407	407	408	408	401	392	383	381	369	405
,, 17 ..	396	396	403	419	415	409	394	403	405	407	410	410	407	403	415	407	404	406	406	406	389	382	365	384	402
,, 18 ..	402	417	416	426	422	412	403	395	392	402	408	412	412	408	410	403	407	407	412	408	395	380	375	370	404
,, 19 ..	374	386	395	405	408	412	400	411	409	411	409	412	407	407	404	411	412	417	411	403	391	377	361	367	400
,, 20 ..	377	389	401	411	413	411	406	406	406	406	403	403	402	404	405	407	407	406	414	412	412	393	368	368	401
,, 21 ..	370	379	396	411	424	421	419	415	412	412	408	408	407	406	404	410	407	412	415	408	398	387	377	375	403
,, 22 ..	385	392	403	412	422	421	408	413	413	411	408	408	409	409	409	409	410	411	410	405	395	385	380	381	405
,, 23 ..	386	398	403	416	420	420	412	410	412	410	410	407	408	407	406	406	406	408	409	406	399	393	394	391	409
,, 24 ..	396	401	407	415	416	414	416	415	413	416	416	410	412	409	407	407	408	411	412	407	398	392	387	392	407
,, 25 ..	392	400	407	409	413	413	410	411	413	415	415	415	416	411	415	413	414	413	414	411	411	403	398	393	409
,, 26 ..	398	407	417	415	427	415	413	410	416	420	418	413	413	413	410	412	408	410	422	413	409	405	379	374	410
,, 27 ..	388	403	420	383	425	403	399	401	399	413	422	430	404	404	398	403	401	402	396	395	392	387	382	383	402
,, 28 ..	387	392	409	402	414	404	408	398	394	401	401	403	403	401	401	399	401	401	400	400	391	388	380	378	398
,, 29 ..	380	388	396	409	413	411	406	404	404	405	402	405	409	410	415	412	411	409	402	407	409	384	384	384	402
,, 30 ..	391	398	400	411	412	414	408	404	404	404	403	403	403	403	410	406	410	408	402	400	391	379	379	382	401
Means ..	383	390	404	410	414	412	407	401	401	405	405	406	405	407	403	402	403	403	404	406	395	386	376	377	400

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Declination (east of north): 16° + tabular minutes.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
December 1 ..	49·4	52·2	52·8	51·7	50·3	49·2	46·6	45·3	45·4	45·4	45·4	45·5	45·9	46·0	46·0	46·0	45·9	45·0	43·8	42·6	40·9	40·7	42·6	46·0	46·3
,, 2 ..	49·4	51·6	51·0	50·1	48·8	47·0	45·0	43·8	44·9	44·9	44·9	45·0	45·9	46·0	45·9	45·6	45·4	44·9	43·8	42·0	40·9	41·0	42·6	42·6	45·5
,, 3 ..	48·2	49·9	51·5	51·0	49·4	48·1	46·6	45·9	45·4	46·0	45·0	44·9	45·4	45·4	45·4	45·0	44·8	43·8	42·6	41·4	39·8	39·8	41·9	43·7	45·4
,, 4 ..	46·0	48·5	50·3	50·8	50·5	47·1	47·0	46·3	45·8	45·6	45·4	45·4	45·2	46·1	44·9	45·0	44·9	43·7	42·9	41·2	39·2	39·1	42·6	45·9	45·4
,, 5 ..	49·4	49·9	52·2	53·2	51·6	50·0	47·7	46·0	45·0	43·7	44·3	44·9	45·0	45·4	45·6	45·9	45·4	45·0	43·7	42·5	40·9	40·4	41·4	42·6	45·9
,, 6 ..	47·1	49·9	51·0	52·1	51·6	49·8	47·1	46·0	45·2	45·3	45·2	45·3	45·4	45·5	45·5	46·0	45·9	46·0	44·9	41·6	40·4	38·7	39·2	40·9	45·6
,, 7 ..	48·8	49·4	51·0	51·3	50·8	48·8	45·4	44·9	44·2	44·3	44·6	43·2	43·7	44·9	44·9	45·0	44·9	43·7	43·2	41·5	40·9	40·4	40·4	42·6	45·1
,, 8 ..	46·0	48·2	49·9	51·0	50·5	49·3	48·2	47·1	46·0	42·2	44·9	44·5	44·9	44·8	44·9	44·9	45·0	44·9	43·7	41·9	40·4	40·9	42·0	43·7	45·4
,, 9 ..	46·6	49·2	50·5	50·1	49·4	48·3	47·7	46·7	46·0	45·9	45·6	43·7	44·9	44·8	44·9	44·9	44·9	45·0	43·8	42·0	39·8	40·4	42·9	45·0	45·5
,, 10 ..	47·2	49·2	49·8	49·0	48·8	47·9	46·6	46·0	45·4	42·6	43·6	43·3	43·2	43·8	44·3	44·9	44·5	43·7	42·5	41·5	40·7	40·4	41·5	44·3	44·4
,, 11 ..	46·6	48·8	49·4	49·0	48·1	47·1	46·6	46·0	45·9	45·4	44·3	44·9	44·9	44·3	44·9	44·9	44·9	44·8	43·6	42·0	40·4	39·3	41·5	43·8	45·1
,, 12 ..	48·2	49·5	50·5	49·9	48·8	47·7	46·1	45·9	46·0	45·6	43·8	43·7	44·9	45·6	45·4	44·9	45·0	44·9	44·3	41·9	42·6	41·6	42·9	45·2	45·6
,, 13 ..	48·2	51·5	52·8	51·0	48·8	47·1	46·6	46·1	45·9	45·8	45·4	46·0	46·0	46·0	45·9	45·4	45·0	44·8	43·2	41·5	40·4	40·4	43·8	47·1	46·0
,, 14 ..	49·4	50·4	49·9	48·8	48·1	47·1	46·0	45·4	45·3	45·4	45·4	45·4	45·0	45·9	45·6	45·4	44·9	43·8	42·8	41·6	40·9	41·5	43·7	45·9	45·6
,, 15 ..	48·8	49·4	49·9	49·8	48·2	47·7	46·0	45·4	46·0	45·3	44·9	44·3	44·9	46·0	45·4	45·3	45·2	44·3	41·9	40·4	40·4	41·6	44·9	47·7	45·6
,, 16 ..	49·9	51·6	51·5	49·9	48·9	46·0	44·3	44·3	45·1	44·8	44·8	45·4	45·8	46·0	46·0	46·0	45·1	44·9	44·6	44·4	42·6	42·0	44·3	47·1	46·1
,, 17 ..	51·7	54·4	56·3	55·6	52·2	49·4	47·0	45·6	44·3	43·3	44·3	44·3	43·7	44·9	45·0	45·4	45·0	44·3	43·7	42·5	40·9	40·4	42·0	44·4	46·3
,, 18 ..	47·1	48·8	49·4	49·4	49·0	47·8	46·6	46·0	45·6	45·4	44·5	44·3	44·9	44·9	45·3	45·2	45·4	44·9	43·8	42·6	40·9	40·8	42·3	45·4	45·4
,, 19 ..	49·9	50·5	52·2	54·4	51·9	50·5	47·4	45·4	45·9	45·4	45·5	43·2	42·6	45·4	45·4	45·4	45·0	44·8	43·7	42·5	42·6	41·4	42·0	44·0	46·1
,, 20 ..	46·3	48·5	49·0	48·8	48·5	47·6	46·8	46·1	45·8	45·4	45·3	45·4	45·0	44·9	44·9	44·9	45·0	45·0	44·3	42·7	41·3	41·3	42·0	44·3	45·4
,, 21 ..	47·3	49·9	50·3	50·3	49·9	49·0	47·1	46·6	46·3	46·2	45·9	45·8	45·9	46·0	46·0	45·9	46·0	45·0	44·3	42·7	41·0	40·4	42·0	42·9	45·9
,, 22 ..	45·4	47·6	49·2	48·7	49·4	48·6	47·9	47·2	46·6	46·4	46·0	45·5	45·4	45·4	45·4	45·3	45·3	45·4	43·2	42·6	41·5	41·5	42·0	44·3	45·7
,, 23 ..	47·7	49·4	49·9	50·0	49·5	48·6	47·2	47·2	46·3	46·6	46·0	46·1	45·9	45·4	44·9	44·9	44·9	44·1	43·2	40·9	39·9	40·4	41·5	42·9	45·6
,, 24 ..	45·3	47·7	49·4	49·4	47·7	46·6	46·4	46·7	46·3	46·2	45·9	44·9	44·3	44·9	43·2	43·7	42·7	42·6	41·5	41·4	40·4	41·8	42·0	43·2	44·4
,, 25 ..	46·2	48·5	50·4	50·0	49·6	47·7	46·1	46·2	46·2	46·0	45·4	45·6	45·4	45·3	45·2	44·9	44·9	44·1	42·5	40·5	41·2	42·7	43·7	45·4	45·6
,, 26 ..	43·7	45·4	46·3	48·2	50·4	50·5	49·4	48·6	46·6	46·0	46·0	46·0	45·9	46·0	45·0	45·0	44·9	44·8	44·3	43·7	42·6	40·9	40·5	41·4	45·5
,, 27 ..	47·4	49·9	51·0	50·5	49·4	48·1	47·4	47·2	47·0	47·0	46·3	46·0	45·4	44·9	44·9	44·9	46·6	42·7	42·6	41·4	42·0	43·7	43·7	44·3	46·0
,, 28 ..	47·9	48·8	50·1	49·9	49·4	46·8	47·1	47·0	46·6	42·0	44·2	45·3	46·0	44·9	45·2	47·6	43·6	43·7	48·2	45·4	42·4	42·8	42·0	44·2	45·9
,, 29 ..	46·0	48·2	48·8	48·2	47·1	46·6	45·4	45·6	46·6	46·4	46·4	45·6	46·0	45·6	45·5	44·9	44·9	44·9	44·3	43·5	43·4	44·1	45·4	45·4	45·8
,, 30 ..	44·9	46·6	47·2	47·7	47·7	47·4	46·6	46·6	45·9	45·9	46·1	46·0	46·0	46·0	45·0	44·6	44·1	43·7	42·6	41·4	41·5	41·3	43·2	44·3	45·1
,, 31 ..	45·4	47·6	48·8	48·3	48·8	48·1	48·2	47·7	46·4	45·6	46·0	46·3	46·6	45·9	45·0	44·9	44·9	44·3	43·3	43·7	43·2	43·7	44·9	45·4	46·0
Means ..	47·5	49·4	50·4	50·3	49·5	48·1	46·8	46·2	45·8	45·2	45·2	45·0	45·2	45·4	45·2	45·2	45·0	44·4	43·6	42·2	41·2	41·1	42·5	44·4	45·6

TABLE OF HOURLY VALUES (GREENWICH MEAN CIVIL TIME)—*continued.*

Horizontal Force: 0·22 . . . C.G.S.

Date.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
1914.																									
December 1 ..	387	397	418	419	430	421	413	404	410	410	409	409	405	405	405	404	405	405	410	414	405	396	410	410	408
,, 2 ..	394	399	411	422	426	422	414	407	407	408	411	406	408	410	408	411	412	416	419	417	417	394	388	383	409
,, 3 ..	383	390	406	415	423	421	416	413	418	419	415	415	417	416	417	420	419	422	428	423	408	388	387	387	411
,, 4 ..	394	404	410	414	429	413	406	401	402	403	406	406	402	408	411	410	401	409	409	409	397	387	373	372	403
,, 5 ..	380	385	401	404	420	418	417	411	407	411	410	409	408	408	406	408	404	411	415	413	409	399	387	382	405
,, 6 ..	387	400	411	421	422	414	408	402	403	404	401	402	402	401	401	402	404	407	410	413	406	394	379	379	403
,, 7 ..	389	390	393	398	404	417	403	404	405	405	420	422	427	423	412	405	414	412	409	409	403	394	389	383	405
,, 8 ..	390	391	396	405	407	423	405	406	412	405	400	402	399	400	400	400	401	402	403	395	389	378	375	375	398
,, 9 ..	389	396	403	411	403	411	405	404	398	402	406	408	398	402	397	397	397	403	406	401	388	386	372	373	398
,, 10 ..	382	392	400	402	409	411	396	399	399	405	402	396	400	400	395	398	407	399	398	397	394	389	389	387	398
,, 11 ..	392	396	402	414	417	416	401	403	404	407	405	405	411	409	403	399	395	402	401	402	398	394	386	389	402
,, 12 ..	387	393	406	413	419	414	409	407	408	408	410	404	403	400	398	396	398	400	400	398	398	388	376	376	400
,, 13 ..	387	391	395	405	413	417	397	394	399	397	400	399	397	396	395	396	396	397	398	394	383	375	373	378	395
,, 14 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, 15 ..	395	396	398	396	399	392	397	402	404	411	410	408	410	405	406	406	405	406	405	397	388	383	381	381	399
,, 16 ..	391	387	408	415	415	411	411	412	406	413	415	415	417	414	424	420	417	421	417	414	401	390	371	378	408
,, 17 ..	388	397	402	406	397	397	402	398	382	379	390	387	401	407	397	396	398	401	401	389	374	374	367	375	392
,, 18 ..	391	396	403	408	408	406	400	399	400	403	404	405	406	406	404	405	407	406	405	401	389	377	367	361	398
,, 19 ..	370	370	391	387	411	417	411	410	402	412	412	409	413	403	403	405	405	405	405	392	391	383	377	374	398
,, 20 ..	382	386	391	396	404	410	404	404	401	399	400	401	402	400	400	399	401	407	400	406	406	401	392	386	399
,, 21 ..	381	388	398	403	407	401	401	399	399	401	400	399	398	401	401	403	403	403	403	403	400	399	391	385	399
,, 22 ..	385	383	392	404	410	408	408	411	411	413	418	418	415	418	418	420	418	417	414	402	406	396	387	382	406
,, 23 ..	382	384	393	400	411	411	410	412	412	410	410	408	407	409	407	407	405	408	410	408	404	404	394	389	404
,, 24 ..	394	398	401	403	404	414	416	416	421	422	422	424	416	411	411	399	394	399	399	397	391	388	388	288	405
,, 25 ..	381	386	390	394	392	404	407	410	409	405	406	405	405	405	405	401	404	404	403	398	389	384	382	382	398
,, 26 ..	380	383	386	390	394	405	407	412	412	410	408	411	409	408	412	406	406	401	401	399	402	394	387	384	400
,, 27 ..	385	397	400	405	405	407	411	406	411	409	411	416	414	411	414	414	415	410	407	401	392	387	386	386	404
,, 28 ..	385	387	390	388	399	395	402	413	421	390	402	405	409	410	412	392	397	400	386	398	376	380	378	383	396
,, 29 ..	382	382	388	397	403	402	400	400	399	398	399	395	395	396	393	395	395	396	397	392	386	383	390	390	394
,, 30 ..	395	395	396	394	395	395	397	401	405	402	402	402	403	403	403	404	403	406	404	403	396	390	386	397	399
,, 31 ..	395	395	400	396	398	402	415	419	417	400	417	417	405	407	406	400	400	402	404	400	395	389	387	390	402
Means ..	387	391	399	404	409	410	406	406	406	405	407	407	407	406	405	404	404	406	406	403	396	389	383	383	401

APPENDIX VIII.

LIMITS OF ERRORS IN SURVEYING.

[By W. T. Neill, District Surveyor, Dunedin.]

At the present time, when greater accuracy is required in field operations in connection with standard traverses and major triangulation, the writer is of opinion that the limit of error of the various classes of measurements should be reduced to a uniform standard, based on the mathematical theory of the probability of errors of observation. The following is an endeavour to attain this desirable end, which may be of interest and value to professional surveyors in the Dominion.

Part 1. Limits of Errors in Surveying.

Under the regulations for conducting the survey of land in New Zealand for 1897 the following are the extreme errors allowable:—

(1.) Minor triangulation, 2 links per mile. Error in the summation of angles of a triangle, 30″.
(2.) Closing error of traverses, 4 links per mile. Error of bearing, 3′.
(3.) Closing error of city traverses, 2 links per mile.

These values were revised under the 1908 regulations, and are given as follows:—

(1.) Minor triangulation, 6 in. per mile. Error in the summation of angles of a triangle, 20″.
(2.) Closing error of traverses, 4 links. Error of bearing, 2′.
(3.) Closing error of city traverses, 1 link per mile.

All work having error in excess of these limits requires revising.

The degree of accuracy attained in field operations depends on a number of causes, among which are—weather-conditions; instability of the ground, as in peat, swamps, and moss growths in forests, and, in town work, the vibration of the traffic, &c. The carefulness and accuracy of the surveyor and the chainmen are large factors in the accuracy of any survey. The principal factor, however, affecting the accuracy of a survey is dependent on the instruments and apparatus used in the performance of the work, and this factor alone will be the subject of the following theoretical investigations:—

A Determination of the Closing Error in Traverses made with a 5 in. Transit Theodolite and a long Steel Band.

Investigations of the effects of errors in surveying require the application of the results derived from the theory of errors. One of the most important results is the probability curve, or curve of errors, the equation of which is—

$$y = k\,e^{-h^2x^2} \qquad (1)$$

This is termed the exponential law of errors, k and h being constants, and e the base of the Napierian system of logarithms.

From equation (1) a criterion of the degree of uncertainty of the result of a number of measures is deduced. The criterion of the degree of uncertainty of the result of a series of equally good measures or observations has three distinct definitions,—

(1.) The mean error, or the average error, is defined as the arithmetic mean of the separate errors taken all with the same sign.
(2.) The error of mean square is defined as the square root of the arithmetic mean of the squares of the individual errors.
(3.) The probable error is such that there are as many errors of greater magnitude as there are of smaller magnitude.

The following table, from Airy's "Theory of Errors," shows the connection between the mean error, the error of mean square, and the probable error, and, when one is known, by use of the table it can be converted to either of the other two.

Proportions of the different constants,—

——	Modulus.	Mean Error.	Error of Mean Square.	Probable Error.
In terms of modulus	1·000000	0.564189	0·707107	0·476949
In terms of mean error	1·772454	1·000000	1·253314	0·845369
In terms of mean error of square ...	1·414214	0·797885	1·000000	0·674506
In terms of probable error	2·096665	1·182916	1·482567	1·000000

These three criteria—namely, the mean error (E_m), the error of mean square (E_s), and the probable error (E_p)—are equally good from a theoretical standpoint, and in selecting one of them for the purpose of testing the accuracy of a field traverse preference is given to that which is easiest to compute—viz., the mean error.

In selecting the mean error as a test of the accuracy of field measurements, the same test must be applied to determine all the instrumental constants. Thus the mean error of reading and sighting of a theodolite and the mean error in the chaining constant must be used throughout. If either the probable error or the error of mean square is used a different set of instrumental constants will ensue, but all leading to the same final result.

From the table of constants the relation is,—

$$E_m = 1{\cdot}183\ E_p \qquad (2)$$

$$E_m = 0{\cdot}798\ E_s \qquad (3)$$

It is necessary to remark that the above errors are true errors, as distinct from apparent errors. For instance, the difference between the sum of three angles of a triangle and 180° is a true error, but the difference between each value of a series of measures of a base-line and the arithmetic mean is an apparent error, because the true length of the line is an unknown quantity. The values are,—

$$\text{Apparent mean error of arithmetic mean} = \pm \frac{E_m}{\sqrt{n}} \qquad (4)$$

$$\text{True mean error of arithmetic mean} = \pm \frac{E_m}{\sqrt{n-1}} \qquad (5)$$

In fixing the limits of error permissible in field-work the accuracy aimed at should not be difficult to obtain with the steel tape and theodolite, without special apparatus. A spring balance to register the pull and a thermometer to give the the temperature are necessary.

The errors in traversing are due to two causes: (1) Errors in the linear measurements; (2) errors in the angular measurements.

Cumulative error in linear measurement is represented by—

$$e = c\sqrt{l} \qquad (6)$$

where c is a constant depending on the apparatus used, and l the length of the line.

For a steel band, on the level, using plummets to effect the marking of the terminals, the value of c has been determined to lie between $\pm$ 0·0015 and $\pm$ 0·0020. Adopting the value 0·002, and taking a stretch of 5 chains, gives, from (6)—

$$e = \pm {\cdot}022\sqrt{500}$$

$$= \pm {\cdot}045 \qquad (7)$$

The above result is open to criticism, but most chainmen would undertake to measure a distance and keep the marking of the separate lengths within the above limit without any special precaution.

The result in (7) includes the error due to inaccurate tension, error due to imperfect alignment, and the personal errors of the chainmen, &c.

When the measured distance is inclined to the horizon the effect of the errors due to angular reading and refraction have to be determined and combined with the result in (7). For lengths between 5 and 10 chains the value of refraction can be taken as 30″. Angles of elevation will be 30″ too great, and angles of depression 30″ too small. In taking these observations in the field a forward reading is usually taken for the first band-length and a backward sight for the second length. If, then, the grade does not change sign (that is, change from, say, uphill to downhill) the effects of refraction will balance each other.

In cases where vertical angles are large, and close readings are required, reciprocal angles can be taken without any undue expenditure of time: thus the refraction can be eliminated by suitable methods of observation, and will not be included in this investigation.

The error due to imperfect reading and sighting of the vertical circle of a 5″ theodolite in good adjustment, for the purpose of obtaining the slopes, can be taken as 1′.

The average slope of all the lines of a traverse to embrace all kinds of surveys is difficult to determine. For road traverse the grades are confined by regulation, and an average of 3° can be taken. The result of experience is that the number of lines with slopes under 10° is very much greater than the number of lines with slopes over 10°. By using an average slope of 10° for the total length of the traverse a larger mean error will be found than if the correct average were used, except in the case of surveys in steep and very broken country.

The reduction formula is—

$$H = l\cos\theta \qquad (8)$$

Where l is the included distance and θ the inclination, the mean error being—

$$E_H = \pm\sqrt{(E_l^2\cos^2\theta + E_\theta^2 l^2\sin^2\theta)} \qquad (9)$$

taking $\theta = 10°$, $l = 500$, $E_l = \pm{\cdot}005$, $E_\theta = 1'$, $E_H = \pm{\cdot}05$ (9)

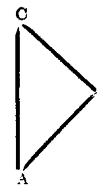
that is, the mean error of measuring a single band length for any line, level or inclined, is $\pm{\cdot}05$.

The errors in the horizontal angles come under the headings—(a) Errors due to sighting; (b) errors due to reading the vernier; (c) errors due to imperfect centring.

The error due to sighting depends very much on atmospheric conditions, and to a lesser extent on the length of the lines, and a constant mean value for all lines can be used.

The reading-error is independent of the length of the lines, and the errors of sighting and reading can be combined and a constant average error of 15″ will be used throughout. The mean error in reading any theodolite can be found by an examination for the errors due to eccentricity and the errors in graduation of the divided circles, by using the constant angle between the two verniers and finding the readings at intervals of 5° or 10° from 0° to 360°. From these readings the exact angle between the verniers can be determined and the eccentricity can be computed. Then by correcting the readings for eccentricity the remainders represent the errors of graduation and reading.

Surveyors often find that an instrument used for measuring the angles of a traverse, by reading one vernier only, consistently gives the bearings of the lines too great or too small when compared with a check-bearing, and no amount of repeating the work will disclose any appreciable error. Such results are caused by eccentricity, or the centres of the axis of rotation and the divided circles not being coincident. This error is eliminated by taking the mean of both verniers, or by finding the error due to eccentricity, which may amount to 10″ in some cases, and correcting each angle.



The error due to imperfect centring is almost negligible for long lines, but it increases very rapidly as the lines shorten. If a maximum error r is decided on, and A,B,C, three consecutive stations of a traverse, then the mean error of centring is—

$$E_c = \pm \frac{4r \, . \, AC}{3\pi \, . \, AB \, . \, BC} \, . \qquad (10)$$

(For the mathematical investigation of the error of centring, see "Effects of Errors in Surveying," by H. Briggs).

To determine an average value for r, consideration has to be given to the plummet, and deflections by wind or other causes. A value of $r = \cdot 05$ will be used.

If the angle ABC is denoted by a,

$$AC^2 = \sqrt{(AB^2 + BC^2 - 2\,AB \cdot BC \cos a)}$$

This is greatest when $a = 180°$, and therefore the mean error of ranging a straight line is greater than that of making a traverse with the same number of stations or sights, a result proved by experience. Having decided on the mean value of the sighting and reading error of the instrument as 15″, the maximum centring displacement as ·05, and the coefficient for the band $c = \cdot 0022$, the mean error of any traverse can be computed and compared with the actual closing error of the survey. If the actual closing error is not greater than the computed mean error the work can be considered as satisfactory. If, however, the closing error is greater than the computed mean error, a revision of the survey should be made.

The following is from a closed survey by steel band and 5 in. theodolite over hilly country.

Denoting the length of the lines by l_1, l_2, l_3, &c., l_n, the bearings of the lines by B_1, B_2, B_3, &c., B_n, the mean error of the bearings by b_1, b_2, b_3, &c., b_n, the mean error in the latitude of the end point—

$$= \pm \sqrt{\left\{ C^2 (l_1 \cos^2 B_1 + l^2 \cos^2 B_2 + l_n \cos^2 B_n) + (l_2^2 b_2^2 \sin^2 B_2 + l_3^2 b_3^2 \sin^2 B_3 + l^2_n b^2_n \cos^2 B_n) \right\}} \qquad (11)$$

The mean error in the departure of the end point—

$$= \pm \sqrt{\left\{ C^2 (l_1 \sin^2 B_1 + l_2 \sin^2 B_2 + l^2_n \sin^2 B_n) + l^2_2 b^2_2 \cos^2 B_2 + l^2_3 b^2_3 \cos^2 B_3 + l^2_n b^2_n \cos^2 B_n) \right\}} \qquad (12)$$

The mean error at the end of the traverse—

$$= \pm \sqrt{\left\{ C^2 (l_1 + l_2 + l_n) + l^2_2 b^2_2 + l^2_2 b^2_2 + l^2_3 b^2_3 + l^2_n b^2_n) \right\}} \qquad (13)$$

Example of traverse over hilly country—

Peg Number.	Bearing.	Distance.	Latitude.	Departure.	Total Latitude.	Total Departure.
		Links.				
1	271° 49′ 20″	1117·2	+ 35·5	− 1116·6	+ 35.5	− 1116·6
2	278 31 00	1093·0	161·9	1081·0	197·4	2197·6
3	346 25 00	391·6	380·6	92·0	578·0	2289·6
4	314 37 00	2017·8	1417·3	1436·3	1995·3	3725·9
5	280 31 00	514·4	+ 93·9	505·8	2089·2	4231·7
6	235 27 00	898·7	− 509·7	740·2	1579·5	4971·9
7	203 08 00	483·2	444·3	189·8	1135·2	5161·7
8	227 57 00	869·6	582·4	645·7	552·8	5807·4
9	340 25 00	422·6	+ 398·2	− 141·6	951·0	5949·0
10	8 33 20	3039·5	3005·7	+ 452·2	3956·7	5496·8
11	19 14 00	3913·7	+ 3695·2	1289·3	7651·9	− 4207·5
12	90 00 00	4209·2	...	+ 4209·2	+ 7651·9	+ 1·7
13	180 00 00	7652·3	− 7652·3	...	− 0.4	+ 1·7
Total	...	26622·8	...	...	.	...

The actual error in latitude is 0·4, and in departure 1·7, therefore the total actual error is $\sqrt{\{(0{\cdot}4)^2 + (1{\cdot}7)^2\}} = 1{\cdot}75$.

To compute the mean error the centring error is obtained by using equation (10), and combining the result with the mean sighting and reading error of 15″ for each angle. A total error of 54″ is found for the bearing of the last line. Then using equation (13) for the total mean error at the end of the traverse, the square of the error due to linear measurement is found to be 1·289, and the square of the mean error due to angular measurement 5·519. The total mean error is $\sqrt{(1{\cdot}289 + 5{\cdot}519)} = 2{\cdot}6$—about 1 in 10,000, or about 0·8 per mile.

The lines in the above traverse being long is favourable to a high degree of accuracy, and the actual error is about ·7 of the mean error, a result that is satisfactory.

This example shows that for open country, with traverse lines from about 5 chains long and upwards, the error of the bearing should not exceed 1′, and the actual closing error in latitude and departure should be not greater than 1 link per mile for each: that is, the actual error should be less than 1·414 per mile for the length of traverse.

The limits of error permissible in traverses deduced from the last example are not applicable to traverses through broken forest country or for surveys in mountainous localities, where the lines are usually short. In a traverse with forty or fifty lines to the mile the error of reading the chain at each station must be considered, and the sighting and reading error should be increased from 15″ to 30″ for each line.

The reading end of the band is divided into links, and the reading taken to the nearest tenth of a link, either by scale or by estimation. When a scale divided into tenths is used the greatest error that can occur is 0·5 link, and since the error may have any value between ·05 and zero the mean error of reading the chain for each station is therefore ·025 link. Taking fifty stations to the mile as an average, the mean error of reading can be found as if it depended on the distance, and consequently combined with the band coefficient. Thus if r denote the reading-error when fifty lines are taken to the mile, and the average line 160 links in length, then—

$$r = \pm {\cdot}025 \sqrt{50/8000}$$
$$= \pm {\cdot}177/\sqrt{8000} = {\cdot}002.$$

Combining this with the value of $c = {\cdot}002$ gives a coefficient of ·0029. Using this value, ·0029, for the band coefficient and 30″ for the sighting and reading error, with ·05 as the greatest displacement in the centring, the mean error can be computed and serve as a guide to the degree of accuracy attainable in this class of work.

Taking the last example, with the lines one-tenth as long as used there, the mean errors are found to be as follows: The closing error in bearing is 2′ 35″; the mean closing error is 0·9. In the case of the angular errors, the error due to imperfect centring is nearly equal to the reading and sighting error. The closing error is 2·71 per mile. For work of this class the error in the bearing should not exceed 3′, and the closing error in latitude and departure should not exceed 2 links to the mile, thus giving an actual closing error of 2·83 per mile on the total length of the traverse.

The next case to consider is surveys in cities, where greater accuracy is desired. Such work usually consists in measuring short distances from standard marks, and turning angles off lines the bearings of which have been accurately measured. When the surveyor, with his staff and instruments, is on the ground the extra time required to measure the distances twice and to take mean bearings is not great. For this work the instrumental constants will be taken as follows: Band coefficient, ·0015 = c; sighting and reading error, 10″ = v; greatest centring displacement, 0·015 link = a. This band coefficient gives an error of ·033 for a 500-band length on the level.

The following example is an actual survey on hilly ground, the grades ranging from 30″ to 15° 30″, the greater number of lines having vertical angles between 6° and 8°. In this case all the operations connected with the computation are shown in full.

Example of City Traverse.

Station.	Observed Bearing.	Measured Distance.	Latitude.	Departure.	Total Latitude from No. 1.	Total Departure from No. 1.
		Links.				
1	...	...	0·00	0·00	0·00	0·00
2	165° 46′ 24″	390·99	− 379·00	+ 96·09	− 379·00	+ 96·09
3	130 30 00	535 00	− 347·45	+ 406·82	− 726·45	+ 502·91
4	185 30 00	250·00	− 248·85	− 23·96	− 975·30	+ 478·95
5	232 00 00	140·00	− 86·19	− 110·32	− 1061·49	+ 368·63
6	320 40 00	100·00	+ 77·35	− 63·38	− 984·14	+ 305·25
7	271 31 00	228·69	+ 6·05	− 228·61	− 987·09	+ 76·74
8	329 34 15	882·20	+ 760·68	− 446·81	− 217·41	− 370·17
1	59 34 15	429·25	+ 217·40	+ 370·12	− 0·01	− 0·05

The actual closing error in this traverse is 0·01 in latitude and 0·05 in departure, or a total error of ·051 for the traverse of 2956 links.

To compute the mean error due to the constants adapted for the theodolite and band, the first step is to determine the centring error from equation (10).

Angular centring error $= \frac{4r \,.\, AC}{3\pi \, AB \,.\, BC}$. Applying this to each station gives the following:—

Square of centring error (using rounded-off values)—

$$(1) = \left(\frac{4 \times \cdot 015}{3 \times 3\cdot 1416}\right)\left(\frac{490}{390 \times 430}\right)^2 = \frac{3\cdot 46}{10^{10}}$$

$$(2) = \frac{4\cdot 05}{10^5}\left(\frac{870}{390 \times 530}\right)^2 = \frac{7\cdot 18}{10^{10}}$$

$$(3) = \frac{4\cdot 05}{10^5}\left(\frac{710}{530 \times 250}\right)^2 = \frac{11\cdot 63}{10^{10}}$$

$$(4) = \frac{4\cdot 05}{10^5}\left(\frac{360}{250 \times 140}\right)^2 = \frac{42\cdot 85}{10^{10}}$$

$$(5) = \frac{4\cdot 05}{10^5}\left(\frac{180}{140 \times 100}\right) = \frac{66\cdot 95}{10^{10}}$$

$$(6) = \frac{4\cdot 05}{10^5}\left(\frac{300}{100 \times 230}\right)^2 = \frac{68\cdot 90}{10^{10}}$$

$$(7) = \frac{4\cdot 05}{10^5}\left(\frac{1020}{230 \times 880}\right)^2 = \frac{10\cdot 29}{10^{10}}$$

$$(8) = \frac{4\cdot 05}{10^5}\left(\frac{990}{880 \times 430}\right)^2 = \frac{2\cdot 77}{10^{10}}.$$

The second step is to determine the mean error in the traverse angles due to the sighting and reading error of 10″. This gives $v = \pm 10'' = 10^{-5}\ 4\cdot 848$ in circular measure, $\therefore v^2 = 10^{-10} \times 23\cdot 50$ for each angle.

The error in the bearing of each line is shown in the following table:—

1.	2.	3.	4.	5.
a^2.	v^2.	1 + 2.	Mean (error)^2 in Bearing.	Line.
$10^{-10} \times 3\cdot 46$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 26\cdot 96$	$10^{-10} \times 26\cdot 96$	2–3
$10^{-10} \times 7\cdot 18$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 30\cdot 68$	$10^{-10} \times 57\cdot 64$	3–4
$10^{-10} \times 11\cdot 63$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 35\cdot 13$	$10^{-10} \times 92\cdot 77$	4–5
$10^{-10} \times 42\cdot 85$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 66\cdot 35$	$10^{-10} \times 159\cdot 12$	5–6
$10^{-10} \times 66\cdot 95$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 90\cdot 45$	$10^{-10} \times 249\cdot 57$	6–7
$10^{-10} \times 68\cdot 90$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 92\cdot 40$	$10^{-10} \times 341\cdot 97$	7–8
$10^{-10} \times 10\cdot 29$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 33\cdot 79$	$10^{-10} \times 375\cdot 76$	8–1
$10^{-10} \times 2\cdot 77$	$10^{-10} \times 23\cdot 50$	$10^{-10} \times 26\cdot 27$	$10^{-10} \times 402\cdot 03$	1–2
$10^{-10} \times 214\cdot 03$	$10^{-10} \times 188\cdot 00$	$10^{-10} \times 402\cdot 03$	...	...

The closing error in the bearing is therefore $10^{-4}\sqrt{4\cdot 0203}$ in circular measure or 0′ 42″ in arc.

The last step consists in computing the error in the total length of the traverse due to the coefficient of the chain and the errors in the traverse due to the angular errors in each line.

$$c = \cdot 0015,\ \Sigma d = 2956 \text{ links},\ \therefore c^2\Sigma d = \cdot 006651.$$

The square of the mean error for each line is as follows:—

$$\begin{array}{ll} (2\text{–}3) & 10^{-10} \times 26\cdot 96 \times 530^2 = \cdot 000757 \\ (3\text{–}4) & 10^{-10} \times 57\cdot 64 \times 250^2 = \cdot 000360 \\ (4\text{–}5) & 10^{-10} \times 92\cdot 77 \times 140^2 = \cdot 000182 \\ (5\text{–}6) & 10^{-10} \times 159\cdot 12 \times 100^2 = \cdot 000159 \\ (6\text{–}7) & 10^{-10} \times 249\cdot 57 \times 230^2 = \cdot 001320 \\ (7\text{–}8) & 10^{-10} \times 341\cdot 97 \times 880^2 = \cdot 026482 \\ (8\text{–}1) & 10^{-10} \times 375\cdot 76 \times 430^2 = \cdot 006948 \\ & \text{Sum} = \cdot 036208 \end{array}$$

$$\text{Mean error of closure} = \pm\sqrt{(\cdot 006651 + \cdot 036208)} = \pm\ \cdot 207.$$

Expressed in terms of a mile it is ·56, or 0·395 in latitude and departure.

The errors in the bearing in the above example due to imperfect centring are a little greater than those caused by the error of sighting and reading. This is accounted for by the three short lines 4–5, 5–6, and 6–7. The error of closure due to chaining is small compared with the total angular error, the angular error being about two and a half times as great as the chaining-error, a result that shows the superiority of the steel-tape measurements compared with the theodolite observations. The actual closing error in the above survey, ·051, represents 1 in 58,000, or ·14 per mile, or ·10 in latitude and departure per mile.

In standard work connecting the permanent monuments of a city survey the closing error should not exceed this limit; such small closing errors can only be obtained by the use of special apparatus for measuring, and high-grade theodolites for the angular work.

The results obtained by the above theoretical investigations agree very well with the closing errors in the surveys by experienced and competent surveyors; and for larger limits allowable by the regulations there is the disadvantage that carelessness and inaccuracy may be induced in the field-work, and frequently mistakes amounting to 5 links are not detected on account of the closing error being within the prescribed limits.

A summary of the results and a suggested limit for the errors in the three classes of work investigated can now be given:—

(1.) For traverses in open country which is level and undulating the theoretical value is 0·8 per mile for the closing error in latitude and departure, and 54″ for the error in bearing.

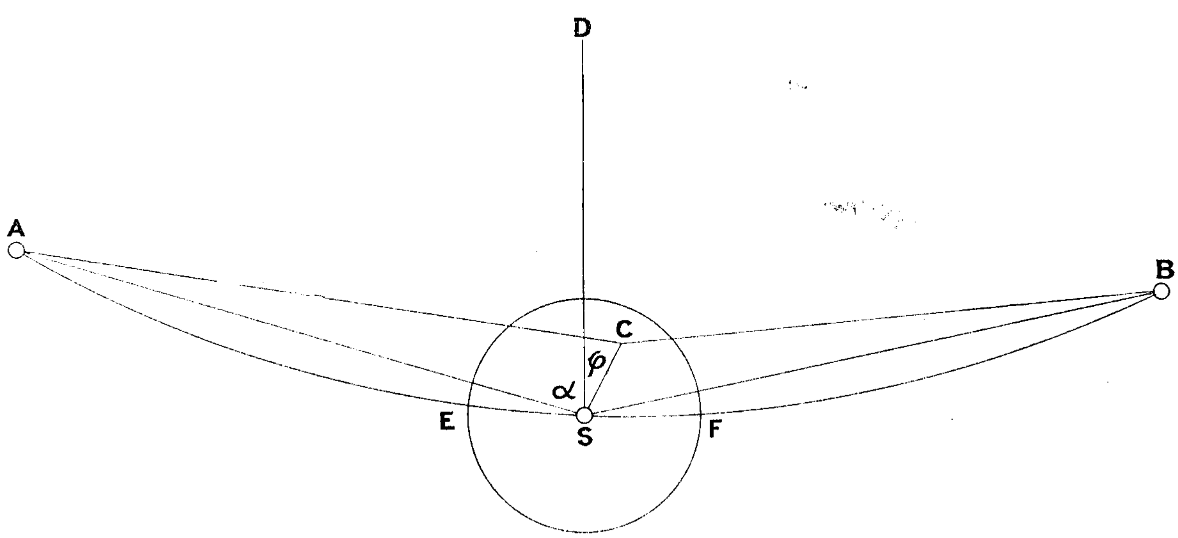
(2.) Traverses in broken forest country or mountainous localities where the lines are short, theory gives 1·9 per mile in latitude and departure, and 2′ 35″ for the closing error in the bearing.

(3.) In town surveys the theoretical values are 0·4 per mile in latitude and departure, and 42″ for the error in bearing.

The suggested limits are as follows: In class (1), 1 link per mile in latitude and departure and 1′ error in the bearing; in class (2), 2 links per mile in latitude and departure and 3′ error in the bearing; in class (3), half a link per mile in latitude and departure and 1′ error in the bearings. These errors are either positive or negative, hence the range of the errors is twice the above amounts.

Error due to Imperfect Centring.

The mean error due to imperfect centring is not given in most text-books on least square. An analytical investigation is given by Briggs in "The Effects of Errors in Surveying," and the following treatment of the problem is somewhat similar:—



Let A, S, and B denote three consecutive stations of the traverse, and r the maximum error permitted in centring. AESB is the arc of a circle passing through the three stations. Describe a circle about S as centre with radius r. Then the point over which the instrument is set will lie within this circle, and the probability of it being over C is equal to that of it being over any other point. Denote the angles ASB by 2α and ACB by 2β. Bisect ASB by the line SD. Denote DSC by ϕ and SC by x. When the instrument stands over C the angle ACB (2β) will be measured instead of ASB (2α), and the angular error is $2(\beta - \alpha)$.

Let AS = D_1 and BS = D_2

$$\sin \text{SAC} = \frac{x \sin(\alpha + \phi)}{D_1}$$

or, since the angle SAC is small,

$$\text{angle SAC} = \frac{x \sin(\alpha + \phi)}{D_1}$$

Similarly, angle SBC $= \dfrac{x \sin(\alpha - \phi)}{D_2}$

$$\therefore \text{SAC} + \text{SBC} = \frac{x \sin(\alpha - \phi)}{D_1} + \frac{x \sin(\alpha + \phi)}{D_2}$$

$$\text{or } 2(\beta - \alpha) = \pm x \left(\frac{\sin(\alpha - \phi)}{D_1} + \frac{\sin(\alpha + \phi)}{D_2} \right) \qquad (14)$$

The value of $2(\beta - \alpha)$ is zero for any point on the arc ESF, and since the radius r of the small circle is not great the tangent at S of the arc ASB will not differ sensibly from the arc ESF within the small circle.

Therefore from (1) for any point on ESF,

$$\frac{x}{D_1}\sin(\alpha + \phi_0) = -\frac{x}{D_2}\sin(\alpha - \phi_0)$$

$$\therefore \tan\phi_0 = \left(\frac{D_1 + D_2}{D_1 - D_2}\right)\tan\alpha$$

$$\text{or } \phi_0 = \tan^{-1}\left\{\left(\frac{D_1 + D_2}{D_1 - D_2}\right)\tan\alpha\right\} \qquad (15)$$

where ϕ_0 is the angle ESD. Therefore where ϕ is less than ϕ_0 or greater than $\pi + \phi_0$ the error $2(\beta - \alpha)$ will be positive, and for all values of ϕ between ϕ_0 and $\pi + \phi_0$ it will be negative. In other words, 2β is greater or less than 2α according as the point C lies above or below ESF.

Suppose the point C to be contained in an elemental area dx by dy, of which dx is in the direction of the radius and dy at right angles, and let the angle subtended by dy at S be $d\phi$. The number of such points as C within the semicircle above ESF, in which $2(\beta - \alpha)$ is positive, is,—

$$\frac{1}{2}(\pi \, . \, r \, . \, ^2/dx, \, dy) \qquad (16)$$

Within the elemental area at a distance x from the centre there are $x\frac{d\phi}{dy}$ such points as C. Therefore the sum of the angular errors for all points in the semicircle above ESF is given by the definite integral—

$$\int_{\phi_0 + \pi}^{\phi_0} . \int_0^r x^2\left(\frac{\sin(\alpha + \phi)}{D_1} + \frac{\sin(\alpha - \phi)}{D_2}\right)\frac{d\phi}{dy}$$

and the mean angular centring error is obtained by dividing this result by (16), and is—

$$= \frac{2}{\pi \, . \, r \, .^2}\int_{\phi_0 + \pi}^{\phi_0} . \int_0^r x^2\left(\frac{\sin(\alpha + \phi)}{D_1} + \frac{\sin(\alpha - \phi)}{D_2}\right)dx \, . \, d\phi.$$

$$= \frac{4 \, . \, r}{3 \, . \, \pi}\sqrt{\left(\frac{1}{D_1^2} + \frac{1}{D_2^2} - \frac{2\cos 2\alpha}{D_1 D_2}\right)}$$

A similar expression with the negative sign determines the mean error of centring of the semicircle below ESF: hence the mean centring error is—

$$E_c = \pm \frac{4r}{3\pi}\sqrt{(D_1^2 + D_2^2 - 2D_1 D_2 \cos 2\alpha)}/D_1 D_2$$

Now, $\sqrt{(D_1^2 + D_2^2 - 2D_1 D_2 \cos 2\alpha)} = AB,$

therefore, $$E_c = \pm \frac{4 \, . \, r \, . \, AB}{3\pi \, . \, AS \, . \, BS} \qquad (17)$$

The distance between two stations adjacent to the one under consideration is termed by Mr. Briggs a transector. Thus AB is the transector of the station S.

Part 2. Limits of Errors in Triangulation.

In practice the accuracy of triangulation is judged from the measured and calculated length of a check base, or the agreement of the computed values of any line through a geometrical figure. A triangulation serves as a back-bone survey, the purpose of it being to establish a number of fixed points over the country with a high degree of accuracy. These triangulation stations control the traverses connected with them, and when well placed the traverses will usually run from one station to the next. The accuracy in the triangulation should be such that when the closing error in the traverse is being assessed there should be no need to take the triangulation error into account.

Now, if x denote the error due to the traverse, and y the error in the triangulation, the total error z is represented by $z = \pm\sqrt{x^2 + y^2}$.

If y in the above expression is one-third of x, $z = \pm\sqrt{\frac{10x^2}{9}} = 1{\cdot}05x$, or the influence of y on z is only about $\frac{1}{20}$ of x, and can be considered negligible.

If the error in the traverse has a maximum value of 1 in 6,000, a suitable error in the triangulation should be 1 in 18,000.

The triangulation error (a) can be divided into the error in the measurement of the base-line (b) and the error due to the angular measurements (c), and therefore $a = \pm\sqrt{b + c}$.

Error in Base-line Measurement.

With the steel ribband it is not difficult to measure a base-line with an accuracy of 1 in 200,000, and the discovery of invar and its application to the measurement of distances provides a rapid and inexpensive method of base-line measurement of a high degree of accuracy.

The metal invar is an iron-nickel alloy containing about 36 per cent. nickel. The coefficient of expansion of invar wires drawn in the steel-works of Imphy ranges from one hundred to fifty times less than that of steel.

It is well known that iron has three different forms—namely, alpha, beta, and gamma iron—each possessing different physical characteristics. Alpha, or iron about atmospheric temperature, is highly magnetic. Alpha iron heated to a dull red becomes beta, and with increase of temperature changes to gamma at a cherry red. Beta iron is non-magnetic. The expansion of the iron when heated on the passage from the beta to gamma form changes, and a sharp contraction occurs. The effect of alloying the iron with nickel lowers the temperature at which allotropic change takes place, and with 36 per cent. of nickel the alloy fluctuates between the beta and gamma forms at ordinary temperatures. This means that invar wires will have a slight expansion until a certain temperature is reached, and afterwards contract if the temperature increases, the total range depending on the percentage of nickel added.

The coefficient of linear expansion of an $\frac{1}{8}''$ invar tape was determined by Dr. Glazebrook as follows:—

$$L_t = L_0 \,[1 + \cdot 0000007_4\, T - \cdot 000000008_9\, T^2]$$

$$\text{or } \theta = \frac{L_t - L_0}{L_0} = 10^{-6} \cdot 74T - 10^{-6} \cdot 0089T^2$$

$$\therefore \frac{d\theta}{dT} = 74 - 1 \cdot 78T = 0.$$

$$T = 41 \cdot 6^\circ.$$

Thus the tape expands from 0° to 41·6° C., and with a further rise of temperature it contracts.

The extension for 1° C. at 0° C. is 100·000073 – 100 for 1 chain, or $10^{-4} \times \cdot 73$; the extension for a steel band for 1° C. is $10^{-4} \times 11 \cdot 25$; and the extension of this invar tape is about $\frac{1}{15}$ that of a steel one at 0° C. It is therefore not difficult to obtain with the invar tape an accuracy of $\pm 2\mu$, or 1 in 500,000, in the base-measurement at a reasonable cost, a result that is considered sufficiently accurate for primary work. Consequently, when the accuracy of the triangulation is 1 in 18,000 the error of the base-measurement of $\pm 2\mu$ is negligible compared to the errors of the angular measurements.

When the angles of a triangle have been measured by the same method, the mean angular error can be taken as of equal amount in each of them; and since the sum of the angles of a triangle is sensibly 180°, the error in the measurement of each angle is a known quantity: thus if the sum of the observed angles is 180° + 12″, the correction to be applied to each observed angle is – 4″.

Suppose the three angles of a triangle observed, and one side known: it is required to find the form of the triangle in order that the other sides may be least affected by errors in the observations. An admittedly unsatisfactory investigation of this problem is given under "Geodesical operations" in Todhunter's "Spherical Trigonometry" (4th edition), the result being that an equilateral is the best-conditioned triangle.

In the case of a single triangle the equilateral is the best-conditioned, as is shown as follows:—

Let the side (a) and the three angles be measured: then—

$$b = a\,\frac{\sin B}{\sin A} \qquad c = a\,\frac{\sin C}{\sin A}$$

If each angle have a mean error e, the error in $b = be\sqrt{(\cot^2 A + \cot^2 B)}$, and the mean error in $c = ce\sqrt{(\cot^2 A + \cot^2 C)}$. The smallest error in b is when A = B, and the smallest error in c is when A = C, or the best result is obtained when the triangle is equilateral.

When a triangle forms one link in a triangulation scheme, the angular errors will not only affect the computed lengths of the unmeasured sides, but will be carried forward through the whole scheme; and the triangle must be treated as an agent for transmitting distance, and each of the unmeasured sides must be given the same weight. Thus the first condition for the best form is that the triangle be of isosceles shape. The second condition is that the triangle will have the best form when it fulfils its function as a transmitter of distance with a minimum of error.

In the triangle ABC the second condition is fulfilled when the ratio of the error in a or b to the side a or b is the least possible. Thus if l_a and l_b are the errors in a and b, then $\frac{l_a}{a} = \frac{l_b}{b}$ is a minimum.

In an isosceles triangle—

$$C = \pi - 2A \qquad (1)$$

and

$$a = \frac{c \sin A}{\sin C} \qquad (2)$$

$$E_a = \pm \sqrt{\left\{\left(\frac{da}{dc}\right)^2 E_c^{\,2} + \left(\frac{da}{dA}\right)^2 \nu_a^{\,2} + \left(\frac{da}{dC}\right)^2 \nu^2\right\}}$$

$$= \pm \sqrt{\left\{\frac{\sin^2 A}{\sin^2 C} \cdot E_c^{\,2} + a^2 \nu^2 \cot^2 A + a^2 \nu^2 \cot^2 C\right\}}$$

$$\therefore \frac{E_a}{a} = \pm \sqrt{\left\{\nu^2 (\cot^2 A + \cot^2 C) + \left(\frac{E_c}{C}\right)^2\right\}} \text{ by (2),}$$

$$= \pm \sqrt{\left\{\nu^2 (\cot^2 A + \cot^2 2A) + \left(\frac{E_c}{C}\right)^2\right\}} \text{ by (1).}$$

This has its least value when $\cot^2 A + \cot^2 A$ is a minimum. Putting—

$$y = \cot^2 A + \cot^2 2A$$

$$\frac{dy}{dA} = 2 \cot A + \cot 2A \sec^2 A = 0$$

$$\therefore \cos^2 2A + 3 \cos 2A = -1$$

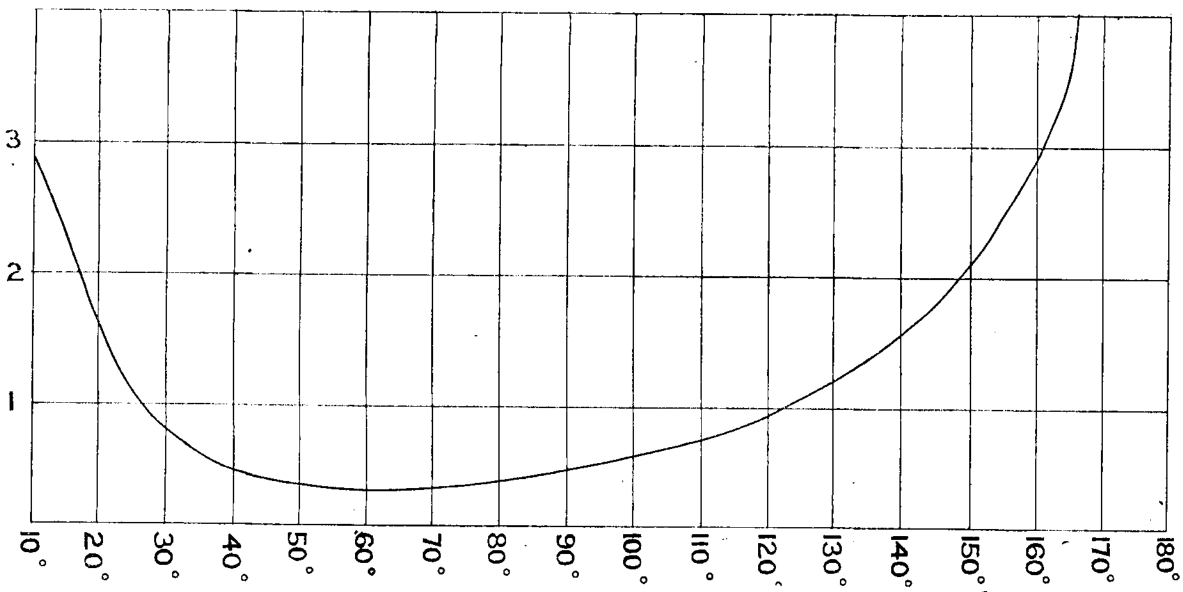
$$\cos 2A = \frac{\sqrt{5} - 3}{2}$$

$$A = 66^\circ\ 15' \text{ nearly.}$$

The theoretical best shape is therefore an isosceles triangle, with the angles adjacent to the base, equal to 56° 15′, and the apical angle to 67° 30′. In such a triangle the unmeasured sides are less than the base in length, consequently a triangulation scheme could not be advantageously laid out with triangles of this form, but they can be used with advantage to expand a short base by the quadrilateral method.

A point of great importance in a triangulation scheme is that the stations should be spread over the country at fairly regular intervals, and this is attained by triangles not differing much from the equilateral form; and for economical reasons the shape of the triangles is governed by the topography of the country to be surveyed, since the stations must usually be fixed on elevated points that command a clear view of the surrounding country.

By plotting the curve $y = \cot^2 A + \cot^2 2A$ for values of C between 0° and 180°, at intervals of 10°, a graphical representation is obtained, from which it is easy to see how far the angles of an isosceles triangle may safely depart from the equilateral form.



The diagram shows that for isosceles triangles the angle at the apex may vary from 50° to 90° and the triangle remain well-conditioned. The ordinate increases rapidly for angles less than 30° or greater than 120°, so that no angle in a triangle should lie outside these limits, a well-known rule which is generally observed.

The survey districts in the Dominion of New Zealand are about 12½ miles square, and the sides of the minor triangles are usually from three to five miles in length; thus there are usually about twenty triangles in a district, generally depending on a measured base. The error in the summation of the three angles in a triangle, according to the latest regulations, is not to exceed 20″. By taking 21″ as the error in the summation of the triangles a correction of 7″ for each angle may be used, and the error in an average set of triangles computed.

Taking the formula—

$$\frac{E_a}{a} = \pm \sqrt{\left\{ \nu^2 (\cot^2 A + \cot^2 C) + \left(\frac{E_c}{C}\right)^2 \right\}} \qquad (3)$$

where C is the base-line and l_c in the error in the base-measurement, by following a chain of triangles which leads to a check base or returns to the original base a comparison can be obtained of the measured and computed lengths, and the fractional error thus found can be used as a test of the accuracy of the angular results.

The fractional error in the second triangle, using the computed value of (a) as a new base, gives—

$$\frac{E_d}{d} = \pm \sqrt{\left\{ \nu^2 (\cot^2 D + \cot^2 F) + \left(\frac{E_a}{a}\right)^2 \right\}} \qquad (4)$$

$$= \pm \sqrt{\left\{ \nu^2 (\cot^2 A + \cot^2 C + \cot^2 D + \cot^2 F) + \left(\frac{E_a}{a}\right)^2 \right\}} \text{ by (1).}$$

Similarly, if z is the n^{th} line—

$$\frac{E_z}{z} = \pm \sqrt{\left\{ \nu^2 \left(\begin{array}{c}\text{sum of squares of cotangents of angles} \\ \text{opposite lines used as bases}\end{array} \right) + \left(\frac{E_c}{c} \right)^2 \right\}} \qquad (5)$$

When the triangles are well conditioned, or are nearly equilateral in shape, (3) reduces to—

$$\frac{E_z}{z} = \pm \sqrt{\frac{\nu^2\, 2n}{3} + \left(\frac{E_c}{c}\right)^2}$$

If the n^{th} line returns to the base, and since the error in the base is independent of the angle observations, the total error due to angular measurement is given by—

$$\frac{E_z}{c} + \pm \nu \sqrt{\frac{2n}{3}} \qquad (6)$$

Taking the triangles around the boundary of a district, a fair average of the number of triangles in the chain is 15, and therefore $n = 16$.

If $\nu = 7'' = 10^{-5} \times 3{\cdot}394$ in radians, then $\frac{E_z}{c} = \frac{1}{9000}$, very nearly.

This is the most favourable result that can be expected in this class of survey, since the triangles are all equilateral. If 50° is taken as a fair average for obtaining the angular errors the resulting error due to angular measurement is $\frac{E_z}{c} = \frac{1}{8800}$.

These results are usually obtained by actual experience in minor triangulation, in which the angles are measured with a 5 in. theodolite.

For the triangulation to be of value as a controlling agent the accuracy should be 1 in 18,000 instead of 1 in 9,000, as determined by the error in the summation of the angles of a triangle not exceeding 21″. The accuracy of the work can be increased by reducing the number of triangles, with a corresponding increase in the length of the sides, or by measuring bases at intermediate points, or by reducing the error in the summation of the triangles. The first method, of making the triangles larger, is the most economical, but it suffers from the disadvantage that the stations are widely separated and are often too distant to be available for checking traverses that do not extend from one station to the next. The second method, of measuring base-lines at more frequent intervals, has very little to recommend it. In the first place, suitable base-lines must be situated on fairly level or easy country to measure over, and even on flat plains the bases would require to be very numerous to add greatly to the accuracy of the results. Thus to double the accuracy, or to obtain 1 in 18,000, would require a measured base-line at every third triangle. The third method, of reducing the error in the summation of the angles of the triangles, is the most practicable, but it means the employment of larger and more powerful instruments than 5 in. theodolites.

To find the error in the summation of the angles of the triangles, to ensure an accuracy of 1 in 18,000 between the measured and computed values through a chain of 15 triangles, the average angles from which the (cotangents)² are used being taken as 50°, gives, by using the formulæ (4), 10″; or the mean error in each angle should not exceed 3⅓″. To obtain this result the methods of observing and the instrument used will require a short notice.

There are two methods in general use for observing angles—namely, repetition and reiteration. In repetition, an angle is multiplied a number of times on the graduated limb; the result is obtained by dividing the total angle by the number of repetitions. In the reiteration or direction method the angle is obtained as the mean of a number of simple measurements on different parts of the graduated circle.

Let ν'' denote the error in the measurement of an angle. Now, ν is a total error due to two principal causes—viz., the error of reading and the error of sighting. Let E_r be the mean error in taking one reading of a vernier or reading-microscope. Now, E_r will include the effects of uneven graduation of the divided circle. Let E_s denote the sighting-error and be held to include the small errors due to imperfect levelling, and instrumental errors not completely eliminated by the act of observing on both faces. Consider an angle measured by n repetitions on each face, by an instrument equipped with two verniers. Each vernier is read twice in obtaining the multiple angle on each face. The mean error of reading of the multiple angle is therefore $\pm E_r\sqrt{2}$ for each vernier. Dividing the multiple angle by n and taking the mean of the two verniers reduces the reading-error for each face to $\pm E_r/n$, or a final result of $\pm E_r/n\sqrt{2}$ for the mean error of reading.

Again $2n$ sights are taken on each face, and their influence on the multiple angle is therefore $\pm E_s\sqrt{2n}$, or $\pm E_s\sqrt{\frac{2}{n}}$ on the quotient, and taking the mean of the two faces $\pm E_s/\sqrt{n}$ is the mean error of sighting.

Combining the errors of reading and sighting gives: Mean error in an angle measured by n repetitions on each face,—

$$\nu_1 = \pm \sqrt{\left\{ \frac{E_r^2}{2n^2} + \frac{E_s^2}{n} \right\}} \qquad (7)$$

When an angle is measured by n reiterations on each face, the mean of $2n$ angles is taken, each angle being measured separately by both verniers. Reading one angle by one vernier a mean reading-error of $\pm E_r\sqrt{2}$ results, which reduces to $\pm E_r$ by taking the mean of both verniers.

When the mean of the $2n$ angles is obtained the reading-error in the final result is $\pm E_r/\sqrt{2n}$. In the measurement of each angle two sights are taken, and the mean error in each due to sighting is $\pm E_s\sqrt{2}$. The final result as the mean of $2n$ angles is therefore $\pm E_s/\sqrt{n}$.

Combining the errors of reading and sighting gives: Mean error in an angle measured by n reiteration on each face:—

$$r_2 = \pm \sqrt{\left(\frac{E^2_r}{2n} + \frac{E^2_s}{n}\right)} \qquad (8)$$

The sighting-error is equal in each method, and if the reading-error is equal to the sighting-error

$$r_1 : r_2 = \sqrt{1 + 2n} : \sqrt{3n}$$

or, for an angle measured by three repetitions and also by three reiterations on each face—

$$r_1 : r_2 = \sqrt{7} : 3$$
$$= 2{\cdot}65 : 3.$$

In the introduction to the "Adjustment of Observations" (2nd edition), by Wright and Hayford, is the following: "The repeating theodolite has fallen far short of the expectations of its first advocates, who hoped that with it the errors of measurement of an angle could be reduced almost indefinitely. The mechanical difficulties have proved insurmountable, and the repeating theodolite is now known to be capable of no greater accuracy than the direction instrument." The writer, after several years' experience in testing the two methods with several instruments, concurs with the above quotation, and is of opinion that preference should be given to the method of directions, which is usually more expeditious in the field.

The amount of eccentricity and the errors of graduations should be determined for every instrument. The analysis is given in most text-books on geodesy and practical astronomy. The following results were obtained by the writer from an 8 in. transit instrument by Troughton and Simms:—

Vertical circle: Verniers apart, 180° 00′ 14·6″; line of no eccentricity, 49° 19′ 00″ (el. face right); correction to vernier, A – 9·3″ (α – 229° 19′). A second analysis of the vertical circle disclosed a small error of 1·51″, due to the pivot being of elliptical form. As the instrument is an old one the wear on the under-surface is quite noticeable.

Horizontal circle: Verniers apart, 180° 00′ 03″; line of no eccentricity, 79° 11′ 30″; correction for a single reading to vernier—A = 4·36″ sin (α – 79° 11′ 30″); B = – 4·36′ sin (α – 79° 11′ 30″). The mean of the two verniers is free from the error due to eccentricity.

In the above formulæ α is the angle or bearing under the vernier. In the case of a traverse running in the direction of 169° or thereabouts, and only one vernier used, the bearing would soon be affected by the eccentricity.

The mean error of one vernier of the horizontal circle of the above instrument due to errors of graduation and accidental errors of reading was found to be ± 2·90″. By taking the mean of the two verniers this is reduced to ± 2·06″.

The sighting can be assessed by the observer. An error in sighting of ± 2″ represent 1½ in. at a distance of five miles, and is about equal to one-half the thickness of the signal-pole, and is probably the maximum displacement of the central wires, in the field of view from the signal, that occurs with even an indifferent observer. Accepting this value will give ± 2·83″ as the mean sighting-error in the measurement of an angle. Combining these results by the formula—

$$r_2 = \pm \sqrt{\left(\frac{E_r^{\,2}}{2n} + \frac{E_s^{\,2}}{n}\right)}$$

where n is three reiterations on each face, the usual number of observations at each station in minor triangulation.

Substitute these values of E_r and E_s.

$$r_2 = \pm \sqrt{\frac{(2{\cdot}06)^2}{6} + \frac{(2{\cdot}83)^2}{3}}$$

or

$$r_2 = \pm 1{\cdot}89''.$$

The above amount represents the mean error in an angle measured by this 8 in. theodolite.

Using this result to compute the accurracy in the chain of triangles gives—

$$\frac{E_z}{c} = r_2 \times 4 \times \cot 50^\circ = \frac{1}{33000} \text{ (nearly)}.$$

The increased accuracy obtained by using better instruments in a triangulation survey for the angular measurements is obvious from the above result, and is much preferable to increasing the size of the triangles or measuring a greater number of base-lines.

The results obtained are that a 5 in. theodolite can only be expected to give an accuracy of 1 in 9,000 in a minor-triangulation survey, and that an accuracy of 1 in 18,000 is required for controlling the ordinary traverse by 5 in. theodolite and long measuring-tapes. Further, the desired accuracy can be easily obtained or exceeded by adopting 7 in. or 8 in. theodolites for the angular work.

Fuller investigations of the results contained in this article can be found by consulting the following authorities: "Astronomy" (Chavenet); "Geodesy" (Crandal); "Effects of Errors in Surveying" (Briggs); "Progress of Geodesy" (McCaw); "Adjustment of Observations" (Wright and Hayford).

APPENDIX IX.

EXTRACTS FROM REPORT OF MR. J. LANGMUIR, INSPECTOR OF SURVEYS.

STANDARD SURVEYS.

IN addition to 23 miles of new work, an exceptional amount of reinstatement work has been done in the City of Auckland during the year. This is always a rather complicated work. Under the most favourable circumstances, when due notice of the proposed disturbance is given, and the block can be short-fixed, then the cost is minimized, but if the blocks are disturbed before they are fixed, then the cost is frequently heavy. The Auckland City Council authorities now, however, appreciate the necessity of working with the Department to maintain the usefulness of the survey which has been executed at such a large cost. Other local bodies are also for the most part alive to the importance of this class of survey, and are doing their best to assist in every way, and pay the cost of the reinstatement of the blocks when the necessity arises owing to street or road improvements. A considerable amount of work of this class both in the city and suburbs of Auckland is still in hand unfinished.

PROPOSED WORK FOR THE YEAR 1915-16.

The Auckland City Council is desirous of having a complete standard and alignment survey made of Remuera, Grey Lynn, and Arch Hill, three local districts which have lately joined the city. It will also ask that the survey be taken in hand as soon as possible. The Borough of Onehunga, Mangere Road Board, and the Manukau County Council have all agreed to bear the cost of the standard blocks with cast-iron surface boxes, and it will be a matter for regret if this work cannot be carried out at an early date, but to do so assistance in the field will be required. In regard to alignments, I myself have so far taken the responsibility for all so far determined, and if the surveys of Remuera, Grey Lynn, and Arch Hill are taken in hand there will be a large amount of this work to undertake as the work proceeds, some of it complicated and difficult. The office is in arrears with standard plans, and unless further assistance is given in the office progress will, of necessity, be slow.

SECONDARY TRIANGULATION.

Large signals were built at thirty-four stations extending over country from Whakarara, about 8 miles east of Whangaroa Harbour, to Pohokura, on the boundary between the Auckland and Hawke's Bay Land Districts. Building is now going on about Lake Taupo, but other parties have ceased work for the present. There are still nine stations in the southern part of the district, including White Island, which require signals, and sixteen stations in the northern part; these latter will be taken in hand about August. The building of thirty-four signals does not, perhaps, appear a big turnout, but the parties were not engaged continuously, and a large amount of track and other clearing had to be done, much of it in difficult country and during bad weather. A considerable number of the signals are made of jarrah, but in all other cases the timber has been cut and pit-sawn or axed out on the ground. At one station, "Huruiki," which is built on the top of a rock, over 1,000 superficial feet of totara was sawn on the ground for the signal required.

Mr. H. F. Edgecumbe started observations on the 14th May, and continued same to the 17th November, when he was granted twenty-eight days' sick-leave, but did not take the field again until after Christmas, and little success was obtained when he had to leave the work again on the 1st March owing to a return of his illness. The total number of stations observed at were twenty-two, of which eleven were secondary triangulation, six were old major stations the angles of which were reobserved, and five were extra stations in the vicinity of Auckland for the purpose of a standard triangulation connection to the North Shore.

REVISION OF OLD MAJOR AND MINOR TRIANGULATIONS.

This is a work which should be started at once—in fact, the secondary triangulation will not be of any practical use until this is done. I have had a number of permanent signals erected at such stations as seemed desirable, but at many stations temporary signals will be quite sufficient, and there is no necessity for these to be erected until the observer is on the ground. The old work is disconnected also in many places, and new stations are required to complete polygons, &c. Again, new stations will sometimes be required to take the place of stations destroyed or closed in by plantations.

Taking the three classes of survey which I have been permitted to supervise during the last few years—viz., secondary triangulation, standard surveys, and revision of major and minor triangulation—much more assistance is required if any practical results are to be obtained within a reasonable time. Two observers are required for the secondary triangulation, one extra standard surveyor, one surveyor to start the revision of the old major and minor triangulations where required, and, if possible, a start should be made with the precise levelling of the district. Dealing with all classes of work in hand, the requirements, in order, appear to be as follows:—

(1.) Final determination of the values of the new secondary base-lines measured.

(2.) Continuation of the observation of secondary triangles by two observers for the Auckland District. Extra observations for true meridian are required.

(3.) Computing staff—I presume, in Wellington—to carry out the computations in connection with the secondary triangulation in the first place; but as soon as possible to also undertake the recomputation and harmonizing of the revised old major and minor triangulations therewith.
(4.) Revision of the old major and minor triangulations, these two works to be carried out simultaneously by the same observers.
(5.) Continuation of standard and alignment surveys along the main lines of traffic and close settlement.
(6.) Precise levelling.

In regard to major and minor triangulation closes, &c., I have not given much detail, for the reason that the late Mr. Cussen went fully into the matter, and his valuable report is available for reference. Again, much of the old major work may no doubt be finally adopted, and possibly a good deal of the minor—that is, as far as the observations are concerned; but the whole of the work in the Auckland District requires field revision, in a sense, to complete series and polygons, with a recomputation of the whole of the old work.

Approximate Cost of Paper.—Preparation, not given; printing (1,350 copies), including diagrams and maps, £142.

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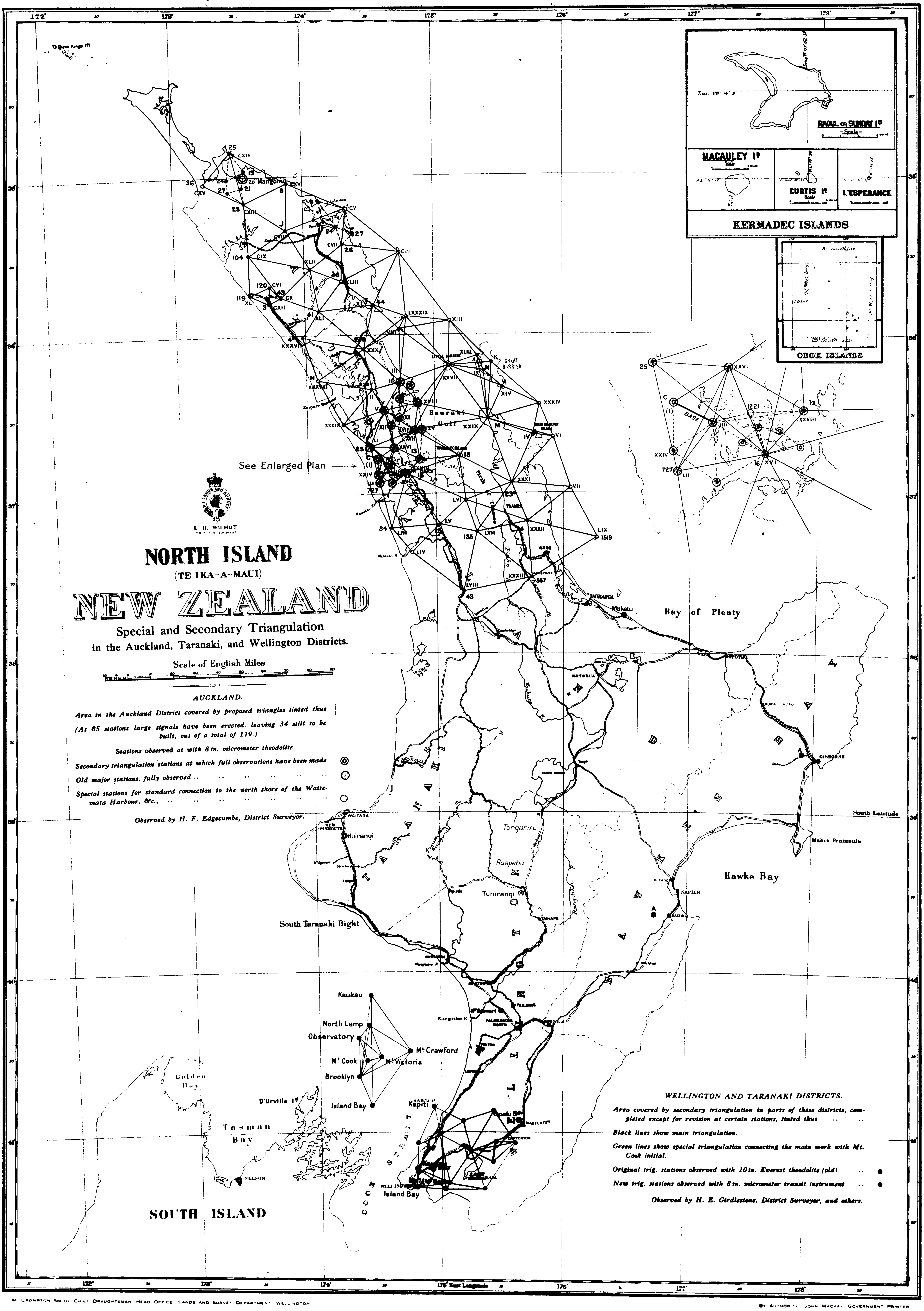

NORTH ISLAND
(TE IKA-A-MAUI)
NEW ZEALAND
Special and Secondary Triangulation
in the Auckland, Taranaki, and Wellington Districts.
Scale of English Miles
E. H. WILMOT
AUCKLAND.
Area in the Auckland District covered by proposed triangles tinted thus
(At 85 stations large signals have been erected, leaving 34 still to be built, out of a total of 119.)
Stations observed at with 8 in. micrometer theodolite.
Secondary triangulation stations at which full observations have been made
Old major stations, fully observed
Special stations for standard connection to the north shore of the Waitemata Harbour, &c.,
Observed by H. F. Edgecumbe, District Surveyor.
See Enlarged Plan
WELLINGTON AND TARANAKI DISTRICTS.
Area covered by secondary triangulation in parts of these districts, completed except for revision at certain stations, tinted thus
Black lines show main triangulation.
Green lines show special triangulation connecting the main work with Mt. Cook initial.
Original trig. stations observed with 10 in. Everest theodolite (old)
New trig. stations observed with 8 in. micrometer transit instrument
Observed by H. E. Girdlestone, District Surveyor, and others.
KERMADEC ISLANDS
RAOUL or SUNDAY Id
MACAULEY Id
CURTIS Id
L'ESPERANCE
COOK ISLANDS
Bay of Plenty
Hawke Bay
Mahia Peninsula
South Latitude
South Taranaki Bight
Tasman Bay
Golden Bay
D'Urville Id
SOUTH ISLAND
NELSON
Kapiti
Island Bay
Kaukau
North Lamp
Observatory
Mt Cook
Mt Victoria
Mt Crawford
Brooklyn
Island Bay
Tongariro
Ruapehu
Tuhirangi
Huirangi
NEW PLYMOUTH
WAITARA
NAPIER
GISBORNE
ROTORUA
TAURANGA
Maketu
Hauraki Gulf
GREAT BARRIER
Mangonui
175° East Longitude

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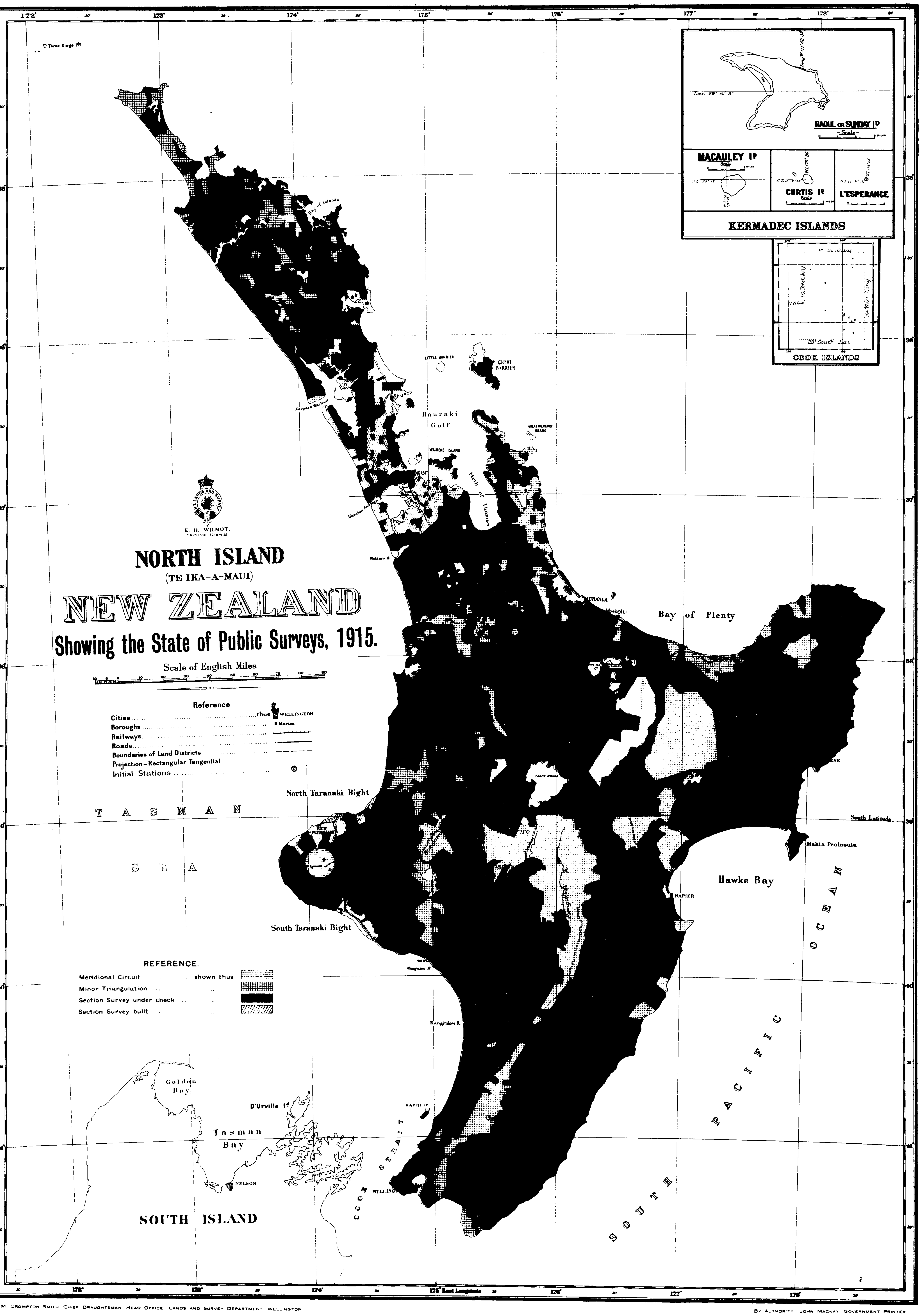

M. Crompton Smith Chief Draughtsman Head Office Lands and Survey Department Wellington

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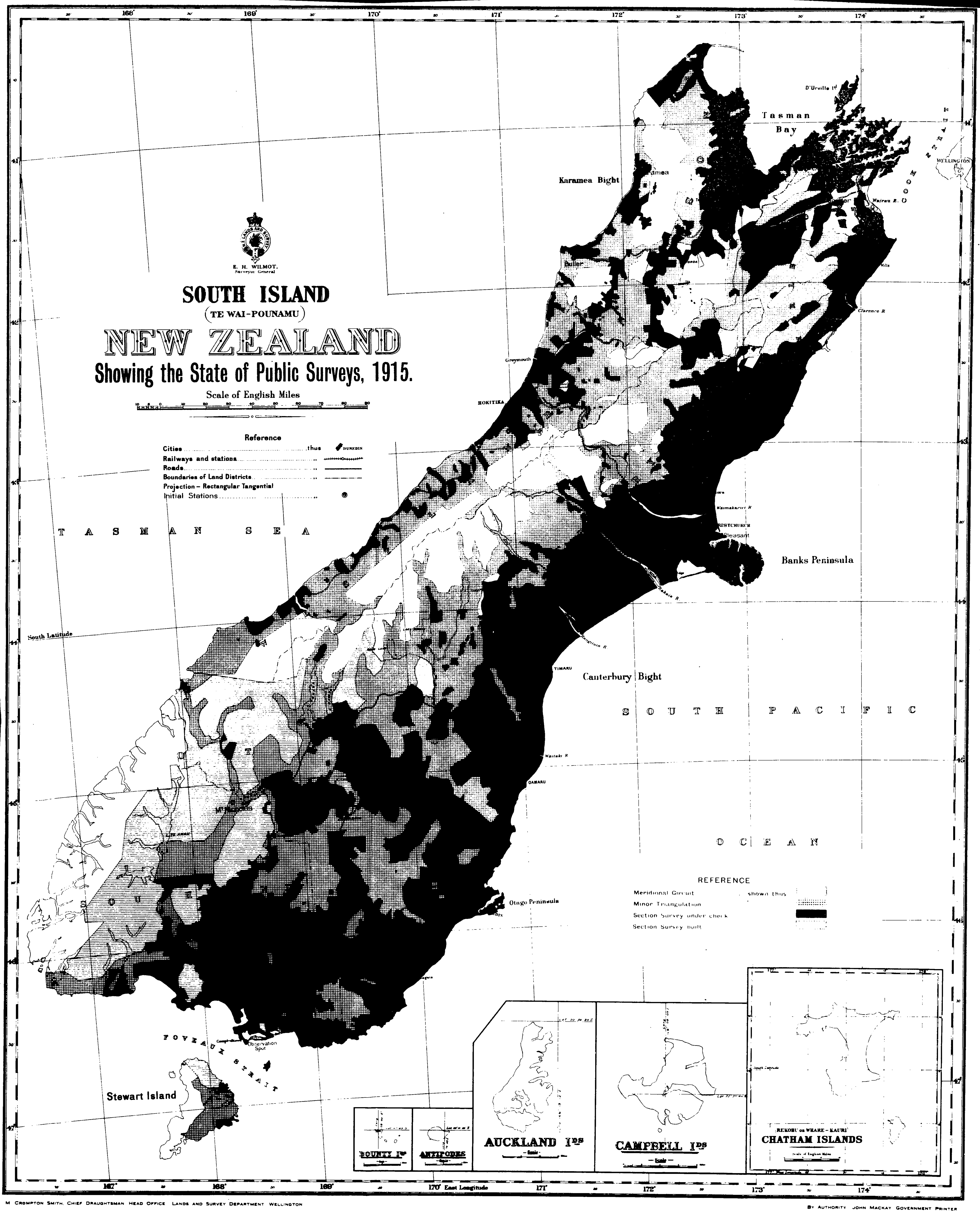

M. CROMPTON SMITH, CHIEF DRAUGHTSMAN HEAD OFFICE LANDS AND SURVEY DEPARTMENT WELLINGTON

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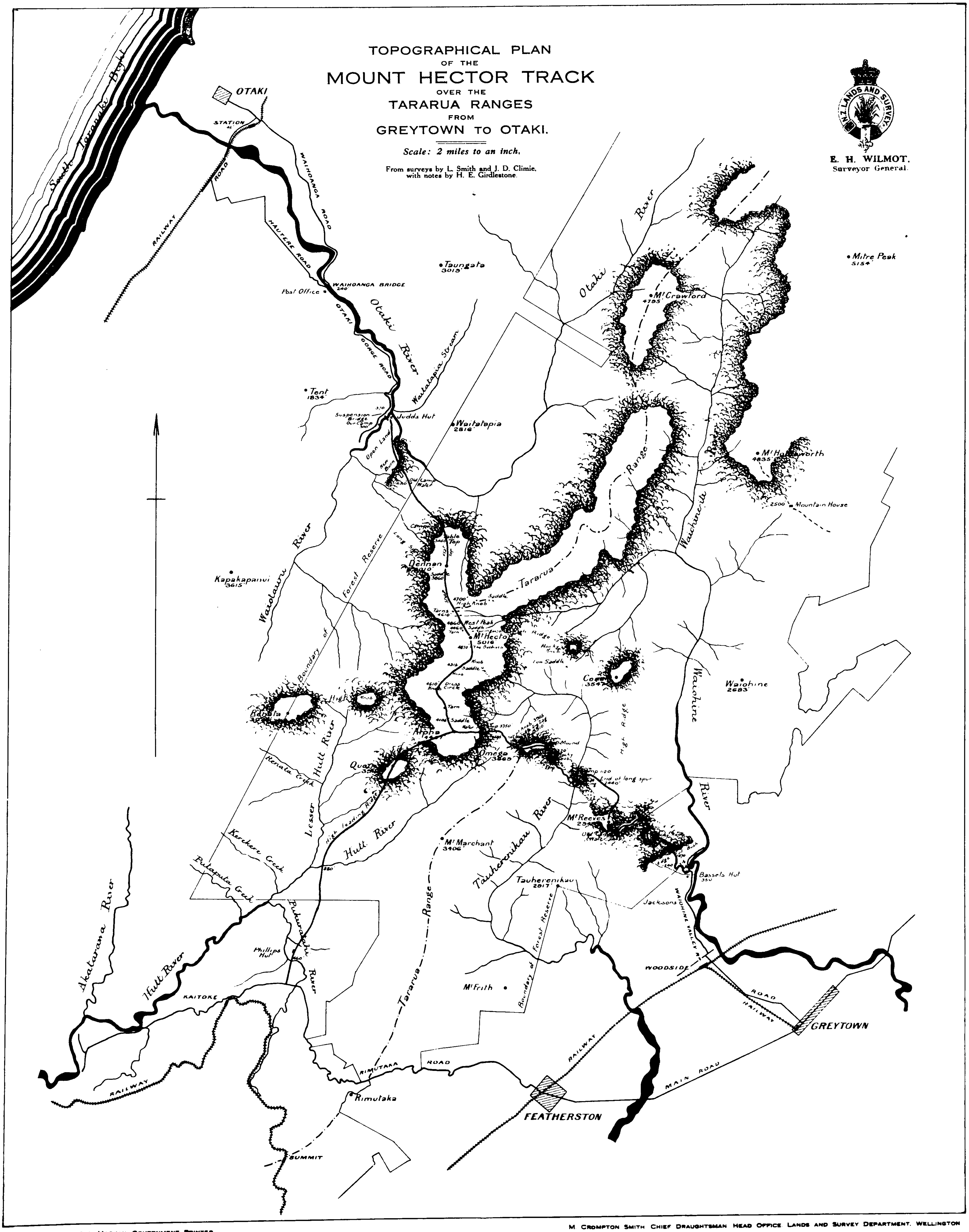
TOPOGRAPHICAL PLAN
OF THE
MOUNT HECTOR TRACK
OVER THE
TARARUA RANGES
FROM
GREYTOWN TO OTAKI.
Scale: 2 miles to an inch.
From surveys by L. Smith and J. D. Climie, with notes by H. E. Girdlestone.
N.Z. LANDS AND SURVEY
E. H. WILMOT,
Surveyor General.
South Taranaki Bight
OTAKI
STATION
RAILWAY
ROAD
WAIHOANGA ROAD
MAUTERE ROAD
WAIHOANGA BRIDGE
Post Office
OTAKI GORGE ROAD
Otaki River
Waitatapia Stream
Taungata 3015'
Tent 1834'
Suspension Bridge
Judds Hut
Waitatapia 2816'
Open Land
Otaki River
Mt Crawford 4785'
Mitre Peak 5154'
Range
Mt Holdsworth 4835'
Mountain House
Waiohine River
Waiohine 2683'
Tararua
Table Top
Dennan
High Knob
West Peak
Mt Hector 5016
Saddle
Tarn
Alpha
Omega
Ridge
Coe 3547
High Ridge
Kapakapanui 3615'
Waiotauru River
Boundary of Forest Reserve
Renata
Hull River
Renata Creek
Lesser Hull River
Quoin
High leading Ridge
Hull River
Kerekere Creek
Putaputa Creek
Mt Marchant 3406'
Tauherenikau River
Mt Reeves
Bassels Hut
Tauherenikau 2017'
Jacksons
WAIOHINE VALLEY
Tararua Range
Boundary of Forest Reserve
Phillips Hut
Pakuratahi River
Akatarawa River
Hull River
KAITOKE
WOODSIDE
Mt Frith
ROAD
RAILWAY
GREYTOWN
RIMUTAKA
ROAD
RAILWAY
MAIN ROAD
Rimutaka
FEATHERSTON
SUMMIT
RAILWAY

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