RECORDS

OF THE

SURVEY OF INDIA

Volume I

1909-10

PREPARED UNDER THE DIRECTION OF

COLONEL S. G. BURRARD, C.S.I., R.E., F.R.S.
Surveyor General of India

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1912.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1911.

COLONEL R. A. WAHAB, C.B., C.M.G., C.I.E., R.E.

Retired as Deputy Surveyor General, 31st August 1905.

PREFACE.

FOR many years the Annual Report of the Survey of India consisted of two parts, namely (1) abstracts of results, and (2) narrative reports of executive officers. Since the year 1900-01 the narrative reports have been excluded from the Annual Report of the Survey and have been published as a separate volume entitled *Extracts from Narrative Reports.* This last title has been not altogether satisfactory; the reports by executive officers are frequently not narratives of events, but discussions of data. The volume will be hampered if it is to be confined to narratives: it will be more useful if explanatory statements can be included in it. The title of the volume is therefore being changed, and it will in future be known as "Records of the Survey of India."

CONTENTS.

Frontispiece—Portrait of Colonel Wahab, R.E.

PART I.

I.—Topographical Survey.

II.—Triangulation.

III.—Levelling.

IV.—Geodetic Survey.

V.—Magnetic Survey.

VI.—Tidal Operations.

PART II.

RECORDS OF

THE SURVEY OF INDIA.

PART I.

I.—Topographical Survey.

NORTHERN CIRCLE.

BY BREVET-COLONEL W. J. BYTHELL, R.E.

(*Vide* Index map, page 21.)

No. 1 (late 14) party carried out no triangulation during the year under report. It surveyed an area of 5,100·5 square miles on the 1-inch scale in the Abbottabad district of the North-West Frontier Province and in the Rawalpindi, Jhelum, Gujrat and Shahpur districts of the Punjab, and in the Poonch district of Kashmir.

No. 3 (late 12) party carried out no triangulation or traversing, but ran 336·6 linear miles of levelling, and surveyed 3,234·7 square miles on the 1-inch scale in the Jhang, Shahpur, Lyallpur and Mianwali districts of the Punjab. This was partly a re-survey and partly new survey, and was entirely based on traverses carried out in previous seasons.

No. 4 (late 18) party triangulated 1,250 square miles, chiefly in the Salt Range, and surveyed 1,552·07 square miles on the 2-inch scale and 1,762·3 square miles on the 1-inch scale in the Mianwali, Attock and Shahpur districts of the Punjab. It also traversed 492 linear miles in the Shahpur district in advance of detail survey, and a special traverse detachment of this party traversed over an area of 6,000 square miles in districts Lucknow, Unao, Hardoi, Sitapur, Bara-Banki and Rae-Bareli of the United Provinces. This will form the basis for the detail survey of field season 1910-11 which will be carried out by this party.

The Riverain Detachment, which was this year brought under the direct supervision of the Superintendent, traversed 637·23 linear miles of main traverse and 1,650·13 linear miles of minor traverse along the river Sutlej (districts Ludhiana and Jullundur), on the river Beas (district Amritsar and Kapurthala State), and on the river Ravi (districts Amritsar and Sialkot).

FOREST SURVEYS.

No. 4 (late 18) party surveyed an area of 318·27 square miles of forest areas (chiefly rakhs) in the Jhelum and Shahpur divisions of those districts, chiefly in the Salt Range.

No other forests were surveyed by parties of this circle, but No. 1 (late 14) party revised an area of 117 square miles of fairly modern forest survey, in the Jhelum district, south-west of Sohawa, and in the Naoshera district of Kashmir.

No. 1 (LATE 14) PARTY.

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

The head-quarters of the party remained at Rawalpindi throughout the field season.

PERSONNEL.

Imperial Officers.

Major C. H. D. Ryder, D.S.O., R.E., in charge from 1st October 1909 to 13th July 1910.

Lieutenant J. D. Campbell, R.E., attached from 2nd to 13th July 1910 and in charge from 14th July 1910.

Lieutenant A. A. Chase, R.E.

Provincial Officers.

Messrs. T. W. Babonau, H. H. B. Hanby, H. B. Simons (up to 14th March 1910), R. C. Hanson (from 24th November 1909), W. J. B. Miller and W. P. Hales.

Upper Subordinate Service.

Babu Natha Singh, Rai Sahib.

Lower Subordinate Service.

35 Surveyors, etc.

The area under survey lay in the Abbottabad district of the North-West Frontier Province, the Rawalpindi, Jhelum, Gujrat and Shahpur districts of the Punjab, and in Kashmir and Jammu. The country under survey was of an exceedingly varied nature, including as it did the dead level plains of Gujrat and Shahpur, the broken raviny country of Rawalpindi and Jhelum, the Murree Hills, and the slopes of the Pir Panjal range in Kashmir.

Operations in the field commenced at the end of October 1909 and the party returned to recess quarters at Mussooree on various dates between the 15th April and the beginning of June 1910.

TOPOGRAPHY.

The area surveyed on the scale of 1 inch = 1 mile was 5,100·5 square miles.

The party was divided into three camps under Messrs. Babonau, Hanby and Simons.

On Mr. Simons' transfer, Lieutenant Chase held charge of his camp, and towards the close of the field season Mr. Hanson took charge of a camp, surveying three sheets.

The following sheets were completed: $43\frac{G}{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16}$, $43\frac{H}{1, 2, 6, 10, 13, 14}$, this being 4 sheets in excess of the original programme.

FAIR-MAPPING.

Sheets $43\frac{H}{10, 13, 14}$ have been submitted for publication during the year and the remainder will be submitted before the party takes the field.

No. 3 (LATE 12) PARTY.

BY CAPTAIN A. A. MCHARG, R.E.

The party worked in the Jhang, Lyallpur, Shahpur and Mianwali districts in the Punjab.

PERSONNEL.

Strength of party.

Lieutenant E. C. Baker, R.E., in charge from the 21st May 1909 until the 27th of October 1909.

Captain A. A. McHarg, R.E., Deputy Superintendent in charge during the remainder of the year.

Assistants :—

Mr. J. A. Freeman, Extra Assistant Superintendent, 4th grade.

Mr. B. M. Berrill, Extra Assistant Superintendent, 5th grade.

Mr. B. C. Nowland, Officiating Extra Assistant Superintendent, 6th grade.

Mr. F. H. Grant, Sub-Assistant Superintendent, 1st grade.

Mr. H. H. P. Butterfield, Sub-Assistant Superintendent, 2nd grade.

Mr. F. E. R. Calvert, Sub-Assistant Superintendent, 2nd grade.

Mr. Jiya Lal, Sub-Assistant Superintendent, 3rd grade.

25 Surveyors, permanent and temporary.
2 Apprentice Surveyors.
3 Soldier Surveyors.
2 Clerks.
1 Typer.
1 Computer.

The field office opened at Jhang in the Punjab on the 8th of November 1909. Field work was closed on the 30th of April 1910. Work started in recess at Mussooree on the 4th of May 1910.

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

One-inch survey of the whole of standard sheets $44\frac{A}{3, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15 \text{ and } 16}$, parts of $39\frac{M}{9, 13}$ and parts of $44\frac{A}{4 \text{ and } 12}$, and 336 linear miles of levelling.

During recess all the twelve standard sheets surveyed during the year, *viz.*, $44\frac{A}{3, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15 \text{ and } 16}$, will be drawn and forwarded to the Superintendent, Northern Circle, for submission to the reproducing offices.

The country surveyed lay mostly in the Jhelum and Chenab Canal Colonies, the former being partly in the Shahpur and Jhang districts and lying between the Jhelum and Chenab rivers and the latter in the Lyallpur and Jhang districts east of the Chenab river.

The whole of this country was flat with the exception of a few isolated hills in sheets 44 $\frac{A}{9 \text{ and } 13}$ and very much cut up by canals. Most of the country is already under cultivation and presumably the whole area available will later on be taken up.

The average height of the area surveyed is about 550 feet above sea level.

The Chenab being an older canal colony than the Jhelum is very much better wooded. The latter is at present very deficient in this respect.

A certain small area was surveyed in the "*Thal*" (or sandy hills) portion of the Jhang, Shahpur and Mianwali districts.

This country consists of a sandy plain about 50 feet higher than the country along the Jhelum and Chenab river banks, with more or less parallel ridges of sand hills about 10 to 15 feet higher on the average than the plain, very sparsely wooded, with little water and a few villages scattered here and there, chiefly inhabited by graziers and camel-owners whose flocks of sheep and camels keep continually moving on to new grazing grounds.

In the Canal Colonies Messrs. Grant and Butterfield made considerable use of the patwaris' chak maps, plotting the chaks on their plane-tables and then correcting them wherever necessary in the field. If this could have been done by the party before taking the field a much greater outturn would have been the result, but unless properly supervised it is not work that can be left to the average surveyor to do by himself; however (on future occasions in similar country) steps will be taken to make considerably more use of the patwaris' maps than was the case during the year under report. These maps are as a rule very correct and necessarily up to date, and provided they are correctly transferred to the plane-tables, should be of invaluable assistance.

336 miles of levelling was carried out. This was chiefly of use in connecting up the railway, canal and G. T. data and giving heights to points in areas outside the irrigation limits.

In both the Canal Colonies canal-contoured maps (contours at 1 foot intervals) have been used for giving heights to cross-roads, corners of villages, etc., on the fair sheets.

No. 4 (LATE 18) PARTY.

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

The field head-quarters of the party remained at Mianwali throughout the field season and opened there on 1st November. Recess head-quarters continued at Mussooree.

PERSONNEL.

Captain L. C. Thuillier, I.A., Deputy Superintendent in charge.
Captain M. N. MacLeod, R.E., Assistant Superintendent.
Mr. G. J. S. Rae, Extra Assistant Superintendent, 3rd grade.
Mr. H. W. Biggie, Extra Assistant Superintendent, 4th grade.
Mr. C. E. C. French, Extra Assistant Superintendent, 5th grade.
Mr. Maya Das Puri, Extra Assistant Superintendent, 6th grade (up to 30th June 1910).
Mr. A. B. Hunter, Extra Assistant Superintendent, 6th grade.
Mr. F. C. Pilcher, Sub-Assistant Superintendent, 1st grade (up to 23rd September 1910).
Mr. Abdul Aziz, Sub-Assistant Superintendent, 2nd grade (up to 30th September 1910).
Mr. H. T. Hughes, Sub-Assistant Superintendent, 2nd grade (up to 30th May 1910).
Babu Vidya Nath Suri, Probationer, Upper Subordinate Service (from 1st April 1910).

Surveyors	36
Traversers	18
Draftsmen	22
Computers	19
Clerks	3
Typers	2
Hospital Assistant	1
Menials	412

Previous to this the Shahpur traverse section commenced work on 11th October at Khushab and an advance party under Mr. A. B. Hunter at Mianwali on 25th October. Later the United Provinces traverse detachment opened at Lucknow on 19th November.

Surveyors were distributed over the area for survey in sheets 38 $\frac{P}{10, 11, 12, 13, 14, 15, 16}$, 43 $\frac{D}{1, 2, 3, 4, 6, 6, 7}$. Later, for economy's sake, sheet 43 $\frac{D}{5}$ was dropped.

Under these arrangements all sections were able to finish about the middle of April, except three or four surveyors who completed later. Mr. French with a few good draftsmen closed earlier and proceeded to Mussooree to project and plot all fair sheets and to get all exterior work on them (margins, headings, footnotes, etc.) cleared off wholesale, which meant a considerable saving of time.

Shahpur Traverse.—This work was required during the current field season for the use of this party and also No. 3 (late 12) party. Work lay in sheets 39 $\frac{M}{9, 13, 14}$, 43 $\frac{D}{3, 4, 7, 8}$, 44 $\frac{A}{1, 2}$. Field work was completed by the end of November and computation by middle of December.

United Provinces Traverse.—The programme consisted of traverse work in sheets 63 $\frac{A}{3, 4, 7, 8, 10, 11, 12, 14, 15, 16}$, 63 $\frac{B}{1, 2, 3, 5, 6, 7, 9 \text{ to } 16}$, 63 $\frac{E}{3, 4, 7, 8}$. Field work started on 19th November and was completed by 20th April. During recess all computations were completed.

Cantonment Surveys.—Cantonment Section No. 1 was placed under the officer in charge of No. 18 party on 1st April.

Three cantonments as under were surveyed during the year under report :—

Dharmsala, detail survey completed.

Meerut, only additions and alterations undertaken.

Lucknow, detail survey and some extra traversing completed.

Maps of 8 cantonments were sent for publication and 9 were published during the year. Six maps, *viz.*, Barrackpore, Dum Dum, Shillong, Meerut, Lucknow and Nowshera Cavalry Cantonment (now called Risalpur), remain in office. Barrackpore and Dum Dum await certain corrections ; Shillong and Risalpur are now being sent for publication, and Meerut and Lucknow will be ready by the middle of November.

Fair mapping of all sheets was completed and submitted for publication by the end of recess.

Computations of triangulation and United Provinces traverse were completed during recess.

United Provinces Traverse Detachment.

The programme consisted of traverse work in districts Lucknow, Unao, Hardoi, Sitapur, Bara-Banki and Rae-Bareli in sheets 63 $\frac{A}{3, 4, 7, 8, 10, 11, 12, 14, 15 \text{ and } 16}$, 63 $\frac{B}{1, 2, 5, 6, 7, 9, 10 \text{ to } 16}$, 63 $\frac{E}{3, 4, 7 \text{ and } 8}$.

The country was perfectly flat and open and well cultivated except near water-courses where the surface was cut up by ravines.

Traverse lines were run along graticules of plane-table sections, picking up as many trijunctions as possible and intersecting conspicuous objects, such as temples, prominent trees, etc. In addition traverse lines were run along railways. For all stations between trijunctions iron cylinders were used.

Punjab Traverse.

In last year's annual report reference is made to Mr. J. deG. Hunter's researches into the traverse data of the Punjab. Nothing further was done in this direction during the year under report as it was evident from comparison of the results obtained from the crinoline tape traversing that there were considerable errors in the old traverse even after the redistribution of errors by Mr. Hunter, and that though perhaps the traverse work would be improved by the readjustments he had made, nothing approaching finality could be reached till some data at a distance from the origin and the existing data could be obtained on which to close the work. Captain MacLeod, therefore, considered that till some further triangulation or Yaderin traverse was done for this purpose it would be waste of labour to attempt a redistribution of errors which would only have to be revised later when fresh data were available.

RIVERAIN DETACHMENT.

By Mr. Maya Das Puri.

PERSONNEL.

Captain M. N. MacLeod, R.E., in charge up to 30th June 1910.

Mr. Maya Das Puri, Extra Assistant Superintendent, 6th grade, in charge from 1st July 1910.

50 Surveyors, Traversers, Draftsmen, Computers, etc.

The detachment was separated from No. 4 party (Northern Circle) on the 1st July 1910, was formed into an independent detachment, and was placed under the orders of the Superintendent, Northern Circle. While under No. 4 party (Northern Circle), the work was carried under the instructions of Captain M. N. MacLeod, R.E. The following out-door work was completed during the season :—

Class of work.	Taversed.			Number of villages.	Number of stations fixed.	Number of corners of squares laid out.	Number of squares.
	Straight length of rivers.	Number of linear miles.	Number of square miles.				
Main circuits	225	637·23	663	..	1,123	..	..
Detail traversing	130	1,650·13	296	201	6,915	..	..
Base lines	130	..	514	..	..	742	247

The total cost of traversing, laying out base lines and preparing *musavis* (settlement mapping sheets) during the year was Rs. 38,006-9-10 (Rs. 102-7-7 per square mile), and that of the fair drawing, tracing, etc., Rs. 7,049-0-8.

The field season lasted from 1st October 1909 to 10th June 1910, and the detachment again left for the field on 17th September 1910.

The work was commenced on the Sutlej (districts Ludhiana and Jullundur) early in October 1909, on the Beas (district Amritsar and Kapurthala State) in December 1909, and on the Ravi (districts Amritsar and Sialkot) during January 1910. The plotting and compiling section was shifted to Ludhiana on 15th November 1909, and after completing the work there, left for Amritsar on 4th February 1910, where it remained till 9th April 1910, and finally returned to Lahore on 14th April 1910 for recess. The computing office remained at Lahore during the whole year.

Main circuits were run with 330 and 500-foot long crinoline tapes, above the high banks, on both sides of the rivers Sutlej, Beas, Ravi and Chenab, in districts Ludhiana, Jullundur, Ferozepur, Lahore, Kapurthala State, districts Amritsar, Sialkot, Gujranwala and Gujrat, and they were connected with each other after every 7th or 8th mile and with 11 trigonometrical stations.

Base lines, facing one another, were laid out on both banks of the river Sutlej (Ludhiana and Jullundur), Beas (Amritsar and Sialkot), on the *pukha* ground, away from water action about ¾ mile apart from each other, for the future demarcation and survey of riverain boundaries. Generally three corners of a square were marked on the ground so as to save the patwaris the trouble of laying out a right angle.

The ground under survey was broken, sandy and marshy.

Nearly all the computations were finished in the field season. The completion of traverse records, writing of village names and computations of main circuits, carried late in the season, were done during the recess.

SOUTHERN CIRCLE.

BY COLONEL T. F. B. RENNY-TAILYOUR,* R.E.

(*Vide* Index map, page 21.)

The appointment of Deputy Surveyor General was abolished on the 1st March 1910 and that of Superintendent, Southern Circle, which was held by Colonel Renny-Tailyour, was created on the same date. Nos. 5 (late 1) and 6 (late 2 and 17) parties working in Bombay, the Central Provinces and Berar and the Cantonment Sections until they were absorbed on the 1st April 1910 were under the Deputy Surveyor General and the Superintendent, Southern Circle; the latter officer took over from the Superintendent, Eastern Circle, the superintendence of Nos. 7 (late 3) and 8 (late 19) parties working in Madras, Coorg and Mysore from the 1st April 1910.

* Colonel T. F. B. Renny-Tailyour, R.E.
Lieutenant-Colonel J. M. Fleming, I.A., from 13th October 1909 to 28th February 1910.

The Coorg detachment was absorbed by the late No. 3 party on the 1st November 1909, the late Nos. 2 and 17 parties were amalgamated into one party which was called No. 2 party on the 1st March 1910, Nos. 1 and 2 Cantonment Sections were absorbed in other circles on the 1st April 1910 and Nos. 1, 2, 3 and 19 parties were re-numbered Nos. 5, 6, 7 and 8 parties, respectively, on the 1st June 1910.

No. 5 (late 1) party completed an area of 1,763 square miles of 1-inch new survey and 528 square miles of 1½-inch new survey in the Jubbulpore, Mandla, and Damoh districts of the Central Provinces and in the Rewah State in Central India. An area of 2,278 square miles of triangulation was also completed in the Hoshangabad district of the Central Provinces and in the Bhopal State in Central India.

No. 6 (late 2 and 17) party completed an area of 3,078 square miles of 1-inch original survey, 78 square miles of 2-inch original survey, 262 square miles of 2-inch re-survey and 1,564 square miles of 1-inch revision survey in the Nagpur and Wardha districts of the Central Provinces, in the Yeotmal district of Berar, in the Indore State in Central India, in the East Khandesh district of Bombay and in the Aurangabad district of Hyderabad. An area of 5,032 square miles of triangulation was completed in the Chanda district of the Central Provinces, in the Yeotmal and Buldana districts of Berar and in the Nander and Sirpur Tandur districts of Hyderabad. 788 linear miles of forest boundary traverse were also completed.

No. 7 (late 3) party absorbed the Coorg detachment on the 1st November 1909 and commenced work in Southern India. The party completed an area of 876 square miles of 1-inch original survey, 413 square miles of 2-inch original survey and 875 square miles of 1-inch revision survey in Coorg, in the South Kanara and Malabar districts of Madras and in Mysore. An area of 1,850 square miles of triangulation was also completed in the South Kanara district of Madras.

No. 8 (late 19) party completed an area of 2,396 square miles of 1-inch original survey, 509 square miles of 2-inch original survey and 190 square miles of 1-inch supplementary survey in the Nilgiri, Malabar and Coimbatore districts of Madras and in the Cochin State in Madras. An area of 900 square miles of triangulation was completed in the Madura and Tinnevelly districts of Madras and in the Travancore State in Madras. 312 linear miles of traverse was also completed.

No. 5 (LATE 1) PARTY.

Major C. L. Robertson, C.M.G., R.E., in charge.
Lieutenant C. F. Nation, R.E., attached from 8th September 1910.
Messrs. F. S. Bell (to 25th February 1910), F. P. Walsh, W. Skilling, B. M. Berril, C. West, R.E. Saubolle and Munshi Lal, B.A.
28 Surveyors, 3 Soldier-Surveyors, 1 Draftsman, 3 Computers, 2 Clerks and 1 Hospital Assistant.

The work done by the party during the year under report was in continuation of that done during the previous year and was carried out in the Jubbulpore, Mandla, Damoh and Hoshangabad districts of the Central Provinces and in the Rewah and Bhopal States in Central India.

The party took the field on the 25th October 1909 and left on the 20th April 1910 for recess quarters which were transferred from Poona to Bangalore. In order to reduce expenditure the programme was considerably curtailed soon after the commencement of the field season; this curtailment caused considerable hardship on many of the surveyors. Sheets $64\frac{A}{4, 8, 11, 12, 15, 16}$ were entirely surveyed, the survey of sheet $64\frac{A}{14}$ was completed and sheets $55\frac{M}{6, 7, 8}$ were partially surveyed. In addition to a small secondary series the triangulation of sheets $55\frac{I}{4, 8}$ and $55\frac{J}{1, 3, 5, 7}$ and of portions of sheets $55\frac{J}{2, 6, 11}$ was carried out.

In the programme for this year's work it was proposed to undertake the detail survey of a considerable area by means of revision survey; the previous survey was, however, found to be so inferior that practically no use could be made of it, and it has been decided therefore to classify the whole outturn as new survey.

The country in which the detail survey was carried out was for the most part hilly and wooded, this being specially so to the eastward where the hills on the border between the Mandla district and the Rewah State rise to some 3,000 feet above sea level and are covered with extensive forest reserves. The triangulation lay partly over the Pachmarhi hills and plateau and partly in the valley of the Narbada river.

The mapping of sheets $64\frac{A}{4, 8, 11, 12, 14, 15, 16}$ was commenced, but, owing to the introduction of new methods necessitating the special training of draftsmen and to the delays which occurred in obtaining enlargements of the plane-table sections, the work was considerably retarded and all the sheets will not be completed by the end of the recess season; the unfinished sheets will be completed in the drawing section of the Southern Circle Office. The completion of 8 sheets which were arrears from the previous recess season also interfered with the current mapping.

The triangulation computations have not been entirely worked out, but more than sufficient have been completed for the requirements of next field season. No triangulation charts have been prepared.

Extract from report by Major C. L. Robertson, C.M.G., R.E.

The existing maps on the 1-inch scale of the portions of the Mandla district and Rewah Native State in question were merely rather indifferent compilations from old cadastral surveys, supplemented by extra-departmental information; the hill drawing making no pretence to represent contours, and the publication being all in black. They were therefore not considered of sufficient value to justify an attempt at revising them. The existing survey of the portions of the Jubbulpore district, however, falling in these sheet areas is of a higher class, being actual topographical work though of doubtful value as far as the contouring is concerned and, as with the remainder of the sheet areas, published in only one colour. Over these areas it was decided to class the work as revisionary, and for this purpose tracings of the outline of the existing survey were given to the surveyors with instructions to transfer these in blue on to their plane-tables bit by bit in advance of their work, and to check this transfer on the ground, correcting it where necessary before inking it up, and to re-contour the whole at 50 feet vertical intervals. This re-contouring has been based on a fresh tertiary triangulation extended over the area by Mr. F. S. Bell during the previous season.

In practice the existing outline as transferred was found to be so generally out of position to a slight extent, sometimes in one direction and sometimes in another, that it was found to rather confuse than assist the surveyors. The so-called revisionary survey, therefore, resolved itself into new survey and, for all purposes of cost and outturn rates, should be treated as such.

The scale of 1½ inch = 1 mile was selected as that of revision survey in the western areas, as some of the fair sheets of comparatively recent surveys over these had been drawn on this scale and the preparation of photographic blue prints for the purpose of correction and contouring in the field was simplified by its adoption.

As in the case of the 1-inch revisionary survey, that done here on the 1½-inch scale resolved itself practically into new survey for the same reasons, *viz.*, that the existing outline was found on examination to be generally, though seldom extensively, out of position, rendering contouring impossible without what to all intents and purposes amounted to re-survey of the outline.

I am of opinion that for anything but work which is intended simply to supplement survey which is known to be of good quality, or of which an accurate correction is not required, the use of blue prints of previous survey is a mistake, as it is of little if any assistance to the careful surveyor, while it affords the dishonest one an opportunity of scamping his work.

No. 6 (LATE 2 AND 17) PARTY.

Captain H. L. Crosthwait, R.E. (late No. 17 party), in charge from 5th November 1909 to 3rd February 1910.

Captain H. Wood, R.E. (late No. 2 party), in charge to 13th May 1910 and from 13th June 1910 to 19th July 1910.

Lieutenant S. W. S. Hamilton, R.E. (late No. 17 party), attached to 16th June 1910 and in charge to 4th November 1909, from 4th to 28th February 1910 and from 14th May 1910 to 12th June 1910.

Lieutenant K. W. Pye, R.E., in charge from 16th August 1910 to 5th September 1910.

Lieutenant J. A. Field, R.E. (late No. 2 party), attached and in charge from 20th July 1910 to 15th August 1910 and from 6th September 1910.

Messrs. A. Ewing to 6th May 1910, C. G. Lee, Amar Singh, J. H. S. Wilson, P. R. Anderson, J. R. Newland to 30th June 1910, E. A. Meyer, A. K. Mitra, F. B. Kitchen, C. O. Picard, P. C. Mitra, F. C. Saint, E. J. Hanby, R. B. Gilden, C. B. Sexton, A. J. Booth and R. M. Wyatt.

Messrs. R. V. Joshi and Dharmu.

44 Surveyors, 7 Soldier-Surveyors, 6 Pupil Surveyors, 4 Draftsmen, 1 Typer, 4 Clerks and 2 Hospital Assistants.

On the 1st March 1910 Nos. 2 and 17 parties were amalgamated and the work of both parties and of the combined party appears in this report.

The work was continued in the previous theatres of operations, that of the late No. 2 party in the Nagpur, Wardha and Chanda districts of the Central Provinces, in the Yeotmal district of Berar and in the Nander and Sirpur Tandur districts of Hyderabad, while that of the late No. 17 party was in the Indore State, in Central India, in the East Khandesh district of Bombay, in the Buldana district of Berar and in the Aurangabad district of Hyderabad.

Field work was commenced at the end of October 1909 and finished by the beginning of May 1910, the party arriving on the 8th May 1910 at recess quarters which were transferred from Poona to Bangalore. Owing to difficulties in recruiting *khalasis* some of the surveyors were delayed in commencing work. Very shortly after the commencement of the field season orders were received to reduce expenditure as much as possible; in consequence a number of surveyors were sent on leave or discharged, the programme was considerably modified and the distribution of the party altered. Sheets 46 $\frac{O}{15}$, 46 $\frac{P}{1, 4, 6, 7, 8, 9, 10, 11, 13, 14}$ and 55 $\frac{L}{8, 9, 10, 12, 13, 14}$ were entirely surveyed and small portions of sheets 46 $\frac{P}{3, 12}$ and 55 $\frac{L}{15, 16}$ were also surveyed. Triangulation was carried out in sheets 55 $\frac{D}{2, 3, 6, 7, 10, 11}$, 55 $\frac{P}{4}$, 56 $\frac{E}{9, 10, 11, 13, 14}$, 56 $\frac{I}{1, 2, 5, 9, 13}$ and 56 $\frac{M}{1}$, while sheets 55 $\frac{D}{4, 8, 12}$ and 56 $\frac{A}{1, 5, 9}$ were reconnoitred, but unfortunately the officer concerned fell ill before he could undertake the triangulation. Theodolite forest boundary traverses were undertaken in sheets 55 $\frac{L}{8, 12, 16}$, 55 $\frac{P}{4}$, 56 $\frac{I}{5, 9, 13}$ and 56 $\frac{M}{1}$.

The scene of operations in Berar lay in the valley of the Wardha river and in the hills lying to the west of it. Into the extreme north of the area surveyed project the southern spurs of an outlying range of the Satpura hills; these hills rising some 500 to 600 feet from the plain are mostly covered with reserved forests and being much cut up by the drainage are intricate and difficult. The abrupt change from these hills to the level plains of the Wardha river is almost as great as the difference they present to the surveyors, the latter being as easy as the former is difficult. West of the Wardha river in the south-west corner of the area surveyed the eastern edge of the Yeotmal plateau occurs; the country here is much broken up, the features though prominent and well marked are as intricate in design as they are diminutive in size and, as in previous years, the surveyors found them hard to delineate. The country surveyed in East Khandesh and Aurangabad lay on the northern edge of the Deccan plateau and on the southern side of the Tapti valley. Although the *ghat* on the edge of the plateau with its sudden drop of 700 to 1,000 feet forms a natural barrier dividing the two areas, they are very similar from the point of view of a surveyor, well marked features abound, the ground is open, villages are numerous, water is plentiful and transport is easy to obtain. The small area surveyed along the boundary between Indore and East Khandesh offers the reverse picture; heavily wooded, rugged hills in continuation of the Satpura range, little water, few communications, sparsely inhabited, and with little or no transport—all combine to make the work as difficult as possible.

Sheets $46 \frac{O}{15}$, $46 \frac{P}{1, 4, 5, 7, 8, 9, 10, 11, 13, 14}$ and $55 \frac{L}{8, 9, 10, 12, 13, 14}$ have been mapped and will be completed by the end of the recess season leaving no arrears of standard sheets. In addition 8 sheets of the 2-inch forest editions of standard sheets have been prepared, but in future this class of work will be undertaken in the drawing section of the Southern Circle Office.

The triangulation computations have not been entirely worked out, but more than sufficient have been completed for the requirements of next field season. The traversing computations have been completed. No triangulation charts have been completed.

Extract from a report by Captain H. Wood, R.E.

For revision survey on the 1-inch scale the system mentioned below was adopted. It should be noted that of the sheets for revision survey on this scale, in $46 \frac{P}{1, 2, 3, 5, 6, 9, 10}$ were numerous isolated reserved forests which had been previously surveyed on the 4-inch scale, while in sheets $46 \frac{P}{9, 13, 14}$ were forests which had not been surveyed on any larger scale than the 1-inch. These latter had to be re-surveyed on the 2-inch scale. In order to utilize the 4-inch scale survey of the forests mentioned above, reductions on the 1-inch scale of the published forest maps, printed in black on bank post paper, were obtained during recess. These were cut up, fitted and lightly pasted in their correct positions on copies of the old Bombay topographical survey sheets which had been previously made up to graticule limits of the new standard sheet series, the corrected graticule lines being ruled up in black and trigonometrical stations and points plotted on them.

The corrected 1-inch sheets with the reductions of 4-inch work superimposed were sent to Calcutta and blue prints on Whatman drawing paper obtained . . . . . .

The surveyor using these blue prints revised the work in the ordinary way, but the detail in the previously surveyed forest reserves was accepted as correct and inked upon the P. T. sections after the roads had been classified and any new ones inserted.

Where the contouring was light the 50 feet contours were inked up on the plane tables after being checked on the ground by heights taken by the surveyor, who had with him as a guide a copy of the 4-inch published map on which the camp officer had inked up the 50 feet contours in red.

Where the contouring was heavy the ground had to be contoured anew, and the new contouring was compared by the camp officer with that shown on the 4-inch map and any differences checked on the spot. This method of preparing the blue prints for surveyors would have been most satisfactory, but unfortunately the blue prints supplied were not always exactly correct to the dimensions given and in some cases were considerably distorted.

This gave a certain amount of difficulty with the detail survey and next season a different method will be tried.

Experiments were also carried out with Bristol board and Southampton board in lieu of Whatman's paper to see if distortions of the sections could be overcome. The Southampton board was a complete failure, but the Bristol board promised well and it is hoped that the difficulties will be overcome by its use. . . . . . .

The following method of transferring from the traces to the fair map was used during recess and found very successful. After all the traces had been prepared in the usual way they were carefully cut along the graticule lines and mounted on the plotted prick-off sheet in their relative places, being stuck down in five or six places with a minute drop of perfectly clear gum. The sheet was then vandyked and a blue print taken on 210-lb. drawing paper. The traces were then removed from the prick-off sheet and remounted on tracing paper (leaving room for marginal remarks, etc.), and the hill traces were then similarly mounted on the prick-off sheet and a blue vandyked print of them obtained in the same way. These blue prints were used as the fair sheets, being inked up in the ordinary way. This process of transferring the detail not only saved a great deal of time (the more complicated the work the more time is saved), but also, as it was done mechanically, the transferring was more accurate.

A possible method . . . . of obtaining blue prints of both outline and contours on one sheet would be to make vandyke plates of the outline and hill traces separately and to combine the two in the printing . . . .

Note by Mr. A. Ewing.

The second method of having two plates, one for the outline and the other for the contours, and getting a combined print is a waste of time as it entails bad registration and is a roundabout way of getting the outline and contours on one sheet.

A simpler and quicker method will be to draw both outline and contours on each 5-minute trace, only the 250 feet contours being shown when the contouring is close.

No. 7 (LATE 3) PARTY.

Captain C. P. Gunter, R.E., in charge to 16th June 1910.

Lieutenant S. W. S. Hamilton, R.E., in charge from 17th June 1910 to 20th July 1910.

Lieutenant A. H. Gwyn, I.A., attached and in charge from 21st July 1910 to 30th September 1910.

Messrs. R. Waller-Senior to 3rd April 1910, W. M. German, J. O'B. Donaghey, W. E. S. Swiney, H. D. W. Stotesbury, and J. C. St. C. Pollett.

Messrs. Eknath Battu and Abdul Hakk.

25 Surveyors, 1 Draftsman and 2 Clerks.

This year the party for the first time worked in Southern India. The work was in continuation of that done the previous year by the Coorg detachment which was absorbed in the party, the sphere of operations lying in Coorg, in the adjoining South Kanara and Malabar districts of Madras and in Mysore.

Field work was commenced on the 20th November 1909 and finished on the 4th June 1910. The programme was cut down at the beginning of the field season owing to financial reasons. Only seven sheets, 48 $\frac{P}{10, 12, 13, 14, 16}$ and 57 $\frac{D}{3, 4}$, were completely surveyed, the work of the Coorg detachment in sheet 48 $\frac{P}{11}$ was completed and very small scattered areas amounting to about 100 square miles in sheets 48 $\frac{P}{3, 4, 7, 8}$ were surveyed but are not available for mapping. Triangulation was carried out in sheets 48 $\frac{K}{9, 10, 11, 12, 13, 14, 15, 16}$, 48 $\frac{O}{2, 3, 4, 8, 12}$, 48 $\frac{P}{3}$ and 57 $\frac{D}{3, 4}$.

The country varied exceedingly in character extending from the low Malabar coast land, over the Western Ghats ard the hills of Coorg, into the great plateau of Mysore. On the whole it is not easy to work in; except in the open country of Mysore traversing was the usual method of survey. The cost-rates of the detail survey are misleading, they were influenced largely by the abandonment, after commencement, of the survey of the four sheets 48 $\frac{P}{3,4,7,8}$, a number of surveyors having to be sent away and a large number (proportionally) of senior officers being left; the enhanced rates of travelling allowance and contingent expenditure have also increased the figures.

The country under survey in Coorg is of an extremely picturesque character consisting of wooded hills, some of which are covered with coffee estates, and which are interspersed with long paddy fields. The inhabitants live in substantial houses around the edges of these fields and there are no large towns. The old Coorg fortifications, locally known as *kadangas*, are an interesting feature, some of them dating from the ninth century A.D.; sometimes several miles long, they run along hill tops in the most advantageous positions for defence, occasionally ramifying and throwing out smaller branches. They consist simply of a high parapet and a deep ditch, the combined height and depth of which is sometimes 35 feet.

Sheets 48 $\frac{P}{10,12,13,14,16}$ and 57 $\frac{D}{3,4}$ have been mapped and will be completed soon after the end of the recess season. Owing to inaccuracies having been discovered in sheets 48 $\frac{P}{11,15}$ which were surveyed by the Coorg detachment, the completion of their mapping has been delayed.

The computations of the triangulation have been completed. Triangulation charts 84 I, 84 K, 94 A and 94 B, which are arrears from the work of the party in Burma, are nearly completed.

Extract from a report by Lieutenant A. H. Gwyn, I.A.

Use of Land Record maps in Coorg.—These maps are made by joining up village maps, so distortion is one of their faults; nevertheless when reduced to the 1-inch scale on tracing paper and transferred to the plane-table in blue pencil they were useful for surveying the edges of cultivation, which in Coorg are an unfailing guide for contouring.

No. 8 (LATE 19) PARTY.

Captain C. M. Browne, D.S.O., R.E., in charge from 22nd November 1909 to 2nd April 1910.

Lieutenant S. W. S. Hamilton, R.E., in charge from 21st July 1910.

Lieutenant C. G. Lewis, R.E., attached and in charge to 21st November 1909 and from 3rd April 1910 to 20th July 1910.

Messrs. J. Smith to 10th April 1910, W. F. E. Adams, E. J. Biggie, S. F. Norman from 13th June 1910, M. Mahadeva Mudaliar, Balaji Dhondiba, M. S. Ganesa Aiyar and A. J. Fraser.

Mr. Anantarao Dhondiba.

26 Surveyors, 2 Traversers and 2 Clerks.

The work carried on by the party was of the same nature as, and in continuation of, that of the previous year and covered parts of the Nilgiri, Coimbatore, Malabar, Madura and Tinnevelly districts of Madras and of the Travancore and Cochin States in Madras.

The party took the field on the 23rd November 1909 and returned to recess quarters on the 4th June 1910. Sheets 58 $\frac{B}{1,2,5,6,9,10,13,14,15}$ were entirely surveyed, the survey of sheets 58 $\frac{A}{11,12,15,16}$ were completed and sheet 58 $\frac{B}{3}$ was partially surveyed. Triangulation was carried out and the old triangulation examined in sheets 58 $\frac{G}{1,2,5,6,7}$ and in a portion of sheet 58 $\frac{G}{3}$. Traverse lines were run along the backwaters near the coast.

The Nilgiris and the hilly portions of Malabar, Coimbatore and Cochin present the usual features of hill country met with in the Western Ghats, comparatively open jungle at the base of the hills, giving way as the ground rises to dense moist evergreen forest with thick undergrowth and few communications, and finally reaching the upper plateaux about 6,000 feet in elevation; these platteaux consist of large undulating open downs interspersed with clear streams of running water where plane-tabling is simple. The plains of Coimbatore consist of large open stretches of cultivated land where plane-tabling is extremely easy and progress rapid. Moving westwards from Coimbatore through the "Palghat Gap" we come to the plains of the west coast; the aspect of the land changes rapidly, the dry cultivation of Coimbatore gives place to paddy fields surrounded by dense groves of cocoanut and palmyra palms, the inhabitants are no longer grouped together in villages but are scattered over the whole country, an endless succession of mud and thatch. Progress in this country must always be slow, triangulation points are few and far between, *in situ* fixings are very rarely obtained and plane-table traversing is the only method remaining.

The mapping of sheets $58 \frac{A}{11, 12, 15, 16}$ and $58 \frac{B}{1, 2, 5, 6, 9, 10, 13, 14, 15}$ was taken in hand, but owing to the late return of the party to recess quarters and to the introduction of new methods necessitating the special training of draftsmen, all the sheets will not be completed by the end of the recess season and the mapping of the unfinished sheets will be continued during next field season.

The computations of the triangulation and traversing have practically been completed. Triangulation charts 49 M, 49 N and 58 A have nearly been completed.

On the whole, considering the notoriously malarious tracts in which part of the work was carried out during the field season, the health of the party was good throughout the year. Two *khalasis* died.

Extract from a report by Lieutenant S. W. S. Hamilton, R.E.

". . . . . The country adjoining the coast . . . . . is extremely intricate and requires not only a first class surveyor, but also a man who is a first class draftsman to survey it properly on the scale of 1 inch to 1 mile.

In future it is intended to survey the coastal areas on the scale of 1½ inches to 1 mile. This scale will be sufficiently large to enable the more indifferent draftsmen to show a sufficiency of detail and at the same time a largely increased outturn will be obtained . . . . .

. . . . . The very large amount of detail and the extraordinary intricacies of the cultivation limits that the sheets of the party, especially those on the coast, contain, render fair mapping very slow, the dotting of the cultivation limits in one sheet alone having taken 2½ months to complete, while this work has not taken less than a month or six weeks in any sheet that borders on the coast, to say nothing of the innumerable habitations scattered over the country in every direction. Ornamentation is close and contouring often intricate, while the contouring of sheets other than those on the coast, ranging as it does from 400 to 8,000 feet is extremely heavy.

EASTERN CIRCLE.

By Colonel G. B. Hodgson, I.A.

(*Vide* Index Map, page 21).

Lieutenant-Colonel P. J. Gordon, I.A.

The superintendence of the parties working in Southern India, Burma and Assam, Nos. 3, 10, 11, 19, 20 and the Burma Drawing Office was held by Lieutenant-Colonel P. J. Gordon, I.A., up to the 31st of March 1910. On the completion of the reorganisation of the department on the 1st April 1910, Colonel G. B. Hodgson, I.A., then on leave, was appointed Superintendent in charge of the newly formed Eastern circle which at present comprises only 3 parties, Nos. 10, 11 and 12 (old 20) and a nucleus drawing office. Lieutenant-Colonel Gordon was appointed to officiate for him, and continued to hold charge until the close of the year. Nos. 3 and 19 parties and the drawing office were at the same time transferred to the Southern circle and No. 9 party will be transferred from the Northern to the Eastern circle at the close of the ensuing season.

As no offices were available at the time at Shillong, which is to be the head-quarters of the Eastern circle, it was decided that the Superintendent's office should remain at Bangalore until the end of the year. The offices of the Director of Land Records and Agriculture and Inspector General of Police, Eastern Bengal and Assam, at Shillong are, however, expected to be available in March 1910, and the office of the Superintendent, Eastern circle, will then move to Shillong and will be located in these offices temporarily until the office of the Accountant General, which the Local Government has offered to place at our disposal, becomes available in the following October.

Burma.—Nos. 10 and 11 parties continued operations in the Katha, Bhamo, and Myitkyina districts of Upper Burma and the Shan States, completing between them 7,515 square miles of topography on the 1-inch scale in sheets 92 H and 93 E, I, J, N and O. No. 10 party triangulated and traversed 4,415 square miles in sheets 92 D and H and No. 11 party 3,050 square miles in Karenni and the Southern Shan States in sheet 94 E. No. 10 party will in future be employed in the north of the province and No. 11 party after completing the survey of Karenni will probably be transferred to Tavoy and Mergui, of which districts the Local Government have expressed a wish for topographical maps.

Eastern Bengal and Assam.—No. 12 party continued work in the Sylhet and Cachar districts of Assam and the Khasi and Jaintia Hills; an area of 2,550 square miles in sheet 78 O was triangulated and traversed and 1,802 square miles were surveyed in detail in sheet 83 D of which 421 square miles consisted of reserved forests and were surveyed on the 2-inch scale.

Cantonment Surveys.

No. 2 Cantonment Section, which was formerly organized as an independent detachment, was attached to and became an integral part of No. 10 party from the 1st of April 1910. The survey of the Secunderabad cantonment was completed and also that of the Mandalay, Bhamo, Maymyo and Meiktila cantonments in Burma. The survey of the cantonments was carried out on the 16-inch and of the bazars on the 64-inch scale. The survey of the Rangoon cantonment will be carried out during 1910-11, and the survey of the cantonments of India and Burma will then be completed.

Six probationers of the Burma Land Records Department after a year's course of instruction at Dehra Dun were attached to No. 10 party and received a practical training in cadastral survey in the field. During the course, which lasted for twelve months, 6,629 acres in the Bhamo and Yamethin districts were surveyed on the 16-inch scale and 221 acres of Yamethin town were surveyed on the 64-inch scale. It is proposed to attach five officers of the Burma Land Records Department to this party for a similar training during 1910-11.

No. 10 PARTY.

Captain L. G. Crosthwait, I.A.

Messrs. O. D. Smart, F. S. Bell, C. S. Littlewood, W. G. Jarbo, E. Claudius, Asmatullah Khan, S. M. Kenny, Abdul Rahim, K.S., W. H. Strong.

Mr. Lachman Jadu, R.S.

32 Surveyors, 3 Traversers, and 2 Soldier-Surveyors under training.

Upper Burma and Shan States.—The party commenced field work in the middle of November 1909 and returned to recess quarters at Maymyo at the end of May 1910. It was divided into 3 sections: (1) Topographical, (2) Cantonment, (3) Land Records training section. The topographical section was again divided into 4 camps under Messrs. Jarbo Asmat Ullah Khan, Kenny and Lachman Jadu. The whole of the season's work lay at a high altitude, partly in the Shan States and partly in the Bhamo and Myitkyina districts, and owing to the invigorating climate the health of the party throughout the season was excellent, although the cold at night was often very great and the field season was unduly prolonged in order that the programme might be completed. There was no difficulty in obtaining labour and ready assistance was at all times given by the local authorities. The country operated in consisted chiefly of high sparsely wooded hills and grassy uplands inhabited by Kachins, Chinese and various tribes of Shans, and varied in altitude from 532 feet on the Shweli river to 8,371 feet in the Kokang district of the Hsenwi State to the east of the Salween river, and included 150 miles of the Burma-China boundary. The country outside the boundary was sketched as far as possible during the progress of the survey of the boundary, and the area thus mapped amounts to 592 square miles, which is not included in the outturn given in the tabular statement at page 18. Mr. Abdul Rahim was deputed to attend a meeting of British and Chinese officials to assist in defining the alignment of portion of the boundary.

The triangulation was carried out by Messrs. Claudius, Strong and Abdul Rahim and was connected with the new G. T. Upper Irrawaddy series which is now in course of observation and consequently only preliminary values of the data were available. All the computations of the triangulation and traversing were completed and the drawing of 4 charts of sheets 84 M, 92 L, 93 A and 93 E was also completed.

The fair maps were drawn on the 1½-inch scale for publication on the 1-inch in 18 sheets, of which 15 will be submitted for publication before the party takes the field again and the remaining 3 sheets will be completed in the circle drawing office.

CANTONMENT SECTION.

The party hitherto known as No. 2 Cantonment Section was merged in this party from the 1st April 1910. During the season under report the survey of the cantonments of Bhamo, Mandalay, Maymyo and Meiktila was completed and that of Rangoon commenced. They were all surveyed on the 16-inch scale with contours at 5 feet vertical intervals. The bazars were surveyed on the 64-inch scale and were not contoured. They were connected with trigonometrically fixed stations which were in all cases adopted as the stations of origin. Vertical angles were observed at all stations of the traversing and the contouring was based on the heights obtained therefrom. The traverse stations were marked with rough stones or bricks.

The average daily outturn per surveyor was 11 stations and 74 chains of traversing; 15·25 acres of 16-inch detail survey and 1·91 acres on the 64-inch scale. This does not include contouring, of which the average daily outturn was 22·58 acres.

The only fair maps drawn this season were those of the bazars of Secunderabad and Bolaram which were surveyed the previous season on the scale of 105·6-inches to the mile; 122 sheets were drawn and 81 submitted for publication.

The maps of the cantonments of Jubbulpore, Pachmarhi and Cannanore which were all surveyed by this section in former seasons were published, and also those of 25 out of the 49 bazars of Secunderabad.

TRAINING SECTION.

Mr. Littlewood was placed in charge of this section which was formed for the purpose of giving a practical training in cadastral survey in the field to probationers of the Burma Land Records Department who had already gone through a preliminary course of instruction at Dehra Dun. The course lasted 12 months during which the pupils carried out some traversing, 16-inch cadastral survey and 64-inch town survey and the computations, mapping and area calculations connected therewith.

No. 11 PARTY.

Shan States.—The party commenced field work in the middle of November 1909 and returned to recess quarters in Maymyo in the middle of May 1910. It was divided into 3 camps under Lieutenant Baker and Messrs. Fielding and Dewar. Owing to the long distance to be traversed by road before the party reached its field of operations, field work was in progress for only 4½ months.

Captain R. H. Phillimore, R.E., in charge up to 16th May 1910.

Captain E. C. Baker, R.E., in charge from 17th May 1910.

Messrs. Jagdamba Prasad, C. S. Littlewood, S. S. M. Fielding, V. W. Morton, T. P. Dewar, A. A. Graham, J. G. D. Vander-Beek and H. St. J. Kenny.

Mr. Hayat Muhammad.

19 Surveyors and 2 Soldier-Surveyors and 2 pupils under training.

The programme of detail survey was completed. It was carried out on the 1-inch scale with contours at 100 feet vertical intervals except in a few places where the ground admitted of an interval of 50 feet. In the fair maps, however, contours are drawn with an interval of 50 feet, the intervening contours being interpolated at that stage.

The country surveyed in detail comprised part of the Shan States up to the frontier of China and the limits of the Wa States included in sheets 93 $\frac{I}{2, 6, 10, 11, 12, 14}$, 93 $\frac{J}{9, 10, 11, 12, 14, 15, 16}$, 93 $\frac{O}{1 \text{ and } 2}$, 93 $\frac{N}{3, 4}$. The survey of the Wa States is not contemplated at present and the limits up to which the survey was to be carried out were defined by the Local Government. The country consisted for the most part of bold rolling hills generally well wooded but not dense. Military police escorts were provided for the officer in charge of the party and those in charge of camps, but the inhabitants were friendly and hospitable and little difficulty was experienced in obtaining supplies except in Karenni and in the Manglum States where there was scarcity. The health of the party was good.

One surveyor was employed on special work in sheet 94 M in connection with the boundary between the Shan States and Siam. His outturn has not been included in this report as it was not supervised in any way, and falls into the area to be surveyed next season when it will be examined and reported on.

The area surveyed was mapped on the 1½-inch scale in 17 sheets of which 12 will be submitted for publication before the party leaves recess quarters and the remainder will be completed in the circle drawing office.

The triangulation computations were completed and 8 charts, 93 L, N, O, P, 94 M and 102 C, D, G, with their corresponding general report volumes, were completed. Material is available for two more charts, 93 J and 94 I, and these will be taken up next season.

No. 12 (LATE 20) PARTY.

Eastern Bengal and Assam.—Field work commenced early in November 1909 and closed about the middle of May 1910 giving a field season of just over six months. The recess quarters of the party were changed from Bangalore to Shillong, where the party arrived at the end of May 1910.

Major A. Mears, I.A., in charge.
Lieutenant G. F. T. Oakes, R.E.

Messrs. C. Ç. Byrne, Pramadaranjan Ray, J. H. Williams, Amjad Ali, L. Williams, and J. O'C. Fitzpatrick.

31 Surveyors, 3 Traversers and 2 Soldier-Surveyors under training, 2 Draftsmen and 2 Computers.

The small outturn of 1 and 2-inch original survey was partly due to the intricate nature of the ground and thick forest growth. Large areas of unsurveyed waste land affected the outturn of supplementary survey and an abnormal amount of sickness amongst the native establishment retarded the progress of every class of survey. The cost-rates are consequently very high this season, excepting that of the triangulation which is considerably less than that of last season when the rate was high owing to the small area triangulated.

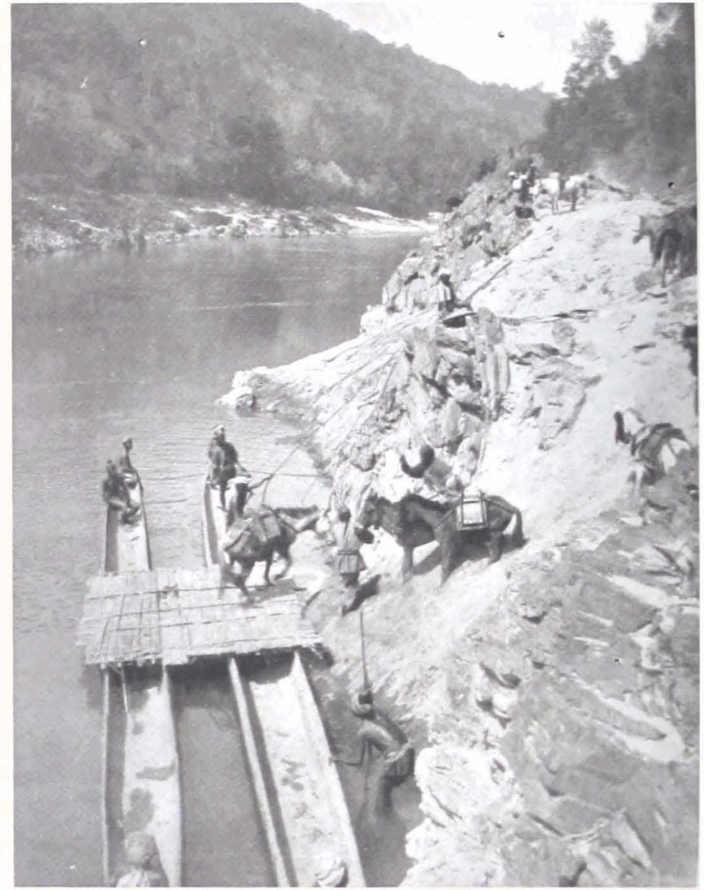
The triangulation this season lay in the Khasi and Jaintia hills and was based on the G. T. eastern frontier meridional series as revised in 1897-98 after the great earthquake of the former year, and on the Khasi hills secondary series of No. 15 party, observed during the season under report and previous season. The work was carried out under great difficulties. Coolies for transport purposes were obtained with much difficulty. During the latter part of November and early December a good deal of rain fell and from the middle of January to nearly the end of March dense haze was experienced. Lieutenant Oakes reports that at times it was not possible to distinguish signals at a distance of even 3 miles and consequently he was obliged to place his stations closer together than would have been necessary otherwise. From March till the latter part of May it rained incessantly, with terrific wind storms. The observers' theodolites were nearly blown over on more than one occasion and all their tents were damaged beyond repair. Under these conditions it is not surprising that the programme of triangulation was not completed. A small portion of the area had been triangulated in 1903-04 when a 4-inch survey of reserved forest was carried out and the Khasi hills secondary series mentioned above runs right across the sheet. Triangulation was also carried out in this sheet in 1863-65 and some of the stations were found and connected with the present work, and it is anticipated that it will be possible to utilize this old work to a certain extent.

The traversing was mainly confined to the flat country to the south of the Khasi and Jaintia hills and amounted to 270 linear miles. The theodolite stations were marked with wooden pegs, but in the open country at intervals of about a mile, 3 consecutive stations were marked with zinc cylinders over which mounds of earth were thrown.

With the exception of one sheet, the programme of detail survey was completed. Sheets $83\frac{D}{2, 3, 5, 6, 7, 9, 13}$ were surveyed on the 1-inch scale and $83\frac{D}{10, 11, 14, 15}$ on the 2-inch. These latter were partly surveyed last season and consisted mainly of reserved forests. Black reductions on bank-post paper of the areas for supplementary and revision survey were prepared on the 1-inch scale and the detail was transferred square by square to mounted and projected plane-tables. This method was considered more satisfactory than working direct on blue prints which are generally found to be slightly distorted. The area revised during this season was originally surveyed on the 2-inch scale in 1881-83 and little fault could be found with the accuracy of the old survey except for the contouring which had to be done *de novo*, and again this season the cadastral maps which came under supplementary survey were found to be excellent but were much interspersed with unsurveyed waste land.

The area under detail survey was of an extremely varied nature, embracing the open cultivated plains and tea garden lands of districts Sylhet and Cachar and the hilly forest-clad portions of these districts adjoining the Lushai Hills and Hill Tippera State. The plains of Sylhet and Cachar are for the most part open, cultivated and densely populated and it was found by no means easy to map the congested village sites on the 1-inch scale. In Hill Tippera and the Lushai Hills and the adjoining areas of districts Sylhet and Cachar the country was hilly and

Ta Loi-hseng (ferry).



Ta Kawng-et (ferry).

covered with the densest cane, bamboo and evergreen jungle and was very difficult to survey.

The entire area surveyed is being mapped on the 1½-inch scale for publication on the 1-inch. Owing to the ill-health of the establishment during the recess also, the progress of the mapping was not so good as could have been desired. Five sheets will be submitted for publication before the close of the recess season, and 6 sheets will be completed in the circle drawing office.

TOPOGRAPHICAL SURVEY.

Table showing outturns of detail survey on various scales.

Scale.	Class of survey.	Circle.	Party.	Locality.	Class of country.	OUTTURN. Total square miles.	OUTTURN. Average per man per month. Square miles.	Average number of fixings per square mile.
1-inch .	Survey .	N.	No. 3	Punjab . .	Flat, open and intersected with canals.	3,235	32·9	14
		N.	No. 4	Do. . .	Flat, open, partly desert.	1,762	46·5	14
		S.	No. 5	Central Provinces	Hilly and wooded .	1,763	18·0	12
		S.	No. 6	Bombay and Berar	Open, cultivated .	3,078	23·0	16
		S.	No. 7	Mysore, Coorg and Malabar.	Varied, mostly wooded.	876	26·0	16
		S.	No. 8	Madras (Nilgiris) and Travancore.	Varied . . .	2,396	18·0	18
		E.	No. 10	Northern Shan States.	Bold, lightly wooded hills.	3,305	33·2	6
		E.	No. 11	Do. do.	Bold, lightly wooded hills.	3,997	34·2	6
		E.	No. 12	Assam, Lushai Hills.	Partly cultivated, partly forest.	1,060	17·7	23
1-inch .	Re survey.	N.	No. 1	Punjab and Kashmir.	Varied, mostly flat and open.	5,100	31·8	7
		S.	No. 6	Bombay . .	Open, cultivated .	1,564	30·0	7
		S.	No. 7	Mysore . .	Open, undulating .	875	67·0	5
		E.	No. 10	Northern Shan States.	Bold, lightly wooded hills.	211	43·6	4
		E.	No. 12	Lushai Hills .	Varied . . .	322	25·4	23
1-inch .	Supplementary Survey.	S.	No. 8	Madras . .	Low-lying coast land.	190	30·0	8
		E.	No. 12	Sylhet and Cachar	Varied . . .	420	20·0	23
1½-inch	Survey .	S.	No. 5	Central Provinces	Hilly and wooded .	528	16·0	15
2-inch .	Do. .	N.	No. 4	Punjab . .	Hilly and broken .	1,552	17·0	28
		S.	No. 6	Bombay and Berar.	Hilly, dense forest .	78	5·0	50
		S.	No. 7	Mysore, Coorg and Malabar.	Do. do. .	413	8·0	56
		S.	No. 8	Madras (Nilgiris)	Hilly forest dense and open.	509	7·0	62
		E.	No. 12	Lushai Hills .	Dense forest . .	421	6·0	68
2-inch .	Re-survey.	S	No. 6	Berar . .	Forest . . .	262	11·0	28

NOTE.—In order to reduce expenditure the programmes and establishments of parties were cut down soon after the commencement of the field season. This has adversely affected the outturns.

TOPOGRAPHICAL SURVEY.

Table showing outturns of triangulation, traversing and levelling.

Circle.	Party.	Locality.	TRIANGULATION.															TRAVERSING.					LEVELLING.
			Instrument used: diameter in inches.	Area in square miles.	Square miles to each point, fixed.	Square miles to each height.	SECONDARY.			MINOR.			TERTIARY.			INTERSECTED POINTS.		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 mile.	Linear miles.
							Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Number of points fixed.	Linear error per mile in feet.						
N.	No. 3	Punjab	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	336
N.	No. 4	Punjab and United Provinces.	6	1,250	3·6	3·6	..	..	..	37	6·7	0·09	..	..	..	348	0·4	6,000	1,856	4,501	1·8	0·23	..
S.	No. 5	Central Provinces	7	1,832	153	153	10	7·0	0·1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
			6	2,278	..	..	..	..	..	..	..	..	48	7·0	0·4	*	*	..	..	..	..	..	..
S.	No. 6	Bombay and Berar.	6	5,032	..	..	..	..	..	*	*	*	*	*	*	*	*	..	788	3,762	9·0	1·5	..
S.	No. 7	Mysore	6	1,850	5·1	5·1	..	..	..	32	13·1	0·2	..	..	..	328	0·5	..	..	..	..	..	..
S.	No. 8	Madras	6	900	4·3	4·3	..	..	..	..	..	..	11	5·0	0·4	196	0·5	..	312	2,742	1·5	2·1	..
E.	No. 10	Northern Shan States.	6	4,415	9·2	9·7	..	..	..	31	5·6	0·2	8	11·0	0·2	277	0·6	..	63	3,242	1·2	1·2	..
E.	No. 11	Do. do.	6	3,050	6·3	6·5	..	..	..	24	7·7	0·1	8	13·0	0·3	454	0·4	..	..	..	..	..	..
E.	No. 12	Assam and Hill Tippera State.	6	2,005	6·8	7·0	..	..	..	52	10·9	0·2	..	..	..	234	0·5	..	271	1,048	5·5	2·6	..

* Figures not computed in time for insertion.

TOPOGRAPHICAL SURVEY.

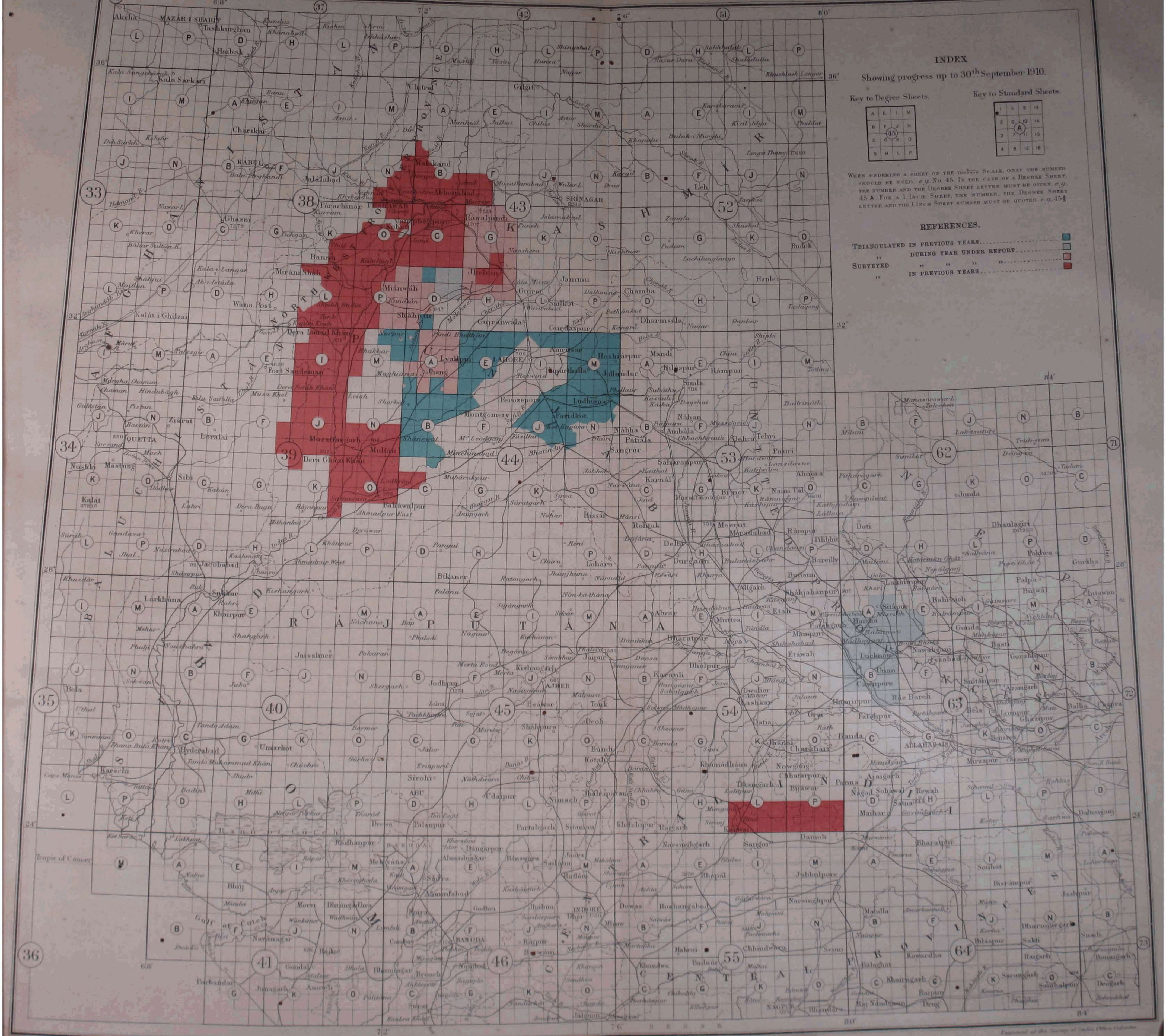
Abstract of costs and cost-rates.

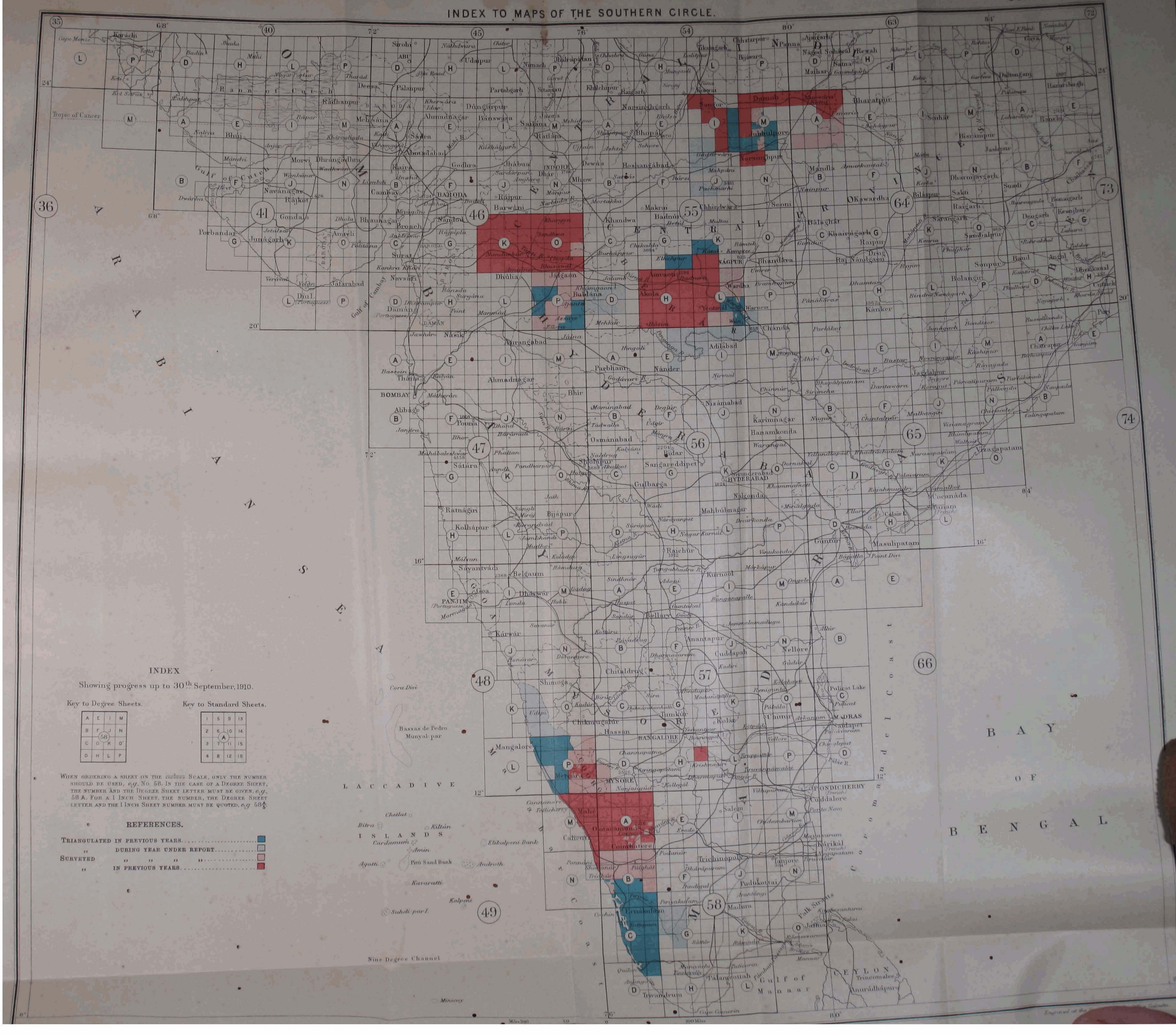
Circle.	Party.	Locality.	Class of country.	COST-RATES, RUPEES. Detail survey, per square mile. 1-inch survey.	1-inch re-survey.	1-inch supplementary survey.	1¼-inch survey.	2-inch survey.	2-inch re-survey.	Triangulation, per square mile. Secondary.	Minor and tertiary.	Traversing, per linear mile. Topographical.	Forest boundary.	Fair mapping per square mile.	Total survey outturns on all scales. Square miles.	Total cost of party.	Inclusive cost-rate per square mile.	Remarks.
																Rs.	Rs.	
N.	No. 1	Punjab . .	Varied, open . .	...	13·3	...	...	..	...	...	—	...	...	9·0	5,100	1,00,951	19·8	
N.	No. 3	Do. . .	Flat, open . .	13·9	—	—	—	—	...	...	—	—	...	8·6	3,235	76,928	23·8	
N.	No. 4	Do. . .	Do. . . .	5·6*	...	...	...	20·2*	...	...	3·8	13·9	...	—	3,314	98,964†	29·7	† Excluding Rs. 35,356 on local surveys.
S.	No. 5	Central Provinces	Hilly, wooded . .	19·8	...	...	18·0	...	...	3·7	8·1	..	..	12·8	2,291	91,086	39·8	
S.	No. 6	Bombay and Berar.	1-inch work open, cultivated. 2-inch forest, hilly.	15·2	14·6	...	...	75·7	44·4	—	7·6	...	22·1	6·5	4,982	1,74,999	35·1	
S.	No. 7	Mysore and Coorg	Varied, mostly wooded.	33·4	8·1	—	...	64·7	—	...	6·2	...	...	5·3	2,164	97,032	44·9	
S.	No. 8	Madras . .	Do. do. .	16·0	—	14·3	...	32·6	—	...	8·8	8·3	—	13·8	3,095	94,378	30·5	
E.	No. 10	Northern Shan States.	Bold, lightly wooded hills	25·2*	11·6*	...	—	—	—	—	7·1	—	—	—	3,516	1,33,860‡	38·1	‡ Excluding Rs. 43,131 on local surveys.
E.	No. 11	Do. do.	Do. do. .	22·5	—	—	...	—	—	—	9·1	...	—	4·8	3,997	1,41,726	35·5	
E.	No. 12	Assam . .	Hilly, with dense forest.	34·9*	29·3*	29·5*	..	94·8*	...	—	16·7	25·0	—	—	2,223	1,38,934	62·5	

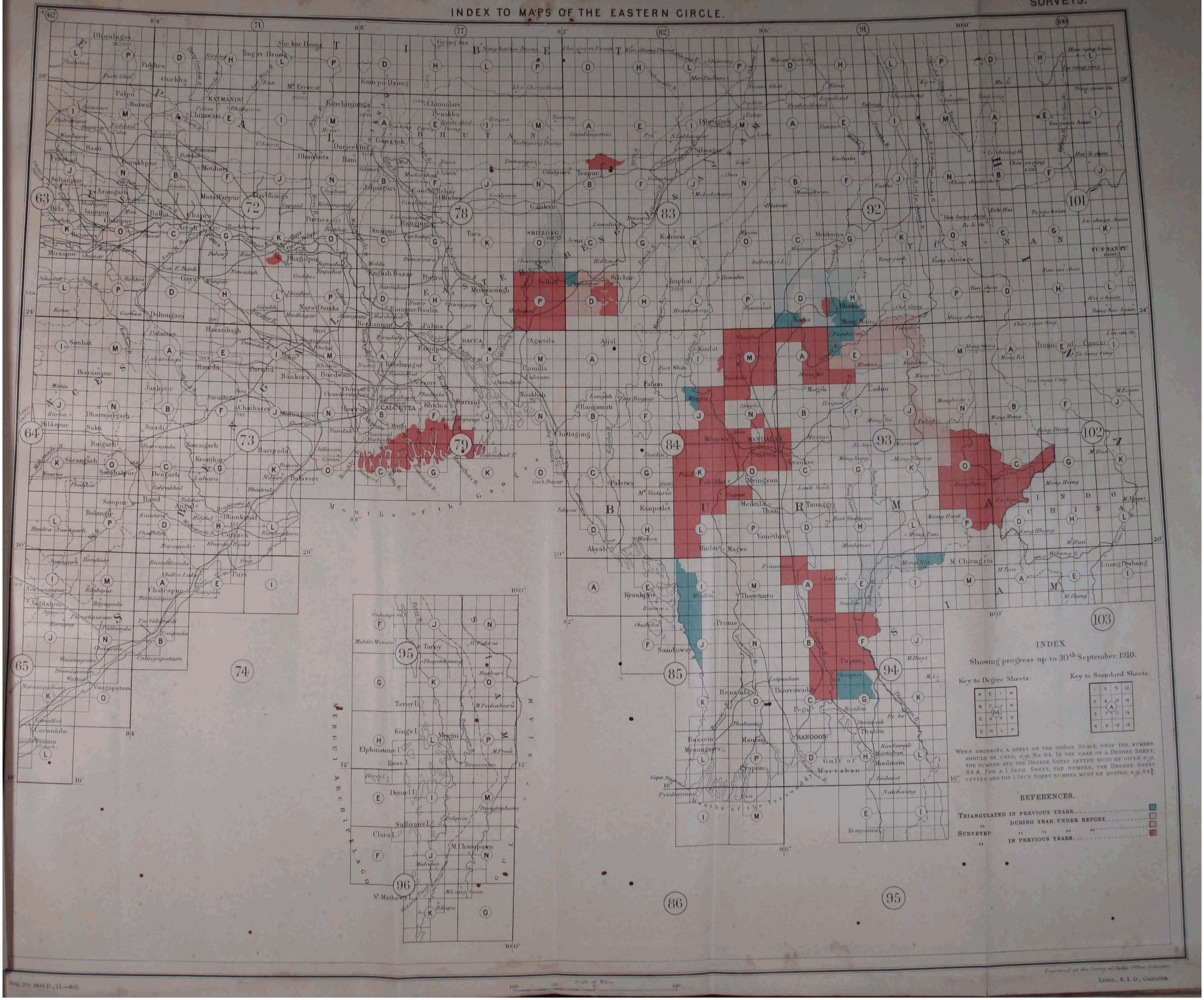
* Inclusive rate for survey and mapping.

NOTE.—In order to reduce expenditure programmes and establishments of parties were cut down soon after the commencement of the field season. This has adversely affected the cost-rates.

INDEX TO MAPS OF THE NORTHERN CIRCLE.




INDEX TO MAPS OF THE SOUTHERN CIRCLE.
INDEX
Showing progress up to 30th September, 1910.
Key to Degree Sheets.
Key to Standard Sheets.
When ordering a sheet on the 1/1000000 Scale, only the number should be used, e.g. No 58. In the case of a Degree Sheet, the number and the Degree Sheet letter must be given, e.g., 58 A. For a 1 Inch Sheet, the number, the Degree Sheet letter and the 1 Inch Sheet number must be quoted, e.g 58 A/5.
REFERENCES.
Triangulated in previous years
" during year under report
Surveyed " " " "
" in previous years
ARABIAN SEA
BAY OF BENGAL
LACCADIVE ISLANDS
Tropic of Cancer
BOMBAY
MADRAS
HYDERABAD
BANGALORE
MYSORE
NAGPUR
CEYLON
Gulf of Manaar
Palk Strait
Nine Degree Channel


INDEX TO MAPS OF THE EASTERN CIRCLE.
INDEX
Showing progress up to 30th September 1910.
Key to Degree Sheets.
Key to Standard Sheets.
When ordering a sheet on the 1/1000000 Scale, only the number should be used, e.g. No. 84. In the case of a Degree Sheet, the number and the Degree Sheet letter must be given, e.g. 84 A. For a 1 Inch Sheet, the number, the Degree Sheet letter and the 1 Inch Sheet number must be quoted, e.g. 84 A/5
REFERENCES.
Triangulated in previous years
" during year under report
Surveyed " " "
" in previous years
CALCUTTA
DACCA
SHILLONG
MANDALAY
RANGOON
KATMANDU
Mouths of the Ganges
Gulf of Martaban
MERGUI ARCHIPELAGO
Engraved at the Survey of India Offices, Calcutta.
Litho., S. I. O., Calcutta.

II.—Triangulation.

BY MAJOR H. H. TURNER, R.E.

No. 15 (late 24) Party.

(Vide Index maps, page 32.)

The work of the party during the past year included principal, secondary and tertiary triangulations.

PERSONNEL.

Captain C. M. Browne, D.S.O., R.E., in charge from 1st October to 8th November 1909.
Major H. H. Turner, R.E., in charge from 9th November 1909 to 30th September 1910.

Imperial Officers.

Mr. J. deGraaff Hunter, M.A.
Lieutenant E. B. Cardew, R.E.
Lieutenant F. J. M. King, R.E. (joined the party on 1st March 1910).
Lieutenant H. G. Bell, R.E. (joined the party on 23rd March 1910).
Lieutenant K. Mason, R.E. (joined the party on 15th March 1910).

Provincial Officers.

Mr. H. B. Simons (joined the party on 15th March 1910).
Mr. C. H. Tresham.
Mr. Abdul Hai.
Mr. V. D. B. Collins.
Mr. F. W. Smith.
Mr. G. A. Norman.
Mr. B. T. Wyatt.
Mr. Abdul Karim.
Mr. K. S. Gopalachari.
Mr. Mohan Lall Arora (left the Department on 15th September 1910).

New Provincial Service.

Mr. V. P. Wainright.
Mr. C. S. McInnes.

PRINCIPAL TRIANGULATION.

Work was carried out during the year on three separate series.

1. The North Baluchistan Series emanating from the sides Zawa-Zibra of the Kalat Longitudinal Series was extended by Mr. Tresham through the whole length of Northern Baluchistan and closed on the side Tounsa-Langawala of the Great Indus Series.

2. The Kashmir Series emanating from the side Nerh-Khagriana of the North-West Himalaya Series was continued by Mr. J. deGraaff Hunter to latitude 34° 50′.

3. The Upper Irrawaddy Series is a new series started by Lieutenant Cardew from the side Tangte-Lakar Bum of the Great Salween Series.

The North Baluchistan Series.

Mr. Tresham left Mussoorie on the 19th August 1909 for Chaman where he assembled his field party. Having arranged for the posting of his lamp-squads he himself marched for Narishela arriving there on the 4th September 1909.

In 1908 Lieutenant Oakes carried the series from its base in a northerly direction up to latitude 30° 30′ and observed the forward angles of the pentagon which is the north-west corner figure of the series. Mr. Tresham completed this figure and by the end of December 1909 had extended the series in an easterly direction by means of a tetragon and quadrilateral to meridian 68° 30′. As there was some difficulty about escorts and the weather was unpropitious for the continuation of the work in the higher hills, Mr. Tresham changed his base of operations to the extreme east of the series, and commenced to work westward from the side Tounsa-Langawala of the Great Indus Series, on which it had been decided to close the series. By the end of April he had observed the four quadrilaterals required to close on his western work and thereby completed the series.

In addition to his triangulation work, he observed 3 astronomical azimuths at Gandak, Saleghar and Tounsa.

The instrument used throughout the observations was No. II 12″ micrometer theodolite.

The detachment arrived at Khanai on the 9th May 1910 where the field establishment was broken up and Mr. Tresham returned to Mussoorie for recess, arriving there on the 19th May.

The completion of this series closes the circuit which, starting from the base Gandpahar-Kharko of the Great Indus Series, includes 130 miles of the Kalat

KOLAHOI NORTH PEAK (Gwashbrari.)

Height 17,830 feet, λ. 34°.9′.55″, L. 75°.19′.42″.

From a negative taken by Lieut. K. Mason, R.E., on 29th June 1910.

Photo-Engraved & printed at the Offices of the Survey of India, Calcutta, 1911.

Longitudinal Series, the whole length 340 miles of the North Baluchistan Series and 340 miles of the Great Indus Series.

The closing errors on the side Tounsa-Langawala are as follows :—

	Value from Great Indus Series.	Value from North Baluchistan Series.	Error.
Side Tounsa-Langawala .	62,321·8 ft.	62,323·0 ft.	1·2 ft.
Latitude of Tounsa . .	30° 41′ 51″ ·59	30° 41′ 51″ ·63	0″·04
Latitude of Langawala . .	30° 51′ 26″ ·93	30° 51′ 26″ ·98	0″·05
Longitude of Tounsa . .	70° 41′ 27″ ·31	70° 41′ 27″ ·55	0″·24
Longitude of Langawala . .	70° 45′ 45″ ·07	70° 45′ 45″ ·32	0″·25
Azimuth at Tounsa of Langawala.	201° 07′ 42″ ·87	201° 07′ 45″ ·89	3″·02
Height of Tounsa . . .	593 ft.	580·5 ft.	12·5 ft.
Height of Langawala . .	500 ft.	484 ft.	16 ft.

The large error in height is probably due to the long rays employed on the Kalat and North Baluchistan Series.

The probable error by the formula $E=\frac{2}{3}\sqrt{\frac{\epsilon\,\Delta^2}{3\,N}}$ gives $E=0''{\cdot}15$ for the North Baluchistan Series, an accuracy exceeding that of the Kalat Longitudinal Series.

The country through which the series passes was in a somewhat unsettled condition, necessitating large military escorts on many of the hills. In order to obviate the necessity of asking the military authorities to provide these escorts for a second season, it was determined to attempt the completion of the series this year.

In order that this might be accomplished Mr. Tresham had to remain in the field for a period of nine months. Eight months of this was spent in continuous observation work ; this in principal work entails a very severe strain on an observer. In spite of this Mr. Tresham's work throughout the season is of the highest quality, as is attested by the results given in the table below.

The following statement gives a summary of the season's work :—

Number of principal stations observed	17
,, ,, ,, newly fixed	15
,, ,, ,, ,, built	5
Length of triangulation completed in miles	261
Area of triangulation in miles	6,580
Average triangular error of 24 triangles	0·303
Values of astronomical geodetic azimuths at Gandak . .	+0·06
,, ,, ,, Saleghar . .	+1·08
,, ,, ,, Tounsa . . .	+11·65

The health of the detachment throughout the season's work was good.

Kashmir Principal Series.

In last year's annual report mention was made of the commencement of this series, but no detail of the year's work was given. It is proposed to include in this report a description of the work from April 1909 to September 1910.

Season 1909.—The detachment assembled at Rawalpindi under Lieutenant Cardew at the end of April 1909, Mr. Hunter joining a few days later.

The base originally chosen was the side Nerh-Khagriana of the North-West Himalaya Series. The decision to commence the series having been arrived at somewhat suddenly no advance reconnaissance had been made. After observations had been commenced it was found impossible to build up any other figure than a single triangle on the base selected. This being an unsatisfactory method of starting a new series, it was decided to form a pentagon by including two more stations of the North-West Himalaya Series, Nerh becoming the central station of the pentagon. As the builders and lampmen had already gone on in advance this connection had to be left over till season 1910.

After assisting in the observations at the first station, Lieutenant Cardew handed over charge of the detachment to Mr. Hunter.

Observations were taken by Mr. Hunter in May and June at Nerh-Khagriana and Mianjani, but on reaching his fourth station Kafir-Khan on July 5th the monsoon had already set in and the detachment marched to recess quarters at Gandabal.

The advance parties under Messrs. Wainright and McInnes after rebuilding the stations on Kaj Nag, Ismail di Dori, Marinag and Manganwar were likewise obliged by inclement weather to retire to recess quarters.

Mr. Wyatt, to whom had been allotted the work of repairing the stations of Montgomerie's Old Series, was able to carry on his work continuously throughout the rainy season. He rebuilt in all eight stations, returning to India early in September.

A start to resume work was made from Gandabal on the 27th August; owing however to continuous heavy rain the station of Gharital was not reached till the 15th September. It was then found that it was not suitable and a new station had to be selected and built on Kakwa ka Pahar. Observations were taken at this station and at Kafir Khan. Ismail di Dori was reached on the 24th October, but the weather conditions had then become so bad that work had to be closed.

In the meantime advance stations had been built at Chotiwala and Gunga (this latter has since been rejected) and Mr. McInnes crossed over the Barai Pass, but before he could select a station on the far side bad weather set in and he was forced to return.

The detachment returned to Dehra Dun on the 18th November 1909.

The instrument used by Mr. Hunter was No. IV 12″ micrometer theodolite.

The health of the detachment throughout the season was good.

Season 1910.—The detachment assembled at Rawalpindi in the middle of March 1910.

The work of completing the observation for the initial pentagon of the series was first undertaken. For this purpose the stations of Nerh, Kandi and Gangachoti had to be visited.

At the forward hills beyond Gangachoti great difficulty was experienced by the lamp-squads in reaching the stations. The altitudes were from 12,000 to 16,000 feet and the snow at this early period of the year was a serious obstacle.

Observations were finally concluded at Gangachoti on the 20th May.

The station of Kakwa ka Pahar and Chotiwala were then visited but only back angles could be observed from the latter before the end of June, when severe thunder storms announced the approach of the monsoon and preparations were made to retire into recess quarters at Nagmarg. This place was selected as being free from cholera, an epidemic of which had just broken out in Kashmir.

The following new stations had been built up to the end of August: Zinghi Chish, 14,000 feet; Yasho Chish, 16,218 feet; Liowi, 17,430 feet; Chamuri, 15,340 feet; Choki, 13,400 feet. The last is situated just north of Gilgit and will probably be the most northerly station of the series, and for the present of the Indian Survey.

If Mr. Hunter's programme for September can be carried out by the end of this season three figures of the series will have been completed giving a total length of triangulation of 90 miles and covering an area of 1,600 square miles.

An astronomical azimuth was observed at Gangachoti.

Throughout the season's work Mr. Hunter has used the new No. V 12″ micrometer theodolite.

The horizontal limb of this instrument is read by three micrometer microscopes as against two of the other instruments of this type possessed by the Survey of India. The results obtained by the instrument are good, but the great advantage obtained is that less observation work is entailed, since a change of face is also a change of zero. The actual accuracy of the new instrument as compared with the old ones cannot well be given as the conditions of the work in Kashmir differ largely from those ordinarily obtaining. The observations are taken to and from hills covered with snow and the strain on the observer at heights of 14,000 and 16,000 feet is far greater than on hills less than 10,000 feet.

Owing to the difficulty of transporting the 12″ theodolite to the tops of some of the higher hills the 8″ micrometer theodolite may have to be used on some of the highest stations selected.

In addition to his triangulation work Mr. Hunter carried out a series of comparisons to see the relative height measuring values of the following instruments:—

Mercury barometers.
Aneroid barometers.
Hypsometers.

The results proved that the aneroid barometers differed greatly from one another and from the mercury barometers. The mercury barometers so long as both were intact gave sensibly the same readings, but the deduced heights were too small. The hypsometers invariably gave a height considerably in excess of that obtained by triangulation. At 16,000 feet the excess was as much as 600 feet.

Further details of the comparisons are given in the following table.

Table of meteorological observations.

Stations.	Triangulated height.	Mercury barometers reduced to 62° F.						Aneroid barometers.							Thermometers; Boiling point.			Radio-meter.		Temperature range.			Remarks.
		Hicks 1577.	Number of readings.	Range.	Carey 58.	Number of readings.	Range.	Hicks 5428.	Number of readings.	Range.	Hicks 5502.	Number of readings.	Range.	Height.	Temperature.	Air temperature.	Calculated height.	Temperature.	Air temperature.	Maximum.	Minimum.	No. of readings.	
Nerh . . .	6,076	24"·06	3	·07"	24"·00	3	·01"	23"·87	3	·08"	23"·75	3	·09"	..	201°·05	46°·9	6,119	..	..	55°	43°	..	
Kandi . .	4,375	25"·14	2	0	24"·96	2	·09"	25"·45	2	·04"	25"·56	2	·04"	..	Not taken					87°	64°	..	
Gangachoti .	9,990·7	20"·89	16	·16"	20"·83	16	·12"	20"·46	4	·03"	20"·77	15	·33"	..	194°·22	57°·7	10,339	133°·0	55°·5	62°·5	34°·0	..	
Kakwa ka Pahar	12,985·5	18"·69	3	·05"	18"·69	3	·01"	17"·92	3	·05"	19"·00	3	·19"	12,670*	189°·11	57°·0	13,510	Not taken owing to mist.		58°·2	38°·2	..	
Chotiwala . .	16,120 Appr.	16"·59	6	·21"	Broken	..	..	15"·60	6	·28"	16"·88	6	·55"	15,910*	183°·75	49°·5	16,747	134°	62°·5	65°·5	24°·0	..	

N.B.—1. Heights marked thus * are deduced from simultaneous observations taken at Baramulla.
2. Radiometer—only maximum readings obtained given.
3. Range of temperature—only maximum and minimum readings obtained given.

The following statement gives a summary of triangulation for seasons 1909-10 and 1910-11 :—

Number of principal stations observed at	9
,, ,, ,, newly fixed	7
,, ,, ,, ,, built	11
Length of triangulation completed in miles	90
Area of triangulation in square miles	1,600
Average triangular error of seven triangles	0″·591
Values of astronomical geodetic azimuth	—13″·72

Mr. Abdul Hai has been employed during season 1910 in repairing stations of Montgomerie's Series. By August he had visited and repaired 7 stations between Haramukh and Skardu. From Skardu he has gone up the Indus valley to visit stations from which it is hoped a base will be obtainable to take observations next season to Teram Kangri, the high peak situated at the head of the Siachen glacier discovered by Dr. Longstaff during his explorations in 1909. Dr. Longstaff believes this peak to be one of the highest of the Himalaya and it is very desirable to obtain an accurate record of its height.

Upper Irrawaddy Series.

This series is a new series based on the side Tangte-Lakar Bum of the Great Salween Series.

As the topographical work was about to commence in the district round Bhamo, it was thought preferable to commence this series, so that the stations might be utilised, rather than continue the Great Salween Series. The series runs northward from its base following the Burma frontier as far as latitude 26°; it will then bend westward and follow the northern frontier to meridian 96° when a connection will be made with the Mandalay Meridional Series by an extension of this latter to latitude 26°. It is hoped that it will be possible to extend the new series later to meet the Assam Valley Series and form a second connection with the India triangulation, the other connection having been made in season 1898-99 by means of the Manipur Longitudinal Series.

The detachment under Lieutenant Cardew reached Bhamo on the 9th November 1909 and field work commenced on the 20th of that month.

Lieutenant Cardew completed two quadrilaterals but was prevented by haze from observing the last ray of the third quadrilateral, though forward rays of the fourth figure were obtained from one station.

An astronomical azimuth was observed at Kumtung Bum.

Mr. Norman and Mr. Abdul Karim were employed throughout the season in selecting and building advance stations.

The field season was closed at Myitkina on the 13th March 1910, and the detachment left for India on the 28th March.

The following statement gives a summary of the season's work :—

Number of principal stations observed at	9
,, ,, ,, newly fixed	4
,, ,, ,, ,, ,, provisionally . .	3
,, secondary ,, ,, ,, ,, ...	3
Length of triangulation completed in miles	112
Area of triangulation in square miles	2,900
Average triangular error of eight triangles	0″·381
Value of astronomical geodetic azimuth	–6″·68

The health of the detachment was good throughout the season.

SECONDARY TRIANGULATION.

Up to the present time no regular programme for secondary triangulation has ever been prepared. In former years, when necessity arose, a series was run either by a member of the topographical or of the trigonometrical branch according as the one or the other had an observer available. If undertaken by the former, permanent stations were not built and much good work has thus been lost. It is proposed in future to carry out a regular scheme of secondary triangulation which will break up the gaps between the principal triangulation, giving permanent points which, besides being available for present work, will be preserved in the same manner as principal stations for the use of posterity.

The form of pillar selected for these stations is square to distinguish it from the round pillar used for principal work. The length of the sides of the triangles is limited to 10 miles ; this, however, will probably with advantage be altered to 15 or even to 20 miles.

The work has so far been executed with 8″ micrometer theodolites, but 6″ would probably give sufficient accuracy.

The signals observed vary with the nature of the country ; where thick haze predominates, it is necessary to resort to luminous signals, but with clear weather work of a high order can be done to non-luminous signals.

The advantage of the latter is that they need no signaller to be kept on the station, and expenditure is considerably reduced. To obtain the full benefit of this, however, it is necessary to arrange to fix up the signal so that there is no possibility of its losing its centering or perpendicularity. The best method of securing this would seem to be to have a central hollow core to the pillar ; the signal post could be fixed firmly in this and be stayed up by ropes or a wooden framework in addition. As the hollow core would not exceed 4 inches in diameter and would be flush with the top of the pillar, the station could be used either for luminous or non-luminous signals. The only objection would be that there would be no actual top mark ; if, however, sufficient care is bestowed on building in the core, its axis should be a straight line joining the actual mark with an imaginary point vertically above it. This imaginary point could always be found by taking the centre point of the circle or square forming the top of the core.

Two secondary series, the Mawkmai and the Khasi Hills, were commenced during the season under review ; these were selected as topographical operations were about to commence in these districts.

The Mawkmai Series.

The Mawkmai Series is based on the side Letpathaung-Suletaung of the Mandalay Principal Meridional Series. It runs eastward along parallel 19°·30′ until it reaches the Siamese boundary, which it then follows until it meets the side Loi Pakhan-Loi Tum of the Monghsat Secondary Series about the meridian 99° 30′.

Mr. Collins who had built the stations of the series up to the meridian of 98° in 1908-09 was in charge of the detachment; he was assisted by Mr. Mohan Lal Arora and Mr. Gopalachari.

The detachment arrived at Pyinmana early in November 1909; but owing to the wet weather commencement of the work was delayed until the 11th of that month.

Mr. Mohan Lal Arora took up the work of selection and building stations from the point where it ceased the preceding season. He completed this work and observed at three stations at the eastern end of the series.

Mr. Gopalachari joined the detachment on the 9th December and observed at 14 stations of the west end of the series.

Mr. Collins after instructing Mr. Gopalachari in his work proceeded to the middle of the series and worked eastward, finally joining up with the Monghsat Series on the side Loi Putpakka-Loi Kan Mong, to enable his work to be based on this series, so that the data thus obtained could be utilised for topographical work.

Next season the gap between Mr. Gopalachari's and Mr. Collins' work will be filled in and the series extended to the side Loi Pakhan-Loi Tum of the Monghsat Series.

8″ micrometer theodolites were used by all the observers.

Luminous signals were used for the base stations; at all other stations non-luminous signals were employed.

The outturn during the season is as follows :—

Number of new stations built	16
,, stations observed at	31
,, ,, fixed	36
Length of triangulation completed in miles	140
Area of triangulation completed in miles	1,810
Average triangular error of 25 triangles	1″·59

The series when completed will be 200 miles in length.

The health of the detachment was good throughout the season.

The Khasi-Jaintia Hill Series.

This series was initiated in order to give data for the topographical operations now being carried on in this district.

Unfortunately the series was based on a side of the Eastern Frontier Principal Series, the stations of which are known to have been seriously disturbed by the earthquake of 1897. The series will be run through the Garo Hills during the coming field season to meet the Brahmaputra Meridional Series on a side of which it will be finally based. Until this is done the data computed are only provisional.

Mr. Smith, who was in charge, assembled his detachment at Shillong on the 8th November 1909; preliminary arrangements necessitated a halt there till the 27th November.

Mr. Smith then proceeded westward erecting signals on the stations built the preceding season. He commenced observations at his most westerly stations on the 27th December. On the 23rd April 1910 he closed work on the side Landau Modo-Mautherrichan of the Eastern Frontier Series. A very dense haze was experienced throughout the progress of the work, and Mr. Smith found that observing to non-luminous signals was impossible; these had therefore to be replaced by luminous signals.

Mr. Wyatt was employed in selecting and building stations for the extension of the series eastwards between the parallels of 25° 30′ and 26° starting from the base Laidera-Dinghei of the Eastern Frontier Series.

Mr. Smith used an 8″ micrometer theodolite for his observations.

The following is the outturn of the season's work :—

Stations observed at	12
,, newly fixed	10
,, ,, built	24
Length of triangulation completed in miles	41
Area of triangulation in square miles	400
Average triangular error of 10 completed triangles	3″·17

TERTIARY TRIANGULATION.

The topographical survey of Kashmir carried out in the years 1855 to 1863 was on the $\frac{1}{2}$-inch scale; for the purposes of that survey a good main secondary series of triangulation was run having minor series branching from it. The stations appertaining to these series are for the most part still in existence and can be utilised for the present survey.

The present survey except in the high mountainous districts is to be on the 1-inch scale, and the points of the old tertiary triangulation, even if in existence, are not numerous enough for the larger scale.

The tertiary triangulation had therefore to be taken in hand *de novo*, and for this purpose Lieutenant King, R.E., with Mr. Simons and Lieutenant Mason, R.E., as assistants, was detailed to start triangulating in sheets 43 $\frac{F}{11, 12, 15, 16}$, 43 J and 43 $\frac{N}{3, 4, 7, 8}$.

Lieutenant King assembled his detachment at Rawalpindi on the 15th March 1910.

Mr. Simons took up the work in 43 F.

Lieutenant King started reconnoitring in 43 $\frac{J}{12, 16}$ and 43 $\frac{N}{3, 4}$ keeping Lieutenant Mason with him for instructional purposes.

At the end of August the triangulation in the following sheets had been completed:—

43 $\frac{F}{11, 12, 15, 16}$

43 $\frac{J}{4}$ and portions of 43 $\frac{J}{3, 7}$

43 $\frac{J}{8, 12, 16}$ have also been reconnoitred.

Lieutenant King and Mr. Simons closed their field season in the middle of September owing to the prevalence of cholera.

During the recess season all the detachments have been employed on the computations of their field work; these have all been completed.

In addition Lieutenant Cardew has been employed in checking and continuing the computations of Captain Wood's Tibet triangulation in order to add to the number of fixed peaks in that country. No additions could be made in the eastern portion of the work, but several new peaks have been located in the west.

III.—Levelling.

BY MR. C. F. ERSKINE.

No. 17 Party (Triangulation and Levelling).

Up to the end of February 1910 the levelling operations formed part of the work of No. 25 Party (Tidal and Levelling), and the strength of the levelling detachments was included in the personnel of that party. From March 1st 1910 the Tidal and Levelling Sections were separated, and a new party, designated No. 17 Party (Triangulation and Levelling), was created, of which the levelling Sections of the late No. 25 Party formed the nucleus.

Imperial Officers.

Mr. C. F. Erskine, in charge up to February 28th, 1910.

Major J. M. Burr, R.E., in charge from March 1st, 1910.

Provincial Officers.

Messrs. E. H. Corridon, A. M. Talati, O. N. Pushong, D. H. Luxa, T. F. Kitchen, H. St. J. Kenny and O. D. Jackson.

Upper Subordinate Officers.

Messrs. Karuna Kumar Das and Bidhu Bhushan Shome.

Subordinate Establishment.

9 Recorders.

The personnel of the party during the year under report was as shown in the margin.

Strength of levelling detachments.—During the year under report three levelling detachments were engaged on spirit-levelling operations. The strength of these detachments in the field was as detailed below.

No. 1 Detachment.—Mr. E. H. Corridon 1st leveller, Mr. H. St. J. Kenny 2nd leveller, Mr. Bidhu Bhushan Shome under training.

No. 2 Detachment.—Mr. O. N. Pushong 1st leveller, Mr. T. F. Kitchen 2nd leveller; Mr. D. H. Luxa joined this detachment in February 1910 on completion of the erection of rock-cut bench-marks on the Himalayan lines.

No. 3 Detachment.—Mr. A. M. Talati 1st leveller, Mr. O. D. Jackson 2nd leveller, Mr. Karuna Kumar Das under training. Mr. D. H. Luxa also worked with this detachment up to November 24th, 1909, and after that date he was deputed to lay down rock-cut bench-marks on the Himalayan lines in advance of levelling operations.

Programme for past field season.—The following programme of work was allotted to the detachments :—

No. 1 Detachment—

(*i*) New levelling from Wuntho to Myitkyina.

(*ii*) Revision levelling from Rangoon to Pyinmana.

(*iii*) The connection of the standard bench-marks at Rangoon, Pegu, Toungoo, Mandalay, Shwebo, Meiktila, Magwe, Wuntho and Myitkyina, with the adjacent lines of levels.

No. 2 Detachment—

(*i*) Levelling from Hardwar along the railway line to Kotdwara, and thence along the road to Lansdowne.

(*ii*) Levelling from Bareilly along the railway line to Kathgodam, and thence along the road to Naini Tal (Brewery).

(*iii*) Levelling from Ambala along the railway line to Kalka, and thence by the cart road to Solon.

(*iv*) Levelling from Siliguri to Tindharia by road.

(*v*) The connection of the standard bench-marks at Lucknow, Patna (Bankipur), Muzaffarpur, Motihari, Bhagalpur, Purneah, Dinajpur, Gauhati, Dhubri, Burdwan, Balasore, Cuttack, Berhampur (Madras), Vizagapatam, Coconada, Bezwada, Nellore and Rewah, with the adjacent lines of levels.

Subsequently the connection of the new standard bench-mark at Calcutta was added to the above programme, and the levelling from Ambala to Solon, and the connection of the standard bench-marks at Gauhati and Dhubri were postponed until next field season.

No. 3 Detachment—

(*i*) The connection of the standard bench-marks at Sadikganj, Bahawalpur, Khanpur, Sukkur, Karachi, Jacobabad, Hyderabad (Sind), Rajkot, Godhra, Baroda, Surat, Dhulia, Mhow and Bhopal (2), with the adjacent lines of levels.

(*ii*) Levelling from Shikarpur to Jacobabad, including the connection of the standard bench-mark at the latter town.

(*iii*) Levelling from Pali h. s. to Godhra, including the connection of the standard bench-mark at the latter town.

(*iv*) Levelling from Laluwali G. T. Survey Station to Khanpur, and thence to Rohri along the railway line.

(*v*) Levelling from Lahore along the railway line to Pathankot, and thence along the cart road *viâ* Dharmsala to Dharmkot.

No. 1 LEVELLING DETACHMENT.

Tabular statement of outturn of work.—Season 1909-10.

Section.	Month.	Number of miles of double levelling: Main Line (Ms. chs. lks.)	Branch Line (Ms. chs. lks.)	Total (Ms. chs. lks.)	Total number of feet: Rise.	Fall.	Number of stations at which instrument was set up.	Bench-marks connected: Primary: Rock-cut.	Interred.	Engraved.	Standard.	Principal stations of triangulation.	Secondary: Embedded.	Inscribed.	Metal bolts.	Secondary stations of triangulation.	Revenue survey stations.	Railway.	P. W. D.	Marine Survey.	Old: Embedded.	Old: Inscribed.
Rangoon to Pyinmana	November 1909	51 16 74	16 49 70	67 66 44	193·073	178·104	762	..	..	..	2*	..	1	29	..	..	..	1	7	...	8	34
	December "	83 65 14	2 29 04	86 14 18	366·991	254·173	970	..	..	..	..	..	..	63	..	..	..	1	..	..	9	20
	January 1910	71 07 32	10 20 68	81 28 00	375·236	297·448	985	..	..	..	..	2	..	54	..	..	..	4	1	..	9	32
	February "	17 54 60	1 26 08	19 00 68	183·494	100·343	230	..	..	..	..	..	..	9	..	1	..	1	..	..	2	4
	TOTAL	223 63 80	30 45 50	254 29 30	1,118·794	830·068	2,947	..	..	..	2	2	1	155	..	1	..	7	8	..	28	90
Connection of standard bench-marks at Mandalay and Shwebo.	February 1910	... .	14 17 26	14 17 26	..	..	136	1	..	..	2	..	..	6	..	..	..	..	..	..	3	8
Wuntho to Myitkyina	February 1910	32 63 80	0 49 08	33 32 88	184·369	508·567	407	2	..	..	..	..	4	22	..	..	...	1	..	...	1	2
	March "	87 78 88	1 43 60	89 42 48	1,128·832	911·646	964	..	..	..	...	..	11	48	..	1	...	..	...	...	...	..
	April "	56 17 56	13 51 34	69 68 90	345·026	436·111	986	2	..	..	2	1	6	27	..	..	..	..	..	..	...	..
	TOTAL	177 00 24	15 64 02	192 64 26	1,658·227	1,856·324	2,357	4	..	..	2	1	21	97	..	1	..	1	...	...	1	2
Connection of standard bench-marks at Magwe, Meiktila, Toungoo and Rangoon.	May 1910	.. ..	3 35 84	3 35 84	...	..	65	..	..	..	4	..	..	...	...	..	...	...	...	..	4	2
	GRAND TOTAL	399 21 02	65 45 64	464 66 66	2,777·021	2,686·392	5,505	5	..	...	10	3	22	258	...	2	..	8	8	..	36	102

* One old.

No. 2 LEVELLING DETACHMENT.

Tabular statement of outturn of work.—Season 1909-10.

Section.	Month.	Number of miles of double levelling: Main Line (Ms. chs. lks.)	Branch Line (Ms. chs. lks.)	Total (Ms. chs. lks.)	Total number of feet: Rise.	Fall.	Number of stations at which instrument was set up.	Primary: Rock-cut.	Interred.	Engraved.	Standard.	G. T. Survey principal	Secondary: Embedded.	Inscribed.	Rock-cut.	G. T. Survey secondary.	P. W. D. and Irrigation.	Marine.	Railway.	Remarks.
Hardwar to Lansdowne.	October 1909	21 02 20	0 75 04	21 77 06	35·473	253·704	245	..	..	..	..	..	1	18+3*	..	..	..	..	..	* Old.
	November „	53 32 60	6 09 77	59 42 37	2,967·229	275·149	883	..	..	..	..	1	3	30	12	..	..	..	..	
	December „	10 64 78	0 65 34	11 50 12	2,467·897	62·018	395	1	..	..	..	..	..	2	14	..	..	..	..	
	TOTAL	85 19 40	7 70 15	93 09 55	5,470·599	590·871	1,523	1	..	..	..	1	4	50+3*	26	..	..	..	..	* Old.
Bareilly to Naini Tal (Brewery).	December 1909	48 13 88	1 62 78	49 76 66	401·379	230·798	534	..	..	..	1*	..	4	41+4*	..	..	1	..	..	* Old.
	January 1910	29 70 74	6 61 62	36 52 36	4,028·684	277·009	783	..	..	..	..	1	2	21	12	..	1	..	..	
	TOTAL	78 04 62	8 44 40	86 49 02	4,430·063	507·807	1,317	..	..	..	1*	1	6	62+4*	12	..	2	..	..	* Old.
Connection of G. T. Survey standard bench-marks.	January 1910	.. .. ..	7 65 44	7 65 44	..	..	102	..	..	..	2	..	1*	4+4*	..	..	..	..	1	* Old.
	February „	.. .. ..	19 66 42	19 66 42	..	..	258	..	1*	1+2*	6	2*	2*	13+14*	..	..	1	..	..	* Old.
	TOTAL	.. .. ..	27 51 86	27 51 86	..	..	360	..	1*	1+2*	8	2*	3*	17+18*	..	..	1	..	1	* Old.
Siliguri to Tindharia.	February 1910	18 29 40	1 32 26	19 61 66	2,440·100	16·262	444	1	..	..	..	..	1*	6+2*	7	..	..	..	2†	* Old. † Brass bolts.
Connection of G. T. Survey standard bench-marks.	March 1910	.. .. ..	62 09 78	62 09 78	..	..	714	..	..	..	4	1*	2*	16+31*	3	..	1	..	..	* Old.
	April „	.. .. ..	17 19 80	17 19 80	..	..	249	1	..	..	4	..	6*	22+12*	2	..	3+3*	1*	..	* Old.
	May „	.. .. ..	3 72 36	3 72 36	..	..	56	..	..	..	1	..	1*	1+2*	1	..	..	..	..	* Old.
	TOTAL	.. .. ..	83 21 94	83 21 94	..	..	1,019	1	..	..	9	1*	9*	39+45*	6	..	4+3*	1*	..	* Old.
	GRAND TOTAL	181 53 42	128 60 61	310 34 03	12,340·762	1,114·940	4,663	3	1*	1+2*	17+1*	2+3*	10+13*	174+72*	51	..	7+3*	1*	3	* Old.

No. 3 LEVELLING DETACHMENT.

Tabular statement of outturn of work.—Season 1909-10.

Section.	Month.	Number of miles of double levelling: Main Line (Ms. chs. lks.)	Number of miles of double levelling: Branch Line (Ms. chs. lks.)	Number of miles of double levelling: Total (Ms. chs. lks.)	Total number of feet: Rise.	Total number of feet: Fall.	Number of stations at which instrument was set up.	Bench-marks, Primary: Rock-cut.	Primary: Interred.	Primary: Engraved.	Primary: Standard.	Primary: G. T. Survey, principal.	Secondary, Old: Embedded.	Secondary, Old: Inscribed.	Secondary: Embedded.	Secondary: Inscribed.	Secondary: G. T. Survey, secondary.	Secondary: Railway.	Secondary: P. W. D.	Remarks.
Connection of Sadikgunj standard bench-mark.	October 1909	.. .. ..	18 65 34	18 65 34	41·045	38·306	269	..	..	..	1	2	..	..	..	5	..	..	2	
	November „	.. .. ..	14 09 58	14 09 58	92·646	108·285	194	..	..	..	..	1	2	..	..	1	..	..	2	
	TOTAL	.. .. ..	32 74 92	32 74 92	133·691	146·591	463	..	..	..	1	3	2	..	..	6	..	..	4	
Connection of Bahawalpur standard bench-mark.	November 1909	.. .. ..	19 27 84	19 27 84	69·855	55·511	235	..	..	..	1	1	1	..	..	14	..	1	1	
Laluwali G. T. S. to Rohri	November 1909	36 08 24	8 48 38	44 56 62	131·317	152·109	514	..	..	..	1	1	..	..	2	32	..	3	1	
	December „	81 48 26	24 70 49	106 38 75	227·036	283·429	1,064	..	1	..	..	5	..	..	7	59	..	3	5	
	January 1910	20 65 98	1 75 44	22 61 42	77·302	69·523	248	1	..	..	..	..	1	1	1	11	..	5	2	
	TOTAL	138 42 48	35 34 31	173 76 79	435·655	505·061	1,826	1	1	..	1	6	1	1	10	102	..	11	8	
Connection of Sukkur standard bench-mark.	January 1910	.. .. ..	4 45 94	4 45 94	74·804	56·895	67	2	..	..	1	..	1	5	..	..	..	..	..	
Connection of *Jacobabad* standard bench-mark.	January 1910	.. .. ..	30 02 10	30 02 10	94·376	105·178	292	..	..	1	1	1	1	6	2	18	..	..	1	
Connection of Karachi standard bench-mark.	January 1910	.. .. ..	13 53 88	13 53 88	67·659	19·665	190	4	..	2	1	2	..	7	..	7	1	..	..	
Connection of Hyderabad standard bench-mark.	January 1910	.. .. ..	5 62 30	5 62 30	42·377	13·577	86	2	..	..	1	..	2	3	..	9	..	..	..	
Connection of Rajkot standard bench-mark.	February 1910	.. .. ..	2 16 52	2 16 52	22·094	47·324	33	1	..	1	1	..	1	4	..	3	..	..	..	

No. 3 LEVELLING DETACHMENT—*continued.*

Tabular statement of outturn of work.—Season 1909-10.—continued.

Section.	Month.	NUMBER OF MILES OF DOUBLE LEVELLING. Main Line. Ms. chs. lks.	Branch Line. Ms. chs. lks.	Total. Ms. chs. lks.	TOTAL NUMBER OF FEET. Rise.	Fall.	Number of stations at which instrument was set up.	NUMBER OF BENCH-MARKS CONNECTED. Primary. Rock-cut.	Intorred.	Engraved.	Standard.	G. T. Survey, principal.	Secondary. Old. Embedded.	Old. Inscribed.	Embedded.	Inscribed.	G. T. Survey, secondary.	Railway.	P. W. D.	Remarks.
Connection of Godhra standard bench-mark.	February 1910	.. .. ..	24 09 96	24 09 96	321·667	186·139	281	11	..	..	1	..	..	1	1	19	1*	1	..	* Old.
Connection of Baroda standard bench-mark.	February 1910	.. .. ..	3 28 08	3 28 08	53·679	35·550	57	..	...	1	1	..	2	2	..	6	..	..	...	
Connection of Surat standard bench-mark.	February 1910	.. .. ..	4 52 66	4 52 66	45·461	59·756	65	..	...	...	1	..	1	3	..	9	..	..	..	
Connection of Dhulia standard bench-mark.	February 1910	.. .. ..	3 43 46	3 43 46	91·265	10·023	52	3	..	..	1	..	..	4	..	4	..	..	..	
Connection of Mhow standard bench-mark.	February 1910	.. .. ..	4 21 18	4 21 18	22·251	70·038	64	..	..	..	1	..	1	5	..	2	..	..	3	
Connection of Bhopal standard bench-marks.	February 1910	.. .. ..	8 13 74	8 13 74	191·912	81·852	123	3	..	..	2	..	..	3	..	4	..	2	..	
Lahore to Dharmkot hill (Dharmsala).	March 1910	66 61 50	10 45 90	77 27 40	310·227	172·783	808	..	..	1	1*	2	6	5	5	54	..	..	1	* Old.
	April "	84 48 36	5 25 47	89 73 83	6,217·446	2,215·374	1,830	37	..	..	..	1	..	..	4	52	..	..	5	
	May "	3 10 14	0 12 60	3 22 74	2,293·901	1·133	304	11	..	..	..	..	..	..	..	..	..	..	..	
	TOTAL	154 40 00	16 03 97	170 43 97	8,821·574	2,389·290	2,942	48	..	1	1	3	6	5	9	106	..	..	6	
	GRAND TOTAL	293 02 48	208 10 86	501 13 34	10,488·320	3,782·450	6,776	75	1	6	16†	16	19	49	22	309	2†	15	23	† Includes one old.

No. 1 Levelling Detachment.

List of Great Trigonometrical Survey principal stations connected by spirit-levelling in 1909-10.

Name of station.	Height in feet above Mean Sea Level.		Difference of height by triangulation in feet.	Remarks.
	*Spirit-levelling.	Triangulation.		
Mandalay Meridional Series.				
Toungoo S.	176·940	185·7	+8·760	Upper mark-stone.
Omaza S.	291·000	300·7	+9·700	Ditto.
Thônbinzin H. S.	1,912·064	1,931·9	+19·836	Ditto.

* The heights in this column have received a correction of +0·904 foot to reduce them to M. S. L. at Elephant Point Open Coast Tidal Station.

No. 2 Levelling Detachment.

List of Great Trigonometrical Survey principal stations connected by spirit-levelling in 1909-10.

Name of station.	Height in feet above Mean Sea Level.		Difference in height by triangulation in feet.	Remarks.
	By spirit-levelling.	By triangulation.		
Great Arc Meridional Series.				
Mahesari T. S.	817·373	821	+3·627	Height of upper mark-stone.
North-East Longitudinal Series.				
Behari T. S.	668·017	670·2*	+2·183	* Height of mark-stone at ground floor. (Height given in volume to top of tower = 708 feet and height of tower given = 37·8 feet.)

No. 3 Levelling Detachment.

List of Great Trigonometrical Survey principal stations connected by spirit-levelling in 1909-10.

Name of station.	Height in feet above Mean Sea Level.		Difference of height by triangulation in feet.	Remarks.
	Spirit levelling.	Triangulation.		
Jhambhera Tower Station—*Sutlej Series*	607·411	(606·9)*	..	* Height of original mark-stone at ground floor. The spirit-levelling height refers to the new mark-stone fixed in 1909-10 at ground floor.
Fatehgarh Tower Station—*Sutlej Series*	504·834	(568)*	..	
Godri Tower Station—*Sutlej Series*	379·511	380·7	+1·189	Height of mark-stone at ground floor.
Moni-Dhai Tower Station—*Jogi-Tila Meridional Series*	558·709	(562·81)*	...	
Lalgarh Tower Station—*Great Indus Series*	282·815	282·77	—0·045	Height of mark-stone at ground floor.
Sultan-ka-got Tower Station—*Great Indus Series*	189·155	188	—1·155	Ditto ditto.

List of Great Trigonometrical Survey principal stations connected by spirit-levelling in 1909-10—continued.

Name of station.	Height in feet above mean sea level.		Difference of height by triangulation in feet.	Remarks.
	Spirit levelling.	Triangulation.		
Karachi Observatory Station—*Great Indus Series*	31·836	(35·44)*	..	* Height of original upper mark-stone. The spirit-levelling height refers to new upper mark-stone fixed in 1893-94.
Mutrani Hill Station—*Great Indus Series*	254·387	253	—1·387	Height of upper mark-stone
Vin Tower Station—*Eastern Sind Meridional Series*	243·628	249	+5·372	Height of mark-stone at ground floor.
Kot Sabzal Tower Station—*Eastern Sind Meridional Series.*	270·861	274	+3·139	Height of upper mark-stone.
Got Mir Muhammad Hill Station—*Eastern Sind Meridional Series.*	266·684	270	+3·316	Ditto. ditto.
Dewari Tower Station—*Eastern Sind Meridional Series.*	265·926	270	+4·074	Ditto. ditto.
Vijnot Tower Station—*Eastern Sind Meridional Series*	257·910	263	+5·090	Height of mark-stone at ground floor.
Tung Tower Station—*Gurhagarh Meridional Series*	757·333	757·6	+0·267	Ditto ditto.
Chowinda Station—*Gurhagarh Meridional Series*	832·733	833	+0·267	Height of upper mark-stone.
Pagwansir Station—*North-West Himalaya Series*	957·421	949·8	—7·621	Height of upper mark-stone. The mark-stone was found about 10 feet above ground level; in the Synoptical Volume the pillar is given only 2 feet above ground level.

Difference between levellers (First—Second) :—

No. 1 Detachment—

Section Rangoon to Pyinmana.

At 50th mile	—0·066 foot
„ 100th „	+0·002 „
„ 150th „	+0·011 „
„ 200th „	+0·024 „
„ end of section	+0·033 „

Section Wuntho to Myitkyina.

At 50th mile	—0·050 foot.
„ 100th „	—0·029 „
„ 150th „	+0·007 „
„ end of section	—0·054 „

No. 2 Detachment—

Section Hardwar to Lansdowne.

At 50th mile	—0·019 foot.
„ end of section	—0·023 „

Section Bareilly to Naini Tal Brewery.

At 50th mile	+0·003 foot.
„ end of section	—0·080 „

Section Siliguri to Tindharia.

At end of section	—0·155 foot.

No. 3 Detachment—

Section Laluwali G. T. S. to Rohri.

At 50th mile	—0·055 foot.
„ 100th „	—0·153 „
„ end of section	—0·143 „

Section Lahore to Dharmkot.

At 50th mile	+0·136 foot.
„ 100th „	+0·185 „
„ end of section	+0·009 „

Rock-cut bench-marks.—The bench-marks hitherto determined by spirit-levelling operations in India are mostly situated on alluvium : in many instances they have been inscribedon bridges, culverts and railway platforms. These bench-marks were originally intended to be of use to engineers, but they cannot be regarded as permanent standards of height, and are therefore useless for scientific purposes. It is evident that marks cut on solid ground rock, if carefully selected, are the only ones that can be accepted as really permanent. On examining the lists of bench-marks already fixed, the number of marks that have been engraved on ground rock was found to be extremely small. In 1909 steps were taken to increase the number of rock-cut bench-marks in all parts of India. Instructions were issued to the levelling officers to fix as many bench-marks as possible on ground rock in the course of their work. It is intended to have many more bench-marks on ground rock in future, as the levelling operations are extended, and suitable sites become available. A rock-cut bench-mark consists of the inscription G. T. S. O B. M. neatly and deeply engraved on the rock, which has been previously smoothed off where necessary.

In order as far as possible to prevent these marks being obliterated by atmospheric causes and by growth of vegetation, some of them are protected by pillars. A protecting pillar for rock-cut bench-marks was introduced in 1909. The pillar is of masonry, 2 feet square and 1 foot in height, with a hollow centre 6 inches square. The top of the pillar is closed in by a stone slab which bears the inscription G. T. SURVEY O UPPER MARK. The slab is fixed so that the circle inscribed on it is vertically above the circle cut on the rock *in situ*. During the year under report 150 rock-cut bench-marks were laid down and connected with levelling, and of these 49 were protected by masonry pillars of the above description.

Himalayan lines of levelling.—The following lines of levels have been proposed :—

(1) Siliguri to Tindharia.
(2) Bareilly to Naini Tal (Brewery).
(3) Hardwar *viâ* Najibabad to Lansdowne.
(4) Lahore *viâ* Pathankot to Dharmkot.
(5) Ambala to Solon.
(6) Rawalpindi to Murree.

Levelling operations had already been carried out from Dehra Dun to Mussooree in 1905 and 1907. This line was to be the model on which the other Himalayan lines were to be based, and steps were taken early in the season last year to place this line on a permanent scientific basis, by improving the inscriptions on the existing rock-cut bench-marks on the line, and by laying down additional rock-cut bench-marks and protecting the same by masonry pillars. Sixteen new rock-cut bench-marks were erected between Rajpur, Mussooree, Banog and Landour, and these were duly connected by spirit-levelling; of these bench-marks 15 were protected by masonry pillars. The new rock-cut bench-marks consisted of the inscription G. T. S. D. ↑ H. instead of the usual inscription G. T. S. B. ○ M., in order to distinguish them from the old bench-marks. The standard bench-mark built at Mussooree was also connected by levelling in the course of the above work. During the season under report the first four of the Himalayan lines mentioned above have been completed. The last two lines mentioned will be completed during the field season of 1910-11.

During the past year 30 standard bench-marks were erected and 41 connected, 4 are under construction and 37 have been proposed for construction.

The following is a complete list of the standard bench-marks as they stood at the close of the year 1909-10 :—

Agra, Ahmedabad, Ahmednagar,* Akola, Aligarh, Allahabad (two), Ambala, Attock, Bahawalpur, Balasore, Bangalore, Bankipore, Bareilly, Barisal,* Baroda, Belgaum, Bellary, Benares, Berhampur (Madras), Bezwada, Bhagalpur, Bhopal (two), Bijapur, Bikanir, Bilaspur, Bombay (two), Burdwan, Calcutta, Calicut, Chittagong,* Cocanada, Comilla,* Cuddapah, Cuttack, Dacca,* Deesa, Dehra Dun (two), Delhi, Deolali, Dera Ismail Khan, Dhubri,* Dhulia, Dibrugarh,† Dinajpur, Ferozepore, Fyzabad, Gauhati,* Ghazipur, Godhra, Gorakhpur, Gwalior, Hinganghat, Hyderabad (Sind), Jacobabad, Jhansi, Jhelum, Jodhpur, Jubbulpore, Karachi, Khanpur, Kirkee, Lahore, Lucknow, Ludhiana, Madras, Madura, Magwe, Mandalay, Meerut, Meiktila, Mhow, Mirzapur, Motihari, Mozuffarnagar, Multan, Mussooree, Muttra, Muzaffarpur, Myitkina, Mymensingh,† Nagpur, Negapatam, Nellore, Pegu, Peshawar, Poona (two), Purneah, Raichur, Raipur, Rajkot, Rangoon, Rawalpindi, Rewah, Rurki, Sadikganj, Saharanpur, Salem, Sambalpur, Satara, Saugor, Secunderabad (three), Shahjehanpur, Sholapur, Shwebo, Silchar,† Sitapur, Sukkur, Surat, Sylhet,† Tinnevelly, Toungoo, Trichinopoly, Vizagapatam, Wuntho.

Totals.—

Completed and connected	110
Completed, not yet connected	7
Under construction	4
TOTAL	121

Revision levelling, Rangoon to Mandalay.—The original levelling from Rangoon to Mandalay was carried out in season 1892-93. Subsequently in season 1902-03 a branch line of levels to Magwe and Minbu was started from Thazi railway station, situated on the Rangoon-Mandalay main line of levels, and levelling operations were also extended from Mandalay *viâ* Sagaing to Shwebo.

Before commencing new work it was necessary to verify the heights of the old bench-marks at Thazi and Mandalay railway stations. The check-levelling carried out at both places disclosed such grave discrepancies between the old and the new heights of some of the bench-marks, that strong doubts were entertained as to the accuracy of the old levelling generally, and also as to the stability of the old bench-marks; and it was decided to revise the line from Mandalay towards Rangoon, until some old bench-marks were found the heights of which could be proved without doubt to have remained unaltered. Revision levelling was accordingly resumed from Mandalay in season 1903-04, and carried as far south as Pyinmana. The general results of this revision were not considered to be satisfactory, inasmuch

* Completed, but not yet connected.
† Under construction.

as it could not be proved conclusively that any old bench-marks had remained undisturbed since 1892-93. If the embedded bench-mark at Mandalay was accepted as undisturbed, the bench-marks towards Pyinmana appeared to have sunk : on the other hand by accepting Pyinmana embedded bench-mark as correct, the bench-marks towards Mandalay seemed to have risen. This question could only be satisfactorily solved by continuing the revision levelling from Pyinmana down to Rangoon. This was done during the season under report.

Revision levelling was commenced at Rangoon in November 1909, and closed at Pyinmana in February 1910. Complete data are now available, and by combining the results of the present revision work with those of season 1903-04 we are able to determine with some degree of certainty what changes have occurred in the position of the various bench-marks since they were first connected in 1892-93.

These results are set forth in the accompanying tables and the differences between the original and the revised levelling are shown in the last column of the tables.

The heights of both the original and the revised levels are based on Graham Smith's bench-mark at Rangoon, which has been proved to have remained unaltered in height since 1892-93. This bench-mark was erected by the Marine Survey many years before the advent of the first levelling party of the Survey of India in Burma, and all the heights in Rangoon were originally based on it. It is the bench-mark of reference for the Rangoon tidal observatory, and is connected by levelling every year by the tidal inspecting officer, with the bed-plate of the tide-gauge and other neighbouring bench-marks, to see if any relative changes have occurred in their various heights. No appreciable change in this bench-mark has as yet been discovered by the tidal officers, and further this is borne out by the results of the revision levelling carried out by the levelling detachment in November 1909.

It will be seen from the accompanying table that the difference of height between this bench-mark and four other bench-marks at Rangoon as now determined, is practically identical with that found in 1892-93.

The differences between the old and the revision levelling may be due to the following causes :—

(1) Errors in the adopted length of the mean staff in the old or in the revised levelling, or in both.
(2) Observational inaccuracies.
(3) Movements of bench-marks during the time that has elapsed between the original and the revision work.

It may here be stated that there is no reason at all to question the accuracy of the revision levelling, as regards the first two causes of error mentioned above. Great care has been taken during the last ten years to determine the true length of the staves frequently in the field. The staves are now compared with a portable standard bar once a week, and the method of comparison has been greatly improved. The general system of levelling has been reconstructed and many improvements have been introduced, to place it on a more scientific basis, in order to obtain the maximum amount of accuracy. If therefore any errors have been introduced into the work on account of the first two causes, the old levelling must be responsible for the same.

On examining the records of the original levelling it was found that the staves were only compared with the standard bar at Rangoon on commencing work, and again at Mandalay at the close of the operations. The consequent unit corrections applied to the observed differences of level were therefore inadequate and inaccurate. The country between Rangoon and Mandalay varies so greatly in character from wet to dry, that frequent comparisons of the staves are absolutely necessary. When the revision levelling party was at work in Lower Burma, the water in the rice fields through which the railway passes was almost up to the level of the line, and the detachment was compelled to encamp on the platforms of the railway stations.

The work of 1892-93 must therefore be burdened with any errors arising from this source; but looking at the discrepancies between the original and the revised levelling, it appears that they cannot be wholly attributed to any error in the adopted length of the mean staff. It is probable that only a fraction of the discrepancies disclosed are due to this cause. In support of this view it may be noted that from Rangoon to Tawa, a distance of 40 miles, the observed heights of bench-marks are all within 10 feet, but the discrepancies on this length range from 0·001 to 0·265 of a foot. These could not possibly be due to the erroneous length adopted for the mean staff, unless we are prepared to accept that the mean staff was wrong by 0·1 to 0·2 of a foot. Similarly when we examine the differences at various points further along the line, we find that there is no regularity or harmony between these differences and the corresponding heights, as will be seen from the following table :—

Number of bench-mark.	Height above Rangoon. H.	Difference between old and revised levels. (R—O).	Rise or Fall. Δ H.	Variation in difference. Δ (R—O).	Staff error necessary to account for variation =10 + Δ (R—O)/Δ H.
	Feet.	Feet.	Feet.	Feet.	
76	26·6	+0·068			
			0·3	—0·057	—1·900
108	26·3	+0·011			
			39·3	+0·001	+0·000
125	65·6	+0·012			
			76·1	+0·031	+0·004
150	141·7	+0·043			
			0·2	—0·097	—4·850
183	141·9	—0·054			
			27·7	+0·061	+0·022
195	169·6	+0·007			
			34·2	—0·027	—0·008
207	203·8	—0·020			
			201·9	+0·039	+0·002
$\frac{1}{244}$	405·7	+0·019			
			34·6	+0·075	+0·022
255	371·1	+0·094			
			100·5	+0·111	+0·011
$\frac{a}{263}$	471·6	+0·205			
			66·3	—0·071	—0·011
$\frac{a}{269}$	537·9	+0·134			
			111·0	+0·082	—0·007
283	648·9	+0·216			
			129·7	—0·014	—0·001
297	519·2	+0·202			
			282·7	+0·007	+0·000
338	236·5	+0·209			
			0·4	+0·057	+1·425
$\frac{c}{344}$	236·1	+0·266			

The values in the above table have been taken from localities in which several discrepancies appear to be in close accord.

There is then the question of observational inaccuracies. There is no direct evidence to prove that the results have been appreciably affected by systematic errors of observation, but considering that the levelling of 1892-93 was done under the old system, when it was customary to observe at long distances regardless of the unsteady appearance of the staves due to radiation, it is possible that the results may have been, to a certain extent, affected by systematic cumulative errors. The line Rangoon to Mandalay runs approximately from South-by-East to North-by-West, hence one staff, the northern one, was constantly illuminated, while the other staff was shaded from the sun. Radiation is apparent earlier and to a greater extent on the illuminated staff than on the shaded one, and hence a constant error might be introduced into the levelling on this account.

Since the year 1900 steps have been taken to remedy this defect in the levelling work, by making it a rule that no observations are to be taken at a longer distance than 5 chains, and these only under the most favourable conditions of the weather when no radiation is appreciable on the staff.

It must be borne in mind that any satisfactory discussion or investigation of the observational errors must be based on the assumption that the bench-marks concerned have retained their original heights ; but as explained later on, there are strong grounds for believing that the whole line of levelling between Rangoon and Mandalay has suffered more or less from the movement of bench-marks. It is therefore clearly impossible to ascertain the extent to which the results of 1892-93 have suffered from observational errors.

We now come to the last, though by no means the least, possible cause of the discrepancies, namely, the movements of bench-marks during and after the original levelling. By looking at the table of differences between the old and the revision levelling it is found that the discrepancies at many bench-marks are considerable and out of harmony with the neighbouring bench-marks, and there seems to be no other way of explaining these exceptional discrepancies than by attributing them to the fact that the bench-marks have either sunk or risen since they were originally determined in 1892-93. For instance, bench-marks Nos. 17, 19, 37, 39, 45, 119, 186, 203, $\frac{a}{239}$, $\frac{a}{243}$ and 322 appear to have sunk, while bench-marks Nos. 30, 83, 232, $\frac{a}{202}$, 263, 274, $\frac{a}{280}$, 280, 286, 291, $\frac{a}{291}$, 302, 303, 306, 307, 312 and 321 seem to have risen : the extent of the movement in either case being from 0·1 to 0·4 of a foot.

The discrepancy at bench-mark No. 30 appears as if it might be due to human agency, while the disturbance at the other bench-marks is probably due to the rising or sinking of the ground on which they were erected. The difference *inter se* between two consecutive bench-marks Nos. 321 and 322 only 3 miles apart amounts to over 1 foot, the former having apparently risen and the latter having sunk six inches. Almost all the bench-marks along the line Rangoon to Mandalay are situated along the railway line, being on the parapets of bridges and on culverts or on the platforms of railway stations. The discrepancies might partially have been caused by the vibration due to moving loads on bridges which were originally built for a lighter type of rolling stock, combined with the constantly recurring repairs to bridges, etc. When so many bench-marks show unmistakable signs of subsidence or upheaval, a reasonable doubt may be entertained regarding the stability of the remaining bench-marks.

If now it is accepted that the discrepancies found in the majority of the bench-marks are due to changes in their positions, the following conclusions are arrived at :—

(1) There has apparently been a slight subsidence from Rangoon to near Tangyi, the embedded bench-mark at Rangoon having remained intact.

(2) The embedded bench-mark at Tawa has remained practically unaltered, but the embedded bench-mark at Pegu has sunk slightly. From Pegu the bench-marks have risen to about Paungdawthi, after which the discrepancy becomes inappreciable.

(3) The line from Paungdawthi to Pyinmana may be accepted as correct, with the exception of the embedded bench-marks at Peinzalok, Toungoo, Yedashe, Pyiwin and Pyinmana, which have sunk.

(4) Shortly after leaving Pyinmana there is a slight upheaval which gradually increases in magnitude to about mile 270 from Rangoon, after which it remains fairly constant until the end of the line; the maximum amount of upheaval being visible between Meiktila Road and Hanza railway stations.

Results of revision levelling from Rangoon to Mandalay.

BENCH-MARKS OF THE ORIGINAL LEVELLING CONNECTED DURING THE REVISIONARY OPERATIONS. Description.	No.	Distance from Rangoon.	OBSERVED HEIGHT ABOVE (+) OR BELOW (—) RANGOON AS DETERMINED IN 1892-93.	1909-10.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Graham Smith's bench-mark	1/20	0·00	0·000	0·000	0·000
Cut on iron pillar (N. W.), wharf godown	1a/20	0·05	+1·114	+1·107	—0·007
Cut on iron pillar (S. W.), wharf godown	1b/20	0·07	+1·224	+1·072	—0·052
Bed-plate of tide gauge	1c/20	0·14	+4·217	+4·183	—0·034
Old standard bench-mark	20	0·38	+3·698	+3·633	—0·065
Cut on steps, Rangoon General Post Office	19	0·52	+0·678	+0·576	—0·102
Cut on rubbish bin, Latter Street wharf	18	1·04	+1·018	+0·920	—0·098
Cut on Canal Road bridge	17	2·07	+4·886	+4·744	—0·142
Cut on basement, Sule Pagoda	21	0·74	+3·479	+3·472	—0·007
Cut on platform coping, railway station	23	1·29	+9·647	+9·648	+0·001
Embedded at Rangoon railway office	a/22	1·48	+13·882	+13·879	—0·003
Cut on plinth of railway office	1a/22	1·49	+15·126	+15·098	—0·028
Cut on pier of girder bridge	30	7·34	+4·272	+5·459	+1·187
Cut on abutment of girder bridge	31	7·86	+2·148	+2·072	—0·076
Embedded at Togyaunggale railway station	a/32	8·45	+1·623	+1·468	—0·155
Cut on abutment of girder bridge	33	10·05	+1·980	+1·929	—0·051
Cut on girder bridge	34	11·23	+2·709	+2·646	—0·063
Cut on girder bridge	36	13·72	+3·980	+3·909	—0·071
Cut on girder bridge	37	15·85	+6·730	+6·573	—0·157
Embedded at Ledaunggan railway station	39	17·12	+4·748	+4·483	—0·265
Cut on girder bridge	43	21·05	+5·152	+5·069	—0·083
Cut on girder bridge	44	22·29	+6·121	+6·053	—0·068

Results of revision levelling from Rangoon to Mandalay—continued.

Bench-marks of the original levelling connected during the revisionary operations. — Description.	No.	Distance from Rangoon.	Observed height above (+) or below (—) Rangoon as determined in 1892-93.	Observed height above (+) or below (—) Rangoon as determined in 1909-10.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Embedded at Dabein railway station .	45	23·76	+7·944	+7·790	—0·154
Cut on girder bridge	47	25·03	+7·432	+7·317	—0·115
Cut on girder bridge	48	25·76	+5·710	+5·621	—0·089
Cut on girder bridge	51	28·90	+6·151	+6·091	—0·060
Cut on girder bridge	52	30·31	+7·108	+7·037	—0·071
Embedded at Tongyi railway station .	54	31·36	+7·951	+7·866	—0·085
Cut on girder bridge	58	34·72	+10·605	+10·507	—0·098
Cut on girder bridge	61	37·87	+8·579	+8·539	—0·040
Cut on girder bridge	62	38·59	+8·721	+8·689	—0·032
Embedded at Tawa railway station . .	63	39·23	+9·589	+9·561	—0·028
Cut on girder bridge	65	41·42	+9·914	+9·913	—0·001
Cut on girder bridge	66	42·30	+10·856	+10·858	+0·002
Cut on girder bridge	67	43·32	+11·643	+11·656	+0·013
Cut on girder bridge	68	44·56	+14·800	+14·882	+0·082
Cut on girder bridge	69	45·54	+16·365	+16·357	—0·008
Cut on girder bridge	70	46·17	+17·363	+17·363	0·000
Embedded at Pegu railway station . .	72	47·58	+16·087	+15·991	—0·096
Cut on girder bridge	74	49·94	+18·452	+18·476	+0·024
Cut on girder bridge	76	54·48	+26·589	+26·657	+0·068
Cut on girder bridge	77	55·83	+23·603	+23·697	+0·094
Cut on girder bridge	78	57·05	+22·704	+22·786	+0·082
Embedded at Payagyi railway station .	79	58·10	+25·063	+25·122	+0·059
Cut on girder bridge	83	62·62	+27·231	+27·337	+0·106
Embedded at Pyinbongyi railway station .	87	65·92	+23·573	+23·556	—0·017
Cut on girder bridge	88	67·14	+20·866	+20·928	+0·062
Cut on girder bridge	90	69·91	+21·229	+21·306	+0·077
Cut on girder bridge	91	70·31	+20·969	+21·030	+0·061
Cut on girder bridge	94	73·75	+24·850	+24·942	+0·092
Cut on girder bridge	96	76·08	+25·827	+25·888	+0·061
Embedded at Paungdawthi railway station	97	76·84	+25·501	+25·483	—0·018
Cut on girder bridge	98	77·53	+24·542	+24·570	+0·028

Results of revision levelling from Rangoon to Mandalay—continued.

BENCH-MARKS OF THE ORIGINAL LEVELLING CONNECTED DURING THE REVISIONARY OPERATIONS. Description.	No.	Distance from Rangoon.	OBSERVED HEIGHT ABOVE (+) OR BELOW (—) RANGOON AS DETERMINED IN 1892-93.	1909-10.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Cut on girder bridge	99	78·70	+28·634	+28·678	+0·044
Cut on girder bridge	100	80·40	+29·454	+29·507	+0·053
Cut on girder bridge	101	81·45	+30·117	+30·165	+0·048
Cut on girder bridge	107	88·21	+30·337	+30·355	+0·018
Embedded at Pyuntaza railway station .	108	88·83	+26·293	+26·304	+0·011
Cut on base of distant signal . . .	109	89·24	+25·044	+25·065	+0·021
Cut on girder bridge	112	93·59	+27·845	+27·925	+0·080
Embedded at Peinzalôk railway station .	119	102·69	+50·782	+50·611	—0·171
Cut on girder bridge	122	105·14	+60·431	+60·490	+0·059
Cut on girder bridge	124	107·49	+68·975	+69·006	+0·031
Cut on girder bridge	125	108·70	+65·609	+65·621	+0·012
Embedded at Kyauktaga railway station .	126	109·77	+67·896	+67·835	—0·061
Embedded at Penwegôn railway station .	131	115·31	+87·947	+87·900	—0·047
Embedded at Ka-nyut Kwin railway station	140	124·68	+95·923	+95·907	—0·016
Cut on girder bridge	142	126·43	+105·095	+105·136	+0·041
Cut on girder bridge	143	127·50	+109·015	+109·058	+0·043
Embedded at Pyu railway station . .	150	135·24	+141·690	+141·741	+0·043
Cut on girder bridge	154	138·24	+128·480	+128·498	+0·018
Cut on girder bridge	158	142·23	+114·489	+114·486	—0·003
Embedded at Nyaungchidauk railway station.	160	144·28	+109·867	+109·835	—0·032
Cut on girder bridge	163	147·02	+120·397	+120·412	+0·015
Embedded at Kywebwe railway station .	166	150·34	+118·846	+118·834	—0·012
Embedded at Oktwin railway station .	176	159·39	+117·297	+117·251	—0·046
Cut on girder bridge	179	162·05	+116·400	+116·371	—0·029
Cut on culvert	181	164·43	+132·659	+132·614	—0·045
Cut on girder bridge	182	165·01	+138·327	+138·284	—0·043
Cut on girder bridge	183	165·14	+141·877	+141·823	—0·054
Cut on girder bridge	184	166·12	+136·917	+136·867	—0·050
Cut on girder bridge	185	166·38	+139·339	+139·311	—0·028
Embedded at Toungoo railway station .	186	166·88	+143·200	+143·054	—0·146
Toungoo S.	1/186	167·41	+163·068	+162·998	—0·070

Results of revision levelling from Rangoon to Mandalay—continued.

BENCH-MARKS OF THE ORIGINAL LEVELLING CONNECTED DURING THE REVISIONARY OPERATIONS.			OBSERVED HEIGHT ABOVE (+) OR BELOW (—) RANGOON AS DETERMINED IN		Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
Description.	No.	Distance from Rangoon.	1892-93.	1909-10.	
		Miles.	Feet.	Feet.	Feet.
Cut on girder bridge	189	168·29	+135·870	+135·796	—0·074
Cut on girder bridge	193	172·08	+135·882	+135·880	—0·002
Cut on culvert	195	175·71	+169·571	+169·578	+0·007
Cut on railway platform coping . .	196	176·37	+181·003	+181·008	+0·005
Embedded at Kyungon railway station .	a 197	176·44	+181·736	+181·713	—0·023
Cut on railway platform coping . .	197	176·42	+180·974	+180·964	—0·010
Cut on parapet of culvert	198	177·62	+176·622	+176·647	+0·025
Cut on girder bridge	199	179·63	+172·414	+172·415	+0·001
Cut on girder bridge	201	182·07	+165·061	+165·025	—0·036
Cut on culvert	202	183·84	+181·943	+181·880	—0·063
Embedded at Yedashe railway station .	203	184·19	+183·675	+183·560	—0·115
Cut on girder bridge	204	185·65	+181·886	+181·861	—0·025
Cut on girder bridge	206	188·40	+192·996	+192·992	—0·004
Cut on girder bridge	207	189·85	+203·766	+203·746	—0·020
Cut on girder bridge	208	191·50	+203·617	+203·614	—0·003
Embedded at Swa railway station . .	209	192·42	+203·344	+203·288	—0·056
Cut on railway platform coping . .	210	192·45	+202·858	+202·850	—0·008
Cut on girder bridge	213	194·27	+193·369	+193·384	+0·015
Cut on base of distant signal . . .	215	196·44	+203·237	+203·244	+0·007
Cut on girder bridge	217	198·49	+193·836	+193·935	+0·099
Cut on girder bridge	219	200·75	+202·398	+202·449	+0·051
Cut on rail opening	200	201·80	+222·899	+222·906	+0·007
Embedded at Myohla railway station .	221	202·11	+223·420	+223·382	—0·038
Cut on railway platform coping . .	222	202·14	+223·605	+223·625	+0·020
Cut on Myohla bridge	223	202·85	+217·641	+217·656	+0·015
Cut on pillar near Myohla bridge . .	a 223	202·87	+216·490	+216·465	—0·025
Cut on girder bridge	228	209·08	+229·215	+229·228	+0·013
Embedded at Thawati railway station .	a 229	210·85	+239·861	+239·843	—0·018
Cut on girder bridge	230	211·36	+247·571	+247·568	—0·003
Cut on culvert	231	212·43	+259·113	+259·102	—0·011
Cut on girder bridge	232	213·19	+255·729	+255·944	+0·215
Cut on culvert	233	213·89	+254·732	+254·738	+0·006

Results of revision levelling from Rangoon to Mandalay—continued.

Bench-marks of the original levelling connected during the revisionary operations. Description.	No.	Distance from Rangoon.	Observed height above (+) or below (—) Rangoon as determined in 1892-93.	Observed height above (+) or below (—) Rangoon as determined in 1909-10 and 1903-04.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Embedded at Pyiwin railway station .	a/239	220·16	+256·459	+256·213	—0·246
Embedded at Pyinmana railway station .	a/243	226·00	+298·511	+298·377	—0·134
Cut on platform coping	243	225·96	+298·856	+298·817	—0·039
Cut on drain coping	a/244	266·70	+317·843	+317·841	—0·002
G. T. S. intersected point, Pyinmana . .	1/244	227·04	+405·652	+405·671	+0·019
Cut on girder bridge	244*	226·46	+303·205	+303·192	—0·013
Cut on culvert of parapet	245	228·97	+289·379	+289·357	—0·022
Cut on culvert of parapet	246	230·46	+288·402	+288·396	—0·006
Cut on girder bridge	247	231·89	+298·326	+298·299	—0·027
Cut on girder bridge	248	233·22	+327·519	+327·537	+0·018
Cut on culvert of parapet	249	234·88	+363·497	+363·521	+0·024
Cut on railway platform coping . . .	250	236·17	+376·242	+376·253	+0·011
Embedded at Kyidaungan railway station	a/250	236·29	+376·098	+376·119	+0·021
Cut on girder bridge	251	236·49	+374·682	+374·737	+0·055
Cut on bridge	252	237·71	+365·653	+365·685	+0·032
Cut on girder bridge	253	238·77	+368·632	+368·656	+0·024
Cut on girder bridge	254	239·46	+375·973	+376·037	+0·064
Cut on culvert of parapet	255	241·22	+371·105	+371·199	+0·094
Cut on girder bridge	256	242·52	+387·585	+387·670	+0·085
Cut on girder bridge	a/256	243·93	+393·917	+394·014	+0·097
Cut on culvert of parapet	257	245·28	+390·583	+390·649	+0·066
Cut on girder bridge	a/257	246·20	+402·441	+402·494	+0·053
Cut on culvert of parapet	258	247·24	+402·199	+402·250	+0·051
Embedded at Shwemyo railway station .	259	247·75	+413·168	+413·092	—0·076
Cut on culvert of parapet	260	248·58	+420·108	+420·167	+0·059
Cut on girder bridge	261	250·04	+435·321	+435·390	+0·069
Cut on girder bridge	a/261	251·64	+459·915	+460·042	+0·127
Cut on girder bridge	262	252·51	+462·593	+462·667	+0·074
Cut on base of distant signal	a/262	254·00	+469·439	+469·715	+0·276
Embedded at Tatkon railway station .	263	254·34	+471·419	+471·746	+0·327
Cut on railway platform coping . . .	a/263	254·38	+471·560	+471·765	+0·205

* Revision 1903-04 commences from this bench-mark.

Results of revision levelling from Rangoon to Mandalay—continued.

Bench-marks of the original levelling connected during the revisionary operations. Description.	No.	Distance from Rangoon.	Observed height above (+) or below (—) Rangoon as determined in 1892-93.	1903-04.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Cut on culvert abutment	264	255·30	+463·028	+463·146	+0·118
Cut on drain	265	257·05	+475·443	+475·557	+0·114
Cut on culvert of parapet	266	258·05	+496·080	+496·228	+0·148
Cut on girder bridge	$\frac{a}{266}$	259·34	+502·761	+502·878	+0·117
Cut on girder bridge	267	260·33	+524·524	+524·606	+0·082
Cut on girder bridge	268	261·58	+526·139	+526·288	+0·149
Cut on railway platform coping . . .	269	262·41	+538·444	+538·620	+0·176
Embedded at Nyaunglun railway station .	$\frac{a}{269}$	262·45	+537·939	+538·073	+0·134
Cut on culvert of parapet	270	263·98	+556·963	+557·131	+0·168
Cut on girder bridge	271	265·14	+568·495	+568·672	+0·177
Cut on culvert	$\frac{a}{271}$	266·50	+576·250	+576·466	+0·216
Cut on culvert	272	267·73	+587·364	+587·580	+0·216
Cut on girder bridge	273	268·21	+598·725	+598·944	+0·219
Cut on railway platform coping . . .	274	269·06	+616·953	+617·274	+0·321
Cut on base of home signal	$\frac{a}{274}$	269·28	+618·179	+618·455	+0·276
Cut on barrel drain	275	270·24	+634·638	+634·871	+0·233
Cut on irrigation pipe	276	271·50	+643·298	+643·534	+0·236
Cut on culvert	$\frac{a}{276}$	272·96	+654·958	+655·234	+0·276
Cut on girder bridge	277	273·58	+655·082	+655·339	+0·257
Embedded at Yamethin railway station .	278	275·50	+640·309	+640·236	—0·073
Cut on railway platform coping . . .	279	275·58	+640·307	+640·510	+0·203
Cut on girder bridge	280	276·64	+639·343	+639·681	+0·338
Cut on girder bridge	$\frac{a}{280}$	277·76	+631·907	+632·219	+0·312
Cut on girder bridge	$\frac{b}{280}$	282·65	+659·021	+659·241	+0·220
Cut on railway platform coping . . .	281	283·25	+659·902	+660·141	+0·239
Embedded at Shweda railway station .	$\frac{a}{281}$	283·43	+658·891	+659·118	+0·227
Cut on girder bridge	282	284·18	+658·701	+658·922	+0·221
Cut on girder bridge	283	285·29	+648·941	+649·157	+0·216
Cut on girder bridge	284	286·05	+642·324	+642·546	+0·222
Cut on girder bridge	$\frac{a}{284}$	286·53	+638·901	+639·083	+0·182
Embedded at Pyawbwe railway station .	285	288·39	+622·624	+622·861	+0·237

Results of revision levelling from Rangoon to Mandalay—continued.

Bench-marks of the original levelling connected during the revisionary operations. Description.	No.	Distance from Rangoon.	Observed height above (+) or below (—) Rangoon as determined in 1892-93.	Observed height above (+) or below (—) Rangoon as determined in 1903-04.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Cut on railway platform coping . . .	286	288·44	+623·097	+623·421	+0·324
Cut on culvert	287	289·69	+616·300	+616·537	+0·237
Cut on culvert	288	290·44	+622·138	+622·388	+0·250
Cut on barrel drain	289	291·52	+616·395	+616·648	+0·253
Cut on rail opening parapet . . .	a/289	292·88	+604·057	+604·272	+0·215
Embedded at Shanywa railway station .	290	293·78	+589·300	+589·410	+0·110
Cut on railway platform coping . .	291	293·83	+589·391	+589·736	+0·345
Cut on barrel drain	a/291	294·09	+559·873	+560·292	+0·419
Cut on drain	292	296·38	+545·520	+545·779	+0·259
Cut on drain	293	297·91	+532·947	+533·156	+0·209
Cut on girder bridge	294	299·08	+530·713	+530·853	+0·140
Embedded at Nyaungyan railway station .	a/294	300·08	+527·704	+527·812	+0·108
Cut on railway platform coping . . .	295	300·12	+528·400	+528·536	+0·136
Cut on girder bridge	296	301·12	+527·135	+527·314	+0·179
Cut on girder bridge	297	302·23	+519·233	+519·435	+0·202
Cut on girder bridge	298	303·84	+518·456	+518·657	+0·201
Cut on culvert of parapet	299	305·50	+512·363	+512·626	+0·263
Embedded at Meiktila Road railway station	300	306·79	+514·319	+514·426	+0·107
Cut on railway platform coping . .	a/300	306·91	+514·732	+514·977	+0·245
Cut on barrel drain	301	308·48	+509·251	+509·448	+0·197
Cut on drain	302	309·66	+518·022	+518·400	+0·378
Cut on culvert	303	310·57	+512·141	+512·460	+0·319
Cut on barrel drain	304	311·63	+511·928	+512·080	+0·152
Cut on girder bridge	305	312·33	+512·169	+512·403	+0·234
Cut on culvert	306	313·52	+509·722	+510·139	+0·417
Cut on girder bridge	307	314·59	+507·538	+507·996	+0·458
Cut on culvert	308	315·83	+501·835	+502·030	+0·195
Cut on railway platform coping . . .	309	316·33	+501·790	+502·070	+0·280
Embedded at Hanza railway station .	a/309	316·38	+501·349	+501·625	+0·276
Cut on girder bridge	b/309	317·08	+479·540	+479·724	+0·184
Cut on barrel drain	310	318·56	+462·799	+462·910	+0·111
Cut on irrigation pipe	a/310	319·59	+444·374	+444·547	+0·173

Results of revision levelling from Rangoon to Mandalay—continued.

Bench-marks of the original levelling connected during the revisionary operations. Description.	No.	Distance from Rangoon.	Observed height above (+) or below (—) Rangoon as determined in 1892-93.	Observed height above (+) or below (—) Rangoon as determined in 1903-04.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Cut on barrel drain	311	320·39	+433·753	+433·936	+0·183
Cut on girder bridge	a/311	321·53	+427·296	+427·552	+0·256
Embedded at Thedaw railway station	312	323·00	+427·958	+428·268	+0·310
Cut on culvert	313	323·89	+420·886	+421·060	+0·174
Cut on irrigation pipe	a/313	325·29	+407·064	407·287	+0·223
Cut on irrigation pipe	314	326·56	+395·661	+395·758	+0·097
Cut on girder bridge	315	327·73	+388·483	+388·661	+0·178
Cut on culvert	316	328·63	+381·985	+382·206	+0·221
Embedded at Samôn railway station	a/316	329·04	+368·831	+369·173	+0·342
Cut on girder bridge	317	330·39	+351·628	+351·787	+0·159
Cut on irrigation pipe	a/317	333·29	+337·333	+337·547	+0·214
Cut on girder bridge	318	333·97	+337·630	+337·710	+0·080
Cut on girder bridge	319	336·18	+322·229	+322·378	+0·149
Cut on irrigation pipe	321	339·56	+305·279	+305·845	+0·566
Embedded at Kume Road railway station	322	342·43	+303·330	+302·880	—0·450
Cut on railway platform coping	323	342·46	+303·900	+304·001	+0·102
Cut on girder bridge	324	343·67	+298·818	+298·943	+0·125
Cut on girder bridge	325	345·60	+301·650	+301·765	+0·115
Cut on girder bridge	326	347·33	+298·229	+298·373	+0·144
Cut on base of home semaphore	a/326	348·18	+291·913	+292·054	+0·141
Cut on girder bridge	b/326	351·08	+282·743	+282·890	+0·147
Cut on base of home semaphore	327	353·48	+278·569	+278·712	+0·143
Embedded at Minzu railway station	a/327	353·54	+278·107	+278·226	+0·119
Cut on girder bridge	328	355·26	+276·545	+276·681	+0·136
Cut on girder bridge	329	357·76	+273·934	+274·079	+0·145
Cut on girder bridge	330	358·80	+271·120	+271·263	+0·143
Embedded at Kyaukse railway station	a/330	360·09	+268·322	+268·462	+0·140
Cut on base of home semaphore	331	360·09	+268·696	+268·843	+0·147
Cut on girder bridge	332	361·04	+262·014	+262·175	+0·161
Cut on base of home semaphore	334	364·33	+254·988	+255·143	+0·155
Embedded at Bilin railway station	a/334	364·41	+253·951	+253·851	—0·100

Results of revision levelling from Rangoon to Mandalay—concluded.

BENCH-MARKS OF THE ORIGINAL LEVELLING CONNECTED DURING THE REVISIONARY OPERATIONS. Description.	No.	Distance from Rangoon.	OBSERVED HEIGHT ABOVE (+) OR BELOW (—) RANGOON AS DETERMINED IN 1892-93.	1903-04.	Difference in height (revised—original). The + sign denotes that the revised height was greater and the — sign less than the original height.
		Miles.	Feet.	Feet.	Feet.
Cut on girder bridge	336	366·89	+249·916	+250·093	+0·177
Cut on base of home semaphore . . .	337	369·95	+238·745	+238·941	+0·196
Cut on girder bridge	338	371·01	+236·492	+236·701	+0·209
Cut on canal bridge	339	372·91	+245·673	+245·917	+0·244
Cut on Myitnge bridge	340	377·09	+232·372	+232·571	+0·199
Cut on Myitnge bridge	a/340	377·53	+232·542	+232·806	+0·264
Cut on base of home semaphore . . .	341	378·28	+237·452	+237·728	+0·276
Embedded at Myitnge railway station .	a/341	378·31	+236·653	+236·908	+0·255
Cut on railway platform coping . . .	344	383·98	+234·754	+235·111	+0·357
Cut on girder bridge	a/344	385·53	+234·566	+234·797	+0·231
Cut on base of water column, Mandalay .	b/344	386·43	+234·342	+234·687	+0·345
Cut on base of home semaphore, Myohaung	345	384·00	+235·487	+235·816	+0·329
Embedded at Mandalay railway station .	c/344	386·74	+236·123	+236·389	+0·266
Embedded at Marine Transport Office, shore	a 1/344	388·74	+211·112	+211·300	+0·188
Cut on revetment wall, Mandalay shore .	a 2/344	388·61	+225·777	+225·972	+0·195
Cut on S. railway gate, Fort Dufferin . .	c 1/344	387·48	+236·116	+236·222	+0·106
P. W. Department bench-mark, Fort Dufferin	c 2/344	388·52	+233·790	+233·913	+0·123
B. M. embedded at Fort Dufferin . .	c 3/344	388·57	+232·002	+232·228	+0·226

IV.—Geodetic Survey.

A.—ASTRONOMICAL LATITUDES.

BY MAJOR H. L. CROSTHWAIT, R.E.

No. 13 (late 22) Party.

PERSONNEL.

Major H. L. Crosthwait, R.E., in charge from 5th April 1910.

Lieutenant H. J. Couchman, R.E., till 29th June 1910 (in charge till 4th April 1910).

Mr. R. Waller-Senior, from 20th April 1910.

2 Computers.

During the season of 1909-10, 11 latitude stations were occupied, 5 of these being situated on that portion of the Karara Meridional Series which lies north of the Ganges and the remainder on the North-East Longitudinal Series.

The method of observation and the instrument used were the same as in the season 1907-08, the electric glow lamp for illuminating the field of the telescope being most satisfactory. One of the levels, Holme's No. 6, was found to be cracked at the beginning of the season and was replaced by No. 10. On an average the programme at each station consisted of 64 observations to 54 stars, the great majority of these being taken from Newcomb's catalogue of fundamental stars, the Greenwich catalogue of 1880 being used in only a few cases.

The results of the season's observations are exhibited in the following table :—

TABLE I.

Name of station.	Longitude.	Height above M. S. L.	Astronomical latitude.	Seconds of Geodetic latitude.	Deflection A—G.
Sora T. S.	81° 12′	400	26° 17′ 26″·39	18″·83	+ 7″·56
Pariaon ,,	81° 22′	346	25° 50′ 11″·59	5″·26	+ 6″·33
Parewa ,,	81° 12′	380	26° 38′ 11″·44	4″·00	+ 7″·44
Utiamau ,,	81° 12′	386	26° 59′ 61″·62	57″·08	+ 4″·54
Imlia ,,	81° 8′	428	27° 19′ 17″·83	18″·90	—1″·07
Masi ,,	81° 23′	406	27° 38′ 14″·79	25″·17	—10″·38
Dadaura ,,	81° 43′	420	27° 43′ 3″·51	18″·33	—14″·82
Manichauk ..	82° 5′	360	27° 36′ 28″·91	48″·14	—19″·23
Basadela ,,	82° 17′	366	27° 23′ 50″·71	63″·24	—12″·53
Pathardi ,,	82° 45′	320	27° 25′ 56″·11	74″·77	—18″·66
Ghaus ,,	83° 6′	296	27° 20′ 48″·34	65″·08	—16″·74

All the stations are situated on the plains of Oudh and it is improbable that any orographical correction within a radius of at least 10 miles will have to be applied. The Himalayas are visible from the last 5 stations, Manichauk, the nearest to them, being about 18 miles distant.

The deflections deduced are in accordance with those found on the neighbouring meridional series, the Amua, the change of sign from +ve to —ve occurring at about latitude 27° 21′ on the Amua and at 27° 15′ on the Karara Series.

The local maximum of southerly deflection at Sora would seem to indicate that gravity is in excess between this station and Pariaon.

The following table gives further details of the observations :—

TABLE II.

Station.	Number of stars.	Number of observations.	Seconds of latitude.	P. e.	P. e. of unit weight.	EW—WE.	Apparent error of Micrometer value per revolution.
Sora T. S. .	47	55	26·39	±0·044	±0·211	+0·03	—0·0051
Pariaon ,, .	49	72	11·59	±0·037	±0·184	—0·14	+0·0003
Parewa ,, .	47	61	11·44	±0·041	±0·204	—0·02	—0·0016
Utiamau ,, .	54	67	1·62	±0·046	±0·243	+0·11	—0·0005
Imlia ,, .	60	65	17·83	±0·048	±0·255	—0·00	—0·0019
Masi ,, .	53	58	14·79	±0·062	±0·316	+0·25	+0·0083
Dadaura ,, .	54	62	3·51	±0·044	±0·227	—0·01	+0·0037
Manichauk ,, .	59	66	28·91	±0·038	±0·207	+0·17	—0·0023
Basadela ,, .	60	63	50·71	±0·032	±0·172	+0·03	—0·0021
Pathardi ,, .	47	60	56·11	±0·039	±0·196	+0·02	—0·0077
Ghaus ,, .	66	74	48·34	±0·044	±0·253	+0·16	—0·0061
Means .	54	64	..	..	±0·224	+0·05	—0·0014

The micrometer value used was 69·212 per revolution and was determined from observations to 203 star couples.

During the recess an investigation was undertaken with a view to ascertaining whether the condition known as isostasy exists in India. The method followed was that which has been used in the United States by Mr. J. F. Hayford.

The investigation involved the computation of the deflection of the plumb line in the meridian caused by visible masses up to a distance of 2,564 miles from about 106 selected latitude stations ; and for the same quantity in the prime vertical at 18 longitude stations.

To these deflections were then applied certain factors which gave the deflection which should be produced if isostatic compensation were complete down to a depth of 113 kilometers, which is the most probable depth Mr. Hayford obtained, as the result of his work in the United States. This gave what may be called the theoretical deflection of the plumb line based on certain assumptions as to the density of the earth as a whole, and of that of the crust. Having obtained the theoretical deflection it was compared with the actual one, or (A—G) for the station. The difference between the two gives the unaccounted-for deflection. If isostasy were complete down to the depth mentioned, and provided the assumed densities represent those which actually occur in nature, then the theoretical and actual deflection would be the same. The amount by which they differ would be a measure of the incompleteness of the isostatic state. But we are by no means certain that the assumed density ratio is correct; nor, indeed, that any one density is suitable for all places, or again that the density is uniformly distributed, as the formula assumes. These seem to me to be weaknesses inherent in all mathematical methods of treating puestions regarding the constitution of the earth's crust. We are attempting to apply invariable rules and methods to a subject where every variety of conditions may exist.

The formula for the deflection of the plumb line is the well-known one taken from Clarke's Geodesy :—$D = 12''{\cdot}44 \ \frac{\delta}{\Delta} h \, (\text{Sin } a^1 - \text{Sin } a_1) \text{ Log}_e \frac{r^1}{r_1}$. Where $\frac{\delta}{\Delta}$ is the ratio of the surface density to the mean density of the earth, h the mean height of the compartment above sea level, a^1 and a_1 the azimuths of the radial lines, and r^1 and r_1 the radii of the circles.

In order to simplify an otherwise very laborious computation Mr. Hayford adopted the following values :— $\frac{\delta}{\Delta} = \frac{2{\cdot}67}{5{\cdot}576} = \frac{1}{2{\cdot}09}$, $(\text{Sin } a^1 - \text{Sin } a_1) = 0{\cdot}25$, $\frac{r_1}{r_1} = 1{\cdot}426$. When these are substituted in the above formula, the deflection produced at the station by any compartment whose mean height is h becomes$=0{\cdot}0001000$ (h in feet); from this it follows that every hundred feet of height of compartment, above mean sea level, produces a deflection of $0''{\cdot}01$ at the station under consideration.

The boundaries of compartments were defined by lines drawn, to the proper scale, on sheets of transparent celluloid which were placed on the map. The mean height was then estimated, as near as it could be, from the information given on the map. In many cases the available information was very meagre, and the resultant mean height was consequently involved in some doubt. This, however, is due to a deficiency inherent in the available maps, and not in the system.

B.—PENDULUM OPERATIONS.

By Captain H. M. Cowie, R.E.

No. 14 (Late 23) Party.

Captain H. McC Cowie, R.E.
Mr. Hanuman Prasad.
3 Computers, etc.

The latitude observations in Central India had indicated the existence of a belt of relatively high density in the earth's crust. The limits of this belt, so far as could be gathered from the latitude results, ran on the north from about Ujjain through Cawnpore, eastwards, and in the south from Dhulia in Khandesh to Bilaspur and eastwards.

The gravity operations of the last two seasons have had in view the more precise location of the limits of the areas of high and low density, the collection of data, from which it was hoped conclusions might be drawn as to the nature of this belt of high density, whether it corresponded to any extent to the topographical configuration, whether it was, that is to say, visible, or whether it lay concealed below the surface.

The operations of 1908-09 dealt with the south-western portion of the belt, lying in the area Ujjain, Dhulia, Amraoti, Hoshangabad. In 1909-10 the region lying to the east of this was worked over, the stations being distributed over the districts of Saugor, Seoni, Bilaspur, Sultanpur, approximately between latitudes 21° and 26° and longitudes 79° and 83°.

The stations visited were :—

TABLE 1.

Station.	Latitude.	Longitude.	Height.
			Feet.
Saugor	23° 51′ 47″	78° 48′	1,757
Damoh	23° 49′ 54″	79° 26′	1,213
Katni	23° 50′ 25″	80° 26′	1,254
Umaria	23° 31′ 37″	80° 54′	1,499
Pendra	22° 46′ 41″	82° 0′	1,996
Bilaspur	22° 3′ 53″	82° 12′	878
Raipur	21° 13′ 56″	81° 41′	996
Amgaon	21° 21′ 31″	80° 28′	1,032
Seoni	22° 5′ 29″	79° 29′	2,032
Jubbulpore	23° 8′ 54″	79° 59′	1,467
Maihar	24° 15′ 38″	80° 48′	1,161
Allahabad	25° 25′ 55″	81° 55′	288

Saugor is situated on an extensive plateau, tolerably level, though broken here and there by low hills, distributed singly and in ranges. The country is mostly covered by trap beds, but in places are found inlying hills of Vindhyan formations. The general level is about 1,700 feet above sea with hills running up to some 300 or 400 feet higher. Damoh and Katni lie further to the east in country of much the same topographical aspect as that round Saugor though lower lying and less broken by hills. These two stations lie on Vindhyan beds, the trap in this region extending only a short distance east of Saugor. Umaria and Pendra are further to the south-east, just to the east of the Central Indian trap overflows. The former, on Vindhyan formations, in country very irregular in surface features and broken up, is over the Rewa State coal-fields. The latter in higher lying, rolling country, is near the high ground dividing the drainage areas of the Ganges, the Nerbudda and the Mahanadi. A short distance to the west lies the peak of Amarkantak, marking the eastern limit of the great trap overflow. Bilaspur and Raipur are both in plains to the south of the east Satpura highlands. Amgaon, to the north-west of Raipur, is on the southern fringe of the Satpuras, in generally open country interspersed with rocky outcrops. Seoni lies on the Satpura plateau which here forms a small upland surrounded by hills. Those to the south are generally peaked and much indented in outline, while those to the north, being trap, are usually flattened at the top or of straighter outline. Jubbulpore lies on a plain on the northern slopes of the Satpura high ground, in the Nerbudda valley. This plain is broken and diversified all round the horizon by single hills and small ranges, those to the south belonging generally to the trappean area of Central India. Maihar lies in the tract between the Gangetic plains and the Central Indian highland. The country slopes gently from south-west to north-east, the plain being broken occasionally by rocky hills.

At each of these stations a building with a pucca floor was available for the pendulum observatory. At some places however the rooms were small, and at others indifferently weatherproof, making the controlling of the temperature a matter of difficulty. At Umaria and Seoni the rooms were small, and at Saugor, Pendra and Seoni the protection against the sun's rays was not as perfect as could have been wished. In Table 2 are given the temperature variations during the hours of observations.

TABLE 2.

Station.	Night.		Day.		Mean.	
	Average temperature C.	Hourly change.	Average temperature C.	Hourly change.	Average temperature C.	Hourly change.
Dehra Dun, November 1909	21·60	+0·12	21·01	+0·23	21·31	+0·17
Saugor	21·42	+0·03	20·65	+0·25	21·04	+0·13
Damoh	20·63	+0·07	18·91	+0·29	19·77	+0·18
Katni	20·91	+0·15	20·46	+0·22	20·69	+0·19
Umaria	17·82	+0·02	16·27	+0·35	17·05	+0·18
Pendra	19·01	+0·11	18·85	+0·18	18·86	+0·15
Bilaspur	24·38	+0·09	23·86	+0·14	24·12	+0·12
Raipur	22·14	+0·11	21·91	0·00	22·03	+0·06
Amgaon	21·22	+0·19	20·58	+0·06	20·89	+0·12
Seoni	22·52	—0·15	19·53	+0·29	21·06	+0·07
Jubbulpore	23·82	—0·08	21·44	+0·17	22·63	+0·05
Maihar	25·70	+0·12	25·42	+0·20	25·57	+0·16
Allahabad	27·01	+0·03	26·60	+0·05	26·80	+0·04
Dehra Dun, April 1910	27·11	+0·04	27·24	+0·10	27·50	+0·07

Determinations of the flexure of the pendulum support were made, as usual, both before and after the series of observations at each station. The values of the correction ranged from 36·5 to 54·7. They are given in Table 3, and call for no special remark.

TABLE 3.

Station.	Date.	Observed flexure.	Adopted mean.	Station.	Date.	Observed flexure.	Adopted mean.
Dehra Dun	November 8	38·6		Bilaspur	January 10	48·2	
	13	37·8	38·2		14	45·4	
					15	46·2	46·8
Saugor	November 26	50·8					
	30	51·1	50·9	Amgaon	January 31	46·0	
					February 4	44·4	45·4
Damoh	December 4	42·7					
	9	42·3	42·5	Seoni	February 13	45·0	
					18	45·0	45·0
Katni	December 12	54·9					
	15	54·6	54·7	Jubbulpore	February 25	42·0	
					March 2	41·5	41·8
Umaria	December 19	37·4					
	23	38·6	38·0	Maihar	March 15	46·4	
					19	45·9	46·2
Pendra	December 30	54·3					
	January 4	49·8	52·1	Allahabad	March 25	44·3	
					31	45·5	44·8
Raipur*	January 20	39·3		Dehra Dun	April 20	38·2	
	24	38·8	39·1		25	34·2	36·5

The clock rate was determined by Mr. Hanuman Prasad, using the Bent Transit Instrument by Messrs. Troughton and Simms. The mean p. e. of a clock rate determined from observations on two successive nights was $\pm 0^s{\cdot}014$ and the mean p. e. of the rate derived from observations to one star on two successive nights was $\pm 0^s{\cdot}051$.

* As will be seen from the dates, this station came after Bilaspur.

In Table 4 are given the times of vibration of the four pendulums at Dehra Dun in November 1909 and in April 1910. The mean time of vibration was adopted for the reduction of the observations during the season.

TABLE 4.

Times of vibration of the four pendulums at Dehra Dun.

Date.	137	138	139	140	Mean.
1909					
Nov. 8—9	0·5072515	0·5074953	0·5071559	0·5070847	0·5072476
9—10	2546	4965	1575	0858	2486
10—11	2545	4975	1574	0869	2491
11—12	2549	4980	1566	0855	2488
Means	0·5072546	0·5074968	0·5071569	0·5070857	0·5072485
1910					
Apl. 20—21	0·5072587	0·5074972	0·5071578	0·5070843	0·5072495
21—22	2574	4967	1588	0864	2498
22—23	2563	4974	1577	0861	2494
Means	0·5072575	0·5074971	0·5071581	0·5070856	0·5072496
General means adopted for season.	0·5072561	0·5074969	0·5071575	0·5070857	0·5072491
Differences, Apl.—Nov.	+29	+3	+12	—1	+11

In the narrative report for 1908-09 attention was drawn to the gradual change which has been taking place in the mean pendulum since the commencement of operations in January 1904, the time of vibration slowly getting shorter. This change has been still operative during the period between the beginning of 1909 and the beginning of 1910. The mean time of vibration of the mean pendulum during the season 1908-09 was $0^{s}\cdot5072497$.

In Table 5 are shown the times of vibration of the mean pendulum at each of the stations visited, the differences from the time of vibration at Dehra Dun and the local values of g deduced therefrom. The adopted value of g at Dehra Dun, upon which the station values are based, is 979·063 dynes. This value was determined in the beginning of 1904 and is based on comparative observations made at Kew and Dehra Dun.

The mean p. e. of the time of vibration of the mean pendulum, as computed from the differences between individual values of this quantity and the station mean, is $\pm 1^{s}\cdot72 \times 10^{-7}$ which corresponds to about $\pm 0\cdot0007$ dynes.

TABLE 5.

Station.	Time of vibration.	Difference from Dehra.	Observed value of g.
	s.	s.	Dynes.
Dehra Dun	0·5072491	..	979·063
Saugor	0·5073350	0·0000859	978·731
Damoh	0·5073281	790	978·758
Katni	0·5073283	792	978·757
Umaria	0·5073327	836	978·740
Pendra	0·5073593	1102	978·638
Bilaspur	0·5073481	990	978·681
Raipur	0·5073659	1168	978·612
Amgaon	0·5073655	1164	978·614
Seoni	0·5073634	1143	978·622
Jubbulpore	0·5073381	890	978·719
Maihar	0·5073212	721	978·784
Allahabad	0·5072802	311	978·943

Table 6 shows for each station the observed value of g, the corrections for height and mass above sea level and the deduced value of g''_0 at sea level. γ_0 is the theoretical value of the same quantity derived from Helmert's 1884 formula.

$\gamma_0 = 978{\cdot}000\ (1 + 0{\cdot}005310 \sin^2\phi)$ where ϕ is the latitude of the point of observation.

TABLE 6.

Station.	Observed value of g.	Correction for Height.	Mass.	g''_0	γ_0	Difference. $g''_0 - \gamma_0$
	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.
Saugor	978·731	+0·164	—0·061	978·834	978·850	—0·016
Damoh	978·758	+0·113	—0·042	978·829	978·848	—0·019
Katni	978·757	+0·117	—0·044	978·830	978·848	—0·018
Umaria	978·740	+0·140	—0·050	978·830	978·827	+0·003
Pendra	978·638	+0·186	—0·070	978·754	978·778	—0·024
Bilaspur	978·681	+0·082	—0·030	978·733	978·733	0·000
Raipur	978·612	+0·093	—0·035	978·670	978·681	—0·011
Amgaon	978·614	+0·096	—0·036	978·674	978·689	—0·015
Seoni	978·622	+0·189	—0·067	978·744	978·735	+0·009
Jubbulpore	978·719	+0·137	—0·051	978·806	978·803	+0·003
Maihar	978·784	+0·108	—0·041	978·851	978·877	—0·026
Allahabad	978·943	+0·027	—0·010	978·960	978·958	+0·002

Combining the values of $g''_0 - \gamma_0$ with those of the previous year, determined in the tract to the west of that now considered, and arranging stations according to height above sea level, we get the following series:—

Station.	Height.	$g''_0 - \gamma_0$
	Feet.	Dynes.
Mortakka	576	—0·006
Jalgaon	760	+0·012
Bilaspur	878	0·000
Mukhtiara	926	—0·035
Raipur	996	—0·011
Hoshangabad	1,002	+0·004
Khandwa	1,014	+0·038
Amgaon	1,032	—0·015
Amraoti	1,123	+0·010
Maihar	1,161	—0·026
Damoh	1,213	—0·019
Katni	1,254	—0·018
Shahpur	1,284	—0·005
Ellichpur	1,314	+0·009
Jubbulpore	1,467	+0·003
Umaria	1,499	+0·003
Ujjain	1,612	—0·031
Saugor	1,757	—0·016
Mhow	1,903	—0·033
Pendra	1,996	—0·024
Seoni	2,032	+0·009
Asirgarh	2,077	+0·017
Badnur	2,103	+0·006

It is difficult to form any connection between these values of $g''_0 - \gamma_0$ and either the altitude or the geological formation of the country concerned.

Damoh (—19), Ujjain (—31), Mhow (—33), Saugor (—16), Pendra (—24) may all be described as situated in high-lying, rolling country; Mortakka (—6) and Mukhtiara (—35) in a narrow valley and Jalgaon (+12) and Hoshangabad (+4) in wider valleys. Asirgarh (+17), Seoni (+9) and Badnur (+6) all lie over the main mass of the Satpuras ; Khandwa (+38), Jubbulpore (+3), Shahpur (—5) on the lower Satpura plateaux ; and Katni (—18), Umaria (+3), Amgaon (—15) and Maihar (—26) are on the fringe of high ground. Bilaspur (0), Raipur (—11), Amraoti (+10) and Ellichpur (+9) lie in plains to the south of the Satpura mass.

The first group of stations in high-lying country certainly all show negative results. Four of these stations are situated north of the line of the Nerbudda. If we go south of the Nerbudda, we find a tendency to positive results at places also in high ground. Along the fringe of the highland and in plains to the south the values of $g''_{o}—\gamma_{o}$ are of an indeterminate character, ranging from +10 to —24.

In these two paragraphs the values of $g''_{o}—\gamma_{o}$ are given in brackets in units of the third decimal place of a dyne.

We find greater discordances when we turn to the main geological conditions. Ujjain (—31) and Mhow (—33) lie on trap beds, on the centre of a large overflow. Khandwa (+38) and Asirgarh (+17) are also on the trap. Jalgaon (+12), Badnur (+6) and Seoni (+9) are on the edge of the trap, as are Mortakka (—6), Saugor (—16) and Pendra (—24). Umaria (+3) lies on Gondwana formations, just off the trap, so does Shahpur (—5). Jubbulpore (+3) is just off the trap, and Raipur (—11), Bilaspur (0) and Amgaon (—15) are on similar formations, though the latter are further from the trap.

A glance at the map, however, shows that there is a tendency for the results, positive and negative, to group themselves. Ujjain, Mhow, Mukhtiara and Mortakka all fall together forming a group of negative values. Saugor, Damoh, Katni and Maihar form a second, while Amgaon, Raipur and Pendra with 0 at Bilaspur constitute a third. Between the first two negative clusters and the third stretches a belt of positive values with one anomalous negative at Shahpur.

A further investigation of the results of the Pendulum observations in India has been commenced under the hypothesis, recently put forward by Mr. Hayford of the United States Coast and Geodetic Survey, that isostatic compensation exists within a probable depth of about 70 miles.

This investigation has been applied to 42 of the Pendulum stations, but so far the effect of the topography and its compensation has only been computed up to a radius of 100 miles from each. These partial results do not show any greater accordance with the observed facts than does the uncompensated Bouguer reduction up to a similar radius : as, however, Mr. Hayford has shown that large effects may be produced by regions lying outside the 100 mile radius, it is necessary to apply his system in its entirety, to at least a few selected stations, before we can form any definite idea of the applicability of his hypothesis to India.

V.—Magnetic Survey.

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

No. 18 Party.

Captain R. H. Thomas, R.E., in charge up to 30th June 1910.

Captain H. J. Couchman, R.E., in charge from 1st July 1910.

Lieutenant H. T. Morshead, R.E., from 8th November 1909.

Messrs. E. C. J. Bond, H. P. D. Morton, R. P. Ray, N. R. Mazumdar, R. B. Mathur.

19 Recorders, etc.

The present report deals with the work of the magnetic survey in 1909-10.

The report is divided into three main heads as follows :—

I. An account of the operations in the field and recess quarters, with a table of the preliminary values of the magnetic elements at field and repeat stations in 1909-10, and an index chart showing the positions of all stations of observation to date.

Note.—For convenience of reference the table and index chart are placed at the end of Part III.

II. A note on the working of the magnetic observatories in the survey year 1909-10.

III. Tables of results at the magnetic observatories in 1909.

I.—FIELD OPERATIONS AND RECESS WORK IN 1909-10.

1. WORK OF THE FIELD DETACHMENTS.
2. WORK OF THE IMPERIAL OFFICERS.
3. WORK DURING RECESS.
   - SECULAR CHANGE IN H. F.
   - DIURNAL RANGE IN H. F. IN SOUTH INDIA.
   - H. F. BASE LINES AND INSTRUMENTAL DIFFERENCES IN H. F.
4. VALUES OF DISTRIBUTION COEFFICIENTS IN 1909-10.
5. PROGRAMME OF WORK FOR 1910-11.
6. RESULTS PUBLISHED IN THIS REPORT.

1. *Work of the field detachments.*—The field season opened on October 25th 1909, and closed at the end of April 1910.

Four field detachments were employed during the year, under Messrs. Bond, Morton, Ray and R. B. Mathur. The first two re-observed at nearly all the old field stations in the area lying between Lat. 16°—19° and Long. 73°—78° in order to investigate the abnormal secular change in H. F. found at four re-occupied field stations in this locality. Both observers also surveyed several small areas in detail, and Mr. Morton observed at three new stations on the Nagda-Muttra Railway, and took the usual comparative observations at the Alibag Observatory.

Mr. Ray's detachment was employed on detail survey in Central India, two or three areas being dealt with. That under Mr. R. B. Mathur worked along the outer ranges of the Himalaya from Naini Tal to Dharmsala.

Time did not admit of the magnetic survey of the Andaman and Nicobar Islands. It is, however, intended to do this during the coming field season.

The number of new stations of the preliminary survey occupied was 69, of detail survey stations 71, while 100 old stations were re-occupied including those visited by the Imperial officers.

The total number of stations of the preliminary survey to date is 1,330.

2. *Work of the Imperial officers.*—Two Imperial officers were available throughout the year.

The four observatories were inspected and comparative observations made at each. All the repeat stations were visited with the exception of Port Blair (time not being available for this), and in addition observations were made at several old field stations. Lieutenant Morshead, R.E., made half-hourly observations of H. F. at Tuticorin for 4 days in January 1910 to investigate the apparent rapid increase in diurnal variation in South India. These observations are referred to elsewhere in this report.

3. *Work during recess.*—The party was inspected by the Superintendent, Trigonometrical Surveys, during June 1910.

The computation of the previous season's field work and the reduction and tabulation of the base station results for 1909 have been completed.

Secular change in H. F.

No time has been available to investigate in detail the secular change found from the field stations re-occupied during the past field season, but a cursory inspection of the values found in the abnormal area mentioned in 1 above seems to show that the agreement between the values at the 4 field stations previously occupied is a coincidence. These values were —54γ and —58γ at Kirkee and Dhond and —34γ and —31γ at Kolhapur and Miraj, and it seemed that in this area the horizontal force was decreasing rapidly. This has not been borne out by the detailed examination of the area. Positive and negative values of secular change are equally common and of amounts varying from 0 to 100γ. The reason seems to be that owing to a lack of sufficient details it is often impossible to identify the old site within several feet. The whole country is composed of Deccan trap,—a magnetic rock, which often occurs on the surface,—and a change of 10 feet in the position of the station may alter the value of H. F. by 100 or 200γ. The values originally found are thus not comparable with the later ones and the secular change cannot be deduced with any degree of accuracy.

The remedy is, of course, to mark certain selected field stations permanently, and this will be done during the ensuing field season. This procedure was adopted for the repeat stations, and though in a few cases the marks have disappeared, it is significant that the values of secular change in H. F. found from them show a progressive and fairly regular change over the whole of India, though owing to the variation in secular change being large (—40γ in Quetta to +40γ in South Burma) the number of repeat stations is insufficient and it is essential to obtain further values.

Diurnal range in H. F. in South India.

In Part I, page 7, of last year's narrative report mention was made of the intention to take half-hourly observations of H. F. at Tuticorin to determine whether the increase in diurnal range was more rapid in low magnetic latitudes than elsewhere.

The observations at Trichinopoly made in January 1909 showed that the range there was about 8γ less than in Kodaikanal, and this difference was greater than would be expected.

In January 1910, therefore, Lieutenant Morshead, R.E., made half-hourly observations from 8 A.M. to 4 P.M. on 4 days at Tuticorin, Lat. 8° 48′ and obtained a diurnal range from 8 A.M. (minimum) to 11 A.M. (maximum) of 48γ. The range between the same hours of the same 4 days at Kodaikanal (Lat. 10° 14′) was 43γ. It seems fairly clear that Kodaikanal is not abnormal, and also that though the diurnal range does probably increase more rapidly in South India, the assumed linear relation between this range and latitude is sufficiently correct.

H. F. base lines and instrumental differences in H. F.

During practically the whole of the recess season, the Imperial officers have been engaged on the investigation of the instrumental differences in H. F. of the field and observatory magnetometers from the survey standard at Dehra Dun.

As it was thought that the changes in these differences as published in the narrative report of 1907-08 might be eliminated by using the second distribution coefficient, or "Q term," in the expression $(1 + \frac{P}{r^2} + \frac{Q}{r^4} + \ldots)^{-1}$, this term was computed for all magnets by the formulæ given in last year's report. With these new distribution coefficients the base lines of the magnetographs were recomputed and also the values of H. F. as obtained with the different magnetometers at the times of comparison.

The initial difficulty was to decide when, if ever, changes in P and Q occurred. Such changes were usually looked for when there was an apparent change in m_0, in order to determine whether this change was real, or could be eliminated by using different values of P and Q before and after the apparent change. In practically no case could an assumed change in the distribution coefficient be substantiated, for a sudden change in the base line would be found which could be avoided by keeping P and Q constant and assuming a real change in m_0.

Some evidence of real instrumental change has, however, been found when a large drop, of 2 or 3 C. G. S. units, in m_0 has occurred, and though this change has not been eliminated by using new values of P and Q, such new values have occasionally been taken and the change in the base line corrected for. An actual instance will elucidate this point. In May 1908 the moment of the Dehra Dun standard magnet dropped from 911·2 C. G. S. to 894·2 C. G. S.; the value of the distribution coefficient used before the change was $\bar{1}$·99315 while the mean of subsequent observations was $\bar{1}$·99332. If no *real* instrumental change had occurred at this point this change of P and Q would have produced a fall of 6γ in the base line: actually, however, the recomputed base line rose suddenly by about 18γ and the comparisons of the field instruments with the standard showed a similar change, as the following table will show :—

Magnet. (1)	October 1907. (2)	May 1908. (3)	Change (3)—(2).
17—2	—68	—53	+15
17—3	—23	+3	+26
17—5	—23	—2	+21
17—6	—28	—4	+24
			Mean +22

(NOTE.—Magnets Nos. 4 and 10 were compared just before this large drop in the moment of 17 and do not show this change.)

This shows that the apparent rise in the base line is due to a real change in the magnetometer magnet and not merely in the magnetograph, and it is therefore necessary to correct values of H. F. subsequent to May 1908 by the amount of this instrumental change. It appears, however, that this change is not a permanent one, for the instrumental comparisons in October 1908 tend to show that the standard magnet had recovered itself. These comparisons are shown below :—

Magnet. (1)	May 1908. (2)	October 1908. (3)	Change (3) – (2).
17—2	—53	—79	—26
17—3	+3	—22	—25
17—5	—2	—31	—29
17—6	—4	—36	—32
			Mean —23

It will be noticed that the mean change of No. 17 from October 1907 to October 1908 as shown by the comparisons is —6γ, precisely the same amount as that produced by the substitution of a new distribution coefficient. It would thus appear—

(1) that no real change of P and Q occurred in May 1908 ;

(2) that an instrumental change of about 25γ took place when the moment of No. 17 fell suddenly in May 1908 followed by a recovery which was complete before October 1908.

Evidence of the truth of (2) is found in the comparisons of the Kodaikanal magnet No. 16 with No. 17 ; these showed that the difference 17—16 in December 1907 was —28γ and in January 1909 —31γ. Thus indicating that if any change in No. 17 occurred in May 1908 the magnet had recovered itself by January 1909.

Other instances of instrumental change taking place when the moment falls suddenly occur at Barrackpore in November 1906 and at Kodaikanal in May 1909. The latter is too recent to admit of any evidence of subsequent recovery, but in Barrackpore the change seems to have been permanent and of about +20γ in magnitude. In the narrative report of 1907-08, page 14, it will be noticed that the H. F. in Barrackpore rose 20γ between December 1906 and January 1907. This rise occurred at no other observatory and always seemed doubtful, but it is now seen to be due to an instrumental change in the magnet and can be confidently corrected for.

Apart from these sudden changes coincident with a drop in moment there seems little evidence that P and Q have altered appreciably in any of the observatory magnets. The case of the field magnets is more difficult, as we have no such good test of their invariability as is given by the base lines in the case of the observatory magnets.

The practice has been to compute the distribution coefficient from 3 or 4 months' observations, and when this value differs largely from the previous mean, it has been used in a preliminary computation of m and H. Such cases are rare and in view of the apparent constancy of the observatory magnets it seems probable that these changes are not real. The differences of all magnets from the standard have been recomputed, but the values obtained cannot as yet be considered final.

It is believed, however, that the values of the base lines now obtained are correct as these have been subjected to a rigid examination by plotting the mean values of H. F. in each month, obtained from the 'quiet' days, and comparing the results of the different observatories. The agreement is quite satisfactory and the annual variation in force shows a great similarity.

These base lines show distinct signs of annual variation, especially in the case of Barrackpore. In each year there is a fall in November and December followed by a rise in February and March, and it is unfortunate that these rapid changes should occur during the field season when it is important to know the value of the base line on each day in which a field observation has been made, in order to correct for disturbance.

During this general recomputation of base lines and instrumental differences several cases of personal error have been noticed. The clearest of these was at Kodaikanal in 1908 when the permanent observer proceeded on three months' leave and another carried out his duties during this period. Immediately after this change of observers, the moment of the magnet dropped 0·46 C. G. S. units and the base line 19γ, both returning to their previous values when the permanent observer resumed his duties. To ensure continuity of record it is, of course, necessary to allow for this personal error though it is difficult to find a reason for it. Similar cases have occurred when the field instruments have changed hands (in one case a difference of nearly 30γ was found), but these can be easily allowed for in the instrumental differences.

4. *Values of distribution coefficients in 1909-10.*—The table below gives the values of $P_{1\cdot2}$ and $P_{2\cdot3}$ for the field magnets in the season 1909-10. No. 10S is the ordinary short magnet of No. 10 magnetometer bearing the same proportion to the deflecting magnet $\frac{1}{1\cdot40}$ as do the other deflected magnets, while 10K is somewhat longer being $\frac{1}{1\cdot23}$ of the long magnet. The distribution factor $(1-\frac{P_{1\cdot2}}{r^2})$ has been used to obtain the values of H given in the abstract at the end of this report, and the correction on account of the Q term to these and all other published values of H will be made subsequently.

No. of magnet.	P from 22·5 and 30 cms.					P from 30 and 40 cms.					Remarks.
	Mean from all observations.	Adopted mean value.	Total number of observations.	Number of rejected observations.	Number of observations used in finding mean.	Mean from all observations.	Adopted mean value.	Total number of observations.	Number of rejected observations.	Number of observations used in finding mean.	
2A	7·45	7·50	80	16	64	9·70	9·75	158	39	119	
3A	6·19	6·20	66	3	63	7·27	7·32	71	15	56	
4A	7·55	7·55	91	1	90	8·68	8·63	113	18	95	
5A	7·22	7·22	59	1	58	8·06	8·10	67	13	54	
6A	7·84	7·83	79	1	78	8·01	8·01	89	13	76	
6A	8·01	8·01	6	..	6	6·62	6·62	12	..	12	At Alibag.
10	5·40	5·49	84	4	80	7·38	7·41	74	14	60	Magnet 10 S suspended.
10	—4·89	—4·87	50	2	48	—2·72	—2·57	48	16	32	Magnet 10 K suspended.

It has been mentioned in a previous report that the mean value of force on one quiet day often differs largely from that of another, and consequently where these days are not the same in any month for all observatories the mean values of force are not comparable, and there would be difficulty in deducing the annual variation. This is now being remedied. The selection of "quiet days" common to all the observatories has been made and these are now being measured and tabulated, but owing to missing or defective traces it has been most difficult to find 5 suitable quiet days common to all observatories, and in some cases 4 (and occasionally 3) days are being used.

6. *Results published in the report.*—A table showing the approximate values (uncorrected) of the magnetic elements at the field and repeat stations is appended, together with an index chart showing all stations of observation and areas surveyed in detail to date. The tabulation of the results obtained at the four observatories are published for 1909.

II.—THE MAGNETIC OBSERVATORIES IN 1909-10.

A.—DEHRA DUN OBSERVATORY.
B.—BARRACKPORE ,,
C.—TOUNGOO ,,
D.—KODAIKANAL ,,

A.—DEHRA DUN OBSERVATORY.

1. GENERAL REMARKS ON WORKING.
2. MEAN VALUES OF H. F. AND DECLINATION CONSTANTS.
3. MEAN VALUES OF BASE LINES.
4. MEAN SCALE VALUE AND TEMPERATURE RANGE.
5. MEAN MONTHLY VALUES OF MAGNETIC ELEMENT IN 1909 AND SECULAR CHANGE, 1908-09.

1. *General remarks on working.*—The observatory remained in charge of Surveyor K. K. Dutta.

The magnetographs have given good results throughout the year. The H. F. instrument has been opened twice to remedy small defects in November 1909 and June 1910. Some slight interference was observed in the declination instrument in December; this was removed by giving the magnet a large deflection.

The V. F. magnetograph had, as usual, to be opened several times for cleaning and balancing. On one of these occasions some minute insects found their way inside and great difficulty was experienced in removing them.

The underground room was kept fairly dry in spite of the heavy rains. In the middle of August, the surrounding passage was flooded to a depth of 3 feet, but the water was kept out of the magnetograph room by raising the barrier at the door.

The walls and floor are now to be plastered with Portland cement to prevent the percolation of subsoil water, and it is hoped that this will prove successful.

2. *Mean values of H. F. and declination constants.*—The following table gives the monthly mean values of the magnetic collimation, the distribution coefficients $P_{1 \cdot 2}$ and $P_{2 \cdot 3}$, and the moment m_0 of the magnet No. 17 during 1909:—

Mean values of the constants of the magnetometer No. 17 in 1909.

Months.	DECLINATION CONSTANTS.	H. F. CONSTANTS.				Mean M.	M. accepted.	REMARKS.
		MEAN VALUES OF P'S.						
	Mean magnetic collimation.	$P_{1\cdot2}$	$P_{2\cdot3}$	$P_{1\cdot2}$ accepted.	$P_{2\cdot3}$ accepted.			
January	—9': 32"	7·14	7·88	7·23 throughout.	8·06 throughout.	894·32	894·57	
February	: 29"	7·12	7·71			894·46	894·57	
March	32"	7·21	8·26			894·05 894·56(1)	894·57	(1) By chronograph.
April	: 31"	7·23	8·17			894·25	894·57	
May	: 28"	7·21	8·15			893·94	894·57	
June	: 29"	7·29	8·06			894·14	894·57	
July	: 30"	7 26	8·35			894·15	894·57	
August	: 30"	7·31	8·09			894·44 894·58(1)	894·57	
September	: 30"	7·25	8·03			894·41 894·58(1)	894·57	
October	: 30"	7·26	7·96			894·29	894·57	
November	: 30"	7·25	7·93			893·83(2) 893·41(3)	893·83(2) 893·41(3)	(2) To 12th. (3) 15th to 30th.
December	: 27"	7·14	8·17			893·30	893·30	

3. *Mean values of base lines.*—The table below gives the mean values of the H. F. and declination base lines actually used to obtain the values of force, etc., given in the tables at the end of this report. These are not the latest values (using the Q term) found during this recess. The V. F. base lines are not shown, as there have been frequent changes.

The abstract of the base line value of magnetograph at Dehra Dun Observatory in 1909.

Months.	DECLINATION.		REMARKS.	HORIZONTAL FORCE.		REMARKS.
	Mean value of base line.	Base line accepted.		Mean value of base line.	Base line accepted.	
January	1° : 41'·0	..	..	·33032	..	
February	40'·9	..	..	·33032	..	
March	40'·9	..	..	·33034	..	
April	40'·9	..	..	·33030	..	
May	40'·5	..	..	·33034	..	
June	40'·7	..	..	·33035	..	
July	40'·8	..	..	·33032	..	
August	40'·8	..	To 12th	·33034	..	To 11th.
September	43'·1 43'·5	..	From 14th To 22nd.	·33092 ·33084 ·33080	.. .. ..	14th to 16th. 17th to 22nd. 23rd to 30th.
October	43'·9	..	From 26th	·33075 ·33067	.. ..	1st to 13th. 16th to 30th.
November	44'·0	..	..	·33075 ·33116 ·33034 ·32971	.. ..	1st to 12th. 15th to 19th. 24th to 25th. 27th to 29th.
December	44'·2	..	..	·33022	..	30th Nov. to end.

4. *Mean scale value and temperature range.*—The mean scale value of the H. F. magnetograph up to August 1909 was 4·11γ for an ordinate of 0·04″. After the re-erection in September the scale value fell to 4·06γ and remained so up to November 21st, when, the instrument being opened and the torsion head turned, the value rose to 4·10. The mean temperature of the H. F. magnetograph was 27°·25 C. with a maximum of 27°·43 in July and a minimum of 26°·90 in February.

The scale value of the V. F. instrument varied from 4·39 to 5·15. The mean temperature was 80°·32 F., the maximum 80°·87 occurring in July and the minimum 79°·46 in February.

The temperatures of reduction are 27° C. and 81° F. respectively.

5. *Mean monthly values and secular change.*—The following table gives the mean monthly values of the magnetic element in 1909 with the secular change for 1908-09 deduced therefrom. It will be observed that the great magnetic storm of September 25th, 1909, lowered the value of H. F. greatly, this being the usual result.

Secular change at Dehra Dun, 1908-09.

Months.	Horizontal Force ·33000 C. G. S. +			Declination E. 2° +			Dip N. 43° +			Vertical Force ·31000 C. G. S. +			Remarks.
	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ	
January	306	278	—28	37·4	36·0	—1·4	38·7	45·1	+6·4	767	859	+92	The values in 1909 are means of 4 days only.
February	303	286	—17	37·5	35·8	1·7	30·5	45·7	6·2	779	876	97	Ditto.
March	290	277	—22	37·2	35·6	1·6	40·1	45·0	5·8	785	872	87	
April	292	297	+5	37·2	35·0	2·2	41·6	45·4	3·8	807	883	76	
May	297	290	—7	37·0	34·8	2·2	41·8	46·3	4·5	815	893	78	
June	296	296	±0	36·4	34·6	1·8	42·5	46·6	4·1	828	903	75	
July	300	293	—7	36·1	34·7	1·4	42·1	46·7	4·6	824	902	78	
August	296	292	—4	36·0	34·4	1·6	42·8	46·8	4·0	833	902	69	The values in 1909 are from 2 days only.
September	273	265	—8	36·5	34·1	2·4	44·1	51·2	7·1	836	959	123	The values in 1909 are from 3 day only.
October	280	234	—46	36·3	34·6	1·7	44·3	52·3	8·0	845	951	106	The values in 1909 are means of 4 days only.
November	283	246	—37	36·5	34·3	2·2	45·0	51·5	6·5	861	946	85	
December	286	258	—28	36·3	33·2	3·1	44·3	51·9	7·6	850	965	115	
Mean	293	276	—17	36·7	34·8	—1·9	42·2	48·0	+5·7	819	909	+90	

B.—Barrackpore Observatory.

1. General Remarks on Working.
2. Mean values of H. F. and declination constants.
3. Mean values of base lines.
4. Mean scale value and temperature range.
5. Mean monthly values of magnetic elements in 1909 and secular change, 1908-09.

---

1. *General remarks on working.*—The observatory remained in charge of K. N. Mukerji throughout the year.

The V. F. instrument had to be opened several times for cleaning and balancing, but otherwise the instruments worked satisfactorily.

2. *Mean values of constants.*—The following table gives the monthly mean values of the magnetic collimation, the distribution coefficients $P_{1 \cdot 2}$ and $P_{2 \cdot 3}$ and the moment m_0 of the magnet No. 20 during 1909 :—

Mean values of the constants of the magnetometer No. 29 in 1909.

Months.	DECLINATION CONSTANTS.	H. F. CONSTANTS.						REMARKS.
		MEAN VALUES OF P'S.						
	Mean magnetic collimation.	P_1's	P_2's	P_1's accepted.	P_2's accepted.	Mean M.	M accepted.	
January . . .	—7′ 10″ (1) —7′ 57″ (2)	0·57 (1) 6·34 (2)	7·94 (1) 7·82 (2)	0·76 (1) 6·44 (2)	8·00 (1) 7·87 (2)	948·86 (1) 940·81 (2)	948·88 (1) 940·81 (2)	(1) Till 19th. (2) From 21st.
February . . .	—7′ 53″	0·43	7·82	0·44	7·87	940·65	940·60	
March . . .	—7′ 53″	0·47	8·09	6·44	7·87	940·68	040·66	
April . . .	—7′ 53″	0·43	7·86	0·44	7·87	940·61 (3) 940·47 (4)	040·60(3) 040·48(4)	(3) 3rd to 11th. (4) 15th to 28th.
May . . .	—7′ 55″	6·42	7·82	0·44	7·87	940·50	940·48	
June . . .	—7′ 53″	0·40	7·87	0·44	7·87	040·37 (5) 040·27 (6)	940·37 (5) 040·28 (6)	(5) To 9th. (6) From 12th.
July . . .	—7′ 56″	6·41 (7)	7·77 (7)	6·44 (7)	7·87 (7)	040·28 (7) 040·30 (8)	040·28 (7) 040·25 (8)	(7) To 21st. (8) From 24th.
August . .	—7′ 57″	0·41 (9)	7·73 (9)	6·42 (9)	7·77 (9)	940·31 (9)	940·25 (9)	(9) From 24th July.
September . .	—7′ 58″	6·44 (10)	7·83(10)	6·42 (10)	7·77 (10)	040·20 (10)	040·25 (10)	(10) To 3rd October.
October . . .	—7′ 56″	6·41 (11)	7·08(11)	6·41 (11)	7·08 (11)	040·37 (11) 930·07 (12)	040·37 (11) 030·07 (12)	(11) 9th to 16th. (12) From 20th.
November. . .	—7′ 50″	6·50 (12)	7·60(12)	0·06 (12)	7·09 (12)	930·04	030·04	
December . .	—7′ 51″	6·73	7·69	0·06	7·69	040·01 (13) 940·36 (14)	939·04 (13) 040·36 (14)	(13) To 9th. (14) From 15th.

3. *Mean values of base lines.*—The table below gives the mean monthly base lines of the H. F. and declination magnetographs actually used. Those of the V. F. are not shown.

The abstract of base line value of magnetograph at Barrackpore Observatory in 1909.

Months.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of base line.	Base line accepted.	REMARKS.	Mean value of base line.	Base line accepted.	REMARKS.
January .	—0°: 4′·5	—0°: 4′·6	..	·37073	·37073	The moment of the magnet fell from 948·88 to 940·81 on 19th January, so the value of February was uncertain. The base line for that month is therefore rejected. *a* = uniform change of base line.
February .	4′·7	4′·6	..	57	69	
March .	4′·7	4′·6	..	65	65	
April . .	4′·5	4′·6	..	68	68 *a*	
May . .	4′·7	4′·6	..	74	74 *a*	
June . .	4′·6	4′·6	..	69	69	
July . .	4′·6	4′·6	..	71	71	
August .	4′·6	4′·6	..	68	68	
September .	4′·7	4′·6	..	70	70	
October .	4′·7	4′·6	..	66	66 *a*	
November .	4′·7	4′·6	..	58	58	
December .	4′·9	4′·9	..	60	60	

4. *Mean scale values and temperature range.*—The mean scale values of the H. F. and V. F. instruments were 4·86γ and 4·53γ respectively, the limiting values being 4·85 and 4·89 in the first case and 4·50 and 4·56 in the second.

The mean temperatures of the H. F. and V. F. instruments were 31°·60 C. and 89°·26 F. respectively with maxima of 33°·21 C. and 92°·03 F. in December and minima of 28°·83 C. and 84°·08 F. in January.

The temperatures of reduction are 31°C and 89°F.

5. *Mean monthly values and secular change.*—The following table gives the mean monthly values of the magnetic elements in 1909 with the secular change for 1908-09 deduced therefrom.

Secular change at Barrackpore in 1908-09.

Months.	Horizontal Force ·37000 C. G. S. +			Declination E. 0°+			Dip N. 30° +			Vertical Force ·22000 C. G. S.			Remarks.
	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	
	γ	γ	γ	′	′	′	′	′	′	C.G.S.	C.G.S.	C.G.S.	
January . .	301	301	..	67·0	62·9	—4·7	32·0	30·8	+4·8	..	71	+71	The values in 1909 are means of 4 days only.
February . .	305	307	+2	07·4	62·5	4·9	33·0	30·0	3·6	17	72	55	Ditto.
March . .	306	295	—11	66·8	62·2	4·6	32·9	37·5	4·6	18	78	60	
April . .	293	315	+22	66·4	61·6	4·8	34·6	37·0	2·4	34	82	48	
May . .	301	309	+8	66·4	61·1	5·3	34·2	37·6	3·4	34	88	54	
June . .	300	310	+10	65·7	60·9	4·8	34·5	38·1	3·6	38	96	58	
July . .	301	308	+7	65·6	60·6	5·0	34·3	38·7	4·4	34	103	69	
August . .	294	303	+9	65·1	60·2	4·9	35·1	39·1	4·0	42	106	64	
September .	275	291	+16	64·8	59·8	5·0	36·1	40·4	4·3	45	118	73	
October . .	294	261	—33	64·3	59·7	4·6	35·8	42·0	6·2	53	123	70	Ditto.
November. .	299	293	—6	63·8	59·2	4·6	36·4	40·3	3·9	64	117	53	
December .	308	302	—6	63·6	58·2	5·4	36·3	40·8	4·5	68	130	62	
Means . .	298	300	+2	65·6	60·7	—4·9	34·6	38·7	+4·1	37	99	+61	

C.—TOUNGOO OBSERVATORY.

1. GENERAL REMARKS ON WORKING.
2. MEAN VALUES OF H. F. AND DECLINATION CONSTANTS.
3. MEAN VALUES OF BASE LINES.
4. MEAN SCALE VALUE AND TEMPERATURE RANGE.
5. MEAN MONTHLY VALUES OF MAGNETIC ELEMENTS IN 1909 AND SECULAR CHANGE, 1908-09.

1. *General remarks on working.*—The observatory remained in charge of Shri Dhar throughout the year.

With the usual exception of the V. F. instrument the magnetographs gave good results throughout the year.

2. *Mean values of H. F. and Declination Constants.*—The following table gives the monthly mean values of the magnetic collimation and distribution coefficients $P_{1\cdot 2}$ and $P_{2\cdot 3}$ and the moment m_0 of the magnet No. 19A during 1909 :—

Mean value of the constants of the magnetometer No. 19 with magnet 19A in 1909.

Months.	DECLINATION CONSTANTS. Mean magnetic collimation.	H. F. CONSTANTS. MEAN VALUES OF P'S. $P_{1\cdot2}$	$P_{2\cdot3}$	$P_{1\cdot2}$ accepted.	$P_{2\cdot3}$ accepted.	Mean M.	REMARKS.
January	—1′:17″	8·67	9·25	8·56 throughout.	9·32 throughout.	899·55 (1) 899·46 (2)	(1) To 14th. (2) From 16th to February 17th.
February	16″	8·63	9·36			899·24 (3)	(3) From 20th
March	32″	8·63	9·14			899·02 (4) 898·83 (5)	(4) To 13th. (5) From 17th.
April	26″	8·53	9·29			898·67 (6) 898·51 (7)	(6) To 14th. (7) From 17th.
May	11″	8·58	9·11			898·32 (8) 898·11 (9)	(8) To 19th. (9) From 22nd to June 12th.
June	28″	8·52	9·29			897·94 (10)	(10) From 16th.
July	20″	8·57	9·27			897·72 (11) 897·64 (12)	(11) To 14th. (12) From 17th.
August	19″	8·47	9·49			897·47 (13) 897·41 (14)	(13) To 14th. (14) From 18th to September 8th.
September	23″	8·52	9·30			897·20 (15) 896·98 (16)	(15) From 11th to 25th. (16) From 29th to October 13th.
October	18″	8·54	9·44			896·77 (17)	(17) From 16th to November 17th.
November	18″	8·60	9·42			896·45 (18)	(18) From 20th to December 8th.
December	18″	8·54	9·46			896·34 (19)	(19) From 11th to 29th.

3. *Mean values of base lines.*—The table below gives the mean monthly base lines of the H. F. and declination magnetographs actually used. Those of the V. F. are not shown.

The observed values of the declination base line have varied considerably, but these changes do not appear to be real, for no sudden slips have been noticed in the magnetograms when the base line has appeared to alter by 2′. During the inspection of the observatory by the officer in charge it was noticed that the clamping screw of the wooden box was loose in its hold, and after this was tightened the base lines remained steady for some months. It appears therefore that the magnetometer was at fault, and as, from the comparative observations in December 1908 and 1909, the base lines computed with No. 10 instrument showed no appreciable change, a constant value has been assumed for the whole of 1909.

The magnetometer will be carefully examined when the observatory is next inspected.

The abstract of the base line value of the magnetograph at Toungoo in 1909.

Months.	DECLINATION.	HORIZONTAL FORCE.		REMARKS.
	Accepted base line.	Observed base line with 19A.	Accepted base line reduced to 19.	
January	—0°: 9'.1 throughout.	·38506	·38485	
February		503	482	
March		501	480	
April		498	477	
May		496	475	a=base line assumed to be changing uniformly.
June		495	a	
July		488	467	
August		488	467	
September		488	a	
October		481	460	
November		481	460	
December		481	460	

4. *Mean scale value and temperature range.*—The mean scale value of the H. F. instrument was 5·41 γ with limiting values of 5·39 and 5·43. That of the V. F. varied from 5·19 to 5·40.

The mean temperatures were 89°·08 F. and 88°·69 F. for the H. F. and V. F. magnetographs respectively with maxima of 89°·36 and 89°·07 in April and minima of 89°·00 and 88°·28 in December.

The temperature of reduction is 89° F. in both cases.

5. *Mean monthly values and secular change.*—The following table gives the mean monthly values of the magnetic elements in 1909 with the secular change for 1908-09 deduced therefrom :—

Secular change at Toungoo in 1908-09.

Months.	HORIZONTAL FORCE ·38000 C. G. S. +			DECLINATION E. 0° +			DIP N. 22° +			VERTICAL FORCE ·16000 C. G. S. +			REMARKS.
	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ	
January	766	747	—19	86·7	32·2	—4·5	61·1	61·0	—0·1	469	460	—9	The values in 1909 are means of 4 days only.
February	767	759	8	86·3	81·9	4·4	60·8	60·5	0·3	466	458	8	Ditto.
March	760	754	15	35·8	81·5	4·3	61·4	61·2	0·2	475	465	10	
April	758	776	+18	35·1	31·1	4·0	63·1	60·6	2·5	493	467	26	
May	763	774	11	35·5	30·5	5·0	61·9	61·4	0·5	479	477	2	
June	762	777	15	34·5	30·4	4·1	61·8	61·7	0·1	477	483	+6	
July	766	777	11	34·2	29·8	4·4	61·7	61·0	0·7	477	472	—5	
August	762	780	18	33·6	29·3	4·3	61·5	61·4	0·1	473	479	+6	
September	748	766	18	33·5	28·8	4·7	62·2	61·0	0·3	477	481	4	
October	704	735	—29	32·9	28·6	4·3	62·7	63·0	+0·3	490	482	—8	
November	763	774	+11	32·5	28·1	4·4	63·2	61·7	—1·5	496	481	—15	
December	764	776	+12	32·6	27·5	5·1	61·4	62·2	0·8	473	480	+16	
Means	763	766	+4	34·4	30·0	—4·5	61·9	61·5	—0·6	479	475	—4	

D.—KODAIKANAL OBSERVATORY.

---

1. *General remarks on working.*—The observatory remained in charge of Surveyor Ramaswami Iyengar throughout the year.

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

The magnetographs worked satisfactorily, except that it was necessary to adjust the balance of the V. F. instrument on several occasions.

2. *Mean values of H. F. and declination constants.*—The following table gives the monthly mean values of the magnetic collimation, the distribution coefficients $P_{1\cdot2}$ and $P_{2\cdot3}$ and the moment m_o of the magnet No. 16 during 1909 :—

Mean value of the constants of the magnetometer 16 in 1909.

Months.	DECLINATION CONSTANTS.	H. F. CONSTANTS.						REMARKS.
		MEAN VALUES OF P'S.				Mean M.	M accepted.	
	Mean magnetic collimation.	$P_{1\cdot2}$	$P_{2\cdot3}$	$P_{1\cdot2}$ accepted.	$P_{2\cdot3}$ accepted.			
January . .	−2′: 24″	6·96	9·14	6·96	9·14	923·17	923·17	
February . .	26″	7·22	8·88	7·07	8·92	922·84	922·85	
March . .	28″	6·93	9·01	7·07	8·92	922·85 (1)	922·85 (1)	(1) To 3rd April.
April . . .	25″	7·06	8·85	7·07	8·92	923·18 (2)	923·18 (2)	(2) From 7th.
May . . .	41″	6·93	9·00	6·97	9·04	920·94 (3) ·53 (4)	920·94 (3) ·56 (4)	(3) To 19th. (4) From 22nd.
June . . .	58″	7·00(5)	9·09(5)	6·97(5)	9·04(5)	920·92 (5) ·49 (6)	920·56 (6)	(5) To 5th. (6) From 9th to July 3rd.
July . . .	35″	6·98(7)	9·06(7)	6·95(7)	8·89(7)	918·74 (7)	918·74 (7)	(7) From 7th.
August . .	38″	7·01	8·87	6·95	8·89	918·68	918·63	
September . .	38″	6·88	8·78	6·95	8·89	·62	·63	
October . .	38″	6·97	8·89	6·95	8·89	·67	·63	
November . .	32″	6·99	8·93	6·95	8·89	·56	·63	
December . .	35″	6·93	8·85	6·95	8·89	·60	·63	

3. *Mean values of base lines.*—The table below gives the mean monthly base lines of the H. F. and declination magnetographs actually used. Those of the V. F. are not shown.

The abstract of the base line value of the magnetograph at Kodaikanal in 1909.

Months.	Declination.			Horizontal Force.		
	Mean value of base line.	Accepted base line.	Remarks.	Mean value of base line.	Accepted base line.	Remarks.
January	1° : 32′·8	1° : 32′·8 throughout.	..	·36949	·36949	a=by interpolation.
February	32′·9		..	38	a	
March	32′·8		..	42	a	
April	32′·7		..	42	a	
May	32′·8		..	69	a	
June	32′·7		..	61	a	
July	32′·8		..	60	a	
August	32′·9		..	56	·36956	
September	32′·8		..	60	60	
October	32′·6		..	58	58	
November	32′·8		..	55	55	
December	32′·6		..	54	54	

4. *Mean scale values and temperature range.*—The mean scale value of the H. F. instrument was 6·14γ with limiting values of 6·13 and 6·15. That of the V. F. magnetograph varied from 5·57 to 6·47.

The mean temperatures were 18°·95 C. and 66°·11 F. for the H. F. and V. F. instruments respectively with maxima of 19°·15 and 66°·58 in January and minima of 18°·81 and 65°·96 in December.

The temperatures of reduction are 19° C. and 66° F.

5. *Mean monthly values and secular change.*—The following table gives the mean monthly values of the magnetic elements in 1909 with the secular change for 1908-09 deduced therefrom :—

Secular change at Kodaikanal in 1908-09.

Months.	Horizontal Force ·37000 C. G. S. +			Declination W 0° +			Dip N. 3° +			Vertical Force ·02000 C. G. S.			Remarks.
	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	Values, 1908.	Values, 1909.	Secular change, 1908-09.	
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ	
January	436	442	+6	43·2	47·0	+4·7	80·5	36·1	+5·6	204	356	+62	The values in 1909 are means of 4 days only.
February	434	450	16	43·7	49·2	4·5	31·0	36·9	5·0	300	365	65	Ditto.
March	438	450	12	44·4	48·5	4·1	31·1	36·8	5·7	302	365	63	
April	430	466	30	44·3	49·3	5·0	31·7	38·3	6·6	308	382	74	
May	435	463	28	44·6	40·8	5·2	31·9	38·5	6·6	310	385	75	
June	431	464	33	45·3	50·1	4·8	34·0	80·0	6·0	332	389	57	
July	438	466	28	45·4	50·3	4·9	83·9	30·0	6·0	332	400	68	
August	431	474	43	46·1	50·7	4·6	34·2	80·0	5·7	335	401	66	
September	424	467	43	46·3	50·9	4·6	34·3	40·1	5·8	336	402	66	
October	437	439	2	46·6	51·3	4·7	34·0	40·3	6·3	333	402	69	Ditto.
November	430	460	30	47·2	51·7	4·5	35·1	41·5	6·4	345	417	72	
December	439	463	24	47·6	52·1	4·5	36·3	42·1	5·8	358	423	65	
Means	434	459	+25	45·4	50·1	+4·7	33·2	39·1	+5·9	324	391	+67	

III.—TABLES OF RESULTS.

INDEX TO TABLES.

For each observatory the following tables are given :—

1. Hourly means corrected for temperature, of declination, horizontal force, vertical force and dip for five selected quiet days per month.
2. Diurnal inequality of each deduced from 1.

TABLE A.

Mean values of the magnetic elements at the observatories in 1909.

Observatory.	Latitude.	Longitude.	Declination.	H. F. C. G. S.	V. F. C. G. S.	Dip.
Dehra Dun . . .	30° 19′ 19″ N.	78° 3′ 19″ E.	2° 34′·8 E.	·33276	·31909	43° 48′·0 N.
Barrackpore . .	22° 46′ 29″ N.	88° 21′ 39″ E.	1° 0′·7 E.	·37300	·22099	30° 38′·7 N.
Toungoo . . .	18° 55′ 45″ N.	96° 27′ 3″ E.	0° 30′·0 E.	·38766	·16475	23° 1′·5 N.
Kodaikanal . . .	10° 13′ 50″ N.	77° 27′ 46″ E.	0° 50′·1 W.	·37459	·02391	3° 39′·1 N.

D=Dehra Dún . { Lat. 30° 19′ 19″ ; Long. 78° 3′ 19″ }

B=Barrackpore . { Lat. 22° 46′ 39″ ; Long. 88° 21′ 39″ }

B.—*Dates of magnetic disturbances, 1909.*

T=Toungoo . { Lat. 18° 55′ 45″ ; Long. 96° 27′ 3″ }

K=Kodaikanal . { Lat. 10° 13′ 50″ ; Long. 77° 27′ 46″ }

Date.	January.				February.				March.				April.				May.				June.				July.				August.				September.				October.				November.				December.				REMARKS.
1909	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	
1	M	M	M	S	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	S	C	C	C	C	C	C	C	C	C	C	C	...	C	C	C	M	M	C	M	C	C	C	C	S	S	S	S	
2	M	M	M	M	M	M	M	M	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)	S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S	
3	G	G	G	M	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S	...	S	S	S	S	S	S	C	C	C	C	C	(C)	(C)	(C)	(C)	
4	G	G	G	M	S	S	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	...	S	S	S	S	S	S	—	C	C	C	C	C	C	C	C	
5	C	C	C	C	C	C	C	C	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	...	S	S	C	—	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	
6	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	...	S	S	S	—	C	C	C	S	S	S	C	S	S	S	S	
7	C	C	C	C	C	C	C	C	S	S	S	C	(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	...	C	C	S	S	S	S	C	C	C	C	C	C	C	C	C	
8	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	C	C	C	C	S	S	C	C	S	S	S	C	...	S	S	S	S	S	S	S	S	C	C	C	C	C	C	—	
9	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	...	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	—	
10	C	C	C	—	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)	S	C	C	C	C	C	C	C	S	S	S	S	...	(C)	(C)	(C)	(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	—	
11	C	C	C	—	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	S	C	C	C	C	C	C	C	—	S	S	S	...	C	C	C	(C)	(C)	(C)	(C)	S	S	S	C	C	C	C	C	
12	C	C	C	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	—	C	C	S	...	C	C	C	S	C	C	C	S	S	S	C	(C)	(C)	(C)	(C)	
13	S	S	S	S	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	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	
14	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	G	G	G	G	S	S	S	S	S	S	S	C	—	(C)	(C)	(C)	...	C	C	C	C	C	C	C	S	C	C	C	S	S	S	S	
15	C	C	C	C	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	C	C	C	C	G	G	G	G	S	S	S	S	S	S	S	S	—	C	C	C	C	C	C	C	—	C	C	C	S	S	S	S	S	S	S	C	
16	C	C	C	C	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	C	C	S	S	C	C	C	C	C	C	C	C	—	C	C	C	C	C	C	C	—	C	C	C	S	S	S	S	S	S	S	S	
17	(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	S	S	S	C	S	S	S	C	
18	S	C	C	C	C	C	C	C	M	S	S	S	S	S	S	C	S	S	S	S	C	C	C	C	C	C	C	C	—	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C	S	S	S	C	
19	C	C	C	C	(C)	(C)	(C)	(C)	M	M	M	M	S	S	C	C		S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	—	S	S	S	C	C	C	C	—	M	M	M	C	C	C	C	S	C	C	C	
20	C	C	C	C	C	C	C	C	M	M	M	M	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	S	S	C	C	C	C	C	
21	—	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	—	C	C	C	M	M	M	S	(C)	(C)	(C)	(C)	S	S	S	C	S	S	S	S	
22	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	(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)	S	S	S	S	S	S	S	S	
23	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C	C	—	C	C	C	C	C	C	S	C	S	S	S	S	S	S	—	C	C	C	(C)	(C)	(C)	(C)	M	M	M	S	S	S	S	C	C	C	C	C	
24	C	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)	C	—	C	C	(C)	(C)	(C)	(C)	S	C	S	S	S	S	S	S	—	(C)	(C)	(C)	C	C	C	C	M	M	M	—	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	
25	S	S	S	S	C	C	C	C	S	S	S	C	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	C	—	C	C	C	VG	VG	VG	VG	S	S	S	C	(C)	(C)	(C)	(C)	C	C	C	C	
26	S	S	S	C	C	C	C	C	S	S	S	C	S	S	S	S	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)	—	C	C	C	VG	VG	VG	VG	C	C	C	C	C	C	C	C	C	C	C	C	
27	S	S	S	S	S	S	S	S	M	S	S	S	S	S	S	S	C	C	C	S	(C)	(C)	(C)	(C)	C	C	C	C	—	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)	M	M	M	M	C	C	C	C	
28	S	S	C	S	C	C	C	C	M	M	M	S	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	—	(C)	(C)	(C)	S	S	S	M	C	C	C	C	C	C	C	C	C	C	C	C	
29	M	M	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	C	C	C	C	
30	M	M	M	M	...	...	...	...	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)	—	S	S	S	G	G	G	M	C	C	C	C	G	G	G	M	(C)	(C)	(C)	(C)	
31	G	G	G	G	...	...	...	...	C	C	C	C	...	...	...	...	C	C	C	C	...	...	...	...	C	C	C	C	—	S	S	S	...	...	...	...	C	C	C	C	...	...	...	...	S	S	S	C	
C	17	19	20	17	18	18	19	19	15	16	16	20	20	18	21	22	25	25	24	23	18	23	21	21	21	21	22	23	4	20	20	20	8	16	16	16	13	18	19	21	15	17	17	24	18	19	19	20	
S	6	5	5	6	9	9	8	8	11	12	12	8	10	10	9	8	4	4	5	6	12	7	9	9	10	10	9	8	6	11	11	11	4	10	10	10	10	8	9	6	13	11	11	4	13	12	12	8	
M	4	4	3	4	1	1	1	1	5	8	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	2	3	4	3	2	1	1	1	2	...	...	...	...	
G	3	3	3	1	...	...	...	...	...	...	...	...	...	...	...	...	2	2	2	2	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	...	...	...	...	...	1	1	1	...	...	...	...	...	
V.G.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	2	2	...	...	...	...	...	...	...	...	...	...	...	...	

NOTE.—The Magnitude of the Disturbances [illegible]

Hourly Means of the Declination as determined at Dehra Dún from the selected quiet days in 1909.

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.
E2°+													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	36·2	36·2	36·1	35·9	35·7	35·5	35·5	35·5	36·1	37·4	37·5	36·4	35·2	35·1	35·3	35·5	35·8	36·1	36·1	36·1	36·0	36·0	36·1	36·2	36·2	36·0
February	35·8	35·8	36·1	35·8	35·7	35·4	35·4	35·6	36·2	35·9	35·3	35·1	34·9	35·0	35·6	36·4	36·8	36·6	35·8	35·9	35·8	35·8	35·7	35·9	36·0	35·8
March	35·7	35·6	35·7	35·6	35·4	35·4	35·4	36·2	37·3	38·0	37·6	35·9	34·3	33·5	33·9	34·8	35·7	36·0	35·5	35·4	35·4	35·4	35·6	35·7	35·8	35·6
October	34·9	34·8	34·8	34·7	34·6	34·6	34·6	35·5	36·3	36·4	35·5	33·9	32·6	32·2	33·0	34·2	34·7	34·6	34·5	34·6	34·7	34·5	34·7	34·6	34·7	34·6
November	34·5	34·6	34·5	34·3	34·2	34·0	34·0	34·2	34·9	35·0	34·5	34·1	33·6	33·7	34·5	34·8	34·6	34·2	34·3	34·2	34·2	34·1	34·3	34·4	34·4	34·3
December	33·6	33·5	33·2	33·2	32·9	32·8	32·7	32·7	32·7	33·3	33·7	33·6	32·8	32·6	32·7	33·0	33·4	33·4	33·5	33·5	33·4	33·4	33·4	33·4	33·5	33·2
Means	35·1	35·1	35·1	34·9	34·8	34·6	34·6	35·0	35·6	36·0	35·7	34·8	33·9	33·7	34·2	34·8	35·2	35·2	35·0	35·0	34·9	34·9	35·0	35·0	35·1	34·9
													Summer.													
April	35·4	35·4	35·4	35·3	35·1	35·1	35·5	36·5	37·8	37·8	36·3	34·1	32·7	32·0	32·4	33·6	34·7	35·3	35·3	35·1	34·8	35·0	35·0	35·2	35·3	35·0
May	35·0	35·0	35·1	35·1	35·1	35·2	36·2	37·2	37·7	37·3	35·7	34·0	32·6	32·1	32·4	33·1	33·7	34·6	34·9	34·5	34·2	34·3	34·5	34·6	34·9	34·8
June	34·8	35·2	35·2	35·3	35·3	35·3	36·3	37·1	37·2	36·8	35·4	33·6	32·5	31·9	31·9	32·5	33·2	34·0	34·5	34·3	34·3	34·3	34·4	34·5	34·7	34·6
July	34·9	35·0	35·1	35·1	35·2	35·4	36·2	36·8	36·9	36·6	35·4	34·3	33·2	32·8	32·5	32·9	33·5	34·3	34·7	34·3	34·1	34·1	34·2	34·4	34·6	34·7
August	34·5	34·6	34·4	34·5	34·6	35·0	36·5	38·1	36·4	37·1	35·0	33·1	31·8	30·9	31·5	32·5	33·4	34·5	35·1	34·7	34·2	34·1	34·1	34·2	34·4	34·4
September	34·4	34·4	34·5	34·4	34·4	34·4	34·6	35·7	36·4	36·3	35·1	33·7	32·5	31·4	31·9	32·7	33·5	34·0	34·4	34·0	34·0	33·8	33·9	34·0	34·6	34·1
Means	34·8	34·9	35·0	35·0	34·9	35·1	35·9	36·9	37·4	37·0	35·5	33·8	32·6	31·9	32·1	32·9	33·7	34·5	34·8	34·5	34·3	34·3	34·4	34·5	34·8	34·6

Diurnal Inequality of the Declination at Dehra Dún 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	+0·2	+0·2	+0·1	−0·1	−0·3	−0·5	−0·5	−0·5	+0·1	+1·4	+1·5	+0·4	−0·8	−0·9	−0·7	−0·5	−0·2	+0·1	+0·1	+0·1	0	0	+0·1	+0·2	+0·2
February	0	0	+0·3	0	−0·1	−0·4	−0·4	−0·2	+0·4	+0·1	−0·5	−0·7	−0·9	−0·8	−0·2	+0·6	+1·0	+0·8	0	+0·1	0	0	−0·1	+0·1	+0·2
March	+0·1	0	+0·1	0	−0·2	−0·2	−0·2	+0·6	+1·7	+2·4	+2·0	+0·3	−1·3	−2·1	−1·7	−0·8	+0·1	+0·4	−0·1	−0·2	−0·2	−0·2	0	+0·1	+0·2
October	+0·3	+0·2	+0·2	+0·1	0	0	0	+0·9	+1·7	+1·8	+0·9	−0·7	−2·0	−2·4	−1·6	−0·4	+0·1	0	−0·1	0	+0·1	−0·1	+0·1	0	+0·1
November	+0·2	+0·3	+0·2	0	−0·1	−0·3	−0·3	−0·1	+0·6	+0·7	+0·2	−0·2	−0·7	−0·6	+0·2	+0·5	+0·3	−0·1	0	−0·1	−0·1	−0·2	0	+0·1	+0·1
December	+0·4	+0·3	0	0	−0·3	−0·4	−0·5	−0·5	−0·5	+0·1	+0·5	+0·4	−0·4	−0·6	−0·5	−0·2	+0·2	+0·2	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2	+0·3
Means	+0·2	+0·2	+0·2	0	−0·1	−0·3	−0·3	+0·1	+0·7	+1·1	+0·8	−0·1	−1·0	−1·2	−0·7	−0·1	+0·3	+0·3	+0·1	+0·1	0	0	+0·1	+0·1	+0·2
Summer.																									
April	+0·4	+0·4	+0·4	+0·3	+0·1	+0·1	+0·5	+1·5	+2·8	+2·8	+1·3	−0·9	−2·3	−3·0	−2·6	−1·4	−0·3	+0·3	+0·3	+0·1	−0·2	0	0	+0·2	+0·3
May	+0·2	+0·2	+0·3	+0·3	+0·3	+0·4	+1·4	+2·4	+2·9	+2·5	+0·9	−0·8	−2·2	−2·7	−2·4	−1·7	−1·1	−0·2	+0·1	−0·3	−0·6	−0·5	−0·3	−0·2	+0·1
June	+0·2	+0·6	+0·6	+0·7	+0·6	+0·7	+1·7	+2·5	+2·6	+2·2	+0·8	−1·0	−2·1	−2·7	−2·7	−2·1	−1·4	−0·6	−0·1	−0·3	−0·3	−0·3	−0·2	−0·1	+0·1
July	+0·2	+0·3	+0·4	+0·4	+0·5	+0·7	+1·5	+2·1	+2·2	+1·9	+0·7	−0·4	−1·5	−1·9	−2·2	−1·8	−1·2	−0·4	0	−0·4	−0·6	−0·6	−0·5	−0·3	−0·1
August	+0·1	+0·2	0	+0·1	+0·2	+0·6	+2·1	+3·7	+4·0	+2·7	+0·6	−1·3	−2·6	−3·5	−2·9	−1·9	−1·0	+0·1	+0·7	+0·3	−0·2	−0·3	−0·3	−0·2	0
September	+0·3	+0·3	+0·4	+0·3	+0·3	+0·3	+0·5	+1·6	+2·3	+2·2	+1·0	−0·4	−1·6	−2·7	−2·2	−1·4	−0·6	−0·1	+0·3	−0·1	−0·1	−0·3	−0·2	−0·1	+0·5
Means	+0·2	+0·3	+0·4	+0·4	+0·3	+0·5	+1·3	+2·3	+2·8	+2·4	+0·9	−0·8	−2·0	−2·7	−2·5	−1·7	−0·9	−0·1	+0·2	−0·1	−0·3	−0·3	−0·2	−0·1	+0·2

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 Dehra Dún from the selected quiet days in 1909.

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.
·33000+													**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 .	272	273	274	276	276	278	280	281	283	284	282	283	288	285	281	279	276	275	276	277	276	276	277	279	279	278
February	279	280	280	278	280	278	280	283	286	29[illegible]	295	300	303	305	302	294	287	284	280	279	279	279	280	280	280	286
March .	271	276	270	273	272	275	273	272	271	274	280	285	287	293	293	288	278	273	279	271	271	274	271	273	273	277
October .	230	230	229	234	233	232	233	233	229	227	234	242	251	253	248	243	234	237	228	228	228	230	232	237	235	234
November .	245	241	241	242	242	244	245	249	253	255	258	262	261	257	251	245	241	238	240	239	237	240	240	242	244	246
December	252	248	253	253	251	251	253	257	264	266	268	270	266	263	263	261	258	254	256	257	255	256	256	256	256	258
Means .	258	258	258	259	259	260	261	263	264	266	270	274	276	276	273	268	262	259	259	259	258	259	259	261	261	263
													Summer.													
April . .	290	290	291	292	292	293	293	290	290	294	304	312	319	322	318	309	299	292	289	288	288	289	291	292	293	297
May . .	284	285	284	285	283	285	287	284	283	284	289	296	304	308	309	306	299	290	284	282	285	287	285	287	290	290
June . .	289	290	291	291	291	291	294	295	296	294	298	303	308	311	311	307	300	294	292	290	291	290	291	290	292	296
July . .	290	290	287	287	286	287	293	295	295	295	298	299	303	306	304	301	297	291	286	285	287	289	290	292	293	293
August .	292	289	294	294	293	293	295	293	284	283	284	292	303	311	306	298	289	285	281	282	286	293	290	292	291	292
September .	263	264	263	264	264	264	264	260	258	258	261	263	269	279	278	275	270	265	265	258	258	263	264	265	265	265
Means .	285	285	285	286	285	286	288	286	284	285	289	294	301	306	304	299	292	286	283	281	283	285	285	286	287	289

Diurnal Inequality of the Horizontal Force at Dehra Dún 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.	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	−4	−2	−2	0	+2	+3	+5	+6	+4	+5	+8	+7	+5	+1	−2	−3	−2	−1	−2	−2	−1	+1	+1
February . .	−7	−6	−6	−8	−6	−8	−6	−3	0	+6	+9	+14	+17	+19	+16	+8	+1	−2	−6	−7	−7	−7	−6	−6	−6
March . .	−6	−1	−7	−4	−5	−2	−4	−5	−6	−3	+3	+8	+10	+16	+16	+11	+1	−4	−4	−6	−6	−3	−6	−5	−4
October . .	−4	−4	−5	0	−1	−2	−1	−1	−5	−7	0	+8	+17	+19	+14	+9	0	−7	−6	−6	−6	−4	−2	+3	+1
November . .	−1	−5	−5	−4	−4	−2	−1	+3	+7	+9	+12	+16	+15	+11	+5	−1	−5	−8	−6	−7	−9	−6	−6	−4	−2
December . .	−6	−10	−5	−5	−7	−7	−5	−1	+6	+8	+10	+12	+8	+5	+5	+3	0	−4	−2	−1	−3	−2	−2	−2	−2
Means .	−5	−5	−5	−4	−4	−3	−2	0	+1	+3	+7	+11	+13	+13	+10	+5	−1	−4	−4	−4	−5	−4	−4	−2	−2
Summer.																									
April . . .	−7	−7	−6	−5	−5	−4	−4	−7	−7	−3	+7	+15	+22	+25	+21	+12	+2	−5	−8	−9	−9	−8	−6	−5	−4
May . . .	−6	−5	−6	−5	−7	−5	−3	−6	−7	−6	−1	+6	+11	+18	+19	+16	+9	0	−6	−8	−5	−3	−5	−3	0
June . . .	−7	−6	−5	−5	−5	−5	−2	−1	0	−2	+2	+6	+12	+15	+15	+11	+4	−2	−4	−6	−5	−6	−5	−6	−4
July . . .	−3	−3	−6	−6	−7	−6	0	+2	+2	+2	+5	+6	+10	+13	+11	+8	+4	−2	−7	−8	−6	−4	−3	−1	0
August . .	0	−3	+2	+2	+1	+1	+3	+1	−8	−9	−8	0	+11	+19	+14	+6	−3	−7	−11	−10	−6	+1	−2	0	−1
September . .	−2	−1	−2	−1	−1	−1	−1	−5	−7	−7	−4	−2	+4	+14	+13	+10	+5	+1	0	−7	−7	−2	−1	0	0
Means .	−4	−4	−4	−3	−4	−3	−1	−3	−5	−4	0	+5	+12	+17	+15	+10	+3	−3	−6	−8	−6	−4	−4	−3	−2

NOTE.—When the sign is + the H. F. is greater and when − it is less than the mean.

·31000 +

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 .	862	862	862	861	861	861	862	862	865	864	859	851	849	851	855	851	858	859	859	859	859	859	860	860	860	859
February .	879	873	877	878	878	877	877	879	878	877	873	869	868	873	876	876	876	875	875	877	877	877	878	878	878	876
March .	875	876	873	875	874	875	875	878	879	876	867	859	856	861	867	872	874	873	873	874	876	876	876	877	877	872
October .	953	954	954	953	953	953	954	959	958	953	947	938	933	941	947	951	951	950	952	953	953	955	956	957	955	951
November .	950	949	940	943	948	948	948	950	948	943	940	938	939	942	944	945	946	945	947	947	947	949	949	949	950	945
December .	965	964	964	964	963	962	965	963	965	964	962	962	960	961	964	967	968	963	969	968	967	968	968	968	968	965
Means .	914	914	913	913	913	913	914	915	916	913	908	903	901	905	909	911	912	912	913	913	913	914	915	915	915	912

Summer.

April .	886	886	886	886	886	886	889	890	889	881	873	863	869	873	879	883	885	885	884	884	885	886	887	887	887	883
May .	897	897	897	897	897	893	902	901	897	883	878	874	877	882	883	891	893	895	896	896	897	898	897	898	898	893
June .	907	907	908	907	907	907	911	909	904	897	893	889	892	892	894	898	901	904	905	905	906	906	906	907	908	903
July .	906	905	905	906	906	906	909	909	907	904	899	892	891	889	893	897	900	903	904	904	904	905	906	906	907	903
August .	908	903	909	907	907	909	915	912	907	903	893	885	884	887	890	893	903	905	905	904	906	908	906	906	907	902
September .	961	962	961	961	962	961	963	966	965	961	953	948	940	950	953	955	958	959	959	959	961	963	963	963	963	959
Means .	911	911	911	911	911	911	915	915	912	906	898	893	894	896	900	904	907	909	909	909	910	911	911	911	912	907

Diurnal Inequality of the Vertical Force at Dehra Dún 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.	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	+3	+3	+2	+2	+2	+3	+3	+6	+5	0	−8	−10	−8	−4	−2	−1	0	0	0	0	0	+1	+1	+1
February	+3	+2	+1	+2	+2	+1	+1	+3	+2	+1	−3	−7	−8	−3	0	0	0	−1	−1	+1	+1	+1	+2	+2	+2
March	+3	+4	+1	+3	+2	+3	+3	+6	+7	+4	−5	−13	−16	−11	−5	0	+2	+1	+1	+2	+4	+4	+4	+5	+5
October	+2	+3	+3	+2	+2	+2	+3	+8	+7	+2	−4	−13	−15	−10	−4	0	0	−1	+1	+2	+2	+4	+5	+6	+4
November	+4	+3	+3	+2	+2	+2	+2	+4	+2	−3	−6	−8	−7	−4	−2	−1	0	−1	+1	+1	+1	+3	+3	+3	+4
December	0	−1	−1	−1	−2	−3	0	−2	0	−1	−3	−3	−5	−4	−1	+2	+3	+3	+4	+3	+2	+3	+3	+3	+3
Means	+2	+2	+1	+1	+1	+1	+2	+3	+4	+1	−4	−9	−11	−7	−3	−1	0	0	+1	+1	+1	+2	+3	+3	+3
Summer.																									
April	+3	+3	+3	+3	+3	+3	+6	+7	+6	−2	−10	−15	−15	−10	−4	0	+2	+2	+1	+1	+2	+3	+4	+4	+4
May	+4	+4	+4	+4	+4	+5	+9	+8	+4	−5	−15	−10	−16	−11	−5	−2	0	+2	+3	+3	+4	+5	+4	+5	+5
June	+4	+4	+5	+4	+4	+4	+8	+6	+1	−6	−10	−14	−11	−11	−9	−5	−2	+1	+2	+2	+3	+3	+3	+4	+5
July	+4	+3	+3	+4	+4	+4	+7	+7	+5	+2	−3	−10	−11	−13	−9	−5	−2	+1	+3	+3	+2	+3	+4	+4	+5
August	+6	+6	+7	+5	+5	+7	+13	+10	+5	+1	−9	−17	−18	−15	−12	−4	+1	+3	+3	+2	+4	+6	+4	+4	+5
September	+2	+3	+2	+2	+3	+2	+4	+7	+6	+2	−6	−11	−10	−9	−6	−4	−1	0	0	0	+2	+1	+4	+4	+4
Means	+4	+4	+4	+4	+4	+4	+8	+8	+5	−1	−9	−14	−13	−11	−7	−3	0	+2	+2	+2	+3	+4	+4	+4	+5

Hourly Means of the Dip as determined at Dehra Dún from the selected quiet days in 1909.

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.
N. 49° +													**Winter.**													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	45·6	45·5	45·5	45·3	45·3	45·2	45·2	45·1	45·2	45·1	44·9	44·4	44·2	44·3	44·7	45·0	45·2	45·3	45·2	45·2	45·2	45·2	45·3	45·1	45·1	45·1
February	46·1	46·1	46·0	46·1	46·1	46·1	46·0	45·9	45·7	45·4	45·0	44·6	44·3	44·5	44·8	45·2	45·6	45·7	45·9	46·1	46·1	46·1	46·1	46·1	46·1	45·7
March	46·3	46·1	46·3	46·3	46·3	46·1	46·3	46·5	46·5	46·2	45·5	44·8	44·5	44·5	44·8	45·3	45·9	46·1	46·1	46·3	46·4	46·2	46·4	46·4	46·4	45·9
October	52·7	52·7	52·8	52·5	52·5	52·5	52·6	52·8	53·0	52·8	52·1	51·2	50·7	50·8	51·4	51·9	52·3	52·7	52·7	52·8	52·8	52·8	52·7	52·5	52·5	52·3
November	51·7	51·9	51·9	51·8	51·8	51·7	51·6	51·5	51·2	50·8	50·5	50·2	50·3	50·7	51·1	51·4	51·8	51·8	51·8	51·9	52·0	52·0	52·0	51·8	51·8	51·5
December	52·1	52·3	52·1	52·1	52·1	52·1	52·1	51·8	51·6	51·4	51·2	51·1	51·2	51·4	51·6	51·8	52·0	52·3	52·2	52·1	52·1	52·1	52·1	52·1	52·1	51·9
Means	49·1	49·1	49·1	49·0	49·0	49·0	49·0	48·9	48·9	48·6	48·2	47·7	47·5	47·7	48·1	48·4	48·8	49·0	49·0	49·1	49·1	49·1	49·1	49·0	49·0	48·7
													Summer.													
April	46·0	46·0	45·9	45·9	45·9	45·8	46·0	46·2	46·1	45·5	44·5	43·8	43·5	43·6	44·1	44·8	45·5	45·8	45·9	45·9	46·0	46·0	45·9	45·9	45·9	45·4
May	46·8	46·8	46·8	46·8	46·9	46·8	47·0	47·0	46·9	46·4	45·6	45·0	44·8	44·8	45·1	45·4	45·9	46·5	46·8	46·9	46·8	46·8	46·8	46·8	46·6	46·3
June	47·2	47·1	47·1	47·0	47·0	47·0	47·1	46·9	46·7	46·3	45·9	45·5	45·3	45·2	45·3	45·7	46·3	46·7	46·9	47·0	47·0	47·0	47·0	47·1	47·0	46·6
July	47·0	47·0	47·0	47·2	47·2	47·2	47·0	46·9	46·8	46·7	46·3	45·8	45·6	45·3	45·6	46·0	46·3	46·8	47·2	47·2	47·1	47·0	47·0	46·9	47·0	46·7
August	47·0	47·2	47·0	46·9	47·0	47·0	47·2	47·2	47·4	47·2	46·7	45·3	45·2	44·9	45·3	46·2	46·9	47·2	47·4	47·4	47·2	47·0	47·0	46·9	47·0	46·8
September	51·4	51·4	51·4	51·4	51·4	51·4	51·5	51·8	51·8	51·6	51·0	50·7	50·4	50·0	50·2	50·4	50·9	51·1	51·2	51·5	51·6	51·5	51·5	51·4	51·4	51·2
Means	47·6	47·6	47·5	47·5	47·6	47·5	47·6	47·7	47·6	47·3	46·7	46·1	45·8	45·6	45·9	46·4	47·0	47·4	47·6	47·7	47·6	47·6	47·5	47·5	47·5	47·2

Diurnal Inequality of the Dip at Dehra Dún 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	+0·5	+0·4	+0·4	+0·2	+0·2	+0·1	+0·1	0	+0·1	0	−0·2	−0·7	−0·9	−0·8	−0·4	−0·1	+0·1	+0·2	+0·1	+0·1	+0·1	+0·1	+0·2	0	0
February	+0·4	+0·4	+0·3	+0·4	+0·4	+0·4	+0·3	+0·2	0	−0·3	−0·7	−1·1	−1·4	−1·2	−0·9	−0·5	−0·1	0	+0·2	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4
March	+0·4	+0·2	+0·4	+0·4	+0·4	+0·2	+0·4	+0·6	+0·6	+0·3	−0·4	−1·1	−1·4	−1·4	−1·1	−0·6	0	+0·2	+0·2	+0·4	+0·5	+0·3	+0·5	+0·5	+0·5
October	+0·4	+0·4	+0·5	+0·2	+0·2	+0·2	+0·3	+0·5	+0·7	+0·5	−0·2	−1·1	−1·6	−1·6	−0·9	−0·4	0	+0·4	+0·4	+0·5	+0·5	+0·5	+0·4	+0·2	+0·2
November	+0·2	+0·4	+0·4	+0·3	+0·3	+0·2	+0·1	0	−0·3	−0·7	−1·0	−1·3	−1·2	−0·8	−0·4	−0·1	+0·3	+0·3	+0·3	+0·4	+0·5	+0·5	+0·5	+0·3	+0·3
December	+0·2	+0·4	+0·2	+0·2	+0·2	+0·2	+0·2	−0·1	−0·3	−0·5	−0·7	−0·8	−0·7	−0·5	−0·3	−0·1	+0·1	+0·4	+0·3	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2
Means	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·2	+0·2	−0·1	−0·5	−1·0	−1·2	−1·0	−0·6	−0·3	+0·1	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3
Summer.																									
April	+0·6	+0·6	+0·5	+0·5	+0·5	+0·4	+0·6	+0·8	+0·7	+0·1	−0·9	−1·6	−1·9	−1·8	−1·3	−0·6	+0·1	+0·4	+0·5	+0·5	+0·6	+0·6	+0·5	+0·5	+0·5
May	+0·5	+0·5	+0·5	+0·5	+0·6	+0·5	+0·7	+0·7	+0·6	+0·1	−0·7	−1·3	−1·5	−1·5	−1·2	−0·9	−0·4	+0·2	+0·5	+0·6	+0·5	+0·5	+0·5	+0·5	+0·3
June	+0·6	+0·5	+0·5	+0·4	+0·4	+0·4	+0·5	+0·3	+0·1	−0·3	−0·7	−1·1	−1·3	−1·4	−1·3	−0·9	−0·3	+0·1	+0·3	+0·4	+0·4	+0·4	+0·4	+0·5	+0·4
July	+0·3	+0·3	+0·3	+0·5	+0·5	+0·5	+0·3	+0·2	+0·1	0	−0·4	−0·9	−1·1	−1·4	−1·1	−0·7	−0·4	+0·1	+0·5	+0·5	+0·4	+0·3	+0·3	+0·2	+0·3
August	+0·2	+0·4	+0·2	+0·1	+0·2	+0·2	+0·4	+0·4	+0·6	+0·4	−0·1	−1·0	−1·6	−1·9	−1·5	−0·6	+0·1	+0·4	+0·6	+0·6	+0·4	+0·2	+0·2	+0·1	+0·2
September	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·6	+0·6	+0·4	−0·2	−0·5	−0·8	−1·2	−1·0	−0·8	−0·3	−0·1	0	+0·3	+0·4	+0·3	+0·3	+0·2	+0·2
Means	+0·4	+0·4	+0·3	+0·3	+0·4	+0·3	+0·4	+0·5	+0·4	+0·1	−0·5	−1·1	−1·4	−1·6	−1·3	−0·8	−0·2	+0·2	+0·4	+0·5	+0·4	+0·4	+0·3	+0·3	+0·3

NOTE.—When the sign is + the Dip is greater and when − it is less than the mean.

Hourly Means of the Declinations as determined at Barrackpore from the selected quiet days in 1909.

E. 0.°+

Winter.

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.
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	63·1	63·0	63·0	62·8	62·7	62·4	**62·1**	62·1	62·9	63·8	**64·2**	63·4	62·5	62·4	62·6	62·7	62·8	62·9	62·9	63·0	63·0	62·9	62·9	63·0	63·0	62·9
February	62·8	62·6	62·6	62·6	62·5	62·3	**61·8**	62·1	62·8	62·7	62·2	62·0	61·9	62·4	63·1	63·6	**63·7**	63·1	62·3	62·5	62·5	62·4	62·3	62·3	62·4	62·5
March	62·2	62·1	62·0	62·0	62·0	61·7	61·9	62·8	63·7	**64·0**	63·7	62·3	61·1	**60·9**	61·1	61·9	62·8	62·8	62·2	62·2	62·0	62·0	62·0	62·2	62·2	62·2
October	59·8	59·9	59·9	59·9	59·7	59·5	59·8	60·7	**61·4**	61·0	59·9	58·9	58·2	**58·1**	59·0	59·8	60·1	59·7	59·6	59·7	59·6	59·6	59·6	59·8	59·6	59·7
November	59·3	59·2	59·3	59·0	58·9	58·8	**58·6**	59·0	59·5	59·7	59·3	58·9	59·0	59·6	**60·0**	59·7	59·4	58·8	58·9	59·0	59·0	58·8	59·0	59·0	59·1	59·2
December	58·5	58·4	58·2	58·0	57·8	57·7	57·6	**57·5**	57·9	58·6	**59·1**	58·8	58·4	58·1	58·1	58·3	58·7	58·6	58·3	58·4	58·2	58·2	58·2	58·3	58·3	58·2
Means	61·0	60·9	60·8	60·7	60·6	60·4	60·3	60·7	61·4	**61·6**	61·4	60·7	**60·2**	60·3	60·7	61·0	61·3	61·0	60·7	60·8	60·7	60·7	60·7	60·8	60·8	60·8

Summer.

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.
April	61·8	61·9	61·8	61·8	61·5	61·5	61·8	63·2	**63·9**	63·7	62·4	60·7	59·5	**59·5**	60·1	61·0	61·9	62·3	61·9	61·4	61·3	61·4	61·4	61·6	61·7	61·6
May	61·4	61·5	61·5	61·4	61·3	61·5	62·4	63·3	**63·5**	62·7	60·9	59·2	**58·4**	58·5	59·1	60·0	60·9	61·4	61·8	61·3	60·7	60·7	60·9	61·0	61·3	61·1
June	60·9	61·1	61·3	61·2	61·3	61·2	61·9	63·1	**63·3**	62·9	61·5	59·9	59·2	**59·1**	59·3	59·3	60·1	60·5	60·8	60·6	60·4	60·4	60·5	60·6	60·8	60·9
July	60·7	60·7	60·8	60·9	60·9	61·0	61·8	62·8	**62·9**	62·0	60·8	60·0	59·1	**58·9**	59·1	59·3	59·8	60·4	60·8	60·4	59·9	60·0	60·0	60·2	60·4	60·6
August	60·1	60·1	60·2	60·2	60·3	60·4	61·8	63·8	**63·8**	62·6	60·4	58·3	**57·4**	57·5	58·0	59·0	59·9	60·5	60·4	60·0	59·8	59·8	59·9	60·1	60·0	60·2
September	60·0	60·1	60·1	60·2	60·1	60·1	60·9	62·4	**62·4**	61·0	59·7	58·5	57·6	**57·4**	58·0	59·1	59·9	60·2	60·0	59·6	59·5	59·8	59·7	59·7	59·7	59·8
Means	60·8	60·9	61·0	61·0	60·9	61·0	61·8	63·1	**63·3**	62·5	61·0	59·4	**58·5**	53·5	58·9	59·7	60·4	60·9	61·0	60·6	60·3	60·4	60·4	60·5	60·7	60·7

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.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·2	+0·1	+0·1	−0·1	−0·2	−0·5	−0·8	−0·8	0	+0·9	+1·3	+0·5	−0·4	−0·5	−0·3	−0·2	−0·1	0	0	+0·1	+0·1	0	0	+0·1	+0·1
February	+0·3	+0·1	+0·1	+0·1	0	−0·2	−0·7	−0·4	+0·3	+0·2	−0·3	−0·5	−0·6	−0·1	+0·6	+1·1	+1·2	+0·6	−0·2	0	0	−0·1	−0·2	−0·2	−0·1
March	0	−0·1	−0·2	−0·2	−0·2	−0·5	−0·3	+0·6	+1·5	+1·8	+1·5	+0·1	−1·1	−1·3	−1·1	−0·3	+0·6	+0·6	0	0	−0·2	−0·2	−0·2	0	0
October	+0·1	+0·2	+0·2	+0·2	0	−0·2	+0·1	+1·0	+1·7	+1·3	+0·2	−0·8	−1·5	−1·6	−0·7	+0·1	+0·4	0	−0·1	0	−0·1	−0·1	−0·1	+0·1	−0·1
November	+0·1	0	+0·1	−0·2	−0·3	−0·4	−0·6	−0·2	+0·3	+0·5	+0·1	−0·3	−0·2	+0·4	+0·8	+0·5	+0·2	−0·4	−0·3	−0·2	−0·2	−0·4	−0·2	−0·2	−0·1
December	+0·3	+0·2	0	−0·2	−0·4	−0·5	−0·6	−0·7	−0·3	+0·4	+0·9	+0·6	+0·2	−0·1	−0·1	+0·1	+0·5	+0·4	+0·1	+0·2	0	0	0	+0·1	+0·1
Means	+0·2	+0·1	0	−0·1	−0·2	−0·4	−0·5	−0·1	+0·6	+0·8	+0·6	−0·1	−0·6	−0·5	−0·1	+0·2	+0·5	+0·2	−0·1	0	−0·1	−0·1	−0·1	0	0
Summer.																									
April	+0·2	+0·3	+0·2	+0·2	−0·1	−0·1	+0·2	+1·6	+2·3	+2·1	+0·8	−0·9	−2·1	−2·1	−1·5	−0·6	+0·3	+0·7	+0·3	−0·2	−0·3	−0·2	−0·2	0	+0·1
May	+0·3	+0·4	+0·4	+0·3	+0·2	+0·1	+1·3	+2·2	+2·4	+1·6	−0·2	−1·9	−2·7	−3·6	−2·0	−1·1	−0·2	+0·3	+0·7	+0·2	−0·4	−0·4	−0·2	−0·1	+0·2
June	0	+0·2	+0·4	+0·3	+0·4	+0·3	+1·0	+2·2	+2·4	+2·0	+0·6	−1·0	−1·7	−1·8	−1·6	−1·3	−0·8	−0·4	−0·1	−0·3	−0·5	−0·5	−0·4	−0·3	−0·1
July	+0·1	+0·1	+0·2	+0·3	+0·3	+0·4	+1·2	+2·2	+2·3	+1·4	+0·2	−0·6	−1·5	−1·7	−1·5	−1·3	−0·8	−0·2	+0·2	−0·2	−0·7	−0·6	−0·6	−0·4	−0·2
August	−0·1	−0·1	0	0	+0·1	+0·2	+1·6	+3·6	+3·6	+2·4	+0·2	−1·9	−2·8	−2·7	−2·2	−1·2	−0·3	+0·3	+0·2	−0·2	−0·4	−0·4	−0·3	−0·1	−0·2
September	+0·2	+0·3	+0·3	+0·4	+0·3	+0·3	+1·1	+2·6	+2·6	+1·2	−0·1	−1·3	−2·2	−2·4	−1·9	−0·7	+0·1	+0·4	+0·3	−0·2	−0·3	0	−0·1	−0·1	−0·1
Means	+0·1	+0·2	+0·3	+0·3	+0·2	+0·3	+1·1	+2·4	+2·6	+1·8	+0·3	−1·3	−2·2	−2·2	−1·8	−1·0	−0·3	+0·2	+0·3	−0·1	−0·4	−0·3	−0·3	−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 Horizontal Force in C. G. S. Units (Corrected for temperature) at Barrackpore from the selected quiet days in 1909.

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.
	·37,000+											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 .	**298**	291	291	293	295	297	299	303	306	313	**318**	317	316	314	311	304	300	297	297	296	296	294	293	295	298	301
February .	**294**	296	296	295	295	297	299	305	313	322	326	332	**334**	329	323	317	310	306	301	300	299	296	297	299	300	307
March .	**283**	284	288	284	285	285	289	289	292	301	312	320	**324**	320	315	306	296	293	290	289	286	287	287	286	288	295
October .	251	**250**	251	252	256	256	256	254	254	260	270	283	**292**	289	280	271	266	259	253	253	250	250	252	252	258	261
November .	280	284	282	283	285	286	290	293	305	313	319	**322**	318	310	302	295	290	285	285	282	281	**280**	283	283	285	293
December .	**288**	291	290	295	295	294	295	301	308	316	321	**326**	324	318	312	307	300	297	294	295	295	295	294	295	296	302
Means .	**281**	283	283	284	285	286	288	291	296	304	311	317	**318**	313	307	300	294	290	287	286	285	284	284	285	288	293
												Summer.														
April .	303	304	304	305	306	307	307	307	310	324	339	346	**350**	347	338	327	316	307	303	302	**300**	301	302	303	304	315
May .	297	297	297	297	298	297	300	305	308	317	327	336	**340**	338	331	322	314	306	298	**294**	295	297	298	297	301	309
June .	**297**	299	300	300	301	303	305	311	313	318	324	330	335	**335**	328	320	310	303	302	300	300	301	300	300	301	310
July .	299	301	310	299	298	299	303	309	312	316	322	325	328	**331**	324	319	313	303	296	**294**	296	298	299	301	303	308
August .	298	203	296	311	300	300	302	304	303	304	310	317	**322**	321	314	307	302	296	295	295	**295**	295	297	297	299	303
September .	285	285	286	286	288	289	289	286	**280**	284	294	300	308	**314**	311	305	298	291	292	288	285	283	283	284	284	291
Means .	297	297	297	298	299	299	301	304	304	311	319	326	331	**331**	324	317	309	301	298	296	**295**	296	297	297	299	306

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.																									
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	−13	−10	−10	−8	−6	−4	−2	+2	+5	+12	+17	+16	+15	+13	+10	+3	−1	−4	−4	−5	−5	−7	−8	−6	−3
February	−13	−11	−11	−12	−12	−10	−8	−2	+6	+15	+19	+25	+27	+22	+16	+10	+3	−1	−6	−7	−8	−11	−10	−8	−7
March	−12	−11	−7	−11	−10	−10	−6	−6	−3	+6	+17	+25	+29	+25	+20	+11	+1	−2	−5	−6	−9	−8	−8	−9	−7
October	−10	−11	−10	−9	−5	−5	−5	−7	−7	−1	+9	+22	+31	+28	+19	+10	+5	−2	−8	−8	−11	−11	−9	−9	−3
November	−13	−9	−11	−10	−8	−7	−3	0	+12	+20	+26	+29	+25	+17	+9	+2	−3	−8	−8	−11	−12	−13	−10	−10	−8
December	−14	−11	−12	−7	−7	−8	−7	−1	+6	+14	+19	+24	+22	+16	+10	+5	−2	−5	−8	−7	−7	−7	−8	−7	−6
Means	−12	−10	−10	−9	−8	−7	−5	−2	+3	+11	+18	+24	+25	+20	+14	+7	+1	−3	−6	−7	−8	−9	−9	−8	−5
Summer.																									
April	−12	−11	−11	−10	−9	−8	−8	−8	−5	+9	+24	+31	+35	+32	+23	+12	+1	−8	−12	−13	−15	−14	−13	−12	−11
May	−12	−12	−12	−12	−11	−12	−9	−4	−1	+8	+18	+27	+31	+29	+22	+13	+5	−3	−11	−15	−14	−12	−11	−12	−8
June	−13	−11	−10	−10	−9	−7	−5	+1	+3	+8	+14	+20	+25	+25	+18	+10	0	−7	−8	−10	−10	−9	−10	−10	−9
July	−9	−7	−8	−9	−10	−9	−5	+1	+4	+8	+14	+17	+20	+23	+16	+11	+5	−5	−13	−14	−12	−10	−9	−7	−5
August	−5	−5	−7	−2	−3	−3	−1	+1	0	+1	+7	+14	+19	+18	+11	+4	−1	−7	−8	−8	−8	−8	−6	−6	−4
September	−6	−6	−5	−5	−3	−2	−2	−5	−11	−7	+3	+9	+17	+23	+20	+14	+7	0	+1	−3	−6	−8	−8	−7	−7
Means	−9	−9	−9	−8	−7	−7	−5	−2	−2	+5	+13	+20	+25	+25	+18	+11	+3	−5	−8	−10	−11	−10	−9	−9	−7

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 the selected quiet days in 1909.

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+																										
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 .	073	073	074	075	074	075	076	077	077	073	066	061	061	065	068	068	071	073	074	073	072	073	073	073	074	071
February .	073	073	073	073	073	074	076	077	076	071	068	065	064	065	067	069	072	071	072	073	073	074	075	074	074	072
March .	083	083	083	083	083	084	084	086	083	078	068	063	061	065	069	074	076	077	079	080	082	083	082	083	083	078
October .	130	129	129	129	129	130	130	132	129	124	117	113	112	115	117	119	120	119	121	122	123	123	124	124	124	123
November .	121	121	121	122	121	122	123	123	121	116	112	109	108	109	109	110	113	117	119	119	119	119	120	120	120	117
December .	132	132	132	132	132	132	133	134	133	131	129	125	123	123	125	128	129	129	131	131	131	130	131	131	131	130
Means .	102	102	102	102	102	103	104	105	103	099	093	089	088	090	093	095	097	098	099	100	100	100	101	101	101	099
Summer.																										
April .	085	085	086	086	086	086	089	087	083	075	068	065	068	075	080	083	084	084	084	085	086	086	087	087	088	082
May . .	093	093	093	092	092	092	094	091	086	079	076	073	075	076	080	085	087	090	091	091	093	093	093	093	093	088
June .	098	098	097	098	097	098	100	099	098	095	091	089	090	090	090	093	095	095	096	097	097	097	098	097	097	096
July . .	107	107	107	107	106	107	109	108	105	103	098	093	091	094	096	099	103	102	104	106	108	108	108	108	108	103
August .	110	110	110	110	109	111	113	109	104	099	096	095	100	102	103	105	106	106	106	106	108	109	109	108	109	106
September .	122	122	122	122	122	122	123	121	118	113	109	106	107	110	114	117	117	117	119	120	121	121	122	123	122	118
Means .	103	103	103	103	102	103	105	103	099	094	090	087	089	091	094	097	099	099	100	101	102	102	103	103	103	099

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.																									
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	+2	+2	+3	+4	+3	+4	+5	+6	+6	+2	−5	−10	−10	−6	−3	−3	0	+2	+3	+2	+1	+2	+2	+2	+3
February	+1	+1	+1	+1	+1	+2	+4	+5	+4	−1	−4	−7	−8	−7	−5	−3	0	−1	0	+1	+1	+2	+3	+2	+2
March	+5	+5	+5	+5	+5	+6	+6	+8	+5	0	−10	−15	−17	−13	−9	−4	−2	−1	+1	+2	+4	+5	+4	+5	+5
October	+7	+6	+6	+6	+6	+7	+7	+9	+6	+1	−6	−10	−11	−8	−6	−4	−3	−4	−2	−1	0	0	+1	+1	+1
November	+4	+4	+4	+5	+4	+5	+6	+6	+4	−1	−5	−8	−9	−8	−8	−7	−4	0	+2	+2	+2	+2	+3	+3	+3
December	+2	+2	+2	+2	+2	+2	+3	+4	+3	+1	−1	−5	−7	−7	−5	−2	−1	−1	+1	+1	+1	0	+1	+1	+1
Means	+3	+3	+3	+3	+3	+4	+5	+6	+4	0	−6	−10	−11	−9	−6	−4	−2	−1	0	+1	+1	+1	+2	+2	+2
Summer.																									
April	+3	+3	+4	+4	+4	+4	+7	+5	+1	−7	−14	−17	−14	−7	−2	+1	+2	+2	+2	+3	+4	+4	+5	+5	+6
May	+5	+5	+5	+4	+4	+4	+6	+3	−2	−9	−12	−15	−13	−12	−8	−3	−1	+2	+3	+3	+5	+5	+5	+5	+5
June	+2	+2	+1	+2	+1	+2	+4	+3	+2	−1	−5	−7	−6	−6	−6	−3	−1	−1	0	+1	+1	+1	+2	+1	+1
July	+4	+4	+4	+4	+3	+4	+6	+5	+2	0	−5	−10	−12	−9	−7	−4	0	−1	+1	+3	+5	+5	+5	+5	+5
August	+4	+4	+4	+4	+3	+5	+7	+3	−2	−7	−10	−11	−6	−4	−3	−1	0	0	0	0	+2	+3	+3	+2	+3
September	+4	+4	+4	+4	+4	+4	+5	+3	0	−5	−9	−12	−11	−8	−4	−1	−1	−1	+1	+2	+3	+3	+4	+5	+4
Means	+4	+4	+4	+4	+3	+4	+6	+4	0	−5	−9	−12	−10	−8	−5	−2	0	0	+1	+2	+3	+3	+4	+4	+4

Hourly Means of the Dip as determined at Barrackpore from the selected quiet days in 1909.

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 .	37·4	37·3	37·4	37·4	37·2	37·2	37·2	37·1	37·0	36·4	35·7	35·5	35·5	35·8	36·1	36·4	36·8	37·1	37·2	37·1	37·0	37·2	37·2	37·2	37·1	36·8
February .	37·2	37·1	37·1	37·2	37·2	37·2	37·2	37·0	36·6	35·9	35·6	35·1	35·0	35·2	35·6	36·0	36·5	36·6	36·8	36·9	37·0	37·2	37·2	37·0	37·0	36·6
March .	38·3	38·3	38·1	38·3	38·3	38·3	38·2	38·3	38·0	37·3	36·1	35·5	35·2	35·6	36·1	36·8	37·3	37·5	37·8	37·9	33·1	38·2	38·1	38·2	38·1	37·5
October .	42·8	42·8	42·7	42·7	42·5	42·6	42·6	42·8	42·6	42·0	41·2	40·4	39·9	40·3	40·8	41·3	41·6	41·8	42·1	42·2	42·4	42·4	42·4	42·4	42·1	42·0
November .	41·0	40·9	40·9	41·0	40·8	40·8	40·8	40·6	40·0	39·4	38·9	38·5	38·6	39·0	39·3	39·7	40·1	40·6	40·7	40·8	40·9	40·9	40·9	40·9	40·8	40·3
December .	41·5	41·4	41·4	41·2	41·2	41·2	41·2	41·1	40·7	40·2	39·9	39·4	39·4	39·6	40·0	40·4	40·8	40·9	41·1	41·1	41·1	41·0	41·1	41·1	41·1	40·8
Means .	39·7	39·6	39·6	39·6	39·5	39·6	39·5	39·5	39·2	38·5	37·9	37·4	37·3	37·6	38·0	38·4	38·9	39·1	39·3	39·3	39·4	39·5	39·5	39·5	39·4	39·0
Summer.																										
April .	37·7	37·6	37·7	37·6	37·6	37·6	37·8	37·6	37·2	36·1	35·0	34·6	34·6	35·2	35·9	36·6	37·0	37·4	37·6	37·7	37·8	37·8	37·8	37·8	37·8	37·0
May .	38·4	38·4	38·4	38·4	38·3	38·4	38·4	38·0	37·5	36·7	36·1	35·5	35·5	35·6	36·2	36·9	37·4	37·9	38·3	38·4	38·5	38·4	38·4	38·4	38·3	37·6
June .	38·8	38·7	38·6	38·6	38·5	38·5	38·6	38·3	38·1	37·7	37·2	36·8	36·7	36·7	37·0	37·5	38·0	38·3	38·4	38·6	38·6	38·5	38·6	38·6	38·5	38·1
July .	39·3	39·2	39·3	39·3	39·3	39·3	39·3	39·0	38·6	38·3	37·8	37·3	37·1	37·1	37·5	38·0	38·5	38·8	39·2	39·4	39·5	39·4	39·4	39·3	39·2	38·7
August .	39·5	39·5	39·7	39·4	39·4	39·5	39·6	39·2	39·0	38·5	38·1	37·7	37·9	38·1	38·4	38·9	39·1	39·4	39·4	39·4	39·5	39·6	39·5	39·5	39·4	39·1
September .	40·9	40·9	40·8	40·8	40·8	40·7	40·8	40·8	40·8	40·3	39·7	39·2	39·0	38·9	39·3	39·8	40·0	40·3	40·4	40·7	40·8	40·9	41·0	41·0	40·9	40·4
Means .	39·1	39·1	39·1	39·0	39·0	39·0	39·1	38·8	38·5	37·9	37·3	36·9	30·8	36·9	37·4	38·0	38·3	38·7	38·9	39·0	39·1	39·1	39·1	39·1	39·0	38·5

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.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·6	+0·5	+0·6	+0·6	+0·4	+0·4	+0·4	+0·3	+0·2	−0·4	−1·1	−1·3	−1·3	−1·0	−0·7	−0·4	0	+0·3	+0·4	+0·3	+0·2	+0·4	+0·4	+0·4	+0·3
February	+0·6	+0·5	+0·5	+0·6	+0·6	+0·6	+0·6	+0·4	0	−0·7	−1·0	−1·5	−1·6	−1·4	−1·0	−0·6	−0·1	0	+0·2	+0·3	+0·4	+0·6	+0·6	+0·4	+0·4
March	+0·8	+0·8	+0·6	+0·8	+0·8	+0·8	+0·7	+0·8	+0·5	−0·2	−1·4	−2·0	−2·3	−1·9	−1·4	−0·7	−0·2	0	+0·3	+0·4	+0·6	+0·7	+0·6	+0·7	+0·6
October	+0·8	+0·8	+0·7	+0·7	+0·5	+0·6	+0·6	+0·8	+0·6	0	−0·8	−1·6	−2·1	−1·7	−1·2	−0·7	−0·4	−0·2	+0·1	+0·2	+0·4	+0·4	+0·4	+0·4	+0·1
November	+0·7	+0·6	+0·6	+0·7	+0·5	+0·5	+0·5	+0·3	−0·3	−0·9	−1·4	−1·8	−1·7	−1·3	−1·0	−0·6	−0·2	+0·3	+0·4	+0·5	+0·6	+0·6	+0·6	+0·6	+0·5
December	+0·7	+0·6	+0·6	+0·4	+0·4	+0·4	+0·4	+0·3	−0·1	−0·6	−0·9	−1·4	−1·4	−1·2	−0·8	−0·4	0	+0·1	+0·3	+0·3	+0·3	+0·2	+0·3	+0·3	+0·3
Means	+0·7	+0·6	+0·6	+0·6	+0·5	+0·6	+0·5	+0·5	+0·2	−0·5	−1·1	−1·6	−1·7	−1·4	−1·0	−0·6	−0·1	+0·1	+0·3	+0·3	+0·4	+0·5	+0·5	+0·5	+0·4
Summer.																									
April	+0·7	+0·6	+0·7	+0·6	+0·6	+0·6	+0·8	+0·6	+0·2	−0·9	−2·0	−2·4	−2·4	−1·8	−1·1	−0·4	0	+0·4	+0·6	+0·7	+0·8	+0·8	+0·8	+0·8	+0·8
May	+0·8	+0·8	+0·8	+0·8	+0·7	+0·8	+0·8	+0·4	−0·1	−0·9	−1·5	−2·1	−2·1	−2·0	−1·4	−0·7	−0·2	+0·3	+0·7	+0·8	+0·8	+0·8	+0·8	+0·8	+0·7
June	+0·7	+0·6	+0·5	+0·5	+0·4	+0·4	+0·5	+0·2	0	−0·4	−0·9	−1·3	−1·4	−1·4	−1·1	−0·6	−0·1	+0·2	+0·3	+0·5	+0·5	+0·4	+0·5	+0·5	+0·4
July	+0·6	+0·5	+0·6	+0·6	+0·6	+0·6	+0·6	+0·3	−0·1	−0·4	−0·9	−1·4	−1·6	−1·6	−1·2	−0·7	−0·2	+0·1	+0·5	+0·7	+0·8	+0·7	+0·7	+0·6	+0·5
August	+0·4	+0·4	+0·6	+0·3	+0·3	+0·4	+0·5	+0·1	−0·1	−0·6	−1·0	−1·4	−1·2	−1·0	−0·7	−0·2	0	+0·3	+0·3	+0·3	+0·4	+0·5	+0·4	+0·4	+0·3
September	+0·5	+0·5	+0·4	+0·4	+0·4	+0·3	+0·4	+0·4	+0·4	−0·1	−0·7	−1·2	−1·4	−1·5	−1·1	−0·6	−0·4	−0·1	0	+0·3	+0·4	+0·5	+0·6	+0·6	+0·5
Means	+0·6	+0·6	+0·6	+0·5	+0·5	+0·5	+0·6	+0·3	0	−0·6	−1·2	−1·6	−1·7	−1·6	−1·1	−0·5	−0·2	+0·2	+0·4	+0·5	+0·6	+0·6	+0·6	+0·6	+0·5

NOTE.—When the sign is + the Dip is greater and when − it is less than the mean.

Hourly Means of the Declination as determined at Toungoo from the selected quiet days in 1909.

E 0°+

Winter.

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.
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	32·3	32·4	32·2	32·1	32·0	31·8	31·5	31·3	31·8	32·7	33·1	32·7	32·1	32·2	32·3	32·1	32·2	32·4	32·2	32·3	32·2	32·2	32·2	32·3	32·2	32·2
February .	32·0	32·0	31·9	31·9	31·8	31·8	31·3	31·4	31·9	31·9	31·7	31·5	31·6	32·2	32·6	32·9	33·0	32·5	31·8	31·6	31·6	31·5	31·5	31·5	31·5	31·9
March .	31·3	31·3	31·4	31·3	31·3	31·1	31·2	31·8	32·5	32·8	32·3	31·6	30·5	30·3	30·6	31·5	32·1	31·9	31·5	31·4	31·4	31·4	31·3	31·2	31·2	31·5
October .	28·6	28·6	28·8	28·7	28·6	28·5	28·8	29·6	29·9	29·5	28·6	27·9	27·3	27·3	28·1	28·8	29·1	28·6	28·4	28·7	28·5	28·4	28·4	28·7	28·6	28·6
November .	28·4	28·3	28·3	28·2	28·1	28·0	27·9	28·2	28·4	28·3	28·1	27·8	27·8	28·2	28·5	28·4	28·4	28·1	27·8	27·9	27·9	27·9	27·8	27·9	28·0	28·1
December .	27·6	27·6	27·5	27·3	27·3	27·0	27·0	26·8	27·0	27·6	28·1	28·2	27·9	27·6	27·4	27·7	28·0	27·9	27·6	27·6	27·6	27·4	27·4	27·5	27·5	27·5
Means .	30·0	30·0	30·0	29·9	29·9	29·7	29·6	29·9	30·3	30·5	30·3	30·0	29·5	29·6	29·9	30·2	30·5	30·2	29·9	29·9	29·9	29·8	29·8	39·9	29·8	30·0

Summer.

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.
April .	31·1	31·2	31·2	31·2	31·0	30·8	31·4	32·3	32·9	32·7	31·8	30·8	29·7	29·7	30·0	30·3	31·5	31·6	31·1	30·7	30·6	30·6	30·6	30·8	30·9	31·1
May .	30·6	30·7	30·8	30·7	30·6	30·7	31·6	32·4	32·6	31·8	30·6	29·4	28·6	28·5	28·9	29·4	30·0	30·6	30·9	30·7	30·2	30·2	30·2	30·3	30·4	30·5
June .	30·2	30·3	30·4	30·4	30·5	30·6	31·1	32·2	32·6	32·2	31·1	30·4	29·4	28·2	29·4	29·4	29·8	30·0	30·1	30·0	29·8	29·7	29·8	29·9	30·1	30·4
July .	29·8	29·9	30·0	30·1	30·2	30·2	30·9	31·7	31·6	30·9	30·0	29·3	28·8	28·7	28·7	28·9	29·5	29·5	29·6	29·4	29·3	29·3	29·3	29·4	29·6	29·8
August .	29·1	29·1	29·3	29·3	29·3	29·5	30·9	32·2	32·4	31·3	29·5	27·9	27·2	27·3	27·6	28·2	29·0	29·4	29·4	29·1	29·0	29·0	28·9	29·1	29·1	29·3
September .	28·9	29·1	29·2	29·2	29·2	29·1	30·0	30·9	30·8	29·7	28·7	28·0	27·1	26·8	27·3	28·3	28·9	29·0	28·8	28·8	28·6	28·6	28·6	28·7	28·8	28·8
Means .	30·0	30·1	30·2	30·2	30·1	30·2	31·0	32·0	32·2	31·4	30·3	29·3	28·5	28·4	28·7	29·1	29·8	30·0	30·0	29·8	29·6	29·6	29·6	29·7	29·8	30·0

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.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·1	+0·2	0	−0·1	−0·2	−0·4	−0·7	−0·9	−0·4	+0·5	+0·9	+0·5	−0·1	0	+0·1	−0·1	0	+0·2	0	+0·1	0	0	0	+0·1	0
February . .	+0·1	+0·1	0	0	−0·1	−0·1	−0·6	−0·5	0	0	−0·2	−0·4	−0·3	+0·3	+0·7	+1·0	+1·1	+0·6	−0·1	−0·3	−0·3	−0·4	−0·4	−0·4	−0·4
March . .	−0·2	−0·2	−0·1	−0·2	−0·2	−0·4	−0·3	+0·3	+1·0	+1·3	+0·8	+0·1	−1·0	−1·2	−0·9	0	+0·6	+0·4	0	−0·1	−0·1	−0·1	−0·2	−0·3	−0·3
October . .	0	0	+0·2	+0·1	0	−0·1	+0·2	+1·9	+1·3	+0·9	0	−0·7	−1·3	−1·3	−0·5	+0·2	+0·5	0	−0·2	+0·1	−0·1	−0·2	−0·2	+0·1	0
November . .	+0·3	+0·2	+0·2	+0·1	0	−0·1	−0·2	+0·1	+0·3	+0·2	0	−0·3	−0·3	+0·1	+0·4	+0·3	+0·3	0	−0·3	−0·2	−0·2	−0·2	−0·3	−0·2	−0·1
December . .	+0·1	+0·1	0	−0·2	−0·2	−0·5	+0·5	−0·7	−0·5	+0·1	+0·6	+0·7	+0·4	+0·1	−0·1	+0·2	+0·5	+0·4	+0·1	+0·1	+0·1	−0·1	−0·1	0	0
Means . .	0	0	0	−0·1	−0·1	−0·3	−0·4	−0·1	+0·3	+0·5	+0·3	0	−0·5	−0·4	−0·1	+0·2	+0·5	+0·2	−0·1	−0·1	−0·1	−0·2	−0·2	−0·1	−0·2
Summer.																									
April . . .	0	+0·1	+0·1	+0·1	−0·1	−0·3	+0·3	+1·2	+1·8	+1·6	+0·7	−0·3	−1·4	−1·4	−1·1	−0·8	+0·4	+0·5	0	−0·4	−0·5	0·5	−0·5	−0·3	−0·2
May . . .	+0·1	+0·2	+0·3	+0·2	+0·1	+0·2	+1·1	+1·9	+2·1	+1·3	+0·1	−1·1	−1·9	−2·0	−1·6	−1·1	−0·5	+0·1	+0·4	+0·2	−0·3	−0·3	−0·3	−0·2	−0·1
June . . .	−0·2	−0·1	0	0	+0·1	+0·2	+0·7	+1·8	+2·2	+1·8	+0·7	0	−1·0	−1·2	−1·0	−1·0	−0·6	−0·4	−0·3	−0·4	−0·6	−0·7	−0·6	−0·5	−0·3
July . . .	0	−0·1	+0·2	+0·3	+0·4	+0·4	+1·1	+1·9	+1·8	+1·1	+0·2	−0·5	−1·0	−1·1	−1·1	0·9	−0·3	−0·3	−0·2	−0·4	−0·5	−0·5	−0·5	−0·4	−0·2
August . .	−0·2	−0·2	0	0	0	+0·2	+1·6	+2·9	+3·1	+2·0	+0·2	−1·4	−2·1	−2·0	−1·7	−1·1	−0·3	+0·1	+0·1	−0·2	−0·3	−0·3	−0·4	−0·2	−0·2
September . .	+0·1	+0·3	+0·4	+0·4	+0·4	+0·3	+1·2	+2·1	+2·0	+0·9	0·1	−0·8	−1·7	−2·0	−1·5	−0·5	+0·1	+0·2	0	0	−0·2	−0·2	−0·2	−0·1	0
Means .	0	+0·1	+0·2	+0·2	+0·1	+0·2	+1·0	+2·0	+2·2	+1·4	+0·3	−0·7	−1·5	−1·6	−1·3	−0·9	−0·2	0	0	−0·2	−0·4	−0·4	−0·4	−0·3	−0·2

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 Toungoo from the selected quiet days in 1909.

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+													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 .	733	734	736	737	739	740	743	747	752	760	772	770	767	763	755	748	742	742	741	741	742	741	741	741	745	747
February .	746	747	748	749	747	750	750	755	766	777	784	788	788	779	769	760	756	752	754	750	747	748	747	751	753	759
March .	738	739	742	741	741	741	744	746	755	768	781	791	792	785	772	761	750	744	745	744	742	741	742	742	744	754
October .	728	724	725	725	729	730	729	726	732	742	754	767	769	762	750	740	735	733	727	724	725	724	725	727	734	735
November .	758	761	760	760	762	763	765	772	782	794	801	805	803	791	783	777	771	769	768	768	765	764	764	766	766	774
December .	761	762	765	769	770	769	769	775	782	792	799	801	801	795	784	777	772	770	767	769	770	769	768	769	768	776
Means.	744	745	746	747	748	749	750	754	762	772	782	787	787	779	769	761	754	752	750	749	749	748	748	749	752	758
													Summer.													
April .	762	762	762	763	764	765	766	767	776	793	810	819	816	811	798	785	774	764	762	761	761	760	761	763	764	776
May .	762	761	762	762	762	762	763	768	777	789	803	811	812	805	795	785	774	767	762	759	759	762	763	762	763	774
June .	763	764	765	767	767	769	771	775	782	790	796	801	804	803	797	784	772	768	767	769	769	769	769	768	768	777
July .	765	769	769	768	767	768	769	778	783	788	794	799	799	799	794	785	778	770	765	765	766	768	768	770	772	777
August .	772	773	772	774	775	775	776	779	787	791	800	802	803	799	793	784	776	770	770	771	769	770	772	772	776	780
September .	758	758	759	760	761	763	762	758	760	767	778	783	788	787	782	772	767	764	763	765	758	757	757	758	762	766
Means.	764	765	765	763	766	767	768	771	778	786	797	803	804	801	793	783	774	767	765	765	764	764	765	766	768	775

Diurnal Inequality of the Horizontal Force at Toungoo as deduced from the preceding Table.

Winter.

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.
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 . .	−14	−13	−11	−10	−8	−7	−4	0	+5	+13	+25	+23	+20	+16	+8	+1	−5	−5	−6	−6	−5	−6	−6	−6	−2
February . .	−13	−12	−11	−10	−12	−9	−9	−4	+7	+18	+25	+29	+29	+20	+10	+1	−3	−7	−5	−9	−12	−11	−12	−8	−6
March . . .	−16	−15	−12	−13	−13	−13	−10	−8	+1	+14	+27	+37	+38	+31	+18	+7	−4	−10	−9	−10	−12	−13	−12	−12	−10
October . .	−7	−11	−10	−10	−6	−5	−6	−9	−3	+7	+19	+32	+34	+27	+15	+5	−0	−2	−8	−11	−10	−11	−10	−8	−1
November . .	−18	−13	−14	−14	−12	−11	−9	−2	+8	+20	+27	+31	+29	+17	+9	+3	−3	−5	−6	−6	−9	−10	−10	−8	−8
December . .	−15	−14	−11	−7	−6	−7	−7	−1	+6	+16	+23	+25	+25	+19	+8	+1	−4	−6	−9	−7	−6	−7	−8	−7	−8
Means.	−14	−13	−12	−11	−10	−9	−8	−4	+4	+14	+24	+29	+29	+21	+11	+3	−4	−6	−8	−9	−9	−10	−10	−9	−6

Summer.

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.
April . . .	−14	−14	−14	−13	−12	−11	−10	−9	0	+17	+34	+43	+40	+35	+22	+9	−2	−12	−14	−15	−15	−16	−15	−13	−12
May . . .	−12	−13	−12	−12	−12	−12	−11	−6	+3	+15	+29	+37	+38	+31	+21	+11	−0	−7	−12	−15	−15	−12	−11	−12	−11
June . . .	−14	−13	−12	−10	−10	−8	−6	−2	+5	+13	+19	+24	+27	+26	+20	+7	−5	−9	−10	−8	−8	−8	−8	−9	−9
July . . .	−12	−8	−8	−9	−10	−9	−8	+1	+6	+11	+17	+22	+22	+22	+17	+8	+1	−7	−12	−12	−11	−9	−9	−7	−5
August . . .	−8	−7	−8	−6	−5	−5	−4	−1	+7	+11	+20	+22	+23	+19	+13	+4	−4	−10	−10	−9	−11	−10	−8	−8	−4
September . .	−8	−8	−7	−6	−5	−3	−4	−8	−6	+1	+12	+17	+22	+21	+16	+6	+1	−2	−3	−1	−8	−9	−9	−8	−4
Means.	−11	−10	−10	−9	−9	−8	−7	−4	+3	+11	+22	+28	+29	+26	+18	+8	−1	−8	−10	−10	−11	−11	−10	−9	−7

NOTE.—When the sign is + the Horizontal Force is greater than the mean.
" " " " − " " less "

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Toungoo from the selected quiet days in 1909.

·16000+

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 .	463	463	463	462	462	462	463	462	462	459	452	**448**	449	451	454	456	461	463	463	464	464	464	464	465	**465**	460
February .	462	462	462	462	462	461	460	459	451	452	446	**446**	455	461	464	**465**	462	458	451	459	457	457	458	458	459	458
March .	471	471	471	470	470	470	472	**472**	468	458	450	**447**	450	454	469	468	468	466	466	468	469	470	470	471	472	465
October .	487	487	488	487	487	487	**490**	489	481	473	466	**466**	468	476	482	484	483	481	483	484	485	485	487	488	487	482
November .	487	486	486	486	486	487	486	**488**	486	479	477	475	**473**	475	474	474	476	478	481	481	482	482	483	484	484	481
December .	490	490	490	489	489	489	490	489	490	490	487	485	485	**484**	486	489	490	489	489	490	491	491	492	492	**492**	489
Means .	477	477	477	476	476	476	**477**	477	474	469	463	**461**	463	467	470	473	473	473	473	474	475	475	476	476	477	473
Summer.																										
April .	471	471	471	470	470	470	474	474	467	455	448	**445**	453	462	468	472	**475**	472	468	469	471	472	472	473	473	467
May .	482	481	481	481	481	482	**486**	485	480	471	**464**	465	465	470	475	478	480	479	477	475	475	477	478	478	478	477
June .	485	485	485	485	485	486	489	**489**	487	478	474	474	**473**	476	480	483	484	484	483	482	483	484	484	484	485	483
July .	478	478	478	477	477	478	**480**	479	474	468	467	465	463	**462**	464	468	471	474	474	472	473	474	474	475	475	472
August .	483	483	483	482	482	484	**490**	486	476	466	458	**457**	466	472	476	481	485	486	483	483	485	485	485	485	485	479
September .	485	486	485	485	485	485	**489**	486	475	467	461	**460**	468	477	484	487	486	484	482	483	484	485	486	486	486	481
Means .	481	481	481	480	480	481	**485**	483	477	468	462	**461**	465	470	475	478	480	480	478	477	479	480	480	480	480	477

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.												
Months.																									
January	+3	+3	+3	+2	+2	+2	+3	+2	+2	−1	−8	−12	−11	−9	−6	−4	+1	+3	+3	+4	+4	+4	+4	+5	+5
February	+4	+4	+4	+4	+4	+3	+2	+1	−1	−6	−12	−12	−3	+3	+6	+7	+4	0	−1	+1	−1	−1	0	0	+1
March	+6	+6	+6	+5	+5	+5	+7	+7	+3	−7	−15	−18	−15	−11	−5	+3	+3	+1	+1	+3	+4	+5	+5	+6	+7
October	+5	+5	+6	+5	+5	+5	+8	+7	−1	−9	−16	−16	−14	−6	0	+2	+1	−1	+1	+2	+3	+3	+5	+6	+5
November	+6	+5	+5	+5	+5	+6	+5	+7	+5	−2	−4	−6	−8	−6	−7	−7	−5	−3	0	0	+1	+1	+2	+3	+3
December	+1	+1	+1	0	+0	0	+1	0	+1	+1	−2	−4	−4	−5	−3	0	+1	0	0	+1	+2	+2	+3	+3	+3
Means	+4	+4	+4	+3	+3	+3	+4	+4	+1	−4	−10	−12	−10	−6	−3	0	0	0	0	+1	+2	+2	+3	+3	+4
													Summer.												
April	+4	+4	+4	+3	+3	+3	+7	+7	0	−12	−19	−22	−14	−5	+1	+5	+8	+5	+1	+2	+4	+5	+5	+6	+6
May	+5	+4	+4	+4	+4	+5	+9	+8	+3	−6	−13	−12	−12	−7	−2	+1	+3	+2	0	−2	−2	0	+1	+1	+1
June	+2	+2	+2	+2	+2	+3	+6	+6	+4	−5	−9	−9	−10	−7	−3	0	+1	+1	0	−1	0	+1	+1	+1	+2
July	+6	+6	+6	+5	+5	+6	+8	+7	+2	−4	−5	−7	−9	−10	−8	−4	−1	+2	+2	0	+1	+2	+2	+3	+3
August	+4	+4	+4	+3	+3	+5	+11	+7	−3	−13	−21	−22	−13	−7	−3	+2	+6	+7	+4	+4	+6	+6	+6	+6	+6
September	+4	+5	+4	+4	+4	+4	+8	+5	−6	−14	−20	−21	−13	−4	+3	+6	+5	+3	+1	+2	+3	+4	+5	+5	+5
Means	+4	+4	+4	+3	+3	+4	+8	+6	0	−9	−15	−16	−12	7	2	+1	+3	+3	+1	0	+2	+3	+3	+3	+3

Hourly Means of the Dip as determined at Toungoo from the selected quiet days in 1909.

N. 22°+

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	1·7	61·6	61·6	61·4	61·4	61·3	61·3	61·1	61·0	60·5	59·6	**59·3**	59·5	59·8	60·3	60·6	61·2	61·4	61·4	61·5	61·5	61·5	61·5	61·5	61·4	61·0
February .	**61·1**	61·1	61·1	61·1	61·1	61·0	60·9	60·6	60·1	59·4	58·8	**58·6**	59·3	60·0	60·6	60·9	60·8	60·7	60·5	60·8	60·7	60·7	60·8	60·7	60·7	60·5
March .	**62·1**	62·1	62·0	61·9	61·9	61·9	62·0	61·9	61·3	60·2	59·1	**58·6**	58·8	59·3	60·2	61·1	61·5	61·5	61·5	61·7	61·8	61·9	61·9	62·0	62·0	61·2
October .	63·6	63·7	63·8	63·7	63·6	63·5	63·8	**63·8**	63·0	62·1	61·2	**60·8**	60·9	61·7	62·5	63·0	63·1	63·0	63·4	63·5	63·6	63·6	63·7	63·7	63·4	63·0
November .	**62·7**	62·5	62·5	62·5	62·5	62·5	62·4	62·3	61·8	60·9	60·5	60·3	**60·1**	60·7	60·9	61·1	61·4	61·6	61·9	61·9	62·1	62·1	62·2	62·2	62·2	61·7
December	**62·8**	62·7	62·7	62·5	62·4	62·5	62·5	62·3	62·1	61·8	61·3	**61·1**	61·1	61·2	61·8	62·2	62·4	62·4	62·5	62·5	62·6	62·6	62·7	62·7	62·7	62·2
Means .	**62·3**	62·3	62·3	62·2	62·2	62·1	62·2	62·0	61·6	60·8	60·1	**59·8**	60·0	60·5	61·1	61·5	61·7	61·8	61·9	62·0	62·1	62·1	62·1	62·1	62·1	61·6
													Summer.													
April .	61·3	61·3	61·3	61·2	61·2	61·1	61·4	61·4	60·6	59·1	58·1	**57·6**	58·3	59·1	59·9	60·7	61·3	61·3	61·1	61·2	61·3	**61·5**	61·4	61·4	61·4	60·6
May .	62·1	62·1	62·1	62·1	62·1	62·1	**62·4**	62·2	61·5	60·5	59·5	**59·3**	59·3	59·9	60·6	61·1	61·6	61·8	61·7	61·7	61·7	61·8	61·8	61·8	61·8	61·4
June .	62·3	62·3	62·3	62·2	62·2	62·3	**62·4**	62·3	61·9	60·9	60·5	60·3	**60·1**	60·4	60·9	61·5	62·0	62·1	62·1	61·9	62·0	62·1	62·1	62·1	62·2	61·7
July .	61·7	61·6	61·6	61·6	61·6	61·7	**61·8**	61·4	60·9	60·3	60·0	59·7	59·5	**59·5**	59·8	60·4	60·8	61·3	61·5	61·3	61·3	61·4	61·4	61·4	61·3	61·0
August .	61·9	61·9	61·9	61·8	61·7	61·9	**62·3**	61·9	60·9	60·0	59·1	**59·0**	59·6	60·2	60·7	61·4	61·9	62·2	62·0	61·9	62·2	62·1	62·1	62·1	61·9	61·4
September .	62·5	62·6	62·5	62·5	62·4	62·3	**62·7**	62·6	61·7	60·9	60·1	**59·8**	60·3	61·0	61·7	62·2	62·3	62·2	62·1	62·1	62·4	62·5	62·6	62·6	62·5	61·9
Means .	62·0	62·0	62·0	61·9	61·9	61·9	**62·2**	62·0	61·3	60·3	59·6	**59·3**	59·5	60·0	60·6	61·2	61·7	61·8	61·8	61·7	61·8	61·9	61·9	61·9	61·9	61·3

Diurnal Inequality of the Dip 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.												
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·7	+0·6	+0·6	+0·4	+0·4	+0·3	+0·3	+0·1	0·0	−0·5	−1·4	−1·7	−1·5	−1·2	−0·7	−0·4	+0·2	+0·4	+0·4	+0·5	+0·5	+0·5	+0·5	+0·5	+0·4
February . .	+0·6	+0·6	+0·6	+0·6	+0·6	+0·5	+0·4	+0·1	−0·4	−1·1	−1·7	−1·9	−1·2	−0·5	+0·1	+0·4	+0·3	+0·2	0·0	+0·3	+0·2	+0·2	+0·3	+0·2	+0·2
March . .	+0·9	+0·9	+0·8	+0·7	+0·7	+0·7	+0·8	+0·7	+0·1	−1·0	−2·1	−2·6	−2·4	−1·9	−1·0	−0·1	+0·3	+0·3	+0·3	+0·5	+0·8	+0·7	+0·7	+0·8	+0·8
October . .	+0·6	+0·7	+0·8	+0·7	+0·6	+0·5	+0·8	+0·8	0·0	−0·9	−1·8	−2·2	−2·1	−1·3	−0·5	0·0	+0·1	0·0	+0·4	+0·5	+0·6	+0·6	+0·7	+0·7	+0·4
November .	+1·0	+0·8	+0·8	+0·8	+0·8	+0·8	+0·7	+0·6	+0·1	−0·8	−1·2	−1·4	−1·6	−1·0	−0·8	−0·6	−0·3	−0·1	+0·2	+0·2	+0·4	+0·4	+0·5	+0·5	+0·5
December . .	+0·6	+0·5	+0·5	+0·3	+0·2	+0·3	+0·3	+0·1	−0·1	−0·4	−0·9	−1·1	−1·1	−1·0	−0·4	0·0	+0·2	+0·2	+0·3	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5
Means . .	+0·7	+0·7	+0·7	+0·6	+0·6	+0·5	+0·6	+0·4	0·0	−0·8	−1·5	−1·8	−1·6	−1·1	−0·5	−0·1	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5	+0·5
													Summer.												
April . .	+0·7	+0·7	+0·7	+0·6	+0·6	+0·5	+0·8	+0·8	0·0	−1·5	−2·5	−3·0	−2·3	−1·5	−0·7	+0·1	+0·7	+0·7	+0·5	+0·6	+0·7	+0·9	+0·8	+0·8	+0·8
May . . .	+0·7	+0·7	+0·7	+0·7	+0·7	+0·7	+1·0	+0·8	+0·1	−0·9	−1·9	−2·1	−2·1	−1·5	−0·8	−0·3	+0·2	+0·4	+0·3	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4
June . . .	+0·6	+0·6	+0·6	+0·5	+0·5	+0·6	+0·7	+0·6	+0·2	−0·8	−1·2	−1·4	−1·6	−1·3	−0·8	−0·2	+0·3	+0·4	+0·4	+0·2	+0·3	+0·4	+0·4	+0·4	+0·5
July . . .	+0·7	+0·6	+0·6	+0·6	+0·6	+0·7	+0·8	+0·4	−0·1	−0·7	−1·0	−1·3	−1·5	−1·5	−1·2	−0·6	−0·2	+0·3	+0·5	+0·3	+0·3	+0·4	+0·4	+0·4	+0·2
August . .	+0·5	+0·5	+0·5	+0·4	+0·3	+0·5	+0·9	+0·5	−0·5	−1·4	−2·3	−2·4	−1·8	−1·2	−0·7	0·0	+0·5	+0·8	+0·6	+0·5	+0·8	+0·7	+0·7	+0·7	+0·5
September . .	+0·6	+0·7	+0·6	+0·6	+0·5	+0·4	+0·8	+0·7	−0·2	−1·0	−1·8	−2·1	−1·6	−0·9	−0·2	+0·3	+0·4	+0·3	+0·2	+0·2	+0·5	+0·6	+0·7	+0·7	+0·6
Means . .	+0·7	+0·7	+0·7	+0·6	+0·6	+0·6	+0·9	+0·7	0·0	−1·0	−1·7	−2·0	−1·8	−1·3	−0·7	−0·1	+0·4	+0·5	+0·5	+0·4	+0·5	+0·6	+0·6	+0·6	+0·6

Note. When the sign is + the Dip is greater and when − it is less than the mean.

Hourly Means of the Declination as determined at Kodaikanal from the selected quiet days in 1909.

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 O° + Winter.																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	47·8	47·9	47·9	48·0	48·1	48·2	48·5	48·7	48·4	48·0	47·7	47·5	47·8	47·7	47·9	47·7	47·7	48·0	48·0	47·7	47·7	47·9	47·9	47·9	47·9	47·9
February	48·2	48·2	48·1	48·2	48·3	48·5	48·8	48·9	49·2	49·0	49·1	49·1	48·5	47·6	47·1	47·0	47·0	47·7	48·2	48·0	48·1	48·2	48·3	48·3	48·3	48·2
March	48·7	48·7	48·7	48·8	48·8	48·9	48·9	48·5	48·4	48·2	48·1	48·5	48·9	49·0	48·6	48·1	47·7	47·9	48·4	48·5	48·6	48·7	48·7	48·7	48·7	48·5
October	51·2	51·2	51·2	51·3	51·4	51·4	51·3	51·0	50·8	51·2	51·7	52·1	52·0	51·6	51·2	50·6	50·7	51·0	51·1	51·1	51·2	51·3	51·3	51·3	51·3	51·3
November	51·6	51·6	51·6	51·7	51·9	52·0	52·2	52·4	52·0	51·7	51·9	52·0	51·8	51·2	50·8	50·9	51·3	51·7	51·8	51·7	51·7	51·8	51·8	51·8	51·7	51·7
December	52·0	52·0	52·1	52·3	52·4	52·6	52·7	53·1	52·8	52·2	52·1	51·8	51·8	51·6	51·5	51·8	51·7	51·7	52·0	51·8	51·9	52·0	52·1	52·1	52·1	52·1
Means	49·9	49·9	49·9	50·1	50·2	50·3	50·4	50·4	50·3	50·1	50·1	50·2	50·1	49·8	49·5	49·4	49·4	49·7	49·9	49·8	49·9	50·0	50·0	50·0	50·0	50·0
Summer.																										
April	49·2	49·2	49·2	49·2	49·4	49·4	49·2	48·7	48·7	48·9	49·4	49·8	50·3	50·4	50·0	49·3	48·8	48·7	49·0	49·4	49·6	49·6	49·5	49·4	49·4	49·3
May	49·6	49·6	49·5	49·5	49·5	49·5	49·0	48·4	48·5	49·3	50·2	50·9	51·1	50·9	50·4	50·0	49·7	49·3	49·3	49·9	50·2	50·2	50·1	50·0	49·7	49·8
June	50·1	50·0	49·9	49·8	49·8	49·8	49·5	48·8	48·8	49·2	50·1	50·9	51·1	51·0	50·6	50·2	50·1	50·1	50·3	50·5	50·6	50·6	50·5	50·5	50·3	50·1
July	50·3	50·3	50·2	50·2	50·1	50·1	49·7	49·2	49·2	49·8	50·5	50·9	50·9	50·7	50·7	50·5	50·1	50·0	50·1	50·7	50·8	50·9	50·7	50·7	50·6	50·3
August	50·8	50·7	50·7	50·7	50·7	50·6	49·6	48·4	48·4	49·1	50·7	52·0	52·7	52·7	52·2	51·6	51·0	50·6	50·5	50·7	50·8	50·9	50·8	50·8	50·8	50·7
September	51·0	50·9	50·8	50·8	50·8	50·8	50·2	49·2	49·3	50·2	51·0	51·7	52·3	52·1	51·3	50·7	50·4	50·5	50·9	51·2	51·2	51·2	51·2	51·2	51·1	50·9
Means	50·2	50·1	50·1	50·0	50·1	50·0	49·5	48·3	48·8	49·4	50·3	51·0	51·4	51·3	50·9	50·4	50·0	49·9	50·0	50·4	50·5	50·6	50·5	50·4	50·3	50·2

Diurnal Inequality of the Declination at Kodaikanal 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	−0·1	−0·2	−0·3	−0·6	−0·8	−0·5	−0·1	+0·2	+0·4	+0·1	+0·2	0	+0·2	+0·2	−0·1	−0·1	+0·2	+0·2	0	0	0	0
February	0	0	+0·1	0	−0·1	−0·3	−0·6	−0·7	−1·0	−0·8	−0·9	−0·9	−0·3	+0·6	+1·1	+1·2	+1·2	+0·5	0	+0·2	+0·1	0	−0·1	−0·1	−0·1
March	−0·2	−0·2	−0·2	−0·3	−0·3	−0·4	−0·4	0	+0·1	+0·3	+0·4	0	−0·4	−0·5	−0·1	+0·4	+0·8	+0·6	+0·1	0	−0·1	−0·2	−0·2	−0·2	−0·2
October	+0·1	+0·1	+0·1	0	−0·1	−0·1	0	+0·3	+0·5	+0·1	−0·4	−0·8	−0·7	−0·3	+0·1	+0·7	+0·6	+0·3	+0·2	+0·2	+0·1	0	0	0	0
November	+0·1	+0·1	+0·1	0	−0·2	−0·3	−0·5	−0·7	−0·3	0	−0·2	−0·3	−0·1	+0·5	+0·9	+0·8	+0·4	0	−0·1	0	0	−0·1	−0·1	−0·1	0
December	+0·1	+0·1	0	−0·2	−0·3	−0·5	−0·6	−1·0	−0·7	−0·1	0	+0·3	+0·3	+0·5	+0·6	+0·3	+0·4	+0·4	+0·1	+0·3	+0·2	+0·1	0	0	0
Means	+0·1	+0·1	+0·1	−0·1	−0·2	−0·3	−0·4	−0·4	−0·3	−0·1	−0·1	−0·2	−0·1	+0·2	+0·5	+0·6	+0·6	+0·3	+0·1	+0·2	+0·1	0	0	0	0
Summer.																									
April	+0·1	+0·1	+0·1	+0·1	−0·1	−0·1	+0·1	+0·6	+0·6	+0·4	−0·1	−0·5	−0·9	−1·1	−0·7	0	+0·5	+0·6	+0·3	−0·1	−0·3	−0·3	−0·2	−0·1	−0·1
May	+0·2	+0·2	+0·2	+0·3	+0·3	+0·3	+0·8	+1·4	+1·3	+0·5	−0·4	−1·1	−1·3	−1·1	−0·6	−0·2	+0·1	+0·5	+0·5	−0·1	−0·4	−0·4	−0·3	−0·2	+0·1
June	0	+0·1	+0·2	+0·3	+0·3	+0·3	+0·6	+1·3	+1·3	+0·9	0	−0·8	−1·0	−0·9	−0·5	−0·1	0	0	−0·2	−0·4	−0·5	−0·5	−0·4	−0·4	−0·2
July	0	0	+0·1	+0·1	+0·2	+0·2	+0·6	+1·1	+1·1	+0·5	−0·2	−0·6	−0·6	−0·4	−0·4	−0·2	+0·2	+0·3	+0·2	−0·4	−0·5	−0·6	−0·4	−0·4	−0·3
August	−0·1	0	0	0	0	+0·1	+1·1	+2·3	+2·3	+1·6	0	−1·3	−2·0	−2·0	−1·5	−0·9	−0·3	+0·1	+0·2	0	−0·1	−0·2	−0·1	−0·1	−0·1
September	·0·1	0	+0·1	+0·1	+0·1	+0·1	+0·7	+1·7	+1·6	+0·7	−0·1	−0·8	−1·4	−1·2	−0·4	+0·2	+0·5	+0·4	0	−0·3	−0·3	−0·3	−0·3	−0·3	−0·2
Means	0	+0·1	+0·1	+0·2	+0·1	+0·2	+0·7	+1·4	+1·4	+0·8	−0·1	−0·8	−1·2	−1·1	−0·7	−0·2	+0·2	+0·3	+0·2	−0·2	−0·3	−0·4	−0·3	−0·2	−0·1

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 Kodaikanal from the selected quiet days in 1909.

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.													
			·37000+																							
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 .	420	421	422	423	423	423	423	429	449	479	491	496	490	476	456	440	431	429	430	432	430	429	429	431	430	442
February .	431	433	432	431	431	431	431	443	465	496	516	520	502	474	450	433	433	443	442	438	436	434	435	435	434	450
March .	423	426	423	425	425	426	424	430	452	487	516	530	521	501	472	450	438	439	440	433	430	430	427	427	426	450
October .	417	417	417	421	420	418	417	427	452	483	506	512	496	471	449	439	434	430	426	420	417	416	417	420	420	439
November .	444	443	443	441	443	444	447	460	480	499	505	501	486	476	470	464	461	456	451	447	444	445	445	445	446	460
December .	444	443	448	448	447	446	449	456	471	485	493	497	495	490	482	473	462	456	454	455	453	452	452	451	451	463
Means .	430	431	431	432	432	431	432	441	462	488	505	509	498	481	463	450	443	442	441	438	435	434	434	435	435	451
													Summer.													
April .	441	442	443	444	444	443	441	449	480	518	550	551	536	504	473	451	442	446	451	448	445	444	444	444	445	466
May .	443	444	444	444	443	443	445	449	467	495	519	532	531	512	483	463	446	442	441	446	447	447	445	445	448	463
June .	446	447	449	449	450	449	450	453	464	479	500	517	517	502	486	465	453	451	451	452	452	450	451	450	452	464
July .	454	454	453	452	453	453	456	457	465	484	496	507	504	498	488	474	460	453	448	452	454	454	455	456	456	466
August .	455	455	459	458	457	457	461	473	491	516	530	536	522	505	486	471	457	454	457	456	455	457	456	458	459	474
September .	444	445	446	448	450	450	449	458	479	512	528	535	528	504	477	461	453	455	457	452	447	447	444	446	445	467
Means .	447	448	449	449	450	449	450	457	474	501	521	530	523	504	483	464	452	450	451	451	450	450	449	450	451	467

Diurnal Inequality of the Horizontal Force at Kodaikanal 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.	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 . .	−22	−21	−20	−19	−19	−19	−19	−13	+7	+37	+49	+54	+48	+34	+14	−2	−11	−13	−12	−10	−12	−13	−13	−11	−12
February . .	−19	−17	−18	−19	−19	−19	−19	−7	+15	+46	+66	+70	+52	+24	0	−17	−17	−7	−8	−12	−14	−16	−15	−15	−16
March . .	−27	−24	−27	−25	−25	−24	−26	−20	+2	+37	+66	+80	+71	+51	+22	0	−12	−11	−10	−17	−20	−20	−23	−23	−24
October . .	−22	−22	−22	−18	−19	−21	−22	−12	+13	+44	+67	+73	+57	+32	+10	0	−5	−9	−13	−19	−22	−23	−22	−19	−19
November . .	−16	−17	−17	−16	−17	−16	−13	0	+20	+39	+45	+41	+26	+16	+10	+4	+1	−4	−9	−13	−16	−15	−15	−15	−14
December . .	−19	−20	−15	−15	−16	−17	−14	−7	+8	+22	+30	+34	+32	+27	+19	+10	−1	−7	−9	−8	−10	−11	−11	−12	−12
Means . .	−21	−20	−20	−19	−19	−20	−19	−10	+11	+37	+54	+58	+47	+30	+12	−1	−8	−9	−10	−13	−16	−17	−17	−16	−16
Summer.																									
April . . .	−25	−24	−23	−22	−22	−23	−25	−17	+14	+52	+84	+85	+70	+38	+7	−15	−24	−20	−15	−18	−21	−22	−22	−22	−21
May . . .	−20	−19	−19	−19	−20	−20	−18	−14	+4	+32	+56	+69	+68	+49	+23	0	−17	−21	−19	−17	−16	−16	−18	−18	−15
June . . .	−18	−17	−15	−15	−14	−15	−14	−11	0	+15	+36	+53	+53	+38	+22	+1	−11	−13	−13	−12	−12	−14	−13	−14	−12
July . . .	−12	−12	−13	−14	−13	−13	−10	−9	−1	+18	+30	+41	+38	+32	+22	+8	−6	−14	−18	−14	−12	−12	−11	−10	−10
August . .	−19	−19	−16	−16	−17	−17	−13	−1	+17	+42	+56	+62	+48	+31	+12	−3	−17	−20	−17	−18	−19	−17	−18	−16	−15
September . .	−23	−22	−21	−19	−17	−17	−18	−9	+12	+45	+61	+66	+61	+37	+10	−6	−14	−12	−10	−15	−20	−20	−23	−21	−22
Means . .	−20	−19	−18	−18	−17	−18	−17	−10	+7	+34	+54	+63	+56	+37	+16	−3	−15	−17	−16	−16	−17	−17	−18	−17	−16

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 Kodaikanal from the selected quiet days in 1909.

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.
·02000+													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 .	365	365	365	365	365	365	365	364	363	351	348	343	341	339	337	343	350	355	358	360	360	361	363	364	364	356
February .	370	370	370	370	370	370	370	371	369	365	355	351	355	360	363	366	367	364	362	365	365	365	367	368	367	365
March .	370	372	370	372	371	372	373	373	370	366	357	349	346	346	351	355	362	362	365	367	369	370	371	371	372	366
October .	409	410	410	411	410	410	413	411	406	395	386	383	386	388	392	397	397	397	403	405	406	407	410	412	411	402
November	423	422	422	423	422	423	422	423	422	419	417	411	414	415	413	410	406	406	411	413	414	415	416	416	417	417
December .	423	425	426	425	424	424	424	425	426	424	426	423	423	419	415	416	419	419	422	424	425	425	425	426	426	423
Means .	394	394	394	394	394	394	395	395	393	387	382	377	378	378	379	381	384	384	387	389	390	391	392	393	393	388
													Summer.													
April .	390	390	390	389	389	390	392	394	389	383	374	365	360	364	372	380	384	383	379	379	381	381	383	384	385	382
May . .	389	389	389	389	388	390	393	395	391	384	377	369	365	368	373	378	387	389	387	386	388	389	389	391	392	385
June	394	393	394	393	393	393	395	396	393	388	387	384	380	383	386	387	388	386	387	387	388	389	390	390	391	389
July . .	399	399	398	398	398	399	401	403	401	399	401	401	400	401	398	400	400	401	399	398	399	401	402	402	403	400
August .	408	409	410	410	411	411	415	412	405	393	382	376	377	383	390	394	398	401	402	403	404	407	407	408	409	401
September .	411	412	412	413	413	412	415	413	402	393	385	378	379	384	392	398	403	403	403	403	404	407	408	409	410	402
Means .	399	399	399	399	399	399	402	402	397	390	384	379	377	381	385	390	393	394	393	393	394	396	397	397	398	393

Diurnal Inequality of the Vertical Force at Kodaikanal 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.	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	+9	+9	+9	+9	+9	+9	+9	+8	+6	−5	−8	−13	−15	−17	−19	−13	−6	−1	+2	+4	+4	+5	+7	+8	+8
February	+5	+5	+5	+5	+5	+5	+5	+6	+4	0	−10	−14	−10	−5	−2	+1	+2	−1	−3	0	0	0	+2	+3	+2
March	+5	+7	+5	+7	+6	+7	+8	+8	+5	+1	−8	−16	−19	−19	−14	−10	−3	−3	0	+2	+4	+5	+6	+6	+7
October	+7	+8	+8	+9	+8	+8	+11	+9	+4	−7	−16	−19	−16	−14	−10	−5	−5	−5	+1	+3	+4	+5	+8	+10	+9
November	+6	+5	+5	+6	+5	+6	+5	+6	+5	+2	0	−6	−3	−2	−4	−7	−11	−11	−6	−4	−3	−2	−1	−1	0
December	+3	+2	+3	+2	+1	+1	+1	+2	+3	+1	+3	0	0	−4	−8	−7	−4	−4	−1	+1	+2	+2	+2	+3	+3
Means	+6	+6	+6	+6	+6	+6	+7	+7	+5	−1	−6	−11	−10	−10	−9	−7	−4	−4	−1	+1	+2	+3	+4	+5	+5
Summer.																									
April	+8	+8	+8	+7	+7	+8	+10	+12	+7	+1	−8	−17	−22	−18	−10	−2	+2	+1	−3	−3	−1	−1	+1	+2	+3
May	+4	+4	+4	+4	+3	+5	+8	+10	+6	−1	−8	−16	−20	−17	−12	−7	+2	+4	+2	+1	+3	+4	+4	+6	+7
June	+5	+4	+5	+4	+4	+4	+6	+7	+4	−1	−2	−5	−9	−6	−3	−2	−1	−3	−2	−2	−1	0	+1	+1	+2
July	−1	−1	−2	−2	−2	−1	+1	+3	+1	−1	+1	+1	0	+1	−2	0	0	+1	−1	−2	−1	+1	+2	+2	+3
August	+7	+8	+9	+9	+10	+10	+14	+11	+4	−8	−19	−25	−24	−18	−11	−7	−3	0	+1	+2	+3	+6	+6	+7	+8
September	+9	+10	+10	+11	+11	+10	+13	+11	0	−9	−17	−24	−23	−18	−10	−4	+1	+1	+1	+1	+2	+5	+6	+7	+8
Means	+6	+6	+6	+6	+6	+6	+9	+9	+4	−3	−9	−14	−16	−12	−8	−3	0	+1	0	0	+1	+3	+4	+4	+5

Hourly Means of the Dip as determined at Kodaikanal from the selected quiet days in 1909.

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. N.3°+																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	37·0	37·0	37·0	37·0	37·0	37·0	37·0	36·8	36·5	35·4	35·0	34·5	34·4	34·3	34·2	34·9	35·6	36·0	36·3	36·5	36·5	36·6	36·8	36·8	36·8	36·1
February .	37·4	37·4	37·4	37·4	37·4	37·4	37·4	37·4	37·1	36·6	35·5	35·1	35·6	36·2	36·6	37·0	37·1	36·8	36·6	36·9	36·9	36·9	37·1	37·2	37·1	36·0
March .	37·4	37·6	37·4	37·6	37·5	37·6	37·7	37·7	37·3	36·7	35·7	34·9	34·7	34·8	35·4	35·9	36·6	36·6	36·9	37·1	37·3	37·4	37·5	37·5	37·6	36·8
October .	41·0	41·1	41·1	41·2	41·1	41·1	41·4	41·2	40·6	39·4	38·4	38·1	38·5	38·8	39·3	39·8	39·8	39·9	40·4	40·7	40·8	40·9	41·1	41·3	41·2	40·3
November .	42·2	42·1	42·1	42·2	42·1	42·2	42·0	42·1	41·8	41·5	41·3	40·7	41·1	41·2	41·1	40·9	40·5	40·5	41·0	41·2	41·3	41·4	41·5	41·5	41·6	41·5
December .	42·4	42·3	42·4	42·3	42·2	42·2	42·2	42·3	42·3	42·0	42·1	41·8	41·9	41·5	41·2	41·3	41·7	41·7	42·0	42·2	42·3	42·3	42·3	42·4	42·4	42·1
Means .	39·6	39·6	39·6	39·6	39·6	39·6	39·6	39·6	39·3	38·6	38·0	37·5	37·7	37·8	38·0	38·3	38·6	38·6	38·9	39·1	39·2	39·3	39·4	39·5	39·5	39·0
Summer.																										
April .	39·2	39·2	39·1	39·0	39·0	39·1	39·3	39·5	38·8	38·1	37·1	36·2	35·9	36·4	37·3	38·2	38·6	38·5	38·1	38·1	38·3	38·3	38·5	38·6	38·7	38·3
May .	39·1	39·0	39·0	39·0	39·0	39·1	39·4	39·6	39·1	38·3	37·5	36·7	36·3	36·7	37·3	37·9	38·8	39·1	38·9	38·8	36·9	39·0	39·0	39·2	39·3	38·5
June .	39·5	39·4	39·5	39·4	39·4	39·4	39·6	39·6	39·3	38·7	38·5	38·2	37·8	38·2	38·5	38·7	38·9	38·7	38·8	38·8	38·9	39·0	39·1	39·1	39·2	39·0
July .	39·9	39·9	39·8	39·8	39·8	39·9	40·1	40·2	40·0	39·7	39·8	39·8	39·7	39·8	39·6	39·9	40·0	40·1	39·9	39·8	39·9	40·1	40·2	40·2	40·3	39·9
August .	40·7	40·8	40·9	40·9	41·0	41·0	41·3	41·0	40·2	39·0	37·9	37·3	37·5	38·1	38·9	39·3	39·8	40·1	40·2	40·3	40·4	40·6	40·6	40·7	40·8	39·9
September .	41·1	41·1	41·1	41·2	41·2	41·1	41·4	41·2	40·0	39·0	38·2	37·5	37·6	38·2	39·1	39·8	40·3	40·3	40·2	40·3	40·4	40·7	40·8	40·9	41·0	40·1
Means .	39·9	39·9	39·9	39·9	39·9	39·9	40·2	40·2	39·6	38·8	38·2	37·6	37·5	37·9	38·5	39·0	39·4	39·5	39·4	39·4	39·5	39·6	39·7	39·8	39·9	39·3

Diurnal Inequality of the Dip at Kodaikanal 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	+0·9	+0·9	+0·9	+0·9	+0·9	+0·9	+0·9	+0·7	+0·4	−0·7	−1·1	−1·6	−1·7	−1·8	−1·9	−1·2	−0·5	−0·1	+0·2	+0·4	+0·4	+0·5	+0·7	+0·7	+0·7
February	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·2	−0·3	−1·4	−1·8	−1·3	−0·7	−0·3	+0·1	+0·2	−0·1	−0·3	0	0	0	+0·2	+0·3	+0·2
March	+0·6	+0·8	+0·6	+0·3	+0·7	+0·8	+0·9	+0·9	+0·5	−0·1	−1·1	−1·9	−2·1	−2·0	−1·4	−0·9	−0·2	−0·2	+0·1	+0·3	+0·5	+0·6	+0·7	+0·7	+0·8
October	+0·7	+0·8	+0·8	+0·9	+0·8	+0·8	+1·1	+0·9	+0·3	−0·9	−1·9	−2·2	−1·8	−1·5	−1·0	−0·5	−0·5	−0·4	+0·1	+0·4	+0·5	+0·6	+0·8	+1·0	+0·9
November	+0·7	+0·6	+0·6	+0·7	+0·6	+0·7	+0·5	+0·6	+0·3	0	−0·3	−0·8	−0·4	−0·3	−0·4	−0·6	−1·0	−1·0	−0·5	−0·3	−0·2	−0·1	0	0	+0·1
December	+0·3	+0·2	+0·3	+0·2	+0·1	+0·1	+0·1	+0·2	+0·2	−0·1	0	−0·3	−0·2	−0·6	−0·9	−0·8	−0·4	−0·4	−0·1	+0·1	+0·2	+0·2	+0·2	+0·3	+0·3
Means	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·3	−0·4	−1·0	−1·5	−1·3	−1·2	−1·0	−0·7	−0·4	−0·4	−0·1	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5
Summer.																									
April	+0·9	+0·9	+0·8	+0·7	+0·7	+0·8	+1·0	+1·2	+0·5	−0·2	−1·2	−2·1	−2·4	−1·9	−1·0	−0·1	+0·3	+0·2	−0·2	−0·2	0	0	+0·2	+0·3	+0·4
May	+0·6	+0·5	+0·5	+0·5	+0·5	+0·6	+0·9	+1·1	+0·6	−0·2	−1·0	−1·8	−2·2	−1·8	−1·2	−0·6	+0·3	+0·6	+0·4	+0·3	+0·4	+0·5	+0·5	+0·7	+0·8
June	+0·5	+0·4	+0·5	+0·4	+0·4	+0·4	+0·6	+0·6	+0·3	−0·3	−0·5	−0·8	−1·2	−0·8	−0·5	−0·3	−0·1	−0·3	−0·2	−0·2	−0·1	0	+0·1	+0·1	+0·2
July	0	0	−0·1	−0·1	−0·1	0	+0·2	+0·3	+0·1	−0·2	−0·1	−0·1	−0·2	−0·1	−0·3	0	+0·1	+0·2	0	−0·1	0	+0·2	+0·3	+0·3	+0·4
August	+0·8	+0·9	+1·0	+1·0	+1·1	+1·1	+1·4	+1·1	+0·3	−0·9	−2·0	−2·6	−2·4	−1·8	−1·0	−0·6	−0·1	+0·2	+0·3	+0·4	+0·5	+0·7	+0·7	+0·8	+0·9
September	+1·0	+1·0	+1·0	+1·1	+1·1	+1·0	+1·3	+1·1	−0·1	−1·1	−1·9	−2·6	−2·5	−1·9	−1·0	−0·3	+0·2	+0·2	+0·1	+0·2	+0·3	+0·6	+0·7	+0·8	+0·9
Means	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·9	+0·9	+0·3	−0·5	−1·1	−1·7	−1·8	−1·4	−0·8	−0·3	+0·1	+0·2	+0·1	+0·1	+0·2	+0·3	+0·4	+0·5	+0·6

NOTE.—When the sign is + the Dip is greater and when — it is less than the mean.

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1909-10.

FIELD STATIONS.

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
1262	Nushki . . .	29 32 40	66 2 0	42 13	E 2 26	·3246	H is derived from mean M₀ throughout.
1263	Kurdagap . .	29 45 30	66 26 10	42 33	„ 2 52	·3239	
1264	Mastung Road .	29 52 40	66 50 30	42 49	„ 3 0	·3238	
1265	Ramnagar . .	29 23 30	79 7 20	42 28	„ 2 17	·3371	
1266	Lansdowne . .	29 49 40	78 41 20	43 3	„ 2 28	·3351	
1267	Chaumasu . .	29 54 0	78 44 0	43 8	„ 2 30	·3352	
1268	Pokhra . . .	29 54 50	78 55 40	43 9	„ 2 31	·3353	
1269	Saraikhet . .	29 53 10	79 4 40	43 7	„ 2 30	·3354	
1270	Masi . . .	29 49 0	79 16 50	43 2	„ 2 26	·3342	
1271	Ranikhet . .	29 38 50	79 26 0	42 49	„ 2 22	·3364	
1272	Almora . . .	29 35 50	79 39 10	42 41	„ 2 23	·3367	
1273	Mournala . .	29 27 10	79 47 0	42 28	„ 2 21	·3375	
1274	Lohaghat . .	29 24 20	80 5 30	42 27	„ 2 17	·3381	
1275	Pithoragarh . .	29 35 0	80 12 30	42 35	„ 2 19	·3383	
1276	Askote . . .	29 45 40	80 19 30	42 58	„ 2 27	·3372	
1277	Nachani . .	29 54 20	80 9 40	43 11	„ 2 29	·3365	
1278	Kafkote . .	29 57 0	79 53 40	43 14	„ 2 29	·3365	
1279	Baijnath . .	29 54 40	79 36 50	43 8	„ 2 22	·3360	
1280	Simli . . .	30 13 50	79 15 20	43 41	„ 2 36	·3340	
1281	Dungripant . .	30 14 10	78 52 0	43 42	„ 2 34	·3334	
1282	Tehri . . .	30 23 10	78 28 40	43 55	„ 2 38	·3325	
1283	Nahan . .	30 33 30	77 17 50	44 3	„ 2 45	·3312	
1284	Abiana . . .	31 5 30	76 33 10	45 19	„ 2 59	·3281	
1285	Bubhor . .	31 24 30	76 22 20	45 22	„ 3 5	·3263	
1286	Hamirpur . .	31 41 10	76 31 20	45 52	„ 3 2	·3249	
1287	Galma . . .	31 36 0	76 52 30	45 47	„ 3 1	·3248	
1288	Pangna . .	31 23 10	77 7 20	45 46	„ 3 2	·3277	
1289	Sema or Semu .	31 11 50	76 55 30	45 7	„ 2 56	·3265	
1290	Jutogh . . .	31 6 20	77 6 0	45 0	„ 2 51	·3274	
1291	Bagund . .	31 0 10	77 27 30	45 0	„ 2 41	·3283	
1292	Hatkoti . .	31 8 0	77 44 50	44 58	„ 2 50	·3285	
1293	Sungri . . .	31 18 40	77 41 50	45 22	„ 2 52	·3270	
1294	Rampur . .	31 26 50	77 38 0	45 34	„ 2 49	·3262	
1295	Kotgarh . .	31 18 40	77 28 50	45 22	„ 2 49	·3275	
1296	Kot . . .	31 31 0	77 25 10	45 43	„ 2 51	·3255	
1297	Manglaur . .	31 40 0	77 17 50	46 2	„ 2 57	·3240	
1298	Bajaura. . .	31 50 50	77 9 50	46 11	„ 3 2	·3236	
1299	Urla . . .	31 55 20	76 53 10	46 17	„ 3 4	·3229	
1300	Palampur . .	32 7 20	76 32 [illegible]0	46 41	„ 3 0	·3211	
1301	Dharmsala . .	32 12 0	76 19 30	46 47	„ 3 10	·3204	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1909-10—continued.

FIELD STATIONS—*continued.*

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
1302	Dera-Gopipur	31 52 50	76 12 30	46 14	E 3 15	·3228	H is derived from mean M_o throughout.
1303	Hoshiarpur	31 31 50	75 54 20	45 31	„ 3 3	·3240	
1304	Khatema	28 54 50	79 58 10	41 41	„ 2 9	·3416	
1305	Gulbarga	17 18 50	76 49 10	19 49	W 0 8	·3762	
1306	Aland	17 33 30	76 34 50	21 9	E 1 9	·3872	
1306(a)	Aland (a)	17 32 50	76 34 40	20 35	„ 1 13	·3835	
1307	Talmud	17 49 20	76 45 20	19 56	W 0 21	·3777	
1308	Bhálki	18 2 10	77 11 40	20 49	E 0 15	·3752	
1309	Kandhar	18 51 40	77 11 30	23 9	„ 0 12	·3704	
1310	Rahiri	19 59 40	76 17 20	25 14	„ 0 29	·3650	
1311	Sarsuti	19 59 50	76 29 50	25 28	„ 0 23	·3660	
1312	Kowotah	19 49 50	76 50 10	25 3	„ 0 20	·3690	
1313	Jaygad	17 17 50	73 13 20	20 7	W 0 1	·3723	
1314	Moosa-Kazi-Bandar	16 37 10	73 20 0	18 27	„ 0 26	·3749	
1315	Malvan	16 3 30	73 27 20	17 6	„ 0 26	·3744	
1316	Honávar	14 16 40	74 26 30	13 1	„ 0 44	·3762	
1317	Chundauver	14 23 40	74 29 0	13 25	„ 0 26	·3764	
1318	Tadri	14 31 20	74 21 30	14 11	„ 0 24	·3748	
1319	Khed	18 51 30	73 53 20	23 38	E 0 35	·3697	
1320	Ghoda	19 3 10	73 49 50	23 21	W 0 1	·3682	
1321	Singwa	19 0 0	74 4 20	23 5	„ 0 4	·3703	
1322	Naráyangaon	19 6 40	73 58 10	23 53	E 0 53	·3678	
1323	Jamkhed	19 39 40	75 39 0	24 21	„ 0 39	·3709	
1324	Paithan	19 28 30	75 22 50	24 25	„ 0 34	·3722	
1325	Miri	19 17 0	74 58 0	24 1	„ 0 13	·3694	
1326	Tadwale	18 22 40	76 3 10	24 21	W 1 7	·3660	
1327	Alote	23 45 30	75 32 40	33 2	E 0 33	·3576	
1328	Darah	24 50 0	76 0 50	34 49	„ 1 25	·3541	
1329	Siwai Madhopur	26 1 30	76 21 0	36 48	„ 1 41	·3491	
1330	Hindaun	26 45 30	77 2 10	38 5	„ 1 51	·3470	

DETAIL SURVEY STATIONS.

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
123 D	Goona	24 38 40	77 18 50	34 12	E 1 24	·3542	H is derived from mean M_o throughout.
124 D	Awan	24 24 20	77 8 50	34 0	„ 0 42	·3559	
125 D	Binagaon	24 11 10	77 2 0	33 19	„ 0 58	·3590	
126 D	Beoura	23 55 0	76 54 20	32 28	„ 1 15	·3607	
127 D	Pachor	23 41 40	76 44 20	32 18	„ 1 17	·3609	
128 D	Narsinghgarh	23 42 10	77 4 20	32 45	„ 0 46	·3606	
129 D	Borasia	23 38 30	77 26 20	31 11	„ 1 43	·3537	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1909-10—continued.

DETAIL SURVEY STATIONS—*continued*

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
130 D	Gunjari	23 54 50	77 15 30	33 31	E 1 53	·3603	H is derived from mean M_0 throughout
131 D	Koláras	24 5 40	77 15 20	34 19	„ 1 16	·3532	
132 D	Jámner	24 10 40	77 12 30	33 40	„ 1 7	·3575	
133 D	Narkhera	24 4 0	77 13 20	33 51	„ 1 39	·3528	
134 D	Sutália	23 59 40	77 8 10	33 7	„ 1 40	·3610	
135 D	Thojpura	24 3 50	77 17 20	33 51	„ 2 2	·3528	
136 D	Lateri	24 3 50	77 24 30	33 20	„ 1 5	·3540	
137 D	Sironj	24 6 0	77 41 0	32 58	„ 1 0	·3598	
138 D	Ejda	23 57 10	77 44 10	33 35	„ 1 32	·3548	
139 D	Nateran	23 45 40	77 46 50	32 36	„ 1 49	·3572	
140 D	Garispur	23 40 30	78 6 30	32 57	„ 0 35	·3572	
141 D	Síwás (Begumganj)	23 35 50	78 20 30	32 57	„ 0 47	·3506	
142 D	Garhi	23 24 10	78 9 0	32 39	„ 0 55	·3641	
143 D	Raesen	23 19 30	77 47 10	33 1	„ 1 18	·3647	
144 D	Chandpura or Sultanganj.	23 8 0	77 56 0	31 10	„ 0 48	·3655	
145 D	Bareli	23 0 50	78 13 50	31 7	„ 0 57	·3639	
146 D	Udepura	23 4 40	78 31 10	31 27	„ 0 54	·3636	
147 D	Alli Baro	23 7 10	78 44 50	31 32	„ 0 54	·3635	
148 D	Jethari	23 12 30	78 37 10	31 27	„ 0 58	·3631	
149 D	Bámori	23 12 40	78 17 50	31 23	„ 0 48	·3645	
150 D	Sara	23 20 50	78 17 20	32 27	„ 0 42	·3650	
151 D	Soderpur	23 23 40	78 25 0	32 4	„ 0 50	·3670	
152 D	Sirmaur	23 24 0	78 32 20	32 27	„ 1 17	·3633	
153 D	Mowakhera	23 31 10	78 22 40	33 34	„ 1 8	·3581	
154 D	Basadei	23 36 30	78 30 30	33 28	„ 1 26	·3549	
155 D	Maria	23 44 10	78 24 20	34 27	„ 0 59	·3475	
156 D	Sehora	23 47 30	78 34 50	32 14	„ 1 18	·3580	
157 D	Ráhatgarh	23 47 40	78 23 30	32 50	„ 0 35	·3632	
158 D	Barodia	23 54 0	78 19 50	33 44	„ 0 53	·3577	
159 D	Khurai	24 3 20	78 19 50	33 32	„ 1 22	·3613	
160 D	Anjankhed	20 3 20	77 8 20	25 13	„ 0 26	·3644	
161 D	Yeothi	20 1 30	77 0 10	25 12	„ 0 29	·3675	
162 D	Támsi	20 9 0	77 4 0	25 56	„ 0 16	·3653	
163 D	Pipalgaon	20 3 10	77 17 10	25 27	„ 0 25	·3733	
164 D	Kalamba	20 8 50	77 12 20	25 7	W 0 16	·3711	
165 D	Karli	20 16 0	77 10 10	25 53	E 1 47	·3602	
166 D	Mangrúl-Pir	20 19 10	77 21 50	25 11	„ 0 42	·3703	
167 D	Garwad	20 25 50	77 25 30	26 4	„ 0 13	·3690	
168 D	Gota	20 24 20	77 32 20	26 5	„ 0 56	·3702	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1909-10—continued.

DETAIL SURVEY STATIONS—*concluded.*

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
169 D	Sukli . . .	20 28 10	77 38 10	25 40	E 0 7	·3669	H is derived from mean M_0 throughout.
170 D	Aukuthwadi . .	20 31 40	77 31 50	26 25	„ 0 25	·3672	
171 D	Ujlesar . . .	20 33 40	77 23 40	26 40	„ 0 27	·3671	
172 D	Sakri . . .	20 42 20	77 39 40	26 23	„ 0 34	·3700	
173 D	Badnera . .	20 51 20	77 44 20	27 12	„ 0 33	·3734	
174 D	Asegaon . .	21 7 0	77 35 0	27 18	„ 0 32	·3697	
175 D	Ellichpur . .	21 18 30	77 31 0	27 52	„ 0 57	·3706	
176 D	Sálmenda . .	21 30 20	77 41 40	28 40	„ 0 30	·3637	
177 D	Jhallar . . .	21 43 30	77 44 20	28 51	„ 0 49	·3533	
178 D	Chicholi. . .	20 0 50	77 39 50	29 6	„ 0 47	·3658	
179 D	Khamapur . .	21 57 10	77 30 0	29 1	„ 0 41	·3660	
180 D	Ratamati . .	21 48 10	77 29 40	28 44	„ 0 35	·3625	
181 D	Lakajhiri . .	21 44 30	77 33 30	28 37	„ 0 48	·3625	
182 D	Biba . . .	21 42 50	77 29 0	28 27	„ 1 1	·3612	
183 D	Kharimal . .	21 36 30	77 26 0	29 6	„ 0 27	·3685	
184 D	Chikalda . .	21 24 0	77 18 50	28 36	„ 0 41	·3715	
185 D	Chikli . . .	21 30 40	77 7 40	29 12	„ 0 24	·3641	
186 D	Ghurgipati . .	21 19 50	77 1 30	27 55	„ 0 45	·3589	
187 D	Akot . . .	21 6 10	77 3 0	27 25	„ 0 36	·3716	
188 D	Susarda . .	21 24 0	76 46 10	28 38	„ 0 51	·3592	
189 D	Aki . . .	21 28 20	76 55 10	28 50	„ 1 2	·3685	
190 D	Gondwari . .	21 32 10	76 48 40	27 59	W 0 13	·3647	
191 D	Dewali . . .	21 33 50	76 42 30	28 5	E 1 5	·3644	
192 D	Bod . . .	21 38 0	76 57 10	28 10	„ 0 40	·3650	
193 D	Jamnapur . .	21 50 20	76 49 40	28 47	„ 0 45	·3669	

REOBSERVED FIELD STATIONS.

46	Ruk Junction. .	27 48 20	68 38 20	39 31	E 2 4	·3350	H is derived from mean M_0 throughout.
49	Bubak Road . .	26 29 0	67 46 10	37 24	„ 2 0	·3403	
54(*a*)	Sibi . . .	29 32 40	67 51 40	42 31	„ 2 44	·3255	
62	Rojhanwali . .	30 0 50	73 15 40	43 17	„ 2 37	·3299	
67	Patiála . . .	30 20 40	76 24 0	43 52	„ 2 50	·3314	
81	Lala Musa . .	32 42 40	73 57 0	47 25	„ 3 24	·3149	
88	Peshawar . .	34 0 40	71 33 40	48 56	„ 3 47	·3083	
92	Kundian . .	32 27 30	71 28 20	47 40	„ 3 20	·3084	
105	Sachin . . .	21 4 40	72 52 40	27 33	„ 0 24	·3656	
134	Mirpur Khas . .	25 31 40	69 0 40	35 43	„ 1 52	·3446	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1909-10—continued.

REOBSERVED FIELD STATIONS—*continued.*

Serial No.	Name of station.	Latitude.	Longitude.	Dip.	Declination.	Horizontal Force.	REMARKS.
		° ′ ″	° ′ ″	° ′	° ′	C. G. S.	
139	Viramgam . .	23 8 10	72 3 30	31 25	E 1 9	·3565	H is derived from mean M_0 throughout.
143	Rajkot . . .	22 18 20	70 48 40	29 40	„ 0 31	·3620	
148	Abu Road . .	24 29 0	72 46 40	33 50	„ 1 27	·3536	
169	Kalyán . . .	19 15 0	73 8 20	25 19	W 0 24	·3677	
170	Lonavla . .	18 45 10	73 24 20	23 0	E 0 2	·3718	
171	Kirkee, site No. 2 .	18 33 20	73 50 10	22 59	„ 0 24	·3679	
172	Dhond . . .	18 28 0	74 35 10	22 4	„ 0 36	·3710	
173	Jeur . . .	18 15 50	75 9 40	21 45	„ 0 2	·3721	
174	Barsi, site No. 2 .	18 14 30	75 42 20	21 39	„ 0 15	·3719	
175	Hotgi . . .	17 33 40	76 0 20	20 22	„ 0 4	·3743	
176	Ghangapur . .	17 20 20	76 36 0	19 31	„ 0 5	·3750	
177	Wadi . . .	17 3 0	77 0 0	18 58	„ 0 6	·3764	
212	Mormugao . .	15 24 20	73 47 20	15 31	W 0 18	·3753	
213	Castle Rock . .	15 24 0	74 18 50	14 37	„ 0 28	·3818	
214	Belgaum .	15 50 30	74 31 10	16 31	„ 0 27	·3740	
215	Gokak Road . .	16 14 0	74 44 40	17 22	„ 0 1	·3769	
216	Miraj . . .	16 49 10	74 38 10	19 11	„ 0 15	·3776	
217	Kolhápur . .	16 41 50	74 14 10	18 11	E 0 7	·3760	
218	Karad . . .	17 18 40	74 13 10	19 44	0 0	·3738	
219	Wathar . .	17 53 20	74 8 10	21 8	E 0 11	·3708	
220	Rajewadi . .	18 23 0	74 8 30	22 38	W 1 2	·3693	
221	Ahmednagar . .	19 4 20	74 43 10	23 20	E 0 12	·3707	
222	Puntamba . .	19 45 40	74 37 20	24 44	„ 0 30	·3670	
232	Delhi . . .	28 40 20	77 14 20	41 10	„ 1 59	·3396	
260	Kavas . . .	25 52 20	71 31 40	36 10	„ 2 7	·3458	
287	Tokara . .	30 50 50	76 55 20	44 34	„ 2 50	·3290	
327	Tuticorin . .	8 48 10	78 9 0	..	W 1 25	·3816	
359	Chaman . .	30 56 10	66 25 20	44 43	E 2 59	·3169	
371	Ratagaon (Vijapur)	19 56 40	74 45 50	..	„ 0 20	·3705	
372	Aurungabad . .	19 51 30	75 20 20	25 20	„ 0 34	·3699	
373	Jálna . . .	19 51 50	75 53 0	25 4	„ 0 39	·3703	
374	Satona . . .	19 29 30	76 21 30	24 22	„ 0 33	·3713	
375	Parbhani . . .	19 15 20	76 46 50	24 4	„ 0 48	·3747	
376	Nanded . .	19 9 30	77 18 10	24 13	„ 0 3	·3709	
377	Dharmabad . .	18 53 10	77 51 30	23 11	„ 0 9	·3735	
539	Datia . . .	25 38 40	78 27 30	35 41	„ 1 0	·3532	
546	Bhílsa . . .	23 31 10	77 48 50	33 13	„ 2 18	·3560	
568	Saugor . . .	23 50 50	78 44 20	33 1	„ 1 36	·3504	
573	Cawnpore . .	26 27 0	80 21 0	37 27	„ 1 42	·3629	
590	Anjhi . . .	27 38 20	79 59 20	39 34	„ 1 51	·3467	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1909-10—continued.

REOBSERVED FIELD STATIONS—*continued.*

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
612	Kotah . . .	25 11 30	75 51 40	35 36	E 1 32	·3524	H is derived from mean M₀ throughout.
618	Naiakila . .	24 3 40	77 15 30	33 50	„ 2 37	·3538	
641	Silwáni . . .	23 18 20	78 26 20	31 15	„ 1 3	·3660	
648	Manchar, site No. 2	19 0 30	73 56 40	22 30	„ 0 16	·3691	
649	Sangamner . .	19 34 20	74 13 30	24 10	„ 0 16	·3677	
650	Shevgaon . .	19 21 20	75 14 0	24 20	„ 0 29	·3708	
653	Ter, site No. 2 .	18 19 40	76 9 10	21 34	W 0 7	·3748	
655	Udgir . . .	18 23 30	77 7 0	22 9	E 0 40	·3756	
656	Aurad . . .	18 15 0	77 24 30	21 51	W 0 32	·3743	
658	Rajasoor . .	17 48 30	77 2 30	20 58	E 0 13	·3757	
661	Bijapur . .	16 50 0	75 43 20	18 20	„ 0 4	·3737	
665	Gadag . . .	15 25 10	75 38 10	16 2	W 0 4	·3741	
666	Alur . . .	15 49 30	75 39 0	16 41	„ 0 17	·3780	
667	Alimatti . .	16 21 10	75 53 20	17 42	„ 0 13	·3764	
671	Pandharpur . .	17 39 40	75 19 30	20 50	E 0 38	·3725	
682	Kumta . .	14 26 10	74 24 50	12 58	„ 0 16	·3851	
683	Kárwár . .	14 47 30	74 7 20	14 15	W 0 22	·3770	
684	Vengurla . .	15 51 30	73 37 20	16 26	„ 0 12	·3759	
685	Devgad . .	16 21 50	73 21 50	18 13	E 0 20	·3675	
686	Ratnágiri . .	16 59 10	73 18 50	17 36	„ 0 33	·3762	
687	Dabhol . . .	17 35 20	73 10 0	19 49	W 0 19	·3720	
688	Bánkot . . .	17 58 20	73 2 30	22 1	E 0 37	·3679	
689	Rewadanda . .	18 32 20	72 57 0	22 44	„ 0 43	·3688	
702	Vizianàgram . .	18 6 40	83 24 0	22 17	W 0 23	·3838	
712	Nandyal . .	15 28 20	78 28 0	15 59	„ 0 23	·3809	
746	Chanda . .	19 57 50	79 17 40	25 7	E 0 30	·3740	
751	Hingoli . . .	19 43 30	77 9 0	25 31	„ 0 49	·3666	
752	Básim . . .	20 6 50	77 8 20	26 41	„ 1 47	·3653	
753	Karanja . .	20 28 30	77 29 20	28 8	„ 0 47	·3608	
767	Dhamtari . .	20 42 40	81 32 40	26 40	„ 0 33	·3730	
779	Amraoti . .	20 55 30	77 45 50	27 15	„ 0 19	·3647	
794	Betul . . .	21 54 50	77 53 40	28 53	„ 0 48	·3666	
795	Palsia . . .	21 45 20	77 31 0	28 39	„ 1 4	·3575	
796	Rangubali . .	21 42 40	77 8 20	28 13	„ 0 41	·3659	
797	Darni . . .	21 32 40	76 53 10	28 2	„ 0 13	·3684	
798	Jiri . .	21 10 40	76 50 50	28 41	„ 0 36	·3682	
799	Anjangaon . .	21 10 40	77 18 30	27 20	„ 0 24	·3703	
871	Laksam . .	23 15 40	91 7 20	31 43	„ 0 53	·3734	
942	Sihawa . . .	20 18 40	81 54 40	26 11	„ 0 41	·3734	
943	Raigarh. . .	19 53 20	82 4 20	25 9	„ 0 37	·3702	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1909-10—continued.

REOBSERVED FIELD STATIONS—*concluded.*

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
944	Dabgaon . .	19 27 0	82 24 40	24 9	E 0 16	·3768	H is derived from mean M. throughout.
945	Jeypore . .	18 51 30	82 34 40	22 56	„ 0 18	·3737	
948	Bobbili . . .	18 34 30	83 21 10	22 17	„ 0 0	·3802	
961	Mandalay . .	21 59 50	96 6 30	29 13	„ 0 34	·3801	
975	Myitkyina . .	25 23 20	97 24 10	36 13	„ 1 30	·3613	
977	Bhamo . . .	24 15 30	97 13 10	33 45	„ 0 51	·3730	
992	Kindat . . .	23 44 10	94 26 0	32 48	„ 0 51	·3725	
1068	Prome . . .	18 49 40	95 13 20	22 45	„ 0 23	·3882	
1071	Bassein . .	16 46 20	94 44 30	18 0	„ 0 18	·3918	
1195	Moulmein . .	16 29 40	97 37 30	17 36	„ 0 27	·3928	

REPEAT STATIONS.

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal Force. C. G. S.	REMARKS.
I	Udaipur . .	24 35 33	73 41 57	34 4	E 1 20	·3527	H is derived from mean M. throughout.
II	Karáchi. . .	24 49 50	67 2 2	34 26	„ 1 39	·3454	
III	Quetta . . .	30 11 52	67 0 20	43 23	„ 3 3	·3222	
IV	Baháwalpur . .	29 23 27	71 40 37	42 21	„ 2 50	·3312	
V	Ráwalpindi . .	33 35 16	73 3 6	48 28	„ 3 42	·3110	
VI	Bharatpur . .	27 13 27	77 29 28	38 59	„ 1 52	·3458	
VII	Bangalore . .	12 59 35	77 35 58	9 58	W 0 45	·3827	
VIII	Dhárwár . .	15 27 26	74 59 35	15 33	„ 0 16	·3766	
IX	Porbandar . .	21 38 20	69 37 6	29 2	E 1 14	·3596	
X	Fyzabad . .	26 47 27	82 7 40	38 6	„ 1 41	·3528	
XI	Sambalpur . .	21 28 3	83 58 24	23 7	„ 0 41	·3733	
XII	Waltair . .	17 42 57	83 19 1	21 20	„ 0 12	·3791	
XIII	Darjeeling . .	26 59 49	88 16 39	38 31	„ 1 28	·3567	
XIV	Gaya . . .	24 46 30	84 58 54	34 25	„ 1 2	·3660	
XV	Secunderábád .	17 27 11	78 29 16	20 21	„ 0 11	·3795	
XVI	Bhusával . .	21 2 46	75 47 18	27 12	„ 0 46	·3682	
XVII	Jubbulpore .	23 8 57	79 56 44	31 15	„ 1 0	·3639	
XVIII	Tavoy . . .	14 4 50	98 12 30	12 8	„ 0 23	·3958	
XIX	Lashio . . .	22 56 47	97 44 40	31 20	„ 0 38	·3765	
XX	Akyab . . .	20 7 53	92 53 18	25 29	„ 0 35	·3834	
XXI	Silchar or Cáchár .	24 49 43	92 47 21	34 46	„ 1 3	·3690	
XXII	Dibrugarh . .	27 29 24	94 55 40	39 38	„ 1 8	·3581	

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.

Where blanks occur, values have already been found during previous field seasons, or the observations have not been completed.

All Longitudes are referable to that of the Madras Observatory taken at the value 80°14′47″ East from Greenwich.

VI.—Tidal Operations.

BY MR. C. F. ERSKINE.

No. 16 Party.

Imperial Officer.
Mr. C. F. Erskine, in charge.
Provincial Officers.
Messrs. H. G. Shaw and Syed Zille Hasnain.
Subordinate Establishment.
1 Clerk, 15 Computers, Artificers and 3 Tidal Observatory Clerks.

Work of the year.—During the year under report tidal registrations by self-registering tide-gauges were recorded at the ports of Aden, Karáchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. In addition, tide pole readings of high and low waters were taken during daylight at the ports of Bhávnagar, Akyab and Chittagong, with the object of comparing the actual times and heights with the predictions; all the observations were made under the direction of this department and under the immediate control of the Port Officers concerned.

The reduction by harmonic analysis of the observations for 1909 of the 9 stations named above has been completed. The tide tables for 1911 have arrived in India and have been distributed. The work of publication of the tide tables for 40 ports for the year 1913 is in progress in England. Data for these predictions were despatched from the office in Dehra Dun in January 1910.

List of Tidal Stations.—The following table gives a list of the 42 ports at which tidal observations have been registered, together with the periods of observation from 1874 when tidal operations were commenced 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.	31	
4	Maskat	Ditto	1893	1898	5	
5	Bushire	Ditto	1892	1901	8	
6	*Karáchi*	Ditto	1868 1881	1880 Still working.	*13 } 43 30 }	*Small Tide-gauge working.
7	Hanstal	Ditto	1874	1875	1	Tide Tables not published.
8	Navánar	Ditto	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	Probandar	Automatic	1898	1902	2	Years 1898, 1899 and 1902 are excluded.
11	Port Albert Victor (Kathiáwár).	Personal	1881	1882	1	

Serial No.	Stations.	Automatic or Personal observations.	Date of Commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
11A	Port Albert Victor (Kathiáwár)	Automatic	1900	1903	4	
12	Bhávnagar	Ditto	1889	1894	5	Tide-pole readings still taken.
13	*Bombay (Apollo Bandar)*	Ditto	1878	Still working.	32	
14	*Bombay (Prince's Dock)*	Ditto	1888	Still working.	22	Property of Port Trust.
15	Mormugão (Goa)	Ditto	1884	1889	5	
16	Kárwár	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	Pámban Pass	Ditto	1878	1882	4	
25	Negapatam	Ditto	1881	1888	5	Years 1883-84-85 are excluded.
26	*Madras*	Ditto	1880 Re-started 1895	1890 Still working.	10 } 25 15 }	
27	Cocanáda	Ditto	1886	1891	5	
28	Vizagapatam	Ditto	1879	1885	6	
29	False-point	Ditto	1881	1885	4	
30	Dublat (Saugor Island)	Ditto	1881	1886	5	
31	Diamond Harbour	Ditto	1881	1886	5	
32	*Kidderpore*	Ditto	1881	Still working.	29	
33	Chittagong	Ditto	1886	1891	5	Tide-pole readings still taken.
34	Akyab	Ditto	1887	1892	5	Tide-pole readings still taken.
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	30	
39	Amherst	Ditto	1880	1886	6	
40	*Moulmein*	Ditto	1880 Re-started 1909	1886 Still working.	6 } 7 1 }	
41	Mergui	Ditto	1889	1894	5	
42	*Port Blair*	Ditto	1880	Still working.	30	

Working of Observatories.

Aden.—This observatory was inspected by Mr. Syed Zille Hasnain in February 1910. The observatory was found in good order, but the communication hole at the bottom of the float cylinder had become enlarged, the result being that the sea water flowed too freely in and out of the cylinder, causing at times great oscillation of the float, which affected the movement of the pencil on the diagram. The Port Engineer of Aden has been requested to have a new cylinder made and arrangements will be made at the time of the next inspection of this observatory to remove the old cylinder, and fix a new one in its place.

With the exception of a few short interruptions, owing to the pencil failing to mark, or to the stoppage of the driving clock, the tide-gauge has worked well during the past year.

Karáchi.—This observatory was inspected by Mr. C. F. Erskine assisted by Mr. Syed Zille Hasnain, in February 1910. The tide-gauge and the auxiliary instruments were thoroughly overhauled and cleaned, and the cylinder was cleared of mud both from the inside and outside.

No interruptions have occurred either in the registrations of the tide-gauge or of the auxiliary instruments during the past year.

Apollo Bandar (Bombay).—This observatory was inspected by Mr. C. F. Erskine assisted by Mr. Syed Zille Hasnain in January and February 1910. The observatory was found neat and clean, but the tide-gauge was in need of cleaning. After having been thoroughly cleaned the instrument was left in adjustment and in good working order.

During the past year there have been three minor interruptions in the tidal registrations due to the stoppage of the driving clock.

Prince's Dock (Bombay).—This observatory was inspected by Mr. C. F. Erskine assisted by Mr. Syed Zille Hasnain, in January and February 1910. On overhauling the tide-gauge it was discovered that from some unknown cause the band had a double twist in it near its junction with the float; owing to this the float was raised nearly three quarters of an inch, and in consequence there was a corresponding change in the working zero of the tide-gauge. The float at this observatory was not provided with a swivel on the clip where it was connected with the band: to remedy this defect a new float with a swivel at the top has been substituted for the old one; there will now be no risk of a similar accident occurring again.

During the past year there have been several interruptions in the tidal registrations, ranging from two to twenty-seven hours, due to the pencil wire breaking; this is a contingency it is impossible to guard against.

Madras.—This observatory was inspected by Mr. C. F. Erskine assisted by Mr. Syed Zille Hasnain in January 1910. It was found clean and tidy and the tide-gauge was working well.

There have been no interruptions in the tidal registrations during the year under report.

Kidderpore.—This observatory was inspected by Mr. C. F. Erskine assisted by Mr. Syed Zille Hasnain, in November 1909. The tide-gauge was found to be working well; an examination of the daily reports showed that no breaks in the tidal registrations had occurred since the last inspection. The graduated staff was found to be slightly out of position; it was refixed correctly.

Rangoon.—This observatory was inspected by Mr. C. F. Erskine assisted by Mr. Syed Zille Hasnain, in December 1909. The cabin and the bridge leading to it required some minor repairs, and the Deputy Conservator of the Port was requested to have them done.

The tide-gauge was working satisfactorily and there had been no breaks in the tidal registrations since the last inspection.

Last year all the auxiliary instruments were removed from this observatory as the Port Commissioners did not consider them necessary. Subsequently the Deputy Conservator of the Port intimated that the registrations of the above instruments were required by the port authorities. In conformity with this request an anemometer and a rain gauge were despatched to Rangoon from Dehra Dun, and these instruments were set up in the tidal observatory at the time of inspection. The Officer in charge of the Mathematical Instrument Office, Calcutta, was asked to supply 1 standard barometer, 1 self-registering barograph and a maximum and minimum thermometer. These instruments had not arrived by the time the inspecting officers left Rangoon, but have since been received and set up at the observatory.

Moulmein.—This observatory was inspected by Mr. C. F. Erskine assisted by Mr. Syed Zille Hasnain, in December 1909. The tide-gauge was found in working order but was greatly in need of cleaning. It was thoroughly overhauled and cleaned and left in correct adjustment.

A few minor interruptions in the tidal registrations have occurred during the past year, these being chiefly due to the stoppage of the driving clock.

Port Blair.—This observatory was inspected by Mr. Syed Zille Hasnain in December 1909. On taking the tide-gauge to pieces for cleaning purposes, it was found that through corrosion the float had leaked considerably, and that there was a great deal of water in it. The float was carefully repaired and refixed. The cylinder at this observatory was a very old one and the communication hole in it had become too large. A new cylinder was therefore made under the supervision of the Port Officer. The old cylinder was removed with some difficulty, and the new one was fixed in position. The tide-gauge and the auxiliary instruments were thoroughly overhauled and cleaned and left in adjustment. The opportunity was also taken to have the observatory repaired.

Tidal Constants.—The tidal observations for a year at nine stations have been reduced, and the tabulated values of the tidal constants thus derived are appended. There are no arrears.

VALUES OF THE TIDAL CONSTANTS, ADEN, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0 = 5·790 feet.

S_1	H = R =	·091	M_6	R =	·006	Q_1	R =	·152	T_2	R =	·018
	κ = ζ =	179°·87		ζ =	307°·88		ζ =	132°·83		ζ =	190°·28
S_2	H = R =	·677		H =	·007		H =	·142		H =	·018
	κ = ζ =	243°·09		κ =	347°·18		κ =	35°·15		κ =	191°·28
S_4	H = R =	·006	M_8	R =	·003	L_2	R =	·048	$(MS)_4$	R =	·013
	κ = ζ =	291°·30		ζ =	309°·81		ζ =	20°·23		ζ =	28°·07
S_6	H = R =	·005		H =	·003		H =	·074		H =	·013
	κ = ζ =	209°·29		κ =	122°·21		κ =	213°·32		κ =	161°·18
S_8	H = R =	·001	O_1	R =	·698	N_2	R =	·433	$(2SM)_2$	R =	·020
	κ = ζ =	221°·19		ζ =	82°·72		ζ =	140°·81		ζ =	228°·65
				H =	·653		H =	·437		H =	·020
				κ =	37°·20		κ =	221°·74		κ =	95°·55
M_1	R =	·111	K_1	R =	1·371	λ_2	R =	...	$2N_2$	R =	·068
	ζ =	201°·26		ζ =	211°·89		ζ =	...		ζ =	152°·55
	H =	·052		H =	1·315		H =	...		H =	·068
	κ =	353°·01		κ =	34°·06		κ =	...		κ =	181°·31
M_2	R =	1·547	K_2	R =	·185	ν_2	R =	·146	$(M_2N)_4$	R =	·009
	ζ =	92°·85		ζ =	52°·65		ζ =	267°·09		ζ =	18°·03
	H =	1·562		H =	·170		H =	·147		H =	·010
	κ =	225°·95		κ =	236°·54		κ =	227°·54		κ =	232°·07
M_3	R =	·012	P_1	R =	·401	μ_2	R =	·071	$(M_2K_1)_3$	R =	·031
	ζ =	184°·40		ζ =	222°·99		ζ =	291°·68		ζ =	63°·85
	H =	·012		H =	·401		H =	·073		H =	·030
	κ =	204°·05		κ =	32°·61		κ =	197°·88		κ =	19°·13
M_4	R =	·004	J_1	R =	·103	R_2	R =	...	$(2M_2K_1)_3$	R =	·011
	ζ =	32°·01		ζ =	192°·48		ζ =	...		ζ =	264°·46
	H =	·004		H =	·096		H =	...		H =	·010
	κ =	298°·21		κ =	63°·27		κ =	...		κ =	348°·49

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·054	336°·38	·056	28°·56
„ Fortnightly „	·052	333°·11	·045	17°·24
Luni-Solar „ „	·005	180°·37	·005	47°·27
Solar-Annual „	·358	71°·58	·358	351°·95
„ Semi-Annual „	·070	302°·61	·070	143°·35

Values of the Tidal Constants, Karachi, 1908.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1908 observations at Karachi; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1908 observations.

Short Period Tides.

$A_0 = 7·163$ feet.

S_1	H = R =	·095	M_6	R =	·051	Q_1	R =	·177	T_2	R =	·045
	κ = ζ =	210°·63		ζ =	38°·31		ζ =	119°·64		ζ =	304°·45
S_2	H = R =	·962		H =	·050		H =	·175		H =	·045
	κ = ζ =	323°·82		κ =	212°·80		κ =	51°·57		κ =	306°·25
S_4	H = R =	·012	M_8	R =	·005	L_2	R =	·077	$(MS)_4$	R =	·042
	κ = ζ =	348°·79		ζ =	355°·37		ζ =	100°·24		ζ =	254°·49
S_6	H = R =	·008		H =	·004		H =	·073		H =	·041
	κ = ζ =	293°·01		κ =	228°·03		κ =	301°·50		κ =	312°·66
S_8	H = R =	·001	O_1	R =	·676	N_2	R =	·632	$(2SM)_2$	R =	·022
	κ = ζ =	21°·80		ζ =	165°·67		ζ =	170°·21		ζ =	174°·64
				H =	·670		H =	·630		H =	·022
				κ =	47°·20		κ =	278°·79		κ =	116°·47
M_1	R =	·111	K_1	R =	1·345	λ_2	R =	...	$2N_2$	R =	·127
	ζ =	134°·01		ζ =	225°·79		ζ =	...		ζ =	94°·11
	H =	·075		H =	1·338		H =	...		H =	·127
	κ =	40°·97		κ =	46°·48		κ =	...		κ =	253°·10
M_2	R =	2·629	K_2	R =	·252	ν_2	R =	·179	$(M_2N)_4$	R =	·030
	ζ =	236°·57		ζ =	136°·59		ζ =	249°·59		ζ =	173°·05
	H =	2·621		H =	·254		H =	·178		H =	·030
	κ =	294°·74		κ =	317°·89		κ =	317°·64		κ =	339°·79
M_3	R =	·035	P_1	R =	·411	μ_2	R =	·077	$(M_2K_1)_3$	R =	·069
	ζ =	235°·02		ζ =	232°·94		ζ =	143°·99		ζ =	146°·17
	H =	·035		H =	·411		H =	·076		H =	·068
	κ =	322°·27		κ =	43°·38		κ =	260°·32		κ =	25°·02
M_4	R =	·028	J_1	R =	·137	R_2	R =	...	$(2M_2K_1)_3$	R =	·022
	ζ =	215°·86		ζ =	298°·36		ζ =	...		ζ =	104°·81
	H =	·028		H =	·135		H =	...		H =	·022
	κ =	332°·19		κ =	64°·59		κ =	...		κ =	40°·46

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·031	43°·50	·031	353°·08
„ Fortnightly „	·016	214°·43	·016	329°·54
Luni-Solar „ „	·009	198°·02	·009	139°·86
Solar-Annual „	·131	141°·06	·131	60°·62
„ Semi-Annual „	·154	321°·76	·154	160°·89

VALUES OF THE TIDAL CONSTANTS AT KARACHI, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Karachi; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0 = 7·164 feet.

Tide		Value
S_1	H = R =	·089
	κ = ζ =	188°·91
S_2	H = R =	·971
	κ = ζ =	322°·49
S_4	H = R =	·011
	κ = ζ =	12°·88
S_6	H = R =	·007
	κ = ζ =	299°·85
S_8	H = R =	·001
	κ = ζ =	291°·04
M_1	R =	·105
	ζ =	218°·19
	H =	·050
	κ =	10°·68
M_2	R =	2·580
	ζ =	159°·10
	H =	2·604
	κ =	293°·69
M_3	R =	·033
	ζ =	318°·37
	H =	·034
	κ =	340°·26
M_4	R =	·027
	ζ =	61°·77
	H =	·028
	κ =	330°·96
M_6	R =	·044
	ζ =	162°·49
	H =	·045
	κ =	206°·27
M_8	R =	·002
	ζ =	356°·19
	H =	·002
	κ =	174°·55
O_1	R =	·705
	ζ =	91°·26
	H =	·660
	κ =	47°·30
K_1	R =	1·391
	ζ =	223°·69
	H =	1·335
	κ =	45°·80
K_2	R =	·260
	ζ =	136°·20
	H =	·239
	κ =	319°·97
P_1	R =	·396
	ζ =	234°·72
	H =	·396
	κ =	44°·41
J_1	R =	·099
	ζ =	09°·72
	H =	·092
	κ =	79°·65
Q_1	R =	·153
	ζ =	142°·25
	H =	·144
	κ =	46°·91
L_2	R =	·082
	ζ =	270°·71
	H =	·126
	κ =	284°·49
N_2	R =	·632
	ζ =	195°·10
	H =	·638
	κ =	278°·32
λ_2	R =	...
	ζ =	...
	H =	...
	κ =	...
ν_2	R =	·215
	ζ =	318°·89
	H =	·217
	κ =	281°·53
μ_2	R =	·073
	ζ =	3°·67
	H =	·074
	κ =	272°·85
R_2	R =	...
	ζ =	...
	H =	...
	κ =	...
T_2	R =	·005
	ζ =	343°·41
	H =	·005
	κ =	344°·48
$(MS)_4$	R =	·037
	ζ =	168°·03
	H =	·038
	κ =	302°·62
$(2SM)_2$	R =	·016
	ζ =	226°·53
	H =	·016
	κ =	91°·94
$2N_2$	R =	·069
	ζ =	213°·48
	H =	·070
	κ =	245°·32
$M_2N)_4$	R =	·027
	ζ =	134°·05
	H =	·027
	κ =	351°·85
$(M_2K_1)_3$	R =	·059
	ζ =	108°·25
	H =	·057
	κ =	64°·95
$(2M_2K_1)_3$	R =	·027
	ζ =	283°·88
	H =	·026
	κ =	10°·95

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·021	253°·43	·022	304°·80
„ Fortnightly „	·050	293°·04	·043	335°·56
Luni-Solar „ „	·031	272°·52	·031	137°·93
Solar-Annual „	·204	147°·25	·204	67°·56
„ Semi-Annual „	·142	302°·39	·142	143°·02

VALUES OF THE TIDAL CONSTANTS AT BOMBAY, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Bombay; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0=10·148 feet.

Tide			Tide			Tide			Tide		
S_1	H = R =	·085	M_6	R =	·018	Q_1	R =	·152	T_2	R =	·022
	κ = ζ =	197°·39		ζ =	3°·24		ζ =	145°·68		ζ =	8°·17
S_2	H = R =	1·568		H =	·018		H =	·142		H =	·022
	κ = ζ =	4°·18		κ =	48°·21		κ =	50°·97		κ =	9°·25
S_4	H = R =	·022	M_8	R =	·009	L_2	R =	·091	$(MS)_4$	R =	·082
	κ = ζ =	227°·22		ζ =	180°·77		ζ =	287°·26		ζ =	242°·16
S_6	H = R =	·005		H =	·009		H =	·139		H =	·083
	κ = ζ =	171°·44		κ =	0°·73		κ =	301°·23		κ =	17°·15
S_8	H = R =	·002	O_1	R =	·690	N_2	R =	·971	$(2SM)_2$	R =	·030
	κ = ζ =	191°·31		ζ =	92°·71		ζ =	231°·03		ζ =	224°·04
				H =	·647		H =	·980		H =	·030
				κ =	49°·16		κ =	314°·85		κ =	89°·05
M_1	R =	·113	K_1	R =	1·450	λ_2	R =	...	$2N_2$	R =	·143
	ζ =	220°·59		ζ =	223°·61		ζ =	...		ζ =	247°·89
	H =	·054		H =	1·392		H =	...		H =	·145
	κ =	13°·27		κ =	45°·70		κ =	...		κ =	280°·56
M_2	R =	3·931	K_2	R =	·408	ν_2	R =	·270	$(M_2N)_4$	R =	·002
	ζ =	196°·51		ζ =	176°·39		ζ =	353°·60		ζ =	2°·60
	H =	3·968		H =	·374		H =	·272		H =	·002
	κ =	331°·50		κ =	0°·13		κ =	316°·81		κ =	221°·42
M_3	R =	·069	P_1	R =	·403	μ_2	R =	205	$(M_2K_1)_3$	R =	·079
	ζ =	1°·78		ζ =	235°·96		ζ =	32°·89		ζ =	191°·59
	H =	·070		H =	·403		H =	·209		H =	·077
	κ =	24°·26		κ =	45°·67		κ =	308°·87		κ =	148°·67
M_4	R =	·093	J_1	R =	·106	R_2	R =	...	$(2M_2K_1)_3$	R =	·069
	ζ =	38°·44		ζ =	212°·50		ζ =	...		ζ =	343°·57
	H =	·095		H =	·099		H =	...		H =	·067
	κ =	308°·42		κ =	82°·20		κ =	...		κ =	71°·46

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·047	262°·81	·049	313°·37
„ Fortnightly „ . .	·029	290°·48	·025	332°·57
Luni-Solar „ „	·021	240°·50	·021	105°·51
Solar-Annual „	·122	112°·62	·122	32°·92
„ Semi-Annual „	·121	354°·29	·121	194°·88

VALUES OF THE TIDAL CONSTANTS, PRINCE'S DOCK, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Prince's Dock; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0 = 8·119 feet.

S_1	H = R =	·086	M_6	R =	·012	Q_1	R =	·154	T_2	R =	·027
	κ = ζ =	202°·40		ζ =	122°·93		ζ =	147°·22		ζ =	25°·03
S_2	H = R =	1·602		H =	·012		H =	·144		H =	·027
	κ = ζ =	5°·44		κ =	167°·90		κ =	52°·51		κ =	26°·11
S_4	H = R =	·025	M_8	R =	·007	L_2	R =	·110	$(MS)_4$	R =	·113
	κ = ζ =	208°·56		ζ =	286°·34		ζ =	275°·30		ζ =	263°·96
S_6	H = R =	·004		H =	·008		H =	·168		H =	·115
	κ = ζ =	227°·82		κ =	106°·30		κ =	289°·26		κ =	38°·95
S_8	H = R =	·002	O_1	R =	·694	N_2	R =	·980	$(2SM)_2$	R =	·035
	κ = ζ =	127°·57		ζ =	92°·58		ζ =	332°·55		ζ =	249°·13
				H =	·650		H =	·989		H =	·035
				κ =	49°·03		κ =	316°·37		κ =	114°·14
M_1	R =	·109	K_1	R =	1·458	λ_2	R =	...	$2N_2$	R =	·158
	ζ =	219°·04		ζ =	223°·51		ζ =	...		ζ =	255°·19
	H =	·052		H =	1·399		H =	...		H =	·160
	κ =	11°·72		κ =	45°·61		κ =	...		κ =	287°·86
M_2	R =	4·027	K_2	R =	·404	ν_2	R =	·294	$(M_2N)_4$	R =	·010
	ζ =	197°·19		ζ =	177°·33		ζ =	353°·39		ζ =	201°·25
	H =	4·064		H =	·370		H =	·297		H =	·010
	κ =	332°·18		κ =	1°·07		κ =	316°·60		κ =	60°·07
M_3	R =	·068	P_1	R =	·405	μ_2	R =	·231	$(M_2K_1)_3$	R =	·098
	ζ =	4°·30		ζ =	236°·51		ζ =	44°·11		ζ =	189°·63
	H =	·069		H =	·405		H =	·235		H =	·095
	κ =	26°·79		κ =	46°·21		κ =	314°·09		κ =	146°·71
M_4	R =	·098	J_1	R =	·109	R_2	R =	...	$2M_2K_1)_3$	R =	·080
	ζ =	63°·03		ζ =	214°·54		ζ =	...		ζ =	355°·53
	H =	·100		H =	·102		H =	...		H =	·078
	κ =	333°·01		κ =	84°·24		κ =	...		κ =	83°·41

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·049	257°·08	·051	308°·24
,, Fortnightly ,, ...	·033	306°·06	·029	348°·15
Luni-Solar ,, ,, ...	·025	205°·72	·025	70°·73
Solar-Annual ,, ...	·154	116°·38	·154	35°·67
,, Semi-Annual ,, ...	·096	355°·59	·096	196°·18

VALUES OF THE TIDAL CONSTANTS, MADRAS, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Madras; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0 = 2·354 feet.

S_1	H = R =	·023	M_6	R =	·004	Q_1	R =	·005	T_2	R =	·012
	κ = ζ =	81°·58		ζ =	67°·38		ζ =	312°·51		ζ =	160° 64
S_2	H = R =	·456		H =	·004		H =	·005		H =	·012
	κ = ζ =	269°·26		κ =	113°·86		κ =	218°·59		κ —	161°·75
S_4	H = R =	·001	M_8	R =	·001	L_2	R =	·034	$(MS)_4$	R =	·005
	κ = ζ =	138°·01		ζ =	260°·54		ζ =	264° 21		ζ =	29°·20
S_6	H = R =	·002		H =	·001		H =	·052		H =	·005
	κ = ζ =	96°·71		κ =	82°·51		κ =	278°·41		κ =	165°·39
S_8	H = R =	·001	O_1	R =	·101	N_2	R =	·238	$(2SM)_2$	R =	·013
	κ = ζ =	63°·44		ζ =	6°·89		ζ =	152°·13		ζ =	346°·50
				H =	·095		H =	·240		H =	·013
				κ =	323°·87		κ =	236°·73		κ =	211°·01
M_1	R =	·010	K_1	R =	·306	λ_2	R =	...	$2N_2$	R =	·028
	ζ =	107°·88		ζ =	154°·80		ζ =	...		ζ =	170°·03
	H =	·005		H =	·293		H =	...		H =	·028
	κ =	260°·81		κ =	336°·87		κ =	...		κ =	203°·74
M_2	R =	1·080	K_2	R =	·122	ν_2	R =	·076	$(M_2N)_4$	R =	·000
	ζ =	104°·67		ζ =	87°·62		ζ =	281°·85		ζ =	116°ʳ57
	H =	1·090		H =	·112		H =	·077		H =	·000
	κ =	240°·16		κ =	271°·32		κ =	245°·80		κ =	336°·66
M_3	R =	·004	P_1	R =	·093	μ_2	R =	·029	$(M_2K_1)_3$	R =	·014
	ζ =	358°·36		ζ =	172°·39		ζ =	294°·13		ζ =	90°·86
	H =	·004		H =	·093		H =	·029		H =	·013
	κ =	21°·60		κ =	342°·12		κ =	205°·11		κ =	48°·43
M_4	R =	·004	J_1	R =	·014	R_2	R =	...	$(2M_2K_1)_3$	R =	·004
	ζ =	239°·04		ζ =	113°·04		ζ =	...		ζ =	234°·46
	H =	·004		H =	·013		H =	...		H =	·003
	κ =	150°·02		κ =	342°·45		κ =	...		κ =	323°·37

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·018	279°·44	·019	330°·33
„ Fortnightly „	·054	326°·12	·047	7°·67
Luni-Solar „ „	·042	352°·39	·042	216°·90
Solar-Annual „	·312	303°·30	·312	223°·57
„ Semi-Annual „	·329	277°·57	·329	118°·12

VALUES OF THE TIDAL CONSTANTS, KIDDERPORE, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0=10·770 feet.

Tide		Value	Tide		Value	Tide		Value	Tide		Value
S_1	H = R =	·099	M_6	R =	·158	Q_1	R =	·033	T_2	R =	·104
	κ = ζ =	204°·23		ζ =	272°·38		ζ =	91°·38		ζ =	205°·41
S_2	H = R =	1·557		H =	·162		H =	·031		H =	·104
	κ = ζ =	96°·73		κ =	320°·49		κ =	358°·32		κ =	206°·54
S_4	H = R =	·100	M_8	R =	·073	L_2	R =	·231	$(MS)_4$	R =	·702
	κ = ζ =	107°·97		ζ =	87°·52		ζ =	67°·90		ζ =	295°·98
S_6	H = R =	·005		H =	·075		H =	·354		H =	·709
	κ = ζ =	15°·95		κ =	271°·66		κ =	82°·36		κ =	72°·02
S_8	H = R =	·005	O_1	R =	·227	N_2	R =	·729	$(2SM)_2$	R =	·074
	κ = ζ =	325°·98		ζ =	66°·35		ζ =	316°·71		ζ =	134°·28
				H =	·213		H =	·736		H =	·075
				κ =	23°·89		κ =	42°·15		κ =	358°·25
M_1	R =	·019	K_1	R =	·427	λ_2	R =	...	$2N_2$	R =	·049
	ζ =	130°·67		ζ =	229°·93		ζ =	...		ζ =	90°·95
	H =	·009		H =	·410		H =	...		H =	·049
	κ =	283°·87		κ =	51°·98		κ =	...		κ =	125°·79
M_2	R =	3·687	K_2	R =	·481	ν_2	R =	·312	$(M_2N)_4$	R =	·306
	ζ =	278°·95		ζ =	264°·76		ζ =	65°·00		ζ =	157°·27
	H =	3·721		H =	·441		H =	·315		H =	·312
	κ =	54°·98		κ =	88°·42		κ =	29°·75		κ =	18°·75
M_3	R =	·026	P_1	R =	·155	μ_2	R =	·272	$(M_2K_1)_3$	R =	·089
	ζ =	320°·22		ζ =	238°·03		ζ =	264°·71		ζ =	66°·00
	H =	·027		H =	·155		H =	·277		H =	·087
	κ =	344°·28		κ =	47°·78		κ =	176°·79		κ =	24°·09
M_4	R =	·756	J_1	R =	·008	R_2	R =	...	$(2M_2K_1)_3$	R =	·043
	ζ =	119°·01		ζ =	256°·48		ζ =	...		ζ =	237°·71
	H =	·770		H =	·008		H =	...		H =	·042
	κ =	31°·08		κ =	125°·57		κ =	...		κ =	327°·73

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide .	·369	316°·42	·382	7°·02
„ Fortnightly „	·342	346°·21	·297	27°·17
Luni-Solar „ „	·880	177°·62	·888	41°·58
Solar-Annual „	2·769	228°·80	2·769	149°·05
„ Semi-Annual „	·912	125°·	·912	325°·54

VALUES OF THE TIDAL CONSTANTS, RANGOON, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Rangoon; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0 = 10·303 feet.

Tide		Value	Tide		Value	Tide		Value	Tide		Value
S_1	H = R =	·094	M_6	R =	·230	Q_1	R =	·023	T_2	R =	·036
	κ = ζ =	106°·96		ζ =	40°·38		ζ =	61°·15		ζ =	147°·98
S_2	H = R =	2·130		H =	·237		H =	·022		H =	·036
	κ = ζ =	169°·18		κ =	90°·08		κ =	138°·92		κ =	149°·12
S_4	H = R =	·092	M_8	R =	·103	L_2	R =	·479	$(MS)_4$	R =	·499
	κ = ζ =	267°·49		ζ =	286°·47		ζ =	141°·97		ζ =	74°·40
S_6	H = R =	·103		H =	·107		H =	·736		H =	·504
	κ = ζ =	26°·18		κ =	112°·75		κ =	156°·67		κ =	210°·97
S_8	H = R =	·003	O_1	R =	·305	N_2	R =	1·101	$(2SM)_2$	R =	·163
	κ = ζ =	59°·74		ζ =	70°·08		ζ =	32°·09		ζ =	176°·95
				H =	·285		H =	1·111		H =	·165
				κ =	28°·17		κ =	118°·34		κ =	40°·38
M_1	R =	·011	K_1	R =	·713	λ_2	R =	...	$2N_2$	R =	·110
	ζ =	109°·62		ζ =	211°·28		ζ =	...		ζ =	237°·84
	H =	·005		H =	·684		H =	...		H =	·111
	κ =	263°·09		κ =	33°·31		κ =	...		κ =	273°·78
M_2	R =	5·815	K_2	R =	·648	ν_2	R =	·471	$(M_2N)_4$	R =	·212
	ζ =	354°·27		ζ =	347°·71		ζ =	152°·76		ζ =	292°·09
	H =	5·869		H =	·594		H =	·476		H =	·216
	κ =	130°·84		κ =	171°·33		κ =	118°·29		κ =	154°·91
M_3	R =	·046	P_1	R =	·195	μ_2	R =	·511	$(M_2K_1)_3$	R =	·128
	ζ =	109°·04		ζ =	249°·44		ζ =	10°·42		ζ =	87°·47
	H =	·047		H =	·195		H =	·521		H =	·124
	κ =	133°·89		κ =	59°·21		κ =	283°·56		κ =	46°·07
M_4	R =	·540	J_1	R =	·028	R_2	R =	...	$(2M_2K_1)_3$	R =	·116
	ζ =	256°·47		ζ =	231°·63		ζ =	...		ζ =	319°·77
	H =	·551		H =	·026		H =	...		H =	·114
	κ =	169°·61		κ =	100°·42		κ =	...		κ =	50°·87

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·143	329°·79	·148	20°·1[illegible]
„ Fortnightly „	·153	338°·31	·133	18°·69
Luni-Solar „ „	·311	180°·37	·314	43°·81
Solar-Annual „ . . .	1·198	228°·72	1·198	148°·95
„ Semi-Annual „	·134	178°·38	·134	18°·85

VALUES OF THE TIDAL CONSTANTS, MOULMEIN, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Moulmein; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_o = 8·603 feet.

S_1	H = R =	·093	M_6	R =	·081	Q_1	R =	·023	T_2	R =	...
	κ = ζ =	140°·30		ζ =	125°·99		ζ =	143°·77		ζ =	...
S_2	H = R =	1·495		H =	·083		H =	·022		H =	...
	κ = ζ =	144°·08		κ =	175°·99		κ =	51°·71		κ =	...
S_4	H = R =	·068	M_8	R =	·059	L_2	R =	·316	$(MS)_4$	R =	·760
	κ = ζ =	223°·20		ζ =	286°·94		ζ =	127°·46		ζ =	63°·91
S_6	H = R =	·001		H =	·061		H =	·485		H =	·767
	κ = ζ =	128°·66		κ =	113°·60		κ =	142°·21		κ =	200°·57
S_8	H = R =	·002	O_1	R =	·241	N_2	R =	·786	$(2SM)_2$	R =	·142
	κ = ζ =	170°·54		ζ =	86°·87		ζ =	7°·76		ζ =	167°·71
				H =	·226		H =	·793		H =	·143
M_1	R =	·008		κ =	45°·07		κ =	94°·16		κ =	31°·05
	ζ =	286°·84	K_1	R =	·473	λ_2	R =	...	$2N_2$	R =	·097
	H =	·004		ζ =	215°·35		ζ =	...		ζ =	184°·45
	κ =	80°·36		H =	·454		H =	...		H =	·098
M_2	R =	4·079		κ =	37°·38		κ =	...		κ =	220°·59
	ζ =	332°·87	K_2	R =	·434	ν_2	R =	·325	$(M_2N)_4$	R =	·345
	H =	4·116		ζ =	325°·37		ζ =	134°·66		ζ =	279°·21
	κ =	109°·54		H =	·398		H =	·328		H =	·351
M_3	R =	·030		κ =	148°·97		κ =	100°·33		κ =	142°·28
	ζ =	130°·01	P_1	R =	·144	μ_2	R =	·394	$(M_2K_1)_3$	R =	·128
	H =	·030		ζ =	245°·81		ζ =	353°·76		ζ =	124°·91
	κ =	155°·01		H =	·144		H =	·401		H =	·124
M_4	R =	·927		κ =	55°·59		κ =	267°·10		κ =	83°·61
	ζ =	246°·95	J_1	R =	·030	R_2	R =	...	$(2M_2K_1)_3$	R =	·108
	H =	·944		ζ =	233°·75		ζ =	...		ζ =	320°·70
	κ =	160°·28		H =	·028		H =	...		H =	·106
				κ =	102°·48		κ =	...		κ =	52°·00

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·227	320°·01	·235	10°·27
„ Fortnightly „	·361	347°·55	·314	27°·83
Luni-Solar „ „	1·071	175°·41	1·081	38°·75
Solar-Annual „	2·406	230°·99	2·406	151°·22
„ Semi-Annual „	·456	97°·99	·456	208°·45

VALUES OF THE TIDAL CONSTANTS, PORT BLAIR, 1909.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1909 observations at Port Blair; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1909 observations.

Short Period Tides.

A_0 = 4·868 feet.

S_1	H = R =	·013	M_6	R =	·003	Q_1	R =	·023	T_2	R =	·024
	κ = ζ =	68°·52		ζ =	333°·41		ζ =	343°·23		ζ =	286°·47
S_2	H = R =	·962		H =	·003		H =	·022		H =	·024
	κ = ζ =	313°·62		κ =	22°·44		κ =	250°·64		κ =	287°·61
S_4	H = R =	·005	M_8	R =	·002	L_2	R =	·082	$(MS)_4$	R =	·008
	κ = ζ =	173°·80		ζ =	254°·48		ζ =	263°·07		ζ =	71°·57
S_6	H = R =	·001		H =	·002		H =	·126		H =	·008
	κ = ζ =	221°·16		κ =	79°·82		κ =	277°·67		κ =	207°·90
S_8	H = R =	·004	O_1	R =	·161	N_2	R =	·407	$(2SM)_2$	R =	·022
	κ = ζ =	162°·07		ζ =	343°·04		ζ =	188°·76		ζ =	274°·03
				H =	·150		H =	·411		H =	·022
				κ =	300°·89		κ =	274°·66		κ =	137°·69
M_1	R =	·021	K_1	R =	·418	λ_2	R =	...	$2N_2$	R =	·049
	ζ =	97°·03		ζ =	144°·41		ζ =	...		ζ =	246°·46
	H =	·010		H =	·401		H =	...		H =	·049
	κ =	250°·38		κ =	326°·44		κ =	...		κ =	281°·92
M_2	R =	1·973	K_2	R =	·261	ν_2	R =	·132	$(M_2N)_4$	R =	·007
	ζ =	142°·96		ζ =	127°·56		ζ =	305°·89		ζ =	100°·01
	H =	1·992		H =	·242		H =	·133		H =	·007
	κ =	279°·29		κ =	311°·19		κ =	271°·07		κ =	322°·24
M_3	R =	·009	P_1	R =	·135	μ_2	R =	·092	$(M_2K_1)_3$	R =	·014
	ζ =	355°·87		ζ =	155°·40		ζ =	23°·67		ζ =	122°·01
	H =	·009		H =	·135		H =	·094		H =	·013
	κ =	20°·37		κ =	325°·16		κ =	296°·34		κ =	80°·38
M_4	R =	·007	J_1	R =	·021	R_2	R =	...	$(2M_2K_1)_3$	R =	·006
	ζ =	159°·03		ζ =	98°·21		ζ =	...		ζ =	147°·60
	H =	·007		H =	·020		H =	...		H =	·006
	κ =	71°·70		κ =	327°·13		κ =	...		κ =	238°·23

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·011	11°·45	·011	61°·89
" Fortnightly "	·062	326°·97	·054	7°·60
Luni-Solar " "	·017	231°·92	·017	95°·58
Solar-Annual "	·214	206°·20	·214	126°·44
" Semi-Annual "	·052	350°·94	·052	191°·42

Sale of tide tables.—The amount realized on the sale of tide tables during the year ending September 1910 was Rs. 1,967-5-0.

Errors in predictions.—The five tabular statements which are appended show the percentage and amount of error in the predicted times and heights of high and low water for the year 1909 at 12 stations, as determined by comparisons of the predictions given in the tide tables with the actual values measured from the tidal diagrams at 9 stations, and from the tide poles at 3 stations; the former are made in this office, and the latter by the port officials concerned.

TABLE A.

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 1909.

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.	682	49	40	5	3	3
Karachi	Auto.	705	41	47	7	4	1
Bhavnagar	T. P.	365	53	46	1	..	..
Bombay { Apollo Bandar	Auto.	701	42	42	7	6	3
Bombay { Prince's Dock	Auto.	689	34	46	10	6	4
Madras	Auto.	706	34	47	12	5	2
Kidderpore	Auto.	705	16	32	16	19	17
Chittagong	T. P.	365	33	31	9	12	15
Akyab	T. P.	365	99	1	..	..	..
Rangoon	Auto.	705	34	36	12	13	5
Moulmein	Auto.	699	23	41	13	16	7
Port Blair	Auto.	704	48	41	5	5	1

TABLE B.

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 1909.

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.	675	42	40	8	7	3
Karachi	Auto.	704	39	46	8	6	1
Bhavnagar	T. P.	365	52	47	1	..	..
Bombay { Apollo Bandar	Auto.	703	42	45	7	5	1
Bombay { Prince's Dock	Auto.	688	37	46	9	6	2
Madras	Auto.	706	45	42	7	5	1
Kidderpore	Auto.	705	20	39	13	17	11
Chittagong	T. P.	365	36	29	8	9	18
Akyab	T. P.	365	98	1	..	1	..
Rangoon	Auto.	705	26	37	14	18	5
Moulmein	Auto.	699	23	32	11	17	17
Port Blair	Auto.	704	43	46	6	4	1

TABLE C.

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 1909.

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.	682	6·7	94	6	..	..
Karachi	Auto.	705	9·3	81	18	1	..
Bhavnagar	T. P.	365	31·4	58	27	14	1
Bombay { Apollo Bandar	Auto.	701	13·9	67	27	5	1
Bombay { Prince's Dock	Auto.	689	13·9	67	25	7	1
Madras	Auto.	706	3·5	83	15	2	..
Kidderpore	Auto.	705	11·7	47	28	12	13
Chittagong	T. P.	365	13·3	47	21	16	16
Akyab	T. P.	365	8·3	90	9	..	1
Rangoon	Auto.	705	16·4	47	32	17	4
Moulmein	Auto.	699	12·7	31	23	20	26
Port Blair	Auto.	704	6·0	95	5	..	..

TABLE D.

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 1909.

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.	675	6·7	94	6	..	..
Karachi	Auto.	704	9·3	78	19	3	..
Bhavnagar	T. P.	365	31·4	56	32	8	4
Bombay { Apollo Bandar	Auto.	703	13·9	71	24	5	..
Bombay { Prince's Dock	Auto.	688	13·9	65	27	7	1
Madras	Auto.	705	3·5	89	10	1	..
Kidderpore	Auto.	705	11·7	48	24	17	11
Chittagong	T. P.	365	13·3	38	26	19	17
Akyab	T. P.	365	8·3	90	9	..	1
Rangoon	Auto.	705	16·4	34	27	20	19
Moulmein	Auto.	699	12·7	38	24	17	21
Port Blair	Auto.	704	6·6	99	1	..	..

TABLE E.

Table of average errors in the predicted times and heights of high and low water at the several tidal stations for the year 1909.

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
Karachi	Auto.	9·3	8	9	·027	·027	3	3
Bhavnagar	T. P.	31·4	6	6	·013	·013	5	5
Bombay { Apollo Bandar	Auto.	13·9	9	8	·024	·018	4	3
Bombay { Prince's Dock	Auto.	13·9	10	9	·024	·024	4	4
Madras	Auto.	3·5	10	8	·071	·048	3	2
Akyab	T. P.	8·3	..	1	·020	·020	2	2
Port Blair	Auto.	6·6	8	8	·025	·025	2	2
General Mean	..	..	7	7	·029	·025	..	..
Riverain.								
Kidderpore	Auto.	11·7	18	16	·043	·043	6	6
Chittagong	T. P.	13·3	15	15	·044	·044	7	7
Rangoon	Auto.	16·4	12	13	·025	·041	5	8
Moulmein	Auto.	12·7	14	17	·059	·040	9	7
General Mean	"	"	15	15	·043	·044	..	..

The foregoing statements for the year 1909 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	85	86
	2 „ „ „ tide pole	100	99
Riverain stations.	3 „ „ „ S. R. tide gauge	61	59
	1 „ „ „ tide pole	64	65

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	97
	2 „ „ „ tide pole	92	94
Riverain stations.	3 „ „ „ S. R. tide gauge	69	65
	1 „ „ „ tide pole	68	64

Percentage of height predictions within one-tenth of mean range of 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.	3 „ „ „ S. R. tide gauge	93	92
	1 „ „ „ tide pole	92	93

Comparison of the predictions at riverain stations.—The predictions for the riverain stations for the year 1909 were compared with those for the previous year, with the following results. The predictions for high water times and heights for 1909 are about the same as in 1908 at all the riverain stations ; for low water times they are the same at Rangoon, better at Kidderpore and Chittagong, and worse at Moulmein : for low water heights they are worse at Chittagong, and better at all the other riverain stations. The greatest difference between the actual and predicted heights of low water for 1909 at the riverain stations was as follows :—

Kidderpore .	3′ 3″ on 4th September 1909, actuals being higher.
Chittagong .	2′ 6″ on 3rd October 1909, actuals being higher.
Rangoon .	2′ 0″ on 14th and 15th October 1909, actuals being lower.
Moulmein	2′ 0″ on 28th to 30th August 1909, actuals being lower.

VII.—Physiographical Changes.

By Colonel S. G. Burrard, R.E., F.R.S.

It is intended in future to maintain a record of all changes that may be noticed to have occurred or to be now occurring in the form and features of the land-surface of India. In order to ensure the co-operation of the several topographical parties the following instructions are being issued :—

Now that a new topographical survey of India is being commenced, officers are requested to include in annual narrative reports brief notes on any marked physiographical changes that may come under observation.

(*i*) The whole area of loose sand that constitutes the Rajputana desert is moving *en masse* towards the north-east under the influence of prevailing winds ; it will be of interest to ascertain in the course of the new survey to what extent the sand has advanced towards Ajmer and Delhi and Ferozepore since the last survey was made, and whether in its advance it is abandoning areas in Sind and Cutch which it formerly occupied.

(*ii*) When sand advances into regions watered by rain, it is carried by streams into the rivers and by rivers into the sea. Its advance may consequently not here be apparent. But in the struggle for mastery between the sand and the rivers, the courses of the latter are apt to be deflected. The Punjab rivers have been driven northwards and have been forced to combine by advances of sand from Rajputana ; the Ghaggar has been choked and the Jumna has been pushed to the east. It will be of interest to learn whether the rivers are still retiring before the sand or whether they are holding their own.

(*iii*) If any considerable area that was formerly cultivated is found now to be desiccated, the change will be worthy of mention in narrative reports.

(*iv*) All rivers that meander over flat alluvial plains are apt to change their courses as their beds get raised by silt. It is of interest to know whether these changes of course are systematic, *i.e.*, always towards one direction, or whether they are oscillatory. Are (for example) the junction-points of the Himalayan rivers, Gogra, Gandak, Kosi, etc., with the Ganges in Bengal all tending to move to the east ?

(*v*) Changes in the position of coast-lines are always worthy of record, more especially if they appear to be systematic.

(*vi*) Very little is as yet known of the rate of growth of the deltas of the rivers of North and South India and of Burma. The effect of irrigation schemes upon deltaic growth is a subject of scientific interest.

PART II.

I.—The Photo-Litho Office.

BY LIEUTENANT O. H. B. TRENCHARD, R.E.

An endeavour was made in last year's report, while recounting the progress of the different sections of the office, to estimate the value of Major Hedley's reorganisation scheme, which had been introduced at the beginning of that year, in connection with the satisfactory results of the year's work. Another year has passed during which a policy of consolidating the reforms and maintaining an improvement in methods has been aimed at. No changes of importance have been made in the superior staff of the office, and this fact has materially contributed towards the end in view. The year under report is the first in which the new system of promotion, an essential feature of the reorganisation, has been applied on a large scale, and the results appear to be satisfactory in every way. In fact one may confidently predict that increased efficiency and additional progress in the future will depend on adherence to the broad lines of the reorganisation scheme.

The first steps to deal with the steadily growing congestion of space in the Photo Branch and Stores Section which was alluded to in last year's report have now been taken, and a comprehensive scheme which includes the erection of a second storey to that part of the building occupied by the Photo Branch and an enlargement of certain of the Stores Section buildings has received the preliminary sanction of the Surveyor General.

Some time must probably elapse before this scheme is carried out in full, but it is to be hoped that every effort will be made to hasten actual building operations so that no mere physical check will be placed in the near future on the continuous expansion of work.

PHOTO BRANCH.

Negative Section.

The outturn of finished negatives in square inches for the year amounts to 1,943,889 at an average cost of Re. 0-5-7 per 100 square inches as compared with 2,173,868 square inches at Re. 0-4-9 per 100 in 1908-09 and 1,649,862 square inches at Re. 0-6-7 in 1907-08. The slight diminution in outturn and increase in cost is accounted for by a marked decrease in the number of reductions of plane-table sections supplied and a corresponding increase in half-tone negatives of hill shading, a class of work necessarily involving greater skill and higher chemical expenditure. The quality of the negatives has been well maintained, but the difficulty of effecting by purely photographic processes any material improvement in reproduction of an indifferently drawn and badly typed original has yet to be fully overcome.

Retouching Section.

The figures given above for negatives apply also to this section. Outturn by area, however, is hardly a fair gauge of the work done, since the proportion of colour negatives to the total dealt with increases yearly, and these require far more labour than plain negatives.

A noticeable improvement has been made in the examination of finished negatives.

Process Engraving Section.

The outturn in photogravure plates and half-tone and line blocks is 371 as compared with 305 in the previous year, and the excess of income over expenditure amounts to Rs. 4,836 as compared with Rs. 3,360.

Although the minimum rates charged for half-tone and line work were reduced from Rs. 1-8-0 per square inch to Re. 1 and as. 10 per square inch respectively in 1908, a further reduction to as. 8 and as. 6 is contemplated in the near future with the object of attracting an increased volume of work from present sources, and from others, such as scientific societies, to whom the present rates are even now prohibitive. The section is now fully able to increase its outturn without numerical reinforcement or loss of working profits.

The new Platen printing machine, the installation of which was just mentioned in last year's report, has been successfully employed in printing all the half-tone and the majority of line work formerly undertaken by the Letterpress Section, and also in high grade proving.

Colour photography by what is known commercially as the half-tone three-colour process was successfully introduced for the first time by the Manager, Photo Branch. This process in India presents difficulties not met with in Europe or near a centre of photographic manufacture. The rapidity with which colour-sensitive commercial dry plates deteriorate in Calcutta, their initial high cost and the difficulty of foretelling requirements, all tend to make their employment out of the question for the work of the department. The other alternative is to use plates coated with collodion emulsion, of which perhaps the best known is that manufactured by Dr. Albert of Berlin. Attempts have been made from time to time to introduce it in this office, but without success, owing to its rapid deterioration at any temperature above 50° F.

In 1907 Mr. Taylor took up the question of manufacturing an emulsion which would be workable in Calcutta, and succeeded in making up by an entirely new and revolutionary method an emulsion which met the requirements. He has since been steadily working to perfect it, and such good results have been obtained that he has overcome another difficulty met with in colour reproduction in India, namely, the comparatively low skill of the native etcher which renders satisfactory results unattainable unless colour negatives can be made to give an accurate reproduction of an original without retouching.

At the present time the Photo Branch is able to prepare plates to any reasonable size with colour sensitiveness equal to or excelling the best obtainable dry plate. The experimental work is, however, not complete and the actual procedure has not been published.

LITHO BRANCH.

Proving and Printing Sections.

In last year's report it was recorded that the old reproach to the office, arrears of publication due to lack of capacity to deal with work in hand, had at last been done away with ; it is now still more a thing of the past.

Despite the credit due to the Litho Branch for this achievement, the situation is not entirely satisfactory. Reorganisation has effected order out of the chaos, as far as this branch is particularly concerned, in the short space of three or four years and that without increasing the total cost of the branch.

The certainty of a large increase in the amount of departmental work to be undertaken in the near future dispels any possible inference that we are now in a position to effect a reduction of establishment. The difficulty is to find a sufficiency of the kind of work required to tide the Litho Branch over the immediate present.

Much economy both of time and cost has been effected, especially in the Proving Section, by an increasing realization throughout the department of the principle that originals for reproduction in colours should be so carefully scrutinized before submission as to render the supply of two sets of proofs unnecessary. It is now becoming more and more an exception to furnish coloured proofs of the standard sheets; results seem to prove that little danger of inaccuracy is incurred by this experiment, and it is hardly necessary to add that publication is greatly expedited. A certain amount of extra work is of course thrown on the Examination Section of this office, but this is more than counterbalanced by the necessary decrease in the former risk of perfunctory examination.

With regard to the machines, the quality of the printing has certainly not deteriorated, the average outturn for any full working day is a trifle bigger, and one or two of the native printers have shown marked improvement.

II.—The Mathematical Instrument Office.

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

During the year under review, namely, from 1st April 1909 to 31st March 1910, there has been a large falling off in the demands made on this office and the accounts of the two departments, store and workshop, show deficits of Rs. 20,176 and Rs. 15,270, respectively.

With regard to the former figure it will be seen from the table below that the requisitions made on the stores have decreased by over a lakh of rupees as compared with the previous years, and consequently the amount brought to credit in the profit and loss statement has diminished by approximately Rs. 25,000, which would have more than covered this loss.

The deficit of Rs. 15,270 on the workshop is also explained in item 2 of the table below which shows that the demands made on the workshop show a shrinkage of about half a lakh, while standing charges, such as supervision, rent, interest on plant and material depreciation, clerical labour, etc., amounting in all to Rs. 65,492, say 30 per cent. of the total outlay, were incapable of any reduction.

Table of comparative values for the last three years.

	1907-08.	1908-09.	1909-10.
	Rs.	Rs.	Rs.
1. Value of instruments issued to public offices	3,66,334	3,31,230	2,38,332
2. Value of work done in workshops	2,54,916	2,41,215	1,88,411
3. Value of repairs to instruments repaired and returned in serviceable condition.	42,542	52,278	55,774
4. Value of instruments received as no longer required.	70,486	71,241	53,446
5. Value of instruments manufactured in workshops for serviceable store.	1,11,901	91,571	53,035
6. Value of instruments and materials obtained from England	4,94,985	4,56,322	2,12,921
7. Value of instruments purchased locally	1,943	3,052	1,948
8. Book value of stock of instruments in the serviceable store	7,62,415	9,77,261	10,22,554
9 Book value of stock of instruments in repairable store	98,578	1,21,746	81,381

The average number of employés and their pay were 365 at Rs. 81,412 in 1907-08, 395 at Rs. 85,457 in 1908-09 and 353 at Rs. 79,810 in 1909-10.

The progress made by the workshops in the way of manufacture has been well maintained, but owing to the falling off in demand for such instruments as optical squares, plane-tables and stands, chains and sight rules, the output has been considerably less than in former years. On the other hand more delicate instruments, such as 5″ Everest theodolites, 6″ Quintants, Cooke's DeLisle clinometers, scales and offsets, protractors, Cooke's reversible levels, curve pens and hand presses, have been put in hand.

During the year a large plan-board was designed and constructed for use in the Photo-Litho studio; it has a surface of 11 feet 9 inches by 10 feet 3 inches. This is the largest adjustable plan-board that has ever been made and used in India; owing to the fact that all the weight is taken by a ball thrust there is no difficulty in levelling it.

The Photo-Litho Office also asked the Mathematical Instrument Office to make up a hand press, having the down pressure taken up by surface bearers or parallels. similar to a proof printing press, the object of the surface bearers being to enable inexperienced draftsmen to give a uniform blackness of typing. The advisability of accepting this pattern is still under consideration.

The Southampton pattern hand press was also remodelled; the keyway was replaced by bearers or guides working against the type box, an improvement which has greatly increased the life and efficiency of the instrument.

Experiments were undertaken with a view to manufacture mirrors for argand lamps by an electro deposit process. A small mirror was made and the result was quite satisfactory, but unfortunately when a full size mirror was attempted numerous difficulties arose, due principally to our native labour not having enough experience. However, it is hoped that further and renewed efforts will result in success.

To enable the Mathematical Instrument Office to turn out straight scales and offsets more rapidly and uniformly, an entire automatic dividing machine was obtained from the Société Genevoise of Geneva. After numerous experiments with different materials and cutting tools the office is now able to manufacture scales much cheaper, but owing to the rise in price of ebonite it has been found impossible to reduce the price of the finished scales.

During the year an electric travelling hoist capable of lifting one ton was installed in the packing section; the hoist travels along an I girder down the centre of the room, and so not only serves for lifting and lowering the cases, but also picks them up from the central gangway and carries them to the manhole and lowers them direct on to carts for despatching.

Another engraving machine by Messrs. Taylor, Taylor and Hobson was received during the year; this and the machine previously received have practically superseded hand engraving.

The punching machine indented for from England also arrived and has done much useful work.

In October 1909 the Chief Engineer, Public Works Department, Madras, forwarded three practically new levels made by Messrs. Ottway & Co., London, for examination and report. It seems that the Superintending Engineer to whom they were issued stated that they were of inferior make and badly finished and for this reason had returned them. The instruments were put to a very searching test and examined in every way for mechanical and optical defects.

This work brought up the question as to the advisability of having some first class, permanent and more up-to-date testing appliances for fine optical work of this nature. At first it was thought it would be necessary to order a complete optical bench from England, but after much investigation and correspondence with the India Store Department, it was decided to construct one ourselves which would be more adapted to Indian labour.

Stock-taking of all the stores has been carried out during the year, and where discrepancies have been found, the necessary enquiries and book corrections were made.

The price list mentioned in last year's report was compl ted and was being passed through the press when the year closed.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
8, HASTINGS STREET

INDEX TO THE SHEETS OF THE

INDIA AND ADJACENT COUNTRIES SERIES

on the Scale of 1:1,000,000.

Published under the direction of The Hon'ble Colonel F. B. Longe, R.E., A.D.C., Surveyor General of India.

1910.

Scale $\frac{1}{16,000,000}$.

Miles 200 0 200 400 600 800 Miles.

REFERENCE.

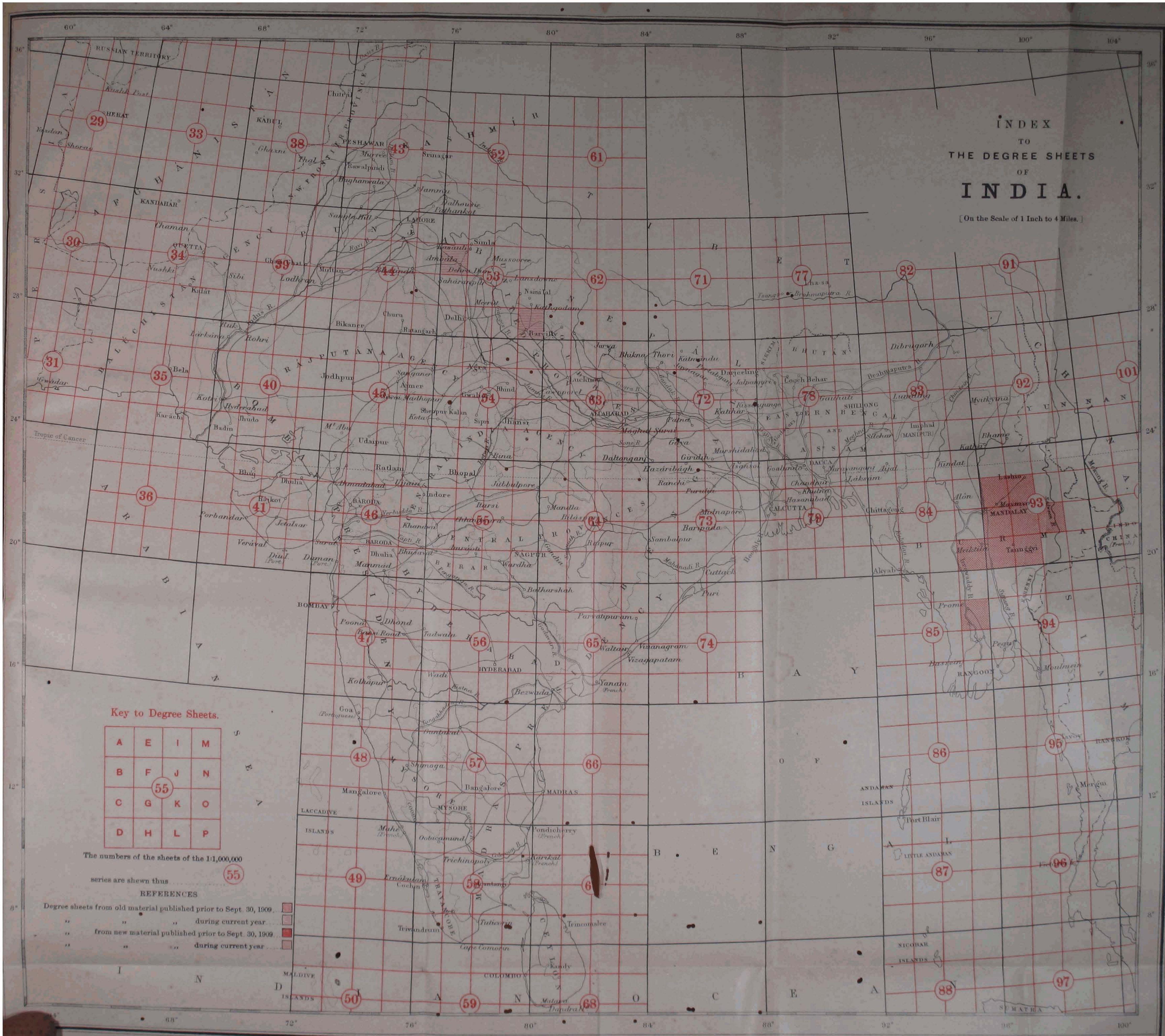
Sheets published

under publication

in hand

No. 3168 D., 11.—S. 1.—1,200.

Litho., S. I. O., Calcutta.



Published under the direction of Colonel S. G. Burrard, R.E., F.R.S., Officiating Surveyor General of India. 1911.

Litho., S. I. O., Calcutta.

PUBLICATION.