Photogravure

Survey of India Offices, Calcutta, 1914.

CAIRN ERECTED TO THE MEMORY OF THE LATE LIEUTENANT H. G. BELL, R.E.,

ON THE SPOT WHERE HE DIED, LUT' GAZ, TAGHDUMBASH PAMÎR.

ERECTED BY THE INDO-RUSSIAN TRIANGULATION DETACHMENT

RECORDS

OF THE

SURVEY OF INDIA

Volume V

REPORTS OF THE SURVEY PARTIES

FOR

1912-13

PREPARED UNDER THE DIRECTION OF

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Surveyor General of India

CALCUTTA
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CONTENTS.

PART I.—TOPOGRAPHICAL SURVEY.

REPORTS FROM THE NORTHERN CIRCLE.

REPORTS FROM THE SOUTHERN CIRCLE.

REPORTS FROM THE EASTERN CIRCLE.

PART II.—GEODETIC AND SCIENTIFIC OPERATIONS.

ILLUSTRATIONS.

MAPS.

(At end of Volume).

APPENDIX.

RECORDS OF

THE SURVEY OF INDIA

PART I.—TOPOGRAPHICAL SURVEY.

NORTHERN CIRCLE.

(*Vide* Index Maps 1 and 4.)

Four field parties worked in this Circle, and in August 1913, a new Party, No. 20, was formed from the Cantonment Section of No. 4 Party, and during the past field season a total area of 27,240 square miles was surveyed consisting of:—

	Sq. Miles.
Survey 1-inch	8,516
Resurvey and Supplementary Survey 1-inch	5,460
Revision Survey 2-inch, 3-inch and 4-inch	253
Revision Survey 1-inch	11,291
Revision Survey ½-inch and ¼-inch	1,720

The Riverain Detachment carried out a total of 7,238 linear miles of chaining over a total area of 2,924 square miles, in the Riverain work, the Khushāb Thal, the Kāngra experimental boundary work and Lower Bāri Doāb Rectangular. No. 20 Party surveyed an area of 11,539 acres in various Cantonments during the year.

Major C. H. D. Ryder, D.S.O., R.E., was in charge of the Circle up to 16th April 1913, and was succeeded by Major C. L. Robertson, C.M.G., R.E., who held charge up to the end of the Survey year.

No. 1 PARTY (KASHMĪR).

BY MAJOR A. A. MCHARG, R.E.

PERSONNEL.

Imperial Officers.

Major F. W. Pirrie, I.A., in charge from the 1st of October 1912 to 12th of April 1913.
Major A. A. McHarg, R.E., in charge from 6th of May to 30th of September 1913.
Lieutenant K. Mason, R.E., attached from the 1st to the 13th of October 1912.

Provincial Officers.

Mr. H. H. B. Hanby, in charge from the 13th of April to the 5th of May 1913.
Mr. E. B. West.
Mr. D. K. Rennick.
Mr. R. C. Hanson.
Mr. W. J. B. Miller.

Upper Subordinate Service.

Mr. Sher Jang, K.B.
Mr. Natha Singh, R.S.
Mr. Lal Singh, R.B., to 30th of June 1913.
Mr. Paras Ram.
Mr. Jamna Prasad.

Lower Subordinate Service.

32 Surveyors, etc.

The head-quarters of the party remained at Srīnagar (Kashmīr) till the 9th of April 1913 after which date they were removed to Mussoorie.

The area under survey lay in the Kashmīr and Jammu State, partly in the Pūnch State and the Mīrpur, Riāsi, and Jammu districts and varied from the low-lying flat country bordering on the Punjab to the high ranges of the Pīr Panjāl and partly in the open mountainous tracts of the Kargil and Skārdu tahsils of the Ladākh districts and the Astor tahsil of the Gilgit district.

Operations in the field (with the exception of a short break lasting roughly one month in October and November 1912) and map drawing continued throughout the year.

Topography.—The area surveyed on the scale of 1 inch=1 mile was 3,091 square miles. One camp with 8 surveyors under the successive charge of Messrs. Hanson, Miller and Rennick was formed.

Sheets 43 $\frac{K}{1, 3, 4, 8 \text{ and remainder of } 10}$ and 43 $\frac{L}{1 \text{ and } 5}$ were completed, and sheets 43 $\frac{L}{2, 3, 6 \text{ and } 7}$ and 43 $\frac{K}{9}$ will be completed by the end of October 1913.

Sheet 43 $\frac{K}{11}$ has also been partly surveyed, but will not be completed until the next summer season.

In addition areas of 684 square miles in sheets 43 $\frac{J}{9 \text{ and } 13}$ and $\frac{N}{1, 5, 6}$ on the half-inch scale and 1,036 square miles in sheets 43 $\frac{N}{7, 11, 14, 15 \text{ and } 16}$ on the quarter-inch scale have also been revised.

Triangulation.—Messrs. Rennick and Miller triangulated an area of 1,555 square miles for future detail surveys on the one-inch scale. The total area triangulated in advance is now 4,065 square miles or roughly 16 standard sheets.

Traversing.—Messrs. Rennick and Jamna Prasad ran 193 linear miles of height traverse in the flat country of the Jammu district in sheets 43 $\frac{L}{10 \text{ and } 14}$ where no triangulation had been found possible nor any previous traverse work ever carried out.

Recess duties.—During the year sheets 43 $\frac{F}{14}$, $\frac{J}{1 \text{ and } 5}$, $\frac{K}{14}$ and $\frac{O}{6}$ were submitted for publication.

Sheets 43 $\frac{K}{14}$ and $\frac{O}{6}$ by Mr. Hanby and

Sheets 43 $\frac{F}{14}$ and $\frac{J}{1 \text{ and } 5}$ by Mr. Hanson.

The following should be completed by the end of October 1913 :—

Sheets 43 $\frac{N}{8}$ and $\frac{O}{2}$ under Mr. Hanby and

Sheets 43 $\frac{J}{2, 6, 10 \text{ and } 14}$ under Mr. Hanson.

Cost Rates.—

1-inch detail survey	Rs. 16·8	per	sq.	mile.
½-inch revision survey	„ 3·3	„	„	„
¼-inch „ „	„ 1·3	„	„	„
Triangulation for 1-inch detail survey	„ 10·1	„	„	„
Fair mapping	„ 8·2	„	„	„
Traversing	„ 16·8	„	linear	„

The total cost of the party was Rs. 1,29,425.

The health of the party during the winter field season was good, and during the summer season fair. Surveyor Garjman Ray unfortunately died in September 1913, and Mr. Natha Singh and surveyor Ram Saran were sent on leave on account of ill health.

The party was twice inspected by the Superintendent, Northern Circle, and once by the Surveyor General.

No. 2 PARTY (PUNJAB).

BY MAJOR E. A. TANDY, R.E.

All work lay in the plains of the Punjab in Ferozepore, Ludhiāna, and neighbouring districts with the western part of the Phūlkiān States, except for 1 sheet on the Hoshiārpur border which contained a bit of Siwālik hills.

PERSONNEL.

Imperial Officers.

Major E.A. Tandy, R. E., in charge up to 17th June.

Lieutenant A. A. Chase, R.E., in charge from 18th June.

Provincial Officers.

Mr. F. B. Powell, from 9th June 1913.
„ J. A. Freeman up to 13th April 1913.
„ Kaunk Singh.
„ R. E. Saubolle.
„ E. C. O'Sullivan.
„ J. McCraken.
„ H. T. Hughes up to 27th April 1913.
„ J. A. Calvert.

Lower Subordinate Service.

66 Surveyors, etc., in field.
Average 28 in recess (excluding absentees).

Topography.—The following 36 one-inch sheets were surveyed and fair drawn during the year:— all sheets in 44 J and 44 N, 44 $\frac{K}{9\ \&\ 13}$, 44 $\frac{O}{1}$ and 44 $\frac{M}{13}$, giving an area of 9,245 square miles.

Also a 6-inch survey of Māler Kotla and environs, at the cost of the State, area nearly 11 square miles.

One surveyor was sent to Dera Ghāzi Khān for a month to sketch in the great alterations due to encroachments of the Indus, for incorporation in the degree sheet of that area. Two or three surveyors were lent for short periods to help No. 3 Party with their traversing and plotting in the field.

No traverse or triangulation was done, as old traverse data will be available for next season's work.

Survey methods.—Sheet 44 $\frac{M}{13}$ was revised by one surveyor in five months using old contoured sheets, as published in black on 4-inch and 2-inch scales. These revised sheets were photographed down to the 1½-inch scale for fair drawing by transfer.

The south-eastern sheets, falling in the Phūlkiān States, were based on new and rather inadequate traverses hurriedly done by No. 3 Party in the earlier part of the season. The party had to await the completion of the traverse before entering on this ground. Results contained occasional inaccuracies up to 10 chains, but these were for the most part well distributed.

All other sheets were done by revising mounted blue prints of the old 1-inch maps. The distortion due to mounting these blue prints caused the usual slight inaccuracies of scale everywhere.

No heights or contours were observed in the plains, though the southern portions, nearer the Bīkaner desert, have sensible undulations with sandy outcrops. Irrigation however extends over most of the area, and where this is the case contoured canal maps are available. These contours though accurate in a large sense are not always topographically satisfactory in shape, so their information was only used to the extent of abstracting heights for the higher and lower parts of undulations, and entering these as clinometer heights on the fair sheets.

Ferozepore and environs was revised on a 3-inch pantographed reduction of old large-scale work; this being photographed down to the 1½-inch scale for fair drawing. Several important towns were also surveyed on the margins of plane-tables on the 1½-inch scale, which enabled them to be drawn in much greater detail, especially in the case of inferior surveyors.

The Māler Kotla 6-inch survey was based on scanty traverse done for the 1-inch work, but fair accuracy was secured by fixing good plane-table points over the work before surveying. Slight modifications of the usual colour conventions were required in order to meet the necessity of showing boundary walls and hedges along roads, etc.

No heights or contours were taken.

Personnel.—The staff of the party was temporarily increased during the field season by 11 surveyors, of whom 7 were old soldier-surveyors recalled from their regiments, and not quite up-to-date in their methods. Three Rurki-trained soldier-surveyors also joined for instruction.

The sad death of Mr. H. C. H. Cooper from pneumonia in November was a great loss to the party. There were a few cases of small-pox, including 2 surveyors, and some bad cases of pneumonia.

Recess duties.—The completion of the large outturn of fair drawing was only rendered possible by sending an advance section to recess early in March with the first 22 sheets, when the remainder of the party moved into the Phūlkiān States.

Instead of taking 1½-inch blue prints from the 1-inch plane-tables direct and having to transfer and adjust these on to the fair sheet, a modification of the Southern Circle's method of traces was tried, as follows:—

> A complete trace was prepared for each sheet on the 1-inch scale, showing graticules, guide lines for marginal typing, and all detail in *single* lines (no railway or boundary symbols or double lines). These traces were then photographed up to the 1½-inch scale and printed direct on to the drawing paper. The arrangement proved very satisfactory.

The bulk of the fair drawing was done by three drawing sections and a typing section, the former first doing outline and then passing on to the typing section, after which they completed the ornament of their own sheets. Each section had to examine and correct each stage of a sheet before passing it on for the next stage; and to ensure this being thoroughly done an extra officer was detailed as examiner, and had to pass each sheet before it was transferred to the typing section or returned back from it. This ensured every stage having two good examinations before the sheet was done, which is a great advantage in dealing with such a large number of sheets, as it reduces enormously the amount of correction and delay in passing the sheets at the end of recess.

In addition to these 36 one-inch sheets and the Māler Kotla map (which was drawn on two 8-inch sheets for reduction to 6-inch), three sheets of Lieutenant Chase's Nepāl boundary work were drawn; as well as the compilation and fair drawing of village boundaries for a boundary edition of the 1-inch sheets of Amritsar district. A "general" section was detailed for all this special work, and miscellaneous duties.

Sheet 44 $\frac{M}{13}$ was the only part of the work not quite completed by the end of recess.

No. 3 PARTY (PUNJAB).

By Mr. J. O. Greiff.

The party was originally intended for work in the United Provinces, in continuation of the previous year's programme. But early in September it was decided to move the party into the Punjab, to undertake the survey of a particular area required by the Irrigation Department.

PERSONNEL.

Imperial Officers.

Captain M. N. MacLeod, R.E., in charge up to 11th April 1913.
Lieutenant A. A. Chase, R.E., attached up to 31st December 1912.
Lieutenant F. B. Scott, I.A., attached up to 24th May 1913.
Lieutenant R. S. Wahab, I.A., attached up to 11th July 1913.

With the exception of a strip of hills in the north, the nature of the country surveyed was flat.

Provincial Officers.

Mr. J. O. Greiff,
in charge from 12th April 1913.
Mr. W. J. Newland,
up to 19th September 1913.
Mr. E. J. Biggie.
Mr. A. C. Bose.
Mr. P. A. T. Kenny.
Mr. A. J. A. Drake.
Mr. F. H. Grant.
Mr. F. J. Grice.
Mr. Moqimuddin,
from 23rd October 1912.

Upper Subordinate Service.

Mr. Mahomed Lutf Ali.
Mr. Mahindar Singh.

Lower Subordinate Service.

61 Surveyors, etc.

The health of the party was good.

Topography.—The country surveyed comprised parts of the districts of Ambāla and Karnāl, and the eastern portions of the Phūlkiān States of Patiāla, Nābha, and Jīnd. Practically the whole of this area, except for the foot-hills of the Punjab Siwāliks in the north, is part of the Indo-Gangetic alluvium plain. It is intersected by many hill torrents, the principal being the Ghaggar, Mārkanda, and Saraswatī. The Sutlej and the Jumna rivers also intersected the north and south-east limits of the work. The greater part of it is cultivated, and much of it irrigated by the Sirhind and Western-Jumna Canal systems. Generally speaking it is well wooded, *dhāk* being the chief growth.

The party was divided into six camps, under Lieutenant Wahab, and Messrs. Newland, Biggie, Kenny, Drake and Grice. Later in the season two small sections were formed, and placed under Messrs. Bose and Grant. The sheets surveyed by each camp were (i) sheets $53\frac{C}{10, 13, 14}$; $44\frac{O}{13}$; (ii) $53\frac{B}{4, 8}$; $53\frac{C}{1, 2, 5, 9}$; (iii) $53\frac{D}{7, 11, 12, 16}$; (iv) $53\frac{B}{15}$, half of $53\frac{B}{6, 10, 14}$, and $53\frac{F}{2, 3}$; (v) $53\frac{B}{1, 5, 9}$, half of $53\frac{B}{6, 10, 14}$; (vi) $53\frac{F}{4, 7, 8}$, $53\frac{G}{1}$; and Mr. Bose $53\frac{C}{6}$; Mr. Grant $53\frac{B}{2, 3}$.

The work consisted partly of revision survey and partly new survey, on the scale of one inch to a mile.

In Ambāla blue prints of the last published 1-inch sheets were used. In Karnāl the old sheets were found to be of not so good a quality, and so reductions of recently prepared settlement 4-inch maps were used, the detail being transferred on to the plane-tables by making each village fit with its plotted trijunctions. Except for topographical features, these were found fairly correct.

There is a serious discrepancy between the Ambāla and Karnāl traverses along the common boundary, the best possible adjustment has been made. The error is probably due to the traverses not being sufficiently connected with triangulation.

In the Phūlkiān States the work was entirely new, based on traverse data.

It was found that the graticules on published 1-inch sheets did not agree with those plotted from rectangular values, the errors amounting to as much as 6 chains. The difference has been eliminated in the fair maps, but the point is worthy of notice for future guidance.

The outturn of the party for the season is as follows :—

1-inch revision survey . . .	4,960 sq. miles.
1-inch new survey	2,764 „
TOTAL .	7,724 „

The cost rate per square mile was Rs. 10·6 and Rs. 11·5 respectively.

Traversing.—The area traversed comprised the Native States of Patiāla, Nābha and Jīnd, in sheets $53\frac{B}{2, 3, 4, 6, 7, 8, 10, 11, 14}$, $53\frac{C}{1, 2, 3, 6, 7, 8, 11}$, $44\frac{N}{3, 4, 7, 8, 10, 11, 12, 14, 15, 16}$, $44\frac{O}{1, 2, 5, 6, 9, 13, 14}$, $44\frac{J}{16}$, $44\frac{K}{1}$.

Lieutenant Scott was placed in charge of the section, and to it were attached also Messrs. Grant and Moqimuddin.

As no maps were available to indicate the positions of the village trijunctions, it was decided to cover the whole area with a "gridiron" of traverse running approximately along 5', minute graticule lines, and to tie it all together, and to the G. T. stations available, by a network of main traverses, run with a crinoline tape, along railways, main roads, etc.

The total area traversed was 6,058·28 square miles at a cost rate of Rs. 4·16 per square mile.

Recess duties.—The whole of the area surveyed, comprising thirty 1-inch sheets, has been mapped during recess, and will be submitted for publication before the end of November.

The party was divided into seven sections and employed as follows :—

(i) Mr. Newland, fair mapping of sheets $53\frac{B}{4, 8}$, $53\frac{C}{1, 2, 5, 6, 9}$.

(ii) Mr. Biggie, sheets $53\frac{B}{7, 11, 12, 16}$, $53\frac{C}{10, 13}$, $44\frac{O}{13}$.

(iii) Mr. Bose on the revision and completion of the traverse computations, and preparation of data for the coming field season.

(iv) Mr. Kenny, fair mapping of $53\frac{B}{10, 14, 15}$, $53\frac{F}{2, 3}$.

(v) Mr. Drake, $53\frac{B}{1, 2, 3, 5, 6, 9}$.

(vi) Mr. Grant, in charge of the typing of all the fair sheets.

(vii) Mr. Grice, fair mapping of $53\frac{C}{14}$, $53\frac{F}{4, 7, 8}$, $53\frac{G}{1}$.

An advance section opened at Mussoorie on the 1st April. An attempt was made to obtain blue print enlargements on the $1\frac{1}{2}$-inch scale direct from the field sheets, but this was found to be impracticable owing to the irregular distortions in the dimensions of the field sheets. So line traces were made of the field sheets, and fitted on to a Bristol board or sheet of drawing paper within correctly projected graticule lines and the blue print enlargements made from these.

A new kind of type ink, Edward Shackell's No. 1 Black Process Proving ink, was tried this year with very satisfactory results.

The cost rate of the fair mapping is Rs. 4·3 per square mile.

No. 4 PARTY (UNITED PROVINCES).

BY CAPTAIN L. C. THUILLIER, I. A.

PERSONNEL.

Imperial Officers.

Captain L. C. Thuillier, I. A., in charge.

Provincial Officers.

Mr. H. W. Biggie.
Mr. G. J. S. Rae.
Mr. C. E. C. French.
Mr. J. C. C. Lears.
Mr. G. E. R. Cooper.
Mr. Duni Chand Puri.

Upper Subordinate Service.

Mr. Mohammad Husain Khan.

Lower Subordinate Service.

68 Surveyors, etc.

The field head-quarters of the party opened at Fyzābād on 21st October 1912 and closed on 5th April 1913; the recess head-quarters continued at Mussoorie.

Topography.—The programme of this work consisted of survey on 1-inch scale of sheets $63\frac{E}{12, 16}$, $63\frac{F}{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13}$ and supplementary survey only of sheets $63\frac{A}{1 \& 2}$, $63\frac{E}{9, 10, 11, 13, 14, 15}$. Sheets $63\frac{A}{1}$ and $63\frac{E}{11}$ were subsequently cut out of our programme.

The whole area for survey lay in the districts of Hardoī, Bahraich, Gondā, Lucknow, Bāra Bankī, Rāe Barelī, Fyzābād, Sultānpur, Partābgarh and Fatehpur.

Surveyors were divided into four camps under Messrs. H. W. Biggie, G. J. S. Rae, J. C. Lears and G. E. R. Cooper respectively.

During the field season six soldier-surveyors were attached to the party to replace surveyors transferred to Nos. 2 and 3 Parties.

These soldier-surveyors had already done a first period of training in the Survey of India and so were not attached for training but simply to supplement the surveyors of the party who had been reduced by transfers to Nos. 2 and 3 Parties.

Three of these soldier-surveyors were found useful and hardworking field surveyors and their services have been asked for again. The other three men were found slow and incompetent.

The average rate of plane-table (excluding the time taken in marching to their work) was 25·2 square miles per mensem for resurvey and 49·9 square miles per mensem for supplementary survey.

Traversing.—This only consisted this season of running supplementary lines of traverse where it was found that surveyors were short of points on which to adjust their work.

The country under survey consisted for the most part of similar country to last season, *viz.*:— a flat plain generally well cultivated and interspersed with an abundance of groves and occasional stretches of "*Ūsar*" plains. Along the Gogrā River occurred a tract of country at lower level than the surrounding plain in which the river swings from bank to bank changing its course nearly every rains.

The chief rivers in the area under survey were a small portion of the Ganges River in the south-west corner of the work, the Gogrā River along the centre of the area, and halfway between the Ganges and the Gogrā the Gumtī River. In the north-west corner of the work the Rāptī River ran through a couple of sheets.

Recess Duties.—All fair maps of sheets surveyed during field season will be completed and sent for publication before the end of October.

The health of the party was good throughout the season. Plague again appeared throughout the area under survey but no cases occurred among members of the party.

No. 20 PARTY (CANTONMENT).

BY MR. A. EWING.

PERSONNEL.

Provincial Officers.

Mr. A. Ewing, Deputy Superintendent in charge, from 1st March 1913.

Mr. C. E. C. French, Extra Assistant Superintendent, from 1st October 1912 to 7th July 1913.

Upper Subordinate Service.

Mr. Dharmu.

Lower Subordinate Service.

12 Surveyors, etc.

During the year this party was formed by order of the Government of India to survey cantonments and towns on large scales. And it was decided that the Cantonment Section of No. 4 Party was to be the nucleus of the new party, and its strength gradually increased by recruiting pupil-surveyors, and by transferring soldier-surveyors from other parties.

These soldier surveyors are to be trained for a further period of two years in this party and are then to be transferred to the Military Works Department to revise and keep up to date all cantonment plans that have been completed by the Survey Department.

On 1st March 1913, Mr. A. Ewing, Deputy Superintendent, was transferred from the Southern Circle Drawing Office to the charge of No. 20 Party with orders to increase the number of surveyors in the Cantonment Section.

From 1st August 1913, after reappropriation of budget allotments, this party was transferred from the administrative control of the Superintendent, Southern Circle, and was placed under that of the Superintendent, Northern Circle.

After the completion of the survey of Quetta Cantonment, Quetta Civil Station and Quetta Fort, which were then in hand, orders were received to survey Saugor and the areas under cultivation within the cantonment boundary. Early in January 1913, a surveyor was sent from Quetta to Saugor to triangulate and traverse that cantonment. In February three surveyors left Quetta to help in the traversing and to do the detail survey after the traversing was completed. The survey of Saugor was completed in June, and from July to September the party was employed at Saugor, the field head-quarters, on the fair mapping of the Quetta and Saugor plans.

An extension of Delhi New Cantonment Area which was surveyed on the 4-inch scale the year previous was urgently wanted, and Mr. C. E. C. French with two surveyors were employed on this work in February and March, and its fair mapping was completed in June.

In and round Saugor eight stations were fixed by triangulation by Gokul Chand, surveyor, with a 6-inch theodolite and the traversing of that cantonment was based on these stations, and angles of elevation and depression were observed at every traverse station, from which their heights were computed. Also eight stations were fixed by triangulation for Guna Cantonment with 6-inch the dolite by Mr. A. Ewing and Gokul Chand. Two trigonometrical stations, *viz.*, Saugor and Hatnī of the Calcutta Longitudinal series and Karāchi Longitudinal series, were visited and found in good order.

In February the field head-quarters were moved from Quetta to Saugor and on the completion of the survey of Saugor three surveyors and one draftsman were granted privilege leave. Eighteen sheets of Quetta Cantonment are nearly completed, and will soon be sent for publication; two sheets of Quetta Civil Station, two sheets of Quetta Fort and six sheets of Saugor Cantonment are in hand. Owing to both draftsmen suffering from writer's cramps, one of them had to take leave, and the completion of the fair mapping of last season's work has been delayed. All the fair mapping will be finished by the end of December when the detail survey of Guna will be completed and its fair mapping taken in hand.

The detail survey was checked by 10·41 linear miles of partal and from 47 fixings by Mr. C. E. C. French, and nearly all the detail survey of Saugor was checked by the Officer in charge.

The areas triangulated, traversed, surveyed and mapped are :—

	Acres.	Cost per acre.
Triangulation	52,288	Rs. 0·02
Traversing	4,015	„ 0·89
Detail survey 4-inch scale	5,280	„ 0·37
„ „ 16 „ „	6,164	„ 1·46
„ „ 64 „ „	95	„ 4·30
Mapping 4 „ „	5,280	„ 0·11
„ 16 „ „	13,714	„ 0·38

The cost of the party for 1912-13 is as follows :—

Cost of Cantonment Section from 1st October 1912 to July 1913	Rs. 18,347
Cost of No. 20 Party from 1st August to September 1913	„ 3,797
Total cost of the party . .	„ 22,144

The programme for the ensuing field season has not been finally settled.

The Director-General of Military Works has proposed Guna, Kamptee and Rājkot and other cantonments about which he will inform the Surveyor General, when he receives reports from his Divisional Officers about their requirements. Sītābaldī Fort, Khandwā, Agar, Deesa, and Deoli have been suggested so that all the more important cantonments in the Mhow Division will be surveyed before this party is transferred some thousands of miles away.

RIVERAIN DETACHMENT.

BY MR. MAYA DAS PURI, RAI SAHIB.

PERSONNEL.

Provincial Officers.

Mr. Maya Das Puri, Rai Sahib, in charge.
Mr. Moqimuddin, up to the 22nd October 1912.

Upper Subordinate Service.

Mr. Chuni Lal Kapur.

Lower Subordinate Service.

77 Surveyors, etc.

Settlement Staff.

155 Tahsildars, etc.

The field-quarters remained at Multān throughout the field season, and the office returned to Lahore at the end of July 1913 for recess.

The detachment continued the work of traversing and laying down base lines. 319 linear and 394 square miles of main traverse, and 3,256 linear and 808 square miles of minor traverse were run. 13,833 theodolite stations were fixed in the area, under water action of the rivers Sutlej, Rāvi, Chenāb, and Jhelum in districts Ferozepore, Lahore, Siālkot, Gujrāt, and Shāhpur, 588 corners of 196 squares were demarcated with permanent mark-stones on both banks of the Sutlej (districts Montgomery and Ferozepore), Chenāb (districts Gujrāt and Siālkot), and the Jhelum (districts Shāhpur and Jhelum) to serve as bases for the future demarcation of boundaries in the bed of these rivers. 3,495 plotted and 697 boundary "*Masavis*" (Settlement mapping sheets) of 407 villages were completed and 49 four-inch sheets were traced, and supplied in time to the Settlement Officers of Ferozepore, Lahore, Siālkot, Gujrāt, and Shāhpur. Besides these, 363 miscellaneous traces were prepared, and all the traverse stations marked during the season were plotted on 51 four-inch sheets. Three four-inch riverain boundary sheets were plotted and compiled, 2 sheets finally completed, and 4 sheets typed.

The 25-acre rectangular survey was carried over the remaining tract commanded by the Lower Bāri Doāb canal in continuation of the last year's work. Fourteen thousand six hundred and twenty-seven 25-acre rectangles were broken. Nearly 56 per cent. of the work was tested by the tahsildars, naib tahsildars, and the survey officers, and 16 per cent. was checked with theodolite traverse. 1,059 linear miles were traversed, and 3,895 theodolite stations were fixed. This work is now completely finished. In all, 73,791 twenty-five acre rectangles were demarcated in 2,883 square miles during the last three seasons at a total cost of Rs. 3,18,278 against an estimated expenditure of Rs. 4,63,586 for cutting 2,500 square miles into 25-acre rectangles.

The Khushāb "*Thal*" (sandy area) survey was suddenly taken up during February 1913 at the special request of the Punjab Government, and was temporarily stopped during May 1913. Points were thrown about ½ mile apart. All existing trijunctions, boundary turnings, and conspicuous marks were picked up. 1,967 linear and 1,070 square miles were traversed, and 3,808 theodolite stations fixed. 258 dressed stones and 84 iron tubes were embedded on selected stations to facilitate future survey and demarcation of fields and boundaries. 591 plotted *Masāvis* on the scale of 12 inches to one mile, were supplied to the Settlement Officer, Shāhpur, early in September 1913. Besides this work 604 *Masāvis* of 36 villages (scale 8 inches=one mile) were reduced to the scale of 4 inches to one mile. The boundaries of these villages were compiled on 29 four-inch sheets with the help of points fixed during the year, showing discrepancies of over two chains and were traced on 63 *Masāvis* for the Settlement Officer, Shāhpur.

With a view to assist the Settlement Officer, Dera Hamīrpur (district Kāngra) in the most difficult part of his work and to utilize the experience thus gained for the future cadastral surveys of the remaining tahsils of the Kāngra district, the Kāngra work was experimentally started during the middle of April 1913 and closed on the 20th July 1913. It was based on the triangulation of old No. 18 Party (Himālaya). Points were laid out about 5 to 15 chains apart, in suitable places under cultivation and along *tikā* (sub-village) and village boundaries by triangulation and traverse using subtense bar where required. The plots were prepared for each *tikā* (sub-village) separately on the scales of 20, 40, and 80 *karms* to one inch (the length of a *karm* = 57·5 inches) according to the nature of the ground.

637 linear miles of traversing and 81 square miles of triangulation were carried out, and 1,840 stations were fixed by theodolite.

784 plotted *Masāvis* of 256 *tikās* (sub-villages) were supplied to the Settlement Officer, Dera Hamīrpur, during the summer.

The experiment has proved successful, and work in the other tahsils of the Kāngra district will be commenced during next cold weather.

The riverain area was broken raviny, sandy, marshy, shrubby, and in parts cultivated. The Lower Bāri Doāb tract was flat, heavily wooded, and sparsely inhabited. The Khushāb "*Thal*" (sandy area) consisted of rolling sand hills covered with scanty scrub, and a few stunted trees and villages, scattered here and there, chiefly inhabited by graziers and camel-owners, with little or no water. The Kāngra portion was hilly, jungly, and cultivated.

The health of the detachment was on the whole satisfactory. One tindal died at home while on departmental leave.

The total expenditure of the detachment from the 1st October 1912 to the 30th September 1913 excluding the pay of temporary riverain khalasis, and including Rs. 6,180 on account of last year's expenditure for the Lower Bāri Doāb work, was Rs. 1,15,632 as detailed below :—

		Rs.
1.	The Riverain Survey	21,906
2.	The Lower Bāri Doāb 25-acre rectangular survey	70,256
3.	The Khushāb *Thal* traversing	17,335
4.	The Kāngra experimental work	5,712
5.	The Nepāl Boundary survey	423
	Total	1,15,632

SOUTHERN CIRCLE.

(*Vide* Index Maps 2 and 5.)

The Southern Circle was under the superintendence of Brevet-Colonel T. F. B. Renny-Tailyour, C.S.I., R.E., up to 15th April 1913 and under Lieutenant-Colonel F. W. Pirrie, I.A., for the remainder of the year.

The Circle consisted of Nos. 5, 6, 7 and 8 Parties and No. 4 Drawing Office.

During the year 13,349 square miles were surveyed, 14,394 square miles were triangulated, and 205 linear miles were traversed by theodolite.

The field surveys consisted of :—

1,086 square miles of	½-inch survey.
6,093 " " "	1-inch survey.
5,155 " " "	1-inch revision survey.
568 " " "	1½-inch survey.
447 " " "	2-inch survey.

The area surveyed is relatively greater than was done during the previous year. The smallness of outturn is caused by the intricate underfeatures in the Central Provinces and Hyderābād State and the excessive difficulty of the dense forest country in the extreme south of the peninsula. It was again found impossible to shew adequately on the 1-inch scale in the field the mass of detail in the low-lying ground along the western sea coast in parts of Madras and Travancore State, so the 1½-inch scale was substituted where necessary and the small increase in cost was amply justified by results.

The Photo-Zinco Section did a great deal of work during the year to assist the work of parties chiefly at the close of the field season and towards the end of recess.

The accommodation at present is inadequate and the cameras and other apparatus cannot be properly protected from the weather, and during the rainy season work was at a stand-still.

The following work was done during the year in the Photo-Zinco Section :—

Description of work.	No. 5 Party.	No. 6 Party.	No. 7 Party.	No. 8. Party.	Total.	REMARKS.
Reproductions to full scale.	...	...	1	...	1	
Enlargements	43	5	28	45	121	
Reductions	44	27	122	20	213	
Originals vandyked	14	17	23	13	67	

NOTES.

1. Except in Madras where the lists prepared by the Director, Madras Revenue Survey, go through a very careful system of checking, a great deal of difficulty was experienced by parties in obtaining the correct spelling of village and other names. Lists were sent to Deputy Commissioners for verification and correction, but when these were received back it was often found that the same name was spelt quite differently even in different parts of the same district and in the same 1-inch sheet.

These difficulties tend to increase where parts of different districts or provinces fall in the same sheet and in the case of degree sheets containing parts of Bombay and the Central Provinces where the system of spelling varies greatly it will probably be best to have the names written in skeleton copies of the degree sheets in their proper positions and have them again verified locally through Settlement Commissioners or other agency.

2. Forest and other maps originally surveyed on scales larger than the 1-inch at various periods vary much in quality and none of them can be reduced and incorporated in the fair maps without again undergoing supplementary survey, and the following has been found the most suitable procedure in the Southern Circle. The large scale maps falling in the area included in the ensuing season's programme were photographically reduced to the 1½-inch scale in blue colour. These reductions were then inked up in black for further reduction to the 1-inch scale, and carefully fitted on to the 1½-inch projected sheets by means of the graticule lines and plotted triangulated points. These reductions were then reduced to the 1-inch scale and printed in blue on Bristol boards or drawing paper mounted on cloth over mill board. The graticule was subsequently drawn in black and any exterior triangulated points plotted and they were then ready for the field.

3. In handing over the Southern Circle Colonel Renny-Tailyour stated that it is always better when the local scale of regular surveys is the 1-inch or ½-inch, larger scale surveys should be carried out at least one season ahead so that they may be available when the regular surveys are taken up and whenever possible this procedure will be followed.

4. As mentioned in the Records Volume III, experiments were continued in the Circle in order to prevent altogether or to reduce to a minimum the expansion and contraction of mounted plane-tables in the field. Paper mounted on cloth pasted on wooden plane-tables expands and contracts according to the changing temperature and humidity of the atmosphere but chiefly across the grain of the wood of the plane-table and not uniformly in all directions. To remedy this four methods have been under trial for some time, as follows:—

(a) Aluminium plane-tables.

(b) The use of Bristol boards in place of drawing paper.

(c) The use of drawing paper mounted on cloth over mill board.

(d) The use of special thick drawing paper unmounted.

(a) Aluminium plane-tables were successful in overcoming unequal contraction and expansion and reduced the alteration in graticule to a negligible quantity, but the tables as at present constructed do not remain flat in use but sag at the edges and the Officer in charge No. 6 Party has suggested that the bracing be strengthened which would probably overcome this evil, but altogether the great expense of aluminium plane-tables does not justify their use.

(b) Six and four ply Bristol boards were used during the field season and were specially useful in the comparatively dry climate of the Central Provinces. The change due to varied temperature and humidity was very small, and nearly proportionate in all directions and their use is completely justified in the case of all experienced surveyors who are clean workers, and have little erasure to do in the field. The Bristol boards should not be fastened down to the plane-table but loosely secured at the corners by suitable clips. In order to make the use of Bristol boards in place of drawing paper thoroughly satisfactory height indicators and scales of feet and chains should be printed on the same quality of Bristol board. The disadvantages of Bristol boards are that they must be packed flat and not rolled and they cannot be traced through a tracing glass and any erasures are difficult to carry out.

(c) In localities where there is excessive humidity and great changes of humidity during the field season drawing paper mounted on cloth over mill board is more suitable than Bristol boards for work in the field. The change in graticule is very small and uniform in all directions, though the precautions as regards mounting and securing the mill boards advocated by Colonel Renny-Tailyour in the Records Volume III should be carefully carried out.

(d) Thick drawing paper (Whatman's, Imperial, 300 lbs.) specially prepared by Messrs. Balston was tried with success and was used unmounted and only loosely secured at the corners by clips, but the paper should be harder in texture and harder and smoother in surface and until a further consignment of this paper is received and further tried under varied conditions it would be premature to give a final opinion as to its utility.

5. The ordinary survey pattern clinometer as at present made in the Mathematical Instrument Office, Calcutta, is a very good instrument if intelligently used and kept in proper adjustment and is quite accurate enough for all ordinary contouring purposes but to get the best work out of these instruments they require to be very carefully adjusted at the time of issue and carefully handled and readjusted by inspecting officers in the field and the following method of doing so is suitable:—

The instrument should be taken from its box and the vanes set up and then it should be laid on its side on a piece of machine ruled section paper and the vanes adjusted so that they are at right angles to the base plate. The distance between the zero of the tangent scale to the centre of the axis of vision of the eyepiece should then be checked. This in most clinometers is 8 inches.

The distances from —·40 and +·40 to the centre of the axis of vision should then be verified, those are usually 8·616 inches but if the horizontal line is not 8 inches these distances will be different but can easily be calculated. After the above preliminary adjustments have been made the level can then be adjusted against the natural tangents obtained from theodolite vertical angles. The advantage of using the ordinary clinometer whenever possible is that there is less strain on the eye if the distant objects are distinct and clearly defined than in using any form of telescopic clinometer. In particular localities where ill-defined distant objects have to be observed in taking heights the telescopic clinometer as invented by Captain Pye is very suitable and was used with success in the ½-inch survey of Hyderābād State by No. 6 Party and the officer in charge of that party will use it extensively for the same purpose during 1913-14 and considers that it will be of great use also in adjusting ordinary clinometers in the field. The advantage of these instruments is the increased accuracy and the disadvantage is that index errors are likely to develop which will entail frequent checking against theodolite observations. The strain on the eye in using any form of telescope is also a disadvantage.

6. In traversing forest boundaries with theodolite it is often impossible, owing to local conditions, to

follow the actual line and the pillars have to be fixed by off-sets. With the concurrence of the Chief Conservator, Central Provinces, the forest boundaries were fixed by No. 6 Party by plane-table traverse on the 4-inch scale and the surrounding detail carefully surveyed at the same time on that scale; this arrangement is not only less expensive but more accurate and convenient and seems to meet with the requirements of the Forest Department.

7. The old Mysore 1-inch sheets were found very accurate but wanting in much detail required for a modern map, and required supplementary survey in the field.

The 1-inch compilations supplied by the Director, Madras Revenue Survey, from the work of his department although not consistently of the same quality were in general very accurate and of great assistance to No. 7 Party.

8. The opinions of officers in charge of parties regarding the special blue tinted paper sent for trial for the fair maps are on the whole unfavourable. The surface seemed to be greasy and unsuitable for either typing or fine drawing. The only favourable report was received from No. 8 Party where the blue tinted paper was found suitable for his heavy outline and hill sheets. However, there is no doubt that if the surface could be made smoother and harder the blue paper would be more restful to the eyes of draftsmen and map examiners.

9. A separate type sheet was used by No. 6 Party, but the system is not advocated as it entails great inconvenience to examining officers and will cause extra expense in reproduction.

10. The use of two ply Bristol boards was made by No. 6 Party for fair mapping and the procedure is advocated and these thin Bristol boards were found nearly as pliable as drawing paper. The detail could be drawn finer and the typing was sharper and clearer than on drawing paper.

11. The special roller drawing pens made at the suggestion of the Officer in charge of No. 5 Party by the Mathematical Instrument Office for roads and boundaries were used with success and the procedure adopted by No. 8 Party seems the most suitable which is to put the symbols on the fair maps in blue by means of the roller pens and then ink them over in black when any change of emphasis can be given as required.

12. The most suitable methods of dealing with the field maps on return to recess seemed to be as follows:—

(a) The field maps were enlarged individually to the 1½-inch scale and from these a combined trace was made on a projected sheet of tracing paper and the whole was vandyked on to drawing paper or two ply Bristol boards in blue.

(b) The largest plane-table section falling in a particular 1-inch sheet was completed up to graticule limits by pasting on traces of the other plane-tables and then the whole was enlarged to the 1½-inch scale and printed by photo-zincography in blue.

When there is much distortion or inconsistent change of graticule and in consequence adjustments were necessary, the first system was found the best.

When nearly the whole sheet was surveyed on one plane-table and the graticule was about right the second system was found the best.

No. 5 PARTY (CENTRAL PROVINCES).

BY CAPTAIN E. C. BAKER, R.E.

PERSONNEL.

Imperial Officers.

Captain E. C. Baker, R.E., in charge, from 25th October 1912.

Captain K. W. Pye, R.E., to 21st May 1913 In charge from 1st to 24th October 1912.

Lieutenant R. S. Wahab, I.A., from 12th July 1913.

Provincial Officers.

Mr. F. P. Walsh.
Mr. J. H. S. Wilson.
Mr. S. S. McA'Fee Fielding.
Mr. C. West.
Mr. F. C. Pilcher.
Mr. Munshi Lal.
Mr. C. O. Picard.

Upper Subordinate Service.

Mr. Ekunath Battu.
Mr. Ram Narayan Hastir.

Lower Subordinate Service.

33 Surveyors, etc.

The programme of the party included survey and revision survey on the 1-inch scale, and triangulation, in parts of degree sheets 55 J, K, and O, comprising portions of Hoshangābād, Narsinghpur, Chindwāra, Betūl, Seonī, Nāgpur, Bhandāra, Bālāghāt and Wardhā districts of the Central Provinces, and the Amraoti district in Berār. The field season opened at Jubbulpore on October 21st, 1912, and closed at Chhindwāra on April 14th, 1913. From November 8th, 1912, the head-quarters of the party was located at Chhindwāra. The health of the party was fair.

Topography.—To carry out the 1-inch survey, and the 1-inch revision survey of reductions from 4-inch forest surveys, four camps were formed and the following allotment of work was made:—

No. 1 Camp.—Sheets 55 $\frac{J}{3,4}$ and part of $55\frac{J}{10}$ in Hoshangābād, Betūl and Chhindwāra districts.

No. 2 Camp.—Sheets 55 $\frac{O}{3,\ 6,\ 7}$ and part of 55 $\frac{O}{10}$ in Nāgpur, Seonī and Bhandāra districts.

No. 3 Camp.—Sheets 55 $\frac{O}{4,\ 8,\ 11,\ 12}$ and nearly all of 55 $\frac{O}{10}$ in Nāgpur, Bhandāra, Seonī and Bālāghāt districts.

No. 4 Camp.—Sheets 55 $\frac{K}{14,\ 15}$, 55 $\frac{O}{2}$ in the Chhindwāra and Nāgpur districts.

The survey of all the above sheets was completed. The outturns were 2,575 square miles of 1-inch survey, and 1,115 square miles of 1-inch revision survey, making a total of 3,690 square miles. Sheets 55 $\frac{J}{3,\ 4,\ 10}$, 55 $\frac{O}{2,\ 6,\ 10,}$ contained heavily wooded and somewhat hilly country. Sheets 55 $\frac{K}{15}$, 55 $\frac{O}{4,\ 8,\ 12}$ were flat or undulating, while in the remainder of the sheets the nature of the country was varied.

Triangulation.—Four officers were employed on triangulation, and completed sheets 55 $\frac{J}{8,\ 11,\ 12,\ 14,\ 15,\ 16}$, 55 $\frac{K}{1,\ 2,\ 5,\ 6,\ 9,\ 10,\ 11,\ 12}$, 55 $\frac{K}{13,\ 16}$ and 55 $\frac{O}{11,\ 12}$. The triangulation of the last named two was computed in the field and the detail survey of these two sheets was included in the programme of the party. The country triangulated extended from the steep north-western slopes of the Sātpurās across the rolling plateau, and down into the Nāgpur plain, and amounted to 4,972 square miles.

Recess duties.—The fair mapping of all the fourteen sheets surveyed was completed by the end of the recess season. The computation of the triangulation done during the field season was completed during the recess. Degree charts 64 A and 55 O with tables of data were prepared.

No. 6 PARTY (BERĀR).

BY LIEUTENANT C. G. LEWIS, R.E.

PERSONNEL.

Imperial Officers.

Major H. Wood, R.E., in charge up to 30th May 1913.
Lieutenant C. G. Lewis, R.E., in charge from 31st May 1913.

Provincial Officers.

Mr. E. A. Meyer.
Mr. F. B. Kitchen.
Mr. R. B. Gildea.
Mr. J. O'C. Fitzpatrick.
Mr. A. J. Moore.
Mr. A. V. Dickson.

Upper Subordinate Service.

Mr. Lachman Daji Jadu, R.B.
Mr. Dharmu.

Lower Subordinate Service.

33 Surveyors, etc.

The field head-quarters were again located at Bāsim. The season opened on the 28th October 1912 and closed on the 13th April 1913. The health of the party was very good.

The party was employed on ½-inch, 1-inch and 2-inch surveys and triangulation in the Yeotmāl, Akola and Buldāna districts of Berār, in the East Khāndesh district of Bombay and in the Adilābād, Nānder and Parbhani districts of Hyderābād.

Topography.—The surveyors were divided into three camps. Lieutenant Lewis was in charge of the ½-inch survey in sheet 56 $\frac{F}{S.E.}$ and the pupils' camp in sheets 56 $\frac{E}{10,\ 11,\ 14,\ 15}$ on the 1-inch scale. Mr. Meyer carried out 1-inch survey in sheets 56 $\frac{E}{10,\ 14}$, for the first two months of the season and then transferred his surveyors to the 2-inch survey of reserved forests in Akola and Buldāna districts in sheets 55 $\frac{D}{6,\ 7,\ 10,\ 11,\ 15,\ 16}$. Although his camp remained in the field until the middle of May, it was found impossible to complete the programme of 2-inch work. Mr. Gildea was in charge of 1-inch survey in sheets 56 $\frac{I}{1,\ 2,\ 5,\ 9}$ and 2-inch survey in sheets 56 $\frac{I}{2,\ 3}$. One ½-inch sheet was taken up. The outturn on this scale exceeded expectations, amounting to over 60 square miles per man per month in intricate country.

The country under survey was of a varied nature, consisting for the most part of intricate forest-clad hills, and also of large areas of flat cultivated lands in the Pengangā Valley.

The outturns on various scales were as follows :—

$\frac{1}{2}$-inch survey 1,086 square miles.
1-inch survey 1,508 square miles.
2-inch survey 434 square miles.

Triangulation.—Mr. Kitchen was employed on triangulation in sheets $56\frac{A}{10, 11, 12, 14, 15, 16}$ and Mr. Fitzpatrick in sheets $55\frac{D}{1, 5, 9, 13}$. The country under triangulation was open, and flat or slightly undulating throughout. The area triangulated was 2,795 square miles.

Traversing.—With the concurrence of the Chief Conservator of Forests, Central Provinces, no theodolite traversing was carried out but all the boundaries of reserved forests under survey were traversed by plane-table on the 4-inch scale, by the surveyors employed on the detail survey, as it was found that this method ensured better agreement with the topographical details than theodolite traverses. The amount of traversing thus carried out was 985 linear miles.

Recess Duties.—During the recess the party completed the mapping of the following sheets on the $1\frac{1}{2}$-inch scale :— $56\frac{E}{2, 10, 11, 14, 15}$, $56\frac{I}{1, 2, 3, 5, 9}$ (sheets $56\frac{E}{11, 15}$ and $56\frac{I}{3}$ contain only small portions of Berār which have been surveyed on the 1-inch scale), and on the $\frac{3}{4}$-inch scale, sheet $56\frac{E}{S. E.}$. Mr. Gildea was in charge of the mapping section.

The computations of the triangulation done during the field season were completed. Triangulation charts with tables of data for 55 D and 56 E were prepared but not fully completed.

NOTE.—Six aluminium plane-tables were tried in the field, and as regards variation in graticule measurements, proved entirely satisfactory, but they developed the following serious defect. In every case the edges sagged leaving a raised portion in the centre above the screw, on which the sight rule pivotted, making fixings laborious and liable to error. An attempt is being made in the Mathematical Instrument Office to correct this by strengthening the bracing.

A telescopic clinometer designed by Captain Pye, R.E., giving direct readings in natural tangents to four places of decimals was tried and gave most satisfactory results. It is intended to provide camp officers and surveyors working on the $\frac{1}{2}$-inch scale with these instruments.

No. 7 PARTY (MADRAS).

BY CAPTAIN J. D. CAMPBELL, R.E.

The programme of the party included survey and revision survey in the Malabar, South Kanara, Salem, Coimbatore and North Arcot Districts of Madras and the Bangalore, Kolār, and Mysore districts of Mysore, and triangulation in the Salem, Chittoor, and North and South Arcot districts of Madras.

PERSONNEL.

Imperial Officers.

Captain J. D. Campbell, R.E., in charge.

Provincial Officers.

Mr. J. O'B. Donaghey.
Mr. P. R. Anderson.
Mr. H. D. W. Stotesbury.
Mr. Haji Abdul Rahim, K.B., from 1st October 1912.
Mr. H. H. P. Butterfield.
Mr. J. C. St. C. Pollett.

Upper Subordinate Service.

Mr. Kodandera Mandanna.

Lower Subordinate Service.

29 Surveyors, etc.

The head-quarters of the party remained at Bangalore and the party took the field on various dates between 1st September and the 10th November 1912, and returned to recess quarters about the 20th April 1913.

The field work carried out was as follows :—

Survey on the 2-inch scale of 13 square miles of reserved forest in sheets $57\frac{H}{3, 4, 8, 13}$.

Survey on the $1\frac{1}{2}$-inch scale of 312 square miles in sheets $48\frac{P}{4, 8}$.

Survey on the 1-inch scale of 652 square miles in sheets $57\frac{H}{3, 4, 7, 8, 10}$, $57\frac{H}{11, 12, 13, 15, 16}$, $57\frac{L}{1, 5}$.

Revision survey on the 1-inch scale of 4,040 square miles in sheets $57\frac{G}{8, 12, 16}$, $57\frac{H}{3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16}$, $57\frac{L}{1, 5}$.

Triangulation of sheets $57\frac{L}{9, 10, 11}$, $57\frac{L}{12, 13, 14, 15, 16}$ and $57\frac{P}{1, 2, 3, 4, 5, 6, 7, 8}$.

The country surveyed is extremely varied in character. It includes the flat intricate coast, the undulating jungle-clad foot hills of the Western Ghāts, the densely wooded hilly country on both banks of the Cauvery River and the open, undulating Mysore plateau.

Topography.—The 2-inch forest survey presented no difficulties. The work in sheets $48\frac{P}{4, 8}$ was done on the $1\frac{1}{2}$-inch scale owing to the extremely intricate nature of the country and the large amount of detail. The 1-inch survey was assisted by the maps supplied on the 1-inch scale by the Madras Revenue Survey which were of great assistance especially as regards names. The detail was found to vary in accuracy and for this reason the maps have to be used with considerable caution. It is hoped that, in future, more information will be available beforehand as to their probable accuracy in different localities.

The 1-inch revision survey came under two heads :—

(*a*) Revision of the old 1-inch Mysore sheets which were found very accurate. They had, however, to be very considerably supplemented as they contain but little of the detail which is shown on a modern map.

(*b*) Revision of the 4-inch forest maps which were found quite accurate and were only checked, slightly supplemented and recontoured. The 4-inch forest maps were reduced to the $1\frac{1}{2}$-inch scale in blue, and after compilation on projected sheets on that scale were inked up in black and further reduced and printed in blue on the 1-inch scale. A great saving of time and increase of accuracy were obtained by working on these 1-inch reductions in the field.

Triangulation.—The triangulation presented no difficulties. A chart on the $\frac{1}{4}$-inch scale, supplied by the Madras Revenue Survey, enabled the triangulators to pick up a large number of revenue traverse stations. The values obtained were found to agree with the revenue values and in flat country where fixings are unobtainable the village trijunctions, which are all revenue traverse stations, can be confidently used by the plane-tablers as closing points for traverses.

Recess duties.—The 18 completely surveyed sheets will be submitted for publication by the end of recess. Index degree maps have been prepared of 57 L, O, P, and 66 D. The computations of the season's triangulation have been completed.

Triangulation charts are somewhat in arrears as, owing to the heavy programme of computations and mapping, no assistant has been available for the work.

No. 8 PARTY (MADRAS).

BY CAPTAIN C. M. BROWNE, D.S.O., R.E.

PERSONNEL.

Imperial Officers.

Captain C. M. Browne, D.S.O., R.E., in charge.
Captain R. Foster, I.A.

Provincial Officers.

Mr. W. F. E. Adams.
Mr. S. F. Norman.
Mr. J. H. Williams.
Mr. M. Mahadeva Mudaliar.
Mr. Balaji Dhondiba Mandhre, up to 1st November 1912.
Mr. M. S. Ganesa Aiyar.

Upper Subordinate Service.

Mr. Anantarao Dhondiba, Rao Sahib.
Mr. K. Narayanasvami Chetti, promoted from 1st August 1913.

Lower Subordinate Service.

36 Surveyors, etc.

The work carried out by the party was of the same nature and in continuation of that of the previous year and covered parts of Malabar and Madura districts of Madras and the State of Travancore. It comprised surveys on the 1-inch and $1\frac{1}{2}$-inch scales, and triangulation and traversing in advance for future surveys on these scales. Sheets $58\frac{C}{6, 10, 11}$ and $58\frac{G}{1}$ were entirely surveyed, sheets $58\frac{C}{14}$ and $58\frac{G}{2}$ were completed and sheets $58\frac{C}{7, 15}$ were commenced.

The party left Bangalore on the evening of the 15th November and arrived next day at Ernākulam. Beyond that place in order to reach the head-quarters of detail camps at Kumili, Kottayam, Changanācheri and Kānjirapalli, the journeys had to be made by boat and marching.

The head-quarters of the party was located at Pīrmed.

It was with great difficulty, although ample notice was given to the local authorities, that sufficient carts were obtained at particular places for the conveyance of the head-quarters and detail camps to their destinations. Next year these difficulties may with care be avoided and the various detachments will be able to reach their ground by rail and boat.

The work closed in the field on various dates in May 1913 and opened in recess at Bangalore in June.

The health of the party was on the whole good considering the climate encountered, until towards the close of the field season when all suffered more or less from fever and boils and bowel complaints.

Topography.—The topographical work was distributed as follows :—

Camp No. 1.—Worked in sheets $58\frac{G}{1, 2}$ under Mr. Norman chiefly in Travancore State and partly in Madura district on the 1-inch scale. The area dealt with excluded a portion of sheet $58\frac{G}{2}$ which fell in the Periyār-Pambiyār catchment area which had previously been surveyed on the 2-inch scale in 1910-11. The portion of Travancore in sheet $58\frac{G}{5}$ was too small to justify its being published as a separate sheet so it was included as an outrigger to sheet $58\frac{G}{1}$.

Camp No. 2.—Under the supervision of Mr. Adams worked in sheet $58\frac{C}{6}$ and part of sheet $58\frac{C}{10}$ chiefly in Travancore State with small portions of the Malabar district. The former sheet was surveyed on the $1\frac{1}{2}$-inch scale and the latter on the 1-inch scale.

Camp No. 3.—Worked in sheet $58\frac{C}{11}$ and remaining portion of sheet $58\frac{C}{10}$ on the 1-inch scale under the supervision of Mr. Williams.

Camp No. 4.—Worked in sheets $58\frac{C}{14, 15}$ on the 1-inch scale under Mr. Anantarao Dhondiba Mandhre, R. S.

As it was found impossible for any but the best draftsman to show, adequately in the field, the intricate coast country in the Malabar district and in the Travancore State on the 1-inch scale, the $1\frac{1}{2}$-inch was substituted and the area done on this scale was 256 square miles. The country was covered with palm groves and huts, some of which were of a permanent character but the majority temporary structures, and in order to make the resulting map clearer and more easy to read the latter were not surveyed and a footnote will be added to the published sheet to show that the whole country, where not under cultivation, consists of a dense palm grove dotted about with numerous scattered huts.

The total area of 1-inch survey was 1,358 square miles. The character of the country was very varied. Sheets $58\frac{C}{10, 11}$ were densely populated and the detail especially in the valleys was very intricate and the numerous low hills all of about the same height made the contouring laborious. Sheet $58\frac{C}{14}$ included the western slopes of the hills and the country in the higher ground was more open but the valleys were for the greater part covered with forest or rubber estates and gardens. Sheets $58\frac{G}{1, 2}$ include the Cardamom Hills, a large portion of which are covered with dense forest except towards the east where they are grassy and open. The grass is often very high and as difficult to survey as forest except for a short time after being burnt in the spring. Part of sheet $58\frac{G}{2}$ was surveyed previously in 1910-11 as part of the Periyār and Pambiyār catchment area and the work was incorporated by reduction.

From the above remarks regarding the nature of the country and from last year's report, it is clear that no large outturn can be expected from No. 8 Party in the field till more open country is met with.

Triangulation.—The country triangulated was very varied in character and extended from the coast of Travancore over the Ghāts into the plains of Tinnevelly and Madura. Mr. Ganesa Aiyar was under instruction in triangulation with Mr. Mahadeva Mudaliar for part of the field season and afterwards carried out the triangulation of 2,035 square miles in sheets 58 D, G, and H.

Traversing.—Theodolite traverses were carried out by Traverser Keshava Vaijnath Joshi and unclassed surveyor D. R. Joseph and pupil-surveyor N. Gopal Nayar in sheets $58\frac{C}{6, 7, 8, 11, 12}$ and $58\frac{D}{9}$ amounting to 205 linear miles, and it is hoped that in 1914-15 hardly any traversing will be necessary.

Wellington Cantonment.—At the beginning of May K. V. Joshi traversed the boundary of Wellington Cantonment and a revised list of distances and bearings were subsequently supplied to the Military Works Services.

Captain Foster was detailed at the beginning of May 1913 to test the accuracy of the Wellington Cantonment map, and to report what is necessary to be done in order to bring it up to date. A revision of the contouring details and boundaries seems from Captain Foster's report very desirable but should only be undertaken after the military authorities have definitely decided or carried out alterations which are, at present, only proposed.

In last year's report reasons were given for selecting on the ground buildings of sufficient importance to be shown on the $\frac{1}{4}$-inch degree sheets and this work was done at the close of the regular field work, and the only area stil remaining to be dealt with falls in sheets $58\frac{B}{1, 2, 3, 5, 6}$ and it is proposed to detail a surveyor to complete the work in 1913-14.

Recess duties.—The amount of drawing in the party's sheets is very great and it is improbable that the mapping of the field work can be completed before the party again leaves for the field. The area drawn, 1,663 square miles, is 216 square miles in excess of last year which is very satisfactory. In all probability the drawing of four sheets will be unfinished when the party again leaves Bangalore, and the drawing of these will be completed by No. 4 Drawing Office, and the sheets will be finally examined by the Officer in charge No. 8 Party when he returns to recess quarters in 1914. In recess the computations of all traversing were completed but those of the triangulation were not quite finished as it was impossible to spare enough men from the fair drawing, but none of the data uncomputed, will be needed for the coming field season.

Note.—An improvement on form P. 21 (Computation of Clinometric Heights) was devised in this party during recess 1912 and was used throughout the party during the field season. It was found to be very much easier and quicker to use and to check than the old form P. 21 and it is understood that a form designed on similar lines renumbered P. 17 and bound in books has been approved by the Surveyor General and will be introduced throughout the Department. Metal corner clips were used to fasten mill boards to the plane-table and were found to be on the whole satisfactory and they will be given a further trial in the coming field season. An aluminium plane-table was tried but was found to have certain defects. If an improved pattern can be supplied a further trial will be given to it.

EASTERN CIRCLE.

(*Vide* Index Maps 3 and 6.)

The circle was under the superintendence of Brevet-Colonel G. B. Hodgson, I.A., up to 27th April, from which date it was under Lieut.-Col. C. H. D. Ryder, D.S.O., R.E.

11,836 square miles were surveyed during the year, consisting of—

5,059	square miles of	1-inch survey.
4,589	ditto	1-inch supplementary survey.
592	ditto	1-inch revision survey.
1,189	ditto	½-inch revision survey.
407	ditto	2-inch survey.

No. 9 PARTY (BIHĀR AND ORISSA).

BY CAPTAIN R. H. PHILLIMORE, R.E.

PERSONNEL.

Imperial Officer.

Captain R. H. Phillimore, R.E., in charge.

Provincial Officers.

Mr. Dhani Ram Verma.
Mr. E. Claudius (from June till September 21st).
Mr. B. C. Newland.
Mr. A. K. Mitra.
Mr. F. Byrne (till August 5th).
Mr. W. P. Hales.
Mr. D. N. Banerjee.

Upper Subordinate Service.

Mr. Dalbir Rai.
Mr. M. R. Mazumdar (till May 21st).

Lower Subordinate Service.

38 Surveyors, etc.

The party continued work in Singhbhūm and Rānchī districts, working along the northern border of the Orissa Feudatory States, and completed the survey of sheets Nos. $73\frac{B}{9, 10, 11, 12, 13, 14, 15, 16}$ and $73\frac{F}{1, 2, 3, 5, 6, 7, 8, 12}$. Such portions of the Orissa Feudatory States as fell into this area were surveyed on the ½-inch scale.

The reserved forests of Singhbhūm district which had been previously surveyed on the 4-inch scale were now revised on the 1-inch scale, and a few scattered blocks of protected forest were surveyed on the 2-inch scale.

The remaining area had all been surveyed cadastrally within the last ten years.

The party assembled in Chakradharpur on November 11th; some men had to be kept in the field till the end of May to complete the programme, though a start was made with fair mapping from May 5th.

April and May were very hot months and there was a good deal of shirking amongst the surveyors, several of whom were discharged at the close of the field season.

Topography.—The country under survey lies along the borderland of Chotā Nāgpur and the Orissa Feudatory States. The sheets to the north lay on the Rānchī plateau; the country here was well populated and cultivated, healthy and very easy to travel about in; the ground was undulating, with a general level of from 1,500 to 2,000 feet, with protuberances of bare rocky hills of gneiss. Detail could not well be sketched, but fixings were readily made and work could proceed rapidly.

Towards the south, the plateau drops steeply, and the ground becomes broken, intricate and wooded. The western corner of Singhbhūm district is covered with dense *sāl* forest, and is a mass of hills which rise in some places to peaks nearly 3,000 feet above sea level. Villages and cultivation are here more scarce, and surveyors suffered a certain amount from malaria.

$\frac{1}{2}$-inch survey in Gāngpur State could not proceed very rapidly as the hill features did not stand out with prominence. In the low wooded hills surveyors found it difficult to get fixings, and in many places filled in detail by pacing from one point to another.

The party was divided into four camps, the head-quarters being located at Pānposh in Gāngpur State.

Camp No. I.—Under Mr. B. C. Newland numbered ten plane-tablers to start with, and surveyed the north-eastern sheets of 73B on the Rānchī plateau.

Camp No. II. was under Mr. W. P. Hales, who had charge of the $\frac{1}{2}$-inch work in Gāngpur and Bonai States in south-eastern sheets of 73B. Mr. Hales surveyed 170 square miles himself besides supervising three to five surveyors.

Camp No. III.—Under the charge of Mr. Dhani Ram Verma, numbered 11 plane-tablers working in the four north-west sheets of 73F.

Mr. Dalbir Rai was attached to this camp and supervised the work of half a dozen surveyors, besides surveying a small area himself.

Camp No. IV. was under Mr. A. K. Mitra, who had seven men with him. Work lay in the south-western sheets of 73F and covered the thickest of the Singhbhūm forests.

Reductions of the cadastral maps had been compiled into 1-inch sheets by the Bengal Drawing Office; and grey prints on drawing paper were supplied for the topographical supplementary survey. The country was too hilly and undulating for the surveyors to get much advantage from the detail on these cadastral reductions. Boundaries, main roads, large rivers and village sites were of undoubted value, but as the ground had all to be gone over for the survey of contours, the rate of survey was not largely increased.

In absolutely flat country these cadastral reductions will be of far greater help; they will show more detail and the trijunction pillars will become important points for the plane-tabler, who also will have no necessity to cover the whole ground for the sake of the contouring.

The average monthly outturn for supplementary work comes to about 21 square miles a month, possibly 5 per cent. greater than it would have been without the cadastral sheets. In the most favourable ground, on the open Rānchī plateau the best surveyors occasionally touched 40 square miles in a month.

Triangulation.—Surveyor Ram Singh triangulated 800 square miles in sheets Nos. 64 N and O, and also 600 square miles in sheet No. 72L, whilst Mr. F. Byrne, completed the area still remaining in sheet No. 72L.

It is to be noted that in this sheet and its neighbourhood the atmosphere is very hazy throughout the cold weather, a circumstance mainly due to the numerous collieries. For all rays over 10 miles long the use of heliotropes is imperative.

An area of 3,180 square miles was completed at a cost rate of Rs. 3·1. The quantity of the work was not good.

The boundaries of a large number of scattered blocks of protected forests in Singhbhūm district were traversed by theodolite. The outturn amounted to 253 linear miles with a cost rate of Rs. 6·6.

Recess duties.—During recess the fair mapping was completed under the supervision of the following officers :—

Mr. Dhani Ram Verma; sheets 73 $\frac{F}{1, 2, 5, 6}$.

Mr. B. C. Newland; sheets 73 $\frac{B}{9, 10, 13, 14}$ with the incomplete 1-inch sheets 73 $\frac{B}{11 \text{ and } 15}$ and also the $\frac{1}{2}$-inch sheet 73 $\frac{B}{S.E.}$.

Mr. A. K. Mitra; sheets Nos. 73 $\frac{F}{3, 7, 8 \text{ and } 12}$. Such field sections as had been specially mounted on the plane-tables were brought in without any distortion, and several sheets were fair mapped direct on enlargements of the field sections. 4,188 square miles were fair mapped at a cost rate of Rs. 5·3. The computations of triangulation have not been entirely completed, and some of the forest boundary traverses still remain.

No. 10 PARTY (UPPER BURMA).

BY MAJOR E. T. RICH, R.E.

The field season opened on November the 8th, 1912, and closed on May 18th, 1913, when the party returned to Maymyo. The field head-quarters were at Myitkyinā.

PERSONNEL.

Imperial Officers.

Major E. T. Rich, R.E., in charge.
Captain E. B. Cardew, R.E. (from 10th May to 26th August 1913).
Lieutenant W. E. Perry, R.E.

Provincial Officers.

Mr. J. Smith (from 26th May 1913).
Mr. P. Williams (till 22nd October 1912).
Mr. W. G. Jarbo.
Mr. H. B. Simons (from 14th December 1912).
Mr. V. W. Morton.
Mr. Asmat-Ullah Khan, K.S.
Mr. C. B. Sexton.
Mr. A. F. Murphy (from 15th October 1912).

Upper Subordinate Service.

Mr. Hayat Muhammad, K.S. (from 10th May 1913).

Lower Subordinate Service.

34 Surveyors, etc.

The programme of both detail survey and triangulation was not completed. Mr. Hayat Muhammad, K.S., and two surveyors were deputed to the North Burma Exploration Detachment, two other surveyors were transferred, and one surveyor died. The work of six of the best plane-tablers was thus lost.

The triangulation in the Laukhaung hill tracts was hindered considerably by mist and snow which stopped the work at times for stretches of over ten days.

Mr. Simons who was intended to triangulate a large area in the east of 92C, did not join the party till two months later than was anticipated and then was sick for nearly a month after he joined, so that he really did only half a season's work.

The programme of the party was as follows:—

(*a*) One-inch detail survey in sheets 92 $\frac{D}{9, 10, 13}$, $\frac{G}{2, 3, 4, 6, 7, 8, 10, 11, 12, 14, 15}$, $\frac{K}{2, 3}$.

(*b*) 2-inch detail survey of two reserved forests falling in the above sheets with a theodolite traverse of the boundaries.

(*c*) Triangulation of portions of sheets 92 $\frac{J}{4, 7, 8, 11, 12}$, $\frac{K}{1, 2, 5, 6, 9}$, $\frac{C}{7, 8, 11, 12, 15, 16}$, and revision of 800 square miles in sheets 92 $\frac{D}{1, 5, 6}$.

This programme was completed with the exception of the 1-inch detail survey in sheets 92 $\frac{D}{9, 10, 13}$, $\frac{G}{2, 3, 6}$ and triangulation in portions of sheets 92 $\frac{J}{4, 7, 8, 11, 12}$, $\frac{K}{5, 6, 9}$ and $\frac{C}{7, 8, 11}$.

The actual areas of detail survey were 2,347 square miles of 1-inch survey, 125 square miles of 2-inch forest survey and 24 square miles of 1-inch reconnaissance in unadministered territory beyond the China frontier; 2,700 square miles of triangulation and traversing were completed which with previous work makes a total of 5,250 square miles triangulated and traversed in advance. The forest boundary surveys amounted to 207 linear miles of traversing.

Topography.—The party was divided into three detail camps under Lieutenant W. E. Perry, R.E., Mr. W. G. Jarbo and Mr. Asmat-Ullah Khan, K.S., respectively, whilst Messrs. Simons, Morton and Sexton were independently employed on triangulation.

Camp No. 1.—Consisted at the commencement of the season of Lieutenant W. E. Perry, R.E., in charge with two officers, Messrs. Sexton and Murphy, and three traversers doing traversing and one surveyor doing plane-tabling. Later on this camp was broken up. One of the officers, Mr. Sexton, left the camp to do triangulation, the other one, Mr. Murphy, left to do plane-tabling in Camp No. 2, one of the traversers, Khurshed Beg, died, and one surveyor was transferred to Camp No. 3, and Lieutenant Perry himself was transferred to Camp No. 2 for instruction in plane-tabling, leaving only two traversers who were then placed directly under Major Rich.

This camp surveyed 145 square miles on the 1-inch scale, traversed 44 linear miles and completed 207 linear miles of theodolite boundary survey.

Camp No. 2.—Consisted of Mr. W. G. Jarbo in charge with eight surveyors and apprentices and surveyed 1,474 square miles on the 1-inch scale.

Camp No. 3.—Consisted of Mr. Asmat-Ullah Khan, K.S., in charge with ten surveyors and apprentices and surveyed 752 square miles on the 1-inch scale and 125 square miles on the 2-inch scale.

The average outturn per man per mensem of 26 working days was as follows :—

New 1-inch detail survey	30·2	square miles	per mensem.
2-inch ,,	10·1	,, ,,	,,

These averages are slightly less than last year.

Triangulation.—Mr. H. B. Simons triangulated an area of 800 square miles in sheets $92\frac{C}{12, 15, 16}$.

Mr. V. W. Morton triangulated an area of 1,000 square miles in sheets $92\frac{G}{14, 15}, \frac{K}{1, 2}$ with reconnaissance in sheets $92\frac{J}{4, 8}, \frac{K}{5}$.

Mr. C. B. Sexton triangulated an area of 900 square miles in sheets $92\frac{D}{1, 5, 6}$.

The same kind of country was triangulated by all three triangulators consisting of thickly wooded hills and deep valleys sparsely inhabited.

To clear hill tops, for making stations, cost in some cases several hundred rupees as the jungle was so thick.

The total outturn of 2,700 square miles was much smaller than calculated owing to Mr. Simons being only able to work for half the season and to the curious climatic conditions in the area worked over by Mr. Morton.

Mr. Morton commenced his reconnaissance in the beginning of November and completed it soon after X'mas. Before he had time to commence observing, the winter rains set in and the higher hills were blocked by snow. It rained practically every day from the beginning of January till the end of March. As soon as the rains had stopped, heat haze set in completely blocking out all the view. The result was that Mr. Morton's area was only about half what it would otherwise have been.

This year triangulation is being commenced in this tract early in October and it is hoped to complete it early in January before the snow and rains set in.

In each case the instruments used were two vernier 6-inch transit theodolites.

Traversing.—Two officers, and three traversers under the direction of Lieutenant W. E. Perry, R.E., in charge of Camp No. 1 were employed during part of the season in surveying 4-inch boundary traverses round the Maigna, Kawan and Namkwin reserve forests and part of the Zigyun and Talawgyi reserve forests totalling 207 linear miles. In addition 44 linear miles of ordinary traverse were run inside these reserves to help the plane-tablers. The area covered by these latter traverses is included in the area of triangulation as it is only supplementary work. The instruments used were two vernier 5-inch Everest theodolites.

The country under survey consisted for the most part of mountain ranges from 3,000 to 12,000 feet high, intersected with deep valleys, all covered with dense jungle.

The higher ranges were covered with snow from January to April and when the snow cleared away, heat mists obscured the view, so the work in these higher ranges was carried out under considerable difficulties.

In sheets 92 $\frac{G}{4,7,8}$ bordering on the Irrawaddy the country was low lying and consisted of flat plains and low undulating hills covered with dense jungle which necessitated working almost entirely by plane-table traversing.

The local civil, forest and military police officials rendered us every possible assistance.

The health of the party remained good throughout the season except for a few cases of malaria which accounted for the death of one traverser, Khurshed Beg, and two khalasis. Mr. V. W. Morton's camp was struck by lightning on a hill top at the end of March, killing one khalasi and severely injuring two or three others who ultimately recovered.

Recess duties.—The mapping of all the sheets surveyed during the season is well in hand and will all be completed before the party takes the field.

The mapping has been divided into two sections under Lieutenant W. E. Perry, R.E., and Mr. V. W. Morton.

The computations of the triangulation done during the field season have all been completed and rough triangulation charts of sheets 92 D and 92 H with data have been sent to the Superintendent, Eastern Circle.

The traverse computations of all traverses and 4-inch forest boundary surveys have been completed.

The new Maymyo drawing office under Captain E. B. Cardew, R.E., and Mr. J. Smith with five draftsmen commenced work in May and has completed the maps for the preliminary issue of the North Burma Exploration Survey as well as the fair drawing of the detail in degree sheets 92 E, F, I, J, of which he hill drawing will be completed during the winter.

No. 11 PARTY (LOWER BURMA).

BY CAPTAIN L. G. CROSTHWAIT, I.A.

PERSONNEL.

Imperial Officers.

Captain L. G. Crosthwait, I.A., in charge.
Lieutenant H. E. Roome, R.E., from 19th May 1913.

Provincial Officers.

Mr. J. Smith, from 7th December 1912 to 26th May 1913.
Mr. C. Litchfield, up to 15th May 1913.
Mr. C. S. Littlewood, from 10th August 1913 to 27th September 1913.
Mr. A. M. Tulati.
Mr. T. P. Dewar.
Mr. H. St. J. Kenny, up to the 31st May 1913.
Mr. A. J. Booth.
Mr. R. M. Wyatt.

With field head-quarters in Tavoy the party started detail survey at the beginning of November 1912 in the north of the Tavoy district of the Tenasserim division of Lower Burma and returned to recess quarters at Maymyo towards the end of May 1913. Triangulation was also carried out in the south of the same district and extended into the Mergui district.

The country under survey lay between the sea coast and the Siam frontier,

Upper Subordinate Service.
Mr. Raghubar Datt Thaplyal.
Lower Subordinate Service.
31 Surveyors, etc.

practically the whole of it being densely wooded with hills rising to 6,800 feet. A survey was also made of the North and Middle Moscos Islands which lie from 15 to 20 miles off the coast. The district is one of the most thinly populated of Burma and nearly the whole of the population is gathered along the Tavoy River, for which reason, together with the competition set up by the newly started wolfram and tin mining industry, labour is difficult to obtain. The district is badly provided with communications and there being no pack transport obtainable, Chinese mules were brought down from the Yün-nan frontier of the Northern Shan States. Rice is scarce and large quantities had to be sent out from Tavoy.

The programme of detail survey could not be completed before the rain began, parts of three sheets being left unsurveyed. This was due to the great scarcity of local labour, sickness and to the deputation of two first class surveyors to the missions after the submission of the programme.

The climate with an average rainfall of 230 inches is hot and damp and the party suffered considerably from rheumatism, malarial fever and general ill health brought on by the bites of leeches and other insects which abound in the evergreen jungle.

Topography.—The area surveyed comprising sheets 95 $\frac{F}{14, 15, 16}$, 95 $\frac{J}{2, 3, 4, 7, 8, 16}$ and parts of sheets 95 $\frac{J}{6, 11, 12}$ was 1,745 square miles on 1-inch scale, and 215 square miles of reserved forests on 2-inch scale, the party being divided up into three camps under Messrs. C. Litchfield, T. P. Dewar and H. St. J. Kenny. For reasons already stated progress was slow.

Triangulation.—Messrs. A. M. Talati and R. M. Wyatt and surveyor Muhammad Yusuf Khan were employed on triangulation and completed sheets 95 K and O, an area of 3,929 square miles. The triangulation was based on the Eastern Frontier series principal triangulation and the secondary triangulation to Bangkok of 1877.

The pillars and mark stones of some of the stations had entirely disappeared, hollows being found in their place. In such cases the triangulator placed fresh mark stones in the centre of the hollow. The country was mostly uninhabited and difficult to get about in.

Traversing.—A boundary traverse with the theodolite was made of the Pandet-in and part of the Kaleinaung and Heinzè reserved forests. The traverse of the latter two reserves was computed in the field.

Recess duties.—The fair mapping was divided into two sections, one under Mr. T. P. Dewar which drew sheets 95 $\frac{F}{14, 15, 16}$, $\frac{J}{2, 3}$, and the other under Mr. A. J Booth which drew sheets $\frac{J}{4, 7, 8, 16}$.

The season's triangulation was computed during the recess and fair plots made of the forest boundary traverses.

Cost rates.—The cost rates which are given in Table III are slightly higher than last year for 1-inch survey, while they are slightly less for triangulation and fair mapping.

The high rates for traversing and 2-inch survey are due to the density of the jungle in the reserved forests and a large number of surveyors having to be employed for so small an outturn.

Owing to the great demand for labour in the Tavoy district the civil authorities are reluctant to enforce the Government rates and the rising of the already exorbitant wages will make future work expensive.

If the outturn and cost of last year's $\frac{1}{4}$-inch survey be deducted in computing the inclusive cost rate, that for this year shows a small increase only.

Six Superintendents of the Burma Land Records Department were attached to the party for training in plane-tabling in two batches for two months each.

Applicants for mining concessions are required to submit surveys of the areas they require on scales from four to eight inches to a mile, which are reduced to 1-inch scale and fitted on to our maps. As these are frequently theodolite traverse surveys made by well trained European and Indian surveyors, a comparison between the large and small scale surveys puts the 1-inch maps of the party to a severe test for country of this nature. So far they have, on the whole, stood the comparison very well.

A party of Siamese surveyors was carrying out triangulation on the other side of the frontier and some of its stations were on the same hill tops as those of the party.

No. 12 PARTY (ASSAM).

BY MAJOR A. MEARS, I.A.

PERSONNEL.

Imperial Officers.

Major A. Mears, I.A., in charge from 24th October 1912.
Captain G. F. T. Oakes, R.E., in charge from 1st to 23rd October 1912.

Provincial Officers.

Mr. W. Skilling.
Mr. Pramadaranjan Ray, Rai Sahib.
Mr. E. M. Kenny.
Mr. Amjad Ali.
Mr. L. Williams.
Mr. P. C. Mitra.
Mr. H. H. Creed.

Upper Subordinate Service.

Mr. Nanak Chand Puri.
Mr. Sajoni Kumar Ghosal.

Lower Subordinate Service.

41 Surveyors, etc.

The operations of the previous season were continued eastward, being limited to the north by the Bhutān State and on the south by the Khāsi foot hills comprising standard sheets $78\frac{N}{9, 10, 11, 13, 14, 15, 16}$ and $83\frac{B}{1, 2, 3, 4, 5, 6, 7, 8}$. The survey was carried out mainly on the 1-inch scale and consisted partly of original and partly of supplementary survey. The Darranga, Khalingduar, Hājo, Sildar Hill and Singri reserved forests, comprising an area of 37 square miles and situated in the area under survey, were mapped on the 2-inch scale. In addition the Sonaikuchi and Kolahat reserved forests, surveyed on the 4-inch scale during season 1904-05 were revised; the large scale survey proved very good except for the hill features which had to be recontoured. A special survey of the Upper Dihing and Jaipur reserved forests, district Lakhimpur, was also commenced, the work being much hindered by bad weather.

The country under survey much resembled that of the previous season, the hills densely wooded and the alluvial plains of Brahmaputra, where not under cultivation, covered with impenetrable "khagra" grass, some 15 to 20 feet high, with scattered trees and clumps of jungle. Field work commenced about the middle of November and closed at the beginning of May when the weather became very unsettled. The health of the party was good on the whole, a slight outbreak of cholera occurred during the last month of the season from which three khalasis died. Four of the party's surveyors were lent to the Forest Officer, Port Blair, for a special forest survey in the Andaman Islands.

Topography.—The detail survey programme was carried out by three camps under the charge of Messrs. Pramadaranjan Ray, Rai Sahib, Amjad Ali, and L. Williams. To Mr. Pramadaranjan Ray, with a strength of nine surveyors, was allotted the survey of 4½ sheets, Mr. Amjad Ali, with eight surveyors, carried out the survey of 5½ sheets, and Mr. L. Williams, with seven surveyors, surveyed 4 sheets in all. With the exception of the area surveyed by Mr. Ray's camp and a narrow strip along the Bhutān boundary, the country was flat. Portions of the Kāmrūp and Darrang districts are well populated and extensively cultivated; along the foot hills of Bhutān and the Khāsi Hills there are a considerable number of tea gardens. Where not under cultivation, the plains area is covered with high grass jungle and difficult of survey till dry enough to burn. The hills are densely wooded and contain a certain area of *sál* forest. With the exception of the Gauhāti-Shillong road, an excellent metalled road, indifferent footpaths are the only means of communication in the hills; fair cold weather cart roads exist throughout the whole of the plains. The work was somewhat hindered at the start by an outbreak of cholera in the Rangiā Thāna which necessitated a redistribution of plane-tables and the throwing of several surveyors into the same sheet until the epidemic had died out.

Less difficulty was experienced on the whole than in previous years, in obtaining supplies and labour; it was, however, still found necessary to attach a Revenue peon to every three or four surveyors to render assistance in this respect.

A trial was given to Bristol boards and plane-tables mounted with these in place of drawing paper were issued to several surveyors. The idea that projections on boards would be less affected by distortion was not realized, probably owing to the humidity of the atmosphere in Assam; as these boards are distinctly awkward to handle and the surface will stand very little erasing no advantage is obtained from their use.

The detail outturn of the party for the season comprised 3,337 square miles on the 1-inch scale and 43 square miles (includes 6 square miles special forest survey) of reserved forests surveyed on the 2-inch scale. This for the nature of the country may be considered quite a satisfactory outturn. Although a large proportion of the area was nominally a supplementary survey, its resurveying practically amounted to original work; drainage and village site detail had completely changed owing to the many years that had elapsed since the Revenue survey. Rivers were found to have shifted their courses in some cases several miles and in others to have altogether disappeared. The main channel of the Brahmaputra River, except where it is confined by hills or rocky formations, has moved considerably southwards, in places as much as 4 to 5 miles.

The survey cost rates for the year may be considered most satisfactory being the lowest so far on record in the party. The slightly higher rate for revision survey is accounted for by the smallness of the area and the fact that this survey was done early in the season when the jungle was exceptionally dense and the outturns consequently small.

The special 2-inch forest survey cost rate is abnormal; the work was only started during the last month of the field season and was interrupted by daily rain.

Triangulation.—The triangulation was carried out by three Provincial Officers, Messrs. W. Skilling, E. M. Kenny and P. C. Mitra, and was based on the Assam Longitudinal Series. Connections were made to two bench-marks of the Gauhāti-Dibrugarh line of levels from which all the heights of the season's triangulation have been deduced. The area triangulated totalled 2,600 square miles falling in standard sheets $83\ ^{B}_{12,\ 15,\ 16}$, $83\ \frac{F}{2,\ 3,\ 4,\ 6,\ 7,\ 8,\ 10,\ 11,\ 12}$ and comprised the foot hills of the Khāsi and Jaintiā Hills and a block known as the Mīkīr Hills. The latter were triangulated in seasons 1871-72; several of the old stations were found and utilized; the resulting values accorded well. The entire area triangulated was thickly wooded and necessitated very heavy clearing for stations, particularly in sheets $83\frac{F}{7,\ 11}$, which mainly consist of reserved forest. Communications are indifferent in the Mīkīr Hills where coolies are the only possible form of transport. The triangulation cost rate is somewhat above that of previous years due to three Provincial Officers being employed on both field and recess work, one of whom was highly paid; the dense nature of the jungle and the employment of cooly transport also affect the rate.

Traversing.—Supplementary traversing, for the purpose of obtaining heights for the topographical survey of the country, was run in the cadastrally surveyed areas of the Nowgong and Darrang districts. Traversing had also to be resorted to in the plains where impossible to fix sufficient points by triangulation for its detail survey. An attempt was made to traverse the undemarcated boundary between the Darrang districts and the Daflā Hills, but had to be abandoned on account of the denseness of the jungle and lack of communications and villages along the border. This survey will necessitate very complete arrangements for labour and supplies being made beforehand and has therefore been postponed till the coming field season. In all 588·5 linear miles of traversing were run which exclude 43·3 linear miles of forest boundary traverse, 327 selected stations are permanently marked, 566 zinc cylinders were also embedded. The country under traverse differed in no respect from that surveyed in detail.

The cost rate for ordinary and boundary traversing is high and is due to a Provincial and an Upper Subordinate officer having been employed on this work, the boundary traversing having been entirely performed by these officers.

Recess duties.—The fair mapping of the season's survey was distributed between three Drawing Sections under the charge of Messrs. P. Ray, Amjad Ali and L. Williams; sheets surveyed by these assistants being as far as possible allotted them to fair map, the two first named having 5 sheets each to draw and Mr. Williams 4 sheets. The progress of the fair mapping has been very satisfactory. Sheets $78\ \frac{N}{9,\ 13,\ 14}$ and $83\ \frac{B}{1,\ 4,\ 7}$ of the current work have been submitted for publication before the close of the survey year and the remaining sheets $78\ \frac{N}{10,\ 11,\ 15,\ 16}$ and $83\ ^{B}_{2,\ 3,\ 6,\ 8}$ will be completed before the party takes the field. In addition sheets $78\ \frac{O}{1,\ 2,\ 5,\ 6,\ 9}$ and $78\ \frac{N}{1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ 8,\ 12}$ surveyed in season 1911-12 have been completed and submitted for publication during the year under report; this makes a total of 20 standard sheets for the year.

The cost rate for the fair mapping amounts to Rs. 6·7 per square mile which is lower than that for the previous year.

The triangulation and traverse computations of the season have been completed, the work proving satisfactory.

TABLE I.

OUTTURNS OF DETAIL SURVEY.

Scale.	Class of Survey.	Circle.	Party.	Locality.	Outturn. Total Square miles.	Outturn. Average per man per month. Square miles.	Average number of fixings per square mile. In situ (by resection).	Average number of fixings per square mile. Plane-table traverse.
¼-inch .	Revision Survey.	N	No. 1	Kashmīr . . .	1,036	401·0	0·32	...
½-inch .	Survey .	S	No. 6	Hydorābād . . .	1,086	57·9	8·4	...
½-inch .	Revision Survey.	N	No. 1	Kashmīr . . .	684	390·8	0·14	...
		E	No. 9	Bihār and Orissa . .	1,189	47·9	5·0	...
1-inch .	Survey .	N	No. 1	Kashmīr . . .	3,091	37·7	5·6	...
		N	No. 2	Punjab . . .	2,661	33·1	...	15·1
		N	No. 3	Punjab and United Provinces.	2,764	27·0	11·0	5·0
		S	No. 5	Central Provinces . .	2,575	26·0 (*b*)	14·0	...
		S	No. 6	Berār and Hyderābād .	1,508	17·5	23·0	...
		S	No. 7	Madras . . .	652	32·1	9·7	...
		S	No. 8	Madras and Travancore .	1,358	9·9	6·6	26·7
		E	No. 9	Bihār and Orissa . .	32	32·0	3·0	...
		E	No. 10	Upper Burma . .	2,347	30·2	10·0	...
		E	No. 11	Lower Burma . .	1,745	25·2	4·4	5·2
		E	No. 12	Assam	935	24·7	11·0	...
1-inch .	Resurvey .	N	No. 4	United Provinces . .	3,993	25·2	26·0 (*a*)	...
1-inch .	Revision Survey.	N	No. 2	Punjab . . .	6,331	38·4	...	12·7
		N	No. 3	Punjab and United Provinces.	4,960	33·0	11·0	5·0
		S	No. 5	Central Provinces . .	1,115	26·0 (*b*)	9·0	...
		S	No. 7	Madras and Mysore .	4,040	48·6	6·1	...
		E	No. 9	Bihār and Orissa . .	476	33·7	4·0	...
		E	No. 12	Assam	116	23·6	8·0	...
1-inch .	Supplementary Survey.	N	No. 4	United Provinces . .	1,467	49·9	15·3 (*a*)	...
		E	No. 9	Bihār and Orissa . .	2,303	20·8	12·0	...
		E	No. 12	Assam	2,286	28·3	12·0	...
1½-inch	Survey .	S	No. 7	Madras . . .	312	13·8	25·6 (*a*)	...
		S	No. 8	Madras and Travancore .	256	7·9	3·2	36·5
2-inch .	Survey .	S	No. 6	Berār	434	8·3	55·0 (*a*)	...
		S	No. 7	Madras . . .	13	7·0	39·0	...
		E	No. 9	Bihār and Orissa . .	30	4·6	79·0	...
		E	No. 10	Upper Burma . .	125	10·1	...	44·0
		E	No. 11	Lower Burma . .	215	8·6	2·9	56·9
		E	No. 12	Assam	37	8·7	46·0	...
2-inch and 4-inch .	Revision Survey.	N	No. 2	Punjab . . .	253	44·1	7·3	...
6-inch .	Survey (Special.)	N	No. 2	Māler Kotla State (Punjab).	10·50	...	...	...
					acres.			
4-inch .	Survey .	N	No. 20	Delhi	5,280	...	...	...
16-inch	Survey .	N	No. 20	Quetta Civil Station .	1,248	...	...	...
16-inch	Resurvey .	N	No. 20	Saugor Cantonment .	4,916	...	...	...
64-inch	Resurvey	N	No. 20	Saugor Cantonment .	95	...	...	...

(*a*) Including plane-table traverse fixings. | (*b*) Includes 1-inch survey and revision.

TABLE II.

DETAILS OF TRIANGULATION AND TRAVERSING.

Scale.	Class of survey.	Circle.	Party.	Locality.	TRIANGULATION. Instrument used; diameter in inches.	Area in square miles.	Square miles to each point fixed.	Square miles to each height.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	INTERSECTED POINTS. Number of points fixed.	INTERSECTED POINTS. Linear error per mile in feet.	TRAVERSING. Area in square miles.	Linear miles of chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1,000.
1-inch . ½ and ¼-inch	Survey . Revision Survey.	N	No. 1	Kashmir	6	1,705	Computations not completed.							(a)	193	362	″ 10·0	″ 0·48
...	...	N	No. 2	Punjab	No triangulation or traversing was done this year.													
1-inch .	Survey and Revision Survey.	N	No. 3	Punjab and Phūlkiān States	...	...	...	...	...	...	...	...	...	6,058	2,846	6,453	2·0	0·20
1-inch .	Resurvey and Supplementary Survey.	N	No. 4	United Provinces . .	...	...	...	...	...	...	...	...	...	...	248·6	876	...	0·30
16-inch .	Cantonment Survey.	N	No. 20	Saugor and Guna . .	6	82	4·6	4·6	18	8·8	0·31	...	...	7·68	47·7	386	7·0	0·07
1-inch .	Survey .	S	No. 5	Central Provinces . .	6	4,972	4·6	4·6	152	8·9	0·20	1,072	0·50	...	...	...	...	...
1-inch and ½-inch.	Survey .	S	No. 6	Berār and Hyderābād . .	6	2,795	3·9	3·9	95	8·6	0·26	613	0·28	...	...	...	...	...
1-inch and 1½-inch.	Survey .	S	No. 7	Madras	6	4,642	6·4	6·4	42	8·4	0·21	565	0·52	...	...	...	...	...
1-inch and 1½-inch.	Survey .	S	No. 8	Madras and Travancore State	6	1,985	5·0	5·0	30	6·5	1·50	Computations incomplete.		(a)	204·9	1,309	9·0	1·60
1-inch and ½-inch.	Survey and Revision Survey.	E	No. 9	Bihār and Orissa .	6	3,180	Computations not completed.							(a)	253	2,370	Computations incomplete.	
1-inch and 4-inch.	Survey .	E	No. 10	Upper Burma . . .	5 and 6	2,700	9·3	9·4	28	15·0	0·10	270	0·70	(a)	251	4,036	2·6	0·80
1-inch and 2-inch.	Survey .	E	No. 11	Lower Burma . . .	6	3,929	5·2	5·2	26	12·0	0·20	720	0·40	(a)	59	936	1·7	1·40
1-inch and 2-inch.	Survey .	E	No. 12	Assam	6	2,600	5·4	5·5	67	18·0	0·30	405	1·30	1,900	632	3,037	4·4	2·60

(a) Included in area given under triangulation.

TABLE III.

COST-RATES OF SURVEY.

Circle.	Party.	Locality.	COST-RATES, RUPEES. ¼-inch revision survey.	½-inch survey.	½-inch revision survey.	1-inch survey.	1-inch revision survey.	1-inch resurvey.	1-inch supplementary survey.	1½-inch survey.	2-inch survey.	4-inch survey.	16-inch survey.	64-inch resurvey.	Triangulation, per square mile.	TRAVERSING, PER LINEAR MILE. Topographical.	TRAVERSING, PER LINEAR MILE. Forest boundary.	Fair mapping, per square mile.	Total survey outturns on all scales, square miles.	Total cost of party.	REMARKS.
												Per acre.	Per acre.	Per acre.						Rs.	
N	No. 1	Kashmīr	1·3	...	3·3	16·8	...	...	...	...	...	...	...	...	10·1	16·8	...	8·2	4,811	1,12,659	
N	No. 2	Punjab	...	...	...	9·9	8·6	...	...	...	9·2[a]	...	...	...	...	...	...	3·0	9,245	1,11,252	[a] Represents cost-rate for revision survey on 2-inch and 4-inch scales.
N	No. 3	Punjab and United Provinces	...	...	...	11·5	10·6	...	...	...	...	...	...	...	...	8·9	...	4·3	7,724	1,42,734	
N	No. 4	United Provinces	...	...	...	10·7[b]	...	...	...	...	...	...	...	...	...	20·0	...	6·1	5,460	96,477	[b] Includes supplementary survey.
N	No. 20	Delhi, Quetta, Saugor and Guna	...	...	...	...	...	.	...	...	...	0·37	1·46	4·30	0·02[c]	0·92[c]	...	0·3[c]	11,539[d]	22,144	[c] Per acre for 16-inch survey. [d] Acres.
S	No. 5	Central Provinces	...	...	...	14·8	14·2	...	...	...	...	...	...	...	7·1	...	...	6·7	3,690	1,13,888	
S	No. 6	Berār and Hyderābād	...	5·8	...	19·8	...	...	...	...	41·0	...	...	...	7·9	...	1·7[e]	7·1	3,028	99,631	[e] Plane-table survey on 4-inch scale.
S	No. 7	Madras and Mysore	...	...	...	16·1	8·1	...	...	27·8	59·4[f]	...	...	...	1·9	...	...	4·4	5,017	87,604	[f] 13 square miles only.
S	No. 8	Madras	...	...	...	53·5	...	...	...	56·2	...	...	...	...	5·7	49·4	...	14·3	1,614	1,32,777	
E	No. 9	Bihār and Orissa	...	...	8·7	...	17·8	7·3	17·4	...	66·0	...	...	...	3·1	...	6·6	5·3	4,030	1,03,135	
E	No. 10	Upper Burma	...	...	...	25·2	...	...	...	...	57·8	..	...	...	13·5	...	111·0	10·9	2,472	1,33,466[g]	[g] Excludes Rs. 13,273 expended on exploration surveys and mapping and Rs. 22,965 expended on forest boundary surveys.
E	No. 11	Lower Burma	...	...	...	35·9	...	...	...	...	91·5	...	...	...	8·0	...	81·9	10·7	1,960	1,36,638[h]	[h] Excludes Rs. 14,449 for instruction and reconnaissance.
E	No. 12	Assam	...	...	...	17·8	18·3	...	15·5	...	52·2	...	...	...	13·5	27·3	66·6[i]	6·7[i]	3,374[i]	1,38,006[i]	[i] Excludes area and cost, Rs. 2,164, of special forest surveys.

PART II.—GEODETIC AND SCIENTIFIC OPERATIONS.

ASTRONOMICAL LATITUDES.

No. 13 PARTY.

(*Vide* Index Map No. 10.)

PERSONNEL.

Imperial Officer.

Major H. L. Crosthwait, R.E., in charge up to 28th February 1913.
Captain V. R. Cotter, I.A., in charge from 1st March 1913.

Upper Subordinate Service.

Mr. Bidhu Bhusan Shome up to 30th June 1913.

Lower Subordinate Service.

1 Computer.

As no officer was available, no Astronomical Latitudes were observed during the field season 1912-13.

PENDULUM OPERATIONS.

No. 14 PARTY.

(*Vide* Index Map No. 10.)

BY CAPTAIN H. J. COUCHMAN, R.E.

PERSONNEL.

Imperial Officer.

Captain H. J. Couchman, R.E.

Provincial Officers.

Mr. Hanuman Prasad, up to April 30th.
Mr. O. N. Pushong, from May 15th.

Lower Subordinate Service.

4 Computers.

During the season 1912-13, pendulum observations were made at 14 stations situated near the meridian of 78° and stretching from Bhopāl to near Bulandshahr. These observations fill in the gap between those of 1906-07 which ended at Gesupur (latitude 28° 33′) and those of 1908-09 in the northern portion of the Central Provinces.

The list of stations will be found in Table IV. With the exception of Kaliānpur all are situated on flat or undulating country. Near Bhopāl and Guna are scattered hills running up to 300 and 400 feet above the station. Kaliānpur is on the western edge of the high ground which runs up through Sīprī almost to Gwalior. This is the station of origin of the Indian triangulation, and the pendulums were swung in the room, originally built as an office by Sir G. Everest, where Captain Basevi swung his pendulums in 1867.

Thanks to the kindness of the local officials good observing rooms were available at all the stations, and the control of temperature was easily arranged. The only exception was Bīna, where the roof was of loose stone slabs, indifferently weather-proof. Table I. shows the mean temperatures at each station and the hourly changes, and it will be noticed that the mean hourly changes were remarkably constant.

TABLE I.

STATION.	NIGHT.		DAY.		MEAN.	
	Average temperature C.	Hourly change.	Average temperature C.	Hourly change.	Average temperature C.	Hourly change.
	°		°		°	
Dehra Dūn	18·81	+0·10	18·57	+0·08	18·69	+0·09
Bhopāl	19·93	+0·01	18·83	+0·21	19·38	+0·11
Kaliānpur	22·47	+0·08	21·99	+0·02	22·23	+0·05
Bīna	16·53	—0·02	15·26	+0·26	15·90	+0·12
Guna	18·79	+0·10	18·16	+0·07	18·48	+0·08
Lalitpur	17·07	+0·07	16·79	+0·12	16·93	+0·10
Sīprī	21·45	+0·06	21·19	+0·10	21·32	+0·08
Jhānsi	21·85	+0·15	21·87	+0·05	21·86	+0·10
Gwalior	19·80	+0·14	19·59	+0·09	19·70	+0·11
Dholpur	21·63	+0·17	21·83	+0·12	21·73	+0·15
Agra	19·66	+0·11	19·27	+0·10	19·47	+0·10
Muttra	20·72	+0·14	20·80	+0·12	20·76	+0·13
Hāthras	20·61	+0·14	20·36	+0·13	20·48	+0·13
Alīgarh	20·96	+0·12	20·70	+0·08	20·83	+0·10
Khurja	24·96	+0·07	24·77	+0·12	24·86	+0·09
Dehra Dūn	24·15	+0·08	24·21	+0·13	24·18	+0·11

Observations for *flexure* were as usual made at the beginning and end of work at each station, two sets being taken on each occasion. The greatest difference between the mean before and after work was $1·3 \times 10^{-7}$ seconds and the station means varied from 40 to 58. The actual values are not shown as they call for no comment.

The clock rate was determined by Mr. Hanumān Prasād. The mean p. e. of a clock rate determined from observations on two successive nights was $\pm 0·016$ seconds and the mean p. e. of the rate derived from observations to one star on two successive nights was $\pm 0·063$ seconds. These probable errors are very slightly higher than usual, but the error in time of vibration due to clock rate is under 1×10^{-7} seconds.

Table II. shows the times of vibration of the four pendulums at Dehra Dūn in November 1912 and April 1913. The mean time of vibration, 0·5072516 has been adopted for reducing the season's observations. This value agrees exactly with that used for the season 1911-12.

TABLE II.

Times of Vibration of the four pendulums at Dehra Dūn.

Date.	137	138	139	140	Mean.
1912.					
Nov. 11—12	0·5072575	0·5074984	0·5071602	0·5070867	0·5072507
12—13	2605	4985	1621	0864	2519
13—14	2586	4976	1606	0864	2508
14—15	2590	4993	1616	0883	2529
Mean .	0·5072589	0·5074985	0·5071611	0·5070869	0·5072514
1913.					
Apl. 9—10	0·5072586	0·5074978	0·5071585	0·5070863	0·5072504
10—11	2586	5020	1619	0867	2523
15—16	2593	4992	1618	0872	2519
16—17	2593	5001	1631	0892	2529
Mean .	0·5072589	0·5074998	0·5071613	0·5070875	0·5072519
General mean .	0·5072589	0·5074992	0·5071612	0·5070872	0·5072516
Difference, April—Nov. .	±0	+13	+2	+6	+5

It should be noted that these observations were made in the new pendulum room at Dehra Dūn. This room is about 300 feet due south of, and 12 feet below the old pendulum room in the large photo-heliograph building. Observations made in both rooms in April 1912 showed that there was no appreciable difference between them.

In Table III is given the mean time of vibration at each field station, with the value of g deduced therefrom. The value of g at Dehra Dūn has, as usual, been taken as 979·063 dynes.

TABLE III.

Station.	Time of Vibration.	Difference from Dehra Dūn.	Observed value of *g*.
	Sec.	Sec. $\times 10^{-7}$	Dynes.
Dehra Dūn	0·5072516	......	979·063
Bhopāl	3427	+911	978·711
Kaliānpur	3258	+742	978·777
Bīna	3209	+693	978·795
Guna	3179	+663	978·807
Lalitpur	3160	+644	978·814
Sipri	3001	+485	978·876
Jhānsi	2913	+397	978·910
Gwalior	2788	+272	978·958
Dholpur	2681	+165	978·999
Agra	2534	+18	979·056
Muttra	2492	—24	979·072
Hāthras	2484	—32	979·075
Alīgarh	2486	—30	979·075
Khurja	2·5072468	—48	979·082

TABLE IV.

SUMMARY OF RESULTS, 1912-13.

Station.	Latitude.			Longitude.			Height.	Correction for Height.	Correction for Mass (Bouguer.)	Correction for Mass (Hayford.)	$\gamma_\circ$	γ_A	γ_B	γ_C	g	$g-\gamma_A$	$g-\gamma_B$	$g-\gamma_C$
	°	′	″	°	′	″	Feet.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.
Bhopāl	23	15	58	77	25	0	1,630	−0·153	+0·055	+0·007	978·835	978·682	978·737	978·689	978·711	+0·029	−0·026	+0·022
Kaliānpur	24	7	11	77	39	17	1,763	−0·165	+0·059	+0·011	978·892	978·727	978·786	978·738	978·777	+0·050	−0·009	+0·039
Bīna	24	10	41	78	11	46	1,355	−0·127	+0·046	∓0·000	978·896	978·769	978·815	978·769	978·795	+0·026	−0·020	+0·026
Guna	24	38	48	77	19	13	1,569	−0·147	+0·053	+0·007	978·928	978·781	978·834	978·788	978·807	+0·026	−0·027	+0·019
Lalitpur	24	41	29	78	24	26	1,190	−0·112	+0·040	−0·003	978·931	978·819	978·859	978·816	978·814	−0·005	−0·045	−0·002
Sīprī	25	25	52	77	39	25	1,633	−0·144	+0·052	+0·009	978·982	978·838	978·890	978·847	978·876	+0·038	−0·014	+0·029
Jhānsi	25	27	2	78	33	43	858	−0·080	+0·029	−0·007	978·983	978·903	978·932	978·896	978·910	+0·007	−0·022	+0·014
Gwalior	26	13	57	78	12	49	658	−0·062	+0·022	−0·012	979·039	978·977	978·999	978·965	978·958	−0·019	−0·041	−0·007
Dholpur	26	42	1	77	54	47	577	−0·054	+0·019	−0·015	979·072	979·018	979·037	979·003	978·999	−0·019	−0·038	−0·004
Agra	27	10	20	78	1	7	555	−0·050	+0·018	−0·018	979·107	979·057	979·075	979·039	979·056	−0·001	−0·019	+0·017
Muttra	27	28	25	77	41	48	562	−0·053	+0·019	−0·019	979·129	979·076	979·095	979·057	979·072	−0·004	−0·023	+0·015
Hāthras	27	36	52	78	3	22	587	−0·055	+0·020	−0·020	979·139	979·084	979·104	979·064	979·075	−0·009	−0·029	+0·011
Alīgarh	27	53	32	78	0	31	612	−0·057	+0·021	−0·021	979·160	979·103	979·124	979·082	979·075	−0·028	−0·049	−0·007
Khurja	28	14	19	77	51	53	649	−0·061	+0·022	−0·024	979·186	979·125	979·147	979·101	979·082	−0·043	−0·065	−0·019

$$\gamma_\circ = 978{\cdot}030\,(1 + 0{\cdot}005302 \sin^2\phi - 0{\cdot}000007 \sin^2 2\phi)$$

The final results of the season's work are shown in Table IV. This table has been prepared on different lines this year and requires explanation. The first change to be noted is in the formula for computing γ_0, the normal value of gravity at sea-level. Previously we have used Helmert's old formula deduced in 1884, *viz.* :—

$\gamma_0 = 978 \cdot 0(1 + 0 \cdot 005310 \sin^2\phi)$, where ϕ is the latitude of the station.

When one formula has been in use for a number of years it is always a difficult matter to change, as there must be a break of continuity in the published results. However at the present time a new Professional Paper is about to be published, containing an account of the pendulum observations since 1907, the date of the last Professional Paper. In this new paper Helmert's later formula, deduced in 1901, is being used for all stations and it will, therefore, be used in this, and all our future records until and unless a better formula is introduced. Helmert's 1901 formula is:—

$\gamma_0 = 978 \cdot 030(1 + 0 \cdot 005302 \sin^2\phi - 0 \cdot 000007 \sin^2 2\phi)$.

The effect of the change of formula is to increase γ_0 at all stations by amounts varying, in India, from ·029 to ·021.

The next change of procedure is the method by which the anomalies $g - \gamma$ are obtained. Formerly the practice has been to correct g, the observed value of gravity at the station, for height and mass and to compare this corrected value, usually called g_0'', with γ_0. This practice is certainly rather confusing, as it is difficult to say what g_0'' really represents. In the new Professional Paper, therefore, the theoretical corrections for height and mass are applied to the theoretical value of gravity at sea level to obtain the theoretical value at the station, which is then compared with the observed value. The values of $g - \gamma$ are, of course, the same whichever procedure is adopted.

Considering next the actual corrections used, that for height is obtained from the formula $\frac{-2gh}{R}$ where R = radius of earth = 20,900,000 feet.

The formula for the (Bouguer) mass correction has been slightly changed in this report and in the new Professional Paper. The actual formula is $+\frac{2gh}{R} \times \frac{3\delta}{4\Delta}$ where δ = mean surface density of the earth

Δ = mean density of the earth as a whole.

Up to the present we have taken $\delta = 2 \cdot 8$, $\Delta = 5 \cdot 6$ whence $\frac{\delta}{\Delta} = \frac{1}{2}$ and the formula becomes $\frac{3gh}{4R}$. Better values of δ and Δ are, however, 2·67 and 5·576 whence $\frac{\delta}{\Delta} = \frac{1}{2 \cdot 09}$ and these values are now being used, so that the formula for the (Bouguer) mass correction is $+\frac{3gh}{4 \cdot 18R}$.

The (Hayford) mass correction was explained in last year's records and is being dealt with at length in the new Professional Paper. It is based on the assumption that all masses above sea level are of density 2·67 and are compensated by deficiencies of density below sea level, compensation being complete at a depth of 70 miles below that surface. Similarly ocean areas are compensated by excesses of density and the amount of matter in any column standing on a base of unit area and extending from the actual surface of the earth or sea down to a depth of 70 miles below sea level is always the same. Furthermore the whole surface of the earth is taken into account, curvature being amply allowed for.

We now come to the columns in Table IV γ_A, γ_B and γ_C, these suffixes being new. It was necessary to introduce new symbols to replace the g_0 and

g''_0 previously used and also to represent the Hayford, or compensation, method of correcting for mass. The new symbols are self-explanatory.

γ_A stands for γ_0 corrected on the free Air hypothesis, *i.e.*, for height only.

γ_B stands for γ_0 corrected on the Bouguer hypothesis, *i.e.*, for height and mass (Bouguer).

γ_C stands for γ_0 corrected on the Compensation hypothesis, *i.e.*, for height and mass (Hayford).

It is advisable to explain that although the Bouguer correction allows for the effect of surface masses and the Hayford correction for surface masses and their compensation, yet the difference between the two corrections does not represent the effect of compensation. The reason for this is that the Bouguer correction takes no account of the curvature of the earth and consequently the effect of surface masses beyond a certain distance from the station, usually 35 miles, but greater for stations in and near mountainous country, is (rightly on this hypothesis) assumed to be *nil*. The Hayford correction, on the other hand, makes full allowance for curvature and takes into account the surface masses and compensation of the whole earth, and it can be shown that, although the net effect of the topography and compensation in very distant zones is small, this is merely due to the fact that the two effects are almost equal in magnitude but of opposite sign; the effect of the topography alone or of the compensation alone is large.

For example the Hayford correction for all zones extending from about 1,800 miles from the station to the antipodes varies in India from 0·0013 to 0·0022 but the correction for topography alone in these zones varies from 0·094 to 0·117 at the four stations for which the correction has been computed.

The difference between the two mass corrections is, therefore, due to the effect of the compensation of the topography of the whole earth together with the effect of the topography beyond the "certain distance from the station" given above.

The rest of Table IV requires no explanation except that the column headed g gives the observed value of gravity at the station, assuming that at Dehra Dūn the value is 979·063 dynes.

Dealing now with the residuals in the last three columns of the table, we note first that the Bouguer residuals $g-\gamma_B$ are negative throughout. This is no way unusual for, as will be seen in the new Professional Paper, these residuals are negative at practically every station at which observations have so far been made. The reason of this preponderance of negative values is probably this. The values of $g-\gamma$ on the Bouguer hypothesis have a well-known tendency to be positive at stations near the coast and negative in and near high ground. The fundamental formula for γ_0, which has been deduced from a consideration of the Bouguer residuals, has, it is believed, been derived mainly from observations at stations on or near the coast and distant from high ground. Consequently at other stations, such as are dealt with this season, the residuals have a natural tendency to be negative. It is probable that if a new formula for γ_0 were to be derived from Bouguer residuals at all Indian stations the value of the equatorial constant would be about 977·98 instead of 978·03.

However we are really concerned with the relative and not the absolute values of $g-\gamma_B$. The mean residual for the season is 0·031 and if we consider this value indicating normal gravity we see that there are three areas where gravity is relatively in excess. The first of these comprises the stations Bhopāl to Guna, with a maximum at Kaliānpur, and the results show that this area probably forms part of the belt of high density or "hidden chain."

In 1908-09 observations were made at five stations south of Bhopāl on the meridian of 78° and the residuals at these, varying from —0·013 to —0·026, show that gravity was relatively in excess at all. The belt of high density, therefore, probably extends from south of Amraotī, the most southerly of the five stations referred to above, to Guna and possibly on to Sīprī and Jhānsi.

The residual at Lalitpur, however, shows a local defect in gravity, and as the plumb line deflections have confirmed the evidence of the pendulums by indicating this defect and also the relative excess at Jhānsi and Sīprī, and have also suggested a defect between the latter and Guna, it seems probable that if pendulum observations could have been made between Sīprī and Guna a relative defect would have been found. The main area of excessive gravity, therefore, probably ends just north of the line from Guna to Bīna, and seeing that it extends at least as far south as Amraotī we have, after allowing for the topography, an excess of matter to the south of Kaliānpur which lends strong support to the assumption that the deflection at this, the station of origin of the Indian triangulation, is southerly.

It is also to be noted that in the first seven stations of the Table, omitting Bhopāl, we have three pairs, each station in a pair being nearly on the same latitude as the other. Considering the residuals we see that in each case gravity at the western station is relatively greater than at the eastern. Thus Kaliānpur is greater than Bīna by 0·011, Guna than Lalitpur by 0·018, and Sīprī than Jhānsi by 0·008. This if not a coincidence, seems to show that there is a relative deficiency of mass east of Kaliānpur and that the prime vertical deflection there is probably westerly or positive. We cannot, however, be certain of this until observations have been made to the west of Kaliānpur.

The third area where gravity is relatively in excess is that included by the stations Agra to Hāthras and here again the pendulum agrees with the plumb-line. North of Hāthras there is a rapid drop to Khurja, with an equally rapid rise to Gesupur (latitude 28° 33′, observed at in 1907), where the value of $g-\gamma_B$ is —0·043. Once again we have other evidence of this trough of low density in the deflections at four stations on the Great arc. These stations are :—

STATION.	Latitude.		Longitude.		Deflection.
	°	′	°	′	″
Noh	27	51	77	41	0·1 south.
Chandaos	28	5	77	54	0·9 north.
Bostān	28	31	77	33	5·4 ,,
Datairi	28	44	77	41	5·8 ,,

Bostān is close to Gesupur and Chandaos about 9 miles south of Khurja. Between the two stations there is a change in deflection of 4½ seconds, the plumblines being deflected away from each other, showing that there is probably either an excess of mass north of Bostān or south of Chandaos or a defect of mass between them. If there were an excess of mass we should expect to find either a smaller northerly deflection north of Bostān or a greater northerly deflection south of Chandaos but as we find neither of these the assumption of a defect between the two stations is the only one that suits the deflections. It may also be noted that the southerly deflection at Noh, some 12 miles north of Muttra, indicates the probability of an excess of mass to the south and this the pendulums have now shown.

We see therefore that the main features of the season's results are in agreement with the evidence of the plumb line, and the chart facing this page will make this clear.

Turning now to the values of $g-\gamma_c$ *i.e.*, the amounts by which gravity is in excess or defect on the assumption that all surface masses are compensated below sea level, we note first that the positive sign predominates. This is generally the case with these residuals and may merely mean that our formula for γ_0 may have to be slightly altered. The differences from station to station are, however, much the same as those of the Bouguer residuals, though it is, as usual, noticeable that at stations in and near high ground the change in residual is greater. Thus at the first six stations, all of which are over 1,100 feet, the increase varies from 0·043 to 0·048; at the next four from 0·034 to 0·036, and at the remaining stations there is a progressive increase from 0·038 to 0·046, this being due to the greater proximity of the Himālaya.

The total range of the residuals is nearly the same in both cases, *viz.*, 0·046 for the Bouguer and 0·048 for the Hayford.

In the observations of this season, therefore, no improvement has been effected by the assumption of complete compensation. As has often been pointed out large changes in the residuals are only to be expected near large excesses or defects of mass, *i.e.*, near mountains or seas and at such stations the change in the residuals is always in the right direction, since near mountains Bouguer residuals are negative and near seas positive.

In last year's report several instances were given of this improvement, but as the values of γ_0 and of the height and mass corrections at all stations have been recomputed this year it is well to show the results again and to include the new stations at which the corrections have been computed.

Dealing first with stations in the Himālaya or other mountains we have :—

Station	Height.	$g-\gamma_B$	$g-\gamma_C$	Change.
Sandakphū	11,766	−0·155	+·048	+·203
Mussoorie	6,924	−0·123	+·053	+·176
Quetta	5,520	−0·153	+·007	+·160
Ootacamund	7,395	−0·046	+·019	+·065
Yercaud	4,493	−0·057	−·033	+·024

The changes are very great at all the stations except Yercaud and this can hardly be called a mountain station since the hill on which it stands is not of any great extent. The residuals have, however, been improved in every case and the positive sign of the Hayford residuals shows that probably compensation is not quite complete, more especially under the Himālaya.

CHART

OF

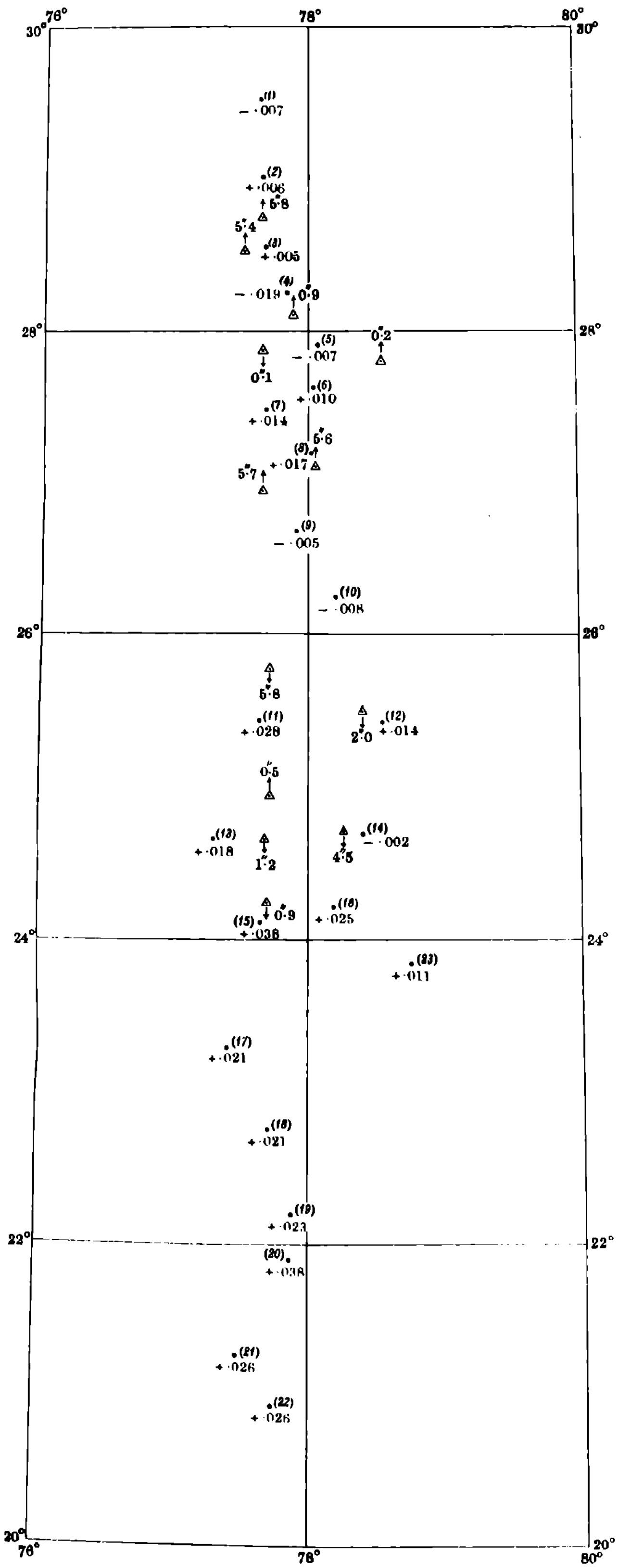
PENDULUM STATIONS

NEAR THE MERIDIAN OF 78°

WITH THE VALUES OF

$g - \gamma_c$

Scale 1 Inch = 76.8 Miles.



Pendulum Station .... •

Latitude Station with deflection in seconds ..... △ 5″·8

REFERENCES

(1) Kaliāna
(2) Meerut
(3) Gesupur
(4) Khurja
(5) Aligarh
(6) Hathras
(7) Muttra
(8) Agra
(9) Dholpur
(10) Gwalior
(11) Sipri
(12) Jhānsi
(13) Goona
(14) Lalitpur
(15) Kalianpur
(16) Bina
(17) Bhopāl
(18) Hoshangabad
(19) Shahpur
(20) Badnur
(21) Ellichpur
(22) Amraoti
(23) Saugor

We next come to stations near the foot of the Himālaya and other mountains.

Station.	Distance from edge of hills in miles.	$g-\gamma_B$	$g-\gamma_C$	Change.
Rājpur	0	−0·143	+0·026	+0·169
Dehra Dūn	7	−0·145	+0·006	+0·151
Kaliāna	60	−0·081	−0·007	+0·974
Silīgurī	8	−0·160	−0·039	+0·121
Jalpaigurī	28	−0·121	−0·020	+0·101
Sibi	12	−0·139	−0·060	+0·079
Jacobābād	40	+0·008	+0·038	+0·030
Pathānkot	12	−0·199	−0·077	+0·122

It will be noticed that the change increases as the hills are approached and that the residuals are reduced in every case except Jacobābād.

The majority of the residuals are negative, although at hill stations they are usually positive. This seems to show that the compensation or partial compensation of the mountains extends beyond them into the plains and we have in these results evidence of the rift, or belt of deficient density, along the foot of the mountains.

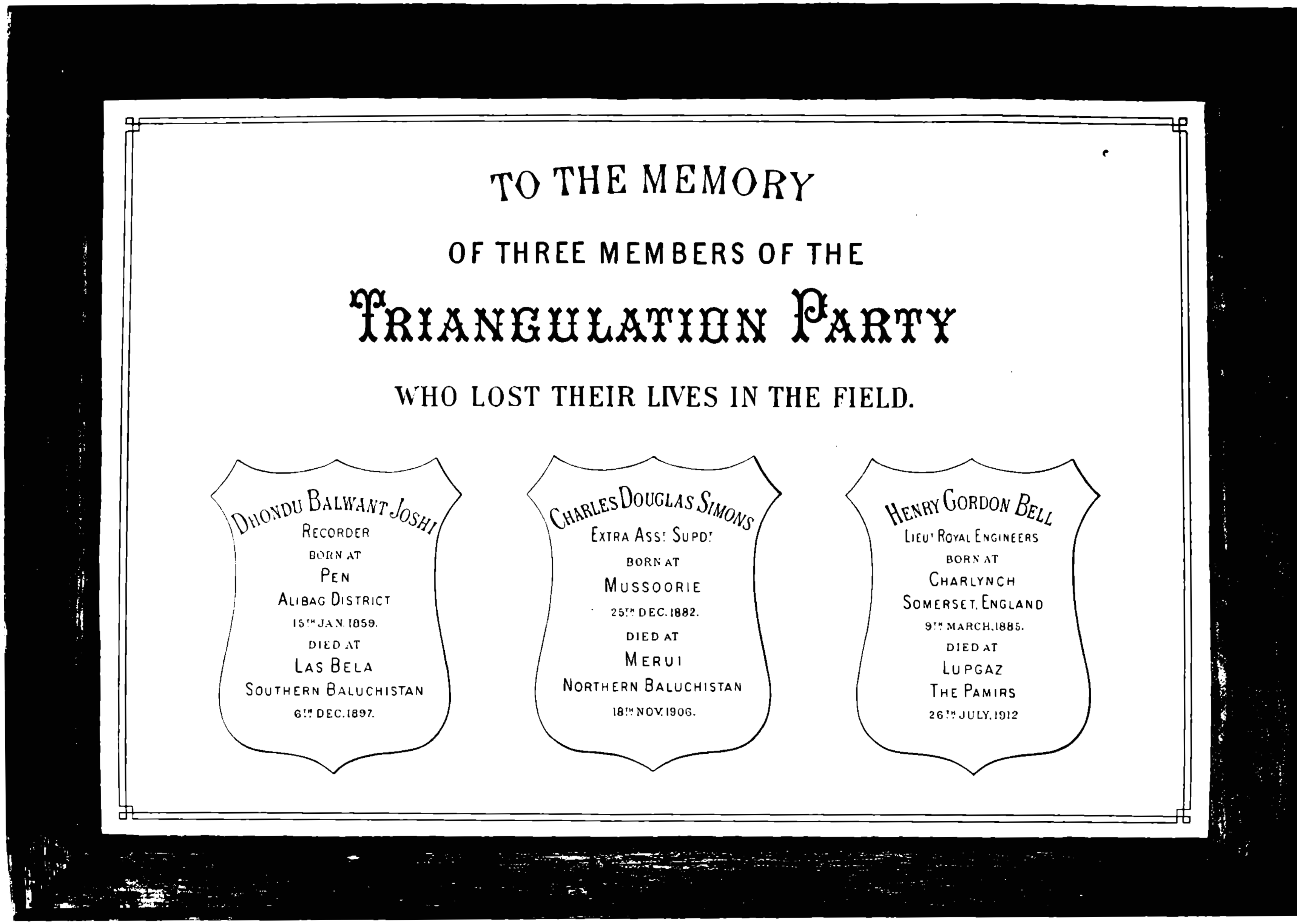
It was stated above that at stations near mountains and seas the change in residual due to the assumption of compensation was always in the right direction and we have seen that for mountain stations this is so. With regard to coast stations we have at present only computed the Hayford residuals at two, Madras and Cuttack. Madras, however, seems to be abnormal in that the Bouguer residual there is negative and the assumption of compensation has increased the residual. The figures are :—

Station.	$g-\gamma_B$	$g-\gamma_C$	Change.
Madras	−0·014	−0·053	−0·039
Cuttack	+0·003	+0·006	+0·003

We see that the residuals are either decreased or increased very slightly and as, at the few other coast stations at which observations have been made, the Bouguer residuals are positive they will be improved by the new method of reduction.

During the next field season it is proposed to observe at several stations on the Bombay coast and the results to be obtained should throw some light on the question of ocean compensation.

An interesting series of observations was made in Dehra Dūn in August 1913. Commander Alessio and Signor Abetti, two members of Dr. de Filippi's expedition to the Karakoram, swung their eight pendulums alongside ours, the observations being extended over a period of four days. No night swings were taken, but it is satisfactory to note that the mean time of vibration of our four pendulums agreed with the mean of the day swings in April 1913 and November 1912, showing that the periodic variation in the clock rate was the same on all three occasions. The results from the Italian pendulums will not be available for more than a year, until the expedition has returned to Genoa, but they will give an independent value of gravity at Dehra Dūn depending, through Genoa, on Potsdam. It is not likely that our present value, 979·063 dynes, is much in error and additional proof of this has lately become available in the publication of the observations made in 1906 by Commander Alessio in Colāba, using the same room as that occupied by Major Lenox-Conyngham in 1904. The difference in the value of *g* obtained by the two observers is only 0·004, both values being based on Potsdam, ours through Dehra Dūn and Kew and theirs through Genoa. This fresh determination of the actual value at Dehra Dūn should, however, be most valuable.


TO THE MEMORY
OF THREE MEMBERS OF THE
TRIANGULATION PARTY
WHO LOST THEIR LIVES IN THE FIELD.
DHONDU BALWANT JOSHI
RECORDER
BORN AT
PEN
ALIBAG DISTRICT
15TH JAN. 1859.
DIED AT
LAS BELA
SOUTHERN BALUCHISTAN
6TH DEC. 1897.
CHARLES DOUGLAS SIMONS
EXTRA ASST SUPDT
BORN AT
MUSSOORIE
25TH DEC. 1882.
DIED AT
MERUI
NORTHERN BALUCHISTAN
18TH NOV. 1906.
HENRY GORDON BELL
LIEUT ROYAL ENGINEERS
BORN AT
CHARLYNCH
SOMERSET, ENGLAND
9TH MARCH, 1885.
DIED AT
LUPGAZ
THE PAMIRS
26TH JULY, 1912

TRIANGULATION.

No. 15 PARTY.

(*Vide* Index Maps 9 and 10.)

BY MAJOR H. M. COWIE, R.E.

PERSONNEL.

Major H. M. Cowie, R.E., Deputy Superintendent, in charge.

Lieutenant K. Mason, R.E., Assistant Superintendent, from 16th February 1913.

Provincial Service.

Mr. C. H. Tresham.
" V. D. B. Collins.
" V. P. Wainright.
" G. A. Norman.
" B. T. Wyatt.
" C. S. McInnes.
" Abdul Karim.
" N. S. Harihara Iyer.

Upper Subordinate Service.

Mr. Jugal Behari Lall.

Lower Subordinate Service.

21 Computers, etc.

During the cold weather of 1912-13, four detachments of this party were employed, one on principal triangulation, two on secondary triangulation, and one on trigonometrical operations for the large scale survey of Bombay City and Island.

During the summer months, one detachment, under, first, Lieutenant H. G. Bell, R.E., and later Mr. V. D. B. Collins, was engaged in continuing the series of triangulation in the Hunza Valley and the Tāghdumbāsh Pāmir, connecting the Indian and Russian systems of triangulation. A report of this detachment's work during 1912 was included in the Annual Report of the party for 1911-12. The report now submitted for 1912-13 continues the account of the Pāmir operations up to the date of the completion of the Indo-Russian connection in August 1913.

The principal detachment under Mr. C. A. Tresham continued the Sambalpur Meridional Series. This Series, commenced in 1911-12, springs from the side Bhursu (XLIX)—Harihārpur (L) of the Calcutta Longitudinal Series in a mean Longitude of 85°, near Rānchī, and extends first south-west till it lies astride the meridian of 84° and then south-wards with a view to eventually joining the South-East Coast Series near Parlākimedi. During 1911-12, the series was carried as far as Latitude 22°, from which parallel the operations of 1912-13 have extended the triangulation to a mean latitude of 19°-40′, leaving only three figures still to be observed before the connection with the East Coast Series is effected.

Of the secondary detachments, one under Mr. G. A. Norman first completed the junction of the Gāro Hills Series, extending eastwards in Latitude 26° approximately from the Brahmaputra Series, with the Khāsi Hills Series which stretches westwards at nearly the same latitude from the Eastern Frontier Series. After finishing observations here, the detachment made a commencement on the Manipur Series which is to connect the Assam Valley Series in the neighbourhood of Golāghāt with the northern end of the Manipur Meridional Series, a little to the east of Manipur.

The other secondary detachment under Mr. V. D. B. Collins carried the Khandwā Series in Latitude 22°, from the Great Arc to the Khanpisura Series, and after completing this work, commenced selecting and building stations for the Akola Series, which, running along the meridian of 76°-30′, is to connect the Khandwā and Bhīr Series.

The 4th detachment furnished by the party completed the triangulation extending over the Island of the Bombay and commenced work on the traverse network, which in combination with the triangulation, will provide accurately fixed points on which to base the large scale survey about to be undertaken. By the end of the field season the positions of 94 points had been determined in the southern and central positions of the island, leaving 24 in the northern part to be fixed during the coming season.

In all districts where detachments of the party worked, the operations were much facilitated by the ready and effective assistance given them by local officials.

The health of the personnel of the party as a whole was good. In the Sambalpur and Manipur detachments there were, from time to time, several cases of fever, but no outbreaks of sickness or disease occurred to impede the progress of the operations.

PRINCIPAL TRIANGULATION.

The Sambalpur Series.—At the end of October, Mr. Tresham resumed work on this series at about Latitude 22°, where observations had been discontinued the previous year, and carried the triangulation southwards through Sambalpur, the Orissa Feudatory States, the Khondmāls and into Ganjām. Between 31st October and 9th March, observations were completed at seventeen stations, astronomical azimuths being determined at two points, Andhari H. S. and Sendur H. S. After the beginning of March, the atmospheric conditions became very unfavourable for the making of precise observations. A thick haze set in, which in combination with the smoke of forest fires, effectually put a stop to the operations after March 25th.

The selection of sites and the building of stations was entrusted to Mr. B. T. Wyatt, Extra Assistant Superintendent, who succeeded in laying out all the stations south of Chirguni Hill Station and Singhijuba Hill Station and in effecting a connection with the East Coast Series.

The country passed through by the series was inhospitable and ill-adapted for triangulation. Rounded hills covered with thick forest, and the absence of communications, made the triangulator's work of no small difficulty, and it is most satisfactory that so much progress was achieved during the season. The quality of the observations themselves proved, as will be seen in the following statement, to be high.

Number of principal stations at which observations were completed	17
Number of secondary stations fixed	4
Number of principal stations built and repaired	17
Number of secondary stations built	1
Progress of series in miles	167
Area covered by figures in square miles	5,014
Number of angles observed	62
Average number of measures of each angle	58
Average triangular error of 22 triangles	0″·185
Maximum triangular error	0″·564
Average difference from 360° of angles at 3 central stations	0″·133
Average errors of observation	0″·37
" " " graduation	1″·68
Value of (Astronomical Azimuth—Geodetic Azimuth)	
at Andhari H. S., Lat. 21°-58′, Long. 84°-15′	6″·07
at Sendur H. S., Lat. 20°-16′, Long. 83°-40′	8″·18
Theodolite used	T. and S. 12-inch Micrometer No. 5.

This series effected during the season a connection with the Sambalpur Secondary Series which emanates from the East Coast Series in latitude 21°-15′ and extends westwards. The closing differences at the common stations were:—

at Chandlī h. s. in	latitude	. . . .	$+0''\cdot01$
" " " "	longitude	. . . .	$-0''\cdot04$
" " " "	height	. . . .	—11 feet.
" Raun " "	latitude	. . . .	$+0''\cdot02$
" " " "	longitude	. . . .	$-0''\cdot02$
" " " "	height	. . . .	−10 feet.

Secondary Triangulation.

The Manipur Series and the Gāro-Khāsi Hills Series.—During the field season of 1897-98, a portion of the Eastern Frontier Principal Series was revised for the purpose of ascertaining whether trigonometrical stations in the Gāro and Khāsi Hills had been displaced either vertically or horizontally by the earthquake of June 1897. As there was no certainty that any appreciable changes had taken place, the operations were mainly of the nature of a reconnaissance made with a view to ascertaining the desirability of undertaking, later on, accurate observations which would provide data for the actual measurement of the movements of the earth' crust due to the earthquake.

This revisionary triangulation was based on a side of the principal series about 25 miles south of Shillong. The position of 22 and the heights of 25 old stations were determined, embracing an area of 1,020 square miles. The results of the operations gave indications of only relative changes, for all the stations introduced into the scheme were found to lie within the disturbed region. The reconnaissance triangulation showed that large relative displacements had taken place and established the desirability of undertaking a rigorous revision of the principal triangulation. No opportunity however presented itself for the carrying out of the necessary observations with a large instrument; so that when the need arose for triangulation for topographical purposes in the region concerned, it was decided to run a good secondary series from the Brahmaputra principal series, assuming this latter to have been unaffected, through the Gāro and Khāsi Hills, to close on the disturbed points of the Eastern Frontier Series. Besides providing topographical data, the Gāro-Khāsi Hills Secondary Series would give further information as to the displacements.

The secondary observations were commenced and completed except at four points during the field season of 1910-11. During the year under report these four points were visited by Mr. Norman and the necessary observations completed. The secondary series now emanates from the stations of Rangir H. S. of the Brahmaputra Meridional Series and Sāmding H. S. of the Assam Longitudinal Series and closes on Landau Modo H. S. and Mautherrichan H. S. of the Eastern Frontier Series. The results of the secondary work show a displacement of Landau Modo H. S. by 7 feet to the south and 7 feet to the east combined with an elevation of the station by 8 feet. Mautherrichan H. S. appears to have been moved 13 feet to the south, 7 feet to the east and to have been raised 21 feet.

After completion of observations on the Gāro-Khāsi Hills Series, Mr. Norman transferred his detachment to Golāghāt to commence work on a secondary series to connect the Assam Valley Principal with the Manipur Meridional Series.

With the exception of one station, the whole of this connecting triangulation was reconnoitred and laid out, but owing to the thick haze which formed over the hills early in April, the observations could not be completed.

On the Gāro-Khāsi Hills triangulation an 8-inch micrometer theodolite was used and on the Manipur work 12-inch micrometer theodolite No. IV.

The Khandwā Series.—Early in November 1912, a detachment was formed under Mr. V. D. B. Collins, Extra Assistant Superintendent, to execute a secondary series along the parallel of 20° between the Khanpisura Series on the west and the Great Arc on the east. The series, one of twenty-four single triangles, was completed on March 3rd, 1913. After this, Mr. Collins commenced building stations for the Akola Secondary Series which is to run along the meridian of 76°-30′E., between the Khandwā and Bhīr Secondary Series.

The following summary gives the main feature of the Khandwā secondary operations:—

Number of principal stations visited and repaired	4
" new secondary stations fixed	20
" triangles	24
Length of series	141 miles.
Area covered by series	1,750 sq. miles.
Average triangular error	1″·41
Maximum " "	3″·78
Closing errors in latitude	0″·46
" " in longitude	0″·24
" " in azimuth	2″·42
Closing errors in height	1·9 feet.
Theodolite used	8-inch micrometer.

BOMBAY CITY TRIANGULATION AND TRAVERSE OPERATIONS.

During the year under report a detachment under Mr. Wainright continued the work of establishing over the island of Bombay a framework to serve as a basis for a large scale survey. The main figure of this framework, a pentagon covering the whole of the island and harbour, is based on the side Karanja H. S.—Colāba of the Bombay Secondary Triangulation, an extension from the Bombay Longitudinal Series. From this pentagon emanate minor triangles fixing 60 points and between these latter about 35 miles of precise traverse were run, determining the positions of 25 permanent and 18 semi-permanent marks. For both the triangulation and the traverse operations 8-inch micrometer theodolites were used, readings being taken on five zeros. As the opaque signals used in the previous season had not proved very satisfactory, heliotropes, suitably stopped down, were made use of in the triangulation.

In addition to the network executed for the large scale survey, two figures were extended southwards from the pentagon to fix the position of the transit pillar in the Alībāg Observatory.

In the traverse operations, the degree of precision that was aimed at and certain local conditions required the devising of special apparatus and the employment of more rigorous methods than are normal in traverse work.

The permanent marks were placed on brass plugs built into masonry one foot below the level of the ground. On account of the small dimensions of the little pit in which the mark was thus situated, it was impossible to adjust a theodolite or a signal over it by means of a plummet, as the point of the latter, when hanging in the pit, was obscured by the shoulders. Recourse was therefore made to a special device for the centring of instruments and signals which had been designed previously by Mr. J. de Graaff Hunter, M.A.

This apparatus consisted essentially of a steel rod, pointed at one end and carrying, at the other, a mark or a sightvane, both point and mark or sightvane being placed in the axis of the rod, to which a spirit level was attached. The point of the rod was so fashioned as to centre itself automatically in the "dot" of the mark when the rod was raised into a vertical position. The mounting of the rod was such as to permit of the latter being securely clamped when the spirit level indicated that it had been brought into the true vertical. At the observing stations a rod with a mark was used, the theodolite being centred over the latter, and at the forward and back stations, rods provided with sightvanes were adjusted. The steel rods were provided also with a small device which indicated the points to which the tape measurements should be referred.

As has been said, the angular measures were made with an 8-inch micrometer theodolite, readings being taken on five zeros.

The linear measurements were made with a 100 feet steel tape. Every day this tape was compared with a standard of length laid down between two brass plates let into the floor of one of the verandahs of the Secretariat building.

During the season, an invar tape of certified length being available, the length of the standard was carefully determined.

The difference between the highest and lowest values of the length of the steel tape during the $2\frac{1}{2}$ months of its use was 0·007 foot.

During the linear measurements, the temperature of the tape, as indicated by a thermometer placed in contact therewith and shielded from the sun, was recorded at intervals, and afterwards corrections for temperature were applied when computing the linear distances measured.

The highest and lowest temperatures recorded were 101° and 69° F. When in use, the tapes were always strained by weights suspended over pulleys so arranged that, while under strain, the tape could be easily brought into the correct alignment. The ends of the successive tape lengths were marked by reference marks which were aligned truly by theodolite.

All the apparatus was found to work satisfactorily, and experience showed that alteration was desirable in one or two respects only, making for lightness and greater portability.

The adjustment of the traverse net has shown that precision of the work varied a good deal. Where the measurements could proceed expeditiously and uninterruptedly, the accidental errors appear to have been small, while in the case of lines which traversed difficult or traffic congested roads, they are considerably larger. The precision of the lines of the net adjusted to triangulated points varies from $\frac{1}{2,000}$ to $\frac{1}{60,000}$, while $\frac{1}{12,000}$ may be taken as generally representing the accidental error generated in lines.

Indo-Russian Triangulation Connection.

During 1912, the whole course to be followed by the series connecting the Indian and Russian systems of triangulation, by way of the Hunza Valley and the Tāghdumbāsh Pāmir, had been reconnoitred, and, except for a distance of some 30 miles, the stations had all been selected and built. Observations, however, had been completed at only a few stations at each end of the series.

During last summer, the operations were continued and brought to a satisfactory conclusion. The completed connection is some 180 miles in length from principal stations just south of Gilgit to the Russian points on the northern edge of the Tāghdumbāsh Pāmir. It consists of thirty-three essential and three extra stations embracing twenty-one figures. The maximum altitude at which stations are situated is about 19,000 feet.

The observations were taken with 6-inch micrometer theodolites, the signals being luminous except in only a few instances when circumstances necessitated the use of an opaque one. Each horizontal angle was measured on six zeros. Owing to the circumstances under which the observations had to be made, no uniformity was possible as regards the time of determining vertical angles. Readings had perforce to be taken when the observers had succeeded in attaining the summit on which the station to be occupied was located and whenever the signals to be observed were visible.

In point of nature of country to be traversed, the series may be divided into two sections, the one comprising the figures extending along the Hunza Valley from Gilgit towards the Kilik Pass, the second those carrying the triangulation across the Tāghdumbāsh Pāmir to the Russian points near the Beyik Pass. In the former, the work was extremely arduous, especially in the 30 miles south of the Kilik Pass, the altitude, coupled with precipitous slopes, snow and inclement weather putting a very severe strain on the powers of endurance of all employed on the work. In the Pāmir Section the difficulties were to some extent reduced by the more easily negotiated hills, though here also the weather proved very trying. When, in addition to adverse conditions of this nature, the ever present anxiety as to the sufficiency of food supplies and the sense of always working against time be remembered, it will be recognised that the extension of reliable triangulation through the mountain mass between Kashmīr and the Pāmir is no insignificant achievement.

The operations during 1913 were entrusted to Lieutenant K. Mason, R.E., in charge of the detachment, and Messrs. V. D. B. Collins and C. S. McInnes, Extra Assistant Superintendents. Arriving on 27th May at Bandipura, the detachment proceeded in two sections to Gilgit *viâ* the Rāj Diāngan and Burzil Passes. A depot was formed at Gilgit and there the detachment was divided into three squads. One of them under Lieutenant Mason marched up the Hunza Valley and over the Mintaka Pass to the Russian stations over the northern edge of the Tāghdumbāsh Pāmir. Commencing the work of observation at these points, the section gradually retraced its steps to the Kilik Pass to connect with the figures laid out from the neighbourhood of Misgar to the Kilik Pass by the second squad under Mr. McInnes.

In the meantime the third squad under Mr. Collins had taken up the extension of the observations from near Hunza, where they had been discontinued in the previous year to Misgar.

By the 25th August, all the observations were completed and a connection effected, through the Hunza Valley Series and the Kashmīr Principal Series, between the points of the Russian Survey on the Pāmir and the triangulation of the G. T. Survey.

This year Captain H. G. W. Hingston, I.M.S., was attached to the detachment. This officer made, in addition to hæmatological investigations, what should prove valuable collections of the fauna and flora of the region besides compiling notes on the geology and obtaining rock specimens. The detachment also took observations to indicate what movement had taken place in the snouts of the Minapin and Hasanābād glaciers, the position of which in 1906 had been marked by Mr. H. H. Hayden of the Geological Survey.

Cloud and weather observations were also made daily.

TIDAL OPERATIONS.

No. 16 PARTY.

(*Vide* Index Map 10.)

BY MR. SYED AULAD HOSSEIN, K.B.

PERSONNEL.

Provincial officers.

Mr. H. G. Shaw, in charge till 28th February 1913.
Mr. Syed Aulad Hossein, K.B., in charge from 1st March 1913.
Mr. Syed Zille Hasnain.

Lower Subordinate Service.

1 Clerk.
15 computers.
2 Tidal Observatory clerks.
2 Artificers.

During the year under report, tidal registrations by self-registering tide-gauges were carried out under the direction of this department, at the ports of Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

The immediate control of all the tidal observatories was entrusted to the Port Officers concerned.

It was mentioned in last year's report that tidal diagrams, recorded by a small self-registering river-gauge at Chittagong, were supplied to this party by the Port Officer for the purpose of checking the predicted times and heights of high and low water at Chittagong, but that the readings obtained from those diagrams failed to answer the above purpose. Since then certain improvements have been introduced in the working of the tide-gauge and the preparation of the diagrams, and consequently, the results obtained from the diagrams for the year 1912 have been found sufficiently good to be used as a check on the predictions for Chittagong.

In addition, tide-pole readings of high and low water were taken during day-light at the ports of Bhaunagar and Akyab, with the object of comparing the actual times and heights with the predictions. This work was done under the direct supervision of the port officers who supplied to this party monthly statements of the times and heights read on the tide-poles at their respective ports.

LIST OF TIDAL STATIONS.

The following is a complete list of the ports at which tidal observations have been carried out from the commencement of the tidal operations in 1874 up to the present time. The permanent stations are shown in italics; the others are minor stations which were closed on the completion of the requisite registrations.

Serial No.	Stations.	Automatic or Personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
1	Suez	Automatic	1897	1903	7	
2	Perim	Ditto	1898	1902	5	
3	*Aden*	Ditto	1879	Still working	34	
4	Maskat	Ditto	1893	1898	5	
5	Bushire	Ditto	1892	1901	8	
6	*Karāchi*	Ditto	1868 1881	1880 Still working	*13 33 } 46	* Small tide-gauge working.
7	Hanstal	Ditto	1874	1875	1	Tide-tables not published.

Serial No.	Stations.	Automatic or Personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
8	Navānar . .	Automatic	1874	1875	1	Tide-tables not published.
9	Okha Point . .	Ditto	1874 Re-started 1904	1875 1906	1 } 2 1 }	Year 1904-05 is excluded.
10	Porbandar . .	Personal	1893	1894	2	
10A	Porbandar . .	Automatic	1898	1902	2	Years 1898, 1899 and 1902 are excluded.
11	Port Albert Victor (Kāthiāwār).	Personal	1881	1882	1	
11A	Port Albert Victor (Kāthiāwār).	Automatic	1900	1903	4	
12	Bhaunagar . .	Ditto	1889	1894	5	
13	*Bombay (Apollo Bandar).*	Ditto	1878	Still working	35	
14	*Bombay (Prince's Dock).*	Ditto	1888	Ditto	25	
15	Marmagao (Goa) .	Ditto	1884	1889	5	
16	Kārwār . . .	Ditto	1878	1883	5	
17	Beypore . .	Ditto	1878	1884	6	
18	Cochin . . .	Ditto	1886	1892	6	
19	Tuticorin . .	Ditto	1888	1893	5	
20	Minicoy . .	Ditto	1891	1896	5	
21	Galle . . .	Ditto	1884	1890	6	
22	Colombo . .	Ditto	1884	1890	6	
23	Trincomalee . .	Ditto	1890	1896	6	
24	Pāmban Pass . .	Ditto	1878	1882	4	
25	Negapatam . .	Ditto	1881	1888	5	Years 1883 to 1885 are excluded.
26	*Madras* . . .	Ditto	1880 Re-started 1895	1890 Still working	10 } 28 18 }	
27	Cocanāda . .	Ditto	1886	1891	5	
28	Vizagapatam . .	Ditto	1879	1885	6	
29	False Point . .	Ditto	1881	1885	4	
30	Dublat (Sāgar Island)	Ditto	1881	1886	5	
31	Diamond Harbour .	Ditto	1881	1886	5	
32	*Kidderpore* . .	Ditto	1881	Still working	32	
33	Chittagong . .	Ditto	1886	1891	5	
34	Akyab . . .	Ditto	1887	1892	5	
35	Diamond Island .	Ditto	1895	1899	5	
36	Bassein (Burma) .	Ditto	1902	1903	2	
37	Elephant Point .	Ditto	1880 Re-started 1884	1881 1888	} 5	Year 1880-81 is excluded.
38	*Rangoon* . .	Ditto	1880	Still working	33	
39	Amherst . .	Ditto	1880	1886	6	
40	*Moulmein* . .	Ditto	1880 Re-started 1909	1886 Still working	6 } 10 4 }	
41	Mergui . . .	Ditto	1889	1894	5	
42	*Port Blair* . .	Ditto	1880	Still working	33	

WORKING OF THE OBSERVATORIES.

The tidal observatories at Port Blair, Rangoon, Moulmein and Madras were inspected during the year by Mr. H. G. Shaw and those at Kidderpore, Apollo Bandar (Bombay), Prince's Dock (Bombay), Karāchi and Aden by Mr. Syed Zille Hasnain. During the inspection of each observatory the working zero and the adjustments of the tide-gauge were subjected to a rigorous examination and the stability of the gauge was tested by check levelling between its bed-plate and the bench-mark of reference. All the instruments were thoroughly overhauled, cleaned and put in perfect working order.

With the exception of Madras, the registrations of the tides at all the other tidal observatories have, on the whole, been satisfactory during the past year.

The following need special mention :—

Aden.—The inspecting officer found that nearly 4 inches of mud had accumulated inside the float cylinder. The mud was taken out and all precautions were taken to maintain free communication between the sea and the cylinder.

Prince's Dock (Bombay).—The tidal registrations at this observatory have been frequently interrupted during the year under report, the chief cause being the breakage of the wire to which the recording pencil is attached. The interruptions did not, however, extend beyond a few hours at a time, the longest interruption being of 43 hours duration.

Madras.—The tide-gauge at this observatory worked uninterruptedly up to the end of July 1913. There was a break for a week in the tidal registrations early in August, due to the passage between the sea and the tide-gauge well being blocked with sand. The passage was cleared and the communication between the sea and the well was restored, but shortly afterwards the passage was blocked again and the working of the tide-gauge was completely stopped from the forenoon of 10th August 1913. The Chief Engineer of the Port reported that it was practically impossible to restore communication between the sea and the tide-gauge well. It was, therefore, decided to abandon the present observatory and to remove the tide-gauge to another place. With the consent and consultation of the officer in charge of the Tidal Party, the Chief Engineer has selected a site near the new entrance to the harbour for a new observatory which is now in course of erection. As soon as it is ready, arrangements will be made to install the tide-gauge in it and re-start observations.

COMPUTATIONS AND REDUCTION OF OBSERVATIONS.

All the computations pertaining to the past year's work have been completed and there are no arrears. The tidal observations at the nine working stations for the year 1912 have been reduced by harmonic analysis, and the values for the tidal constants thus determined are shown in the attached tables.

These tables give the amplitudes (R) and the epochs (ζ) at the various stations; they also give the values of H. and K. which are connected with R. and ζ. in such a way, through the various astronomical quantities involved in the position of the sun and the moon, that if the tidal observations were consistent from year to year, H. and K. would come out the same from each year's reductions.

ADEN, 1912.

Short Period Tides.

A_0 = 5·873 feet.

S_1	H = R =	·110	M_6	R =	·006	Q_1	R =	·188	T_2	R =	·053
	κ = ζ =	174°·14		ζ =	138°·09		ζ =	99°·00		ζ =	207°·26
S_2	H = R =	·673		H =	·007		H =	·160		H =	·053
	κ = ζ =	245°·58		κ =	8°·49		κ =	31°·04		κ =	209°·03
S_4	H = R =	·004	M_8	R =	·003	L_2	R =	·036	$(MS)_4$	R =	·017
	κ = ζ =	196°·99		ζ =	253°·50		ζ =	352°·21		ζ =	58°·62
S_6	H = R =	·004		H =	·004		H =	·032		H =	·018
	κ = ζ =	230°·19		κ =	200°·70		κ =	223°·06		κ =	130°·42
S_P	H = R =	·001	O_1	R =	·787	N_2	R =	·428	$(2SM)_2$	R =	·028
	κ = ζ =	215°·54		ζ =	147°·92		ζ =	102°·03		ζ =	183°·09
				H =	·669		H =	·443		H =	·029
				κ =	38°·29		κ =	220°·49		κ =	106°·29
M_1	R =	·097	K_1	R =	1·458	λ_2	R =	...	$2N_2$	R =	·103
	ζ =	141°·40		ζ =	208°·48		ζ =	...		ζ =	30°·62
	H =	·062		H =	1·315		H =	...		H =	·107
	κ =	49°·19		κ =	35°·89		κ =	...		κ =	190°·75
M_2	R =	1·510	K_2	R =	·238	ν_2	R =	·086	$(M_2N)_4$	R =	·009
	ζ =	151°·85		ζ =	45°·09		ζ =	167°·29		ζ =	81°·10
	H =	1·565		H =	·183		H =	·089		H =	·010
	κ =	228°·65		κ =	239°·63		κ =	279°·87		κ =	276°·36
M_3	R =	·019	P_1	R =	·418	μ_2	R =	·072	$(M_2K_1)_2$	R =	·030
	ζ =	289°·11		ζ =	220°·54		ζ =	38°·10		ζ =	65°·27
	H =	·021		H =	·418		H =	·077		H =	·028
	κ =	224°·31		κ =	30°·88		κ =	191°·70		κ =	329°·47
M_4	R =	·012	J_1	R =	·134	R_2	R =	...	$(2M_2K_1)_3$	R =	·002
	ζ =	170°·79		ζ =	265°·89		ζ =	...		ζ =	147°·72
	H =	·013		H =	·116		H =	...		H =	·002
	κ =	324°·39		κ =	50°·65		κ =	...		κ =	113°·92

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·022	66°·19	·025	24°·53
„ Fortnightly „	·065	243°·28	·045	359°·33
Luni-Solar „ „	·005	228°·55	·005	151°·75
Solar-Annual „	·394	71°·81	·394	351°·47
„ Semi-Annual „	·167	273°·00	·167	112°·32

KARĀCHI, 1912.

Short Period Tides.

$A_0 = 7{\cdot}312$ feet.

S_1 H = R =	·087	M_6 R =	·039	Q_1 R =	·188	T_2 R =	·058
S_1 κ = ζ =	182°·11	M_6 ζ =	337°·25	Q_1 ζ =	108°·97	T_2 ζ =	265°·22
S_2 H = R =	·968	M_6 H =	·043	Q_1 H =	·160	T_2 H =	·058
S_2 κ = ζ =	325°·56	M_6 κ =	212°·12	Q_1 κ =	43°·35	T_2 κ =	267°·05
S_4 H = R =	·008	M_8 R =	·007	L_2 R =	·051	$(MS)_4$ R =	·032
S_4 κ = ζ =	9°·58	M_8 ζ =	272°·86	L_2 ζ =	49°·82	$(MS)_4$ ζ =	242°·51
S_6 H = R =	·009	M_8 H =	·008	L_2 H =	·045	$(MS)_4$ H =	·033
S_6 κ = ζ =	299°·29	M_8 κ =	226°·02	L_2 κ =	281°·35	$(MS)_4$ κ =	320°·80
S_8 H = R =	·001	O_1 R =	·797	N_2 R =	·574	$(2SM)_2$ R =	·027
S_8 κ = ζ =	97°·13	O_1 ζ =	157°·26	N_2 ζ =	157°·15	$(2SM)_2$ ζ =	200°·33
		O_1 H =	·678	N_2 H =	·595	$(2SM)_2$ H =	·028
		O_1 κ =	49°·19	N_2 κ =	277°·90	$(2SM)_2$ κ =	122°·04
M_1 R =	·089	K_1 R =	1·480	λ_2 R =	...	$2N_2$ R =	·118
M_1 ζ =	164°·16	K_1 ζ =	220°·20	λ_2 ζ =	...	$2N_2$ ζ =	79°·91
M_1 H =	·057	K_1 H =	1·335	λ_2 H =	...	$2N_2$ H =	·123
M_1 κ =	72°·69	K_1 κ =	47°·55	λ_2 κ =	...	$2N_2$ κ =	243°·12
M_2 R =	2·497	K_2 R =	·306	ν_2 R =	·127	$(M_2N)_4$ R =	·026
M_2 ζ =	218°·09	K_2 ζ =	125°·91	ν_2 ζ =	205°·28	$(M_2N)_4$ ζ =	167°·65
M_2 H =	2·588	K_2 H =	·235	ν_2 H =	·132	$(M_2N)_4$ H =	·028
M_2 κ =	296°·38	K_2 κ =	320°·33	ν_2 κ =	320°·05	$(M_2N)_4$ κ =	6°·69
M_3 R =	·039	P_1 R =	·385	μ_2 R =	·076	$(M_2K_1)_3$ R =	·055
M_3 ζ =	47°·03	P_1 ζ =	229°·89	μ_2 ζ =	108°·17	$(M_2K_1)_3$ ζ =	123°·90
M_3 H =	·041	P_1 H =	·385	μ_2 H =	·082	$(M_2K_1)_3$ H =	·051
M_3 κ =	344°·46	P_1 κ =	40°·29	μ_2 κ =	264°·75	$(M_2K_1)_3$ κ =	29°·53
M_4 R =	·019	J_1 R =	·142	R_2 R =	...	$(2M_2K_1)_3$ R =	·023
M_4 ζ =	195°·26	J_1 ζ =	281°·55	R_2 ζ =	...	$(2M_2K_1)_3$ ζ =	4°·91
M_4 H =	·021	J_1 H =	·123	R_2 H =	...	$(2M_2K_1)_3$ H =	·022
M_4 κ =	351°·84	J_1 κ =	65°·45	R_2 κ =	...	$(2M_2K_1)_3$ κ =	334°·15

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·098	9°·18	·112	326°·72
„ Fortnightly „	·040	249°·72	·028	4°·16
Luni-Solar „ „ . .	·011	259°·88	·011	181°·59
Solar-Annual „	·121	170°·46	·121	90°·06
„ Semi-Annual „ . .	·192	324°·85	·192	164°·05

BOMBAY (APOLLO BANDAR), 1912.

Short Period Tides.

A_0=10·311 feet.

S_1	H = R =	·097	M_6	R =	·017	Q_1	R =	·190	T_2	R =	·111
	κ = ζ =	191°·55		ζ =	159°·18		ζ =	112°·08		ζ =	333°·39
S_2	H = R =	1·548		H =	·019		H =	·162		H =	·141
	κ = ζ =	3°·54		κ =	35°·24		κ =	47°·10		κ =	335°·24
S_4	H = R =	·023	M_8	R =	·003	L_2	R =	·104	$(MS)_4$	R =	·062
	κ = ζ =	253°·81		ζ =	20°·56		ζ =	83°·40		ζ =	303°·88
S_6	H = R =	·003		H =	·004		H =	·092		H =	·064
	κ = ζ =	174°·29		κ =	335°·31		κ =	315°·12		κ =	21°·57
S_8	H = R =	·001	O_1	R =	·780	N_2	R =	·959	$(2SM)_2$	R =	·044
	κ = ζ =	288°·44		ζ =	157°·04		ζ =	192°·50		ζ =	201°·36
				H =	·663		H =	·994		H =	·046
				κ =	49°·38		κ =	313°·86		κ =	122°·67
M_1	R =	·098	K_1	R =	1·541	λ_2	R =	...	$2N_2$	R =	·204
	ζ =	158°·34		ζ =	218°·26		ζ =	...		ζ =	107°·29
	H =	·063		H =	1·390		H =	...		H =	·211
	κ =	67°·06		κ =	45°·59		κ =	...		κ =	271°·33
M_2	R =	3·836	K_2	R =	·513	ν_2	R =	·189	$(M_2N)_4$	R =	·007
	ζ =	252°·28		ζ =	159°·01		ζ =	254°·83		ζ =	71°·29
	H =	3·976		H =	·394		H =	·196		H =	·007
	κ =	330°·97		κ =	353°·40		κ =	10°·18		κ =	271°·34
M_3	R =	·071	P_1	R =	·408	μ_2	R =	·226	$(M_2K_1)_3$	R =	·019
	ζ =	94°·14		ζ =	232°·55		ζ =	147°·58		ζ =	157°·96
	H =	·075		H =	·408		H =	·243		H =	·017
	κ =	32°·17		κ =	42°·97		κ =	304°·96		κ =	63°·98
M_4	R =	·086	J_1	R =	·135	R_2	R =	...	$(2M_2K_1)_5$	R =	·051
	ζ =	139°·44		ζ =	280°·99		ζ =	...		ζ =	82°·39
	H =	·092		H =	·116		H =	...		H =	·050
	κ =	296°·82		κ =	64°·67		κ =	...		κ =	52°·44

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·111	339°·46	·127	296°·79
„ Fortnightly „ . . .	·059	247°·32	·041	1°·33
Luni-Solar „ „ . . .	·016	229°·25	·017	150°·56
Solar-Annual „ . . .	·024	35°·46	·024	315°·05
„ Semi-Annual „ . . .	·196	335°·29	·196	174°·46

BOMBAY (PRINCE'S DOCK), 1912.

Short Period Tides.

A_0 = 8·300 feet.

S_1 H = R =	·100	M_6 R =	·005	Q_1 R =	·185	T_2 R =	·115
κ = ζ =	189°·78	ζ =	265°·24	ζ =	110°·83	ζ =	334°·29
S_2 H = R =	1·597	H =	·006	H =	·157	H =	·115
κ = ζ =	5°·02	κ =	141°·31	κ =	45°·84	κ =	336°·14
S_4 H = R =	·020	M_8 R =	·004	L_2 R =	·093	$(MS)_4$ R =	·099
κ = ζ =	235°·82	ζ =	189°·46	ζ =	83°·28	ζ =	325°·42
S_6 H = R =	·006	H =	·005	H =	·082	H =	·102
κ = ζ =	213°·69	κ =	144°·22	κ =	315°·00	κ =	41°·11
S_8 H = R =	·002	O_1 R =	·784	N_2 R =	·965	$(2SM)_2$ R =	·054
κ = ζ =	356°·63	ζ =	156°·55	ζ =	193°·21	ζ =	194°·67
		H =	·667	H =	1·001	H =	·055
		κ =	48°·89	κ =	314°·58	κ =	115°·98
M_1 R =	·098	K_1 R =	1·553	λ_2 R =	...	$2N_2$ R =	·218
ζ =	161°·09	ζ =	218°·33	ζ =	...	ζ =	108°·16
H =	·063	H =	1·401	H =	...	H =	·225
κ =	69°·81	κ =	45°·66	κ =	...	κ =	272°·20
M_2 R =	3·930	K_2 R =	·513	ν_2 R =	·153	$(M_2N)_4$ R =	·019
ζ =	253°·13	ζ =	162°·57	ζ =	254°·55	ζ =	190°·76
H =	4·073	H =	·393	H =	·159	H =	·021
κ =	331°·82	κ =	356°·96	κ =	9°·90	κ =	30°·81
M_3 R =	·085	P_1 R =	·409	μ_2 R =	·212	$(M_2K_1)_3$ R =	·038
ζ =	100°·66	ζ =	233°·04	ζ =	151°·05	ζ =	207°·26
H =	·090	H =	·409	H =	·228	H =	·036
κ =	38°·70	κ =	43°·45	κ =	308°·43	κ =	113°·28
M_4 R =	·079	J_1 R =	·136	R_2 R =	...	$(2M_2K_1)_3$ R =	·062
ζ =	171°·84	ζ =	280°·98	ζ =	...	ζ =	95°·26
H =	·085	H =	·117	H =	...	H =	·060
κ =	329°·22	κ =	64°·65	κ =	...	κ =	65°·31

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·121	336°·11	·138	293°·43
„ Fortnightly „	·059	254°·33	·041	8°·33
Luni-Solar „ „	·014	208°·79	·015	130°·10
Solar-Annual „	·044	38°·12	·044	317°·70
„ Semi-Annual „	·196	337°·52	·196	176°·68

MADRAS, 1912.

Short Period Tides.

$A_0 = 2·336$ feet.

S_1	H = R =	·034	M_6	R =	·005	Q_1	R =	·011	T_2	R =	·038
	κ = ζ =	93°·60		ζ =	231°·34		ζ =	79°·74		ζ =	207°·52
S_2	H = R =	·460		H =	·006		H =	·009		H =	·038
	κ = ζ =	270°·65		κ =	108°·91		κ =	15°·55		κ =	209°·39
S_4	H = R =	·002	M_8	R =	·002	L_2	R =	·038	$(MS)_4$	R =	·005
	κ = ζ =	217°·57		ζ =	247°·62		ζ =	33°·90		ζ =	148°·47
S_6	H = R =	·001		H =	·003		H =	·033		H =	·006
	κ = ζ =	48°·81		κ =	204°·38		κ =	265°·85		κ =	227°·66
S_8	H = R =	·0002	O_1	R =	·107	N_2	R =	·222	$(2SM)_2$	R =	·018
	κ = ζ =	333°·44		ζ =	75°·26		ζ =	108°·48		ζ =	289°·63
				H =	·091		H =	·231		H =	·019
				κ =	328°·12		κ =	230°·61		κ =	210°·44
M_1	R =	·029	K_1	R =	·337	λ_2	R =	...	$2N_2$	R =	·045
	ζ =	58°·83		ζ =	149°·62		ζ =	...		ζ =	50°·64
	H =	·018		H =	·304		H =	...		H =	·047
	κ =	327°·80		κ =	336°·93		κ =	...		κ =	215°·72
M_2	R =	1·054	K_2	R =	·146	ν_2	R =	·054	$(M_2N)_4$	R =	·002
	ζ =	162°·34		ζ =	76°·93		ζ =	162°·05		ζ =	42°·51
	H =	1·093		H =	·112		H =	·055		H =	·002
	κ =	241°·53		κ =	271°·28		κ =	278°·13		κ =	243°·84
M_3	R =	·002	P_1	R =	·098	μ_2	R =	·032	$(M_2K_1)_3$	R =	·013
	ζ =	93°·58		ζ =	166°·01		ζ =	20°·43		ζ =	63°·44
	H =	·002		H =	·098		H =	·035		H =	·012
	κ =	32°·36		κ =	336°·45		κ =	178°·81		κ =	329°·93
M_4	R =	·006	J_1	R =	·029	R_2	R =	...	$(2M_2K_1)_3$	R =	·004
	ζ =	28°·37		ζ =	197°·93		ζ =	...		ζ =	344°·75
	H =	·006		H =	·025		H =	...		H =	·003
	κ =	186°·75		κ =	341°·32		κ =	...		κ =	315°·82

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·043	264°·17	·049	221°·22
,, Fortnightly ,, ...	·072	251°·80	·050	5°·26
Luni-Solar ,, ,, . . .	·044	324°·84	·046	245°·65
Solar-Annual ,, . . .	·435	288°·53	·435	208°·09
,, Semi-Annual ,, . .	·348	278°·05	·348	117°·17

KIDDERPORE, 1912.

Short Period Tides.

A_0 = 10·314 feet.

S_1	H = R =	·088	M_6	R =	·132	Q_1	R =	·023	T_2	R =	·069
	κ = ζ =	207°·32		ζ =	73°·36		ζ =	60°·26		ζ =	129°·38
S_2	H = R =	1·563		H =	·147		H =	·019		H =	·069
	κ = ζ =	96°·46		κ =	312°·56		κ =	356°·92		κ =	131°·27
S_4	H = R =	·098	M_8	R =	·060	L_2	R =	·229	$(MS)_4$	R =	·681
	κ = ζ =	105°·14		ζ =	321°·60		ζ =	201°·50		ζ =	349°·90
S_6	H = R =	·002		H =	·069		H =	·202		H =	·706
	κ = ζ =	15°·95		κ =	280°·53		κ =	73°·70		κ =	69°·64
S_8	H = R =	·004	O_1	R =	·237	N_2	R =	·614	$(2SM)_2$	R =	·097
	κ = ζ =	261°·25		ζ =	130°·98		ζ =	275°·45		ζ =	62°·32
				H =	·201		H =	·636		H =	·101
				κ =	24°·41		κ =	38°·42		κ =	342°·58
M_1	R =	·038	K_1	R =	·459	λ_2	R =	...	$2N_2$	R =	·241
	ζ =	89°·85		ζ =	225°·51		ζ =	...		ζ =	231°·72
	H =	·024		H =	·414		H =	...		H =	·250
	κ =	359°·09		κ =	52°·79		κ =	...		κ =	37°·92
M_2	R =	3·671	K_2	R =	·577	ν_2	R =	·157	$(M_2N)_4$	R =	·257
	ζ =	334°·88		ζ =	254°·04		ζ =	294°·21		ζ =	172°·92
	H =	3·805		H =	·443		H =	·162		H =	·277
	κ =	54°·61		κ =	88°·34		κ =	51°·09		κ =	15°·62
M_3	R =	·054	P_1	R =	·168	μ_2	R =	·310	$(M_2K_1)_3$	R =	·123
	ζ =	25°·93		ζ =	233°·62		ζ =	18°·94		ζ =	140°·16
	H =	·057		H =	·168		H =	·332		H =	·115
	κ =	325°·53		κ =	44°·08		κ =	178°·41		κ =	47°·19
M_4	R =	·690	J_1	R =	·038	R_2	R =	...	$(2M_2K_1)_3$	R =	·048
	ζ =	231°·36		ζ =	288°·29		ζ =	...		ζ =	329°·12
	H =	·741		H =	·033		H =	...		H =	·047
	κ =	30°·82		κ =	71°·36		κ =	...		κ =	301°·30

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·345	52°·67	·393	9°·43
„ Fortnightly „	·322	276°·39	·224	29°·26
Luni-Solar „ „	·858	121°·30	·889	41°·57
Solar-Annual „	2·328	233°·14	2·328	152°·67
„ Semi-Annual „	·793	125°·00	·793	324°·07

RANGOON, 1912.

Short Period Tides.

A_0=10·218 feet.

S_1	H = R =	·153	M_6	R =	·224	Q_1	R =	·022	T_2	R =	·229
	κ = ζ =	141°·22		ζ =	215°·72		ζ =	95°·97		ζ =	117°·58
S_2	H = R =	2·195		H =	·250		H =	·019		H =	·229
	κ = ζ =	169°·95		κ =	96°·52		κ =	33°·47		κ =	119°·50
S_4	H = R =	·090	M_8	R =	·075	L_2	R =	·348	$(MS)_4$	R =	·472
	κ = ζ =	263°·14		ζ =	157°·30		ζ =	293°·58		ζ =	132°·47
S_6	H = R =	·009		H =	·086		H =	·307		H =	·489
	κ = ζ =	39°·97		κ =	118°·37		κ =	166°·03		κ =	212°·74
S_8	H = R =	·003	O_1	R =	·324	N_2	R =	·942	$(2SM)_2$	R =	·161
	κ = ζ =	148°·17		ζ =	125°·45		ζ =	349°·68		ζ =	134°·95
				H =	·275		H =	·976		H =	·167
				κ =	19°·43		κ =	113°·46		κ =	54°·68
M_1	R =	·044	K_1	R =	·759	λ_2	R =	...	$2N_2$	R =	·354
	ζ =	196°·82		ζ =	209°·03		ζ =	...		ζ =	329°·91
	H =	·028		H =	·684		H =	...		H =	·367
	κ =	106°·33		κ =	36°·30		κ =	...		κ =	137°·22
M_2	R =	5·690	K_2	R =	·728	ν_2	R =	·288	$(M_2N)_4$	R =	·187
	ζ =	52°·53		ζ =	335°·15		ζ =	23°·63		ζ =	311°·59
	H =	5·897		H =	·559		H =	·299		H =	·201
	κ =	132°·79		κ =	169°·41		κ =	141°·29		κ =	155°·65
M_3	R =	·045	P_1	R =	·172	μ_2	R =	·555	$(M_2K_1)_3$	R =	·107
	ζ =	80°·99		ζ =	254°·54		ζ =	134°·03		ζ =	195°·07
	H =	·047		H =	·172		H =	·596		H =	·100
	κ =	21°·39		κ =	65°·02		κ =	294°·57		κ =	102°·60
M_4	R =	·507	J_1	R =	·067	R_2	R =	...	$(2M_2K_1)_3$	R =	·136
	ζ =	8°·65		ζ =	297°·07		ζ =	...		ζ =	73°·96
	H =	·544		H =	·058		H =	...		H =	·132
	κ =	169°·18		κ =	79°·83		κ =	...		κ =	47°·23

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·214	45°·38	·244	1°·86
„ Fortnightly „ . . .	·108	275°·70	·075	28°·00
Luni-Solar „ „ . . .	·432	121°·29	·448	41°·03
Solar-Annual „ . . .	1·339	233°·46	1·339	152°·97
„ Semi-Annual „ . . .	·116	125°·45	·116	324°·49

MOULMEIN, 1912.

Short Period Tides.

$A_0 = 8·277$ feet.

S_1	H = R =	·090	M_6	R =	·059	Q_1	R =	·041	T_2	R =	·179
	κ = ζ =	145°·80		ζ =	303°·66		ζ =	105°·17		ζ =	103°·62
S_2	H = R =	1·502		H =	·066		H =	·035		H =	·179
	κ = ζ =	143°·45		κ =	184°·75		κ =	42°·83		κ =	105°·54
S_4	H = R =	·063	M_8	R =	·043	L_2	R =	·261	$(MS)_4$	R =	·773
	κ = ζ =	213°·26		ζ =	129°·04		ζ =	278°·37		ζ =	119°·65
S_6	H = R =	·007		H =	·049		H =	·230		H =	·801
	κ = ζ =	219°·05		κ =	90°·50		κ =	150°·86		κ =	200°·01
			O_1	R =	·268	N_2	R =	·635	$(2SM)_2$	R =	·160
S_8	H = R =	·001		ζ =	144°·13		ζ =	328°·88		ζ =	102°·30
	κ = ζ =	221°·19		H =	·228		H =	·658		H =	·166
				κ =	38°·22		κ =	92°·82		κ =	21°·94
M_1	R =	·029	K_1	R =	·521	λ_2	R =	...	$2N_2$	R =	·221
	ζ =	188°·43		ζ =	209°·62		ζ =	...		ζ =	300°·18
	H =	·019		H =	·470		H =	...		H =	·229
	κ =	97°·99		κ =	36°·88		κ =	...		κ =	107°·69
M_2	R =	4·078	K_2	R =	·482	ν_2	R =	·140	$(M_2N)_4$	R =	·338
	ζ =	29°·62		ζ =	314°·67		ζ =	334°·14		ζ =	298°·47
	H =	4·226		H =	·370		H =	·145		H =	·363
	κ =	109°·98		κ =	148°·92		κ =	91°·94		κ =	142°·78
M_3	R =	·041	P_1	R =	·149	μ_2	R =	·413	$(M_2K_1)_3$	R =	·182
	ζ =	71°·75		ζ =	254°·28		ζ =	118°·68		ζ =	185°·86
	H =	·043		H =	·149		H =	·443		H =	·170
	κ =	12°·29		κ =	64°·77		κ =	279°·41		κ =	93°·48
M_4	R =	·928	J_1	R =	·045	R_2	R =	...	$(2M_2K_1)_3$	R =	·137
	ζ =	0°·80		ζ =	281°·29		ζ =	...		ζ =	74°·12
	H =	·997		H =	·038		H =	...		H =	·133
	κ =	161°·52		κ =	63°·99		κ =	...		κ =	47°·59

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·436	51°·17	·497	7°·59
„ Fortnightly „ . . .	·334	283°·49	·233	35°·68
Luni-Solar „ „ . . .	1·194	122°·49	1·237	42°·12
Solar-Annual „ . . .	2·233	227°·69	2·233	147°·20
„ Semi-Annual „ . . .	·546	92°·83	·546	291°·86

PORT BLAIR, 1912.

Short Period Tides.

A_0 = 4·828 feet.

S_1 H = R =	·022	M_6 R =	·005	Q_1 R =	·012	T_2 R =	·071
S_1 κ = ζ =	101°·00	ζ =	139°·69	ζ =	343°·48	ζ =	266°·57
S_2 H = R =	·969	H =	·005	H =	·011	H =	·071
S_2 κ = ζ =	313°·55	κ =	19°·79	κ =	280°·62	κ =	268°·48
S_4 H = R =	·004	M_8 R =	·002	L_2 R =	·078	$(MS)_4$ R =	·015
S_4 κ = ζ =	242°·82	ζ =	175°·60	ζ =	49°·38	ζ =	93°·95
S_6 H = R =	·003	H =	·002	H =	·069	H =	·016
S_6 κ = ζ =	320°·71	κ =	135°·74	κ =	281°·72	κ =	173°·08
S_8 H = R =	·0003	O_1 R =	·180	N_2 R =	·377	$(2SM)_2$ R =	·023
S_8 κ = ζ =	71°·57	ζ =	46°·73	ζ =	148°·17	ζ =	220°·80
		H =	·153	H =	·390	H =	·023
		κ =	300°·48	κ =	271°·60	κ =	140°·76
M_1 R =	·038	K_1 R =	·450	λ_2 R =	...	$2N_2$ R =	·090
ζ =	59°·32	ζ =	138°·10	ζ =	...	ζ =	75°·82
H =	·024	H =	·406	H =	...	H =	·093
κ =	328°·71	κ =	325°·38	κ =	...	κ =	242°·65
M_2 R =	1·941	K_2 R =	·335	ν_2 R =	·069	$(M_2N)_4$ R =	·004
ζ =	199°·04	ζ =	115°·19	ζ =	203°·31	ζ =	175°·71
H =	2·011	H =	·257	H =	·071	H =	·005
κ =	279°·08	κ =	309°·47	κ =	320°·63	κ =	19°·18
M_3 R =	·006	P_1 R =	·142	μ_2 R =	·088	$(M_2K_1)_3$ R =	·019
ζ =	127°·50	ζ =	150°·56	ζ =	132°·15	ζ =	95°·22
H =	·006	H =	·142	H =	·094	H =	·018
κ =	67°·56	κ =	321°·03	κ =	292°·21	κ =	2°·53
M_4 R =	·018	J_1 R =	·037	R_2 R =	...	$(2M_2K_1)_3$ R =	·010
ζ =	312°·47	ζ =	195°·01	ζ =	...	ζ =	233°·47
H =	·020	H =	·032	H =	...	H =	·010
κ =	112°·54	κ =	337°·91	κ =	...	κ =	206°·27

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·038	39°·54	·043	356°·14
" Fortnightly "	·063	273°·47	·044	26°·02
Luni-Solar " " . . .	·002	104°·55	·002	24°·51
Solar-Annual "	·291	243°·03	·291	162°·55
" Semi-Annual "	·173	325°·33	·173	164°·39

DATA FORWARDED TO ENGLAND.

The following data were prepared and supplied to the Director of the National Physical Laboratory, Teddington, England during the year under report:—

(a) Values of the tidal constants for forty ports for the tide-tables for 1916, ready for use for the tide predicting machine.

(b) Actual values during 1911 of every high and low water measured in duplicate from the tidal diagrams at nine stations and of the tidepole observations taken during day-light at two stations.

(c) Comparisons of the above with predicted values for 1911, the errors being tabulated in such form as to be of use in improving the predictions.

ERRORS IN PREDICTIONS.

The percentage and the amount of errors in the predicted times and heights of high and low water for the year 1912, as given in the tide tables, have been determined by comparison with the actual values obtained from tidal registrations at the nine stations now working. Similar information has also been compiled for three stations at which regular tidal registrations have been stopped, but the actual values of high and low water were obtained from tide-pole readings in the case of two stations (Bhaunagar and Akyab) and from tidal registrations of a small river gauge in the case of the third station (Chittagong).

The errors are tabulated in the five tables herewith appended.

No. 1.

Statement showing the percentage and the amount of the errors in the predicted times of high water at the various tidal stations for the year 1912.

STATIONS.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	679	42	46	6	4	2
Karāchi	Auto.	707	25	36	13	14	12
Bhaunagar	T. P.	366	68	32	0	0	0
Bombay — Apollo Bandar	Auto.	707	44	40	7	6	3
Bombay — Prince's Dock	Auto.	692	39	46	9	3	3
Madras	Auto.	705	39	48	7	5	1
Kidderpore	Auto.	706	27	47	10	11	5
Chittagong *	Auto.	672	23	35	12	14	16
Akyab	T. P.	362	97	2	1	0	0
Rangoon	Auto.	706	47	32	9	6	6
Moulmein	Auto.	684	26	44	13	13	4
Port Blair	Auto.	706	40	45	7	6	2

* Observations taken with a small river gauge by the Port Officer.

No. 2.

Statement showing the percentage and the amount of the errors in the predicted times of low water at the various tidal stations for the year 1912.

Stations.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	676	39	44	7	7	3
Karāchi . . .	Auto.	708	27	35	11	14	13
Bhaunagar . . .	T. P.	366	64	36	0	0	0
Bombay { Apollo Bandar	Auto.	708	39	45	7	6	3
Bombay { Prince's Dock	Auto.	692	39	42	11	6	2
Madras . . .	Auto.	703	46	44	6	3	1
Kidderpore . . .	Auto.	707	30	38	12	12	8
Chittagong* . . .	Auto.	668	19	31	12	17	21
Akyab	T. P.	363	98	2	0	0	0
Rangoon . . .	Auto.	705	27	44	13	13	3
Moulmein . . .	Auto.	684	18	26	9	20	27
Port Blair . . .	Auto.	707	49	41	5	3	2

* Observations taken with a small river gauge by the Port Officer.

No. 3.

Statement showing the percentage and the amount of the errors in the predicted heights of high water at the various tidal stations for the year 1912.

Stations.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	679	6·7	95	5	0	0
Karāchi . . .	Auto.	707	9·3	68	28	4	0
Bhaunagar . .	T. P.	366	31·4	64	30	5	1
Bombay { Apollo Bandar .	Auto.	707	13·9	68	25	6	1
Bombay { Prince's Dock .	Auto.	692	13·9	66	27	6	1
Madras . . .	Auto.	705	3·5	85	14	1	0
Kidderpore . . .	Auto.	706	11·7	43	27	16	14
Chittagong* . . .	Auto.	672	13·3	46	30	15	9
Akyab	T. P.	362	8·3	88	11	1	0
Rangoon . . .	Auto.	706	16·4	49	33	13	5
Moulmein . . .	Auto.	684	12·7	38	28	16	18
Port Blair . . .	Auto.	706	6·6	88	12	0	0

* Observations taken with a small river gauge by the Port Officer.

No. 4.

Statement showing the percentage and the amount of the errors in the predicted heights of low water at the various tidal stations for the year 1912.

Stations.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	676	6·7	97	3	0	0
Karāchi	Auto.	708	9·3	81	17	2	0
Bhaunagar	T. P.	366	31·4	61	33	5	1
Bombay { Apollo Bandar	Auto.	708	13·9	66	29	4	1
Bombay { Prince's Dock	Auto.	692	13·9	68	26	5	1
Madras	Auto.	703	3·5	90	9	1	0
Kidderpore	Auto.	707	11·7	44	27	17	12
Chittagong*	Auto.	668	13·3	36	28	18	18
Akyab	T. P.	363	8·3	92	8	0	0
Rangoon	Auto.	705	16·4	30	26	24	20
Moulmein	Auto.	684	12·7	31	26	20	23
Port Blair	Auto.	707	6·6	94	6	0	0

* Observations taken with a small river gauge by the Port Officer.

No. 5.

Table of average errors in the predicted times and heights of high and low water at the several tidal stations for the year 1912.

Stations.	Automatic or tide-pole observations.	Mean range at springs in feet.	Average Errors: Of time in minutes.		Of height in terms of the range.		Of height in inches.	
			H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Open Coast.								
Aden	Auto.	6·7	8	9	·025	·025	2	2
Karāchi	Auto.	9·3	16	15	·036	·027	4	3
Bhaunagar	T. P.	31·4	5	5	·011	·011	4	4
Bombay { Apollo Bandar	Auto.	13·9	9	9	·024	·024	4	4
Bombay { Prince's Dock	Auto.	13·9	9	10	·024	·024	4	4
Madras	Auto.	3·5	9	8	·071	·048	3	2
Akyab	T. P.	8·3	1	0	·020	·020	2	2
Port Blair	Auto.	6·6	9	7	·025	·025	2	2
General Mean	...	...	8	8	·030	·026	3	3
Riverain.								
Kidderpore	Auto.	11·7	12	14	·050	·043	7	6
Chittagong*	Auto.	13·3	18	20	·038	·050	6	8
Rangoon	Auto.	16·4	10	12	·025	·041	5	8
Moulmein	Auto.	12·7	12	21	·046	·059	7	9
General Mean	...	...	13	17	·040	·048	6	8

* Observations taken with a small river gauge by the Port Officer.

The foregoing statements for the year 1912 may be thus summarised :—

Percentage of time predictions within 15 minutes of actuals.

			High water.	Low water.
			Per cent.	Per cent.
Open coast stations.	6	at which predictions were tested by S. R. tide-gauge	82	82
	2	" " " tide-pole	100	100
Riverain stations.	4	" " " S. R. tide-gauge	70	58

Percentage of height predictions within 8 inches of actuals.

			High water.	Low water.
			Per cent.	Per cent.
Open coast stations	6	at which predictions were tested by S. R. tide-gauge	97	98
	2	" " " tide-pole	97	97
Riverain stations.	4	" " " S. R. tide-gauge	74	62

Percentage of height predictions within one-tenth of mean range at springs.

			High water.	Low water.
			Per cent.	Per cent.
Open coast stations.	6	at which predictions were tested by S. R. tide-gauge	97	98
	2	" " " tide-pole	100	100
Riverain stations.	4	" " " S. R. tide-gauge	94	91

COMPARISON OF THE PREDICTIONS FOR 1912 WITH THOSE FOR THE PREVIOUS YEAR.

The predictions for the year 1912 at the nine stations now working, as well as at two other stations where tidal observations were taken by the Port Officers on tide poles were compared with the corresponding predictions for 1911, and it was found that at all the open coast stations the predictions for 1912 were practically as good as in the previous year, except at Karāchi, where they were distinctly worse both for times and heights of high and low water.

For the riverain ports the results are as follows :—

At Kidderpore the predictions were slightly better.

At Rangoon and Moulmein the predictions were about the same for heights but better for times.

The greatest difference between the actual and predicted heights of low water for 1912 at the riverain ports was as follows :—

Kidderpore	.	2′ 8″	on 1st November 1912, actuals being higher.
Rangoon .	.	2′ 4″	on 1st October 1912, actuals being lower.
Moulmein	.	2′ 5″	on 24th August and 24th September 1912, actuals being lower.

TIDE-TABLES.

The tide-tables for the year 1914 have been received from England and distributed to the various officers concerned. The tide-tables for the year 1915 are now being published in England and the data for the preparation of the tide-tables for 1916 were despatched to England in February 1913.

The amount realized on the sale of the tide-tables during the year ending September 1913 is Rs. 2,127-14-3.

PROGRAMME FOR SEASON 1913-14.

Tidal observations during the coming year will be continued at the nine observatories now working.

LEVELLING.

No. 17 Party.

(*Vide* Index Map 10.)

By Mr. H. G. Shaw.

There were three detachments engaged on levelling operations.

The strength of these detachments was as detailed below :—

Personnel.

Imperial Officers.

Captain V. R. Cotter, I.A., in charge up to 28th February 1913.
Lieutenant A. A. Chase, R.E. (Nepāl Boundary Detachment).

Provincial Officers.

Mr. H. G. Shaw, in charge from 1st March 1913.
Mr. O. N. Pushong, up to 14th May.
Mr. D. H. Luxa.
Mr. T. F. Kitchen.
Mr. F. W. Smith.
Mr. O. D. Jackson.
Mr. Jiya Lal.
Mr. Narendra Nath Chuckerbutty.

Upper Subordinate Officers.

Mr. Ram Singh, Rai Sahib (Nepāl By. Dett.)
Mr. Karuna Kumar Das.

Lower Subordinate Establishment.

3 Computers (2 Computers, Nepāl By. Dett.)
9 Recorders.
2 Clerks.

No. 1 Detachment.

Mr. D. H. Luxa, 1st Leveller, up to 23rd April 1913.

Mr. Jiya Lal, 2nd Leveller, up to 23rd after which date as 1st Leveller.

Mr. Karuna Kumar Das, 2nd Leveller, from 24th April 1913.

3 Recorders.

No. 2 Detachment.

Mr. T. F. Kitchen, 1st Leveller.

Mr. F. W. Smith, 2nd Leveller, from 25th November 1912.

Mr. N. N. Chuckerbutty, 2nd Leveller, up to 24th November 1912.

3 Recorders.

No. 3 Detachment.

Mr. O. D. Jackson, 1st Leveller.
Mr. N. N. Chuckerbutty, 2nd Leveller, from 13th December 1912.
Mr. Karuna Kumar Das, 2nd Leveller, up to 12th December 1912.
3 Recorders.

Programme of work during the field season.

No. 1 Detachment.

This detachment was employed on the following lines of levels :—

(1) The completion of the line Sargodha to Multān by road.
(2) Revisionary levelling from Multān to Māhīwālā T. S. partly by road and partly along the railway line.
(3) Revisionary levelling between Ambāla, Meerut, and Delhi, along the main road.
(4) Levelling from Delhi along the road to Muttra.
(5) Levelling from Murree along the tonga road to Srīnagar (Kashmīr), with branch lines emanating from Srīnagar (*a*) to Pahlgam *viâ* Islāmābād, (*b*) to the Sind Valley, (*c*) towards Bandapur, (*d*) towards Shupiyān.

These branch lines were carried out at the request of the Kashmīr Durbar.

Line Sargodha to Multān.—The line Sargodha to Multān closes the circuits (*a*) Multān, Khemwālā, Segra, Daryākhān, Khushāb, Sargodha, Multān, and (*b*) Multān, Sargodha, Lahore, Ferozepore, Murghai, Khemwālā, Multān.

The closing errors being 0·095 and 0·190 of a foot respectively, as shown in the following tables :—

Lines.	Distance in miles.	Unadjusted difference of orthometric heights in feet.	YEAR.
Circuit A.			
From Standard Bench-mark at Multān Cantonment to ground level mark-stone of Khemwālā G. T. Survey Tower Station.	38·2	+5·477	1907-08 and 1866-67
From ground level mark-stone of Khemwālā G. T. Survey Tower Station to ground level mark-stone of Segra G. T. Survey Tower Station.	120·9	+195·991	1859-60
From ground level mark-stone of Segra G. T. Survey Tower Station to G. T. S. O B. M. at Daryākhān railway station.	2·7	—17·707	1906-07
From G. T. S. O B. M. at Daryākhān railway station to G. T. S. O B. M. at Khushāb railway station.	85·5	+27·129	1910-11
From G. T. S. O B. M. at Khushāh railway station to G. T. S. □ B. M. at Sargodha.	29·5	+0·015	1911-12
From G. T. S. □ B. M. at Sargodha to Standard Bench-mark at Multān Cantonment.	173·5	—211·000	1911-12 and 1912-13
	450·3	—0·095	
Circuit B.			
From Standard Bench-mark at Multān Cantonment to G. T. S. □ B. M. at Sargodha.	173·5	+211·000	1911-12 and 1912-13
From G. T. S. □ B. M. at Sargodha to Standard Bench-mark at Lahore Cantonment.	116·0	+94·254	1911-12
From Standard Bench-mark at Lahore Cantonment to G. T. S. Bench-mark at Ferozepore.	54·6	—63·792	1906-07
From G. T. S. Bench-mark at Ferozepore to Murghai Bench-mark.	312·0	—351·737	1860-61
From Murghai Bench-mark to ground level mark-stone of Khemwālā G. T. Survey Tower Station.	100·0	—115·942	1859-60
From ground level mark-stone of Khemwālā G. T. Survey Tower Station to Standard Bench-mark at Multān Cantonment.	38·5	—5·477	1866-67 and 1907-08
	794·6	+0·190	

The circuit errors shown in the above have been deduced from unadjusted orthometric differences of height.

The line Delhi to Muttra.—The levelling from Delhi to Muttra completes the circuit Delhi, Meerut, Hāthras, Muttra, Delhi, the closing error being 0·158 of a foot as shown below. This error has been deduced from unadjusted differences of orthometric heights.

Lines.	Distance in miles.	Unadjusted difference of orthometric heights in feet.	YEAR.
From + at St. John's Church, Meerut to Hāthras G. T. S. Block-stone Bench-mark.	102·5	—153·222	1861-62
From Hāthras G. T. S. Block-stone Bench-mark to Standard Bench-mark at Muttra.	27·5	—25·314	1905-06
From Standard Bench-mark at Muttra to Standard Bench-mark at Delhi.	96·0	+197·819	1912-13
From Standard Bench-mark at Delhi to + at St. John's Church, Meerut.	45·5	—19·125	1912-13
	271·5	+0·158	

Revision of line Multān to Māhīwālā T. S.—On the revision of the line Multān to Māhīwālā T. S., a distance of 42 miles, only one old bench-mark near Muzaffargarh, about 18 miles from Multān, was found in existence, the rest of the old bench-marks had no inscriptions and were mostly on the tops of parapets of bridges and culverts, which have since been renewed, and hence no comparisons can be made between the old and new values.

The results of this revisionary levelling showed that the bench-mark near Muzaffargarh had remained intact, but at Māhīwālā T. S., a difference of 0·166 of a foot was found between the old and new values; this was probably due to the mark-stone at this station having been tampered with as it was found broken in two pieces.

Revision of line Ambāla to Delhi.—The revision of the old lines of levels from Ambāla, *viâ* Jagādhri, Sahāranpur to Meerut of season 1861-62, and from Meerut to Delhi of season 1866-67, showed that there was a discrepancy of about 0·7 of a foot, between the old and new values of height of the bench-mark 901·6 ↑ inscribed on the upper stone step just outside the wooden sill of the western doorway of the tower of St. Paul's Church at Ambāla. Accepting the old height of this bench-mark as correct, we find that all the old embedded bench-marks along the above route to Delhi, with the exception of the one at Khataulī, show a rise varying from 0·5 to 0·8 of a foot. This would lead one to suspect that the Ambāla Church bench-mark had settled about 8 inches, which is extremely improbable, for if such a large settlement had taken place in this bench-mark, the Church Tower, on the plinth of which this bench-mark is situated, would certainly have showed signs of cracks or separation from the main building, which is not the case.

There is no doubt about the point of reference being identical with that of 1861-62. The only way at present to account for this difference is, that perhaps a gross error has been made between Ambāla and Jagādhri, either in the old or in the revised levelling. It is intended to relevel the line between Ambāla and Jagādhri next field season.

The embedded bench-mark at Khataulī shows a settlement of 0·14 of a foot as compared with Ambāla, or of nearly 10 inches with reference to the other bench-marks of this revision work.

No. 2 DETACHMENT.

This detachment had for its programme :—

(1) Levelling from Comilla to Chittagong.

(2) Levelling from Brāhmanbāria, *viâ* Dacca and Goalundo to Pāchuriā, by road and across country, crossing the Meghnā, Lakhyā, Dhaleswari, and the Padmā or Ganges rivers. The distances across these rivers being respectively, 65, 35, 52, and 109 chains of 66 feet length.

(3) Pāchuriā along the railway line to Farīdpur, and thence across country to Barisāl.

(4) Levelling in Darjeeling.

The line Comilla to Chittagong.—The levelling from Comilla to Chittagong connects Pārvatīpur, *viâ* Gauhāti and Akhaura, with the tidal station at Chittagong with an error of 1·382 feet as given below.

The line Brāhmanbāria to Pāchuriā.—The line Brāhmanbāria to Pāchuriā closes the circuit Porādaha, Pārvatīpur, Gauhāti, Akhaura, Pāchuriā, Porādaha, with an error of 2·706 feet as given below.

Lines.	Distance in miles.	Unadjusted difference of orthometric heights in feet.	YEAR.
G. T. S. □ B. M. at Pārvatīpur above Mean Sea Level.		+114·564 (*Vide* Volume XIX B).	
From G. T. S. □ B. M. at Pārvatīpur to "1895" Gauhāti Railway Station.	228·5	+56·690	1901-02 and 1905-06
From "1895" at Gauhāti Railway Station to G. T. S. □ B. M. at Akhaura Railway Station.	283·5	−152·342	1910-11 and 1911-12
From G. T. S. □ B. M. at Akhaura Railway Station to G. T. S. O. B. M. Tidal test Bench-mark "A" at Chittagong.	131·3	−2·864	1912-13
M. W. L. at Chittagong below G. T. S. O. B. M. Tidal test Bench-mark "A" at Chittagong.	...	−14·666	...
	643·3	+1·382	

Lines.	Distance in miles.	Unadjusted difference of orthometric heights in feet.	YEAR.
From G. T. S. □ B. M. at Porādaha Railway Station to G. T. S. □ B. M. at Pārvatīpur.	129·1	+68·096 (*Vide* Volume XIX B).	1901-02
From G. T. S. □ B. M. Pārvatīpur to "1895" at Gauhāti Railway Station.	228·5	+56·690	1910-11 and 1911-12
From "1895" at Gauhāti Railway Station to G. T. S. □ B. M. at Akhaura Railway Station.	283·5	−152·342	1911-12
From G. T. S. □ B. M. at Akhaura Railway Station to G. T. S. □ Minor B. M. at Pāchuriā Railway Station	136·8	+9·495	1912-13
From G. T. S. □ Minor B. M. at Pāchuriā Railway Station to G. T. S. □ B. M. at Porādaha Railway Station.	45·6	+20·767	1899-1900
	823·5	+2·706	

Closing errors.—A portion of the error of 1·382 feet generated on the line Pārvatīpur to Chittagong may be due to the difference between mean sea level and mean water level at Chittagong, this being a riverain port. The tidal station at Chittagong is only about 12 miles up the river, and therefore the maximum difference between mean sea level and mean water level may be assumed to be not more than 0·3 of a foot.

This would show that the rest of the error, *viz.*, 1·082 feet, is due to levelling. Now as the portion between Chittagong and Akhaura has no unusual features, and the distance between the two points is about 131 miles, it may safely be assumed that nearly the whole of the above error lies between Pārvatīpur and Akhaura.

As shown in the above tables, the error in the whole circuit is 2·706 feet,* it follows therefore that an error of 2·706 feet — 1·382 feet = 1·324 feet, has been generated between Akhaura and Porādaha. As regards the error between Pārvatīpur and Akhaura, the most likely places for the occurrence of a gross error are, the river crossing at Dhubri which was done by the tide-pole method only, and the hill section from Gauhāti to Dumpep, a rise of about 5,917 feet in a

*The revision of the section of single levelling between Pāchuriā and Porādaha has brought to light an error of about 2 feet. The circuit error will therefore be reduced to about 0·7 foot.

distance of 81 miles, and from Dumpep to Tharia Ghāt, a fall of about 5,976 feet in a distance of 25 miles.

With reference to the error of 1·324 feet between Akhaura and Porādaha in a distance of 182 miles, the weak points of this line appear to be (a) the single levelling between Pāchuriā and Porādaha, and the various river crossings, previously mentioned, which were done in the course of the levelling.

With a view to locating the above errors as far as possible, it is intended during the coming field season, to repeat the river crossing at Dhubri by means of "Vertical Angles" and the "Target" methods, and to revise the section, Pāchuriā to Porādaha, by double levelling.

River crossings by the "Target" method.—The three rivers crossed by the "Target" method with levels were the Meghnā (65 chains), the Lakhyā (35 chains), and the Dhaleswari (52 chains).

The target is rectangular shaped and is made of wood 12 inches by 6 inches with a 3-inch square opening in the centre and fitted with a thin brass strip for the reading of the graduation on the staff. A white fan shaped strip is painted on a black ground on each side of the aperture, thus allowing for fine intersections with the level at a considerable distance. It is provided with suitable springs and rollers which enable it to be worked up or down the levelling staff with ease. There is also a clamping screw to clamp the target to the staff for the final reading.

When crossing the above mentioned rivers sites were selected after careful reconnaissances so as to have both rays from the instrument to the staves passing over water, and the distances to the staves equal.

Invariably both levels were used and observations taken by the two levellers. During the course of the observations the height of the instrument was frequently altered so as to avoid bias in reading the staff, such as there might have been had the instrument been kept at the same height throughout the observations. Observations for the crossing of the Meghnā and Lakhyā rivers were taken on one day each only. The results gave the probable error of observation for the crossing of the Meghnā river as $\pm$ 0·0045 of a foot, and for that of the Lakhyā river as $\pm$ 0·0004 of a foot. Observations were taken on several days at the crossing of the Dhaleswari river, the probable error of observations for this crossing being $\pm$ 0·0034 of a foot.

River crossing by the "Vertical Angles" Method.—The following description of the method employed in carrying a line of levels across the Padmā or Ganges river, at Goalundo, is given *verbatim* from the report by Captain V. R. Cotter, I.A., who was in charge of these operations.

This work was undertaken in February 1913, by Captain V. R. Cotter, assisted by Mr. O. N. Pushong.

The breadth of the river at this part varying from a little over a mile to four miles, it was decided to do the crossing with theodolites.

Two twelve inches theodolites, *viz.*, Nos. 2 and IV, were used. Their micrometer heads were turned through a right angle, so that the wires read vertical arcs, and the value of one division of the micrometer of each theodolite was determined by setting the telescopes to solar focus and comparing their values with the values of the eyepiece micrometer of No. 1 zenith sector. The level values were obtained by means of the level tester in the Dehra Dūn bar room.

On arrival at Goalundo it was found that one of the theodolite pillars was not suitably placed. It was situated about three hundred yards from the river bank, whereas the pillar on the other side was within ten yards of the bank. A new pillar was accordingly constructed on the Goalundo side of the river, also within ten yards of the bank. The atmospheric conditions on both banks were very similar. There was no stretch of sand on either side, and the rays of light from both signals traversed only these strips of ten yards of land, the rest of the course of both rays being over water.

The methods employed differed a little from those employed in former operations of the same nature. Endeavours were made (1) to ensure that the rays of light from both signals should pass through the same strata of air ;

(2) to ensure absolutely simultaneous intersections of the signals by both observers.

To obtain condition (1), experiments were made to see whether it was possible to utilize the object glass of each theodolite as the signal for the theodolite on the opposite bank. The want of illumination inside the observatory tents made this idea impracticable. The signal eventually decided on was a 6-inch heliotrope of which the back was painted with a white mark. This signal was placed on the pillar, over the station mark, the centre of the signal being thus about six inches above the mark.

This meant that there was a space of about three feet six inches between the centre of the axis of each theodolite, and the signal beneath it. The reciprocal rays crossed somewhere about the middle of the river, and diverged to a distance of about this amount.

To obtain condition (2), the following procedure was adhered to—(*a*) Each observer directed his theodolite to a point just a little above or below his signal, clamped the vertical limb, and took the readings of the vertical limb microscopes. (*b*) At a prearranged signal both observers went to their respective theodolities, and read their levels. (*c*) As soon as Captain Cotter saw that Mr. Pushong was behind the theodolite and the position of his legs showed that he had commenced to take intersections, the former commenced to take intersections, with the eyepiece micrometer, continuing to do so until it was evident from the latter's position that he had ceased to observe.

Both observers then read their levels again, and took four extra readings of the limb microscopes. This completed an observation on one face.

Face was changed after every two observations and the face lefts and face rights were combined in pairs to give the data for one value of the difference of height.

Fifty such values were obtained, each of which involved four limb settings. As each limb setting involved an average of eight micrometer intersections, some sixteen hundred intersections were made, *i.e.*, eight hundred to each signal; and although these intersections were not divided so as to be absolutely simultaneous on both sides of the river, they may be correctly described as occupying approximately the same intervals of time.

It should be mentioned here that the distance between the pillars on opposite banks was obtained by triangulation with a 6-inch micrometer theodolite and the mean value found to be 109 chains. The two values obtained differed by less than a foot. As a difference from the true value amounting to one chain would not affect the resulting difference of height, this result was considered as having an accuracy much above the requirements of the work.

After the theodolite observations had been completed, the pillars were connected by levelling to permanent marks adjacent to them.

As such a large number of intersections had been taken, not confined to the time of minimum refraction, but spread over several hours of the day, a careful analysis of the results was made. The results of this analysis appeared to prove :—

(*a*) That the method of observing tended to give practically simultaneous reciprocal observations.

(*b*) That the values of height obtained between the hours of 10 A.M. and 1 A.M. were as good as those obtained at the time of minimum refraction.

(*c*) That the co-efficient of refraction appeared to change momentarily to just as great an extent at the time of minimum refraction as at other times. At the time of minimum refraction it changed in both directions, but at other times it rose or fell regularly.

That the co-efficient of refraction was unusually high, the highest being 0·41 and the lowest 0·10.

A value of the difference of height having a probable error of $= \pm 0{\cdot}0057$ of a foot was obtained by accepting all the observations irrespective of the time of day at which they were carried out. The final value of the difference of height accepted was, however, obtained by weighting the observations according to the apparent behaviour of the atmospheric refraction as disclosed by the simultaneous observations.

The detailed discussion of the results is being deferred for incorporation in a professional paper, after the carrying out of some of the other river crossings which have to be done during the next field season.

Levelling in Darjeeling.—The levelling in Darjeeling District was carried out in the Cantonments of Lebong and Takdah and also in the Happy Valley landslip area within the Darjeeling Municipality.

The object of this work was to supply sufficient spirit-levelled heights to enable the detail Surveyors to lay down contours on the large scale maps of the above areas which were then being surveyed.

The services of Mr. Syed Zille Hasnain who had previously supervised similar levelling for the new capital at Delhi, were temporarily borrowed from No. 16 Party to take charge of the detachment.

The levelling in Lebong Cantonment and the Happy Valley area was based on the Trigonometrical height of Observatory Hill *h. s.* (Darjeeling) taken as 7,162 feet. The levelling in Takdah Cantonment had for its origin the Trigonometrical height of Deoral Danda (Takdah) *h. s.* taken as 6,760 feet.

The general procedure adopted in carrying out all the levelling in the Lebong and Takdah Cantonments and also in the Happy Valley area was practically the same as that employed in the levelling done for the new Capital at Delhi in season 1911-12. The work consisted of circuits and sub-circuits interlaced in such a manner that numerous checks were supplied at short distances and it was impossible for any gross error to have crept into the work without being at once detected. All the precautions generally taken in levelling of precision were duly observed in this work, except that the staves were not guyed. Spirit-levelled heights were given of points at an average distance of about 400 feet apart to enable the contours to be drawn as easily and accurately as possible.

The bench-marks whose heights were determined consisted of (1) marks on parapets of bridges and culverts, (2) marks on boundary pillars, (3) marks on permanent buildings, (4) tops of large wooden pegs firmly driven into the ground, (5) permanent bench-marks which were specially built by the local Engineers and consisted of stone slabs about 9″×9″×6″ with $\overset{\text{G.T.S.}}{\underset{\text{B.M.}}{\text{o}}}$ engraved on them, let into masonry platforms or floors of suitable buildings. The heights of all the bench-marks fixed in the course of the above levelling were computed as the field work progressed, and descriptive lists of all the bench-marks with their heights were prepared. In addition, the position of all the bench-marks were roughly plotted on the existing maps of Lebong, Takdah and the Happy Valley area and their heights were also written alongside their positions. These plots with the descriptive lists of bench-marks were made over to the Director of Surveys, Bihār and Orissa, under whose orders the detail survey was being carried out, as soon as the levelling in each area was finished.

In order to facilitate the identification of the bench-marks by the detail surveyors, every bench-mark was allotted a fractional number, the denominator denoting the number of the section to which the bench-mark belonged and the numerator the serial number of the bench-mark in the section.

For instance $\frac{2}{5}$ denoted the second bench-mark in section number 5.

The numbers were boldly painted in black on the bench-marks by the levellers directly they were connected by levelling. The bench-marks were as far as possible placed in conspicuous positions and in addition, lucid descriptions of the same were prepared and entered in the lists of heights supplied to the Director of Surveys, Bihār and Orissa, with rough plots showing the position of every bench-mark.

Remarks on the country levelled over.—The levelling from Brāhmanbāria to Dacca and thence *viâ* Farīdpur to Barisāl presented unusual difficulties. There is no road for the greater portion of these lines, consequently it was very difficult to transport the camp equipment from one place to another, boats were generally employed and would sometimes have to do a circuit of 25 miles, whereas by travelling straight across country the distance would not perhaps be more than 4 or 5 miles, levelling, however, was taken as directly as possible across country in order to complete the line to Barisāl. Owing to heavy rains experienced in the month of March, the whole country became very swampy and sodden, and it was difficult to carry the levelling forward.

Nearly the whole of this country is under water till well into the cold weather and owing to the alluvial nature of the soil, it is very likely that the bench-marks will settle more or less in the course of a few years.

No. 3 Detachment.

The following programme of work was allotted to the detachment:—

(1) Levelling from Henzada to Bassein, along the Ngawun river embankment, *viâ* Ngawun, Lemyethnā, and Ngathainggyaung.

(2) Levelling from Pegu to Mokpalin, by road, canal tow-path, and railway, *viâ* Thanatpin and Abya, with branch lines to Myitkyo, and Tāwa Locks of the Pegu-Sittang Canal.

(3) Levelling from Prome to Taundwingyi by road, *viâ* Allanmyo.

From Table 1 of this detachment, it will be noticed that there are several discrepancies between the old and revised values of bench-marks at Pegu, which could not be ascribed to errors of levelling for the short distances levelled over. The only way to account for them is to assume that the bench-marks concerned have either risen or settled by the amounts of the differences shown against them.

The check levelling at Prome shows that the standard bench-mark at that place has undoubtedly settled by about 0·04 of a foot.

Outturn of work.—The combined tabular statement of the three detachments shows the outturn of work of the party.

Standard Bench-marks.—The Standard bench-marks at Dacca, Barisāl, and Srīnagar (Kashmīr) were connected during the field season.

Bench-marks in Kashmīr territory.—On all the lines of levelling carried out in Kashmīr territory, that is from Kohāla to Srīnagar and the branch lines previously mentioned, a new type of bench-mark somewhat similar to the Standard bench-marks, was introduced instead of the usual embedded pattern. The bench-mark consisted of a stone block about 1½ feet square and 3 feet high, the upper 8 inches dressed in the form of a frustum of a pyramid terminating in a 4-inch side square. The monolith was embedded in a block of masonry 5 feet square, the upper 2 feet of the stone being above the masonry block. The side of the monolith facing the road was dressed.

The inscriptions on these bench-marks have not been cut uniformly. Some monoliths bear the inscription G.T.S. O B.M. on the top, the others have the letters G.T.S. B.M. cut on the dressed side.

Aluminium Staves.—A pair of aluminium staves were tried on the line Murree to Kohāla. This is the first time that metal staves have been used in this Department. So far they have not been successful. They were used along with a pair of wooden staves in the double levelling from Murree to Kohāla, for a distance of about 18 miles, but as the difference between the results given by the metal and wooden staves was large, it was decided to stop using the aluminium staves until further investigations had been made.

The Superintendent of the Trigonometrical Survey inspected the party at Mussoorie on the 4th August 1913.

TABLE I—No. 1 DETACHMENT.

Tabular Statement of Outturn of Work, Season 1912-13.

Section.	Month.	Number of miles of double Levelling.			Total number of feet.		Number of stations at which instrument was set up.	Number of Bench-marks connected.															Remarks.
								Primary.				Secondary.											
		Line.	Extras and branch line.	Total.	Rises.	Falls.		Rock-cut protected.	Standard.	Principal station of Triangulation.	Old.	Old.	Embedded.	Inscribed.	Rock-cut.	Irrigation.	Railway.	P. W. D.	Stone monoliths.	Zinc-plates.	Revenue survey stations.	Secondary station of Triangulation.	
		Mls. chs. lks.	Mls. chs. lks.	Mls. chs. lks.	Feet.	Feet.																	
Amkhas-Multān	October 1912	1 48 84	2 42 84	4 11 68	15·172	24·497	69	...	...	...	1	10	...	2	...	...	...	...	...	...	...		
	Totals	1 48 84	2 42 84	4 11 68	15·172	24·407	69	...	...	...	1	10	...	2	...	...	...	...	...	...	...	...	
Revision-Multān-Māhiwālā	October 1912	19 20 58	7 42 14	26 62 72	95·269	109·487	355	...	...	...	...	4	3	31	...	4	...	2	...	...	...	...	
	November 1912	22 79 44	6 55 34	29 54 78	176·966	135·625	373	...	...	1	1	1	2	17	...	11	...	...	...	..	...	...	
	Totals	42 20 02	14 17 48	56 37 50	272·235	245·112	728	...	...	1	1	5	5	48	...	15	...	2	...	...	...	...	
Revision-Ambāla-Meerut	November 1912	32 75 24	4 62 46	37 57 70	191·086	208·508	388	...	...	...	1	13	...	20	...	...	...	1	...	...	...	...	
	December 1912	70 04 14	8 29 60	78 33 64	386·704	481·383	766	...	...	1	3	17	1	50	...	6	...	15	...	...	...	...	
	January 1913	22 40 42	2 38 54	24 78 96	93·955	143·657	253	...	...	1	1	2	1	27	...	14	...	3	...	...	...	...	
	Totals	125 39 60	15 50 50	141 10 30	671·744	833·548	1,409	...	...	2	5	32	2	97	...	20	...	19	...	...	...	...	
Revision-Meerut-Delhi	January 1913	45 38 00	8 75 54	54 33 54	377·287	358·139	568	...	...	1	2	0	3	86	...	4	2	7	...	...	...	...	
	Totals	45 38 00	8 75 54	54 33 54	377·287	358·139	568	...	...	1	2	0	3	86	...	4	2	7	...	...	...	...	
Delhi-Muttra	January 1913	20 79 50	0 70 80	21 70 30	263·995	355·184	261	...	...	...	1	7	1	19	3	...	...	3	...	...	...	..	
	February 1913	75 02 24	8 62 58	83 64 82	345·391	452·102	824	...	...	1	1	7	7	62	1	8	...	4	...	...	10	...	
	Totals	96 01 74	9 53 38	105 55 12	609·386	807·286	1,085	...	...	1	2	14	8	81	4	8	...	7	...	...	10	...	
Murree-Srinagar	March 1913	18 38 12	3 57 44	22 15 56	24·315	3852·287	710	1	...	...	2	6	...	...	41*	...	...	...	...	...	...	...	*Includes one that was destroyed after original connection.
	April 1913	79 19 34	1 56 06	80 74 40	4238·341	2581·462	1,492	1	...	...	...	...	...	...	126	...	...	2	11	...	...	...	
	May 1913	58 57 20	1 62 78	60 39 09	1698·781	1015·478	808	...	...	...	...	...	...	31	30	...	...	...	13	...	...	1	
	Totals	156 34 66	7 15 28	163 49 04	5961·437	7449·227	3,070	2	...	...	2	6	...	31	197	...	...	2	23	...	...	1	

TABLE I—(*continued*)—No. 1 DETACHMENT.

Tabular Statement of Outturn of Work, Season 1912-13.

Section.	Month.	Number of miles of double levelling. Line.	Extras and branch lines.	Total.	Total number of feet. Rises.	Falls.	Number of stations at which instrument was set up.	Number of bench-marks connected. Primary. Rock-cut protected.	Standard.	Principal station of Triangulation.	Old.	Secondary. Old.	Embedded.	Inscribed.	Rock-cut.	Irrigation.	Railway.	P. W. D.	Stone monoliths.	Zinc-plates.	Revenue survey stations.	Secondary station of Triangulation.	Remarks.
		Mls. chs. lks.	Mls. chs. lks.	Mls. chs. lks.	Feet.	Feet.																	
Srinagar-Islāmābād	May 1913	25 62 62	8 50 62	34 33 24	388·955	372·929	493	...	...	1	...	...	...	16	5	...	...	...	6	4	...	...	
	June 1913	8 17 96	0 12 70	8 30 66	69·711	59·343	161	...	...	...	...	...	...	2	...	...	...	...	2	5	...	...	
	TOTALS	34 00 58	8 63 32	42 63 90	458·666	432·272	654	...	...	1	...	...	...	18	5	...	...	...	8	9	...	...	
Islāmābād-Pahlgam	June 1913	15 18 80	1 15 16	16 33 96	1040·605	115·867	320	...	...	...	...	...	...	3	4	1	...	...	3	10	...	1	
	TOTALS	15 18 80	1 15 16	16 33 96	1040·605	115·867	320	...	...	...	...	...	...	3	4	1	...	...	3	10	...	1	
Srinagar-Sind Valley	June 1913	19 74 58	0 13 28	20 07 86	833·893	370·256	288	...	...	...	...	...	...	2	4	...	...	...	4	7	...	...	
	TOTALS	19 74 58	0 13 28	20 07 86	833·893	370·256	288	...	...	...	...	...	...	2	4	...	...	...	4	7	...	...	
Srinagar-Bandapur	June 1913	11 58 94	0 25 30	12 04 24	82·690	92·035	142	...	...	...	...	...	...	1	...	...	...	...	3	3	...	...	
	TOTALS	11 58 94	0 25 30	12 04 24	82·690	92·035	142	...	...	...	...	...	...	1	...	...	...	...	3	3	...	...	
Srinagar-Shapiyān	June 1913	11 10 10	1 16 42	12 26 52	395·500	54·495	157	...	...	...	...	...	...	1	...	1	...	...	2	3	...	...	
	TOTALS	11 10 10	1 16 42	12 26 52	395·500	54·495	157	...	...	...	...	...	...	1	...	1	...	...	2	3	...	...	
Revision-Kohāla-Murree	July 1913	18 47 64	4 08 64	22 56 28	3841·131	14·583	614	...	...	...	2†	47†	...	...	2	...	...	...	...	...	...	...	†Bench-marks of original levelling reconnected on revision.
	TOTALS	18 47 64	4 08 64	22 56 28	3841·131	14·583	614	...	...	...	2†	47†	...	...	2	...	...	...	...	...	...	...	
	GRAND TOTALS	577 73 70	73 77 14	651 70 84	14568·746	10707·317	9,104	2	...	6	15	123	18	370	216	49	2	37	43	32	10	2	

TABLE I—(*continued*)—No. 2 DETACHMENT.

Tabular Statement of Outturn of Work, Season 1912-13.

Section.	Month.	Number of miles of double levelling. Line.	Number of miles of double levelling. Extras and Auxiliary.	Number of miles of double levelling. Total.	Total number of feet. Rises.	Total number of feet. Falls.	Number of stations at which instrument was set up.	Number of bench-marks connected. Primary. Interred.	Primary. Standard.	Primary. Old. Principal station of Triangulation.	Primary. Principal station of Triangulation.	Secondary. Old. Embedded.	Secondary. Embedded.	Secondary. Old. Inscribed.	Secondary. Inscribed.	Secondary. Public Works Department.	Secondary. Zinc-plates.	Secondary. Metal bolts in Masonry.	Secondary. Tidal.	Remarks.
		Mls. chs. lks.	Mls. chs. lks.	Mls. chs. lks.	Feet.	Feet.														
Comilla to Chittagong	November 1912	47 18 26	3 18 82*	50 37 08	317·352	317·675	578	...	...	...	1	1	3	3	23	1	6	4	...	*Includes check levelling at Comilla.
	December 1912	51 63 56	3 54 10	55 37 66	453·186	462·339	844	...	1	..	1	...	5	...	41	...	2	5	2	
	TOTALS	99 01 82	6 72 92	105 74 74	770·538	780·014	1,422	...	1	...	2	1	8	3	64	1	8	9	2	
Brāhmanbāria to Dacca.	January 1913	44 02 38	4 05 50†	48 07 88	439·934	452·555	600†	1	...	...	..	1	3	6	17	...	13	1	...	†Includes check-levelling at Brāhmanbāria.
	February 1913	19 00 92	..	19 00 92	131·206	120·708	200	1	1	...	...	...	2	...	8	...	6	...	...	
	TOTALS	63 03 30	4 05 50	67 08 80	571·140	573·263	800	2	1	..	...	1	5	6	25	...	19	1	...	
Dacca to Barisāl	February 1913	18 15 48	...	18 15 48	160·000	161·712	194	...	...	...	...	..	1	...	9	...	2	...	...	
	March 1913	71 79 16	9 03 76	81 02 92	467·475	470·018	853	3	..	1	3	2	7	7	27	...	8	...	...	
	April 1913	69 23 92	6 73 80	76 17 72	466·858	473·225	806	2	...	...	2	...	8	...	27	...	14	2	...	
	May 1913	5 23 32	..	5 23 32	45·261	43·973	66	...	1	...	...	...	1	...	9	...	...	1	...	
	TOTALS	164 61 88	15 77 56	180 59 44	1,139·594	1,148·928	1,919	5	1	1	5	2	17	7	72	...	24	3	...	
	GRAND TOTALS	326 67 00	26 75 98	353 62 98	2,481·272	2,502·205	4,141	7	3	1	7	4	30	16	161	1	51	13	2	

TABLE I—(*concluded*)—No. 3 DETACHMENT.

Tabular Statement of Outturn of Work, Season 1912-13.

Section.	Month.	Number of miles of double levelling: Line.	Extras and Auxiliary.	Total.	Total number of feet: Rises.	Falls.	Number of stations at which instrument was set up.	Number of bench-marks connected: Primary: Old Standard.	Standard.	Secondary: Old Embedded.	Old Inscribed.	Embedded.	Inscribed.	Old Rock-cut.	Rock-cut.	Old P. W. D.	P. W. D.	Old Metal bolts in masonry.	Metal bolts in masonry.	Old Railway.	Railway.	Remarks.
		Mls. chs. lks.	Mls. chs. lks.	Mls. chs. lks.	Feet.	Feet.																
Henzada to Bassein	November 1912	19 57 94	5 03 06	24 61 00	155·175	155·946	310	1	...	2	1	1	...	...	...	12	17	...	...	...	...	
	December 1912	78 69 90	0 22 94	79 12 84	899·418	929·543	999	...	...	...	...	7	57	...	...	...	14	...	...	...	...	
	January 1913	22 17 86	0 04 76	22 22 62	303·731	301·874	344	...	1	..	...	1	6	...	...	...	...	..	2*	...	...	*Tidal B. Ms.
	TOTALS	120 65 70	5 30 76	126 16 46	1358·324	1387·363	1653	1	1	2	1	9	63	...	...	12	31	...	2*	...	...	
Pegu to Mökpalin	January 1913	26 58 26	10 11 86	36 70 12	182·989	183·793	438	1	..	1	8	5	6	...	...	...	...	1	...	1	...	
	February 1913	14 13 70	12 26 30	26 40 00	106·240	104·046	306	..	...	...	...	4	16	...	...	...	1	...	...	...	...	
	TOTALS	40 71 96	22 38 16	63 30 12	289·229	287·839	744	1	...	1	8	9	22	...	...	...	1	1	...	1	..	
Prome to Taundwingyi	February 1913	29 06 70	4 13 14	33 19 84	384·261	383·161	398	1	...		6	2	5	2	1	2	...	...	...	...	...	
	March 1913	60 09 12	0 38 70	60 47 82	2435·427	2088·644	1110	...	...	...	...	5	17	...	2	...	...		...	...	...	
	April 1913	22 39 52	4 00 68	26 40 20	251·423	277·379	322	...	...		...	3	12	...	...	...	...	...	...	...	...	
	TOTALS	111 55 34	8 52 52	120 27 86	3071·111	2749·184	1830	1	...	...	6	10	34	2	3	2	...	...	...	...	..	
	GRAND TOTALS	273 33 00	36 41 44	309 74 44	4718·664	4424·386	4227	3	1	3	15	28	119	2	3	14	32	1	2*	1	...	

TABLE II.—No. 1 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by: Original levelling.	Date.	Check levelling 1912-13.	Difference (Check-Original). The sign + denotes that the height was greater and the sign — less in 1912-13 than when originally levelled.	Remarks.
	Miles.	Feet.	.	Feet.	Feet.	
Check-levelling between Amkhas and Multān City, part of line 55A (Sargodha Khemwālā).						
G. T. S. □ B. M. A. D. 1911. At Amkhas . .	0·0	0·000	1911-12	0·000	0·000	
/\ At Town Hall, Multān City	1·0	+8·709	1911-12	+8·719	+0·010	
G. T. S. O B. M. At mosque at junction of roads, Multān.	1·9	+9·831	1911-12	+9·852	+0·021	
Check-levelling at Multān Cantonment, part of line 55A (Sargodha-Khemwālā).						
G. T. S. × B. M. Embedded at Multān Cantonment.	0·0	0·000	1866-67	0·000	0·000	
G. T. S. O B. M. At barrack No. 1 B. I. Lines, Multān.	0·0	+4·558	1907-08	+4·555	—0·003	
G. T. S. O B. M. At barrack No. 4 B. I. Lines, Multān.	0·1	+2·722	1907-08	+2·723	+0·001	
Standard Bench-mark at Multān .	0·1	+2·406	1907-08	+2·406	0·000	
G. T. S. O B. M. At Steeple Tower, St. Mary's Church, Multān.	0·2	+4·880	1907-08	+4·878	—0·002	
G. T. S. O B. M. At Chaplain's office, St. Mary's Church, Multān.	0·3	+4·199	1907-08	+4·196	—0·003	
G. T. S. O B. M. At Block 28, Station Hospital, Multān.	0·5	+4·361	1907-08	+4·358	—0·003	
G. T. S. O B. M. At Block 26, Station Hospital, Multān.	0·6	+4·159	1907-08	+4·160	+0·001	
G. T. S. O B. M. At N. W. Railway Rest House, Multān.	1·3	+2·780	1907-08	+2·771	—0·009	
G. T. S. O B. M. At West end of main platform, Multān Cantonment Railway Station.	1·2	+6·842	1907-08	+6·832	—0·010	
G. T. S. O B. M. On platform coping opposite main exit, Multān Cantonment Railway Station.	1·4	+6·867	1907-08	+6·853	—0·014	
G. T. S. O B. M. At E. end of main platform, Multān Cantonment Railway Station.	1·5	+6·925	1907-08	+6·910	—0·015	

TABLE II—(*continued*).—No. 1 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks—continued.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by			Difference (Check-Original). The sign + denotes that the height was greater and the sign — less in 1912-13 than when originally levelled.	Remarks.
		Original levelling.	Date.	Check levelling, 1912-13.		
	Miles.	Feet.		Feet.	Feet.	
Revision between Multān and Mahīwālā, part of line 55 A (Sargodha-Khemwālā) and 55 (Murghai-Chach).						
G. T. S. × B. M. Embedded at Multān Cantonment.	0·0	0·000	1866-67	0·000	0·000	
⊕ /\ At Road Bridge over Taliri Nāla.	18·0	—7·840	1866-67	—7·829	+0·011	
⊙ At Mahīwālā G. T. S.	42·3	+26·920	1859-60	+27·086	+0·166*	* Mark-Stone found tampered with.
Check-levelling at Ambāla, part of line 61 (Ferozepore-Meerut).						
901·6/\ At St. Paul's Church, Ambāla.	0·0	0·000	1860-61	0·000	0·000	
+ At R. H. A. Memorial, St. Paul's Church, Ambāla.	0·1	+0·503	1906-07	+0·512	+0·009	
Standard Bench-mark at Ambāla .	0·1	+1·829	1906- 7	+1·820	—0·009	
G. T. S. O B. M. At Block 6, Station Hospital, Ambāla.	0·4	+0·029	1906-07	+0·077	+0·048	
+ On Monument Stone, R. C. Church, Ambāla.	1·2	—3·044	1906-07	—3·046	—0·002	
G. T. S. O B. M. At R. C. Church, Ambāla.	1·1	—3·618	1906-07	—3·611	+0·007	
G. T. S. O B. M. At N. W. end of "B" platform, Ambāla Cantonment Railway station.	1·7	—2·667	1906-07	—2·636	+0·031	
G. T. S. O B. M. At S. E. name-plate of "A" platform, Ambāla Cantonment Railway Station.	1·9	—3·532	1906-07	—3·513	+0·019	
G. T. S. O B. M. At Wesleyan Church, Ambāla.	1·0	+3·704	1905-07	+3·737	+0·033	
G. T. S. O B. M. At Block No. 3 of No. 2 Section Hospital, Ambāla.	1·2	+4·969	1906-07	+5·002	+0·033	
G. T. S. O B. M. At Block No. 2 of No. 2 Section Hospital, Ambāla.	1·2	+4·103	1906-07	+4·133	+0·030	
G. T. S. O B. M. At Block No. 42 (Canteen) R. H. A. Lines, Ambāla.	2·0	+10·090	1906-07	+10·114	+0·024	
G. T. S. O B. M. At Block No. 43 (Sergeant's) R. H. A. Lines, Ambāla.	2·1	+11·484	1906·07	+11·479	—0·005	

TABLE II—(*continued*).—No. 1 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks—**continued.**

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by			Difference (Check-Original). The sign + denotes that the height was greater and the sign— less in 1912-13 than when originally levelled.	Remarks.
		Original levelling.	Date.	Check-levelling, 1912-13.		
	Miles.	Feet.		Feet.	Feet.	
Revision between Ambāla and Meerut, part of line 61 (Ferozepore-Meerut).						
901·6 /\ At St. Paul's Church, Ambāla.	0·0	0·000	1860-61	0·000	0·000	
G. T. S. Stone B. M. at Jagādhri .	30·8	+21·888	1861-62	+22·592	+0·704	
G. T. S. „ „ Amadalpur	35·9	+4·417	1861-62	+5·181	+0·764	
G. T. S. „ „ Sirsāwa.	45·0	—5·182	1861-62	—4·528	+0·655	
G. T. S. „ „ Megh Chapar Falls, Sahāranpur.	52·3	+5·609	1861-62	+6·219	+0·610	
G. T. S Stone B. M. at Bhātkheri .	64·0	—25·550	1861-62	—24·730	+0·820	
G. T. S „ „ Deoband .	76·7	—69·702	1861-62	—68·998	+0·704	
Top of milestone Muzaffarnagar 4, at Rāmpur Village.	88·0	—104·773	1905-06	—103·932	+0·841	
G. T. S. Stone B. M. at Muzaffarnagar.	92·0	—111·638 }* —111·617	1861-62 and 1905-06.	—110·984	+0·654 +0·633	* Two values shown in Vol. XIX B.
Top of milestone Muzaffarnagar 3 .	95·0	—99·669	1905-06	—98·475	+1·194†	†Position of milestone changed.
Ground level mark-stone at Begarazpur G. T. S. Tower Station.	98·8	—85·705	1861-62	—85·088	+0· 17	
G. T. S. Stone B. M. at Khatauli .	105·3	—111·822	1861-62	—111·962	—0·140	
Plinth of Ganges Canal M. S. No. 62	105·5	—114·590	1861-62	—114·037	+0·553	
+ At St. John's Church, Meerut	124·7	—162·342	1861-62	—161·793	+0·547	
Check-levelling at Sahāranpur, part of line 61 (Ferozepore-Meerut).						
G. T. S. Stone B. M. at Megh Chapar Falls, Sahāranpur.	0·0	0·000	1861-62	0·000	0·000	
⊙ At base of M. S. Meerut 71, Muzaffarnagar 38, Sahāranpur 2.	0·6	—1·491	1905-06	—1·472	+0·019	
G. T. S. O B. M. At base of M. S. Meerut 70, Muzaffarnagar 37, Sahāranpur 1.	1·6	—7·751	1905-06	—7·744	+1·007	
G. T. S. O B. M. At well at junction of roads.	2·7	—9·441	1905-06	—9·451	—0·010	
O On top of F. S. 1 between miles 37 and 38 from Muzaffarnagar.	3·0	—10·930	1905-06	—10·932	—0·002	
Standard Bench-mark at Sahāranpur	3·7	—4·521	1905-06	—4·520	+0·001	
G. T. S. O B. M. At church of England, Sahāranpur.	3·7	—4·366	1905-06	—4·353	+0·013	

TABLE II—(*continued*).—No. 1 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks—continued.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by: Original levelling.	Date.	Check-levelling, 1912-13.	Difference (Check-Original). The sign + denotes that the height was greater and the sign — less in 1912-13 than when originally levelled.	Remarks.
	Miles.	Feet.		Feet.	Feet.	

Check-levelling at Muzaffarnagar, part of line 61 (Ferozepore-Meerut).

Ground level mark-stone at Begarazpur G. T. S. Tower Station.	0·0	0·000	1861-62	0·000	0·000	
O On stone prism opposite F. S. 4 between miles 3 and 4 Muzaffarnagar.	3·1	—17·856	1905-06	—17·842	+0·014	
Top of mile 3 from Muzaffarnagar	3·6	—13·964	1905-06	—13·387	+0·577	Position of mile-stone changed.
O At stone prism opposite F. S. 5 between miles 2 and 3 Muzaffarnagar.	4·3	—15·989	1905-06	—15·960	+0·029	
G. T. S. Stone B. M. at Muzaffarnagar.	6·7	—25·912 * / —25·933	1861-62 and 1905-06.	—25·896	+0·016 / +0·037	* Two values shown in Vol. XIX B.
/\ On stone at gate of Town Hall, Muzaffarnagar.	6·9	—12·852	1905-06	—12·840	+0·012	
G. T. S. O B. M. At Sessions Judge's Kachahri, Muzaffarnagar.	7·1	—8·101	1905-06	—8·078	+0·023	
Standard Bench-mark at Muzaffarnagar.	7·4	—8·746	1905-06	—8·724	+0·022	
Top of mile-stone Muzaffarnagar 4 at Rāmpur Village.	10·8	—19·068	1905-06	—18·844	+0·024	

Check-levelling at Meerut, part of line 61 (Ferozepore-Meerut) and of line 62 A (Meerut-Delhi).

+ At St. John's Church, Meerut.	0·0	0·000	1861-62	0·000	0·000	
Standard Bench-mark at St. John's Church, Meerut.	0·1	—1·300	1905-06	—1·305	—0·005	
G. T. S. O B. M. On culvert in Church Street ½ mile S. of St. John's Church, Meerut.	0·6	—3·260	1905-06	—3·244	+0·016	
G. T. S. O B. M. At protecting wall of Catch-water on the Mall, Meerut.	1·4	—1·936	1905-06	—1·963	—0·027	
G. T. S. O B. M. At Suitor's waiting shed at Deputy Commissioner's Kachahri, Meerut.	2·2	—8·826	1905-06	—8·837	—0·011	
Standard Bench-mark at Public Works Department offices, Meerut.	2·5	—7·975	1905-06	—7·994	—0·019	
G. T. S. O B. M. At General Mile Pillar, Meerut.	0·8	—[illegible]	1866-67	—6·644	+0·012	
Ψ At Somru Bridge, Meerut.	1·2	—[illegible]	1866-67	—4·585	—0·009	

TABLE II—(*continued*).—No. 1 Detachment.

Discrepancies between the Old and New Values of Bench-marks—continued.

Description of bench-marks of the original levelling that were connected for check-levelling.		Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by: Original levelling.	Date.	Check-levelling, 1912-13.	Difference (Check-Original). The sign + denotes that the height was greater and the sign — less in 1912-13 than when originally levelled.	Remarks.
		Miles.	Feet.		Feet.	Feet.	
	Revision of line Meerut-Delhi, line 62 A (Meerut-Delhi).						
+	At St. John's Church, Meerut.	0·0	0·000	1861-62	0·000	0·000	
G. T. S. O B. M.	At General Mile Pillar, Meerut.	0·8	—6·656	1866-67	—6·644	+0·012	
ψ	At Sormu Bridge, Meerut	1·2	—4·576	1866-67	—4·585	—0·009	
G. T. S. O B. M.	At well 2½ chs. N. of F. S. 6 between miles 12 and 13, Meerut.	13·5	—21·631	1866-67	—21·726	—0·095	
G. T. S. O B. M.	At bridge over Jalālābād distributary.	19·0	—16·085	1866-67	—16·177	—0·092	
G. T. S. O B. M.	At well 5 chs. N. N. E. of F. S. 2 between miles 25 and 26, Meerut.	25·9	—39·506	1866-67	—38·407	+1·099	None of these B. Ms. were marked by the old levellers and the descriptions were very insufficient so that their identity could not be established with certainty.
G. T. S. O B. M.	At oblique bridge No. 44.	28·2	—40·485	1866-67	—39·542	+0·943	
G. T. S. O B. M.	At well at S. W. corner of Ghāziābād City wall.	30·1	—42·134	1866-67	—42·740	—0·606	
	Standard Bench-mark at Delhi.	41·8	+19·113	1906-07	+19·125	+0·012	
	Check-levelling at Delhi, part of line 62 A (Meerut-Delhi).						
	Standard Bench-mark at Delhi.	0·0	0·000	1906-07	0·000	0·000	
G. T. S. O B. M.	At Beresford Memorial, St. James Church, Delhi.	1·8	—57·176	1906-07	—57·157	+0·019	
G. T. S. O B. M.	At St. James Church, Delhi.	1·8	—58·262	1906-07	—58·243	+0·019	
G. T. S. O B. M.	At Mutiny Memorial, Telegraph office, Delhi.	2·1	—60·839	1906-07	—60·819	+0·020	
G. T. S. O B. M.	At Pirghaib G. T. S. Tower Station, Delhi.	1·0	+29·992	1906-07	+29·995	+0·003	
G. T. S. O B. M.	At King Asoka's Pillar, Delhi.	1·2	+33·437	1906-07	+33·440	+0·003	
B. O. M.	on N. side of Mutiny Memorial Tower, Delhi.	1·4	+34·941	1906-07	+34·943	+0·002	
B. O. M.	on E. side of Mutiny Memorial Tower, Delhi.	1·4	+34·222	1906-07	+34·222	0·000	
G. T. S. O B. M.	Near S. W. Tower of Delhi Railway Station.	1·5	—48·116	1906-07	—48·151	—0·035	
G. T. S. O B. M.	At S. E. Tower of Delhi Railway Station.	1·5	—48·000	1906-07	—48·038	—0·038	

TABLE II—(*continued*).—No. 1 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks—continued.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by — Original levelling.	Date.	Check-levelling, 1912-13.	Difference (Check-Original). The sign + denotes that the height was greater and the sign — less in 1912-13 than when originally levelled.	Remarks.
	Miles.	Feet.		Feet.	Feet.	
G. T. S. O B. M. At R. C. Church, Delhi.	2·0	—51·699	1906-07	—51·700	—0·001	
G. T. S. O B. M. At Lahore gate, Delhi Fort.	1·9	—64·135	1906-07	—64·131	+0·004	
Check-levelling at Muttra, part of line 62 B (Hathras-Muttra).						
Standard Bench-mark at Muttra.	0·0	0·000	1905-06	0·000	0·000	
G. T. S. O B. M. At Muttra Junction Railway Station.	0·2	+21·583	1905-06	+21·561	—0·022	
G. T. S. O B. M. At Dak bungalow, Muttra.	0·0	—7·487	1905-06	—7·504	—0·017	
G. T. S. O B. M. At Culvert at junction of roads, Muttra.	0·8	+5·680	1905-06	+5·690	+0·010	
G. T. S. O B. M. At Muttra Cantonment Railway Station.	1·4	+13·527	1905-06	+13·529	+0·002	
G. T. S. □ B. M. At Muttra Cantonment Railway Station.	1·5	+13·735	1905-06	+13·712	—0·023	
G. T. S. O B. M. At overbridge at S. end of Jumna bridge.	2·1	+1·857	1905-06	+1·864	+0·007	
G. T. S. O B. M. At N end of N. E. abutment of Jumna bridge.	2·4	+1·619	1905-06	+1·634	+0·015	
Check-levelling at Murree, part of line 56 C (Rāwalpindi-Murree).						
G. T. S. O B. M. At Rock near Cantonment Magistrate's office, Murree.	0·0	0·000	1910-11	0·000	0·000	
G. T. S. O B. M. At Rock at St. George's Terrace, Murree.	0·3	—13·806	1910-11	—13·799	+0·007	
G. T. S. O B. M. At Rock at Holy Trinity Church, Murree.	0·4	+7·989	1910-11	+7·994	+0·005	
G. T. S. O B. M. At Rock below Lady Robert's Home, Murree.	0·8	+106·115	1910-11	+106·130	+0·015	
O G. T. S. B. M. At Rock near drain No. 26.	1·6	+15·601	1910-11	+15·625	+0·024	
G. T. S. O B. M. At „ „ „ No. 27.	1·7	—3·491	1910-11	—3·474	+0·017	
G. T. S. O B. M. At Rock between drains Nos. 44 and 45.	2·3	—137·917	1910-11	—137·947	—0·030	
G. T. S. O B. M. At Rock between drains Nos. 540 and 541.	1·9	—380·700	1910-11	—380·691	+0·009	

TABLE II—(*continued*).—No. 2 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks—continued.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by		Difference (Check-Original). The sign + denotes that the height was greater and the sign — less in 1912-13 than when originally levelled.	Remarks.
		Original levelling, 1911-12.	Check levelling, 1912-13.		
	Miles.	Feet.	Feet.	Feet.	
Check-levelling at Comilla, part of branch line 77-F (Gauhāti to Comilla and Chittagong)					
G. T. S. □ B. M. At Comilla Dak bungalow	0·0	0·000	0·000	0·000	
G. T. S. O B. M. At Comilla Railway Station	0·3	+5·187	+5·189	+0·002	
G. T. S. O B. M. At District Board Office, Comilla.	1·3	+4·959	+4·952	—0·007	
G. T. S. O B. M. At Kachahri, Comilla	1·4	+5·578	+5·589	+0·011	
Check-levelling at Brāhmanbāria, part of branch line 77-I (Akhaura to Dacca and Faridpur).					
G. T. S. O B. M. At Brāhmanbāria Inspection bungalow.	0·0	0·000	0·000	0·000	
G. T. S. O B. M. On E. Home Signal at Brāhmanbāria Railway Station.	0·2	+2·210	+2·215	+0·005	
G. T. S. O B. M. At Brāhmanbāria Railway Station.	0·4	+0·715	+0·721	+0·006	
G. T. S. □ B. M. At Brāhmanbāria Railway Station.	0·4	+8·874	+8·871	—0·003	
G. T. S. O B. M. On bridge opposite T. P. No. $\frac{135}{12}$.	1·5	+4·434	+4·436	+0·002	
G. T. S. O B. M. On bridge between T. P. Nos. $\frac{137}{6 \& 7}$.	3·1	+1·792	+1·773	—0·019	
G. T. S. O B. M. On bridge between T. P. Nos. $\frac{138}{5 \& 6}$.	4·1	+0·690	+0·711	+0·021	

TABLE II—(*continued*).—No. 3 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks—continued.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by		Difference (Check-Original). The sign + denotes that the height was greater and the sign — less in 1912-13 than when originally levelled.	Remarks.
		Original levelling, 1911-12.	Check-levelling, 1912-13.		
	Miles.	Feet.	Feet.	Feet.	
Check-levelling at Henzada, part of Provisional line 88 (Prome to Rangoon).					
Standard Bench-mark at Henzada .	0·0	0·000	0·000	0·000	
O On top of a masonry pillar 17 feet N of Shwe Pyaung Byaung Pagoda, Henzada.	0·7	+3·202	+3·213	+0·011	
G. T. S. □ B. M. 1911 Embedded at P. W. D. Inspection bungalow, Henzada.	0·0	—3·933	—3·935	—0·002	
Iron plug in centre of masonry pillar opposite Henzada P. W. D. Inspection bungalow.	0·1	+3·013	+3·010	—0·003	
Iron plug in centre of masonry mile pillar 8.	0·2	+2·871	+2·868	—0·003	
Iron plug in centre of masonry mile pillar 7.	1·2	+3·146	+3·133	—0·013	
G. T. S. O B. M. On zinc-plate on trunk of a Siras tree 294 feet S. E. of F. P. $\frac{6}{3}$.	1·7	—4·266	—4·263	+0·003	
Iron plug in centre of masonry mile pillar 6.	2·2	+3·567	+3·567	0·000	
Iron plug in centre of masonry mile pillar 5.	3·2	+3·902	+3·908	+0·006	
Iron plug in centre of masonry mile pillar 4.	4·2	+4·171	+4·167	—0·004	
Iron plug in centre of masonry mile pillar 3.	5·2	+4·949	+4·947	—0·002	
Iron plug in centre of masonry mile pillar 2.	6·2	+5·716	+5·717	+0·001	
Iron plug in centre of masonry mile pillar 1.	7·2	+5·078	+5·080	+0·002	
Iron plug in centre of masonry mile pillar 0.	8·2	+5·899	+5·882	—0·017	
O /\ On masonry pillar at Ngawun Inspection bungalow.	8·2	+6·258	+6·259	+0·001	
G. T. S. O B. M. 1911 Embedded at P. W. D. Inspection bungalow, Ngawun.	8·3	+1·956	+1·941	—0·015	

Check-levelling at Pegu, part of Provisional line 87 (Elephant Point to Myitkyinā).

TABLE II—(*continued*).—No. 3 Detachment.

Discrepancies between the Old and New Values of Bench-marks—continued.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by		Difference (Check-Original). The sign + denotes that the height was greater and the sign − less in 1912-13 than when originally levelled.	Remarks.
		Original levelling, 1909-10.	Check-levelling, 1912-13.		
	Miles.	Feet.	Feet.	Feet.	
G. T. S. O B. M. On extreme S. end of platform at Pegu Railway Station.	0·9	+1·718	+1·594	−0·124	
G. T. S. O B. M. On platform, in front of main exit, 1st and 2nd class passengers, Pegu Railway Station.	0·8	+1·854	+1·861	+0·007	
G. T. S. O B. M. On centre of platform, about 2 chs. N. of station building at Pegu Railway Station.	0·9	+1·787	+1·799	+0·012	
□ On masonry pillar 4 chs. N. from N. corner of Pegu Railway Station.	0·9	+0·659	+0·687	+0·028	
G. T. S. O B. M. On N. end of platform on Mandalay line of Pegu Railway Station.	1·0	+1·911	+1·919	+0·008	
O B. M. On N. Distant Signal base, Moulmein line of Pegu Railway Station.	1·6	−0·754	—0·738	+0·016	
Rail embedded in Masonry pillar near 1 mile 4 furlongs.	1·3	+23·930	+24·001	+0·071	
B. O. M. On S. parapet of culvert near F. P. 2 mile 2.	2·0	—3·317	—3·314	+0·003	
G. T. S. O B. M. On W. parapet of culvert on road to P. W. D., S. D.O.'s office, Thanatpin.	6·8	—8·632	—8·570	+0·062	
G. T. S. O B. M. Embedded at P. W. D., S. D.O.'s office, Thanatpin.	6·8	—10·591	—10·536	+0·055	

Check-levelling at Prome, part of Provisional line 88 (Prome to Rangoon), 1911-12

Standard Bench-mark at Prome	0·0	0·000	0·000	0·000	
/\ On plinth of Municipal Tank House, Prome.	0·2	—18·163	—18·142	+0·021	
D. P. W. R. L. 93. Bench-Mark Upper Pegu Roads Division } At S. W. corner of compound of Assistant Engineer's house, Prome.	0·3	—25·839	—25·803	+0·036	
O B. M. On rock 312 feet from M. P. 177.	1·1	+5·240	+5·286	+0·047	
G. T. S. O B. M. On trunk of Siras tree 362 feet from F. P. $\frac{174}{5}$.	3·4	—22·892	—22·838	+0·054	
G. T. S. O B. M. On rock 228 feet N. E. of F. P. $\frac{173}{7}$.	4·1	+12·990	+13·055	+0·065	

TABLE II—(*concluded*).—No. 3 DETACHMENT.

Discrepancies between the Old and New Values of Bench-marks—concluded.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (−) starting bench-mark as determined by		Difference (Check-original). The sign + denotes that the height was greater and the sign − less in 1912-13 than when originally levelled.	Remarks.
		Original levelling, 1909-10.	Check-levelling, 1912-13.		
	Miles.	Feet.	Feet.	Feet.	
Check-levelling at Prome, part of Provisional 88 (Prome to Rangoon), 1911-12.					
G. T. S. O B. M. On platform of outer signal lever opposite 3rd class passenger's entrance of Prome Railway Station.	0·6	−23·709	−23·674	+0·033	
G. T. S. O B. M. On plinth of S. W. return-wall of a skew bridge 10 chs. N. E. or main entrance to Shwe Tshan Daw Pagoda.	0·8	−23·760	−23·723	+0·037	
G. T. S. O B. M. On plinth of a rectangular House, S. E. of Shwe Tshan Daw Pagoda.	0·9	−18·454	−18·417	+0·037	
G. T. S. O B. M. On trunk of tree 104 feet N. E. of Mile post 2.	2·4	−5·586	−5·531	+0·055	
G. T. S. O B. M. On trunk of tree 164 feet from Mile post 3.	3·4	+1·572	+1·626	+0·054	

TABLE III.

List of Great Trigonometrical Survey Stations connected by spirit-levelling, Season 1912-13.

Name of station.		Height in feet above mean sea-level by Spirit-levelling.	Height in feet above mean sea-level by Triangulation.	Difference Triangulation-levelling.	Remarks.
		Feet.	Feet.	Feet.	
No. 1 Detachment	Khemwālā T. S., Great Indus Series	408·964*	409·261†	+0·297‡	Height of new mark-stone at ground floor.
	Māhīwālā T. S., Great Indus Series.	428·464	428·298†	−0·166‡	Height of mark-stone at ground floor.
	Dahera T. S., Great Arc Series.	844·047	843·000	−1·047	Ditto ditto.
	Begarazpur T. S., Great Arc Series.	815·626	815·009†	−0·617‡	*Vide* remarks on page 69, height of mark-stone at ground floor.
	Titaora T. S., Great Arc Series.	768·167	Not observed.	...	Ditto ditto.
	Saini T. S., Great Arc Series.	776·958	782·000	+5·042	Ditto ditto.
	Pīrghaib T. S., Great Arc Series.	787·480	787·477†	−0·003‡	Ditto ditto.
	Pāhera T. S., Great Arc Series.	700·248	710·000	+9·752	Ditto ditto.
	Daurā h. s., Kashmīr Series.	5350·008	5356·000	+5·992	Top of mark-stone.
	Reban H. S., Kashmīr Series.	5443·617	5449·000	+5·383	Ditto ditto.
	Islāmābād h. s., Kashmīr Series.	5881·027	5883·000	+1·973	Ditto ditto.
No. 2 Detachment	Bijar Singh T. S., East Calcutta Series.	+44·123	46·07	+1·947	Foundation mark-stone.
	Pākdiba T. S., East Calcutta Series.	+12·218	14	+1·782	Upper mark-stone.
	Jhandi T. S., East Calcutta Series.	+11·798	15	+3·202	Ditto ditto.
	Chandranāth H. S., Burma Coast Series.	+1152·039	1155	+2·961	Ditto ditto.
	Rāmdiha T. S., Brahmaputra Series.	+16·790	18·83	+2·040	Foundation mark-stone.
	Paipāra T. S., Brahmaputra Series.	+23·077	24	+0·923	Upper mark-stone.
	Khānkhānāpur T. S., Brahmaputra Series.	+24·291	27	+2·709	Ditto ditto.
	Gāzilak T. S., Brahmaputra Series.	+19·828	23	+3·172	Ditto ditto.

* Value of new mark-stone.
† Orthometric height as shewn in Volume XIX B of levelling operations.
‡ Difference between old and new spirit levelled values.

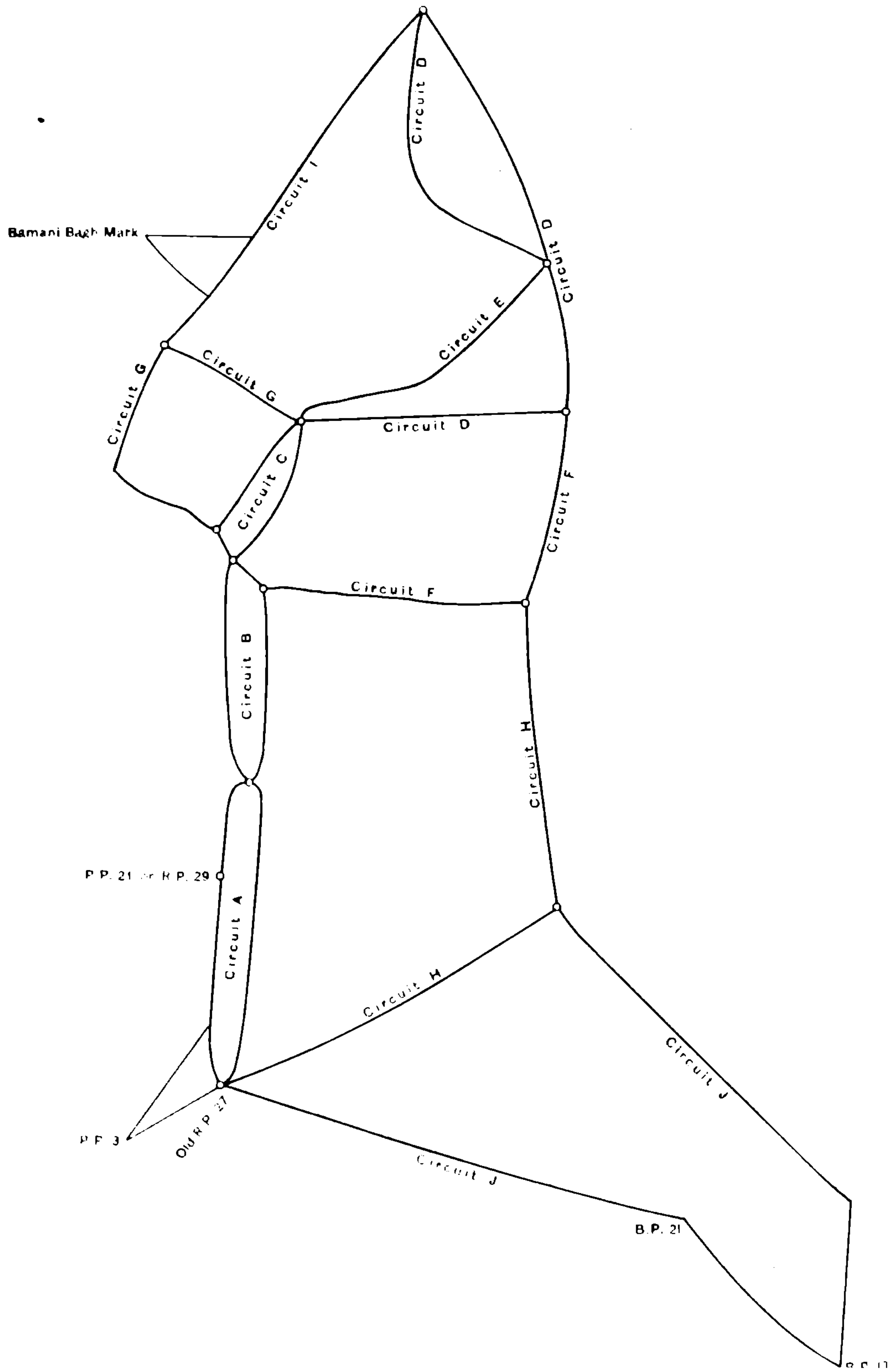
TABLE IV.

Differences between levellers.

No. of detachment.	Section.	Difference.	First—Second.
			Feet.
No. 1 Levelling Detachment.	Line Amkhas-Multān	At 3½ miles or end of line .	−0·005
	Line Multān-Māhīwālā .	„ 42¼ „ „ „ .	+0·071
	Line Ambāla-Meerut .	„ 50th mile . . .	−0·020
	Ditto .	„ 100th „ . .	−0·013
	Ditto .	„ 125¼ miles or end of line .	−0·030
	Line Meerut-Delhi .	„ 45½ „ „ „ .	+0·043
	Line Delhi-Muttra .	„ 50th mile . . .	+0·030
	Ditto .	„ 96th „ or end of line .	+0·054
	Line Murree-Srīnagar	„ 50th „ . . .	+0·102
	Ditto .	„ 100th „ . . .	−0·026
	Ditto .	„ 150th „ . . .	−0·153
	Ditto .	„ 156½ miles or end of line .	−0·140
	Line Srīnagar-Islāmābād .	„ 34th mile „ „ .	−0·019
	Branch Line Islāmābād-Pahlgam.	„ 15¼ miles „ „ .	−0·084
	Branch Line Srīnagar-Bandapur.	„ 11¾ „ „ „ .	−0·037
	Branch Line Srīnagar-Shupiyān.	„ 9¼ „ „ „ .	−0·011
	Branch Line Srīnagar-Sind Valley.	„ 20th mile „ „ .	−0·030
No. 2 Levelling Detachment.	Line Comilla-Chittagong	„ 25th „ . . .	−0·004
	Ditto	„ 50th „ . . .	+0·013
	Ditto	„ 75th „ . . .	+0·048
	Ditto	„ 99th „ or end of line .	+0·071
	Line Brāhmanbāria-Dacca	„ 26th „ . . .	+0·035
	Ditto	„ 63rd „ or end of line .	+0·106
	Line Dacca-Barisāl .	„ 40th „ . . .	+0·032
	Ditto	„ 80th „ . . .	+0·042
	Ditto	„ 122nd „ . . .	+0·048
	Ditto	„ 167th „ or end of line .	+0·077
No. 3 Levelling Detachment.	Line Henzada-Bassein	„ 50th „ . . .	+0·052
	Ditto	„ 120th „ or end of line .	+0·013
	Line Pegu-Môkpalin	„ 41st „ „ „ .	+0·036
	Line Prome-Taungdwi .	„ 50th „ . . .	+0·043
	Ditto .	„ 112th „ or end of line .	−0·061

ROUGH DIAGRAM OF TRAVERSE

(Not to Scale)



APPENDIX.

REPORT ON THE DELIMITATION OF THE BOUNDARY BETWEEN NEPĀL STATE AND NAINĪ TĀL DISTRICT.

BY LIEUTENANT A. A. CHASE, R.E.

A boundary commission assembled in February 1912 to lay down the boundary between Nepāl and Nainī Tāl District. It was found that even if the boundary were correctly laid down in that year it would be almost impossible to lay it down in following years without the assistance of an expert as the boundary was a curved one and did not follow any feature on the ground. In former years it followed the main channel of the Sārdā River but the river has since changed its course.

It was decided therefore to alter the boundary to one of three straight links with a practically even exchange of territory in the alteration.

The Survey of India was asked to lay down on the ground the three straight links as agreed to by both Governments on the Map. As the straight lines were long, and as it was desirable that pillars erected on them should be accurately placed, so that if any were washed away the boundary could again be found on the ground by aligning flags from the nearest two pillars that might remain it was decided to run a preliminary traverse close to the proposed straight links, from the traverse stations of which points on the new boundary could be fixed.

This preliminary traverse was started on the 1st November 1912.

The Commission as noted in the margin assembled on 15th December 1912 and it was decided that day that Lieutenant Chase should proceed, with the assistance of three Foresters, to cut the boundary 20 feet wide and erect pillars at such distances apart as would ensure intervisibility; should erect such reference pillars as he thought advisable; and should make a survey of the boundary to provide for its location in future years; that the British Forest Officers should reassemble to inspect the boundary at the end of February 1913, when it was hoped that the work would be finished.

T. Carr, Deputy Conservator of Forests, Haldwānī Division.
Gulab Rai, Extra Assistant Conservator of Forests, Pilībhīt Division.
H. C. Ross, Special Forest Officer, Tarai and Bhābar Estates.
Lieutenant Basudeva Sharma, Banjanch Naya Mulya Forests, Nepāl.
Lieutenant Chandra Shekar Uppaddiah, Nepāl.

It was now also decided that it would be convenient if the Nepāl representatives remained on the spot with Lieutenant Chase, so that if any points cropped up, he could settle them at once without having to refer to the commission.

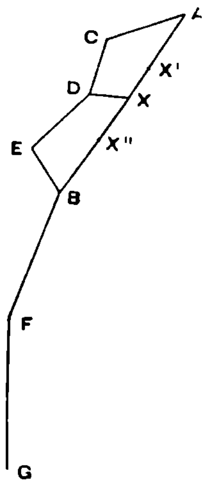
The preliminary traverse noted in paragraph 2 was not finished until the 1st January 1913; the interval, however, was utilized in laying out additional lines of traverse on which the survey would be based.

On 1st January work on cutting the boundary was started and continued up to 7th February by which time a twenty-foot line was cut.

The Commission assembled again on the 25th February and proceeded to inspect the new boundary.

A "Khasra" of the boundary (attached) was then drawn up by Lieutenant Chase, and submitted to the Commission, who accepted it as a true description, and agreed that for local purposes the new boundary would come into force from 1st March 1913.

Method employed in laying down the boundary.



Four points A, B, F and G were shown on the ground as being the ends of the three links agreed upon by the Commission in February 1912.

These points were checked and found to agree with those depicted on the maps agreed to by the two Governments.

These four points were picked up in the preliminary traverse and values were obtained for their co-ordinates.

A glance at the sketch will show that if A and B are the two terminal points of a straight line and A, C, D, E, is a traverse line, A, C, D, and E being traverse stations, it is possible to select any point X on the line A B and find out the distance and bearing of X from the nearest traverse station, say D, by similar triangles.

Thus we select on the map a point X, measure its distance on the map from point A to the nearest chain and then by similar triangles having ascertained the values of the co-ordinates of X we find out the distance D X and the angles C, D, X, and E, D, X.

This procedure was followed right through. The distance D X was computed and then laid out with a theodolite on the ground and then the angles D, X, X′ and D, X, X″ were also computed and laid out, the points X, X′ and X″ being marked by pegs, the distance XX′ and XX″ being about 5 chains. Points similar to X were given to the foresters about a mile apart with instructions to prolong the straight lines XX′ and XX″ until they met similar lines being run by the foresters on either side.

After the line had been cut through by the foresters it was necessary to check the positions of the pegs X to ensure that they had been placed exactly in the line A B. A flag on the position of reference pillar No. 1 described in the Khasra had been placed in prolongation of the line B A, on high ground and visible from any point in the line B A, and with the aid of this Flag it was possible to line up all the pegs between A and B.

In the case of links B, F, and F, G, as shown in the sketch, the lengths of the links being small, from any point in the centre of the link the ends were visible, and it was an easy matter to line up the pegs for Boundary Pillars.

The preliminary traverse being good it was never found necessary to move the pegs X by more than 2 feet in order to bring them into line with the end of the links A, B, F, and G.

The position of reference pillar No. 1 was found by trial and error, moving the theodolite until it was found to be in line with the points A and B.

The positions of the pegs X were selected at such distances apart as would render them suitable as sites for boundary pillars.

It was found that the foresters were not able to prolong and cut straight lines through the jungle for distances much over a mile; over this distance the line was almost invariably deflected to one side or the other.

In practice a 6-foot line was first cut until it met the line from north or south and having ascertained that this was correct the line was broadened to 20 feet.

The positions of the Boundary Pillars from Nos. 1 to 9 as will be seen from the map, lie on islands in the river, and have been chosen so as to give a reasonable chance of most of them remaining for two or three years.

It will be necessary, however, to have the forest line cleared every year and to re-erect any pillars that get washed away.

The positions of such pillars on the ground can easily be located by lining up with flags on to the reference pillar No. 1 which is visible through a telescope from all points on the northernmost link.

The pillars on the centre and southern links stand on ground that has not been inundated for many years and so may be said to be safe.

The ends of these two links, however, are intervisible and re-erection of pillars is therefore a simple matter.

Official description of boundary between Nepāl State and the District of Nainī Tāl.

PREFACE.

The boundary between Nepāl and the District of Nainī Tāl in the United Provinces lies in the midstream of the Sārdā River until the latter bifurcates at a point ¾th mile south of the head works of the Tanakpur Canal.

From this point the boundary runs south in three straight links to the site of the old Reference Pillar No. 27 erected by Mr. Cusson and is now marked by boundary pillar 17.

In the description below these links have been termed the North, Centre and South links. The North end of the North link lies, as stated above, in the midstream of the Sārda River and is marked by the point where the prolongation of the North link cuts the midstream. The Southern ends of these three links are marked by boundary pillars 9, 13 and 17. The Northern ends of the Centre and Southern links are marked by boundary pillars 9 and 13. Along these three links intermediate boundary pillars have been erected at an average distance of a mile apart, and these intermediate pillars are placed so as to be intervisible. The positions of the ends of the links were determined by a Boundary Commission which met in February 1912, and accepted by the Government of India in letter No. 337-F., dated 28th May 1912, to the Resident in Nepāl and by the Nepāl Durbar in a letter from the Prime Minister and Marshal of Nepāl, dated 14th March 1912, to Resident in Nepāl. A reference pillar No. 1 has been erected on the hills north of Baramdeo in prolongation of the north link. This pillar is visible through a telescope from the south end of the north link, *i.e.*, Boundary Pillar 9.

Reference pillars Nos. 2 and 3 have been erected on the sites of Mr. Cusson's reference pillars 38 and 39 to determine the position of Boundary pillar 9 which stands on an island in the Sārdā River. Boundary pillars Nos. 13 and 17 have been erected on the sites of Mr. Cusson's Reference pillars Nos. 33 and 27 and are safe from river erosion.

The bearings given in the Synopsis are reckoned from the North round by East, South and West and the distances recorded are in Gunter's chains of 66 feet divided into 100 links of 7·92 inches.

To guard against the pillars being damaged by animals a circular trench

5 feet wide and 5 feet deep has been dug round them. Boundary pillars 9, 13 and 17 are of the dimensions 10 feet high by 5 feet by 5 feet. Remaining boundary pillars are of dimensions 6 feet high by 4 feet by 4 feet. Reference pillar 1 is of dimensions 20 feet high by 6 feet by 6 feet. Reference pillars 2 and 3 are of dimensions 6 feet high by 4 feet by 4 feet.

All pillars are made in stone or brick masonry as noted in the Synopsis and their numbers are engraved on stone tablets let into the masonry.

Note on the Preliminary Traverse.—The traverse was started from old Reference Pillar No. 27 (now rebuilt and numbered 17) with co-ordinates referred to Sultānpur G. T. S.

The values of these co-ordinates were those taken from the old map published in 1911 and the traverse was run in a series of circuits as shown in the attached diagram. All the old pillars on the boundary were picked up in this new traverse and their co-ordinates thus found differed from those given on the map in every case from a few links up to 2 and 3 chains.

The differences were not constant and it has therefore led to the conclusion that the pillars were not built exactly over the pegs laid down by the traversers.

It is suggested that the traverser drove in pegs one year to mark the position of the pillars and that some time afterwards the pillars were erected.

As the jungle grows in a year up to 15 feet in height it is conceivable that the pegs were not found and that the pillars were built as near as possible to their true positions.

In the demarcation of 1912-13 the pillars were built within a few days of driving in the pegs to mark their positions.

In order to fix the survey geographically, a connection was made to a G. T. S. intersected point Bāmani Bāgh of the North East longitudinal series; page 112, and a connection was also made to p.p. 3 a pillar on the district boundary between Nainī Tāl and Pīlībhīt and p.p. 21 a pillar shown as R. p. 29 on the Sārdā River maps of 1911, picked up in the Tarai Main Traverse of 1887-88, page 5, together with connections to old B. P. 21 and old B. P. 19 picked up on the Pūranpur Tahsil main traverse of 1896, pages 56 and 57.

An attached table shows the difference obtained by bringing the co-ordinates of these to the common origin Sultānpur G. T. S. and it will be seen that the differences are not constant and it has therefore been thought advisable not to insert the Graticules on the 2 inches=1 mile map drawn for publication this year.

No.	Name of Station.	1. Co-ordinates as shown on the map of Sārda river of 1911. Origin Sultānpur, G. T. S.		2. Co-ordinates as found from the new Traverse of 1912-13. Origin old R. P. 27 with co-ordinates as shown in column 1.		3. Co-ordinates from the Terai Traverse of 1887-88-89. Origin Danau, G. T. S. Converted to origin Sultānpur, G. T. S.		4. Purānpur Tehsil Traverse by Land Records Department in 1896. Origin λ 28° 0′ 0″ L 79° 57′ 32·82″. Converted to origin Sultānpur, G. T. S.		5. Co-ordinates as found from λ and L given on p. 412 of the Syn. Volume XXXV, N. E. Longitudinal Series Bāmani Bāgh, λ. 28° 59′ 37·5″ L. 80° 04′ 21·90″		6. Differences from the new Traverse of 1912-13.	
		Meridian.	Perpendicular.	Meridian.	Perpendicular.	Meridian.	Perpendicular.	Meridian.	Perpendicular.	Meridian.	Perpendicular.	Meridian.	Perpendicular.
1	Bāmani Bāgh Mark	...	...	N. 3157·96	W. 1159·45	...	...	...	...	N. 3167·76	W. 1160·24	−9·80	−0·79
2	R. P. 27	N. 2302·12	W. 1190·95	...	...	...	...	...	...	...	...	...	...
3	P. P. 3	...	...	N. 2293·65	W. 1198·83	N. 2298·00	W. 1202·97	...	...	...	...	−4·35	−4·14
4	P. P. 21	...	...	N. 2515·62	W. 1162·50	*N. 2519·80*	*W. 1166·79*	...	...	...	...	−4·18	−4·29
5	B. P. 19	...	...	N. 2169·80	W. 834·75	...	...	N. 2170·70	W. 834·14	...	...	−0·90	+0·61
6	B. P. 21	...	...	N. 2253·48	W. 932·64	...	...	N. 2254·08	W. 932·12	...	...	−0·60	+0·52

No. 3 is found on page 5, Tarai Traverse, 1887-88-89 main circuits.
No. 4 „ „ „ „ „ „ „ „ „ „

Sultānpur, G. T. S. λ 28° 25′ 08·16″ L 80° 18′ 44·30″

No. 5 will be found on page 57, Pūranpur Tahsil, main circuit volume, by Land Records Department.
No. 6 will be found on page 56, Pūranpur Tahsil, main circuit volume, by Land Records Department.

MAGNETIC SURVEY.

No. 18 PARTY.

(*Vide* Index Map 11.)

BY CAPTAIN R. H. THOMAS, R.E.

The present report deals with the work of the magnetic survey in 1912-13; it comprises :—

I. An account of the work in the field and recess quarters.

II. A note on the observatories during 1912-13.

III. Tables of results including :—

(*a*) Preliminary values of the magnetic elements at field and repeat stations.

(*b*) Diurnal variation and inequality of the magnetic elements at each of the four survey base stations.

An index chart showing the progress of the magnetic survey is appended.

PERSONNEL.

Imperial officer.
Captain R. H. Thomas, R.E., in charge.

Provincial officers.
Messrs. H. P. D. Morton, R. P. Ray, N. R. Mazumdar and R. B. Mathur.

Upper Subordinate Service.
Mr. B. B. Shome, from 1st July 1913.

Lower Subordinate Service.
19 Recorders, Surveyors, etc.

I.—FIELD OPERATIONS AND RECESS WORK IN 1912-13.

1. *Work of the field detachments.*—The field season opened on October 23rd, 1912, and closed at the end of April 1913.

The health of the party was on the whole satisfactory, but one Provincial officer was invalided from the field, and at Barrackpore observatory both the observer and recorder had to be relieved owing to severe attacks of malaria, which is always prevalent in the rainy season.

Two field detachments each under a Provincial officer were employed partly on detail survey and revision of the work of the first field season (1901-02) and partly on observations at repeat stations.

The revision work was taken up chiefly because there is some considerable uncertainty as to the correct values to be assigned to the magnetic moments of the field magnets during this first field season, no comparisons of instruments having been made until the beginning of the following season when considerable changes of moment were found in some cases to have meanwhile occurred; there were also changes in the values of P and Q in each instrument which cannot be satisfactorily determined owing to the small number of observations; and finally only one observatory, *viz.*, at Colāba, was working so that the corrections for diurnal variation and disturbance are somewhat uncertain.

2. *Field work of the officer in charge.*—The officer in charge inspected Barrackpore and Toungoo observatories where comparisons of instruments were made, visited several repeat stations and carried out a preliminary magnetic survey of Ceylon.

3. *Field work during 1912-13 and total work to date.*—During the field season full sets of magnetic observations were made at the following:—

58 repeat stations,
19 old stations, revised,
42 new stations in Ceylon,
3 new stations in India,
20 detail stations in Central India.

The total work of the magnetic survey to date includes—

1,401 stations of the fundamental survey.
371 detail survey stations.
73 repeat stations.

Under repeat stations are included observations at the old field stations which were marked by pillars in 1910-11; these number 50 and with the original 23 repeat stations make 73 in all or 1 repeat station to 20 stations of the fundamental survey.

It is intended to re-occupy these stations, with the addition of others as may be found desirable, every year or every second year according to the means available.

4. *Work during recess.*—The computation of the field work and the reduction and tabulation of the results from the base stations for 1912 have been completed.

This year, for the first time, the tabulations are based on the measurements of all available days instead of only five quiet days per month as heretofore.

Reduction of the declination data.

Good progress has been made with the reduction of the declination data of the survey, upon which one section under a provincial officer has been engaged throughout the year.

Corrections for diurnal variation have been applied to all observations up to 1912; corrections for disturbance have been also computed for each observation from each of the four survey base stations for the same period. The latter corrections are for the most part small and of the same order of magnitude as the observational error, but the signs often vary so that the total range may be two or three times this amount. It seems unlikely that any simple law can be found to connect the computed disturbances with geographical co-ordinates, at any rate when dealing with one magnetic element only and such limited investigation as was warranted by the small magnitude of the computed corrections confirms this view; corrections will be therefore applied as found from the nearest observatory or observatories.

Instrumental differences in H. F.

The investigation of the instrumental differences in H. F. has been practically completed, but before finally accepting the conclusions arrived at, it has been decided to carry out an extended comparison of all the survey instruments using different thermometers with each instrument and interchanging observers; the moment of inertia of all the magnets will also be carefully redetermined. This work has been unavoidably delayed for several months owing to the chronograph at Dehra Dūn being out of order. Further investigation has shown that the views expressed in the report for 1910-11, regarding possible changes in the distribution coefficients, require some modification; in one case an undoubted change in P and Q equivalent to a change in H F of 7γ occurred without a concomitant fall in the magnetic moment; this change is shown by the observations at 22·5, 30 and 40 cms. but had previously been overlooked, when changes of P and Q were only expected when large falls in m_0 occurred, as the change occurred during the last season in which the instrument in question was used.

Comparisons of Dehra Dūn standards with instruments of the De Filippi expedition.

The instruments of the De Filippi expedition were compared with the Dehra Dūn standards early in September 1913. Both sets of instruments were found to agree well in declination and dip, but the results in Horizontal Force were unsatisfactory owing to defects in the De Filippi magnetometer.

5. *Programme for 1913-14.*—During the ensuing field season field work will be confined to observations at repeat stations for the determination of secular changes and comparisons of instruments at observatories; this work will occupy one detachment for the whole field season, the other for two to three months.

The detail survey will be discontinued for the present and the available strength of the party will be employed on the reduction of the data already accumulated; the detail survey can be subsequently continued if considered desirable.

6. *Results published in this report.*—Tables showing the approximate values (uncorrected) of the magnetic elements at the field and repeat stations in 1912-13 are appended together with an index chart showing the progress of the magnetic survey to date.

The tabulation of the results from "all available days" at the four survey base stations are published for 1912.

II.—THE OBSERVATORIES IN 1912-13.

A.—DEHRA DŪN OBSERVATORY.

1. The observatory remained in charge of magnetic observer Shri Dhar until the beginning of July 1913 when he proceeded on leave, being relieved by Mr. R. P. Ray.

The H. F. and declination magnetographs have worked well throughout the year; the V. F. magnetograph is still somewhat unsatisfactory; some further adjustment in the relative positions of the knife edge and agate plane seems desirable as this has been found beneficial in the other instruments.

The two absolute houses were thoroughly repaired during May and June 1913 and roofed with ruberoid.

2. *Mean values of constants.*- The table below gives the mean monthly values of magnetic collimation, the distribution co-efficients $P_{1\cdot2}$ and $P_{2\cdot3}$ and the observed and accepted values of m_0 used in the computations for 1912. Included in the table are the monthly mean values of m_0 as determined using the chronograph for the vibration observations; the range in these values is somewhat larger than was expected but the means are derived from at most observations on two days and experience with the field instruments has shown that this is insufficient for a satisfactory determination.

Mean values of the constants of the magnetometer No. 17 in 1912.

Months.	Declination constants. Mean magnetic collimation.	H. F. constants. Mean values of P's. $P_{1\cdot2}$	$P_{2\cdot3}$	Accepted value of $P_{1\cdot2}$	Accepted value of $P_{2\cdot3}$	Mean value of mo. By eye and ear.	By chronograph.	Accepted Mo.	Remarks.
January	—9′: 23″	7·14	7·76	7·17 throughout.	7·80 throughout.	893·05	893·35	893·23 throughout.	
February	—9′: 26″	7·18	7·68			893·32	893·27		
March	—9′: 22″	7·24	7·76			892·83	893·27		
April	—9′: 22″	7·21	7·56			892·73	...		
May	—9′: 20″	7·21	7·71			892·46	...		
June	—9′: 21″	7·15	7·59			892·48	...		
July	—9′: 24″	7·39	7·66			892 98	893·18		
August	—9′: 24″	7·45	7·92			892·90	893·13		
September	—9′: 28″	7·24	7·63			892·76	893·14		
October	—9′: 25″	7·25	7·64			892·98	893·26		
November	—9′: 20″	7·28	7·57			892·93	893·30		
December	—9′: 24″	7·22	7 85			893·08	893·35		

3. *Mean Base line values.*—The table below gives the monthly mean values of the declination and H. F. base lines actually used to obtain the values of H. F., etc., in the tables attached to this report.

Base line value of magnetographs in 1912.

Months.	Declination. Mean value of Base line.	Accepted Base line.	Remarks.	Horizontal Force. Mean value of Base line.	Accepted Base line.	Remarks.
	° ′	° ′				
January	1 : 45·1	1 : 45·		·33010	·33010	
February	1 : 45·1	1 : 45·1		·33012	·33012	
March	1 : 45·2	1 : 45·2		·33013	·33013	The Magnetographs were dismantled on May 22nd for repairs to the observatory.
April	1 : 45·4	1 : 45·4		·33013		
May	1 : 45·5	1 : 45·5		·33013		
June	1 : 30·2	1 : 30·2		Falling rapidly.	·32892 to ·32838	from 11th June to 15th on 25th October.
July	1 : 30·4	1 : 30·4				
August	1 : 30·6	1 : 30·6				
September	1 : 30·7	1 : 30·7				
October	1 : 30·8	1 : 30·8				
November	1 : 31·1	1 : 31·1			·32937 to ·32916	From 16th on 25th October when the H. F. instrument was readjusted.
December	1 : 30·6	1 : 30·6				

4. The mean scale values for 1912 for an ordinate of 1·25 inch were as follows :—

H. F. 4·12γ to May.
4·52γ from June 10th to October 25th.
4·47γ from October 25th.
D. 1·03.
V. F. 4·20 to 6·51γ.

A new quartz fibre was mounted in the H. F. magnetograph on June 10th, and the torsion head was turned on October 25th.

The mean temperature for the year was 27°.0 C with maximum and minimum values of 27°.2 C and 26°,9 C. The temperature of reduction is 27°.C.

5. *Mean monthly values and secular change, 1911-12.*—The following table gives the mean monthly values of the magnetic elements for 1911-12 and the secular change during that period.

Secular changes at Dehra Dūn in 1911-12.

MONTHS.	HORIZONTAL FORCE ·33000 C. G. S. +			DECLINATION E. 2° +			DIP N. 43° +			VERTICAL FORCE ·32000 C. G. S. +		
	1911.	1912.	Secular change.	1911.	1912.	Secular change.	1911.	1912.	Secular change.	1911.	1912.	Secular Change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . .	240	224	—16	30·5	27·2	—3·3	58·9	66·1	+7·2	078	198	+120
February . .	238	225	13	30·2	27·0	3·2	59·8	66·1	6·3	094	199	+105
March . .	246	226	20	30·3	26·7	3·6	59·7	67·0	7·3	100	217	+117
April . . .	241	224	17	30·0	26·5	3·5	60·7	66·9	6·2	114	213	+099
May . . .	243	220	23	29·5	26·5	3·0	61·4	68·0	6·6	130	231	+101
June . . .	247	224	23	29·3	25·6	3·7	62·0	67·8	5·8	143	229	+086
July . . .	243	226	17	29·0	25·7	3·3	62·4	68·5	6·1	147	245	+098
August . .	241	212	29	28·8	25·3	3·5	62·9	69·5	6·6	154	250	+096
September . .	235	214	21	28·4	25·3	3·1	62·7	70·7	8·0	146	274	+128
October . .	229	208	21	28·3	25·2	3·1	63·9	71·5	7·6	163	285	+122
November . .	231	209	22	28·0	25·2	2·8	64·6	71·8	7·2	176	291	+115
December . .	222	203	19	27·6	24·4	3·2	65·3	72·4	7·1	181	296	+115
Means . .	238	218	—20	29·2	25·9	—3·3	62·0	68·9	+6·9	136	244	+108

B.—BARRACKPORE OBSERVATORY.

1. Magnetic observer K. N. Mukerjee remained in charge until early in October 1913 when he proceeded on sick leave. The observatory is extremely unhealthy during the rainy season when malaria of a severe type is prevalent; during this year the whole of the observatory staff were in turn incapacitated from duty.

The declination and H. F. magnetographs worked well during the year while the vertical force instrument was much more satisfactory, the changes in base line which are inevitable in this class of instrument being much more uniform.

2. *Mean values of constants.*—The following table gives the monthly mean values of magnetic collimation, the distribution co-efficients of $P_{1\text{-}2}$ and $P_{2\text{-}3}$ and the moment m_0 of the observatory magnetometer in 1912.

Mean of the Constants of the magnetometer No. 20 in 1912.

MONTHS.	DECLINATION CONSTANTS. Mean magnetic collimation.	H. F. CONSTANTS. Mean values of P's. $P_{1\text{-}2}$	$P_{2\text{-}3}$	Accepted value of $P_{1\text{-}2}$	Accepted value of $P_{2\text{-}3}$	Mean values of m_0	Accepted m_0	REMARKS.
January	—8′ : 0″	6·97	7·57			939·87		
February	—7 : 51	6·98	7·47			939·57		
March	—7 : 47	6·84	7·50			939·63		
April	—7 : 47	6·80	7·37			939·80		
May	—7 : 45	6·86	7·56			939·82		
June	—7 : 46	6·89	7·53	6·82 throughout.	7·61 throughout.	940·07	939·72 throughout.	
July	—7 : 43	6·86	7·50			939·59		
August	—7 : 47	6·95	7·28			940·01		
September	—7 : 50	6·92	7·42			939·90		
October	—7 : 45	6·91	7·22			939·79		
November	—7 : 47	7·01	7·21			940·27		
December	—7 : 53	6·89	7·36			939·77		

3. *Mean values of Base Lines.*—The table below gives the mean monthly base lines of the declination and H. F. instruments used in the computations.

Base line value of the Magnetographs in 1912.

MONTHS.	DECLINATION. Mean value of Base line.	Base line accepted.	REMARKS.	HORIZONTAL FORCE. Mean value of Base line.	Base line accepted.	REMARKS.
	° ′	° ′				
January	−0 : 3·9			·37060	·37060	
February	−0 : 3·9	−0 : 3·9		·37062	·37062	
March	−0 : 3·9			·37061	·37061	Up to 22nd March.
April	−0 : 4·2			·37072		From 23rd March.
May	−0 : 4·1			·37083	·37063 to ·37094	
June	−0 · 4·1			·37083		
July	−0 : 4·2			·37095		
August	−0 : 4·1	−0 : 4·1		·37084	·37095	
September	−0 : 4·1			·37094	·37095	
October	−0 : 4·1			·37093		
November	−0 : 4·1			·37034	·37094 to ·37078	
December	−0 : 4·1			·37078		

4. *Mean scale value and temperature range.*—The mean scale values for the year for an ordinate of 1/25 inch were :—H. F. 4·86γ V. F. 4·64γ and D. 1·03 minutes. The mean temperature for the year was 31°·6 C with maximum and minimum monthly values of 32°·8 C and 30°·5 C : the temperature of reduction is 31° C.

5. ***Mean monthly values and secular change.***—The following table gives the mean monthly values of the magnetic elements for 1911-12 and the secular change during that period.

Secular changes at Barrackpore in 1911-12.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S.+.			DECLINATION E. 0°+.			DIP N. 30°+.			VERTICAL FORCE ·22000 C. G. S.+.		
	1911.	1912.	Secular change.	1911.	1912	Secular change.	1911.	1912.	Secular change.	1911.	1912.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . .	321	354	+33	52·3	46·8	−5·5	43·1	49·0	+5·9	175	283	+108
February . .	327	361	34	52·0	46·4	5·6	43·5	49·1	+5·6	185	287	102
March . . .	339	365	26	51·7	45·7	6·0	44·0	49·0	5·0	199	289	090
April . . .	336	369	33	51·2	45·1	6·1	44·5	49·9	5·4	205	304	099
May . . .	335	373	38	50·7	44·7	6·0	44·4	50·4	6·0	203	315	112
June . . .	342	376	34	50·0	44·1	5·9	45·1	50·3	5·2	217	314	097
July . . .	337	373	41	49·7	43·6	6·1	45·5	50·9	5·4	220	325	105
August . . .	336	369	33	49·4	43·4	6·0	46·2	51·1	4·9	230	322	092
September . .	334	372	38	48·9	42·6	6·3	47·0	51·7	4·7	240	333	93
October . .	335	371	36	48·2	42·4	5·8	47·4	52·1	4·7	247	338	91
November . .	346	370	24	47·8	41·6	6·2	47·4	52·2	4·8	254	339	85
December . .	351	374	23	47·3	41·2	6·1	47·6	52·5	4·9	260	346	86
Means . . .	337	369	+32	49·9	44·0	−5·9	45·5	50·7	+5·2	220	316	+96

C.—TOUNGOO OBSERVATORY.

1. Surveyor K. K. Dutta held charge of the observatory throughout the year.

The H. F. and declination magnetographs have worked well throughout the year; the readjustment of the V. F. instrument referred to in last year's report has also proved satisfactory.

2. *Mean values of declination and H. F. constants.*—The table below gives the mean monthly observed values of magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and the magnetic moment m_0.

The change of collimation in December is due to the replacement of one of the aluminium cells of the collimator magnet; the lens of the old cell had become almost opaque owing to decomposition of the cement joining the two portions of the lens and it is probably to this cause that the previous fluctuations of the value of collimation are to be ascribed.

The new cell necessitated a redetermination of the moment of inertia; the new value agreed with that deduced from comparisons with one of the field instruments before and after the change

Mean values of the constants of the Magnetometer No. 19 in 1912.

Months.	Declination constants. Mean magnetic collimation.	H. F. Constants. Mean values of P's. $P_{1\text{-}2}$	$P_{2\text{-}3}$	Accepted value of $P_{1\text{-}2}$.	Accepted value of $P_{2\text{-}3}$.	Mean values of m_o.	Accepted m_o.	Remarks.
	″							
January . . .	−2 : 27	8·39	9·45	8·41 throughout.	9·50 throughout.	886·56	886·56	
February . . .	−2 : 58	8·44	9·51			885·07		
March . . .	−3 : 10	8·41	9·36			885·26	885·15	Up to 7th May.
April . . .	−3 : 1	8·41	9·56			885·08		
May . . .	−2 : 55	8·42	9·54			885·00		
June . . .	−3 : 10	8·46	9·32			884·89		
July . . .	−3 : 13	8·38	9·54			884·69	884·87	From 9th May.
August . . .	3 : 24	8·41	9·51			884·90		
September . .	−3 : 26	8·33	9·46			884·81		
October . . .	−3 : 21	8·31	9·73			884·62	884·62	
November . .	−3 : 25	8·33	9·71			8844·7	884·47	
December . . .	−3 : 37 (1)	8·31	9·48			884·47		(1) Up to 12th December.
	−9 : 21 (2)							(2) From 13th December.

3. *Mean Base Line values.*—The following table gives the mean monthly values of the observed and accepted values of the declination and H. F. magnetographs.

The observed values of H. F. base line require a correction of -19γ to reduce them to magnet 19 which was in use in the earlier years of the observatory.

The remaining differences between the observed and accepted values of the H. F. base lines are undoubtedly due to indifferent observations ; it is probable that the vibration observations are chiefly at fault and that the observed mean values of m_o are burdened with variable " personal errors."

The accepted Base lines have been derived from comparisons with No. 10 in December 1912 and 1913 and for the present the change during that period has been accepted as uniform.

Base line values of the magnetographs in 1912.

Months.	Declination. Accepted Base line.	Remarks.	Horizontal Force. Mean value of Base line.	Accepted Base line.	Remarks.
January . . .	−0 : 29·7		·38441	·38460	
February . . .			·38449	·38457	
March . . .			·38456	·38455	
April . . .			38463	·38452	
May . . .	−0 : 29·7	Up to 14 h on 21st.	·38463	·38450	
	−0 : 31·0	From 15 h on 21st.			
	−0 : 32·4	From 8 h 30m on 24th.			
	−0 : 31·6	From 11 h 21m on 31st.			

Base line values of the magnetographs in 1912—continued.

Months.	Declination.		Horizontal Force.		
	Accepted Base line.	Remarks.	Mean value of Base line.	Accepted Base line.	Remarks.
	° ′				
June . . .	} —0 : 31·6		·38465	·38447	
July . . .			·38464	·38445	
August . . .			·38468	·38442	
September . .			·38472	·38440	
October . . .			·38465	·38437	
November . .			·38478	·38435	
December . .			·38475	·38432	

4. *Mean scale values and temperature range.*—The mean scale values throughout the year for an ordinate of 1·25 inches were:—

H. F. 5·43γ

V. F. 4·01 to 5·70γ

Declination 1·04 minutes.

The mean temperature for the year was 89°·2 F. with maximum and minimum monthly values of 89°·5 and 88°·9; the temperature of reduction is 89°F.

5. *Secular change 1911-12.*—The annexed table gives the mean monthly values of the magnetic elements for 1911-12 and the secular change during that period.

Secular changes at Toungoo in 1911-12.

Months.	Horizontal Force ·38000 C. G. S. +			Declination E. 0° +			Dip. N. 23° +			Vertical Force ·16000 C. G. S. +		
	1911.	1912.	Secular change.	1911.	1912.	Secular change.	1911.	1912.	Secular change.	1911.	1912.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . .	833	863	+30	21·8	16·2	—5·6	2·4	2·6	+0·2	515	531	+16
February . .	836	873	+37	21·3	15·7	5·6	2·5	2·9	+0·4	519	540	21
March . . .	849	880	+31	21·2	15·1	6·1	2·6	2·7	+0·1	525	540	15
April . . .	848	878	+30	20·7	14·5	6·2	2·7	2·7	0·0	526	539	13
May . . .	845	878	+33	20·0	14·2	5·8	3·0	2·9	−0·1	528	541	13
June . . .	858	896	+38	19·7	13·8	5·9	3·3	2·6	—0·7	538	544	6
July . . .	860	901	+41	19·0	13·3	5·7	3·2	3·2	0·0	537	554	17
August . .	858	891	+33	18·5	12·8	5·7	3·0	2·6	−0·4	534	543	9
September . .	856	896	+40	18·1	12·1	6·0	2·7	2·5	—0·2	530	543	13
October . .	860	901	+41	17·6	11·8	5·8	3·8	2·7	−1·1	546	548	2
November . .	866	905	+39	17·0	11·1	5·9	3·7	4·1	+0·4	548	569	21
December . .	861	907	+46	16·5	10·7	5·8	2·9	5·2	+2·3	535	585	50
Means . . .	853	889	+36	19·3	13·4	−5·9	3·0	3·1	+0·1	532	548	+16

D.—KODAIKĀNAL OBSERVATORY.

1. S. S. Ramaswami Iyengar was in charge throughout the year.

The magnetographs have given good results during the year.

Thanks are due to the Director, Solar Physics Observatory, for his cordial assistance in all matters connected with the magnetic work.

2. *H. F. and declination constants.*—The following table gives the mean monthly values of magnetic collimation, the distribution constants $P_{1 \cdot 2}$ and $P_{2 \cdot 3}$ and the accepted values of the magnetic moment m_0.

The change in m_0 after the 29th February altered the values of the collimation and the distribution constants.

Mean values of the Constants of the Magnetometer No. 16 in 1912.

MONTHS.	DECLINATION CONSTANTS.	H. F. CONSTANTS.					REMARKS.
	Mean magnetic collimation.	MEAN VALUES OF P'S.				Accepted m_0.	
		$P_{1 \cdot 2}$.	$P_{2 \cdot 3}$.	Accepted value of $P_{1 \cdot 2}$.	Accepted value of $P_{2 \cdot 3}$.		
	′ ″						
January	—2 : 37	6·93	8·12	·92(1) (January–February)	8·34 throughout.	917·36	(1) Up to 28th February.
February	—2 : 34	6·94	8·35			917·36	
March	—3 : 13	6·79	8·48	6·68(2) (March–December)		From February 29th to the end of September m_0 fell from 917·36 to 885·49.	
April	—3 : 35	6·73	8·55				
May	—3 : 41	6·74	8·20				
June	—3 : 27	6·75	8·46				
July	—3 : 25	6·78	8·18				
August	—3 : 30	6·62	8·21				(2) From 29th February.
September	—3 : 32	6·55	8·30				
October	—3 : 28	6·72	8·54			885·49 (October–December)	
November	—3 : 33	6·75	8·38				
December	—3 : 31	6·76	8·20				

3. *H. F. and Declination Base line values.*—The following table gives the mean monthly values of the accepted base lines used in computing the monthly values.

Both H. F. and Declination magnetographs were adjusted on 28th February 1912.

Base line values of the magnetographs in 1912.

MONTHS.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of Base line.	Base line accepted.	REMARKS.	Mean value of Base line.	Base line accepted.	REMARKS.
	° ′					
January	1 : 33·2	1° : 33·2 to 8h on 28th February. 1 : 58·6 from 12h on 28th February.			·36936	
February	1 : 33·1				36935	To 8h on 28th February.
March	1 : 58·6				·37190	From 9h on 28th February.
April	1 : 58·5				·37190	Both the H. F. and Declination Magnetographs were adjusted on 28th February 1912.
May	1 : 58·6				·37191	
June	1 : 58·6				·37191	
July	1 : 58·6				·37192	
August	1 : 58·6				·37192	
September	1 : 58·4				·37192	
October	1 : 58·7				·37193	
November	1 : 58·7				·37193	
December	1 : 58·5				·37193	

4. The mean scale values for 1912 for an ordinate of 1·25 inches are:—

H. F. 6·14γ

6·01γ after readjustment on 28th February 1912.

V. F. 4·97 to 5·34γ

Declination 1·03 minutes.

The mean temperature of the H. F. and V. F. magnetographs for the year was 18°·2C with maximum and minimum monthly values of 18°·7C and 17° 7C: the temperature of reduction is 19°C.

5. *Secular change 1911-12.*—The table below gives the monthly mean values of the magnetic elements for 1911-12 and the secular change during that period.

Secular changes at Kodaikānal in 1911-1912.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S. +			DECLINATION W. 1° +			DIP. N. 3° +			VERTICAL FORCE ·02000 C. G. S. +		
	1911.	1912.	Secular change.	1911.	1912.	Secular change.	1911.	1912.	Secular change.	1911.	1912.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January	504	531	+ 27	58·1	63·2	+ 5·1	48·8	56·3	+ 7·5	499	584	+ 85
February	498	540	42	57·9	63·8	5·9	49·6	56·7	7·1	508	588	80
March	511	535	24	58·2	64·5	6·3	50·0	56·9	6·9	513	591	78
April	508	532	24	58·8	64·8	6·0	50·7	57·8	7·1	520	600	80
May	507	529	22	59·4	65·1	5·7	51·0	58·5	7·5	524	607	83
June	512	539	27	60·2	65·7	5·5	52·0	59·3	7·3	535	617	82
July	515	544	29	60·2	66·1	5·9	52·2	59·9	7·7	538	624	86
August	519	544	25	60·7	66·3	5·6	52·7	59·6	6·9	544	621	77
September	528	551	23	61·5	66·9	5·4	52·9	60·2	7·3	547	628	81
October	526	555	29	62·0	67·3	5·3	54·2	60·7	6·5	560	634	74
November	530	559	29	62·5	67·9	5·4	54·8	61·7	6·9	567	645	78
December	527	558	31	62·9	68·4	5·5	55·2	62·0	6·8	571	649	78
Means	515	543	+ 28	60·2	65·8	+ 5·6	52·0	59·1	+ 7·1	536	616	+ 80

III.—TABLES OF RESULTS.

A. Mean values of the magnetic elements at the observatories for 1912.

B. Classification of curves and dates of magnetic disturbances in 1912.

C. Preliminary values of the magnetic elements at field and repeat stations in 1912-13.

D. Tables of results at Dehra Dūn.

E. „ „ Barrackpore.

F. „ „ Toungoo.

G. „ „ Kodaikānal.

For each observatory the following tables are given :—

(*a*) Hourly means (corrected for temperature) of Declination, H. F., V. F. and Dip from all available days.

(*b*) Diurnal inequality deduced from (*a*).

H. Index map showing the progress of the magnetic survey to date.

A.

Mean values of the magnetic elements at observatories in 1912.

Observatory.	Latitude and Longitude.	Dip.	Declination.	H. F.	V. F.
	° ′ ″	° ′	° ′	C. G. S.	C. G. S.
Dehra Dūn . .	30 19 19 N 78 3 19 E	N 44 8·9	E 2 25·9	·33218	·32244
Barrackpore .	22 46 29 N 88 21 39 E	N 30 50·7	E 0 44·0	·37369	·22316
Toungoo . .	16 55 45 N 96 27 3 E	N 23 3·1	E 0 13·4	·38889	·16548
Kodaikānal .	10 13 50 N 77 27 46 E	N 3 59·1	W 1 5·8	·37543	·02616

B.—Dates of Magnetic disturbances, 1912.

... re . {Lat. 30 : 19 : 19 / Long. 78 : 3 : 19}

...re . {Lat. 22 : 46 : 29 / Long. 88 : 21 : 39}

T=Toungoo . {Lat. 18 : 55 : 45 / Long. 96 : 27 : 3}

K=Kodaikanal . {Lat. 10 : 13 : 50 / Long. 77 : 27 : 46}

January.				February.				March.			
D	B	T	K	D	B	T	K	D	B	T	K
[illegible]	S	S	S	C	C	C	C	S	S	S	S
[illegible]	(C)	(C)	(C)	C	C	C	C	S	S	S	S
[illegible]	C	C	C	S	S	S	S	C	C	C	C
[illegible]	C	C	C	S	S	S	C	S	S	S	C
[illegible]	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S
[illegible]	C	S	S	C	C	C	C	S	S	S	S
[illegible]	C	C	C	S	S	C	C	S	S	S	C
[illegible]	S	S	S	S	S	C	C	M	M	M	S
[illegible]	S	S	C	(C)	(C)	(C)	(C)	S	S	S	S
[illegible]	S	S	C	S	S	S	S	S	S	S	S
[illegible]	S	S	C	S	S	S	S	C	C	C	C
[illegible]	S	S	S	S	S	S	S	S	C	C	C
[illegible]	M	M	S	S	S	S	S	C	C	C	C
[illegible]	S	S	S	(S)	(C)	(C)	(C)	S	S	S	S
[illegible]	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S
[illegible]	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)
[illegible]	S	S	S	S	S	S	S	C	C	C	C
[illegible]	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)
[illegible]	S	S	S	S	S	S	C	C	C	C	C
[illegible]	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)
[illegible]	C	C	C	(C)	(C)	(C)	(C)	C	C	C	S
[illegible]	S	S	S	S	(C)	C	C	S	S	S	S
[illegible]	S	S	S	S	S	S	C	C	C	C	C
[illegible]	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)
[illegible]	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)
[illegible]	(C)	(C)	(C)	S	S	S	S	C	C	C	C
[illegible]	(C)	(C)	(C)	S	S	S	S	S	S	S	C
[illegible]	C	C	C	C	C	C	C	S	S	S	S
[illegible]	S	S	S	C	C	C	C	M	M	S	S
[illegible]	S	S	S	...	...	...	...	C	C	C	C
[illegible]	C	C	C	...	...	...	...	C	C	C	C
13	13	12	15	10	12	14	17	15	16	16	18
17	17	18	16	19	17	15	12	14	13	14	13
1	1	1	...	...	...	...	...	2	2	1	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...

April.				May.				June.			
D	B	T	K	D	B	T	K	D	B	T	K
C	C	C	C	C	C	C	C	—	S	S	S
(C)	(C)	(C)	(C)	C	C	C	C	—	S	S	S
C	C	C	C	C	C	C	C	—	S	S	S
C	C	C	C	C	C	C	C	—	C	C	S
S	S	S	S	M	M	M	M	—	C	C	C
S	S	S	S	S	S	S	S	—	C	C	C
S	S	S	C	S	S	S	S	—	C	C	C
C	C	C	C	S	S	S	S	—	S	S	S
C	C	C	C	(C)	(C)	(C)	(C)	—	S	S	S
S	S	S	S	S	S	S	S	S	S	S	S
(C)	(C)	(C)	(C)	S	S	S	C	S	S	S	S
(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S
S	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)
S	S	S	S	S	S	S	S	—	C	C	C
S	S	S	S	C	C	C	C	—	C	C	C
S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)
S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	C
S	S	S	C	(C)	(C)	(C)	(C)	S	S	S	S
C	C	C	C	C	C	C	C	S	C	C	C
S	S	S	S	C	C	C	C	C	C	C	C
(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)
C	C	C	C	—	C	C	C	S	S	S	S
C	C	C	C	—	C	C	C	S	S	S	S
C	C	C	C	—	C	C	C	S	S	S	S
S	S	S	C	—	C	C	C	(C)	(C)	(C)	(C)
S	S	C	C	—	C	C	C	C	C	C	C
S	S	S	C	—	C	C	C	S	S	S	S
(C)	(C)	(C)	(C)	—	C	C	C	S	S	S	S
C	C	C	C	—	S	S	S	S	S	S	S
S	S	S	C	—	C	C	C	C	C	C	C
...	...	...	...	—	S	S	S	...	...	...	...
15	15	16	21	12	20	20	21	7	14	14	14
15	15	14	9	8	10	10	9	12	16	16	16
...	...	...	...	1	1	1	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	10	...	...	...	11	...	...	...

July.				August.				September.			
D	B	T	K	D	B	T	K	D	B	T	K
C	C	C	C	S	S	S	S	S	S	S	S
C	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)
S	S	S	S	S	S	S	S	C	C	C	C
S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S
S	S	S	S	S	S	S	S	S	S	S	C
S	S	S	S	S	S	S	S	S	S	S	C
S	S	S	S	S	S	S	S	C	C	C	C
S	S	S	S	(C)	(C)	(C)	(C)	S	C	C	C
C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S
(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	S
C	C	C	C	C	C	C	C	S	S	S	S
(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	C
(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	C
S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	C	C	C	C	C	(C)	(C)	(C)	(C)
S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)
S	S	S	—	S	S	S	S	M	M	M	M
C	C	C	—	S	S	S	S	M	M	M	M
C	C	C	C	M	M	M	S	C	C	C	C
S	S	S	S	C	C	C	C	C	C	C	C
S	C	C	C	C	C	C	C	C	C	C	C
(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C
—	C	C	C	S	S	S	S	S	S	S	S
(C)	(C)	(C)	(C)	S	C	C	C	M	M	M	M
S	C	C	C	S	S	S	C	S	S	S	S
S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C
S	S	S	S	S	S	S	S	(S)	(C)	(C)	(C)
C	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)
C	C	C	C	S	S	S	C	C	C	C	C
C	C	C	C	S	S	S	S	S	S	S	S
S	S	S	S	C	C	S	S	...	...	...	...
14	17	17	17	14	15	14	16	13	15	15	19
16	14	14	12	16	15	16	15	14	12	12	8
...	...	...	...	1	1	1	...	3	3	3	3
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
1	...	...	2	...	...	...	...	...	...	...	...

October.				November.				December.				Remarks.
D	B	T	K	D	B	T	K	D	B	T	K	
S	S	S	S	S	S	S	S	C	C	C	C	
(C)	(C)	(C)	(C)	S	C	C	C	S	S	S	S	
S	S	S	C	(C)	(C)	(C)	(C)	S	S	S	S	
S	S	C	C	C	C	C	C	(S)	(S)	(S)	(C)	
(C)	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)	
S	S	S	S	S	S	S	—	S	S	S	S	
S	S	S	C	C	C	C	—	M	M	M	M	
S	S	S	S	C	C	C	C	S	S	S	S	
S	C	C	C	S	S	S	S	C	C	C	C	
S	S	S	C	S	S	S	S	S	C	C	C	
M	S	S	S	S	S	S	S	S	S	S	C	
M	S	S	S	C	C	C	C	C	C	C	C	
S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S	
M	M	M	M	M	M	M	M	S	S	S	S	
M	M	M	M	S	S	S	S	C	C	C	S	
S	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)	
S	S	S	S	S	S	S	C	C	C	C	C	
(C)	(C)	(C)	(C)	S	S	S	C	S	S	S	S	
C	C	C	C	S	S	S	C	S	S	S	S	
S	S	S	S	C	C	S	S	C	C	C	C	
S	S	S	—	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	
S	S	S	—	S	S	S	S	S	S	S	S	
S	S	S	C	S	S	S	S	M	M	M	S	
S	S	S	S	C	C	C	C	S	S	S	S	
S	S	S	S	C	C	C	C	S	S	S	C	
C	C	C	C	S	S	S	S	C	C	C	C	
C	C	C	C	S	S	S	C	(C)	(C)	(C)	(C)	
S	S	S	S	C	C	C	C	C	C	C	C	
(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	C	C	C	C	
C	C	C	C	(C)	(C)	(C)	(C)	C	C	C	C	
(C)	(C)	(C)	(C)	...	...	...	...	C	C	C	C	
9	10	12	15	13	14	13	16	15	16	16	18	
18	19	17	12	16	15	16	11	14	13	13	12	
4	2	2	2	1	1	1	1	2	2	2	1	
...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	2	...	...	...	2	...	...	...	...	

(C)—International quiet day. C—Calm. S—Slight. M—Moderate. G—Great. V. G.—Very Great. —Trace lost.

C.—Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1912-13.

FIELD STATIONS.

Serial No.	NAME OF STATION.	Latitude.			Longitude.			Dip.			Declination.			Horizontal Force.	REMARKS.
		°	'	"	°	'	"		°	'		°	'	C. G. S.	
1357	Bentota	6	25	50	80	0	10	S.	5	4	W.	2	7	0·3804	H is derived from mean M_0 throughout.
1358	Galle	6	1	50	80	12	10	,,	6	1	,,	2	12	·3803	
1359	Matara	5	57	50	80	33	10	,,	6	13	,,	2	11	·3804	
1360	Deniyaya	6	21	20	80	33	40	,,	5	17	,,	2	12	·3813	
1361	Ambalantota	6	7	10	81	1	40	,,	5	44	,,	2	9	·3811	
1362	Yatiyantota	7	2	0	80	17	20	,,	3	36	,,	2	0	·3847	
1363	Ratnapura	6	41	40	80	24	20	,,	4	24	,,	2	4	·3818	
1364	Kurunegala	7	28	50	80	21	50	,,	2	40	,,	2	7	·3819	
1365	Galgomuwa	8	0	50	80	16	0	,,	1	30	,,	1	51	·3825	
1366	Anuradhapura	8	21	10	80	23	10	,,	0	30	,,	2	1	·3834	
1367	Horowupotana	8	33	10	80	49	50	,,	0	9	,,	1	43	·3839	
1368	Trincomalee	8	34	40	81	14	10	,,	0	5	,,	1	53	·3854	
1369	Alut Oya	8	13	20	80	54	0	,,	1	2	,,	1	54	·3840	
1370	Topawewa	7	56	40	81	0	10	,,	1	36	,,	1	58	·3846	
1371	Dambulla	7	52	40	80	39	20	,,	3	32	E.	0	10	·3842	
1372	Vavuniya	8	45	30	80	30	20	,,	1	2	W.	1	32	·3844	
1373	Mullaittivu	9	16	10	80	48	50	,,	1	17	,,	1	48	·3844	
1374	Mankulam	9	7	40	80	27	0	,,	1	59	,,	1	37	·3845	
1375	Jaffna	9	39	30	80	0	40	,,	2	26	,,	1	35	·3857	
1376	Elephant Pass	9	31	20	80	24	20	,,	2	8	,,	1	47	·3846	
1377	Manar	8	59	10	79	54	30	,,	1	7	,,	1	35	·3844	
1378	Marichchukkaddi	8	34	50	79	55	0	,,	0	3	,,	1	47	·3831	
1379	Puttalam	8	1	40	79	49	0	,,	1	19	,,	1	48	·3832	
1380	Chilaw	7	34	20	79	46	50	,,	2	27	,,	1	54	·3818	
1381	Negombo	7	12	30	79	49	20	,,	3	28	,,	1	53	·3828	
1382	Kandy	7	17	40	80	37	40	,,	2	37	,,	2	20	·3847	
1383	Nuwara Eliya	6	57	40	80	46	20	,,	4	1	,,	2	4	·3822	
1384	Haputale	6	46	0	80	57	50	,,	4	24	,,	2	3	·3815	
1385	Tanamalwila	6	25	50	81	8	10	,,	5	7	,,	2	11	·3815	
1386	Kirinda	6	13	10	81	20	50	,,	5	36	,,	2	13	·3817	
1387	Muppane	6	51	50	81	21	30	,,	3	49	,,	2	32	·3806	
1388	Bibile	7	9	30	81	14	10	,,	3	22	,,	2	3	·3828	
1389	Batticaloa	7	42	30	81	42	40	,,	2	17	,,	1	57	·3840	
1390	Pottuvil	6	52	30	81	50	30	,,	4	5	,,	2	3	·3837	
1391	Tirukkovil	7	7	50	81	52	10	,,	3	51	,,	2	8	·3840	
1392	Kalmunai	7	24	50	81	50	40	,,	2	47	,,	2	0	·3837	
1393	Kalkuda	7	55	20	81	34	50	,,	1	54	,,	2	1	·3846	
1394	Maha Oya	7	32	0	81	21	20	,,	2	44	,,	1	58	·3836	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1912-13—continued.

FIELD STATIONS—*concluded.*

Serial No.	Name of Station.	Latitude.			Longitude.			Dip.			Declination.			Horizontal Force.	Remarks.
		°	′	″	°	′	″		°	′		°	′		
1395	Kekirawa . .	8	2	10	80	36	20	S.	1	20	W.	1	59	0·3836	H is derived from mean M_o throughout.
1396	Nalanda . .	7	40	10	80	38	20	„	2	13	„	2	3	·3831	
1397	Nugetenne . .	7	18	0	80	51	20	„	3	5	„	2	0	·3830	
1398	Colombo . .	6	54	20	79	52	20	„	4	32	„	1	45	·3803	
1399	Sargodha . .	32	6	0	72	38	30	N	46	48	E.	3	11	·3179	
1400	Sillanwali . .	31	49	40	72	30	40	„	46	26	„	3	12	·3199	
1401	Jhang Maghiāna .	31	15	30	72	19	30	„	45	24	„	2	58	·3224	

OLD STATIONS RE-OBSERVED.

76	Multān (*a*) . .	30	10	50	71	26	50	N	43	57	E.	2	50	0·3257	H is derived from mean M_o throughout.
81	Lāla Mūsa . .	32	42	40	73	57	0	„	47	50	„	3	17	·3148	
85	Khairābād . .	33	54	10	72	13	10	„	49	8	„	3	47	·3084	
89	Jand . .	33	26	20	72	0	50	„	48	39	„	3	37	·3099	
95	Khewra . .	32	38	0	73	0	10	„	48	0	„	3	4	·3130	
100	Pathānkot . .	32	16	20	75	38	40	„	47	7	„	3	19	·3209	
103	Dāhānu Road .	19	58	40	72	44	40	„	25	30	„	0	54	3675	
110	Itola . . .	22	9	10	73	9	40	„	30	2	„	0	50	·3612	
114	Jagudan . .	23	30	50	72	24	0	„	32	39	„	1	4	·3544	
119	Pindwāra (*a*) .	24	48	0	73	2	10	„	34	52	„	1	23	·3508	
121	Khāngta . .	26	33	30	73	37	20	„	38	2	„	1	46	·3453	
127	Sūratgarh . .	29	19	30	73	54	30	„	42	38	„	2	23	·3334	
136	Bhaunagar . .	21	46	40	72	7	40	„	28	34	„	0	9	·3667	
147	Verāval . .	20	54	20	70	22	30	„	27	17	„	0	52	·3625	
156	Jaora . . .	23	38	0	75	7	0	„	32	54	„	1	5	·3569	
160	Māndal . .	25	26	50	74	35	10	„	35	45	„	2	14	·3470	
162	Jaipur . .	26	55	0	75	47	0	„	38	55	„	1	48	·3150	
747	Danura . .	19	46	50	78	45	10	„	26	1	„	0	20	·3744	
1164	Chikni . .	20	5	0	77	53	30	„	25	41	„	0	31	·3712	

DETAIL SURVEY STATIONS.

352D	Nāndgaon . .	20	41	20	77	49	50	N	26	44	E.	0	24	0·3711	H is derived from mean M_o throughout.
353D	Ner (Parsopant) .	20	29	10	77	51	40	„	26	11	„	0	38	·3638	
354D	Yeotmal . .	20	23	20	78	8	50	„	25	50	„	0	28	·3702	
355D	Jodmoha . .	20	19	0	78	17	50	„	25	50	„	1	5	·3687	
356D	Mohoda . .	20	13	40	78	28	20	„	26	1	„	0	45	·3726	
357D	Jhādgaon . .	20	21	30	78	33	30	„	26	20	„	0	33	·3723	
358D	Wadki . .	20	16	40	78	42	50	„	26	5	„	0	25	·3689	
359D	Mārdi . .	20	11	30	78	50	40	„	26	4	„	0	10	·3728	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1912-13—continued.

DETAIL SURVEY STATIONS—*concluded.*

Serial No.	NAME OF STATION.	Latitude.			Longitude.			Dip.			Declination.			Horizontal Force.	REMARKS.
		°	′	″	°	′	″		°	′		°	′	C. G. S.	
360D	Wūn	20	2	20	78	57	20	N.	25	33	E.	0	8	0·3731	H is derived from mean M_o throughout.
361D	Punwat	19	57	20	79	3	0	„	25	7	„	0	11	·3731	
362D	Kāyar	19	54	0	78	54	10	„	25	17	„	0	9	·3697	
363D	Wadhona	19	58	30	78	45	40	„	25	32	„	0	13	·3754	
364D	Pāndharkawada	20	1	30	78	33	0	„	26	6	„	0	11	·3725	
365D	Bori (Patan)	19	51	50	78	34	20	„	25	42	W.	0	21	·3665	
366D	Saorgaon	19	54	50	78	22	20	„	26	22	E.	0	7	·3688	
367D	Sāyatkharda	20	1	30	78	16	50	„	25	47	„	0	20	·3748	
368D	Kurhād	20	8	0	78	10	40	„	26	12	„	0	20	·3724	
369D	Māhāgaon (Kasba)	20	13	10	77	54	20	„	26	8	„	0	41	·3722	
370D	Lādkhed	20	20	40	77	54	40	„	26	32	„	0	33	·3682	
371D	Dārwhā	20	18	30	77	46	0	„	25	58	„	0	8	·3697	

REPEAT STATIONS.

Serial No.	NAME OF STATION.	Latitude °	′	″	Longitude °	′	″	Dip	°	′	Declination	°	′	Horizontal Force	REMARKS
I	Udaipur	24	35	33	73	41	57	N.	34	34	E.	1	13	0·3526	H is derived from mean M_o throughout.
II	Karāchi	24	49	50	67	2	2	„	34	56	„	1	39	·3451	
III	Quetta	30	11	52	67	0	20	„	43	43	„	3	0	·3218	
IV	Bahāwalpur	29	23	27	71	40	37	„	42	47	„	2	46	·3305	
V	Rāwalpindi	33	35	16	73	3	6	„	48	49	„	3	38	·3104	
VI	Bharatpur	27	13	27	77	29	28	„	39	24	„	1	44	·3451	
VII	Bangalore	12	59	36	77	35	58	„	10	21	W.	1	1	·3834	
VIII	Dhārwār	15	27	26	74	59	35	„	15	59	„	0	31	·3776	
IX	Porbandar	21	38	20	69	37	6	„	29	26	E.	1	7	·3598	
X	Fyzābād	26	47	27	82	7	40	„	38	28	„	1	24	·3532	
XI	Sambalpur	21	28	3	83	58	24	„	28	22	„	0	23	·3741	
XIII	Darjeeling	26	59	49	88	16	39	„	38	49	„	1	11	·3576	
XIV	Gayā	24	46	30	84	58	54	„	34	48	„	0	44	·3669	
XV	Secunderābād	17	27	11	78	29	16	„	20	40	W.	0	1	·3804	
XVI	Bhusāwal	21	2	46	75	47	18	„	27	40	E.	0	35	·3684	
XVII	Jubbulpore	23	8	57	79	56	44	„	31	39	„	0	43	·3650	
XVIII	Tavoy	14	4	50	98	12	30	„	12	15	„	0	9	·3981	
XIX	Lashio	22	56	47	97	44	40	„	31	22	„	0	21	·3784	
XX	Akyab	20	7	53	92	53	18	„	25	26	„	0	19	·3852	
46	Ruk Junction	27	48	20	68	38	20	„	40	0	„	2	3	·3344	
71	Lahore	31	35	50	74	18	50	„	46	31	„	2	52	·3200	
88	Peshāwar	34	0	40	71	33	40	„	49	19	„	3	46	·3073	
92	Kūndian	32	27	30	71	28	20	„	48	4	„	3	24	·3092	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1912-13—concluded.

REPEAT STATIONS—*concluded.*

Serial No.	NAME OF STATION.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force. C. G. S.	REMARKS.
105	Sachīn . .	21	4	40	72	52	40	27	59	E.	0	16	·3655	H is derived from mean M_0 throughout.
124	Bikaner . .	28	0	40	73	18	50	40	32	,,	1	57	·3385	
130	Ajmer . .	26	27	30	74	38	30	37	52	,,	1	48	·3461	
134	Mīrpur Khās .	25	31	40	69	0	40	36	10	,,	1	51	·3441	
139	Viramgām . .	23	8	10	72	3	30	31	49	,,	0	59	·3566	
172	Dhond . .	18	28	0	74	35	10	22	40	,,	0	18	·3715	
175	Hotgi . .	17	33	40	76	0	20	20	48	,,	0	3	·3757	
181	Guntakal . .	15	10	20	77	22	40	15	42	W.	0	36	·3807	
187	Perambūr . .	13	6	40	80	15	0	10	47	,,	0	59	·3844	
207	Birūr . . .	13	35	50	75	58	10	11	59	,,	0	49	·3805	
216	Mirāj . . .	16	49	10	74	38	10	19	50	,,	0	13	·3768	
223	Manmād . .	20	14	40	74	26	20	26	14	E.	1	2	·3648	
232	Delhi . .	28	40	20	77	14	20	41	39	,,	1	53	·3396	
283	Sirsa . . .	29	32	10	75	2	40	42	54	,,	2	29	·3334	
328 (*a*)	Tinnevelly . .	8	44	0	77	42	30	1	5	W.	1	48	·3797	
337	Tanjore . .	10	46	40	79	8	20	4	58	,,	1	32	·3827	
375	Parbhani . .	19	15	20	76	46	50	25	3	E.	0	34	·3714	
384	Bezwāda . .	16	31	0	80	36	50	21	56	W.	0	25	·3826	
483	Mānikpur . .	25	3	10	81	5	20	35	23	E.	1	5	·3592	
489	Monghyr . .	25	23	10	86	27	50	35	56	,,	0	55	·3634	
500	Sini . . .	22	47	0	85	56	50	30	49	,,	0	38	·3745	
518	Katārniān Ghāt .	28	19	50	81	7	50	41	1	,,	1	49	·3451	
530	Bettiah . .	26	48	50	84	31	30	38	31	,,	1	22	·3548	
544	Bāran . .	25	5	30	76	30	30	35	45	,,	1	14	·3524	
545	Bina . . .	24	10	50	78	11	0	33	32	,,	1	3	·3572	
557	Indore . .	22	42	10	75	52	40	31	12	,,	0	38	·3680	
573	Cawnpore . .	26	27	0	80	21	0	37	50	,,	1	27	·3534	
598	Kāthgodām . .	29	15	20	79	32	50	42	38	,,	2	5	·3379	
710	Cumbum . .	15	35	50	79	6	40	16	32	W.	0	59	·3827	
746	Chānda . .	19	57	50	79	17	40	25	29	E.	0	17	·3746	
765	Raipur . .	21	15	50	81	38	20	28	22	,,	0	24	·3724	
779	Amraoti . .	20	55	30	77	45	50	27	53	,,	0	7	·3653	
871	Lākshām . .	23	15	40	91	7	20	31	42	,,	0	36	·3750	
961	Mandalay (*b*) .	22	0	10	96	6	0	29	21	,,	0	18	·3821	
1338	Barmer . .	25	44	40	71	26	40	36	47	,,	1	46	·3435	

NOTE.—The above values of Dip, Declination and Horizontal Force are uncorrected for secular change, diurnal variation, instrumental differences, etc., and are to be considered preliminary values only.

All Longitudes are referable to that of Madras Observatory taken at the value 80° 14′ 54″ East from Greenwich.

D.—*Table of results at Dehra Dūn.*

Hourly Means of the Declination as determined at Dehra Dūn from all available days in 1912.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
E. 2° +													**Winter.**													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	27·3	27·2	27·1	27·0	27·0	**26·8**	26·8	27·0	27·6	**27·8**	27·3	26·2	**25·9**	26·4	27·2	28·0	28·1	27·6	27·5	27·6	27·4	27·4	27·4	27·3	27·3	27·2
February	27·1	27·1	27·1	27·1	27·0	27·0	27·0	27·0	27·3	**27·4**	27·1	26·3	25·6	**25·4**	26·1	27·0	27·5	27·5	27·2	27·2	27·1	27·1	27·1	27·1	27·1	26·9
March	26·9	26·9	26·8	26·8	26·6	26·6	26·6	27·1	**28·3**	29·1	28·9	27·7	26·1	24·9	**24·8**	25·6	26·5	26·9	26·8	26·6	26·6	26·7	26·8	26·8	26·9	26·8
October	25·4	25·4	25·2	25·2	25·2	24·8	24·8	25·5	**26·5**	26·3	25·9	24·9	23·7	**23·4**	24·0	24·9	25·3	25·1	25·0	25·0	25·1	25·2	25·2	25·3	25·4	25·1
November	25·5	25·5	25·4	25·3	25·1	24·9	24·9	25·0	25·4	25·5	25·2	24·6	**24·4**	25·0	25·4	25·5	25·5	25·5	25·5	25·5	25·4	25·5	25·5	**25·5**	25·5	25·3
December	**24·7**	24·6	24·5	24·4	24·2	24·1	24·0	**23·8**	23·8	24·3	24·6	24·3	24·1	24·4	24·7	24·6	24·6	24·6	24·6	24·6	24·6	24·6	24·6	24·6	24·6	24·4
Means	26·2	26·1	26·0	26·0	25·9	25·7	25·7	25·9	26·5	**26·7**	26·5	25·7	25·0	**24·9**	25·4	25·9	26·3	26·2	26·1	26·1	26·0	26·1	26·1	26·1	26·1	26·0
E. 2° +													**Summer.**													
April	26·8	26·9	26·9	26·9	26·8	26·8	27·3	28·3	**29·2**	29·1	27·7	26·0	24·7	**24·1**	24·5	25·2	26·1	26·5	26·5	26·3	26·3	26·4	26·6	26·8	26·8	26·6
May	26·7	26·8	26·8	26·8	26·8	27·0	28·0	28·9	**29·2**	28·4	26·6	24·8	23·6	**23·4**	24·2	25·1	25·9	26·5	26·6	26·2	26·1	26·3	26·4	26·6	26·7	26·4
June	25·9	26·1	26·1	26·2	26·1	26·3	27·4	28·3	**28·5**	27·7	26·0	24·5	23·5	**23·3**	23·4	23·8	24·4	25·0	25·5	25·4	25·2	25·3	25·4	25·6	25·8	25·6
July	25·9	26·1	26·1	26·2	26·2	26·4	27·5	28·4	**28·4**	27·7	26·3	24·6	23·6	**23·3**	23·3	23·8	24·4	25·0	25·5	25·4	25·3	25·4	25·5	25·8	25·9	25·7
August	25·6	25·7	25·7	25·7	25·8	26·1	26·9	27·6	**27·7**	26·9	25·6	24·2	23·4	**23·0**	23·4	24·2	25·0	25·5	25·5	25·2	25·2	25·2	25·3	25·4	25·6	25·4
September	25·6	25·7	25·6	25·9	25·8	25·9	26·3	27·3	**27·7**	26·9	25·4	23·8	22·8	**22·7**	23·3	24·3	25·2	25·6	25·4	25·2	25·2	25·3	25·4	25·5	25·5	25·3
Means	26·1	26·2	26·2	26·3	26·3	26·4	27·2	28·1	**28·5**	27·8	26·3	24·7	23·6	**23·3**	23·7	24·4	25·2	25·7	25·8	25·6	25·6	25·7	25·8	26·0	26·1	25·9

Diurnal Inequality of the Declination at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·1	0	−0·1	−0·2	−0·2	−0·4	−0·4	−0·2	+0·4	+0·6	+0·1	−1·0	−1·3	−0·8	0	+0·8	+0·9	+0·4	+0·3	+0·4	+0·2	+0·2	+0·2	+0·1	+0·1
February	+0·2	+0·2	+0·2	+0·2	+0·1	+0·1	+0·1	+0·1	+0·4	+0·5	+0·2	−0·6	−1·3	−1·5	−0·8	+0·1	+0·6	+0·6	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2	+0·2
March	+0·1	+0·1	0	0	−0·2	−0·2	−0·2	+0·3	+1·5	+2·3	+2·1	+0·9	−0·7	−1·9	−2·0	−1·2	−0·3	+0·1	0	−0·2	−0·2	−0·1	0	0	+0·1
October	+0·3	+0·3	+0·1	+0·1	+0·1	−0·3	−0·3	+0·4	+1·4	+1·2	+0·8	−0·2	−1·4	−1·7	−1·1	−0·2	+0·2	0	−0·1	−0·1	0	+0·1	+0·1	+0·2	+0·3
November	+0·2	+0·2	+0·1	0	−0·2	−0·4	−0·4	−0·3	+0·1	+0·2	−0·1	−0·7	−0·9	−0·3	+0·1	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1	+0·2	+0·2	+0·2	+0·2
December	+0·3	+0·2	+0·1	0	−0·2	−0·3	−0·4	−0·6	−0·6	−0·1	+0·2	−0·1	−0·3	0	+0·3	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2
[illegible]	+0·2	+0·1	0	0	0·1	−0·3	−0·3	−0·1	+0·5	+0·7	+0·5	−0·3	−1·0	−1·1	−0·6	−0·1	+0·3	+0·2	+0·1	+0·1	0	+0·1	+0·1	+0·1	+0·1
Summer.																									
April	+0·2	+0·3	+0·3	+0·3	+0·2	+0·2	+0·7	+1·7	+2·6	+2·5	+1·1	−0·6	−1·9	−2·5	−2·1	−1·4	−0·5	−0·1	−0·1	−0·3	−0·3	−0·2	0	+0·2	+0·2
May	+0·3	+0·4	+0·4	+0·4	+0·4	+0·6	+1·6	+2·5	+2·8	+2·0	+0·2	−1·6	−2·8	−3·0	−2·2	−1·3	−0·5	+0·1	+0·2	−0·2	−0·3	−0·1	0	+0·2	+0·3
June	+0·3	+0·5	+0·5	+0·6	+0·5	+0·7	+1·8	+2·7	+2·9	+2·1	+0·4	−1·1	−2·1	−2·3	−2·2	−1·8	−1·2	−0·6	−0·1	−0·2	−0·4	−0·3	−0·2	0	+0·2
July	+0·2	+0·4	+0·4	+0·5	+0·5	+0·7	+1·8	+2·7	+2·7	+2·0	+0·6	−1·1	−2·1	−2·4	−2·4	−1·9	−1·3	−0·7	−0·2	−0·3	−0·4	−0·3	−0·2	+0·1	+0·2
August	+0·2	+0·3	+0·3	+0·3	+0·4	+0·7	+1·5	+2·2	+2·3	+1·5	+0·2	−1·2	−2·0	−2·4	−2·0	−1·2	−0·4	+0·1	+0·1	−0·2	−0·2	−0·2	−0·1	0	+0·2
September	+0·3	+0·4	+0·3	+0·6	+0·5	+0·6	+1·0	+2·0	+2·4	+1·6	+0·1	−1·5	−2·5	−2·6	−2·0	−1·0	−0·1	+0·3	+0·1	−0·1	−0·1	0	+0·1	+0·2	+0·2
Means	+0·2	+0·3	+0·3	+0·4	+0·4	+0·5	+1·3	+2·2	+2·6	+1·9	+0·4	−1·2	−2·3	−2·6	−2·2	−1·5	−0·7	−0·2	−0·1	−0·3	−0·3	−0·2	−0·1	+0·1	+0·2

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

·33000 C. G. S. +

Winter.

Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	221	222	223	224	224	226	226	227	226	223	221	227	232	235	**236**	232	228	222	**220**	220	221	220	221	222	222	225
February .	223	225	225	225	224	225	225	225	224	223	223	227	234	**239**	238	233	228	226	224	224	223	**221**	221	222	222	226
March .	220	221	221	222	223	223	223	224	225	227	228	231	233	**234**	233	228	223	223	222	220	**219**	220	219	222	220	224
October .	204	205	209	208	208	209	210	211	210	209	212	216	219	**220**	215	208	205	204	203	202	**200**	200	201	207	204	208
November .	198	200	201	202	202	203	205	209	213	216	218	**220**	220	213	207	202	200	198	196	194	**193**	**193**	196	198	199	204
December .	196	197	198	198	200	200	202	204	210	**212**	**213**	211	208	204	200	201	200	198	198	196	196	195	**194**	196	197	201
Means .	210	212	213	213	214	214	215	217	218	218	219	222	**224**	224	222	217	214	212	211	209	209	**208**	209	211	211	215

Summer.

Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
April .	216	217	217	215	217	219	218	216	**214**	217	223	230	**234**	234	229	223	220	216	215	215	214	215	216	215	216	219
May .	216	217	218	218	219	219	219	215	**211**	211	219	226	230	**231**	228	223	218	211	213	213	213	214	215	217	216	218
June .	222	222	221	221	221	223	225	223	220	**218**	222	226	231	**234**	232	230	227	223	222	220	222	223	224	224	223	224
July .	219	219	219	219	219	220	222	222	220	219	223	227	232	**234**	234	231	227	221	219	**218**	219	220	220	220	220	223
August .	212	213	212	212	214	213	212	209	204	**201**	202	210	216	221	**222**	219	213	208	208	208	209	210	211	212	212	211
September .	211	212	215	213	213	214	213	208	201	**199**	203	207	215	**220**	220	218	214	211	212	210	211	211	210	211	211	211
Means .	216	217	217	216	217	218	218	216	212	**211**	215	221	226	**229**	228	224	220	215	215	214	215	216	216	217	216	218

Diurnal Inequality of the Horizontal Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−4	−3	−2	−1	−1	+1	+1	+2	+1	−2	−4	+2	+7	+10	+11	+7	+3	−3	−5	−5	−4	−5	−4	−3	−3
February	−3	−1	−1	−1	−2	−1	−1	−1	−3	−3	−3	+1	+8	+13	+12	+7	+2	0	−2	−2	−3	−5	−5	−4	−4
March	−4	−3	−3	−2	−1	−1	−1	0	+1	+3	+4	+7	+9	+10	+9	+4	−1	−1	−2	−4	−5	−4	−5	−2	−4
October	−4	−3	+1	0	0	+1	+2	+3	+2	+1	+4	+8	+11	+12	+7	0	−3	−4	−5	−6	−8	−8	−7	−1	−4
November	−6	−4	−3	−2	−2	−1	+1	+5	+9	+12	+14	+16	+16	+9	+3	−2	−4	−6	−8	−10	−11	−11	−8	−6	−5
December	−5	−4	−3	−3	−1	−1	+1	+3	+9	+11	+12	+10	+7	+3	−1	0	−1	−3	−3	−5	−5	−6	−7	−5	−4
Means	−5	−3	−2	−2	−1	−1	0	+2	+3	+3	+4	+7	+9	+9	+7	+2	−1	−3	−4	−6	−6	−7	−6	−4	−4
Summer.																									
April	−3	−2	−2	−4	−2	0	−1	−3	−5	−2	+4	+11	+15	+15	+10	+4	+1	−3	−4	−4	−5	−4	−3	−4	−3
May	−2	−1	0	0	+1	+1	+1	−3	−7	−7	+1	+8	+12	+13	+10	+5	0	−7	−5	−5	−5	−4	−3	−1	−2
June	−2	−2	−3	−3	−3	−1	+1	−1	−4	−6	−2	+2	+7	+10	+8	+6	+3	−1	−2	−4	−2	−1	0	0	−1
July	−4	−4	−4	−4	−4	−3	−1	−1	−3	−4	0	+4	+9	+11	+11	+8	+4	−2	−4	−5	−4	−3	−3	−3	−3
August	+1	+2	+1	+1	+3	+2	+1	−2	−7	−10	−9	−1	+5	+10	+11	+8	+2	−3	−3	−3	−2	−1	0	+1	+1
September	0	+1	+4	+2	+2	+2	+2	−3	−10	−12	−8	−4	+4	+9	+9	+7	+3	0	+1	−1	0	0	−1	0	0
Means	−2	−1	−1	−2	−1	0	0	−2	−6	−7	−3	+3	+8	+11	+10	+6	+2	−3	−3	−4	−3	−2	−2	−1	−2

NOTE.— When the sign is + the H. F. is greater, and when — it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Dehra Dūn from all available days in 1912.

·32000 +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	194	194	194	194	193	194	193	194	195	194	191	190	192	196	193	196	195	194	194	195	195	196	196	195	195	194
February .	202	202	202	202	202	202	202	202	203	201	198	196	197	198	201	203	203	203	202	202	203	203	202	203	203	201
March .	216	216	216	216	216	220	216	218	220	218	213	207	204	205	209	212	215	216	215	215	216	216	216	217	217	214
October .	283	284	284	284	283	284	284	286	285	282	278	272	271	275	279	281	282	282	282	283	283	284	285	285	284	282
November .	293	292	292	293	292	292	292	293	293	292	288	287	288	288	291	291	292	291	292	291	292	292	293	293	292	291
December .	298	298	298	297	297	297	298	297	298	299	298	294	294	296	296	297	297	297	298	297	298	297	298	298	298	297
Means .	248	248	248	248	247	248	248	248	249	248	244	241	241	243	245	247	247	247	247	247	248	248	248	249	248	247
Summer.																										
April . .	218	218	218	218	218	218	220	222	221	217	210	205	206	210	213	216	217	217	217	217	218	219	219	219	219	216
May . .	228	228	228	228	228	228	231	230	226	220	213	210	213	218	222	227	228	228	229	228	229	229	230	230	230	225
June . .	235	235	235	235	235	237	240	238	234	228	222	216	218	222	224	230	233	235	236	235	236	237	237	237	237	232
July . .	251	252	251	251	252	253	257	255	251	245	238	233	234	236	239	244	248	249	250	249	251	252	252	252	252	248
August .	256	256	256	256	256	256	258	257	256	251	247	244	243	246	248	253	254	254	254	254	255	255	256	256	256	253
September .	274	275	275	274	275	275	276	277	272	267	266	260	262	265	268	271	272	272	272	273	274	274	275	275	275	272
Means	244	244	244	244	244	245	247	247	243	238	233	228	229	233	236	240	242	243	243	243	244	244	245	245	245	241

Diurnal Inequality of the Vertical Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	0	0	0	0	−1	0	−1	0	+1	0	−3	−4	−2	+2	−1	+2	+1	0	0	+1	+1	+2	+2	+1	+1
February	+1	+1	+1	+1	+1	+1	+1	+1	+2	0	−3	−5	−4	−3	0	+2	+2	+2	+1	+1	+2	+2	+1	+2	+2
March	+2	+2	+2	+2	+2	+6	+2	+4	+6	+4	−1	−7	−10	−9	−5	−2	+1	+2	+1	+1	+2	+2	+2	+3	+3
October	+1	+2	+2	+2	+1	+2	+2	+4	+3	0	−4	−10	−11	−7	−3	−1	0	0	0	+1	+1	+2	+3	+3	+2
November	+2	+1	+1	+2	+1	+1	+1	+2	+2	+1	−3	−4	−3	−3	0	0	+1	0	+1	0	+1	+1	+2	+2	+1
December	+1	+1	+1	0	0	0	+1	0	+1	+2	+1	−3	−3	−1	−1	0	0	0	+1	0	+1	0	+1	+1	+1
Means	+1	+1	+1	+1	0	+1	+1	+1	+2	+1	−3	−6	−6	−4	−2	0	0	0	0	0	+1	+1	+1	+2	+1
Summer.																									
April	+2	+2	+2	+2	+2	+2	+4	+6	+5	+1	−6	−11	−10	−6	−3	0	+1	+1	+1	+1	+2	+3	+3	+3	+3
May	+3	+3	+3	+3	+3	+3	+6	+5	+1	−5	−12	−15	−12	−7	−3	+2	+3	+3	+4	+3	+4	+4	+5	+5	+5
June	+3	+3	+3	+3	+3	+5	+8	+6	+2	−4	−10	−16	−14	−10	−8	−2	+1	+3	+4	+3	+4	+5	+5	+5	+5
July	+3	+4	+3	+3	+4	+5	+9	+7	+3	−3	−10	−15	−14	−12	−9	−4	0	+1	+2	+1	+3	+4	+4	+4	+4
August	+3	+3	+3	+3	+3	+3	+5	+4	+3	−2	−6	−9	−10	−7	−5	0	+1	+1	+1	+1	+2	+2	+3	+3	+3
September	+2	+3	+3	+2	+3	+3	+4	+5	0	−5	−6	−12	−10	−7	−4	−1	0	0	0	+1	+2	+2	+3	+3	+3
Means	+3	+3	+3	+3	+3	+4	+6	+6	+2	−3	−8	−13	−12	−8	−5	−1	+1	+2	+2	+2	+3	+3	+4	+4	+4

NOTE.—When the sign is + the V. F. is greater, and when − it is less than the mean.

Hourly Means of the Dip as determined at Dehra Dūn from all available days in 1912.

N. 44° +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mt.	Means.
Winter.																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	6·0	6·0	5·9	5·9	5·8	5·8	5·7	5·7	5·8	5·9	5·9	5·5	5·4	5·4	5·2	5·6	5·8	6·0	6·1	6·2	6·1	6·2	6·2	6·0	6·0	5·8
February .	6·3	6·2	6·2	6·2	6·3	6·2	6·2	6·2	6·4	6·3	6·2	5·8	5·6	5·3	5·6	5·9	6·2	6·3	6·3	6·3	6·4	6·5	6·5	6·5	6·5	6·2
March .	7·3	7·2	7·2	7·1	7·1	7·3	7·1	7·2	7·2	7·0	6·7	6·2	6·0	6·0	6·2	6·7	7·1	7·1	7·1	7·2	7·3	7·3	7·3	7·2	7·3	7·0
October .	11·6	11·7	11·5	11·5	11·5	11·5	11·4	11·5	11·5	11·3	11·0	10·5	10·2	10·4	10·9	11·4	11·6	11·6	11·6	11·8	11·8	11·9	11·9	11·6	11·7	11·4
November .	12·5	12·3	12·3	12·3	12·2	12·2	12·1	11·9	11·7	11·5	11·2	11·1	11·1	11·5	11·9	12·2	12·3	12·4	12·5	12·6	12·7	12·7	12·6	12·5	12·4	12·1
December .	12·9	12·8	12·8	12·7	12·6	12·6	12·6	12·4	12·2	12·1	12·0	11·9	12·0	12·4	12·6	12·6	12·6	12·7	12·8	12·8	12·9	12·9	13·0	12·9	12·8	12·6
Means .	9·4	9·4	9·3	9·3	9·3	9·3	9·2	9·2	9·1	9·0	[illegible]	[illegible]	8·4	[illegible]	[illegible]	[illegible]	[illegible]	9·4	9·4	9·5	9·5	9·6	9·6	9·5	9·5	9·2
Summer.																										
April .	7·6	7·5	7·5	7·7	7·5	7·4	7·6	7·8	7·9	7·5	6·8	6·2	6·0	6·2	6·6	7·1	7·3	7·5	7·6	7·6	7·7	7·7	7·6	7·7	7·6	7·3
May .	8·1	8·0	8·0	8·0	7·9	7·9	8·1	8·3	8·3	8·0	7·1	6·6	6·6	6·8	7·2	7·7	8·0	8·4	8·3	8·2	8·3	8·3	8·3	8·2	8·2	7·9
June .	8·2	8·2	8·2	8·2	8·2	8·2	8·3	8·3	8·2	8·0	7·5	6·9	6·8	6·9	7·1	7·5	7·8	8·1	8·2	8·3	8·2	8·2	8·2	8·2	8·2	7·9
July .	9·2	9·2	9·2	9·2	9·2	9·2	9·3	9·2	9·1	8·8	8·3	7·8	7·6	7·6	7·8	8·2	8·6	9·0	9·1	9·2	9·2	9·2	9·2	9·2	9·2	8·8
August .	9·8	9·8	9·8	9·8	9·7	9·8	9·9	10·0	10·2	10·1	9·9	9·3	8·9	8·8	8·8	9·3	9·6	9·9	9·9	9·9	9·9	9·9	9·9	9·8	9·8	9·7
September .	10·8	10·8	10·7	10·7	10·8	10·7	10·8	11·1	11·3	11·1	10·8	10·3	10·0	9·9	10·0	10·3	10·6	10·7	10·7	10·8	10·8	10·8	10·9	10·9	10·9	10·7
Means .	9·0	8·9	8·9	8·9	8·9	8·9	9·0	9·1	9·2	8·9	8·4	7·9	7·7	7·7	7·9	8·4	8·7	8·9	9·0	9·0	9·0	9·0	9·0	9·0	9·0	8·7

R

Diurnal Inequality of the Dip at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	′	′	′	′	′	′	′	′	′	′	′		′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·2	+0·2	+0·1	+0·1	0	0	−0·1	−0·1	0	+0·1	+0·1	−0·3	−0·4	−0·4	−0·6	−0·2	0	+0·2	+0·3	+0·4	+0·3	+0·4	+0·4	+0·2	+0·2
February	+0·1	0	0	0	+0·1	0	0	0	+0·2	+0·1	0	−0·4	−0·6	−0·9	−0·6	−0·3	0	+0·1	+0·1	+0·1	+0·2	+0·3	+0·3	+0·3	+0·3
March	+0·3	+0·2	+0·2	+0·1	+0·1	+0·3	+0·1	+0·2	+0·2	0	−0·3	−0·8	−1·0	−1·0	−0·8	−0·3	+0·1	+0·1	+0·1	+0·2	+0·3	+0·3	+0·3	+0·2	+0·3
October	+0·2	+0·3	+0·1	+0·1	+0·1	+0·1	0	+0·1	+0·1	−0·1	−0·4	−0·9	−1·2	−1·0	−0·5	0	+0·2	+0·2	+0·2	+0·4	+0·4	+0·5	+0·5	+0·2	+0·3
November	+0·4	+0·2	+0·2	+0·2	+0·1	+0·1	0	−0·2	−0·4	−0·6	−0·9	−1·0	−1·0	−0·6	−0·2	+0·1	+0·2	+0·3	+0·4	+0·5	+0·6	+0·6	+0·5	+0·4	+0·3
December	+0·3	+0·3	+0·2	+0·1	0	0	0	−0·2	−0·4	−0·5	−0·6	−0·7	−0·6	−0·2	0	0	0	+0·1	+0·2	+0·2	+0·3	+0·3	+0·4	+0·3	+0·2
Means	+0·2	+0·2	+0·1	+0·1	+0·1	+0·1	0	0	−0·1	−0·2	−0·4	−0·7	−0·8	−0·7	−0·5	−0·1	+0·1	+0·2	+0·2	+0·3	+0·3	+0·4	+0·4	+0·3	+0·3
Summer.																									
April	+0·3	+0·2	+0·2	+0·4	+0·2	+0·1	+0·3	+0·5	+0·6	+0·2	−0·5	−1·1	−1·3	−1·1	−0·7	−0·2	0	+0·2	+0·3	+0·3	+0·4	+0·4	+0·3	+0·4	+0·3
May	+0·2	+0·1	+0·1	+0·1	0	0	+0·2	+0·4	+0·4	+0·1	−0·8	−1·3	−1·3	−1·1	−0·7	−0·2	+0·1	+0·5	+0·4	+0·3	+0·4	+0·4	+0·4	+0·3	+0·3
June	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·4	+0·4	+0·3	+0·1	−0·4	−1·0	−1·1	−1·0	−0·8	−0·4	−0·1	+0·2	+0·3	+0·4	+0·3	+0·3	+0·3	+0·3	+0·3
July	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·5	+0·4	+0·3	0	−0·5	−1·0	−1·2	−1·2	−1·0	−0·6	−0·2	+0·2	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4
August	+0·1	+0·1	+0·1	+0·1	0	+0·1	+0·2	+0·5	+0·5	+0·4	+0·2	−0·4	−0·8	−0·9	−0·9	−0·4	−0·1	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1	+0·1
September	+0·1	+0·1	0	0	+0·1	0	+0·1	+0·4	+0·6	+0·4	+0·1	−0·4	−0·7	−0·8	−0·7	−0·4	−0·1	0	0	+0·1	+0·1	+0·1	+0·2	+0·2	+0·2
Means	+0·3	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+0·2	−0·3	−0·8	−1·0	−1·0	−0·8	−0·3	0	+0·2	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3

NOTE.—When the sign is + the Dip is greater, and when − it is less than the mean.

E.—Tables of result at Barrackpore.

Hourly Means of the Declination as determined at Barrackpore from all available days in 1912.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
E. 0° +													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	46·8	46·7	46·6	46·6	46·5	46·4	46·3	46·4	47·2	47·4	46·9	45·8	**45·7**	46·4	47·1	47·5	**47·8**	47·3	47·0	47·2	47·0	46·9	46·8	46·8	46·8	46·8
February .	46·3	46·3	46·3	46·3	46·2	46·2	46·2	46·2	46·6	46·7	46·2	45·5	**45·0**	45·3	46·0	46·7	**47·1**	47·0	46·5	46·5	46·5	46·4	46·3	46·3	46·3	46·3
March .	45·7	45·7	45·6	45·7	45·6	45·5	45·6	46·1	47·2	**47·9**	47·7	46·3	44·9	**44·0**	44·1	44·9	45·8	46·2	45·8	45·7	45·6	45·6	45·7	45·8	45·7	45·8
October .	42·3	42·4	42·3	42·3	42·2	42·0	41·9	42·6	**43·6**	43·3	42·7	41·6	**40·8**	40·8	41·5	42·2	42·7	42·4	42·1	42·2	42·2	42·2	42·2	42·3	42·3	42·2
November	41·9	41·9	41·7	41·6	41·4	41·3	41·3	41·4	41·9	**42·2**	41·9	41·4	**41·3**	41·8	42·0	42·0	42·2	42·0	42·0	42·0	41·8	41·7	41·6	41·8	41·9	41·8
December .	41·3	41·3	41·2	41·1	41·0	40·9	40·7	**40·4**	40·6	41·1	41·5	41·3	41·1	41·3	41·3	**41·5**	41·5	41·5	41·4	41·3	41·3	41·3	41·3	41·3	41·2	41·2
Means .	44·1	44·1	44·0	43·9	43·8	43·7	43·7	43·9	44·5	**44·8**	44·5	43·7	**43·1**	43·3	43·7	44·1	44·5	44·4	44·1	44·2	44·1	44·0	44·0	44·1	44·0	44·1
													Summer.													
April .	45·2	45·3	45·3	45·3	45·3	45·3	45·7	46·8	**47·4**	47·0	45·9	44·2	43·1	**43·0**	43·4	44·2	45·0	45·4	45·1	44·9	44·7	44·8	45·0	45·1	45·2	45·1
May .	44·7	44·9	44·9	44·8	44·9	45·2	46·2	47·0	**47·0**	46·0	44·4	43·0	**42·1**	42·3	42·9	43·8	44·5	44·8	44·6	44·3	44·2	44·2	44·4	44·5	44·7	44·6
June .	44·3	44·4	44·5	44·5	44·5	44·6	45·7	46·8	**47·0**	45·9	44·4	42·9	42·0	**41·9**	42·3	42·9	43·5	44·0	44·2	43·9	43·8	43·8	44·0	44·2	44·3	44·2
July .	43·8	44·0	44·0	44·1	44·2	44·4	45·4	46·2	**46·3**	45·4	44·0	42·7	41·9	**41·7**	41·8	42·3	43·1	43·6	43·6	43·4	43·3	43·3	43·4	43·6	43·8	43·7
August .	43·3	43·4	43·4	43·5	43·6	43·7	44·7	45·6	**45·6**	44·6	43·2	41·8	**41·1**	41·2	41·6	42·3	43·1	43·5	43·4	43·1	43·1	43·1	43·1	43·2	43·3	43·3
September .	42·9	42·9	43·0	43·1	43·1	43·2	43·7	44·8	**44·8**	43·7	42·4	40·7	**40·0**	40·2	41·0	42·2	43·1	43·2	42·8	42·7	42·6	42·6	42·6	42·7	42·8	42·7
Means .	44·0	44·2	44·2	44·2	44·3	44·4	45·2	46·2	**46·4**	45·4	44·1	42·6	**41·7**	41·7	42·2	43·0	43·7	44·1	44·0	43·7	43·6	43·6	43·8	43·9	44·0	44·0

Diurnal Inequality of the Declination at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	0	−0·1	−0·2	−0·2	−0·3	−0·4	−0·5	−0·4	+0·4	+0·6	+0·1	−1·0	−1·1	−0·4	+0·3	+0·7	+1·0	+0·5	+0·2	+0·4	+0·2	+0·1	0	0	0
February	0	0	0	0	−0·1	−0·1	−0·1	−0·1	+0·3	+0·4	−0·1	−0·8	−1·3	−1·0	−0·3	+0·4	+0·8	+0·7	+0·2	+0·2	+0·2	+0·1	0	0	0
March	−0·1	−0·1	−0·2	−0·1	−0·2	−0·3	−0·2	+0·3	+1·4	+2·1	+1·9	+0·5	−0·9	−1·8	−1·7	−0·9	0	+0·4	0	−0·1	−0·2	−0·2	−0·1	0	−0·1
October	+0·1	+0·2	+0·1	+0·1	0	−0·2	−0·3	+0·4	+1·4	+1·1	+0·5	−0·6	−1·4	−1·4	−0·7	0	+0·5	+0·2	−0·1	0	0	0	0	+0·1	+0·1
November	+0·1	+0·1	−0·1	−0·2	−0·4	−0·5	−0·5	−0·4	+0·1	+0·4	+0·1	−0·4	−0·5	0	+0·2	+0·2	+0·4	+0·2	+0·2	+0·2	0	−0·1	0	0	+0·1
December	+0·1	+0·1	0	−0·1	−0·2	−0·3	−0·5	−0·8	−0·6	−0·1	+0·3	+0·1	−0·1	+0·1	+0·1	+0·3	+0·3	+0·3	+0·2	+0·1	+0·1	+0·1	+0·1	+0·1	0
Means	0	0	−0·1	−0·2	−0·3	−0·4	−0·4	−0·2	+0·4	+0·7	+0·4	−0·4	−1·0	−0·8	−0·4	0	+0·4	+0·3	0	+0·1	0	0·1	−0·1	0	−0·1
Summer.																									
April	+0·1	+0·2	+0·2	+0·2	+0·2	+0·2	+0·6	+1·7	+2·3	+1·9	+0·8	−0·9	−2·0	−2·1	−1·7	−0·9	−0·1	+0·3	0	−0·2	−0·4	−0·3	−0·1	0	+0·1
May	+0·1	+0·3	+0·3	+0·2	+0·3	+0·6	+1·6	+2·4	+2·4	+1·4	−0·2	−1·6	−2·5	−2·3	−1·7	−0·8	−0·1	+0·2	0	−0·3	−0·4	−0·4	−0·2	−0·1	+0·1
June	+0·1	+0·2	+0·3	+0·3	+0·3	+0·4	+1·5	+2·6	+2·8	+1·7	+0·2	−1·3	−2·2	−2·3	−1·9	−1·3	−0·7	−0·2	0	−0·3	−0·4	−0·4	−0·2	0	+0·1
July	+0·1	+0·3	+0·3	+0·4	+0·5	+0·7	+1·7	+2·5	+2·6	+1·7	+0·3	−1·0	−1·8	−2·0	−1·9	−1·4	−0·6	−0·1	−0·1	−0·3	−0·4	−0·4	−0·3	−0·1	+0·1
August	0	+0·1	+0·1	+0·2	+0·3	+0·4	+1·4	+2·3	+2·3	+1·3	−0·1	−1·5	−2·2	−2·1	−1·7	−1·0	−0·2	+0·2	+0·1	−0·2	−0·2	−0·2	−0·2	−0·1	0
September	+0·2	+0·2	+0·3	+0·4	+0·4	+0·5	+1·0	+2·1	+2·1	+1·0	−0·3	−2·0	−2·7	−2·5	−1·7	−0·5	+0·4	+0·5	+0·1	0	−0·1	−0·1	−0·1	0	+0·1
Means	0	+0·2	+0·2	+0·2	+0·3	+0·4	+1·2	+2·2	+2·4	+1·4	+0·1	−1·4	−2·3	−2·3	−1·8	−1·0	−0·3	+0·1	0	−0·3	−0·4	−0·4	−0·2	−0·1	0

NOTE.—When the sign is + the magnet points to the East, and when − to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Barrackpore from all available days in 1912.

·37000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	350	351	351	353	354	354	357	358	359	359	360	367	369	368	366	364	359	355	352	349	348	348	348	350	350	356
February .	355	356	357	358	358	358	359	359	360	361	364	370	375	378	375	369	363	359	358	357	356	353	354	354	355	361
March .	355	355	355	356	357	358	358	359	363	368	375	381	383	381	376	369	362	358	358	356	354	352	353	354	355	362
October .	365	366	367	370	370	371	373	373	377	381	388	394	395	390	382	374	368	366	364	362	361	360	361	362	366	372
November .	357	359	361	362	363	364	366	370	377	382	387	389	389	383	374	367	363	361	357	354	352	352	352	355	357	367
December .	365	366	367	369	369	371	371	375	380	383	388	391	388	382	377	374	373	370	368	366	365	365	364	363	365	373
Means .	358	359	360	361	362	363	364	366	369	372	377	382	383	380	375	370	365	362	360	357	356	355	355	356	358	365
Summer.																										
April .	355	357	358	357	357	359	361	361	362	370	380	386	388	385	379	370	363	359	357	356	355	355	356	355	356	364
May .	365	366	366	367	367	367	369	371	374	379	386	391	391	389	384	376	371	365	364	364	363	363	364	364	365	372
June .	367	368	368	368	367	368	372	375	377	379	386	389	391	390	385	378	372	368	366	365	365	365	366	367	367	373
July .	368	368	369	369	369	369	372	376	379	382	390	394	397	397	391	384	376	370	367	367	366	367	367	368	368	376
August .	366	366	367	367	367	368	369	367	366	366	371	376	381	382	380	377	371	365	362	362	361	363	363	364	366	369
September .	365	366	368	369	369	370	371	367	362	365	372	377	382	385	381	376	370	366	366	365	364	364	365	365	365	370
Means .	364	365	366	366	366	367	369	370	370	374	381	386	388	388	383	377	371	366	364	363	362	363	364	364	365	371

Diurnal Inequality of the Horizontal Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−6	−5	−5	−3	−2	−2	+1	+2	+3	+3	+4	+11	+13	+12	+10	+8	+3	−1	−4	−7	−8	−8	−8	−6	−6
February	−6	−5	−4	−3	−3	−3	−2	−2	−1	0	+3	+9	+14	+17	+14	+8	+2	−2	−3	−4	−6	−8	−7	−7	−6
March	−7	−7	−7	−6	−5	−4	−4	−3	+1	+6	+13	+19	+21	+19	+14	+7	0	−4	−4	−6	−8	−10	−9	−8	−7
October	−7	−6	−5	−2	−2	−1	+1	+1	+5	+9	+16	+22	+23	+18	+10	+2	−4	−6	−8	−10	−11	−12	−11	−10	−6
November	−10	−8	−6	−5	−4	−3	−1	+3	+10	+15	+20	+22	+22	+16	+7	0	−4	−6	−10	−13	−15	−15	−15	−12	−10
December	−8	−7	−6	−4	−4	−2	−2	+2	+7	+10	+15	+18	+15	+9	+4	+1	0	−3	−5	−7	−8	−8	−9	−10	−8
Means	−7	−6	−5	−4	−3	−2	−1	+1	+4	+7	+12	+17	+18	+15	+10	+5	0	−3	−5	−8	−9	−10	−10	−9	−7
Summer.																									
April	−9	−7	−6	−7	−7	−5	−3	−3	−2	+6	+16	+22	+24	+21	+15	+6	−1	−5	−7	−8	−9	−9	−8	−9	−8
May	−7	−6	−6	−5	−5	−5	−3	−1	+2	+7	+14	+19	+19	+17	+12	+4	−1	−7	−8	−8	−9	−9	−8	−8	−7
June	−6	−5	−5	−5	−6	−5	−1	+2	+4	+6	+13	+16	+18	+17	+12	+5	−1	−5	−7	−8	−8	−8	−7	−6	−6
July	−8	−8	−7	−7	−7	−7	−4	0	+3	+6	+14	+18	+21	+21	+15	+8	0	−6	−9	−9	−10	−9	−9	−8	−8
August	−3	−3	−2	−2	−2	−1	0	−2	−3	−3	+2	+7	+12	+13	+11	+8	+2	−4	−7	−7	−8	−6	−6	−5	−3
September	−5	−4	−2	−1	−1	0	+1	−3	−8	−5	+2	+7	+12	+15	+11	+6	0	−4	−4	−5	−6	−6	−5	−5	−5
Means	−7	−6	−5	−5	5	−4	−2	−1	−1	+3	+10	+15	+17	+17	+12	+6	0	−5	−7	−8	−9	8	−7	−7	−6

NOTE.—When the sign is + the H. F. is greater, and when — it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Barrackpore from all available days in 1912.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
													Winter.													
	·22000 C. G. S. +																									
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	281	281	281	281	282	282	283	284	283	279	275	276	278	279	279	279	280	280	281	281	281	281	281	281	281	280
February	291	291	291	291	291	292	292	292	293	289	286	283	282	285	287	287	289	289	291	291	291	291	291	291	291	289
March	295	294	294	295	296	296	296	298	296	292	287	280	279	280	285	289	290	291	292	293	294	294	295	295	295	291
October	337	337	337	338	338	338	339	340	337	334	330	326	324	327	330	331	332	334	335	335	335	336	337	337	337	334
November	342	342	342	342	342	343	344	345	345	343	339	336	336	335	333	334	337	339	339	340	340	341	341	341	341	340
December	346	346	346	346	346	346	347	347	349	348	346	344	342	341	340	341	344	345	346	346	346	346	346	346	346	345
Means	315	315	315	316	316	316	317	318	317	314	311	308	307	308	309	310	312	313	314	314	315	315	315	315	315	313
													Summer.													
April	307	307	307	307	307	308	310	309	305	300	296	292	295	298	301	304	305	306	306	307	307	308	308	308	308	305
May	314	314	314	314	314	314	316	316	313	309	307	306	307	309	312	313	314	313	313	314	315	315	315	315	315	313
June	320	319	319	320	320	321	322	320	317	314	312	310	311	313	315	317	318	319	319	320	320	321	321	321	321	318
July	326	326	326	326	326	327	328	326	323	320	317	316	318	319	320	322	324	325	326	326	326	326	327	327	327	324
August	328	328	328	328	328	328	330	328	324	321	318	316	318	321	323	325	325	325	325	327	327	329	329	329	329	325
September	335	335	335	335	335	335	336	336	332	329	325	322	323	325	329	331	332	332	333	333	334	335	335	335	336	332
Means	322	322	322	322	322	322	324	323	319	316	313	310	312	314	317	319	320	320	320	321	322	322	323	323	323	320

Diurnal Inequality of the Vertical Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	+1	+1	+1	+1	+2	+2	+3	+4	+3	−1	−5	−4	−2	−1	−1	−1	0	0	+1	+1	+1	+1	+1	+1	+1
February . .	+2	+2	+2	+2	+2	+3	+3	+3	+4	0	−3	−6	−7	−4	−2	−2	0	0	+2	+2	+2	+2	+2	+2	+2
March . .	+4	+3	+3	+4	+5	+5	+5	+7	+5	+1	−4	−11	−12	−11	−6	−2	−1	0	+1	+2	+3	+3	+4	+4	+4
October . .	+3	+3	+3	+4	+4	+4	+5	+6	+3	0	−4	−8	−10	−7	−4	−3	−2	0	+1	+1	+1	+2	+3	+3	+3
November . .	+2	+2	+2	+2	+2	+3	+4	+5	+5	+3	−1	−4	−4	−5	−7	−6	−3	−1	−1	0	0	+1	+1	+1	+1
December . .	+1	+1	+1	+1	+1	+1	+2	+2	+4	+3	+1	−1	−3	−4	−5	−4	−1	0	+1	+1	+1	+1	+1	+1	+1
Means .	+2	+2	+2	+3	+3	+3	+4	+5	+4	+1	−2	−5	−6	−5	−4	−3	−1	0	+1	+1	+2	+2	+2	+2	+2
Summer.																									
April . . .	+2	+2	+2	+2	+2	+3	+5	+4	0	−5	−9	−13	−10	−7	−4	−1	0	+1	+1	+2	+2	+3	+3	+3	+3
May . . .	+1	+1	+1	+1	+1	+1	+3	+3	0	−4	−6	−7	−6	−4	−1	0	+1	0	0	+1	+2	+2	+2	+2	+2
June . . .	+2	+1	+1	+2	+2	+3	+4	+2	−1	−4	−6	−8	−7	−5	−3	−1	0	+1	+1	+2	+2	+3	+3	+3	+3
July . . .	+2	+2	+2	+2	+2	+3	+4	+2	−1	−4	−7	−8	−6	−5	−4	−2	0	+1	+2	+2	+2	+2	+3	+3	+3
August . .	+3	+3	+3	+3	+3	+3	+5	+3	−1	−4	−7	−9	−7	−4	−2	0	0	0	0	+2	+2	+4	+4	+4	+4
September . .	+3	+3	+3	+3	+3	+3	+4	+4	0	−3	−7	−10	−9	−7	−3	−1	0	0	+1	+1	+2	+3	+3	+3	+4
Means .	+2	+2	+2	+2	+2	+2	+4	+3	−1	−4	−7	−10	−8	−6	−3	−1	0	0	0	+1	+2	+2	+3	+3	+3

NOTE.—When the sign is + the V. F. is greater, and when — it is less than the mean.

Hourly Means of the Dip as determined at Barrackpore from all available days in 1912.

N 30° +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	49·1	49·0	49·0	48·9	49·0	49·0	48·9	49·0	48·8	48·6	48·3	48·1	48·1	48·2	48·3	48·4	48·7	48·8	49·0	49·1	49·1	49·1	49·1	49·1	49·1	48·8
February	49·6	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·2	48·9	48·4	48·1	48·2	48·5	48·7	49·1	49·3	49·5	49·5	49·6	49·6	49·6	49·6	49·6	49·2
March	49·8	49·8	49·8	49·8	49·8	49·8	49·8	49·9	49·6	49·1	48·5	47·8	47·6	47·8	48·3	48·9	49·2	49·5	49·5	49·7	49·8	49·9	49·9	49·9	49·8	49·3
October	52·2	52·2	52·2	52·1	52·1	52·1	52·1	52·1	51·8	51·4	50·9	50·4	50·2	50·6	51·1	51·5	51·8	52·0	52·2	52·3	52·3	52·4	52·4	52·4	52·2	51·8
November	52·9	52·8	52·8	52·7	52·7	52·7	52·7	52·6	52·4	52·0	51·5	51·3	51·3	51·4	51·7	52·0	52·4	52·6	52·7	52·9	53·0	53·1	53·1	52·9	52·9	52·4
December	52·9	52·8	52·8	52·7	52·7	52·7	52·7	52·6	52·5	52·3	52·0	51·7	51·7	51·9	52·0	52·2	52·4	52·6	52·8	52·8	52·9	52·9	52·9	53·0	52·9	52·5
Means	51·1	51·0	51·0	51·0	51·0	51·0	51·0	51·0	50·8	50·4	50·0	49·6	49·5	49·7	50·0	50·3	50·6	50·8	51·0	51·1	51·1	51·2	51·2	51·2	51·1	50·7
Summer.																										
April	50·6	50·6	50·5	50·6	50·6	50·5	50·6	50·5	50·2	49·6	48·9	48·4	48·5	48·8	49·3	49·8	50·2	50·4	50·5	50·6	50·6	50·7	50·7	50·7	50·7	50·1
May	50·7	50·7	50·7	50·6	50·6	50·6	50·7	50·6	50·3	49·8	49·4	49·1	49·2	49·4	49·8	50·2	50·5	50·6	50·7	50·8	50·9	50·9	50·9	50·9	50·8	50·4
June	51·0	50·9	50·9	51·0	51·0	51·1	51·0	50·7	50·5	50·2	49·7	49·5	49·5	49·6	50·0	50·4	50·7	50·9	51·0	51·1	51·1	51·2	51·1	51·1	51·1	50·6
July	51·4	51·4	51·4	51·4	51·4	51·4	51·4	51·1	50·7	50·4	49·9	49·7	49·7	49·7	50·1	50·5	51·0	51·3	51·4	51·4	51·5	51·4	51·5	51·5	51·5	50·9
August	51·6	51·6	51·6	51·6	51·6	51·5	51·7	51·6	51·3	51·1	50·8	50·4	50·4	50·5	50·7	51·0	51·2	51·4	51·6	51·7	51·8	51·8	51·8	51·8	51·7	51·3
September	52·1	52·1	52·0	52·0	52·0	52·0	52·0	52·1	52·1	51·7	51·2	50·8	50·6	50·6	51·1	51·4	51·8	51·9	52·0	52·0	52·1	52·2	52·1	52·1	52·2	51·8
Means	51·2	51·2	51·2	51·2	51·2	51·2	51·2	51·1	50·9	50·5	50·0	49·7	49·7	49·8	50·2	50·6	50·9	51·1	51·2	51·3	51·3	51·4	51·4	51·4	51·3	50·9

Diurnal Inequality of the Dip at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·3	+0·2	+0·2	+0·1	+0·2	+0·2	+0·1	+0·2	0	−0·2	−0·5	−0·7	−0·7	−0·6	−0·5	−0·4	−0·1	0	+0·2	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3
February . .	+0·4	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	0	−0·3	−0·8	−1·1	−1·0	−0·7	−0·5	−0·1	+0·1	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4
March . .	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·6	+0·3	−0·2	−0·8	−1·5	−1·7	−1·5	−1·0	−0·4	−0·1	+0·2	+0·2	+0·4	+0·5	+0·6	+0·6	+0·6	+0·5
October . .	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·3	0	−0·4	−0·9	−1·4	−1·6	−1·2	−0·7	−0·3	0	+0·2	+0·4	+0·5	+0·5	+0·6	+0·6	+0·6	+0·4
November . .	+0·5	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·2	0	−0·4	−0·9	−1·1	−1·1	−1·0	−0·7	−0·4	0	+0·2	+0·3	+0·5	+0·6	+0·7	+0·7	+0·6	+0·5
December . .	+0·4	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2	+0·1	0	−0·2	−0·5	−0·8	−0·8	−0·6	−0·5	−0·3	−0·1	+0·1	+0·3	+0·3	+0·4	+0·4	+0·4	+0·5	+0·4
Means .	+0·4	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·1	−0·3	−0·7	−1·1	−1·2	−1·0	−0·7	−0·4	−0·1	+0·1	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5	+0·4
Summer.																									
April . . .	+0·5	+0·5	+0·4	+0·5	+0·5	+0·4	+0·5	+0·4	+0·1	−0·5	−1·2	−1·7	−1·6	−1·3	−0·8	−0·3	+0·1	+0·3	+0·4	+0·5	+0·5	+0·6	+0·6	+0·6	+0·6
May . . .	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·3	+0·2	−0·1	−0·6	−1·0	−1·3	−1·2	−1·0	−0·6	−0·2	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5	+0·4
June . . .	+0·4	+0·3	+0·3	+0·4	+0·4	+0·5	+0·4	+0·1	−0·1	−0·4	−0·9	−1·1	−1·1	−1·0	−0·6	−0·2	+0·1	+0·3	+0·4	+0·5	+0·5	+0·6	+0·5	+0·5	+0·5
July . . .	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·2	−0·2	−0·5	−1·0	−1·2	−1·2	−1·2	−0·8	−0·4	+0·1	+0·4	+0·5	+0·5	+0·6	+0·5	+0·6	+0·6	+0·6
August . .	+0·3	+0·3	+0·3	+0·3	+0·3	+0·2	+0·4	+0·3	0	−0·2	−0·5	−0·9	−0·9	−0·8	−0·6	−0·3	−0·1	+0·1	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5	+0·4
September . .	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·3	−0·1	−0·6	−1·0	−1·2	−1·2	−0·7	−0·4	0	+0·1	+0·2	+0·2	+0·3	+0·4	+0·3	+0·3	+0·4
Means .	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·2	0	−0·4	−0·9	−1·2	−1·2	−1·1	−0·7	−0·3	0	+0·2	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5	+0·4

NOTE.—When the sign is + the Dip is greater, and when − it is less than the mean.

F.—Table of results at Toungoo.

Hourly Means of the Declination as determined at Toungoo from all available days in 1912.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
E. 0° +												Winter.														
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	16·1	16·2	16·1	16·0	15·9	15·8	15·6	15·7	16·2	16·5	16·1	15·5	15·4	15·9	16·3	16·7	16·9	16·7	16·4	16·5	16·4	16·2	16·2	16·1	16·1	16·1
February .	15·5	15·6	15·5	15·6	15·6	15·5	15·4	15·5	15·8	15·8	15·5	15·1	14·7	14·9	15·5	16·0	16·3	16·2	15·9	15·9	15·8	15·7	15·6	15·6	15·5	15·6
March .	15·0	15·0	15·0	15·0	14·9	14·8	14·8	15·2	16·1	16·7	16·6	15·8	14·6	13·8	13·6	14·3	14·9	15·3	15·0	15·1	15·0	15·0	15·0	15·0	15·0	15·1
October .	11·8	11·9	11·9	11·7	11·6	11·4	11·4	12·0	12·7	12·7	12·3	11·5	10·8	10·7	11·0	11·7	12·1	12·1	11·8	11·8	11·6	11·6	11·6	11·7	11·8	11·7
November .	11·2	11·2	11·1	11·1	11·0	10·9	10·8	11·0	11·3	11·6	11·6	11·3	11·2	11·2	11·4	11·3	11·5	11·7	11·5	11·4	11·3	11·3	11·2	11·2	11·2	11·3
December .	10·7	10·7	10·6	10·5	10·3	10·2	10·1	9·9	10·1	10·6	11·0	11·0	10·8	10·7	10·7	10·7	11·0	11·1	11·0	10·9	10·8	10·7	10·6	10·7	10·7	10·7
Means .	13·4	13·4	13·4	13·3	13·2	13·1	13·0	13·2	13·7	14·0	13·9	13·4	12·9	12·9	13·1	13·5	13·8	13·9	13·6	13·6	13·5	13·4	13·4	13·4	13·4	13·4
												Summer.														
April .	14·5	14·6	14·6	14·7	14·6	14·6	14·9	15·9	16·2	16·1	15·2	13·9	13·0	12·9	13·1	13·7	14·4	14·8	14·5	14·3	14·1	14·2	14·2	14·3	14·5	14·5
May .	14·0	14·1	14·2	14·2	14·2	14·3	15·2	16·1	16·3	15·5	14·2	13·0	12·3	12·2	12·7	13·3	14·0	14·3	14·1	13·9	13·8	13·8	13·8	13·9	13·9	14·1
June .	13·9	14·0	14·1	14·2	14·2	14·3	15·1	16·0	16·2	15·7	14·6	13·5	12·6	12·5	12·5	12·8	13·4	13·6	13·8	13·7	13·5	13·4	13·5	13·7	13·9	13·9
July .	13·2	13·4	13·5	13·5	13·5	13·7	14·6	15·5	15·5	14·8	13·8	12·9	12·2	12·0	11·9	12·2	12·7	13·1	13·1	12·9	12·9	12·9	13·0	13·0	13·2	13·3
August .	12·6	12·7	12·9	12·9	13·0	13·1	13·9	14·7	14·7	13·8	12·7	11·6	11·0	11·0	11·4	11·8	12·5	12·9	12·8	12·5	12·3	12·3	12·3	12·4	12·6	12·7
September .	12·1	12·2	12·3	12·3	12·4	12·5	13·0	13·9	14·0	13·1	12·0	10·9	10·1	9·9	10·6	11·6	12·4	12·6	12·2	12·1	12·1	12·1	12·1	12·1	12·1	12·1
Means .	13·4	13·5	13·6	13·6	13·7	13·8	14·5	15·4	15·5	14·8	13·8	12·6	11·9	11·8	12·0	12·6	13·2	13·6	13·4	13·2	13·1	13·1	13·2	13·2	13·4	13·4

Diurnal Inequality of the Horizontal Force at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
													Winter.												
1912 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−6	−6	−4	−4	−2	−2	0	+3	+5	+8	+10	+13	+15	+12	+8	+5	+1	−2	−5	−7	−9	−9	−8	−7	−6
February . .	−7	−7	−3	−4	−4	−3	−3	−3	−1	+4	+11	+15	+21	+19	+12	+6	0	−5	−6	−6	−7	−8	−9	−7	−7
March . .	−9	−9	−9	−8	−8	−7	−5	−5	0	+9	+21	+28	+30	+25	+16	+5	−3	−8	−8	−8	−9	−11	−11	−11	−9
October . .	−8	−8	−8	−5	−4	−4	−3	−3	+1	+11	+20	+27	+26	+20	+10	0	−6	−9	−8	−9	−10	−12	−12	−11	−8
November . .	−9	−8	−6	−5	−4	−4	−2	+1	+8	+16	+24	+27	+24	+18	+10	+2	−5	−8	−9	−12	−13	−13	−13	−11	−9
December . .	−7	−7	−5	−4	−3	−2	0	+2	+6	+11	+15	+19	+17	+12	+6	0	−2	−4	−6	−7	−7	−7	−7	−8	−7
Means . .	−8	−8	−6	−5	−4	−4	−2	−1	+3	+10	+17	+21	+22	+18	+10	+3	−3	−6	−7	−8	−9	−10	−10	−9	−8
													Summer.												
April . .	−10	−9	−8	−7	−8	−7	−6	−6	−1	+11	+24	+30	+29	+23	+14	+2	−7	−9	−10	−10	−10	−11	−11	−10	−10
May . . .	−7	−8	−6	−5	−5	−5	−4	−2	+2	+11	+18	+24	+22	+17	10	+2	−5	−10	−11	−8	−9	−9	−9	−8	−6
June . . .	−7	−6	−6	−5	−5	−6	−4	0	+5	+11	+16	+21	+20	+18	+11	+3	−6	−10	−10	−8	−8	−9	−8	−8	−7
July . . .	−9	−9	−9	−9	−8	−8	−6	−2	+3	+10	+18	+23	+24	+22	+15	+6	−3	−9	−11	−9	−10	−11	−10	−9	−8
August . .	−5	−5	−4	−3	−4	−2	−2	−3	−2	+4	+11	+13	+16	+15	+9	+6	0	−5	−8	−7	−7	−7	−7	·6	−6
September . .	−6	−6	−5	−2	−2	−2	−2	−5	−5	+1	+10	+15	+18	+16	+9	+2	−4	−6	−7	−5	−6	−7	−7	5	−6
Means . .	−7	−7	−6	−5	−5	−5	−4	−3	+1	+8	+16	+21	+22	+19	+12	+4	−4	−8	−9	−8	−8	−9	−8	−7	−7

NOTE.—When the sign is + the H. F. is greater, and when − it is less than the mean.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Toungoo from all available days in 1912.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·38000 C. G. S.+												Winter.														
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	860	860	862	862	864	864	866	869	871	874	876	879	**881**	878	874	871	867	864	861	859	**857**	857	858	859	860	866
February	865	865	869	868	868	869	869	869	871	876	883	887	**893**	891	884	878	872	867	866	866	865	864	**863**	865	865	872
March	868	868	868	869	869	870	872	872	877	886	898	905	**907**	902	893	882	874	869	869	869	868	866	**866**	866	868	877
October	893	893	893	896	897	897	898	898	902	912	921	**928**	927	921	911	901	895	892	893	892	891	**889**	889	890	893	901
November	891	892	894	895	896	896	898	901	908	916	924	**927**	924	918	910	902	895	892	891	888	**887**	887	887	889	891	900
December	898	898	900	901	902	903	905	907	911	916	920	**924**	922	917	911	905	903	901	899	898	898	898	898	**897**	898	905
Means	879	879	881	882	883	883	885	886	890	897	904	908	**909**	905	897	890	884	881	880	879	878	**877**	877	878	879	887
												Summer.														
April	864	865	866	867	866	867	868	868	873	885	898	**904**	903	897	888	876	867	865	864	864	864	**863**	863	864	864	874
May	873	872	874	875	875	875	876	878	882	891	898	**904**	902	897	890	882	875	870	**869**	872	871	871	871	872	874	880
June	885	886	886	887	887	886	888	892	897	903	908	**913**	912	910	903	895	886	883	**882**	884	884	883	884	884	885	892
July	889	889	889	889	890	890	892	896	901	908	916	921	**922**	920	913	904	895	889	**887**	889	888	887	888	889	890	898
August	886	886	887	888	887	889	889	888	889	895	902	904	**907**	906	900	897	891	886	**883**	884	884	884	884	885	885	891
September	888	888	889	892	892	892	892	889	889	895	904	909	**912**	910	903	896	890	888	**887**	889	888	887	887	889	888	894
Means	881	881	882	883	883	883	884	885	889	896	904	909	**910**	907	900	892	884	880	**879**	880	880	879	880	881	881	888

Diurnal Inequality of the Declination at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	0	+0·1	0	−0·1	−0·2	−0·3	−0·5	−0·4	+0·1	+0·4	0	−0·6	−0·7	−0·2	+0·2	+0·6	+0·8	+0·6	+0·3	+0·4	+0·3	+0·1	+0·1	0	0
February	−0·1	0	−0·1	0	0	−0·1	−0·2	−0·1	+0·2	+0·2	−0·1	−0·5	−0·9	−0·7	−0·1	+0·4	+0·7	+0·6	+0·3	+0·3	+0·2	+0·1	0	0	−0·1
March	−0·1	−0·1	−0·1	−0·1	−0·2	−0·3	−0·3	+0·1	+1·0	+1·6	+1·5	+0·7	−0·6	−1·3	−1·5	−0·8	−0·2	+0·2	−0·1	0	−0·1	−0·1	−0·1	−0·1	−0·1
October	+0·1	+0·2	+0·2	0	−0·1	−0·3	−0·3	+0·3	+1·0	+1·0	+0·6	−0·2	−0·9	−1·0	−0·7	0	+0·4	+0·4	+0·1	+0·1	−0·1	−0·1	−0·1	−0·1	+0·1
November	−0·1	−0·1	−0·2	−0·2	−0·3	−0·4	−0·5	−0·3	0	+0·3	+0·3	0	−0·1	−0·1	+0·1	0	+0·2	+0·4	+0·2	+0·1	0	0	−0·1	−0·1	−0·1
December	0	0	−0·1	−0·2	−0·4	−0·5	−0·6	−0·8	−0·6	−0·1	+0·3	+0·3	+0·1	0	0	0	+0·3	+0·4	+0·3	+0·2	+0·1	0	−0·1	0	0
Means	0	0	0	−0·1	−0·2	−0·3	−0·4	−0·2	+0·3	+0·6	+0·5	0	−0·5	−0·5	−0·3	+0·1	+0·4	+0·5	+0·2	+0·2	+0·1	0	0	0	0
Summer.																									
April	0	+0·1	+0·1	+0·2	+0·1	+0·1	+0·4	+1·4	+1·7	+1·6	+0·7	−0·6	−1·5	−1·6	−1·4	−0·8	−0·1	+0·3	0	−0·2	−0·4	−0·3	−0·3	−0·2	0
May	−0·1	0	+0·1	+0·1	+0·1	+0·2	+1·1	+2·0	+2·2	+1·4	+0·1	−1·1	−1·8	−1·9	−1·4	−0·6	−0·1	+0·2	0	−0·2	−0·3	−0·3	−0·3	−0·2	−0·2
June	0	+0·1	+0·2	+0·3	+0·3	+0·4	+1·2	+2·1	+2·3	+1·8	+0·7	−0·4	−1·3	−1·4	−1·4	−1·1	−0·5	−0·3	−0·1	−0·2	−0·4	−0·5	−0·4	−0·2	0
July	−0·1	+0·1	+0·2	+0·2	+0·2	+0·4	+1·3	+2·2	+2·2	+1·5	+0·5	−0·4	−1·1	−1·3	−1·4	−1·1	−0·6	−0·2	−0·2	−0·4	−0·4	−0·4	−0·3	−0·3	−0·1
August	−0·1	0	+0·2	+0·2	+0·3	+0·4	+1·2	+2·0	+2·0	+1·1	0	−1·1	−1·7	−1·7	−1·3	−0·9	−0·2	+0·2	+0·1	−0·2	−0·4	−0·4	−0·4	−0·3	−0·1
September	0	+0·1	+0·2	+0·2	+0·3	+0·4	+0·9	+1·8	+1·9	+1·0	−0·1	−1·2	−2·0	−2·2	−1·5	−0·5	+0·3	+0·5	+0·1	0	0	0	0	0	0
Means	0	+0·1	+0·2	+0·2	+0·3	+0·4	+1·1	+2·0	+2·1	+1·4	+0·4	−0·8	−1·5	−1·6	−1·4	−0·8	−0·2	+0·2	0	−0·2	−0·3	−0·3	−0·2	−0·2	0

NOTE.—When the sign is + the magnet points to the East, and when − to the West of the mean position.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Toungoo from all available days in 1912.

·16000 C. G. S.+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	534	535	535	534	534	534	534	534	533	529	523	522	520	525	529	531	532	531	532	533	533	533	534	534	534	531
February	542	542	542	542	541	541	542	542	540	536	532	530	529	533	537	539	540	539	539	540	541	541	541	541	542	539
March	544	544	544	544	543	543	544	545	543	537	530	525	522	525	533	540	542	541	541	542	543	543	543	544	544	539
October	552	552	552	552	552	552	553	555	551	544	539	537	537	542	546	549	549	549	549	549	550	550	551	552	552	549
November	570	570	570	570	570	570	570	570	570	566	562	561	561	563	564	566	568	568	569	569	569	569	570	571	571	568
December	584	584	584	584	584	584	584	584	585	586	584	582	577	577	578	580	582	584	584	584	584	584	584	585	585	583
Means	554	555	555	554	554	554	555	555	554	550	545	543	541	544	548	551	552	552	552	553	553	553	554	555	555	552
Summer.																										
April	542	542	542	542	542	542	544	543	538	531	525	523	523	529	534	539	541	540	539	540	540	541	542	542	542	538
May	544	544	544	544	544	545	548	546	541	533	528	527	529	534	538	542	544	543	541	543	543	544	544	544	545	541
June	548	548	548	548	548	549	552	551	546	538	534	532	533	539	541	545	547	547	547	547	547	548	548	549	549	545
July	559	559	559	558	558	559	563	560	552	541	537	538	539	543	549	555	559	558	555	554	555	556	557	557	557	553
August	547	547	547	547	547	547	550	548	543	535	530	529	530	534	539	543	546	546	545	545	545	546	546	546	547	543
September	548	548	548	548	548	548	552	550	543	534	529	527	529	536	543	548	550	547	545	547	547	548	548	548	549	544
Means	548	548	548	548	548	548	552	550	544	535	531	529	531	536	541	545	548	547	545	546	546	547	548	548	548	544

Diurnal Inequality of the Vertical Force at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+3	+4	+4	+3	+3	+3	+3	+3	+2	−2	−8	−9	−11	−6	−2	0	+1	0	+1	+2	+2	+2	+3	+3	+3
February	+3	+3	+3	+3	+2	+2	+3	+3	+1	−3	−7	−9	−10	−6	−2	0	+1	0	0	+1	+2	+2	+2	+2	+3
March	+5	+5	+5	+5	+4	+4	+5	+6	+4	−2	−9	−14	−17	−14	−6	+1	+3	+2	+2	+3	+4	+4	+4	+5	+5
October	+3	+3	+3	+3	+3	+3	+4	+6	+2	−5	−10	−12	−12	−7	−3	0	0	0	0	0	+1	+1	+2	+3	+3
November	+2	+2	+2	+2	+2	+2	+2	+2	+2	−2	−6	−7	−7	−5	−4	−2	0	0	+1	+1	+1	+1	+2	+3	+3
December	+1	+1	+1	+1	+1	+1	+1	+1	+2	+3	+1	−1	−6	−6	−5	−3	−1	+1	+1	+1	+1	+1	+1	+2	+2
Means	+2	+3	+3	+2	+2	+2	+3	+3	+2	−2	−7	−9	−11	−8	−4	−1	0	0	0	+1	+1	+1	+2	+3	+3
Summer.																									
April	+4	+4	+4	+4	+4	+4	+6	+5	0	−7	−13	−15	−15	−9	−4	+1	+3	+2	+1	+2	+2	+3	+4	+4	+4
May	+3	+3	+3	+3	+3	+4	+7	+5	0	−8	−13	−14	−12	−7	−3	+1	+3	+2	0	+2	+2	+3	+3	+3	+4
June	+3	+3	+3	+3	+3	+4	+7	+6	+1	−7	−11	−13	−12	−6	−4	0	+2	+2	+2	+2	+2	+3	+3	+4	+4
July	+6	+6	+6	+5	+5	+6	+10	+7	−1	−12	−16	−15	−14	−10	−4	+2	+6	+5	+2	+1	+2	+3	+4	+4	+4
August	+4	+4	+4	+4	+4	+4	+7	+5	0	−8	−13	−14	−13	−9	−4	0	+3	+3	+2	+2	+2	+3	+3	+3	+4
September	+4	+4	+4	+4	+4	+4	+8	+6	−1	−10	−15	−17	−15	−8	−1	+4	+6	+3	+1	+3	+3	+4	+4	+4	+5
Means	+4	+4	+4	+4	+4	+4	+8	+6	0	−9	−13	−15	−13	−8	−3	+1	+4	+3	+1	+2	+2	+3	+4	+4	+4

NOTE.—When the sign is + the Vertical Force is greater, and when — it is less than the mean.

Hourly Means of the Dip as determined at Toungoo from all available days in 1912.

N. 23°+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	2·9	3·0	2·9	2·9	2·8	2·8	2·7	2·7	2·5	2·1	1·6	1·4	1·2	1·7	2·1	2·3	2·6	2·6	2·8	2·9	2·9	2·9	3·0	3·0	2·9	2·5
February	3·4	3·4	3·3	3·3	3·2	3·2	3·3	3·3	3·0	2·6	2·1	1·8	1·5	1·9	2·4	2·7	3·0	3·1	3·1	3·2	3·3	3·3	3·3	3·3	3·4	2·9
March	3·4	3·4	3·4	3·4	3·3	3·3	3·3	3·4	3·1	2·3	1·4	0·8	0·5	0·9	1·8	2·7	3·1	3·2	3·2	3·3	3·3	3·4	3·4	3·5	3·4	2·8
October	3·2	3·2	3·2	3·1	3·1	3·1	3·1	3·3	2·9	2·0	1·4	1·0	1·0	1·6	2·2	2·7	2·9	3·0	3·0	3·0	3·1	3·2	3·3	3·3	3·2	2·7
November	4·6	4·6	4·5	4·5	4·5	4·5	4·4	4·3	4·1	3·5	3·0	2·8	2·9	3·3	3·6	4·0	4·4	4·4	4·6	4·6	4·7	4·7	4·8	4·8	4·7	4·2
December	5·4	5·4	5·4	5·4	5·3	5·2	5·2	5·2	5·1	5·0	4·8	4·5	4·2	4·3	4·6	4·9	5·2	5·4	5·4	5·4	5·4	5·4	5·4	5·6	5·5	5·1
Means	3·8	3·8	3·8	3·8	3·7	3·7	5·7	3·7	3·5	2·9	2·4	2·1	1·9	2·3	2·8	3·2	3·5	3·6	3·7	3·7	3·8	3·8	3·9	3·9	3·9	3·4
Summer.																										
April	3·4	3·4	3·3	3·3	3·3	3·3	3·4	3·3	2·8	1·9	1·0	0·7	0·7	1·4	2·0	2·8	3·2	3·2	3·2	3·3	3·3	3·3	3·4	3·4	3·4	2·8
May	3·3	3·3	3·2	3·2	3·2	3·3	3·5	3·3	2·7	1·9	1·3	1·0	1·2	1·7	2·3	2·8	3·2	3·3	3·2	3·2	3·2	3·3	3·3	3·3	3·3	2·8
June	3·2	3·2	3·2	3·1	3·1	3·2	3·4	3·2	2·6	1·9	1·4	1·1	1·2	1·7	2·1	2·7	3·1	3·2	3·2	3·1	3·1	3·3	3·2	3·3	3·3	2·7
July	3·9	3·9	3·9	3·8	3·8	3·8	4·1	3·7	3·0	1·9	1·4	1·3	1·3	1·7	2·4	3·1	3·7	3·8	3·7	3·5	3·6	3·7	3·7	3·7	3·7	3·2
August	3·1	3·1	3·1	3·0	3·1	3·0	3·2	3·1	2·7	1·9	1·3	1·2	1·1	1·5	2·0	2·4	2·8	3·0	3·0	3·0	3·0	3·1	3·1	3·0	3·1	2·6
September	3·1	3·1	3·1	3·0	3·0	3·0	3·3	3·2	2·7	1·8	1·2	0·8	0·9	1·5	2·2	2·9	3·2	3·0	2·9	3·0	3·0	3·1	3·1	3·1	3·1	2·6
Means	3·3	3·3	3·3	3·2	3·3	3·3	3·5	3·3	2·8	1·9	1·3	1·0	1·1	1·6	2·2	2·8	3·2	3·3	3·2	3·2	3·2	3·3	3·3	3·2	3·3	2·8

Diurnal Inequality of the Dip as determined at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid
Winter.																									
1912 Months.	′	′	′	′	′	′	′		′	′	′	′	′	′	′	′	′	′	′	′	′	′	′		
January	+0·4	+0·5	+0·4	+0·4	+0·3	+0·3	+0·2	+0·2	0	−0·4	−0·9	−1·1	−1·3	−0·8	−0·4	−0·2	+0·1	+0·1	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5	+0·4
February	+0·5	+0·5	+0·4	+0·4	+0·3	+0·3	+0·4	+0·4	+0·1	−0·3	−0·8	−1·1	−1·4	−1·0	−0·5	−0·2	+0·1	+0·2	+0·2	+0·3	+0·4	+0·4	+0·4	+0·4	+0·5
March	+0·6	+0·6	+0·6	+0·6	+0·5	+0·5	+0·5	+0·6	+0·3	−0·5	−1·4	−2·0	— ·3	−1·9	−1·0	−0·1	+0·3	+0·4	+0·4	+0·5	+0·5	+0·6	+0·6	+0·7	+0·6
October	+0·5	+0·5	+0·5	+0·4	+0·4	+0·4	+0·4	+0·6	+0·2	−0·7	−1·3	−1·7	−1·7	−1·1	−0·5	0	+0·2	+0·3	+0·3	+0·3	+0·4	+0·5	+0·6	+0·6	+0·5
November	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·2	+0·1	−0·1	−0·7	−1·2	−1·4	−1·3	−0·9	−0·6	−0·2	+0·2	+0·2	+0·4	+0·4	+0·5	+0·5	+0·6	+0·6	+0·5
December	+0·3	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1	+0·1	0	−0·1	−0·3	−0·6	−0·9	−0·8	−0·5	−0·2	+0·1	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·5	+0·4
Means	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·1	−0·5	−1·0	−1·3	−1·5	−1·1	−0·6	−0·2	+0·1	+0·2	+0·3	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5
Summer.																									
April	+0·6	+0·6	+0·5	+0·5	+0·5	+0·5	+0·6	+0·5	0	−0·9	−1·8	−2·1	2·1	−1·4	−0·8	0	+0·4	+0·4	+0·4	+0·5	+0·5	+0·5	+0·6	+0·6	+0·6
May	+0·5	+0·5	+0·4	+0·4	+0·4	+0·5	+0·7	+0·5	−0·1	−0·9	−1·5	−1·8	−1·6	−1·1	−0·5	0	+0·4	+0·5	+0·4	+0·4	+0·4	+0·5	+0·5	+0·5	+0·5
June	+0·5	+0·5	+0·5	+0·4	+0·4	+0·5	+0·7	+0·5	−0·1	−0·8	−1·3	−1·6	−1·5	−1·0	−0·6	0	+0·4	+0·5	+0·5	+0·4	+0·4	+0·6	+0·5	+0·6	+0·6
July	+0·7	+0·7	+0·7	+0·6	+0·6	+0·6	+0·9	+0·5	−0·2	−1·3	−1·8	−1·9	−1·9	−1·5	−0·8	−0·1	+0·5	+0·6	+0·5	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5
August	+0·5	+0·5	+0·5	+0·4	+0·5	+0·4	+0·6	+0·5	+0·1	−0·7	−1·3	−1·4	−1·5	−1·1	−0·6	−0·2	+0·2	+0·4	+0·4	+0·4	+0·4	+0·5	+0·5	+0·4	+0·5
September	+0·5	+0·5	+0·5	+0·4	+0·4	+0·4	+0·7	+0·6	+0·1	−0·8	−1·4	−1·8	−1·7	−1·1	−0·4	+0·3	+0·6	+0·4	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5	+0·5
Means	+0·5	+0·5	+0·5	+0·4	+0·5	+0·5	+0·7	+0·5	0	−0·9	−1·5	−1·8	−1·7	−1·2	−0·6	0	+0·4	+0·5	+0·4	+0·4	+0·4	+0·5	+0·5	+0·5	+0·5

NOTE.—When the sign is + the Dip is greater, and when — it is less than the mean.

G.—Tables of results at Kodaikānal.

Hourly Means of the Declination as determined at Kodaikānal from all available days in 1912.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
W 1°+													Winter.													
Months.	′	′	′	′	′	′	′		′	′	′	′	′	′	′	′	′	′	′	′	′	′		′	′	′
January	3·3	3·4	3·5	3·6	3·6	3·7	3·9	3·7	3·5	3·1	3·5	3·9	3·9	3·6	3·0	2·6	2·5	2·8	3·0	3·0	3·1	3·2	3·3	3·3	3·3	3·3
February	3·7	3·8	3·8	3·8	3·9	3·9	3·9	3·9	3·9	3·9	4·3	4·6	4·7	4·5	3·9	3·3	3·0	3·2	3·4	3·5	3·6	3·6	3·7	3·7	3·8	3·8
March	4·3	4·3	4·3	4·4	4·5	4·5	4·4	4·3	4·0	3·7	3·7	4·2	4·8	5·2	5·1	4·7	4·3	4·2	4·3	4·4	4·5	4·5	4·5	4·4	4·4	4·4
October	7·2	7·2	7·2	7·3	7·5	7·6	7·6	7·3	7·0	7·0	7·5	7·9	8·1	7·8	7·4	7·0	6·8	7·0	7·2	7·3	7·3	7·4	7·4	7·3	7·3	7·4
November	7·8	7·8	7·9	8·0	8·1	8·1	8·2	8·5	8·3	8·3	8·4	8·2	7·9	7·4	7·3	7·2	7·3	7·4	7·4	7·6	7·7	7·7	7·8	7·8	7·8	7·8
December	8·2	8·2	8·3	8·5	8·6	8·7	8·9	9·2	9·2	8·8	8·7	8·6	8·4	8·2	7·9	7·8	7·9	7·9	8·0	8·1	8·2	8·1	8·2	8·2	8·2	8·4
Means	5·8	5·8	5·8	5·9	6·0	6·1	6·2	6·2	6·0	5·8	6·0	6·2	6·3	6·1	5·8	5·4	5·3	5·4	5·6	5·7	5·7	5·8	5·8	5·8	5·8	5·9
													Summer.													
April	4·6	4·5	4·5	4·5	4·5	4·5	4·2	3·6	3·4	3·8	4·2	5·0	5·8	5·9	5·5	5·1	4·6	4·3	4·5	4·9	5·0	5·0	4·9	4·7	4·6	4·6
May	5·1	5·0	4·9	4·9	4·9	4·8	4·2	3·7	3·8	4·3	5·3	6·2	6·7	6·7	6·2	5·5	5·0	4·8	5·0	5·5	5·6	5·6	5·5	5·2	5·1	5·2
June	5·5	5·4	5·3	5·2	5·2	5·1	4·7	4·0	3·9	4·6	5·5	6·5	7·0	7·1	6·6	6·2	5·9	5·7	5·7	6·0	6·0	6·0	5·9	5·7	5·5	5·6
July	6·0	5·9	5·8	5·8	5·7	5·6	5·0	4·3	4·3	4·7	5·8	6·7	7·2	7·3	7·2	6·7	6·2	6·0	6·1	6·3	6·3	6·3	6·3	6·1	6·0	6·0
August	6·3	6·2	6·1	6·1	6·1	6·0	5·4	4·7	4·8	5·7	6·6	7·5	8·0	7·9	7·3	7·0	6·4	6·2	6·3	6·5	6·7	6·7	6·7	6·5	6·3	6·4
September	7·0	7·0	6·9	6·8	6·8	6·7	6·2	5·4	5·5	6·3	7·3	8·1	8·7	8·4	7·7	6·9	6·3	6·3	6·6	7·0	7·1	7·1	7·1	7·1	7·0	6·9
Means	5·8	5·7	5·6	5·6	5·5	5·5	5·0	4·3	4·3	4·9	5·8	6·7	7·2	7·2	6·8	6·2	5·7	5·6	5·7	6·0	6·1	6·1	6·1	5·9	5·8	5·8

Diurnal Inequality of the Declination at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912. Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	0	−0·1	−0·2	−0·3	−0·3	−0·4	−0·6	−0·4	−0·2	+0·2	−0·2	−0·6	−0·6	−0·3	+0·3	+0·7	+0·8	+0·5	+0·3	+0·3	+0·3	+0·1	0	0	0
February	+0·1	0	0	0	−0·1	−0·1	−0·1	−0·1	−0·1	−0·1	−0·5	−0·8	−0·9	−0·7	−0·1	+0·5	+0·8	+0·6	+0·4	+0·3	+0·2	+0·2	+0·1	+0·1	0
March	+0·1	+0·1	+0·1	0	−0·1	−0·1	0	+0·1	+0·4	+0·7	+0·7	+0·2	−0·4	−0·8	−0·7	−0·3	+0·1	+0·2	+0·1	0	−0·1	−0·1	−0·1	0	0
October	+0·2	+0·2	+0·2	+0·1	−0·1	−0·2	−0·2	+0·1	+0·4	+0·4	−0·1	−0·5	−0·7	−0·4	0	+0·4	+0·6	+0·4	+0·2	+0·1	+0·1	0	0	+0·1	+0·1
November	0	0	−0·1	−0·2	−0·3	−0·3	−0·4	−0·7	−0·5	−0·5	−0·6	−0·4	−0·1	+0·4	+0·5	+0·6	+0·5	+0·4	+0·4	+0·2	+0·1	+0·1	0	0	0
December	+0·2	+0·2	+0·1	−0·1	−0·2	−0·3	−0·5	−0·8	−0·8	−0·4	−0·3	−0·2	0	+0·2	+0·5	+0·6	+0·5	+0·5	+0·4	+0·3	+0·2	+0·3	+0·2	+0·2	+0·2
Means	+0·1	+0·1	+0·1	0	−0·1	−0·2	−0·3	−0·3	−0·1	+0·1	−0·1	−0·3	−0·4	−0·2	+0·1	+0·5	+0·6	+0·5	+0·3	+0·2	+0·2	+0·1	+0·1	+0·1	+0·1
Summer.																									
April	0	+0·1	+0·1	+0·1	+0·1	+0·1	+0·4	+1·0	+1·2	+0·8	+0·4	−0·4	−1·2	−1·3	−0·9	−0·5	0	+0·3	+0·1	−0·3	−0·4	−0·4	−0·3	−0·1	0
May	+0·1	+0·2	+0·3	+0·3	+0·3	+0·4	+1·0	+1·5	+1·4	+0·9	−0·1	−1·0	−1·5	−1·5	−1·0	−0·3	+0·2	+0·4	+0·2	−0·3	−0·4	−0·4	−0·3	0	+0·1
June	+0·1	+0·2	+0·3	+0·4	+0·4	+0·5	+0·9	+1·6	+1·7	+1·0	+0·1	−0·9	−1·4	−1·5	−1·0	−0·6	−0·3	−0·1	−0·1	−0·4	−0·4	−0·4	−0·3	−0·1	+0·1
July	0	+0·1	+0·2	+0·2	+0·3	+0·4	+1·0	+1·7	+1·7	+1·3	+0·2	−0·7	−1·2	−1·3	−1·2	−0·7	−0·2	0	−0·1	−0·3	−0·3	−0·3	−0·3	−0·1	0
August	+0·1	+0·2	+0·3	+0·3	+0·3	+0·4	+1·0	+1·7	+1·6	+0·7	−0·2	−1·1	−1·6	−1·5	−0·9	−0·6	0	+0·2	+0·1	−0·1	−0·3	−0·3	−0·3	−0·1	+0·1
September	−0·1	−0·1	0	+0·1	+0·1	+0·2	+0·7	+1·5	+1·4	+0·6	−0·4	−1·2	−1·8	−1·5	−0·8	0	+0·6	+0·6	+0·3	−0·1	−0·2	−0·2	−0·2	−0·2	−0·1
Means	0	+0·1	+0·2	+0·2	+0·3	+0·3	+0·8	+1·5	+1·5	+0·9	0	−0·9	−1·4	−1·4	−1·0	−0·4	+0·1	+0·2	+0·1	−0·2	−0·3	−0·3	−0·3	−0·1	0

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Kodaikānal from all available days in 1912.

·37000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	522	524	525	526	525	527	528	532	545	561	573	574	561	546	533	525	524	525	524	523	522	523	522	522	523	534
February	526	528	529	529	529	529	529	529	540	558	574	583	577	561	545	535	532	533	533	529	528	526	525	525	525	538
March	514	514	515	516	517	517	517	519	533	556	582	597	588	571	548	528	517	517	519	517	515	514	513	514	514	532
October	536	537	542	542	541	541	541	546	564	589	609	616	607	587	569	552	545	543	540	538	535	533	534	537	536	555
November	538	540	541	542	541	542	544	552	565	580	589	591	586	575	566	556	548	542	537	535	533	532	534	538	538	552
December	546	547	548	549	550	550	551	557	563	573	581	584	584	582	577	570	560	551	549	548	547	546	544	546	546	558
Means	530	532	533	534	534	534	535	539	552	570	585	591	584	570	556	544	538	535	531	532	530	529	529	530	530	545
Summer.																										
April	512	513	513	512	514	514	513	519	539	564	582	589	580	559	535	518	513	513	515	513	512	512	511	511	512	528
May	518	520	521	521	521	520	522	527	542	560	574	575	568	555	537	523	516	514	518	516	516	517	517	518	519	531
June	527	528	529	529	528	529	531	535	545	561	573	579	573	559	543	528	520	521	523	524	525	525	526	527	517	537
July	531	531	532	532	532	532	536	539	550	566	581	587	581	569	553	539	528	524	528	528	528	529	530	530	531	542
August	530	531	532	532	533	533	533	537	550	568	582	588	583	571	557	542	531	526	529	527	527	527	528	529	530	543
September	532	533	536	536	537	536	536	541	558	580	598	604	596	578	558	541	532	533	537	534	533	532	532	532	533	549
Means	525	526	527	527	528	527	529	533	547	567	582	587	580	565	547	532	523	522	525	524	524	524	524	525	525	538

Diurnal Inequality of the Horizontal Force at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912. Months.	γ	γ	γ	γ	γ	γ	γ	γ		γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−12	−10	− 9	− 8	− 9	− 7	− 6	− 2	+11	+27	+39	+40	+27	+12	− 1	− 9	−10	− 9	−10	−11	−12	−12	−12	−12	−11
February . .	−12	−10	− 9	− 9	− 9	− 9	− 9	− 9	+ 2	+20	+36	+45	+39	+23	+ 7	− 3	− 6	− 5	− 5	− 9	−10	−12	−13	−13	−13
March . . .	−18	−18	−17	−16	−15	−15	−15	−13	+ 1	+24	+50	+65	+56	+39	+16	− 4	−15	−15	−13	−15	−17	−18	−19	−18	−18
October . .	−19	−18	−13	−13	−14	−14	−14	− 9	+ 9	+24	+54	+61	+52	+32	+14	− 3	−10	−12	−15	−17	−20	−22	−21	−18	−19
November . .	−14	−12	−11	−10	−11	−10	− 8	0	+13	+28	+37	+39	+34	+23	+14	+ 4	− 4	−10	−15	−17	−19	−20	−18	−14	−14
December . .	−12	−11	−10	− 9	− 8	− 8	− 7	− 1	+ 5	+15	+23	+26	+26	+24	+19	+12	+ 2	− 7	− 9	−10	−11	−12	−14	−12	−12
Means .	−15	−13	−12	−11	−11	−11	−10	− 6	+ 7	+25	+40	+46	+39	+25	+11	− 1	− 7	−10	−11	−13	−15	−16	−16	−15	−15
Summer.																									
April . . .	−16	−15	−15	−16	−14	−14	−15	− 9	+11	+36	+54	+61	+52	+31	+ 7	−10	−15	−16	−13	−15	−16	−16	−17	−17	−16
May . . .	−13	−11	−10	−10	−10	−11	− 9	− 4	+11	+29	+43	+44	+37	+24	6	− 8	−15	−17	−13	−15	−15	−14	−14	−13	−12
June . . .	−10	− 9	− 8	− 8	− 9	− 8	− 6	− 2	+ 8	+24	+36	+42	+36	+22	+ 6	− 9	−17	−16	−14	−13	−12	−12	−11	−10	−10
July . . .	−11	−11	−10	−10	−10	−10	− 6	− 3	+ 8	+24	+39	+45	+39	+27	+11	− 3	−14	−18	−14	−14	−14	−13	−12	−12	−11
August . . .	−13	−12	−11	−11	−10	−10	−10	− 6	+ 7	+25	+39	+45	+40	+28	+14	− 1	−12	−17	−14	−16	−16	−16	−15	−14	−13
September .	−17	−16	−13	−13	−12	−13	−13	− 8	+ 9	+31	+49	+55	+47	+29	+ 9	− 8	−17	−16	−12	−15	−16	−17	−17	−17	−16
Means .	−13	−12	−11	−11	−10	−11	− 9	− 5	+ 9	+29	+44	+49	+42	+27	+ 9	− 6	−15	−16	−13	−14	−14	−14	−14	−15	−13

NOTE.—When the sign is + the H. F. is greater, and when − it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Kodaikānal from all available days in 1912.

·02000 C. G. S.+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	585	585	585	585	585	586	585	585	581	575	570	570	573	578	581	585	584	582	582	583	584	584	585	585	586	582
February	593	594	594	594	593	594	594	594	590	584	579	577	579	583	588	591	590	589	589	590	591	591	591	593	594	589
March	597	597	597	597	597	597	597	599	599	595	588	577	573	574	578	585	590	593	593	593	594	595	596	597	597	592
October	639	640	641	640	640	640	642	643	639	631	623	617	617	617	619	624	628	631	634	634	635	637	638	640	640	633
November	645	646	645	645	644	645	645	643	641	638	635	637	638	635	633	634	636	638	640	641	642	643	645	646	646	641
December	652	652	652	652	652	652	652	650	650	648	648	646	645	641	638	640	644	646	649	649	650	650	650	651	652	648
Means	619	619	619	619	619	619	619	619	617	612	607	604	604	605	606	610	612	613	615	615	616	617	618	619	619	614
Summer.																										
April	605	605	605	604	605	606	607	608	603	596	590	582	579	582	588	595	602	603	602	602	603	604	605	605	606	599
May	612	612	612	611	611	612	615	613	608	602	597	593	593	597	601	606	610	609	609	609	610	611	612	612	612	607
June	619	619	619	619	619	620	623	622	619	614	609	607	605	609	613	618	620	619	617	617	618	618	619	620	620	617
July	625	625	625	625	625	626	630	630	626	620	615	612	613	615	618	622	625	626	624	623	624	625	625	625	626	623
August	630	630	630	630	630	631	633	630	622	614	610	607	608	612	616	622	625	625	625	626	627	628	629	630	630	624
September	634	634	635	634	635	636	638	635	626	617	611	606	607	611	617	623	628	629	628	629	630	632	632	633	634	627
Means	621	621	621	621	621	622	624	623	617	611	605	601	601	604	609	614	618	619	618	618	619	620	620	621	621	616

Diurnal Inequality of the Vertical Force at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912. Months.																									
January . .	+3	+3	+3	+3	+3	+4	+3	+3	−1	−7	−12	−12	−9	−4	−1	+3	+2	0	0	+1	+2	+2	+3	+3	+4
February . .	+4	+5	+5	+5	+4	+5	+5	+5	+1	−5	−10	−12	−10	−6	−1	+2	+1	0	0	+1	+2	+2	+2	+4	+5
March . . .	+5	+5	+5	+5	+5	+5	+5	+7	+7	+3	−4	−15	−19	−18	−14	−7	−2	+1	+1	+1	+2	+3	+4	+5	+5
October . .	+6	+7	+8	+7	+7	+7	+9	+10	+6	−2	−10	−16	−16	−16	−14	−9	−5	−2	+1	+1	+2	+4	+5	+7	+7
November . .	+4	+5	+4	+4	+3	+4	+4	+2	0	−3	−6	−4	−3	−6	−8	−7	−5	−3	−1	0	+1	+2	+4	+5	+5
December . .	+4	+4	+4	+4	+4	+4	+4	+2	+2	0	0	−2	−3	−7	−10	−8	−4	−2	+1	+1	+2	+2	+2	+3	+4
Means .	+5	+5	+5	+5	+5	+5	+5	+5	+3	−2	−7	−10	−10	−9	−8	−4	−2	−1	+1	+1	+2	+3	+4	+5	+5
Summer.																									
April . . .	+6	+6	+6	+5	+6	+7	+8	+9	+4	−3	−9	−17	−20	−17	−11	−4	+3	+4	+3	+3	+4	+5	+6	+6	+7
May . . .	+5	+5	+5	+4	+4	+5	+8	+6	+1	−5	−10	−14	−14	−10	−6	−1	+3	+2	+2	+2	+3	+4	+5	+5	+5
June . . .	+2	+2	+2	+2	+2	+3	+6	+5	+2	−3	−8	−10	−12	−8	−4	+1	+3	+2	0	0	+1	+1	+2	+3	+3
July . . .	+2	+2	+2	+2	+2	+3	+7	+7	+3	−3	−8	−11	−10	−8	−5	−1	+2	+3	+1	0	+1	+2	+2	+2	+3
August .	+6	+6	+6	+6	+6	+7	+9	+6	−2	−10	−14	−17	−16	−12	−8	−2	+1	+1	+1	+2	+3	+4	+5	+6	+6
September . .	+7	+7	+8	+7	+8	+9	+1	+8	−1	−10	−16	−21	−20	−16	−10	−4	+1	+2	+1	+2	+3	+5	+5	+6	+7
Means .	+5	+5	+5	+5	+5	+6	+8	+7	+1	−5	−11	−15	−15	−12	−7	−2	+2	+3	+2	+2	+3	+4	+4	+5	+5

NOTE.—When the sign is + the Vertical Force is greater, and when −, it is less than the mean.

Hourly Means of the Dip as determined at Kodaikānal from all available days in 1912.

N. 3° +

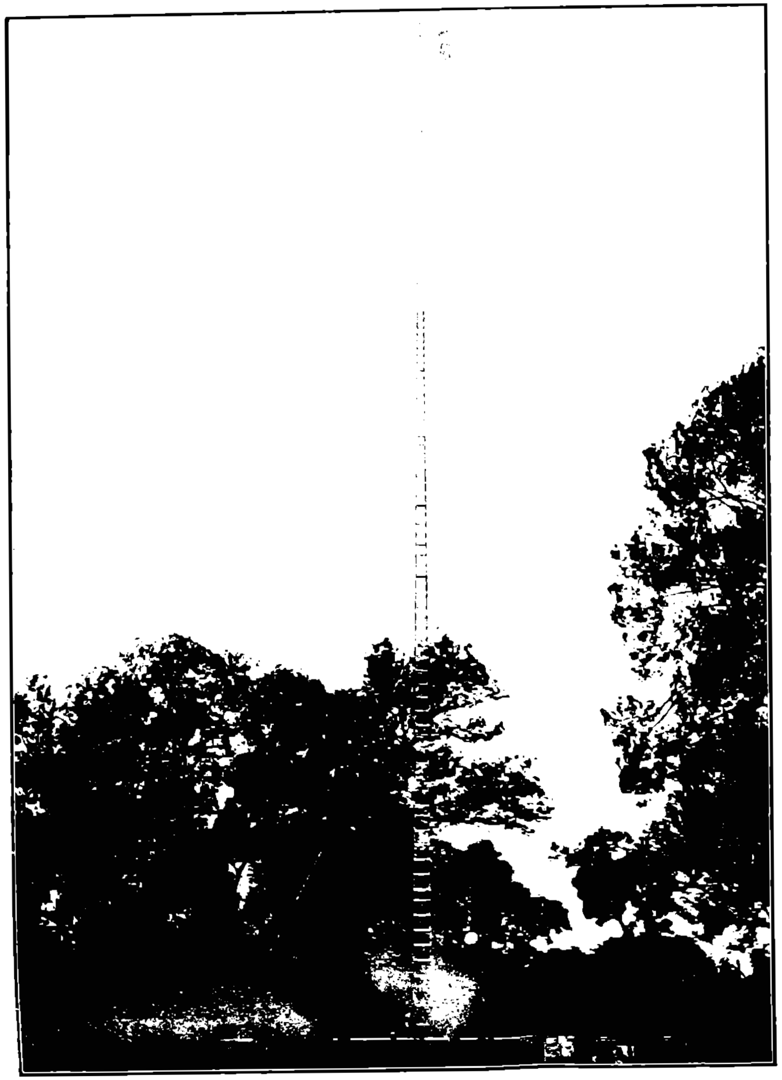
Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	56·5	56·5	56·5	56·4	56·5	56·5	56·4	56·4	56·0	55·3	54·8	54·8	55·1	55·7	56·0	56·5	56·4	56·2	56·2	56·3	56·4	56·4	56·5	56·5	56·6	56·1
February	57·2	57·3	57·2	57·2	57·2	57·2	57·2	57·2	56·8	56·2	55·6	55·4	55·6	56·0	56·6	56·9	56·9	56·8	56·8	56·9	57·0	57·0	57·0	57·2	57·3	56·8
March	57·6	57·6	57·6	57·6	57·6	57·6	57·6	57·8	57·7	57·2	56·4	55·3	55·0	55·2	55·7	56·4	57·0	57·2	57·2	57·2	57·3	57·4	57·5	57·6	57·6	57·0
October	61·3	61·4	61·4	61·4	61·4	61·4	61·5	61·6	61·1	60·2	59·4	58·8	58·8	59·0	59·3	59·8	60·2	60·5	60·8	60·8	60·9	61·1	61·2	61·4	61·4	60·6
November	61·8	61·9	61·8	61·8	61·7	61·8	61·8	61·6	61·3	60·9	60·6	60·8	60·9	60·7	60·6	60·7	61·0	61·2	61·4	61·5	61·6	61·7	61·9	61·9	61·9	61·4
December	62·4	62·4	62·4	62·4	62·4	62·4	62·4	62·2	62·1	61·9	61·8	61·6	61·5	61·2	61·0	61·2	61·6	61·8	62·1	62·1	62·2	62·2	62·3	62·3	62·4	62·0
Means	59·5	59·5	59·5	59·5	59·5	59·5	59·5	59·5	59·2	58·6	58·1	57·8	57·8	58·0	58·2	58·6	58·9	59·0	59·1	59·1	59·2	59·3	59·4	59·5	59·5	59·0
Summer.																										
April	58·4	58·4	58·4	58·3	58·3	58·4	58·5	58·6	58·0	57·2	56·6	55·8	55·6	56·0	56·7	57·4	58·1	58·2	58·1	58·1	58·2	58·3	58·4	58·4	58·4	57·8
May	59·0	58·9	58·9	58·9	58·9	58·9	59·2	59·0	58·4	57·8	57·2	56·9	56·9	57·4	57·8	58·4	58·8	58·7	58·7	58·7	58·8	58·9	59·0	59·0	59·0	58·5
June	59·5	59·5	59·5	59·5	59·5	59·6	59·9	59·8	59·4	58·9	58·3	58·1	58·0	58·4	58·9	59·4	59·7	59·6	59·4	59·4	59·5	59·5	59·5	59·6	59·6	59·3
July	60·1	60·1	60·1	60·1	60·1	60·1	60·5	60·5	60·0	59·4	58·8	58·5	58·6	58·9	59·3	59·7	60·1	60·2	60·0	59·9	60·0	60·1	60·1	60·1	60·1	59·8
August	60·5	60·5	60·5	60·5	60·5	60·6	60·8	60·5	59·7	58·8	58·4	58·1	58·2	58·6	59·1	59·7	60·1	60·1	60·1	60·2	60·3	60·4	60·4	60·5	60·5	59·9
September	60·9	60·9	60·9	60·9	60·9	61·0	60·2	60·9	60·0	59·0	58·4	57·9	58·0	58·5	59·2	59·8	60·3	60·4	60·3	60·4	60·5	60·7	60·7	60·8	60·9	60·1
Means	59·7	59·7	59·7	59·7	59·7	59·8	60·0	59·9	59·3	58·5	58·0	57·6	57·6	58·0	58·5	59·1	59·5	59·5	59·4	59·5	59·6	59·7	59·7	59·7	59·8	59·2

Diurnal Inequality of the Dip at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1912 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·4	+0·4	+0·4	+0·3	+0·4	+0·4	+0·3	+0·3	−0·1	−0·8	−1·3	−1·3	−1·0	−0·4	−0·1	+0·4	+0·3	+0·1	+0·1	+0·2	+0·3	+0·3	+0·4	+0·4	+0·5
February	+0·4	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	0	−0·6	−1·2	−1·4	−1·2	−0·8	−0·2	+0·1	+0·1	0	0	+0·1	+0·2	+0·2	+0·2	+0·4	+0·5
March	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·8	+0·7	+0·2	−0·6	−1·7	−2·0	−1·8	−1·3	−0·6	0	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+0·6	+0·6
October	+0·7	+0·8	+0·8	+0·8	+0·8	+0·8	+0·9	+1·0	+0·5	−0·4	−1·2	−1·8	−1·8	−1·6	−1·3	−0·8	−0·4	−0·1	+0·2	+0·2	+0·3	+0·5	+0·6	+0·8	+0·8
November	+0·4	+0·5	+0·4	+0·4	+0·3	+0·4	+0·4	+0·2	−0·1	−0·5	−0·8	−0·6	−0·5	−0·7	−0·8	−0·7	−0·4	−0·2	0	+0·1	+0·2	+0·3	+0·5	+0·5	+0·5
December	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·2	+0·1	−0·1	−0·2	−0·4	−0·5	−0·8	−1·0	−0·8	−0·4	−0·2	+0·1	+0·1	+0·2	+0·2	+0·3	+0·3	+0·4
Means	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·2	−0·4	−0·9	−1·2	−1·2	−1·0	−0·8	−0·4	−0·1	0	+0·1	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5
Summer.																									
April	+0·6	+0·6	+0·6	+0·5	+0·5	+0·6	+0·7	+0·8	+0·2	−0·6	−1·2	−2·0	−2·2	−1·8	−1·1	−0·4	+0·3	+0·4	+0·3	+0·3	+0·4	+0·5	+0·6	+0·6	+0·6
May	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·7	+0·5	−0·1	−0·7	−1·3	−1·6	−1·6	−1·1	−0·7	−0·1	+0·3	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5
June	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·6	+0·5	+0·1	−0·4	−1·0	−1·2	−1·3	−0·9	−0·4	+0·1	+0·4	+0·3	+0·1	+0·1	+0·2	+0·2	+0·2	+0·3	+0·3
July	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·7	+0·7	+0·2	−0·4	−1·0	−1·3	−1·2	−0·9	−0·5	−0·1	+0·3	+0·4	+0·2	+0·1	+0·2	+0·3	+0·3	+0·3	+0·3
August	+0·6	+0·6	+0·6	+0·6	+0·6	+0·7	+0·9	+0·6	−0·2	−1·1	−1·5	−1·8	−1·7	−1·3	−0·8	−0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+0·5	+0·6	+0·6
September	+0·8	+0·8	+0·8	+0·8	+0·8	+0·9	+1·1	+0·8	−0·1	−1·1	−1·7	−2·2	−2·1	−1·6	−0·9	−0·3	+0·2	+0·3	+0·2	+0·3	+0·4	+0·6	+0·6	+0·7	+0·8
Means	+0·5	+0·5	+0·5	+0·5	+0·5	+0·6	+0·8	+0·7	+0·1	−0·7	−1·2	−1·6	−1·6	−1·2	−0·7	−0·1	+0·3	+0·3	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5	+0·6

NOTE.—When the sign is + the Dip is greater, and when — it is less than the mean.

MAST DESIGNED AS A SIGNAL FOR TRIANGULATION IN WOODED COUNTRIES.



COMPUTING AND TECHNICAL OFFICES.

BY MR. J. DEGRAAFF HUNTER, M. A.

Towards the end of 1912 it was decided by the Meteorological Department to dispense with Dehra Dūn as a meteorological station. As the only remaining object in continuing observations was to accumulate data which might be useful for Survey purposes, a change in programme was made beginning from January 1st, 1913. Observations are now taken at 2 P.M. (standard time) instead of at 10 A.M. and 4 P.M. (local time) as was formerly done: and simultaneous observations have been carried out, by kind consent of the Superintendent, Northern Circle, in his office at Mussoorie. It is hoped that these simultaneous readings will throw light on terrestrial refraction and its annual change.

The present seems a suitable time for publishing the results obtained previous to the time of change of programme.

The Omori Seismograph has now been in good working order at Dehra since July 1912. A statement of the earthquakes recorded by it with the distance of the epicentre in each case when this could be satisfactorily deduced is given in the Table I. This is followed by two Tables (II and III) dealing with Solar Photography at Dehra Dūn. Tables IV and V give data regarding wind velocity. The velocity is given by the number of miles of wind which pass per hour. In Table VI the records of the underground thermometers are given. These readings of wind velocity and underground temperature have now been discontinued. Table VII gives some meteorological records obtained at Dehra year by year from 1899-00 to 1910-11.

TABLE I.

Seismograph Records taken at Dehra Dūn, 1912-13.

No.	Date.	Time of commencement. (Standard time)		Estimated distance of epicentre. (Miles)	Duration.		REMARKS.
		hrs.	mts.		hrs.	mts.	
1	7th July 1912	13	50	4,600	5	00	Repeated shocks of great intensity.
2	30th September 1912	2	32	4,200	2	00	Small.
3	7th November 1912	13	23	5,600	1	15	Distant shock of medium intensity.
4	15th „ „	22	51	200	0	3	Slight local shock.
5	29th „ „	2	28	400	0	22	Medium.
6	24th December 1912	5	35	3,800	0	35	Small.
7	24th December 1912	23	44	4,000	0	30	Small.
8	11th January 1913	18	55	3,300	1	00	Medium.
9	19th „ „	22	41	2,300	1	20	Medium.
10	20th February 1913	14	39·5	?	0	28	Small.
11	24th „ „	7	29·5	400	0	12	Slight.
12	6th March 1913	11	19	200	0	1	Slight.
13	6th March 1913	11	25·5	300	0	2	Slight.
14	6th March 1913	16	33·5	?	0	42	Shock of great intensity.

TABLE I—*concld.*

Seismograph Records taken at Dehra Dūn, 1912-13—concld.

No.	Date.	Time of commencement. (Standard time) hrs.	mts.	Estimated distance of epicentre. (Miles)	Duration. hrs.	mts.	REMARKS.
15	11th March 1913 .	0	38·5	200	0	12	Slight.
16	14th " " .	14	23·5	3,500	1	50	Great.
17	28th " " .	22	42	350	0	6	Slight.
18	9th April 1913 . .	11	3·5	250	0	5	Slight.
19	14th " " . .	13	22	?	0	38	Small.
20	16th " " . .	1	34	400	0	12	Slight.
21	25th " " . .	23	34	2,500	1	50	Medium.
22	15th May 1913 . .	7	19	?	0	1	Slight local shock.
23	30th " " . .	17	29	?	2	00	Medium.
24	26th June 1913 . .	10	45·5	4,500	2	50	Great.
25	27th " " . .	5	00	100	0	5	Local shock of moderate intensity.
26	1st August 1913 . .	22	50·5	3,800	1	5	Medium.
27	6th " " . .	23	39	100	0	2	Slight local shock.
28	7th " " . .	4	3	6,300	2	0	Distant shock of great intensity.
29	21st " " . .	10	33	200	0	7	Local shock of moderate intensity.
30	23rd September 1913 .	2	5	100	0	3	Slight local shock.
31	23rd September 1913 .	3	26	100	0	2	Slight.

NOTE.—"?" indicates that the distances could not be measured as the changes in the character of the tremors were ill-defined.

Solar Photography.

TABLE II.

Showing the Number and Character of Negatives.

YEAR.	NUMBER OF DAYS. When negatives were taken.	Failures. From bad weather.	Failures. From various causes.	TOTAL.	NUMBER OF NEGATIVES. Solar Phenomena. Spots and Faculæ. 8"	Spots and Faculæ. 12"	Spots only. 8"	Spots only. 12"	Faculæ only. 8"	Faculæ only. 12"	None. 8"	None. 12"	TOTAL. 8"	TOTAL. 12"	NUMBER OF WORKING DAYS WHEN PHENOMENA WERE Visible.	Absent.
1899-1900 . .	303	62	...	365	297	2	...	...	230	...	0	...	533	...	303	...
1900-1901 . .	308	55	2	365	127	0	...	...	322	...	75	...	524	6	262	46
1901-1902 . .	314	49	2	365	130	...	...	...	144	...	250	...	524	...	161	153
1902-1903 . .	299	66	...	365	283	2	10	...	123	...	62	...	478	2	202	37
1903-1904 . .	305	61	...	366	456	10	...	...	10	...	...	...	466	10	305	...
1904-1905 . .	313	52	...	365	503	18	...	...	2	...	...	...	505	18	313	...
1905-1906 . .	300	65	...	365	478	59	...	...	...	...	...	...	478	59	300	...
1906-1907 . .	329	36	...	365	508	39		...	30	5	...	...	538	44	320	...
1907-1908 . .	340	26	...	366	576	6		...	2	...	2	...	580	6	330	1
1908-1909 . .	336	29	...	365	559	16		...	21	...	...	...	580	16	336	...
1909-1910 . .	338	27	...	365	471	15		...	67	...	7	...	557	15	331	7
1910-1911 . .	328	37	...	365	287	24	[illegible]	...	224	10	64	1	577	35	289	39
1911-1912 . .	336	30	...	366	162	27	14	4	108	15	209	10	603	56	220	116

TABLE III.

Showing the Visibility of the Sun at Dehra Dun and Greenwich.

Years.	At Dehra Dun.			At Greenwich.		Remarks.
	Number of days on which negatives were taken.	Percentage of days on which negatives showed features.	Number of days on which sun was invisible.	Year.	Number of days on which negatives were taken.	
1880-81*	307	96	55	1880	1 6	*From 1st October to 30th September following.
1881-82	328	100	37	1881	181	
1882-83	318	100	47	1882	221	
1883-84	285	100	78	1883	215	
1884-85	284	100	81	1884	154	
1885-86	290	100	75	1885	206	
1886-87	302	91	61	1886	199	
1887-88	328	71	38	1887	188	
1888-89	315	78	50	1887-88	205	
1889-90	320	99	45	1888-89	182	
1890-91	303	100	62	1889-90	212	
1891-92	304	100	62	1890-91	224	
1892-93	292	100	73	1891-92	219	
1893-94	304	100	61	1892-93	220	
1894-95	313	100	52	1893-94	230	
1895-96	324	100	41	1894-95	199	
1896-97	316	100	49	1895-96	229	
1897-98	325	100	40	1896-97	222	
1898-99	321	100	44	1897-98	191	
1899-1900	303	100	62	1898-99	195	
1900-01	308	85	57	1899-1900	180	
1901-02	314	51	49	1900-01	167	
1902-03	299	88	66	1901-02	178	
1903-04	305	100	61	1902-03	204	
1904-05	313	100	52	1903-04	227	
1905-06	300	100	65	1904-05	212	
1906-07	329	100	36	1905-06	210	
1907-08	340	100	26	1906-07	210	
1908-09	336	100	29	1907-08	212	
1909-10	338	98	27	1908-09	207	
1910-11	328	88	37	1909-10†	194	†For the year ending May 10th, 1910, obtained from the report to the Board of Visitors.
1911-12	336	65	30	1910-11	Not obtainable.	
Mean	313	...	52	...	203	

Wind Velocity.

TABLE IV.

Mean Velocity in miles of the winds at Dehra Dūn during the twelve years 1899-1911, for each month of the year.

YEAR.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
1899-1900 . .	1·55	1·35	1·30	2·16	1·07	1·96	2·46	2·44	1·80	1·22	0·87	0·64
1900-01 . . .	0·81	0·63	0·86	0·99	0·68	1·90	2·08	1·98	2·08	1·35	1·05	0·76
1901-02 . . .	0·47	0·35	0·13	0·20	1·30	2·24	2·56	2·68	2·18	1·52	0·04	0·77
1902-03 . . .	0·74	0·59	0·50	0·80	1·08	1·41	1·63	1·98	2·25	1·54	1·14	0·96
1903-04 . . .	1·17	1·35	1·16	1·01	1·27	1·51	1·90	2·32	1·02	0·65	0·49	0·54
1904-05 . . .	0·70	0·84	0·60	0·66	1·21	1·55	2·16	1·40	1·76	1·55	1·04	1·05
1905-06 . . .	1·28	1·55	0·80	0·90	1·47	2·12	2·53	2·33	2·18	1·35	1·34	1·11
1906-07 . . .	1·37	0·98	0·36	0·83	1·55	2·14	2·12	2·31	2·51	1·59	1·17	1·38
1907-08 . . .	1·10	1·08	0·63	1·00	1·47	1·84	2·37	2·06	1·87	0·95	0·72	0·91
1908-09 . . .	1·03	1·01	0·71	0·85	1·17	...	...	1·68	1·57	0·81	0·92	0·97
1909-10 . . .	...	0·6	0·5	0·9	1·9	2·2	2·9	2·0	1·0	1·4	1·1	0·9
1910-11 . . .	0·0	1·0	1·1	1·6	1·0	2·1	2·1	2·0	1·2	1·0	0·8	0·8
1911-12 . . .	Not available.											

TABLE V.

Mean Velocity in miles of the winds at Dehra Dūn during the twelve years 1899-1911, for each hour of the day.

CIVIL HOURS.	1899-1900.	1900-1901.	1901-1902.	1902-1903.	1903-1904.	1904-1905.	1905-1906.	1906-1907.	1907-1908.	1908-1909.	1909-1910.	1910-1911.	1911-1912.
0 to 1 . .	1·56	1·12	0·85	0·63	0·90	0·70	1·10	1·17	1·06	0·69	1·0	1·0	
1 „ 2 . .	1·43	1·08	0·87	0·57	0·70	0·64	1·05	1·00	0·86	0·58	0·9	0·9	
2 „ 3 . .	1·22	0·82	0·82	0·57	0·70	0·62	0·98	0·89	0·78	0·57	0·8	0·8	Not available.
3 „ 4 . .	1·23	0·76	0·66	0·48	0·67	0·61	0·70	0·76	0·62	0·57	0·7	0·7	
„ 5 . .	0·90	0·69	0·59	0·48	0·60	0·57	0·68	0·73	0·61	0·48	0·6	0·6	
5 „ 6 . .	0·87	0·65	0·53	0·38	0·40	0·52	0·68	0·72	0·56	0·53	0·7	0·7	
6 „ 7 . .	0·79	0·59	0·44	0·40	0·51	0·47	0·63	0·64	0·52	0·51	0·7	0·6	
7 „ 8 . .	0·90	0·56	0·57	0·48	0·55	0·49	0·68	0·70	0·50	0·55	0·7	0.7	
8 „ 9 . .	1·00	0·78	0·79	0·73	0·78	0·74	0·92	1·01	0·82	0·85	1·1	0·9	
9 „ 10 . .	1·59	1·28	1·33	1·15	1·31	1·10	1·49	1·43	1·05	1·10	1·4	1·2	
10 „ 11 . .	1·92	1·70	1·84	1·61	1·73	1·60	1·97	1·82	1·50	1·37	2·2	1·9	
11 „ 12 . .	2·30	2·06	2·28	2·04	2·18	2·08	2·41	2·28	2·18	1·69	2·6	2·4	Not available.
12 „ 13 . .	2·55	2·19	2·40	2·40	2·25	2·38	2·61	2·55	2·52	2·16	3·1	2·8	
13 „ 14 . .	2·87	2·55	2·62	2·86	2·68	2·70	3·24	2·82	2·69	2·27	3·1	2·9	
14 „ 15 . .	2·94	2·78	2·76	2·92	2·73	2·08	3·36	3·06	2·84	2·32	3·5	3·0	
15 „ 16 . .	2·61	2·73	2·67	2·92	2·71	2·51	3·11	3·07	2·68	2·22	3·3	2·8	
16 „ 17 . .	2·29	2·44	2·31	2·66	2·47	2·45	2·82	2·71	2·29	1·76	3·1	2·4	
17 „ 18 . .	1·60	1·63	1·62	1·88	1·80	1·55	2·17	2·01	1·80	1·13	2·2	1·5	
18 „ 19 . .	1·15	0·90	0·98	1·05	0·67	0·83	1·53	1·42	1·06	0·71	1·3	0·8	
19 „ 20 . .	1·23	0·77	0·69	0·58	0·71	0·72	1·12	1·05	0·84	0·67	0·9	0·7	
20 „ 21 . .	1·51	0·97	0·68	0·60	0·89	0·74	1·09	1·11	0·82	0·68	0·8	0·9	Not available.
21 „ 22 . .	1·66	1·16	0·86	0·69	0·97	0·82	1·13	1·16	1·09	0·75	0·9	1·0	
22 „ 23 . .	1·72	1·20	0·85	0·67	0·96	0·78	1·27	1·26	1·08	0·82	1·0	1·0	

TABLE VI.

Mean Monthly Readings of earth thermometers, taken at the Office of the Trigonometrical Survey, Dehra Dūn.

Depth in feet of thermometer bulbs below surface of ground.	Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
	1899-1900	76·90	77·03	76·91	76·70	75·88	74·50	73·80	73·80	74·32	75·21	76·53	77·98
	1900-1901	78·42	78·14	77·64	76·84	75·57	74·17	73·28	73·26	73·80	74·65	76·56	78·38
	1901-1902	78·16	77·68	77·32	76·90	76·26	75·70	75·10	74·90	75·02	75·45	76·28	76·91
	1902-1903	77·42	77·38	77·32	76·82	76·22	75·45	74·87	74·40	74·49	74·80	76·01	76·89
	1903-1904	77 58	77·60	77·52	77·17	76·54	75·90	75·13	74·87	74·88	75·47	76·96	77·61
	1904-1905	77·54	77·60	77·41	76·87	76·21	75·27	74·25	73·64	73·45	73·86	74·52	75·52
25·6	1905-1906	76·02	76·33	76·42	76 20	75·63	74·86	74 21	73·73	73·90	74·89	76·56	77·63
	1906-1907	77·91	77·71	77·65	77·28	76·72	76·00	75·18	74·64	74·40	74·67	75·46	76·50
	1907-1908	76·96	77·22	77·28	77·01	76·49	75·85	75·04	74·83	74·83	75·54	77 56	78·39
	1908-1909	78·42	78·40	78·15	77·84	77·24	76·55	75·91	75·54	75·62	76·14	77·96	78·62
	1909-1910	78·26	77·97	77·80	77·35	76·77	76·00	75·31	74·84	74·90	75·34	77·36	78·22
	1910-1911	78·12	77·84	77·58	77·00	76·24	75·26	74·36	73·87	73·86	74·16	74·84	75·95
	1911-1912	76·50	76·66	76·60	76·15	75·49	74·65	74·15	73·84	73·92	74·98	75·52	74·03
	1899-1900	79·24	78·48	76·92	75·14	73·01	71·72	71·93	73·55	75·90	78·37	79·57	80·13
	1900-1901	79·60	78·31	76·61	73·92	71·22	69·92	70·52	72 83	75·42	78·05	80·04	80·54
	1901-1902	79·83	78·89	77·13	74·93	73·21	72·64	73·43	74·87	77·00	78·50	79 70	79·94
	1902-1903	79·63	78·36	76·56	74·24	72·36	71·34	71·58	73·56	76·11	78·17	80·07	80·41
	1903-1904	80·11	79·05	76·78	74·30	72·09	71·61	71·98	74·20	76·38	78·36	79·44	79·63
	1904-1905	79·40	78·64	76·73	74 24	71·76	69·41	69·26	71·27	74·03	76·32	78·10	79·07
12·8	1905-1906	78·83	78·13	76·50	74·24	72·15	70·79	70 71	72·82	75·66	77·99	80·19	80·06
	1906-1907	79·75	79·00	77·59	75·54	73·63	71·97	71·59	73·87	75·10	77·13	76·90	79·95
	1907-1908	79·96	79·44	77·99	75·62	73·42	72·08	72·47	74·41	76·75	78·76	80·45	80·45
	1908-1909	80·36	79·73	78·13	75·92	73 93	72·87	73·37	74·84	76·86	79·10	80·80	80·42
	1909-1910	80·22	79·61	78·21	75·71	73·59	72·43	72·86	74·64	76·82	78·59	80·35	80·31
	1910-1911	80 02	79 02	77·20	74·76	72·16	70·91	70 88	72·93	75·57	77·33	78 92	79·96
	1911-1912	79·60	78·59	76·06	73·49	71·63	71·08	71·75	73·57	75·80	77·81	79·76	80·41
	1899-1900	80·52	76·86	72·68	68·53	65·83	67·70	72·07	76·36	80·51	81·99	81·86	81·06
	1900-1901	79·34	76·51	72·92	67·37	65·52	66·04	70·54	75·67	80·34	82·81	81·93	81·02
	1901-1902	80·01	77·53	73·27	69·17	68·58	70·67	74 35	78·20	81·95	82·24	82·03	81·46
	1902-1903	79·99	76·31	72·40	68·25	66·46	67·64	71·06	77·08	81·95	83·56	82·48	81·84
	1903-1904	81·00	77·42	73·36	68·62	66·92	68·06	71·92	77·80	80·89	81·58	80·66	80·82
	1904-1905	79·74	76·90	72·42	67·92	64·06	63·57	67·32	74·27	79·21	80·91	81·45	81·66
6·4	1905-1906	80·12	77·35	73·05	68·11	66·52	65·86	70·29	76·98	81·74	82·07	81·61	80·93
	1906-1907	80·53	78·06	74·51	70·19	57·68	67·36	70·10	76·56	81·23	83·68	82·51	82·78
	1907-1908	82·35	78·98	73·60	68·93	66·51	68·04	73·69	79·49	83·63	82·84	81·86	81·82
	1908-1909	81·56	78·20	73·56	69·39	66·79	69·11	74·33	77 96	82·20	82·45	81·77	81·38
	1909-1910	81·29	78·75	73·79	68·63	67·17	68·46	74·24	78·76	82·62	82·71	81·50	81·39
	1910-1911	80·18	76·84	72·31	67·57	65·39	66·90	71·01	77·97	81·96	82·73	83·23	81·97
	1911-1912	80·42	75·99	70·09	66·77	66·35	68·36	72·18	77·90	81·90	82·96	82·45	82·25

TABLE VI—*concld.*

***Mean Monthly Readings of earth thermometers, taken at the Office of the Trigonometrical Survey, Dehra Dūn*—concld.**

Depth in feet of thermometer bulbs below surface of ground.	Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
3·2	1899-1900	80·27	73·88	67·86	63·01	62·01	68·18	74·73	82·53	86·30	84·28	83·01	80·86
	1900-1901	77·52	73·20	66·44	60·41	61·04	65·57	75·27	82·53	87·45	86·39	82·33	81·57
	1901-1902	78·97	73·03	67·53	63·95	66·03	72·36	78·77	84·30	86·81	84·31	82·74	82·17
	1902-1903	78·00	72·15	66·14	62·32	61·62	67·49	76·00	84·53	89·12	87·25	83·09	82·23
	1903-1904	80·10	73·29	67·26	61·82	63·44	67·11	78·18	84·36	86·72	82·82	81·35	81·73
	1901-1905	79·64	72·22	66·05	60·53	56·72	61·61	71·57	81·93	87·08	84·36	83·56	83·20
	1905-1906	79·83	74·26	66·92	61·12	61·40	64·34	76·41	85·83	88·09	84·70	81·71	81·53
	1906-1907	80·41	75·19	68·83	64·20	61·70	65·08	72·53	82·51	87·57	87·47	83·91	85·46
	1907-1908	83·47	76·44	68·19	63·75	62·90	68·71	79·54	86·10	89·71	84·29	82·14	83·34
	1908-1909	81·95	75·02	68·64	63·73	63·02	70·17	78·53	83·74	86·49	83·66	82·07	82·98
	1909-1910	81·55	76·81	68·20	63·21	63·70	69·25	79·68	85·32	87·82	84·08	81·75	82·21
	1910-1911	79·13	73·19	67·19	62·25	62·72	66·53	76·30	86·06	86·49	86·56	84·81	82·37
	1911-1912	79·58	70·96	64·77	62·10	64·48	69·34	76·15	84·10	87·40	85·72	83·31	82·90
1·1	1899-1900	79·09	70·75	62·40	57·84	59·72	69·75	76·36	87·18	90·30	84·72	83·34	79·88
	1900-1901	75·23	70·17	60·16	55·47	58·24	66·53	77·90	87.33	93·18	87·49	81·69	81·02
	1901-1902	77·20	70·46	61·35	59·60	64·38	73·87	80·32	88·94	90·53	84·91	83·15	81·76
	1902-1903	75·28	67·91	59·66	57·10	59·28	67·64	79·86	89·92	94·66	89·07	83·20	81·99
	1903-1904	78·12	68·71	60·88	56·30	61·48	66·62	81·36	88·05	90·26	82·06	81·64	80·60
	1904-1905	77·42	67·08	60·48	55·12	52·07	60·83	73·63	86·62	91·62	84·96	83·73	82·14
	1905-1906	77·87	69·97	60·75	55·75	57·96	63·57	79·57	91·35	89·43	85·55	81·17	80·92
	1906-1907	78·47	72·13	63·61	60·09	58·52	63·96	74·98	88·11	92·92	89·38	84·20	85·27
	1907-1908	81·79	72·66	61·93	58·79	60·46	69·43	82·42	91·40	93·37	84·55	82·10	83·02
	1908-1909	80·70	70·86	62·56	58·06	60·34	70·68	79·65	88·49	88·12	84·06	81·94	83·17
	1909-1910	80·11	73·17	61·86	58·40	60·90	69·99	81·32	90·52	90·61	83·98	81·96	82·13
	1910-1911	76·70	68·59	61·26	57·85	60·75	65·53	79·76	93·37	88·97	89·40	85·49	81·53
	1911-1912	77·82	65·57	59·18	57·99	62·84	68·51	78·08	89·21	91·16	86·72	84·01	82·05
Thermometer in shade.	1889-1900	83·10	75·14	69·59	63·06	66·17	82·01	84·78	90·62	93·04	83·60	81·24	78·97
	1900-1901	79·20	74·36	64·26	60·07	64·41	76·70	86·25	91·67	96·74	85·02	79·26	81·42
	1901-1902	80·98	74·08	66·87	68·64	74·30	82·13	85·19	92·64	90·97	81·52	81·68	81·14
	1902-1903	78·22	73·86	68·30	65·14	68·58	74·51	87·65	94·90	95·03	89·20	80·43	81·10
	1903-1904	80·61	73·87	67·54	64·07	71·45	75·77	90·86	92·33	90·62	80·21	80·07	82·04
	1904-1905	81·69	72·95	66·47	58·53	54·92	69·06	83·51	92·90	91·99	82·89	82·54	82·82
	1905-1906	83·00	75·94	66·65	65·27	62·72	73·86	90·56	97·01	89·53	83·01	79·25	81·68
	1906-1907	81·33	76·29	69·23	67·83	62·40	70·14	82·27	91·68	94·16	88·58	82·56	86·89
	1907-1908	86·28	78·22	70·28	65·69	70·25	80·77	91·40	95·95	94·09	82·03	79·14	84·97
	1908-1909	84·08	75·10	69·36	64·02	69·73	82·72	83·45	94·78	84·64	80·47	79·44	83·66
	1909-1910	83·77	77·47	66·09	65·90	9·93	80·87	87·77	95·53	89·91	80·11	80·10	81·50
	1910-1911	79·31	73·30	66·92	63·04	71·36	70·51	87·07	96·54	86·32	88·04	82·51	80·29
	1911-1912	80·62	68·39	66·97	64·04	71·37	76·61	85·33	92·86	93·06	84·78	81·28	82·30

TABLE VII.

Monthly Meteorological Results of Observations taken at the Office of the Trigonometrical Survey, Dehra Dūn.

Year and Month.	Barometer reduced to 32° Fah. At 10 A.M. Highest.	At 10 A.M. Lowest.	At 10 A.M. Monthly mean.	At 4 P.M. Highest.	At 4 P.M. Lowest.	At 4 P.M. Monthly mean.	Hygrometer. 10 A.M. Monthly mean humidity.	Hygrometer. 4 P.M. Monthly mean humidity.	Thermometer. Dry Bulb. Highest maximum in air.	Dry Bulb. Lowest minimum in air.	Dry Bulb. Monthly mean in air.	Wet Bulb. Lowest minimum.	Rain. Number of days it fell.	Rain. Fall in inches.	Wind. Most frequent direction.	Cloud. At 10 A.M.	Cloud. At 4 P.M.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	°	°	°	°	°	°					
1899.																	
October	27·870	27·651	27·736	27·766	27·581	27·647	38	33	90·9	53·6	71·1	47·4	1	0·03	Calm & S. E.	0·2	0·5
November	27·924	27·653	27·796	27·853	27·569	27·715	39	35	82·3	47·7	63·0	42·7	0	0	W. & Calm.	1·3	2·1
December	27·926	27·712	27·814	27·836	27·622	27·728	43	34	74·8	41·2	56·7	36·2	0	0	W. & Calm.	2·2	2·4
1900.																	
January	27·948	27·617	27·793	27·841	27·552	27·706	57	46	73·5	37·8	53·9	33·9	7	4·53	W.	6·1	5·9
February	27·857	27·632	27·735	27·772	27·548	27·662	60	43	73·8	41·1	56·6	39·1	6	1·24	W. & S. W.	4·3	5·6
March	27·887	27·557	27·683	27·793	27·469	27·598	37	21	91·3	47·1	69·5	41·3	2	0·03	Incomplete.	3·0	4·3
April	27·773	27·517	27·622	27·668	27·420	27·524	35	25	96·0	50·8	73·3	45·7	8	1·62	W.	3·3	4·6
May	27·712	27·399	27·567	27·682	27·282	27·473	31	28	104·6	63·3	81·6	54·1	8	0·68	S. W. & W.	1·7	4·8
June	27·676	27·219	27·407	27·570	27·137	27·310	49	40	104·3	63·1	84·8	60·6	9	4·13	S. W. S. E. & S.	2·1	3·5
July	27·576	27·257	27·393	27·482	27·167	27·310	80	74	96·8	67·6	79·2	66·0	21	23·75	N. & S. E.	7·6	5·8
August	27·560	27·332	27·438	27·451	27·267	27·356	84	81	90·8	69·3	77·3	68·5	28	23·42	S. E. & E.	8·5	7·8
September	27·692	27·515	27·600	27·630	27·415	27·514	81	80	87·0	61·4	74·3	57·2	22	15·10	S. & Calm.	6·9	7·9
October	27·877	27·626	27·740	27·777	27·535	27·657	53	45	85·5	53·4	68·4	49·4	0	0	Calm, S. W.	1·0	1·1
November	27·859	27·659	27·770	27·755	27·597	27·685	53	46	80·6	46·4	63·1	43·9	0	0	Calm.	1·1	2·1
December	22·961	27·701	27·843	27·907	27·621	27·764	65	57	75·1	40·9	55·0	37·4	8	3·23	N.	4·1	5·4

TABLE VII—*contd.*

Monthly Meteorological Results of Observations taken at the Office of the Trigonometrical Survey, Dehra Dūn—contd.*

Year and Month.	Barometer reduced to 32° Fah. At 10 A.M. Highest.	At 10 A.M. Lowest.	At 10 A.M. Monthly mean.	At 4 P.M. Highest.	At 4 P.M. Lowest.	At 4 P.M. Monthly mean.	Hygrometer. 10 A.M. Monthly mean humidity.	Hygrometer. 4 P.M. Monthly mean humidity.	Thermometer. Dry Bulb. Highest maximum in air.	Dry Bulb. Lowest minimum in air.	Dry Bulb. Monthly mean in air.	Wet Bulb. Lowest minimum.	Rain. Number of days it fell.	Rain. Fall in inches.	Wind. Most frequent direction.	Cloud. At 10 A.M.	Cloud. At 4 P.M.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	°	°	°	°	°	°					
1901																	
January	27·993	27·721	27·814	27·826	27·597	27·721	76	59	73·0	39·0	51·9	37·4	10	4·90	E., Calm.	5·8	5·7
February	27·893	27·678	27·791	27·856	27·594	27·712	59	47	74·0	38·5	55·0	36·2	8	3·14	W., S. E.	4·4	5·7
March	27·854	27·669	27·739	27·758	27·580	27·652	47	38	89·4	45·9	65·6	43·6	3	1·32	W., S. W.	2·1	3·2
April	37·700	27·446	27·588	27·640	27·378	27·512	30	19	97·2	54·2	74·4	45·2	0	0	W., S.W., N. W.	4·0	3·5
May	27·638	27·408	27·514	27·531	27·322	27·422	35	27	102·8	61·3	80·7	50·7	5	1·76	W., S. W.	1·9	2·9
June	27·632	27·178	27·375	27·465	27·093	27·286	36	28	107·8	67·6	86·9	55·5	4	1·77	W.	1·7	1·9
July	27·524	27·211	27·377	27·414	27·135	27·295	74	69	105·4	67·5	80·2	62·1	20	16·55	S., S. W.,W.	6·6	6·7
August	27·644	27·226	27·418	27·539	27·183	27·338	88	87	88·8	69·8	76·2	66·8	30	52·12	S.	8·6	8·6
September	27·736	27·423	27·586	27·642	27·317	27·511	71	70	87·9	60·2	75·0	58·4	13	6·07	Calm, N. W.	1·9	4·1
October	27·781	27·511	27·667	27·693	27·409	27·582	60	54	86·7	54·8	71·2	49·6	1	0·72	Calm	0·8	1·0
November	27·869	27·687	27·786	27·777	27·612	27·693	54	48	81·8	47·2	62·6	43·7	...	...	Calm	0·4	0·3
December	27·928	27·739	27·842	27·833	27·665	27·758	52	42	73·7	40·4	54·9	36·3	3	0·41	Calm	2·2	2·7
1902.																	
January	27·971	27·641	27·709	27·836	27·534	27·699	50	39	77·1	41·5	56·4	38·1	...	...	Calm	1·1	1·6
February	27·951	27·720	27·837	27·857	27·642	27·748	35	22	83·6	38·1	60·8	33·6	2	0·33	Calm	2·3	1·6
March	27·772	27·560	27·662	27·652	27·477	27·567	35	22	92·1	51·9	70·2	43·8	2	0·41	W.	3·6	4·1

April	27·694	27·428	27·581	27·628	27·346	27·494	27	17	97·0	55·5	76·6	47·4	5	1·62	W.	3·4	4·7
May	27·666	27·401	27·503	27·564	27·326	27·411	36	28	102·3	63·8	82·8	54·9	4	0·99	W.	2·8	4·2
June	27·553	27·260	27·405	27·472	27·156	27·323	51	43	100·5	64·9	83·0	60·3	6	3·70	W.	2·3	3·0
July	27·506	27·224	27·364	27·412	27·138	27·293	80	76	94·4	67·0	77·4	63·7	22	18·85	S.	8·5	7·7
August	27·558	27·280	27·448	27·468	27·273	27·381	80	79	89·8	68·4	76·8	65·5	23	21·33	Calm	6·8*	7·3†
September	27·681	27·395	27·540	27·609	27·276	27·455	76	72	92·8	63·6	75·9	58·6	17	9·85	S.	5·5	6·1
October	27·852	27·677	27·769	27·763	27·578	27·682	57	56	85·4	53·6	68·7	51·6	4	1·27	Calm	2·6	2·2
November	27·922	27·720	27·825	27·827	27·628	27·738	56	49	78·1	47·6	62·0	43·7	*Nil*	*Nil*	Calm	1·7	2·1
December	27·889	27·700	27·804	27·791	27·605	27·713	49	39	74·5	37·4	54·3	33·7	*Nil*	*Nil*	Calm	1·7	1·7
1903.																	
January	28·036	27·672	27·818	27·956	27·569	27·728	53	40	71·2	37·4	53·5	34·2	6	1·63	Calm	3·7	3·0
February	27·938	27·671	27·817	27·850	27·576	27·733	51	35	84·4	38·5	57·0	36·8	1	0·10	W.	3·4	4·8
March	27·746	27·561	27·651	27·669	27·467	27·575	38	28	89·7	42·6	64·1	37·9	7	0·45	Calm, W.	4·4	5·6
April	27·809	27·445	27·618	27·731	27·376	27·532	23	14	98·1	49·2	75·6	41·4	*Nil*	*Nil*	W.	5·5	4·3
May	27·684	27·376	27·540	27·573	27·272	27·448	27	22	104·4	62·4	82·2	52·4	8	0·37	W.	3·3	3·7
June	27·508	27·249	27·404	27·401	27·147	27·296	39	30	104·6	66·9	86·1	58·5	12	0·96	W.	4·1	4·7
July	27·463	27·238	27·370	27·395	27·166	27·287	64	56	104·5	70·0	81·9	62·6	16	16·11	S.	5·6	6·1
August	27·523	27·297	27·430	27·438	27·183	27·349	83	84	88·9	69·7	76·7	67·2	24	26·15	S. W.	7·6	7·8
September	27·684	27·449	27·551	27·566	27·380	27·463	82	78	87·3	67·3	76·5	65·7	21	12·94	S. E.	6·5	7·0
October	27·792	27·543	27·648	27·292	27·475	27·564	63	59	86·9	54·4	70·8	51·6	6	0·78	S. E.	1·3	2·2
November	27·862	27·639	27·768	27·784	27·596	27·685	51	46	79·7	44·1	61·1	42·0	*Nil*	*Nil*	W.	1·2	1·0
December	27·922	27·664	27·793	27·828	27·612	27·711	55	43	74·9	39·2	55·0	37·1	3	0·98	S.	3·5	1·8
1904.																	
January	27·986	27·606	27·812	27·882	27·532	27·731	54	49	73·2	37·1	53·9	36·1	5	1·56	W.	3·1	4·7
February	27·869	27·677	27·755	27·797	27·590	27·675	51	33	78·1	38·9	59·8	36·6	1	0·06	S. and W.	3·3	3·8

* Mean of 26 days.
† " " 27 "

TABLE VII—*contd.*

Monthly Meteorological Results of Observations taken at the Office of the Trigonometrical Survey, Dehra Dūn—contd.

	BAROMETER REDUCED TO 32° FAH.						HYGROMETER.		THERMOMETER.				RAIN.		WIND.	CLOUD.	
	At 10 A.M.			At 4 P.M.			10 A.M.	4 P.M.	Dry Bulb.			Wet Bulb.					
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean humidity.	Monthly mean humidity.	Highest maximum in air.	Lowest minimum in air.	Monthly mean in air.	Lowest minimum.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 10 A.M.	At 4 P.M.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	°	°	°	°	°	°					
.	27·775	27·590	27·664	27·647	27·508	27·577	52	40	90·3	45·8	65·6	44·2	9	3·46	W.	3·5	4·0
.	27·649	27·328	27·506	27·583	27·219	27·410	31	20	100·4	56·1	78·1	48·7	2	0·19	W.	1·9	2·8
.	27·617	27·407	27·494	27·508	27·287	27·393	36	32	100·9	58·6	80·7	53·7	7	2·00	W.	3·6	4·0
.	27·506	27·205	27·356	27·416	27·152	27·273	55	48	102·3	66·1	82·7	61·7	10	3·74	W.	6·0	6·9
.	27·452	27·285	27·360	27·384	27·183	27·282	87	81	91·1	68·3	76·1	65·5	29	34·62	Calm, W.	8·6	8·8
.	27·499	27·325	27·426	27·463	27·255	27·352	86	82	87·7	69·5	76·6	68·3	26	31·92	Calm	8·7	8·4
.	27·770	27·405	27·561	27·671	27·355	27·480	69	64	88·1	61·1	74·7	56·1	13	6·03	Calm	3·2	3·4
.	27·794	27·575	27·698	27·724	27·514	27·619	52	45	86·0	51·0	70·2	48·6	1	0·53	Calm	0·5	1·2
.	27·959	27·717	27·806	27·870	27·637	27·731	55	47	82·1	44·6	61·6	42·2	3	0·92	Calm	1·3	2·4
.	28·050	27·694	27·853	27·940	27·619	27·770	67	56	74·3	41·1	56·5	39·3	4	2·02	Calm	1·8	3·9
.	28·085	27·715	27·810	27·916	27·589	27·720	73	62	69·2	31·9	51·5	30·3	7	3·37	Calm	5·5	6·3
.	27·873	27·665	27·782	27·792	27·607	27·710	64	55	69·1	30·1	48·5	28·4	6	3·82	W.	5·9	7·6
.	27·951	27·559	27·679	27·881	27·424	27·599	53	43	81·0	41·1	60·9	38·8	4	1·94	S. W.	6·0	6·6
.	27·737	27·512	27·633	27·642	27·423	27·551	31	22	94·4	47·0	72·4	41·6	1	0·20	S. W.	1·9	2·8

May	27·695	27·370	27·529	27·554	27·304	27·427	41	32	101·6	62·8	81·2	52·8	6	2·29	S. W.	2·5	3·7
June	27·502	27·301	27·391	27·443	27·165	27·307	43	37	104·6	68·4	83·8	57·0	4	5·24	S. W.	0·9	2·5
July	27·497	27·214	27·368	27·412	27·118	27·292	80	75	90·6	68·4	78·6	67·4	16	11·77	S. E.	6·4	6·5
August	27·566	27·264	27·430	27·425	27·230	27·350	83	80	89·1	69·3	77·9	68·2	17	15·65	S. W.	8·3	7·5
September	27·682	27·413	27·540	27·575	27·314	27·454	70	69	91·0	64·1	76·3	59·7	11	9·64	W.	4·4	4·6
October	27·805	27·552	27·682	27·727	27·509	27·606	46	40	87·0	53·3	71·1	48·4	0	*Nil*	Calm, S. W.	0·0	1·0
November	27·928	27·618	27·825	27·823	27·578	27·733	45	39	83·5	44·1	63·4	41·0	0	0·05	S. W.	1·3	2·0
December	27·936	27·656	27·788	27·837	27·603	27·710	57	46	73·9	37·0	56·0	36·1	2	1·00	Calm.	2·8	3·5
1906.																	
January	27·926	27·621	27·804	27·861	27·537	27·710	53	38	75·5	36·0	53·7	34·2	2	0·27	Calm.	3·1	4·3
February	27·873	27·482	27·718	27·834	27·436	27·638	66	51	73·2	35·1	54·5	34·0	9	6·03	S. E.	5·9	6·0
March	27·834	27·565	27·719	27·753	27·503	27·642	47	36	83·2	38·8	63·4	40·3	2	0·60	S. W. W.	4·6	5·4
April	27·709	27·442	27·562	27·612	27·338	27·480	26	16	97·6	55·0	77·0	47·8	0	0·03	W.	1·3	1·6
May	27·562	27·295	27·448	27·487	27·216	27·351	26	20	106·5	64·0	85·1	51·6	0	0·08	W.	1·0	3·8
June	27·540	27·316	27·415	27·439	27·222	27·319	49	42	105·4	65·7	82·3	57·0	11	9·80	S. W.	4·5	3·9
July	27·520	27·249	27·349	27·397	27·176	27·270	81	80	90·5	70·8	79·7	68·7	22	24·09	S. E.	7·2	8·1
August	27·587	27·220	27·176	27·527	27·165	27·395	88	85	88·0	69·6	76·1	67·7	24	27·40	N.	9·1	8·5
September	27·644	27·409	27·524	27·508	27·326	27·439	78	76	90·5	66·7	76·4	65·3	15	11·71	N.	5·4	5·9
October	27·785	27·582	27·712	27·690	27·516	27·621	53	50	86·7	53·8	72·0	49·7	1	0·38	N.	0·4	1·7
November	27·930	27·681	27·801	27·814	27·613	27·711	51	44	82·0	48·8	64·3	46·3	0	0	Calm.	0·5	1·2
December	27·920	27·705	27·822	27·815	27·617	27·731	60	49	75·2	39·4	58·1	37·2	1	0·90	Calm.	2·2	3·3
1907.																	
January	27·908	27·536	27·772	27·835	27·512	27·686	64	52	75·4	42·3	57·5	40·2	2	2·61	Calm.	3·4	4·4
February	27·851	27·612	27·746	27·798	27·548	27·672	69	59	76·2	39·0	55·2	38·0	8	5·05	Calm, S. E. & S.	5·7	7·3
March	27·796	27·466	27·710	27·710	27·540	27·627	58	46	81·2	44·2	60·9	41·9	6	2·74	S.	4·0	4·8

TABLE VII—*contd.*

Monthly Meteorological Results of Observations taken at the Office of the Trigonometrical Survey, Dehra Dūn—contd.

Year and Month	Barometer reduced to 32° Fah. At 10 A.M. Highest.	At 10 A.M. Lowest.	At 10 A.M. Monthly mean.	At 4 P.M. Highest.	At 4 P.M. Lowest.	At 4 P.M. Monthly mean.	Hygrometer. 10 A.M. Monthly mean humidity.	Hygrometer. 4 P.M. Monthly mean humidity.	Thermometer. Dry Bulb. Highest maximum in air.	Dry Bulb. Lowest minimum in air.	Dry Bulb. Monthly mean in air.	Wet Bulb. Lowest minimum.	Rain. Number of days it fell.	Rain. Fall in inches.	Wind. Most frequent direction.	Cloud. At 10 A.M.	Cloud. At 4 P.M.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	°	°	°	°	°	°					
1907.																	
April	27·680	27·508	27·605	27·613	27·404	27·514	46	38	91·7	52·3	72·5	49·0	2	0·97	S.	4·1	6·0
May	27·634	27·347	27·517	27·567	27·253	27·429	31	27	99·3	59·3	79·5	49·5	4	1·08	S.	1·7	3·0
June	27·532	27·302	27·392	27·437	27·207	27·303	36	30	103·4	63·7	83·5	56·9	3	1·18	S.	2·6	3·3
July	27·505	27·241	27·358	27·444	27·132	27·273	62	55	102·4	69·0	82·0	60·9	15	10·82	S.	5·1	5·9
August	27·481	27·300	77·406	27·401	27·211	27·319	82	79	89·2	71·7	78·2	69·2	20	19·71	N. E., S.	7·6	7·4
September	27·649	27·391	27·523	27·569	27·323	27·443	63	58	90·6	65·4	78·4	59·1	1	1·02	S.	1·2	3·5
October	27·794	27·536	27·667	27·712	27·431	27·580	40	35	91·6	53·7	73·2	49·4	0	0	S.	0·5	0·2
November	27·878	27·631	27·774	27·751	27·527	27·681	45	36	83·2	45·8	65·3	42·0	0	0	Calm.	0·5	0·9
December	27·886	27·689	27·824	27·826	27·617	27·745	44	35	74·6	38·6	56·6	35·0	0	0	Calm.	0·8	1·4
1908.																	
January	27·951	27·523	27·813	27·850	27·442	27·722	57	48	75·3	37·3	55·4	36·0	3	1·17	Calm.	3·6	5·0
February	27·912	27·584	27·694	27·819	27·503	27·619	52	38	82·0	41·2	59·3	40·2	3	5·85	S.	2·1	3·7
March	27·819	27·539	27·712	27·714	27·426	27·618	29	18	97·9	42·0	67·8	37·1	1	0·10	S.	2·3	2·7
April	27·768	27·427	27·555	27·703	27·357	27·468	27	19	101·8	55·1	79·3	50·8	1	0·75	S. E.	3·0	4·3
May	27·596	27·375	27·500	27·494	27·252	27·403	24	17	106·5	62·4	80·2	53·6	1	1·00	S. E.	0·7	2·2
June	27·473	27·257	27·368	27·413	27·169	27·279	44	36	108·2	65·5	85·0	56·4	9	6·60	N. E.	3·2	5·8

July	27·509	27·281	27·397	27·436	27·217	27·321	79	79	92·7	69·8	78·7	68·5	18	27·92	Calm.	7·5	7·7
August	27·543	27·325	27·453	27·467	27·300	27·376	83	85	88·9	70·5	76·7	69·3	23	26·86	Calm.	8·5	8·3
September	27·648	27·448	27·556	27·548	27·372	27·469	65	63	89·2	64·6	77·0	59·3	7	5·11	S.	2·6	3·7
October	27·758	27·535	27·656	27·652	27·446	27·574	41	35	89·4	53·5	71·9	48·1	0	0	S.	0·4	0·4
November	27·894	27·633	27·772	27·804	27·527	27·690	42	39	81·1	43·9	62·8	40·4	0	0	W.	0·5	1·6
December	27·927	27·731	27·825	27·849	27·664	27·741	49	41	75·2	39·3	57·2	37·2	1	0·20	S. & S. W.	2·5	2·3
1909.																	
January	27·888	27·661	27·760	27·799	27·574	27·671	59	47	71·2	34·5	53·8	33·4	4	1·38	S. W. & N. W.	5·6	6·0
February	27·851	27·645	27·759	27·765	27·545	27·677	50	47	77·6	38·8	59·0	36·0	3	1·84	N.	4·3	4·4
March	27·799	27·556	27·680	27·708	27·471	27·589	31	18	91·0	46·6	68·7	43·0	0	0·01	No record.	2·4	2·0
April	27·691	27·471	27·598	27·581	27·384	27·504	38	37	94·4	58·5	74·5	50·4	8	3·85	No record.	4·3	5·7
May	27·621	27·364	27·488	27·530	27·242	27·393	29	21	102·6	61·1	81·7	51·9	1	0·22	W.	2·1	2·7
June	27·557	27·277	27·385	27·442	27·181	27·299	69	62	97·9	64·8	78·9	64·1	15	10·32	S. E.	5·9	6·2
July	27·512	27·263	27·378	27·410	27·197	27·300	82	84	89·3	70·8	77·8	68·8	26	42·82	S.	8·2	8·5
August	27·597	27·314	27·469	27·491	27·269	27·390	87	86	86·8	70·5	76·2	67·5	25	42·71	S. E. & S.	9·1	8·9
September	27·671	27·385	27·524	27·570	27·316	27·441	74	69	90·5	64·7	76·9	60·8	9	6·03	W.	3·9	4·7
October	27·772	27·542	27·655	27·702	27·456	27·578	50	43	87·5	55·5	72·1	51·5	0	0·02	...	0·1	0·6
November	27·887	27·642	27·756	27·821	27·560	27·679	51	46	84·5	47·9	65·3	44·9	0	0	S 51° W	0·1	0·4
December	27·967	27·700	27·822	27·890	27·588	27·740	62	57	75·3	43·6	55·9	40·0	5	1·98	S 63° W	3·8	5·2
1910.																	
January	27·898	27·624	27·759	27·819	27·529	27·672	61	50	77·0	40·0	54·9	38·0	3	1·72	S 65° W	2·2	3·1
February	27·891	27·575	27·695	27·829	27·453	27·617	48	35	78·1	40·2	58·4	37·4	2	0·98	S 85° W	3·2	3·2
March	27·812	27·487	27·646	27·724	27·407	27·560	31	30	91·8	43·5	68·1	39·8	0	0	N 84° W	3·1	3·7
April	21·695	27·404	27·578	27·604	27·303	27·489	25	16	103·3	55·5	76·2	45·4	2	0·74	S 53° W	3·8	4·0
May	27·622	27·363	27·487	27·544	27·287	27·395	29	21	104·5	57·4	82·7	52·2	2	1·16	S 73° W	2·1	3·0

TABLE VII—*concld.*

Monthly Meteorological Results of Observations taken at the Office of the Trigonometrical Survey, Dehra Dūn—concld.

...nd Month.	Barometer reduced to 32° Fah.						Hygrometer.		Thermometer.				Rain.		Wind.	Cloud.	
	At 10 A.M.			At 4 P.M.			10 A.M.	4 P.M.	Dry Bulb.			Wet Bulb.					
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean humidity.	Monthly mean humidity.	Highest maximum in air.	Lowest minimum in air.	Monthly mean in air.	Lowest minimum.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 10 A.M.	At 4 P.M.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	°	°	°	°	°	°					
. . . .	27·472	27·313	27·404	27·384	27·223	27·305	57	49	104·6	67·9	82·1	62·6	9	5·13	S 52° W	4·8	6·0
. . . .	27·522	27·180	27·395	27·448	27·108	37·324	83	83	89·3	70·4	77·4	69·2	28	34·55	S 27° W	8·7	8·7
. . . .	27·645	27·236	27·430	27·525	27·217	27·348	86	85	88·5	69·5	76·5	68·1	26	47·03	S 30° W	8·7	8·5
. . . .	27·680	27·347	27·496	27·541	27·263	27·405	81	79	90·3	66·5	76·5	64·3	15	12·31	S 55° W	5·7	7·8
. . . .	27·815	27·519	27·681	27·742	27·431	27·595	62	59	86·2	55·3	70·0	51·4	3	5·24	S 31° W	1·3	2·5
. . . .	27·836	27·691	27·759	27·783	27·606	27·680	52	48	78·7	42·3	61·9	40·5	0	0	S 80° W	0·7	1·7
. . . .	27·918	27·686	27·797	27·821	27·614	27·722	52	47	75·1	37·4	56·2	36·4	1	0·23	S 76° W	3·1	4·0
1911.																	
. . . .	27·975	27·433	27·741	27·861	27·369	27·660	67	59	74·4	34·0	54·8	33·1	8	9·05	S 87° W	5·8	6·5
. . . .	27·901	27·642	27·771	27·811	27·591	27·694	53	41	81·1	36·2	59·2	35·8	1	0·59	S 77° W	3·3	4·1
. . . .	27·800	27·532	27·675	27·717	27·459	27·596	57	49	86·2	44·8	62·3	43·8	10	7·18	N 83° W	3·6	6·5
. . . .	27·715	27·431	27·574	27·611	27·368	27·493	37	27	97·2	54·5	74·6	51·6	1	0·21	N 89° W	2·1	2·3
. . . .	27·666	27·310	27·462	27·500	27·230	27·369	30	23	102·0	63·4	83·3	53·6	1	0·16	S 88° W	0·7	1·5
. . . .	27·572	27·249	27·390	27·461	27·172	27·309	66	62	96·2	67·8	79·8	64·4	14	10·76	S 58° W	5·0	5·8
. . . .	27·514	27·203	27·350	27·436	27·158	27·278	66	62	96·0	68·5	81·4	65·8	7	4·39	S 35° W	4·4	5·6
. . . .	27·613	27·198	27·407	27·524	27·158	27·321	82	80	90·1	67·7	77·7	66·0	19	25·38	S 24° W	7·9	8·0
. . . .	27·638	27·382	27·542	27·584	27·322	27·444	79	76	87·0	63·9	75·3	61·7	16	15·88	S 73° W	6·6	1·7

NOTE.

In reply to Mr. Hayden's paper on the relationship of the Himālayas to the Indo-Gangetic Plain and the Indian Peninsula.

BY LIEUT.-COL. G. P. LENOX-CONYNGHAM, R.E.
Superintendent of the Trigonometrical Survey.

To the Records of the Geological Survey of India, Vol. XLIII, Part 2, Mr. Hayden contributes a paper on the relationship of the Himālaya to the Indo-Gangetic Plain and the Indian Peninsula. This paper begins with a study of the geological features of the outer Himālayan Ranges and then proceeds to discuss the theory put foward by Colonel Burrard in Professional Paper No. 12 of the Survey of India, to account for the results of the Geodetic observations made in the Indo-Gangetic Plain, and at stations situated in the Himālaya.

Mr. Hayden endeavours to show that these results are not inconsistent with the theory of Isostasy which has been proved by Mr. J. F. Hayford to account, with a considerable degree of completeness, for the deflections of the plumb-line and abnormalities of gravity that have been observed in the United States of America.

In his discussion Mr. Hayden makes use of data supplied to him by the Trigonometrical Survey and he acknowledges his indebtedness for the figures supplied with so much courtesy as almost to give the impression that he was working in co-operation with the Trigonometrical Survey Office, whence it might perhaps be inferred that his reasoning was accepted in that office. This, however, is not the case, and it is necessary to point out clearly that his conclusions are in the opinion of the present writer based on a misconception of the theory of Isostasy as a whole, and that even if the theory could be so modified as to make it agree with the idea that he seems to have formed, nevertheless the results that he puts forward, as a possible explanation of the observed deflections of the plumb-line, are mutually destructive and do not rest on any consistent theory of the distribution of matter in the earth's crust.

To begin with the theory of Isostasy as a whole. On page 151 Mr. Hayden says—" If the conditions of equilibrium in India are different from those in America there is no valid reason for the tacit assumption that, in a heterogeneous body like the earth, isostatic compensation will occur at the same depth everywhere." Now on page 145 Mr. Hayden quotes Mr. Hayford's definition of the depth of compensation; it runs as follows:— "Let the depth within which the isostatic compensation is complete be called the depth of compensation. At and below this depth the conditions as to stress of any element of mass is isostatic; that is, any element of mass is subject to equal pressure from all directions as if it were a portion of a perfect fluid." By this definition, since there is no tendency for a particle situated in the surface of compensation to move in any direction, that surface is a level or equipotential surface; also since all elements of mass "at and below" this surface are in a condition of hydrostatic equilibrium it follows either that the density of all matter below this surface is uniform or that the matter is arranged in concentric layers of uniform density, the density being everywhere the same function of the depth below the surface of compensation. The form of a rotating mass of such a structure is an ellipsoid of revolution, and we thus see that the surface of compensation must be of this form and that therefore its depth below the surface of the sea, neglecting the small effects of the slight dissimilarities of ellipsoids at different mean distances from the earth's centre, is necessarily invariable.

If a calculation similar to that made by Mr. Hayford for the United States, were made for India, and led to a significantly different depth of compensation, the inevitable conclusion would be that the theory of Isostasy did not in reality represent the distribution of mass in the earth's crust, and that Mr. Hayford solution had merely indicated that depth which made the best of a wrong hypothesis; just as part of a curve drawn according to one law may, by a suitable adjustment of the constants, be made to fit fairly well to a number of points plotted according to some other law, especially when the plotting is not very precise and the points only represent a small part of the complete curve. We are therefore obliged to deny Mr. Hayden's statement and to assert that there is a valid reason for rejecting the idea of different depths of compensation for India and the United States of America.

Even, however, if it were possible for the depth of compensation to vary from one part of the earth to another, Mr. Hayden makes a quite illegitimate use of the freedom he allows himself in this respect. Before going further it may be well to give an outline of the method by which the deflection of the plumb-line at any place is calculated from the topography of the surrounding country.

Contoured maps of the country having been procured, circles are drawn on them with the place of observation as centre. The first circle has a radius of only a few yards, but the radii increase rapidly and for a complete investigation the outer circle must have a radius of over 2,000 miles. These circles are divided up into compartments by radial lines according to certain rules, the increase of the radii and the division of the circles into compartments being so contrived that if the mean height above sea-level of any compartment is 100 feet, the attraction it exerts on a plumb-line suspended at the centre will be 0″·01. It is to be observed that 100 feet of height above sea-level in any compartment has the same effect on the plumb-line, no matter where the compartment may be situated, so that all compartments have equal importance.

The first part of the process consists of estimating the height of each compartment and recording it; this being done, to obtain the deflection that would result from the topography if there were no isostatic compensation, all that is necessary is to take out the algebraic sum of all the quantities so recorded,—positive for hill masses to the south, negative for those to the north, and with signs reversed for negative heights, *i.e.*, depths below sea-level, an allowance being made for the presence of the sea-water.

To obtain the effect of isostatic compensation we must return to the compartments and multiply the recorded height of each by a factor appropriate to the assumed depth of compensation. The algebraic sum of the products obtained is the deflection which the topography and its compensation are together competent to produce if the theory of Isostasy holds good.

In making this calculation all the topography within 2,000 miles of the station is taken into account, so that, even if a variation in the depth of compensation were possible, when once a depth has been adopted in the investigation of the deflection at any station, this depth cannot be departed from in the investigation of the deflection at any other station situated within a distance of 2,000 miles of the first, without involving us in an inconsistency; for it is clearly inadmissible to suppose that there are two depths of compensation underlying the same area.

Turning again to Mr. Hayden's paper the following passage is found on page 157.—"Table 3 shows the deflection along certain lines including some of those selected by Colonel Burrard. I have not, however, restricted myself to a depth of 113·7 km., but give figures also for 329·8 km. The result is instructive in that it indicates a possibility, not I think hitherto considered, that the depth of compensation under the Himālaya may be different from that under the rest of India, for it will be noticed that if these depths be assumed to be 329·8 km. and 113·7 km. respectively, the calculated difference of deflection is in four cases out of five almost exactly the same as the observed difference."

But in view of what has been said above it will be seen that this apparent agreement has no significance, for if 113·7 km. is the depth of compensation for the stations in the plains, that must also be the depth for the Himālayan stations, for the latter are not as a rule more than 100 miles distant from the former. The two calculations are based on incompatible assumptions and the results obtained cannot be used in support of any theory.

It would be possible to apply factors corresponding to different depths of compensation to the various compartments into which the zones surrounding the stations were divided in the analysis of the topography, and so to build up values for the deflections at the stations on an assumption of a sort of sloping floor of compensation, but this would be quite inconsistent with Mr. Hayford's theory of Isostasy, and to make such a calculation except in accordance with some definite and reasonable theory would be waste of time.

On page 161 Mr. Hayden says, "If, lastly, we assume that complete compensation takes place at the surface throughout the whole area to the south of the Himālaya the mean residual . . . . amounts to only 0″·54. This is no doubt an improbable solution . . . ."

It is more than improbable, it is quite impossible. It means that the whole of the matter above sea-level has no density at all and is incapable of exerting any attraction.

The fact that the algebraic sum of the residuals over this area is small is fortuitous and has very little significance. The smallness of the algebraic mean of the residuals is no criterion of the truth of the hypothesis on which the calculations have been based: the true criterion is the smallness of the sum of the squares of the residuals In Professional Paper No. 13 the algebraic means of the residuals found in the several regions into which India was divided by Colonel Burrard,* were legitimately used by Major Crosthwait; for the object in view was to ascertain whether when the deflections are calculated according to Mr. Hayford's hypothesis there is any tendency for a persistence of sign to occur. If no such tendency had been found it would have been evidence that Mr. Hayford's theory had accounted for the peculiarities which had led Colonel Burrard to divide the country into regions each with its special

* Vol. XVIII of the Account of the Operations of the G. T. Survey.

characteristic. It was found, however, that there was a very strong tendency to persistence of sign, as the following figures show :—

Region No. 1,	6 residuals.	All negative . . .	Mean	—16
2,	4 ,,	2 positive, 2 negative . .		— 2
3,	10 ,,	All positive		+ 8
4,	6 ,,	All positive		+ 5
5,	21 ,,	18 positive, 1 negative, 2 zero .		+ 4
7,	23 ,,	20 negative, 2 positive, 1 zero		— 3
8,	17 ,,	12 negative, 3 positive, 2 zero .		— 2
9,	14 ,,	8 positive, 4 negative, 2 zero		+ 1

The persistence of sign in the several regions is extremely remarkable and shows that the peculiarities of the regions are real and not to be explained by any general assumption of isostatic compensation.

APPENDIX.

LIST OF SURVEY OF INDIA PUBLICATIONS.

Unless otherwise stated the publications can be obtained from the Superintendent, Map Publications, 13 Wood Street, Calcutta.

ACCOUNT OF THE OPERATIONS OF THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

Obtainable from the Superintendent of the Trigonometrical Survey, Dehra Dūn, U. P.

Price Rupees 10-8 per volume, except where otherwise stated.

Volume I. The Standards of Measure and the Base-Lines, also an Introductory Account of the early Operations of the Survey, during the period of 1800-1830. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Survey.* Dehra Dūn, 1870 (out of print).

Do. II. History and General Description of the Principal Triangulation, and of its Reduction. *By Colonel J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor General of India and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1879 (out of print).

Do. III. The Principal Triangulation, the Base-Line Figures, the Karāchi Longitudinal, N. W. Himālaya, and the Great Indus Series of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Trigonometrical Survey, and his Assistants.* Dehra Dūn, 1873 (out of print).

Do. IV. The Principal Triangulation, the Great Arc—Section 24°—30°, Rahūn, Gurhāgarh and Jogi-Tīla Meridional Series and the Sutlej Series of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Trigonometrical Survey, and his Assistants.* Dehra Dūn, 1876.

Do. IVA. General Description of the Principal Triangulation of the Jodhpore and the Eastern Sind Meridional Series of the North-West Quadrilateral, with the Details of their Reduction and the Final Results. *Prepared in the Office of the Trigonometrical Branch, Survey of India, Colonel C. T. Haig, R.E., Officiating Deputy Surveyor General in charge, and published under the orders of Colonel G. C. DePrée, S.C., Surveyor General of India.* Dehra Dūn, 1886.

Do. V. Details of the Pendulum Operations by Captains J. P. Basevi, R.E., and W. J. Heaviside, R.E., and of their Reduction. *Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn and Calcutta, 1879.

Do. VI. The Principal Triangulation of the South-East Quadrilateral, including the Great Arc—Section 18° to 24°, the East Coast Series, the Calcutta and the Bider Longitudinal Series, the Jabalpur and the Bilāspur Meridional Series, and the details of their Simultaneous Reduction. *Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1880 (out of print).

Do. VII. General Description of the Principal Triangulation of the North-East Quadrilateral, including the Simultaneous Reduction and the Details of five of the component Series, the North-East Longitudinal, the Budhon Meridional, the Rangīr Meridional, the Amua Meridional, and the Karāra Meridional. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1882.

Do. VIII. Details of the Principal Triangulation of eleven of the component Series of the North-East Quadrilateral, including the following Series; the Gurwāni Meridional, the Gora Meridional, the Hurilāong Meridional, the Chendwār Meridional, North Pārasnāth Meridional, the North Malūncha Meridional, the Calcutta Meridional, the East Calcutta Longitudinal, the Brahmapūtra Meridional, the Eastern Frontier—Section 23° to 26°, and the Assam Longitudinal. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1882.

Do. IX. Electro-Telegraphic Longitude Operations executed during the years 1875-77 and 1880-81, by Lieutenant-Colonel W. M. Campbell, R.E., and Major W. J. Heaviside, R.E. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1883.

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