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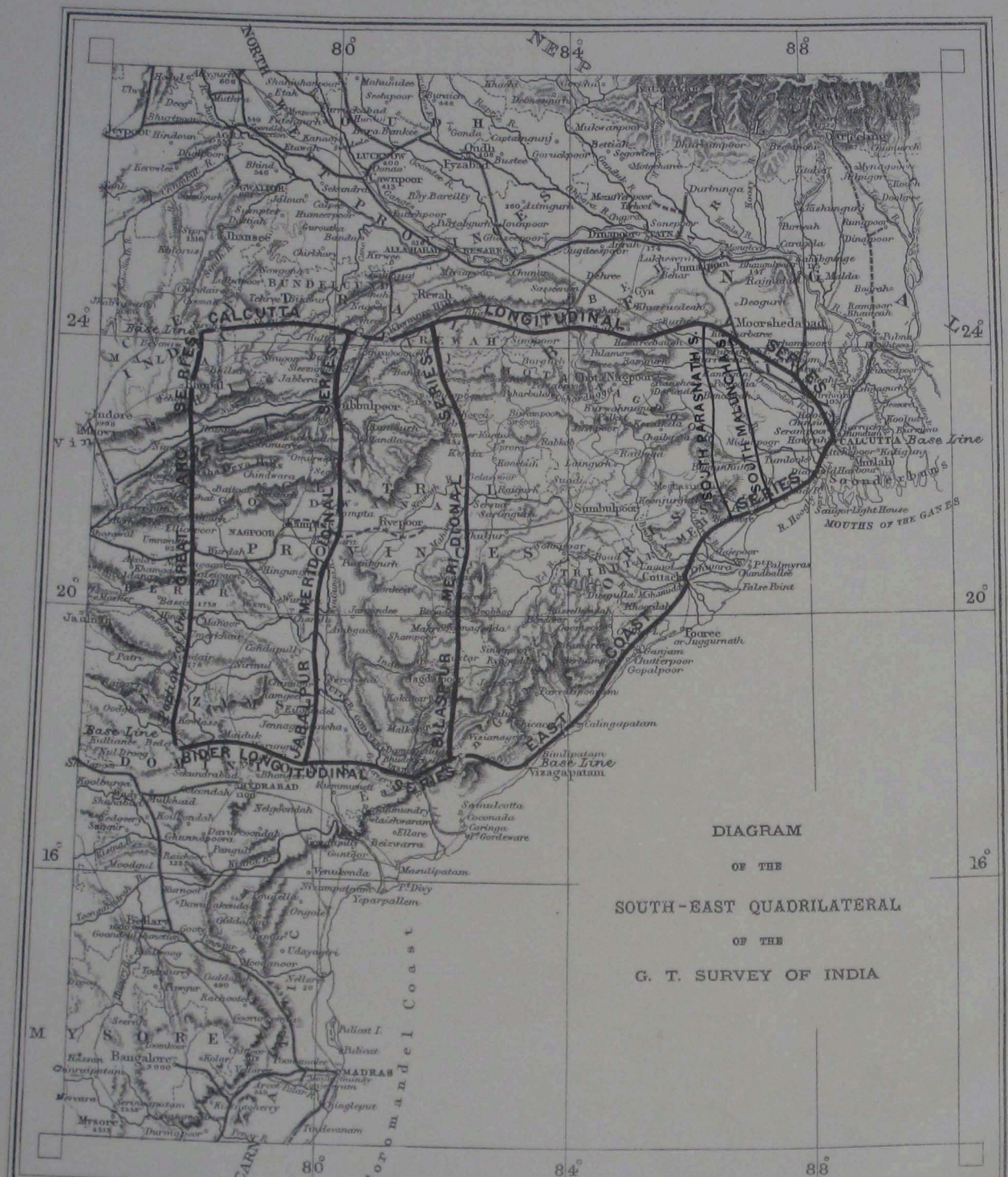
SYNOPTICAL VOLUME XIII A

G. T. SURVEY OF INDIA.

# THE SOUTH PARASNATH AND THE SOUTH MALUNCHA MERIDIONAL SERIES

APPERTAINING TO THE

SOUTH-EAST QUADRILATERAL.




DIAGRAM

OF THE

SOUTH-EAST QUADRILATERAL

OF THE

G. T. SURVEY OF INDIA

C. DYSON, PHOTO.

C. G. OLLENBACH, ZINCO.

*Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, August* 1880.

SYNOPSIS OF THE RESULTS OF THE OPERATIONS OF

# THE GREAT TRIGONOMETRICAL SURVEY OF INDIA

VOLUME XIII A.

---

ACCOUNT OF THE FINAL REDUCTIONS WITH THE DETAILS OF

# THE SOUTH PARASNATH MERIDIONAL SERIES

AND

# THE SOUTH MALUNCHA MERIDIONAL SERIES

OF THE

# SOUTH-EAST QUADRILATERAL.

---

PREPARED IN THE OFFICE OF THE TRIGONOMETRICAL BRANCH, SURVEY OF INDIA,
COLONEL C. T. HAIG, R.E., OFFG. DEPUTY SURVEYOR GENERAL, IN CHARGE.

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# PREFACE.

The South Párasnáth and the South Malúncha Meridional Series, of which the details are given in this volume, form two of the internal chains of the South-East Quadrilateral, or that section of the triangulation of India which is embraced between the parallels of 18° and 24°, and between the meridian of 78° and the East Coast. But as they were executed in the early days of the Survey, with inferior instruments and in a style not at all comparable with that of the other triangulation of the same Quadrilateral, which, in regard to the character of the instruments employed and in the refinements and rigour adopted in execution, stands second to none in India, it was decided to exclude them from the Simultaneous Reduction of the Quadrilateral but after that had been effected, to bring them into accordance with it.

The same reasons which led to their exclusion from the Simultaneous Reduction of the South-East Quadrilateral have caused it to be decided that they should be removed from the class of Principal Triangulation, and that all the details connected with their final reduction together with the data of the secondary triangulation should be included in one volume, which should be classed as one of the series of Synoptical Volumes. This will explain why the present volume differs from others of the same class. A list of these volumes of which this is the twenty-second in order of publication, but is numbered XIII A for the purpose of connecting it with the other Synoptical Volumes of the South-East Quadrilateral, will be found at the end of this volume.

The South Párasnáth and the South Malúncha Meridional Series form two connecting chains between the Calcutta Longitudinal Series and the East-Coast Series. When therefore the latter were finally reduced, the sides of emanation and termination of the former became fixed in length and position; and as they were otherwise entirely independent of one another, their final reduction was in each case a separate operation, which resolved itself into adjusting each series between its initial and terminal sides as they were determined by the final reduction of the South-East Quadrilateral. This has been effected by the method of minimum squares as described in Part I of this volume.

The present volume is divided into two parts. Part I is devoted to the reductions of the two series and Part II gives their details as finally established. The following is a short *résumé* or explanation of their contents.

## Part I.

Chapter I gives a general account of the triangulation of the South Párasnáth and the South Malúncha Meridional Series, indicates the dependency on the triangulation of the South-East Quadrilateral of each for its fixed data, and describes the structure of the Primary Stations, so far as known.

Chapter II describes the procedure followed in the measurement of the horizontal angles: it quotes the mathematical formulæ, employed in the reduction of the triangulation, from Volume II of the *Account of the Operations &c.*, where they are demonstrated: it shews how the final adjustment of the trigonometrical determinations of height was performed; and finally it indicates the general principles of the simultaneous reduction of each Series.

Chapter III gives full details of the separate reductions as follows:—

*First.* A brief statement of the manner in which the details of the final reductions are exhibited.

*Second.* A statement of the independent partial reductions antecedent to the final reduction of each Series.

*Third.* A description of the Reduction Charts which are given at the end of the volume.

*Fourth.* A general outline of the formation of the several Linear and Geodetic Equations of Condition—4 for each Series—which had to be satisfied, in order to produce the requisite consistency in the triangulation *per se*, and between it and the fixed elements on which it depended.

*Fifth.* The method of constructing the co-efficients of the Unknown Quantities in the Equations of Condition, shewing the general notation which was adopted for expressing the values of these co-efficients, and specifying every exception to the general form.

*Sixth.* A synoptical exhibition of the several Equations of Condition, shewing at a glance the triangles of which the angular errors enter as Unknown Quantities into each of the 4 equations appertaining to either Series.

*Seventh.* The numerical values of the Fixed Data on which the reductions are based.

*Eighth.* The values of the Sides and Angles of the so-called Circuit Triangles, as they stood before the Final Reduction of each Series.

*Ninth.* The Latitudes, Longitudes and Azimuths of the Stations on the right hand flank of the Circuit Triangles as they stood before the Final Reduction of each Series.

*Tenth.* The numerical values of the Absolute Terms in the linear and geodetic equations of condition.

*Eleventh.* The numerical values of the $\mu$s and $\phi$s, the geodetic summations—exhibited in the table on page [19]—which are required in forming the co-efficients of the Unknown Quantities (the angular errors) in the geodetic equations of condition.

*Twelfth.* The numerical values of the Co-efficients, $\mathfrak{b}$ and $\mathfrak{c}$, of the Unknown Quantities, in the several linear and geodetic equations of condition.

*Thirteenth.* The Co-efficients, $\mathfrak{B}$ and $\mathfrak{C}$, of the Indeterminate Factors, in the equations in which the values of the angular errors are expressed in terms of those factors.

*Fourteenth.* The equations between the Indeterminate Factors, shewing each significant co-efficient and absolute term as it stood, first on the formation of the equations, and secondly after the successive eliminations of individual factors; finally, the numerical values of the Factors are given.

*Fifteenth.* The values of the Errors, $x$, $y$ and $z$, of the angles of each triangle, resulting from each Final Reduction.

*Sixteenth.* The small Arbitrary Corrections to some of the values of the angular errors, necessitated by the Residual Errors occasioned by reducing the calculated values of the angular errors from 4 places of decimals to 2 places, as employed in the angular and geodetic calculations.

*Seventeenth.* The Final Results of each Reduction shewing the residual errors still remaining unadjusted.

Chapter IV gives the details of the reduction of the Non-circuit Triangles, *viz.*, the triangles excluded from the Simultaneous Reduction, which was needed for the final adjustments of their angles, to satisfy the geometrical conditions of the polygonal figures to which they appertain.

## PART II.

This portion of the volume gives the full details, grouped separately, of the two chains of triangles.

The following is a summary of the information and data of each Series, to which are added a few explanatory remarks where necessary:—

1. Introduction,
2. Alphabetically arranged List of Primary Stations,
3. Numerically arranged List of Primary Stations,
4. Description of Primary Stations,

5. Observations of the Horizontal Angles,
6. Reduction of the Polygonal Figures,
7. The Final Values of the Sides and Angles of the Primary Triangles,
8. The Final Values of the Sides and Angles of the Secondary Triangles,
9. The Azimuths of Surrounding Stations and Points at Primary, Primary-Auxiliary, and Secondary Stations,
10. The trigonometrically determined Differences of Height of the Primary Stations, and the Absolute Height of each station above the Mean Sea Level,
11. The Co-ordinates and Descriptions of all Stations and Points,
12. Astronomical Observations for Azimuth and their Reduction.
13. Addendum to Description of Primary Stations.

1. The Introduction gives a historical sketch of the progress of the whole of the operations in the field,—both Primary and Secondary—from year to year, mentions the Officers by whom they were conducted, and the theodolites with which the primary angles were measured, and indicates, when the information is forthcoming, the work done by each of the Assistants. It has been found convenient to give the Introductions to both Series at the commencement of Part II.

2 and 3. It has been found convenient to indicate the Primary Stations by a system of numerals, as well as by their names. Consequently, at the commencement of the details of each Series two lists are given, in the first of which the stations are arranged alphabetically with the numbers opposite the names, in the second numerically with the names opposite the numbers. Roman numerals have been adopted throughout for the nomenclature of the stations which is progressive in the order from north to south, the first number for each Series being unity.

4 needs no remark.

5. In the pages which are allotted to the observations of the horizontal angles, the observer, the instrument, and the month and year in which the observations were taken are specified at the head of the observations at each station.

In the details of the measures of the angles the reading is given to which the azimuth circle was set at the commencement of the observations and after each change of zero. For an explanation of the principles by which the changes of zero have been governed, reference should be made to Section 1 of Chapter II of Part I. Below the zero settings are recorded the means of the measures on each zero, with a small number below each indicating the number of measures of which it is the mean. Following the several zero means is the general mean of each angle.

6. The Reductions of the Polygonal Figures give the details for each group of angles forming an Independent Trigonometrical Figure, of which the reduction is explained in Section 2 of Chapter II of Part I.

Diagrams of the Figures are given in the Plates, in which the small numerals within each of the observed angles correspond to the subscripts of the general symbol, $x$, which is employed to indicate the error of any angle, the numerical subscript denoting the angle.

7. Tabular statement of the Primary Triangles. The two first columns of this table give the number adopted for each triangle to designate its place in the Series; this number is entered in the first column if the triangle appertains to the chain of single triangles forming the circuit whose closing errors are eliminated by the Simultaneous Reduction; it is entered in the second column for the non-circuit triangles. The triangles which enter the circuit are shown in the Reduction Chart (at the end of this volume) in firm lines, with their distinguishing numbers written in the centre; those which do not enter the circuit are shown in dotted lines, and their numbers are indicated by numerals of a smaller size than the former, commencing with 13 in the South Párasnáth Series and 15 in the South Malúncha Series, 12 and 14 being respectively the number of the last of the circuit triangles. The columns in the table which contain the corrections to the observed angles give, *first* the correction for the error of the angle, with reference merely to the triangle or polygonal figure to which it belongs, as

obtained from the primary reduction; and *secondly* the further correction which has to be applied either for the apportionment of circuit error, should the angle appertain to the circuit, or for the restoration of consistency in the polygonal figure after the application of the circuit errors, should it appertain to a non-circuit triangle. Finally, the corrected plane angles and the lengths of the sides are given, as computed by the rules of Plane Trigonometry, in accordance with Legendre's theorem; see Section 3 of Chapter II, Part I.

8 and 9 need no explanation.

10. The Determinations of the Differences of Height of the several Primary Stations have been deduced from the measurements of the vertical angles, as explained in Section 5 of Chapter II, Part I. In the abstract are given the mean of the measures of each vertical angle, the calculated refraction in each angle and the co-efficient of refraction, the hours of observation, the heights of the signal and of the observer's telescope above the summits of the stations, the differences of height of the said summits, and the absolute height above mean sea level.

It may be here stated that all trigonometrically determined heights invariably refer to the upper surfaces of the central masonry pillars at the stations.

11 needs no explanation.

12. The details and reduction of the Astronomical Observations for Azimuth. No such observations were taken on the South Párasnáth Meridional Series and they were taken only at two stations on the South Malúncha Meridional Series, *viz.*, at Tilabani and Kalsibhanga: the results of the latter are given in this volume, while those of the former have been included with similar observations on the Calcutta Longitudinal Series of the South-East Quadrilateral and published at page 211—$_B$ of Volume VI of the *Account of the Operations &c.* The observations and the method of reducing them are fully described in Chapter XII of Volume II. For reasons which are explained in the first section of that Chapter, the results of circum-polar azimuth observations have not been used in the general reduction of the triangulation, further than to give a more exact mean value of the fundamental astronomical azimuth (at Kaliánpur), than the one obtained by the observations on the spot. At the end of the details of the determination of the azimuth, the difference between the observed value and the value obtained by calculation through the triangulation from the fundamental azimuth is given. Such differences may be of much value in future investigations of the figure of the earth and of the influence of local attraction.

13. Addendum to the Description of Primary Stations. This addendum gives the most recent information which has been received up to date, of the condition of the stations.

The Unit of Length employed in the Indian Survey is the Indian Standard 10-foot Bar **A**, the relations between which and the principal European Standards of Length are given at page 28 of Volume I of the *Account of the Operations &c.*

The adopted Elements of the Figure of the Earth—assumed to be spheroidal—are given at page [13] of this volume.

The Longitudes depend on an astronomically determined value of the Longitude of the Madras Observatory, East of the Royal Observatory at Greenwich, which was deduced about the year 1815. The Longitude of the Madras Observatory has however been recently re-determined, by the Electro-Telegraphic method, by observations which were made at Greenwich, Mokattam (in Egypt), Suez, Aden, Bombay and certain stations of the triangulation in India, and with the following preliminary results;

| | | h | m | s | | |
|---|---|---|---|---|---|---|
| Longitude of Mokattam | ... | 2 | 5 | 6·320 | East of Greenwich | Supplied by Sir G. Airy, from observations taken in connection with Transit of Venus in 1874. |
| Increase for Suez | ... | 0 | 5 | 6·917 | „ | |
| „ Aden | ... | 0 | 49 | 42·656 | „ | By the operations of this Survey; see the Annual Report for 1876-77. |
| „ Bombay | ... | 1 | 51 | 19·983 | „ | |
| „ Madras | ... | 0 | 29 | 43·540 | „ | |
| Longitude of Madras | ... | 5 | 20 | 59·416 | „ | |

This value of the Longitude of Madras is equivalent to 80° 14′ 51″; and as the originally adopted value, on which the longitudes of the whole of the stations of this Survey are based, is 80° 17′ 21″—see page 135 of Volume II of the *Account of the Operations &c.*—the following note may be accepted with considerable confidence;—

**All the Longitudes require a constant correction, probably of − 2′ 30″.**

The Orthography of Indian names in the present volume is in strict agreement with the Gazetted List for Bengal—published under the immediate orders of the Government of India, under date the 29th May 1876—wherever the locality has been identified, and conforms to the spirit of the orders of Government on the subject, as worked out in this and other provincial lists, where there is no clear literal authority. As a general rule the pronunciations of the vowels are as follows:—*a* has a sound as in woman, rural; *á* as in tartan; *i* as in bit; *í* as in ravine; *u* as in bull; *ú* as in rural; *o* as in note; *e* as *a* in say; *au* as *ou* in cloud; *ai* as *i* in ride. When the popular spelling of a name has been accepted by Government, its correct transliteration is given in parenthesis where the name occurs for the first time.

The four charts that accompany this volume are;—a Reduction Chart and a General Chart of each of the two Series: of the former a description will be found in Sec. 3, Chap. III, Part I; the general charts exhibit the whole of the primary stations and triangulation, the positions of all the secondary points, and those portions of the secondary triangulations of which full details of the angles, sides and azimuths are given. With the aid of the charts it is hoped that little difficulty will be met with in finding out any of the data required. The descriptions of the secondary stations are in some cases not as full and clear as is to be desired: this arises from the inadequacy of the information entered on the spot by the Surveyors in their field books; every effort has been made to supplement the field books whenever it was found practicable to do so, in order to facilitate the future identification of the stations; all the information which is forthcoming has now been given.

It now only remains for me to notify the acknowledgments due to those by whose labours this volume has been prepared and is now issued.

The introductory chapters forming Part I were the work of Mr. W. H. Cole, M.A., Deputy Superintendent, who in February 1883 succeeded Mr. Hennessey in charge of the Computing Office and has therefore generally directed the compilation of the volume. The Introductions to both Series were written by Mr. C. Wood. The reduction of the South Párasnáth Meridional Series was effected chiefly with the aid of Baboos Gunga Pershad and Madu Narayan and that of the South Malúncha Meridional Series with the aid of Baboos Kaly Coomar and Shoshee Bhooshan. The volume like its predecessors has been printed at the Trigonometrical Branch Office at Dehra, Mr. Peychers and Baboo Gunga Pershad having rendered valuable service in the examination of the press proofs generally, and Mr. Peychers more particularly in regard to the numerical and mathematical details which require the utmost care in examination and correction to ensure absolute accuracy, and in this respect his experience and assistance have been most valuable.

DEHRA DUN,
*July, 1885.*

C. T. HAIG, COLONEL, R.E.,
*Offg. Deputy Surveyor General,*
*In charge Trigonometrical Branch, Survey of India.*

# ADDENDUM.

PAGE [20] *after* para. 1 of Section 10, *insert* Since the weights of the angles are all taken as equal, the minimum which governs the solution of the foregoing equations will, when $x$ has been eliminated from it, become

$$U = \{(y_1 + z_1)^2 + y_1^2 + z_1^2\} + \ . \ . \ . \ + \{(y_t + z_t)^2 + y_t^2 + z_t^2\}$$

# CORRIGENDUM.

PAGE [33] last line of Section 10, Symbolical Errors, *for* ${}_1E$, ${}_2E$ and ${}_3E$ respectively *read* ${}_2E$, ${}_3E$ and ${}_4E$.

# REFERENCES.

The abbreviations employed in the text are as follows:—

h.s. denotes hill station (secondary)
s. „ station „
t.s. „ tower station „

These abbreviations are only placed after the name of the stations where a theodolite has been set up and observations taken to surrounding points.

The latitudes and longitudes of all points shown on the general chart of each series at the end of the volume which exhibits both Primary and Secondary Triangulation will be found in the text. The latter exhibits numerical values of triangles only to points of a superior class, to which alone, if exhibited on the charts, lines are drawn; the lines are either continuous throughout, or dotted for half the length and continuous for the other half: the dots indicate that the bearing was not observed and in such cases numerical values of azimuths are not given. For other points, difficult to identify or of comparatively less accuracy, numerical values of triangles or azimuths are not given.

W. H. COLE,
*In charge of Computing Office.*

*July, 1885.*

# SOUTH PARASNATH MERIDIONAL SERIES

## AND

# SOUTH MALUNCHA MERIDIONAL SERIES.

ERRATUM IN SYNOPTICAL VOLUME VI.

Page 59—$_{H.}$ 1st Column.

*Note.*—The large dome in Multán Fort has been erroneously named Bháwal Hak's tomb, whereas it should have been called Shah Rukhn-ul-alam's tomb. The following description is intended to be cut out and pasted over that given in the Volume.

Multán Fort,
(*Multán*) Large dome of Shah Rukhn-ul-alam's tomb in fort.

## ADDENDUM.

PAGE [20] *after* para. 1 of Section 10, *insert* Since the weights of the angles are all taken as equal, the minimum which governs the solution of the foregoing equations will, when $x$ has been eliminated from it, become

$$U = \{(y_1 + z_1)^2 + y_1^2 + z_1^2\} + \ . \ . \ . \ + \{(y_t + z_t)^2 + y_t^2 + z_t^2\}$$

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PAGE [33] last line of Section 10, Symbolical Errors, *for* ${}_1E$, ${}_2E$ and ${}_3E$ respectively *read* ${}_2E$, ${}_3E$ and ${}_4E$.

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The abbreviations employed in the text are as follows:—

h.s. denotes hill station (secondary)
s. „ station „
t. „ tower station

# SOUTH PARASNATH MERIDIONAL SERIES

AND

# SOUTH MALUNCHA MERIDIONAL SERIES.

# SOUTH PARASNATH (PARESHNÁTH) MERIDIONAL SERIES.

## INTRODUCTION.

On the approaching completion of the Calcutta Longitudinal Series as originally executed between the years 1825-32, the Hon'ble the Court of Directors of the East India Company expressed a wish that from certain of the sides of this triangulation series of triangles should be carried, *firstly*, to connect some isolated surveys that had already been executed in various districts, and, *secondly*, to furnish reliable bases for future surveys. The then Surveyor General—Captain (afterwards Sir George) Everest, of the Bengal Artillery—after discussing all the preliminaries for giving effect to the wishes of the Hon'ble Court, and making all the arrangements requisite for the undertaking, determined to begin operations with the South Párasnáth Meridional Series, in preference to any of the other series, in order that through it the stations of a minor triangulation in Cuttack (Katak) and Midnapore (Medinípur)—which had been executed some years previously by Lieutenant Buxton of the Bengal Engineers, and from its detached character had hitherto remained unavailable—might be connected with the Great Trigonometrical Survey.

The South Párasnáth Meridional Series emanates from the side Chainpur to Tilabani (LVIII–LXI) of the Calcutta Longitudinal Series, and extends over a meridional distance of a little over 2° or 140 miles: the northern half lies in the Manbhoom (Mánbhúm) and Singhbhoom (Singhbúm) districts of the Chota Nagpore (Chhota Nágpur) Division, and the southern half in the wild and mountainous district which constitutes the tract known as the Tributary Maháls in Orissa (Uresa). The stations are without exception located on hills: as the view from several of these in the portion of the Series, north of parallel 22°, was extensive, the average length of side is there found to be over 25 miles; while in the portion to the south, the average length is reduced to 18 miles.

The northern section of the triangulation as originally executed consisted of unnecessarily complex figures, in the production of which so much time and labour were lost that the advance of the field work was seriously retarded: in the reduction of these figures, however, the redundant rays have been thrown out, and the computation has been confined to two semi-independent sets of primary triangles which have three sides in common. The southern section consists for the most part of single triangles, the exception being at the

terminus where, by a disposition somewhat similar to that which prevails in the northern section, the triangulation has been made to close on three sides of the East Coast Series.

The work was begun in February 1832; but owing to a series of unfortunate circumstances, hereafter mentioned, no progress whatever was made till December 1835, nor was the Series completed till May 1839. An examination of the triangulation disclosed several unusually large triangular errors, due partly to the defective instrumental means available and partly to the unsatisfactory character of the observations themselves: it was therefore decided that the South Párasnáth Series could not take rank with the *Principal* Triangulation of the Great Trigonometrical Survey. The work was, however, so much superior to that of the class known as *Secondary*, that it was determined to publish the results in the same detail as is adopted for principal triangulation, the triangles of the main series being for contradistinction given the nomenclature of primary triangles.

The instrument used throughout the work was Cary's 18-inch theodolite G*: the signals employed were luminous (*i.e.* lamps and heliotropes); and the system of observation for the horizontal angles was two measures on each of twelve zeros. The vertical angles are by no means satisfactory, having been taken at all hours of the day without the essential condition in such cases that the observations at the two ends of a ray should be taken at one and the same hour of the day.

The work lacks the usual astronomical observations for verification of azimuth, nor did the Field party leave any record of the description of the primary stations. The former desideratum is partially supplied by the junction of the triangulation with the East Coast Series whereby the errors have been ascertained and dispersed: and the latter has been met, as well as it could be by information gathered from the records of the Ganjam (Ganjám) Topographical Survey, which connected some of the stations, and from the best existing maps of the country.

The operations were originally entrusted to Lieutenant Western who with the assistants marginally noted, and a native establishment consisting of 1 havildár, 1 náik, 12 barkandázes, and 32 flagmen and carriers, left Calcutta on 1st February 1832, immediately after the completion of the Calcutta base-line. Up to the end of March, the party was engaged in reconnoitering the ground and selecting suitable sites for stations. The season being thus far advanced, observations could only be taken at one station Gorgáburu (1), where Lieutenant Western was encamped for nearly a month, and the party then retired to recess quarters.

*Seasons* 1831-32 *to* 1833-34.

PERSONNEL.

Lieut. J. R. Western, Bengal Engineers, 2nd Asst.

*At first.*

Mr. Murray Torrick, 1st Class Sub-Assistant.
„ E. R. Boileau, 3rd „ „

*Afterwards.*

Mr. T. Thornton, 3rd Class Sub-Assistant.
„ A. Torrick, „ „

Before the commencement of the next field season (1832-33), the country to the south of Párasnáth was, owing to the insurrection of the Kols and Chuárs, in so unsettled a condition that the Surveyor General was induced to apply for a military escort of at least

* For the description of this instrument, see p. 70 of Appendix No. 2 to Vol. II of the *Account of the Operations of the Great Trigonometrical Survey.*

350 men for the protection of the party. Government, however, considered the country in too disturbed a state to admit of survey operations being carried on therein, and suggested that the party should instead be employed in extending the Series to the north of Párasnáth. The entire season was occupied in the extension of the triangulation northwards from the side Durgápur–Párasnáth of the Calcutta Longitudinal Series: and although the angles of two primary and several secondary triangles were observed, the results of this season's operations were found by the Surveyor General to be "so full of errors as to entitle them to no confidence whatever." They therefore stand excluded *in toto* from the work of the Survey Department.

During the next season (1833-34), the country to the south was considered sufficiently settled to admit of the party entering it. Nevertheless, when he reached his ground, Lieutenant Western found it necessary to apply for the services of a small military escort; the months of November and December were spent in inactivity, while awaiting a reply to his application. During the season, observations were taken from ten stations; but on examining the work the Surveyor General reported to Government that the primary triangles were "still so full of large errors as to render them utterly unfit for the Great Trigonometrical Survey of India." The portion of the work executed by Lieutenant Western to the south of Párasnáth therefore also stands excluded *in toto* from both the manuscript and published results of the operations of this Department.

In September 1834 Lieutenant Western's services were placed at the disposal of the Military Department.

For the next season (1834-35) the only officer available for the charge of the Series was Lieutenant P. Bridgman, of the Bengal Artillery, who had received a short training in trigonometrical work on the Budhon Meridional Series under Lieutenant Roderick Macdonald. But this officer had hardly entered his ground when his health completely broke down: he was thus obliged to proceed on sick leave to Europe, and died on the voyage. The operations of the party were therefore suspended; and although it was now four years since they had been started, there was absolutely no result yet obtained beyond the selection of a few stations.

*Season* 1835-36.

PERSONNEL.

Lieut. A. H. E. Boileau, Bengal Engineers, 1st Assistant.
Mr. J. Thornton, 2nd Class Sub-Assistant.

The charge of the party was next entrusted to Lieutenant Boileau, who had for some time past been associated with the Governor General's Agent on a mission in the Western States of Rájputána, and as the duties connected with it were deemed by the Government to be of superior importance, he was unable to join the head-quarters of the party at Midnapore until the 9th of December 1835. He immediately took the field, and commenced observations on the 16th January 1836 at Tilabani, one of the initial stations of this Series. The party kept the field till the 21st of May when, owing to the extent of sickness whereby Lieutenant Boileau himself and more than one-half of his entire native establishment were prostrated, it was obliged to retire to Bankoora (Bánkura) for medical aid. Five primary stations and one secondary were visited this season: but such was the continued ill luck which attended these operations that an examination of the results disclosed such large errors as to render it necessary to reject

however retained. The cause of these discordant results was traced to a serious want of adjustment in the instrument: it was accordingly returned to the Mathematical Instrument Maker at Calcutta for rectification before being any further employed.

*Season* 1836-37.

PERSONNEL.

Lieut. A. H. E. Boileau, Bengal Engineers, 1st Assistant.
Mr. N. Kallonas, 2nd Class Sub-Assistant.

The instrument having been received after repair, the party took the field in the latter end of November; and as the stations were for the most part already selected, observations were continued uninterruptedly from the 7th of December 1836 to the 2nd of May 1837. During this time, ten primary stations were visited, and the triangulation stood completed down to the side Bághmuri–Sátbakra (VIII–IX): also, the station of Badampahár (X) was selected in advance. The party reached their recess quarters at Midnapore on the 8th of May. Lieutenant Boileau's health had suffered so considerably from the climate that he was compelled to proceed in the latter end of July on medical leave for six months.

*Season* 1837-38.

PERSONNEL.

Lieut. A. H. E. Boileau, Bengal Engineers, 1st Assistant.
Mr. N. Kallonas, 2nd Class Sub-Assistant.
„ J. Brown, 3rd „ „

As Lieutenant Boileau was not expected till the end of December, Mr. Kallonas was instructed to leave recess quarters on the 1st of November and to lay out an approximate series of triangles in continuation of the side Sátbakra–Badampahár (IX–X). Mr. Kallonas had succeeded in selecting and clearing a few stations by the 23rd December when Lieutenant Boileau returned and resumed charge of the Series. But although the party kept the field till the 2nd of April, primary observations were taken at only three stations, whereby one triangle more was all that was added to the work of the previous season. At this time, sickness prevailed to such an extent in camp that more than 62 out of 107 men of the native establishment were either on the sick list or had died, and the two Sub-Assistants and the native doctor also were too ill to be out any longer. The party accordingly went into recess quarters.

*Season* 1838-39.

PERSONNEL.

Lieut. A. H. E. Boileau, Bengal Engineers, 1st Assistant.
Mr. N. Kallonas, 1st Class Sub-Assistant.

In order to avoid entering the worst part of the ground too soon after the monsoon, it was decided to begin operations at the southern end at which Mr. Kallonas had selected some stations in the previous season. Accordingly Lieutenant Boileau commenced operations on 5th December at Nilgiri (XXIV of the East Coast Series), and by the end of the month following had completed the observations at two stations and measured one angle at a third. He then made over charge of the party to Mr. Kallonas, he himself having shortly before been nominated to the Agency of Suspension Bridges and Superintendence of the Calcutta Canals. Mr. Kallonas continued the observations during the next three months, and by the 30th of May effected the necessary junction on the side Badampahár–Kusumbani (X–XI) with the northern section of the triangulation.

An examination of the results of the triangulation showed that notwithstanding the adjustments which had been made to the 18-inch theodolite, as before mentioned, there were

still such serious defects* in the instrument—due to imperfect graduation, deficiency of telescopic power, inferiority of levels, &c.—as to vitiate the observations to a not inconsiderable extent. A glance at pages 19 to 21 will show that of the twenty primary triangles which it was decided to retain after elimination of the unnecessary rays and angles, only ten have a triangular error under 3 seconds, while of the others there are five errors ranging from 3 to 5 seconds, three from 8 to 9 seconds, and two from 10 to 15 seconds. A comparison of the values as brought down by this Series with the values furnished by the Simultaneous Reduction of the South-East Quadrilateral, necessitated the dispersion over this triangulation, between the origin Chainpur–Tilabani and the terminus Megásini (Meghásàni)–Bolpál, of the following errors:—

| | | | | |
|---|---|---|---|---|
| In Logarithm of the latter side | ... | ... | ... | + 0·000,0417,4 = 6 inches per mile. |
| „ Azimuth „ | ... | ... | ... | + 2″·72 |
| „ Latitude of Megásini | ... | ... | ... | − 0 ·227 |
| „ Longitude „ | ... | ... | ... | − 0 ·178 |

The trigonometrical determinations of the heights of the stations of this Series above mean sea level depend in the first place upon those of the stations Chainpur and Tilabani, as determined trigonometrically between Sironj and Calcutta by the Calcutta Longitudinal Series adjusted to the spirit-leveled values of its origin and terminus. A comparison of the heights so deduced with the corresponding values of the four obligatory stations of the East Coast Series at the southern extremity of this triangulation, disclosed a mean error of no less than 56 feet, the error between two determinations of the height of the *same* station being in two cases over 50 feet: the generated mean error of 56 feet was dispersed by simple proportion over the intermediate stations; but as the results were still considered somewhat untrustworthy, the final heights will be found given to only the nearest tens of feet.

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*Secondary Triangulation.*

The only secondary triangulation accomplished in connection with this Series was executed by the measurement—with the large theodolite—of the angles at the primary stations between the surrounding prominent hills. This work was carried on *pari passú* with the primary triangulation. The requisite numerical details of angles and side-lengths, and of latitudes, longitudes, and azimuths for fourteen such hills, also the positions only of two other hill peaks, which lie to the north of the side Megásini–Kimhíra (XXV–XXIII) are given in this volume.

In addition to the above the positions of several villages, &c., were determined by Lieutenant Boileau, during the prosecution of the Series, by means of an azimuth and distance—the heights too being in several cases determined by vertical observations. The

* In noticing these, the late Surveyor General—Sir A. S. Waugh—has placed on record that in his opinion the instrument should not be again employed when better means are available. Its sole performance is therefore in connection with the South Pársanáth Meridional Series.

results so obtained however valuable they may be for geographical purposes—and in the case under notice they were specially so, for the tract of country in which the villages, &c., lie was then but little known and had not been surveyed in detail—are not sufficiently accurate for acceptance and publication as final. The details regarding them are therefore wanting in this volume, but they will be found in manuscript Volume XIII, Part I, of the Trigonometrical Survey.

DEHRA DÚN;
*December, 1884.*

C. WOOD,
*Surveyor, 1st Grade.*

# SOUTH MALÚNCHA MERIDIONAL SERIES.

## INTRODUCTION.

The Hon'ble the Court of Directors having, in despatch No. 82 of 2nd August 1844, called for an expression of the Surveyor General's opinion as to the desirability of "comple-"ting the blank space in triangulation between Ganjam (Ganjám) and the Calcutta "Longitudinal Series", that officer replied that "manifold advantages would result from "the extension of a series of triangulation over the unsurveyed space lying between Captain "C. T. Hill's former labours (in the Gumsúr taluka of the Ganjam District) and the Calcutta "Longitudinal Series, together with the connection of such work with the operations of the "Great Trigonometrical Survey, whereby it could have the test of correction applied to it, "relieving it of discrepancies and imparting to the undertaking a character of accuracy and "finality not otherwise to be attained"; and he added, that the blank space had not failed to attract his attention, but that owing to the paucity of officers in the Department he had been prevented in the interests of Indian geography from recommending the taking up of the work. The transfer of Captain C. T. Hill's services to the Survey Department for the prosecution of the work having at the same time been applied for, that officer was appointed in January 1845; and, after necessary theoretical and practical instruction in the use of large instruments and the *modus operandi* of Principal triangulation, he was appointed to the charge of the South Malúncha Meridional Series in the September following, the trained establishment of the Karára Meridional Series—recently completed—being placed under his orders.

The chain of triangles emanates from the side Tilabani to Súsinia (LXI–LXV) of the Calcutta Longitudinal Series, and extending southwards over a meridional distance of $1\frac{1}{2}°$ or 103 miles, it closes on the side Dántún to Sátpautia (XVI–XVII) of the East Coast Series: the northern section lies on the hills in the easternmost part of the Manbhoom (Mánbhúm) district of the Chota Nagpore (Chhota Nágpur) Division, and the southern passes through the Jungle Maháls which form the western portion of the Midnapore (Medinípur) district. As the base on which the Series starts is over 27 miles in length, it was necessary in order to preserve symmetry in the triangles to cut down the length of side *gradually* before entering the lower ground: the average length of the side for the portion of the triangulation lying in the hills will therefore be found to be nearly 20 miles, while in that of the plains portion—in which the view

from the stations was necessarily contracted—the average length is only about 12½ miles. As originally instructed, Captain Hill was to have adopted the side Súsinia–Karásoli (LXV–LXIX) for his origin, and to have laid out the chain as a double series of triangles; but the low undulating and densely-wooded nature of the country southwards did not admit of either one or the other condition being adopted without the aid of lofty towers and extensive ray-cutting; the Series was accordingly shifted westwards and carried down chiefly as a single chain of triangles.

The work was begun in November 1845, and in two seasons was carried down by Captain Hill to a station in the immediate vicinity of Midnapore. For this portion of the work, no better instrument than Troughton and Simms' 18-inch theodolite No. 2* was available.

The party was then diverted to the East Coast Series which commences at Calcutta; and since this latter series did not reach the 87th degree of longitude—the meridian of Malúncha—till nearly six years later, it was not till February 1853 that Mr. J. Peyton, the officer in charge of the East Coast operations was able to connect the Malúncha Series with his triangulation by a chain of four triangles carried northwards from the side Dántún to Sátpautia. The instrument employed by Mr. Peyton was Troughton and Simms' 24-inch theodolite No. 1.*

The signals employed were luminous (*i. e.* lamps and heliotropes); and the system of observation adopted for the horizontal angles was two measures on each of twelve zeros. The vertical angles were, with a few unavoidable exceptions, taken about the time of minimum refraction, and four measures of each angle were usually observed.

The Series does not lack the usual verificatory observations to circumpolar stars for azimuth, nor is the character of the work such as would debar its taking equal rank as a Principal Series with other chains of triangulation done elsewhere about the same time with the 18-inch theodolite; but standing isolated, as it does, in the South-East Quadrilateral—the triangulation of which consists practically of *double* chains executed with *first-class* instruments and all modern refinements—it was not considered desirable to include the South Malúncha Meridional Series in that Quadrilateral as a *Principal* Series, but to adjust it to the finally determined values of its origin and terminus—as derived from the Simultaneous Reduction of the Quadrilateral—and to publish the results in the same detail as is adopted for principal triangulation, the triangles of the main series being for contradistinction given the nomenclature of primary triangles.

*Season* 1845-46.

PERSONNEL.

Captain C. Thorold Hill, 27th Madras Infantry, 2nd Assistant.
Mr. R. Clarkson, Senior 1st Class Sub-Assistant.
" D. Kirwan, 2nd " "
" W. R. N. James, 2nd " "
" J. H. Lawrence, 3rd " "

The party composed of the officer in charge and the assistants marginally named, accompanied by a native establishment consisting of some 70 flagmen and carriers, 1 náik and 12 barkandázes for the protection of Government property, and a native doctor, left the Surveyor General's Field Office—then at Allahabad—on the 6th October 1845, and proceeding by ordinary marches along the Trunk Road, arrived at Rániganj (within 20 miles of the station of Súsinia)

* For the description of these instruments, see respectively pp. 62-64 and 38-40 of Appendix No. 2 to Volume II of the *Account of the Operations of the Great Trigonometrical Survey.*

on the 14th November. An examination of the country during the next month proved the utter impracticability of carrying down the Series from the side Súsinia–Karásoli; for, although during this time the selection of the stations for the first polygon had been effected; yet, the adoption of these involved unusually heavy cutting on no less than nine out of twelve rays through very dense *sál* and blackwood jungle, as well as the erection of not fewer than four towers, owing to the undulating ground presenting no remarkable eminences to take advantage of. These being circumstances wholly unlooked for and unprovided against from the entire want of knowledge of the country, the absolute necessity for altering the base to the side Súsinia–Tilabani was forced on Captain Hill; but this was not of much consequence, as the eastern flank of the Series could still rest on the meridian of Malúncha. The configuration of the country, however, did not admit of a *double* series being laid out on the new base. Immediately after a short reconnaissance for the selection of the advance stations, Captain Hill returned to Tilabani and commenced on 20th December a double series* of circumpolar star observations for azimuth, adopting for the purpose the star δ Ursæ Minoris which at that season of the year is at its *periodic* time: these observations were concluded on 1st January. As, however, from the prevalence of haze, the time was unfavorable for taking horizontal angles on the unusually long side at the origin of the work, Captain Hill moved southward to examine the country further in advance. He returned in March to Súsinia in hopes of being then able to continue the observations; but after a fortnight's forced inactivity from the persistence of the haze, he was compelled to give up the idea and to move on to Kundába (II). At this station the horizontal and vertical angles were all disposed of by the 12th; but to be able to observe the latter it was unavoidably necessary to call in the aid of *maximum* refraction, as the signals were otherwise invisible, and this will account for the abnormal times of observation entered against this station in pp. 54 and 55. Jalhári (I) was next visited, but the length of rays would only admit of the angles being partially observed on this occasion. Before the end of the month (April) the angles at Káema (IV) were completely disposed of; and within the next fortnight those at Tura (III) and Hátiári (V). During the next five days, three of the four horizontal angles at Dhánsola (VI) as well as verticals on three out of five rays, were measured. A favorable opportunity having just then been afforded by a heavy fall of rain which cleared the atmosphere, Captain Hill hurried northwards *viá* Jalhári to Súsinia and Tilabani, and by the 20th of June was able to complete all the horizontal and vertical angles that had unavoidably remained unobserved at these stations. The season being then too far advanced for further work the party returned to recess quarters at Midnapore. Notwithstanding the continued difficulties with which the party had to contend the season's operations brought the Series down to the side Hátiári to Dhánsola (V–VI), *i.e.* a distance of one-half of its entire length; four single triangles in advance further southward and a fifth eastward to connect Midnapore were laid out, and the towers at the stations of the same built.

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* As Tilabani is a station of the Calcutta Longitudinal Series, the results of these observations have for convenience been incorporated in the published results for that Series and will be found at pp. 211—$_B$ to 213—$_B$ of Volume VI of the *Account of the Operations of the Great Trigonometrical Survey.*

Owing to a protracted rainy season the party was unable to leave recess quarters till the 4th of November 1846. Preparing the towers *en route* and raising them very considerably in two instances, Captain Hill was not able to begin observations till the middle of January: visiting in succession the stations of Báuljori (VII), Dhánsola (VI), Hátiári (V), and Kukurmuri (VIII), he was able by the 8th of February to complete both the horizontal and vertical angles at them, including the remeasurement of the southernmost angles observed in the previous season at the stations Hátiári and Dhánsola. The next ten days sufficed for the observations required at Kalábani (IX) and Kalsíbhánga (X) north of the side (IX–X). As no further extension *southward* of the Series was contemplated this season, it being an object to take advantage of the time before the rains set in to lay out the series of triangles which were to be carried down next season from Calcutta along the Coast, Captain Hill determined to leave the observations at Gop (XI) unmeasured for the present, and marched for Calcutta on the 20th February. As, however, the operations of the East Coast Series are independent of the South Malúncha Series, no details of the former are needed here, but, so far as they refer to the work of this season, they will be found duly noticed at pp. IV—*c* and V—*c* of Volume VI of the *Account of the Operations, &c.*

*Season* 1846-47.

PERSONNEL.

Captain C. Thorold Hill, 27th Madras Infantry, 1st Assistant.
Mr. R. Clarkson,* 1st Class Sub-Assistant.
„ W. R. N. James, 2nd „ „
„ C. B. Nield, 3rd „ „
* *Absent on leave from 15th Dec. to 15th Feb.*

Returning to recess quarters at Midnapore in July, Captain Hill completed the observations at Gop, in the immediate vicinity on the 13th of that month, and so closed the work of the Series for a time.

During the season 1849-50, while prosecuting the East Coast Series, Captain Hill determined to further the operations of the South Malúncha Series as opportunity offered. He accordingly deputed his senior assistant, Mr. R. Clarkson, in December 1849 with Troughton and Simms' 24-inch theodolite No. 1, to Kalsíbhánga (X) in order to secure circumpolar star observations for azimuth at that station, while he himself undertook the more difficult and trying duty of laying out the approximate Series to the south of the side (IX–X) at which the work had been left in February 1847. Mr. Clarkson—observing to δ Ursæ Minoris, then at its *periodic* time—completed a double set of observations on each of twelve zeros between the 23rd and 31st December 1849, and then returned to his duties on the East Coast Series. Captain Hill early succeeded in laying out four triangles by the selection of as many stations, and, having arranged for the construction of the towers thereat, he proceeded to his own proper field of work on the East Coast Series. Nothing further was done on the South Malúncha Series till early in the season 1852-53, when Mr. John Peyton, Chief Civil Assistant, then in charge of the East Coast Series, began observations at Kalábani (IX) on 1st January 1853. This officer, thereafter, proceeding successively to Kalsíbhánga, Bánsgaria (XIII), Mauliákhál (XII), Sátpautia, (XVII) and Dántún (XVI), finally concluded the observations of the South Malúncha Series on the 15th February 1853.

*Seasons* 1849-50 *and* 1852-53.

A comparison of the values as brought down by this Series with those furnished by

the Simultaneous Reduction of the South-East Quadrilateral necessitated the dispersion over this triangulation, between the origin Tilábani–Súsinia and the terminus Dántún–Sátpautia, of the following errors:—

| | | | | |
|---|---|---|---|---|
| In Logarithm of the latter side | ... | ... | + 0·000,0225,4 = 3 inches per mile. |
| „ Azimuth „ | ... | ... | ... | − 3″·122 |
| „ Latitude of Sátpautia | ... | ... | ... | − 0 ·064 |
| „ Longitude „ | ... | ... | ... | + 0 ·103 |

The trigonometrical determinations of the heights of the stations of this Series above mean sea level depend in the first place on those of the stations Tilábani and Súsinia as determined trigonometrically between Sironj and Calcutta by the Calcutta Longitudinal Series adjusted to the spirit-leveled values of its origin and terminus. A comparison of the heights so deduced with the corresponding values of the two obligatory stations of the East Coast Series at the southern extremity of this triangulation, disclosed a mean error of only about $5\frac{1}{2}$ feet—the average difference between two determinations of heights of the *same* station being under 3 feet. The generated mean error has been dispersed by simple proportion over the intermediate stations, and the resulting heights given to the nearest foot.

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*Secondary Triangulation.*

In the original instructions issued for the execution of this Series, Captain Hill had been explicitly enjoined by the Surveyor General to take advantage of every opportunity to fix as many of the surrounding peaks and permanent points as were visible from his Primary stations, and otherwise to determine the position of as many of these as possible without interfering with the progress of the Primary Triangulation. But owing to the undulating character of the country, without any hills or remarkable eminences and for the most part covered with thick forest, only two of the hill stations Jalhári and Tura (I and III) afforded the means of fixing secondary stations and points, the positions of 16 of which were determined by observations with the large theodolite at the Primary stations supplemented at the Secondary stations by measurements with a 12-inch instrument by Troughton and Simms. Further south, the lower and cultivated parts were found to be so thickly wooded with large timber of mango, *pipal*, *mahua*, tamarind, and blackwood, that it was actually more difficult and expensive to clear a ray there than in the forests themselves. There was thus practically no view from the stations except along the cleared rays, and this rendered it impossible to undertake Secondary Triangulation without very considerable expenditure of time and money. It thus happened that between the sides Tura–Káema (III–IV) and Kalsíbhánga–Gop (X–XI) only 8 more stations and points could be similarly added, a point in Midnapore being

one of those so determined. Later on, Mr. John Peyton fixed the position of Jagannathpur by observations with the 24-inch theodolite. In addition to the co-ordinates, the requisite numerical details of the angles, side-lengths, and azimuths, in reference to the majority of the secondary stations and points, will be found at pp. 50 to 53.

Besides the foregoing, in season 1846-47, Mr. W. R. N. James, using a 7-inch theodolite by Troughton and Simms, carried a minor series along the valley of the Kusai river from Gop to Kukurmuri (XI to VIII); but as the stations of observation were not marked in any permanent manner, it is not considered desirable to publish any further details of them than the latitudes and longitudes of the stations of observation and of the points fixed therefrom, about 90 in all.

DEHRA DÚN;
*January, 1885.*

C. WOOD,
*Surveyor, 1st Grade.*

# PART I, INTRODUCTORY.

# THE FINAL REDUCTIONS

OF THE

# SOUTH PARASNATH MERIDIONAL SERIES

AND OF THE

# SOUTH MALUNCHA MERIDIONAL SERIES

OF THE

# SOUTH-EAST QUADRILATERAL.

## CHAPTER I.

### ACCOUNT OF THE TRIANGULATION OF THE SOUTH PARASNATH AND SOUTH MALUNCHA MERIDIONAL SERIES.

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# 1.

*The Triangulation included in this Volume.*

The South Párasnáth and South Malúncha Meridional Series form two of the internal chains of that section of the triangulation of India, known as the South-East Quadrilateral, which embraces all the principal triangulation between the Parallels of 17° and 24° and extends from the Meridian of 77° to the Western Coast of the Bay of Bengal.

The South-East Quadrilateral was the second of the five large Sections into which the principal triangulation of India was divided for reduction. With the exception of the two series included in this volume it consisted of modern work executed with large theodolites—having azimuthal circles of 24 and 36 inches diameter—and with all the care and refinement which is characteristic of geodetic operations of the highest class. The South Malúncha and the South Párasnáth Series on the other hand were executed with inferior instruments, and in a style not comparable with the rest of the principal triangulation*. They were therefore not included in the general reduction of the Quadrilateral; but it was decided that after the latter had been finally reduced, these series should be then taken in hand and by the method of minimum squares, be made to harmonize with the rest of the triangulation. It was further decided that owing to the inferiority of the triangulation it should be finally excluded from that classed as 'principal triangulation'; and that both the primary and secondary

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* Colonel Waugh, the Surveyor General, so far back as 1848, remarks with regard to the Párasnáth Series:—"It must be confessed that neither the instrumental means employed nor the style in which it has been executed, will admit of its being ranked as one of the first-rate geodetical performances of the Great Trigonometrical Survey of India".

triangulation should be included in the same volume, which should form one of the series of Synoptical Volumes, differing from them however in that it was to contain the details of the reduction of the primary triangulation.

## 2.

*The Observers and the Instruments employed on the Triangulations.*

### The South Parasnath Meridional Series.

The South Párasnáth Meridional Series emanates from the side Chainpur–Tilabani of the Calcutta Longitudinal Series and follows approximately the Meridian of 86° 25′ till it meets the East Coast Series at the side Megásini–Bolpál.

The Series was first commenced in 1832, but owing to various causes no real progress had been made up to the middle of the year 1836. In 1836-37 eight primary triangles were completed by Lieutenant A. H. E. Boileau of the Bengal Engineers, bringing the Series down to the side Bághmuri–Tongro—the latter station was afterwards rejected—and the remainder of the Series was executed during the next two years partly by Lieutenant Boileau and partly by Mr. Kallonas, one of the Sub-Assistant Surveyors attached to the party. As originally executed the Series was of a very complex character, the observations having been multiplied to a useless extent. Colonel Waugh, the Surveyor General, when the triangulation was first reduced, selected two independent series of large symmetrical triangles, emanating from the side Tilabani to Gorgáburu and re-entering on the side Bághmuri to Sátbakra, all observations not included in this double series being rejected as unnecessary. From Bághmuri–Sátbakra to the side Megásini–Murári the chain is formed of single triangles, after which it closes in rather a complex manner on the three remaining stations of the Nilgiri–Megásini quadrilateral of the East Coast Series as may be seen on reference to Fig. 2 in the Plate at the end of the details of the South Párasnáth Series.

The instrument employed was that now known as Cary's 18-inch G., of which a description is given on page 70 of the Appendixes to Volume II of the *Account of the Operations &c.* It was a theodolite of antiquated pattern found in the Surveyor General's Office at 37 Park Street, Calcutta. It was subjected to extensive alterations under the Surveyor General's direction by Mr. Barrow, the then Mathematical Instrument Maker to Government at Calcutta, but after all it proved far from an efficient instrument. It was not well divided, was very deficient in telescopic power and possessed inferior levels. It was never employed again for geodetic purposes.

### The South Maluncha Meridional Series.

The South Malúncha Meridional Series emanates from the side Tilabani–Súsinia of the Calcutta Longitudinal Series, in about mean longitude 86° 50′, and trending slightly eastward, closes on the side Sátpautia–Dántún of the East Coast Series. It was executed chiefly by Captain C. T. Hill of the Madras Native Infantry, shortly after he joined the

Great Trigonometrical Survey from the Madras Topographical Survey, and while he was awaiting the arrival of a batch of large theodolites, one of which he was to employ on the East Coast Series. The South Malúncha Series was commenced during the field season of 1845-46 and during the early part of the next season was carried as far as the side Kalábani–Kalsíbhánga, when it was stopped in order that the party might be transferred to the East Coast Series, the expected instruments having arrived.

For the next three seasons the party was entirely occupied on the East Coast Series, by which time this had been brought down to near the southern extremity of the South Malúncha Series. The connection of the two series had now to be made, and in 1851-52 Mr. John Peyton who was then in charge of the Operations commenced arrangements for the purpose. Very little was accomplished this season beyond preparing the stations for observation; but so soon as the next season commenced, the final operations were proceeded with and the junction was effected by February 1853.

The instrument employed by Captain Hill was Troughton and Simms' 18-inch No. 2 and by Mr. Peyton the 24-inch No. 1 by the same makers; descriptions of both these theodolites will be found in Appendix No. 2, of Volume II of the *Account of the Operations &c.*

## 3.

### *The Dependency of the Triangulation on the South-East Quadrilateral.*

It has been stated that each of the two series of which the details are given in this Volume, emanates from one series of the South-East Quadrilateral and closes on another. There is no connection between the series themselves; so that when the South-East Quadrilateral had been finally reduced, the reduction of these two series became entirely independent operations. The fixed data for each were the length and position of the side of origin and the same elements of the closing side.

## 4.

### *The Construction of the Principal Stations.*

#### The South Parasnath Meridional Series.

In the case of the South Párasnáth Series the Executive Officer gave no description of the stations. Several of them were visited by the Ganjam Topographical Survey Party during the field seasons of 1858-59 and 1859-60, and mention is made of platforms with station-marks being found in many cases undisturbed. As all the stations were on hills it is presumed that they were of the same form. There is no evidence of their having possessed more than the mark at the surface of the platform although there is, at the same time, nothing to shew that they did not.

## The South Maluncha Meridional Series.

The majority of the stations of the South Malúncha Series are Tower Stations, one so-called tower appears to have been a mound of stones with mark-stones placed at the top and bottom, the others consisted of central pillars of masonry, either solid with mark-stones at top and bottom, or perforated and with mark-stones in the basement. These pillars were in all cases surrounded by a mass of stones and earth, or sun-dried bricks, to the level of the surface for the observatory tent to rest on. The Hill Stations consist of central pillars of small altitude with mark-stones at top and bottom, and are surrounded by platforms from 10 to 16 feet square.

## CHAPTER II.

### THE MEASUREMENT OF THE ANGLES AND THE GENERAL PRINCIPLES FOLLOWED IN THE REDUCTION OF THE TRIANGULATION.

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## 1.

*The Measurement of the Horizontal Angles and their Record.*

The method of observing the horizontal angles was that introduced by Colonel Everest which has been maintained ever since in the Indian Survey. When the instrument had been set up for use and had been properly centred and levelled, either one of the surrounding stations, or a referring mark specially set up for the purpose, was adopted as what is called the 'zero-station', and the telescope was directed to this station and made to read 0° 0′. Observations were then commenced. Either the angle between each station and the R.M. was measured independently twice or thrice, or two or more rounds of observations were made to all the stations. In each case, so soon as the first measures were completed, the telescope was turned over in altitude and brought round in azimuth to point to the zero-station which now read 180° 0′. With this zero-setting another set of observations were taken; the two settings constituting a pair, F.L., or face left, and F.R., or face right. The instrument was then shifted an arbitrary quantity in azimuth and the telescope made to point to the zero station, and observations were again taken on F.L., and F.R., and so on.

The system of zero-settings employed for the South Párasnáth Series was

$$\frac{0^\circ}{180^\circ}, \frac{10^\circ}{190^\circ}, \frac{20^\circ}{200^\circ}, \frac{30^\circ}{210^\circ}, \frac{40^\circ}{220^\circ}, \frac{50^\circ}{230^\circ}.$$

The angles were measured separately to a referring mark and two measures were taken on each zero-setting. The system of zero-settings was the same for the South Malúncha Series; but the more modern method of dispensing with a referring mark and observing to the

stations in rounds was adopted; the measures on each zero-setting were generally two in number but when these did not prove sufficiently accordant more measures were made.

In the Records of the angles the name of the observer and the instrument employed and the date of the observations are given, and below these the means of the measures on each zero are recorded and the number of the measures from which each mean is derived is given beneath it; the general mean of all the measures of each angle is also given.

The Abstracts of the Observed Angles are given on pages 7 to 14 for the South Párasnáth Series and pages 38 to 44 for the South Malúncha Series.

## 2.

### *Preliminary Reduction of the Groups of Angles contained in Independent Trigonometrical Figures.*

So long as chains of triangles are treated as independent of one another, the angles naturally separate themselves into as many groups as there are single triangles and combinations of triangles into single polygonal figures and net-works. Each triangle is subject to the geometrical condition that the three angles equal 180° *plus* the spherical excess, and each group of triangles to additional geometrical conditions, such as that the angles at any central point should together equal 360°, and that the value of any side as calculated through any portion of the figure back to itself should be unaltered.

The formula which has been employed for calculating the spherical excess of triangles in this volume is

$$\epsilon = a\,b \sin C \times \frac{\text{cosec } 1''}{2\,r^2}$$

in which $\epsilon$ is the spherical excess in seconds, $a$, $b$ and $C$ two sides of the triangle and the included angle, and $r$ the radius of curvature for the oblique section of which the azimuth is 45°, that is, $r = \frac{2\rho\nu}{\rho+\nu}$, $\rho$ being the radius of curvature to the meridian and $\nu$ the normal on the axis minor for the mean latitude of the triangle.

The geometrical conditions connecting groups of angles divide themselves generally under three heads, *triangular*, *central* and *side*. The first is as before stated, that the three angles of a triangle must equal 180°+the spherical excess, the second that all the angles meeting at a point and completely surrounding it must equal 360°, or when an angle is measured as a whole and also in parts, the whole should equal the parts, and the third springs from the condition that the value of any side carried through any portion of the figure back on itself should reproduce itself. The excesses or deficiencies which manifest themselves in these comparisons either form the right-hand members of the equations amongst the angular errors furnished by the conditions, or they furnish the means for finding them.

The number of equations for each independent trigonometrical figure is given by the formula

$$N - 2S + 4$$

in which $N$ is the number of angles and $S$ the number of stations.

In order to express the equations the observed angles are denoted by $X_1$, $X_2$, $X_3$, . . . the corresponding angular errors by $x_1$, $x_2$, $x_3$, . . . and the absolute terms of the equations by $e$ with subscripts denoting the equations to which they appertain. The triangular and central equations will then take the form

$$x_1 + x_2 + \ldots = e.$$

Further if $a$ denote the tabular log. difference of sin $X$ for 1″ the side equations will be represented by

$$a_1 x_1 - a_2 x_2 + a_3 x_3 - a_4 x_4 + \ldots = \log \frac{\sin X_1 \cdot \sin X_3 \ldots}{\sin X_2 \cdot \sin X_4 \ldots} = e.$$

These geometrical conditions have to be satisfied in such a manner, that the angles shall receive the most probable of the several systems of correction which present themselves. This is done by the so-called method of solution by minimum squares, which is now so well known that nothing need be said regarding it further than it requires the following expression shall be made a minimum.

$$U = \frac{x_1^2}{w_1} + \frac{x_2^2}{w_2} + \frac{x_3^2}{w_3} + \ldots$$

in which $w_1, w_2, w_3, \ldots$ are the reciprocals of the weights $w_1$, $w_2$, $w_3$, . . . of the observed angles.

In the present reductions the weights of the observed angles have been all assumed to be unity; hence the reciprocal weights, $w_1$, $w_2$, $w_3$, &c., are also each equal to unity; and the minimum equation becomes

$$U = x_1^2 + x_2^2 + x_3^2 + \ldots$$

The following equations—taken from Section 5, Chapter VIII, Volume II—express first the geometrical conditions, secondly their relations with the indeterminate factors, $\lambda_a, \lambda_b, \ldots \lambda_n$, by the introduction of which $U$ is made a minimum, and thirdly the most probable values of the angular errors in terms of the geometrical conditions and the indeterminate factors.

The geometrical equations of condition, $n$ in number between $t$ unknown quantities are :—

$$\begin{aligned}
a_1 x_1 + a_2 x_2 + \ldots + a_t x_t &= e_a \\
b_1 x_1 + b_2 x_2 + \ldots + b_t x_t &= e_b \\
\ldots\ldots\ldots

The equations between the indeterminate factors are:—

$$[aa]\,\lambda_a + [ab]\,\lambda_b + \ . \ . \ . \ + [an]\,\lambda_n = e_a$$
$$[ab]\,\lambda_a + [bb]\,\lambda_b + \ . \ . \ . \ + [bn]\,\lambda_n = e_b$$
$$. \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ .$$
$$[an]\,\lambda_a + [bn]\,\lambda_b + \ . \ . \ . \ + [nn]\,\lambda_n = e_n$$

in which brackets [ ] indicate summations, thus

$$[aa] = a_1 a_1 + a_2 a_2 + \ . \ . \ . \ + a_t a_t.$$

The resulting values of the angular errors are:—

$$x_1 = (a_1\lambda_a + b_1\lambda_b + \ . \ . \ . \ + n_1\lambda_n)$$
$$x_2 = (a_2\lambda_a + b_2\lambda_b + \ . \ . \ . \ + n_2\lambda_n)$$
$$. \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ .$$
$$x_t = (a_t\lambda_a + b_t\lambda_b + \ . \ . \ . \ + n_t\lambda_n)$$

and the value of the minimum, $U$, is

$$\lambda_a e_a + \lambda_b e_b + \ . \ . \ . \ + \lambda_n e_n$$

In the case of a single triangle—one which does not enter with other triangles into the formation of a polygonal figure—there is only one geometrical equation of condition, which is simply

$$x_1 + x_2 + x_3 = e$$

and there is only one 'indeterminate factor', $\lambda$, which is therefore

$$\lambda = \frac{e}{3}$$

Hence

$$x_1 = \lambda\,, \quad x_2 = \lambda\,, \quad x_3 = \lambda\,.$$

## 3.

### *Calculation of the Sides of the Triangles.*

The values of the angular errors having been obtained by the formulæ of the preceding section, are applied to the observed angles with contrary signs. The corrected angles

of every triangle are then reduced to plane angles by the subtraction of one-third of the spherical excess of the triangle from each, and the sides of the triangles are obtained in the ordinary manner. The angular corrections furnished by the figural reductions, besides being the most probable, in so far as the conditions to which they have been subjected are concerned, render each figure or net of triangles consistent, so that the ratio of any one side to any other side is the same by whatever route it is calculated.

## 4.

### *Geodetic Elements of Stations and Sides.*

The origin of co-ordinates, which has been adopted for the Indian triangulation is Kaliánpur, Station 1 of the North-West Quadrilateral, the initial elements at which are

| | | | |
|---|---|---|---|
| Latitude North | 24° | 7′ | 11″·26 |
| Longitude E. of Greenwich | 77 | 41 | 44·75 |
| Azimuth of Station 29 (Súrentál) | 190 | 27 | 5·10 |

as explained in Chapter XI of Vol. II.

But since the positions of all the stations of the North-West, South-East and North-East Quadrilaterals are regarded as having been finally fixed in the Simultaneous Reductions of those figures, any one of these stations may be employed as an origin of co-ordinates whenever it happens to be convenient to do so, and its elements may be adopted in place of those of Kaliánpur. Thus as the South Párasnáth and South Malúncha Series are based on sides of the Calcutta Longitudinal Series, one of the series of the South-East Quadrilateral, the elements of those sides have been adopted as the initial elements of the respective series. As these series also close on sides of the East Coast Series, another series appertaining to the South-East Quadrilateral, the elements of these sides might equally well have been considered initial elements.

The formulæ which have been employed on the successive calculations of latitude, longitude and reverse azimuth are given below.

If **A** and **B** be two stations on the earth's surface, and the latitude and longitude of **A** and the azimuth of **B** at **A** be $\lambda$, $L$ and $A$ respectively, the distance between **A** and **B** being $c$, and if

$\Delta\lambda$ denote the difference of latitude between **A** and **B**
$\Delta L$ „ „ longitude „
$B$ „ azimuth of **A** at **B**
$\Delta A = B-(\pi+A)$
$e$ „ the excentricity of the spheroid
$\rho$ „ the radius of curvature to the meridian at $\lambda$
$\nu$ „ the normal to the meridian at $\lambda$ terminated by the minor axis

then

$$\Delta\lambda = \begin{cases} -\frac{c}{\rho}\cos A \operatorname{cosec} 1'' \\ -\frac{1}{1\cdot 2}\frac{c^2}{\rho.\nu}\sin^2 A \tan\lambda \operatorname{cosec} 1'' \\ -\frac{3}{4}\frac{c^2}{\rho.\nu}\frac{e^2}{1-e^2}\cos^2 A \sin 2\lambda \operatorname{cosec} 1'' \\ +\frac{1}{1.2.3}\frac{c^3}{\rho.\nu^2}\sin^2 A \cos A\,(1+3\tan^2\lambda) \operatorname{cosec} 1'' \end{cases}$$

$$\Delta L = \begin{cases} -\frac{c}{\nu}\frac{\sin A}{\cos\lambda} \operatorname{cosec} 1'' \\ +\frac{1}{1.2}\frac{c^2}{\nu^2}\frac{\sin 2A \tan\lambda}{\cos\lambda} \operatorname{cosec} 1'' \\ -\frac{1}{1.2.3}\frac{c^3}{\nu^3}\frac{(1+3\tan^2\lambda)\sin 2A\cos A}{\cos\lambda} \operatorname{cosec} 1'' \\ +\frac{1}{1.2.3}\frac{c^3}{\nu^3}\frac{2\sin^3 A \tan^2\lambda}{\cos\lambda} \operatorname{cosec} 1'' \end{cases}$$

and

$$B = \pi + A + \begin{cases} -\frac{c}{\nu}\sin A \tan\lambda \operatorname{cosec} 1'' \\ +\frac{1}{4}\frac{c^2}{\nu^2}\left\{1+2\tan^2\lambda+\frac{e^2\cos^2\lambda}{1-e^2}\right\}\sin 2A \operatorname{cosec} 1'' \\ -\frac{c^3}{\nu^3}\left(\frac{5}{6}+\tan^2\lambda\right)\frac{\tan\lambda}{2}\sin 2A\cos A \operatorname{cosec} 1'' \\ +\frac{1}{2.3}\frac{c^3}{\nu^3}\sin^3 A \tan\lambda\,(1+2\tan^2\lambda) \operatorname{cosec} 1'' \end{cases}$$

For the derivation of these formulæ, and also for the manner in which they have been arranged for calculation, see Chapter IX of Volume II., also the *Auxiliary Tables to facilitate the Calculations of the Survey Department of India.*

The values of the elements of the Figure of the Earth which have been employed in the calculations are those known as "Everest's Constants, 1st set", and are :—

Semi-axis major, $a$ = 20,922,932 feet, Log = 7·320 6225 4

Semi-axis minor, $b$ = 20,853,375 feet, „ = 7·319 1763 4

Ellipticity, $c = \frac{a-b}{a} = \frac{1}{300{\cdot}80}$ „ = $\bar{3}$·521 7196 8

$e^2 = \frac{a^2-b^2}{a^2} = 0{\cdot}0066378$ „ = $\bar{3}$·822 0271 8

$1-e^2 = 0{\cdot}9933622$ „ = $\bar{1}$·997 1076 1

from which $\rho$ and $\nu$ are found by the well known formulæ.

## 5.

*Reduction of the Vertical Angles for the Determination of Differences of Height and Co-efficients of Refraction.*

The relative heights of the principal stations of this Survey are determined in almost all instances by measuring the reciprocal vertical angles. The heights so obtained are controlled, wherever possible, by connecting the stations of the triangulation with those of lines of Spirit Levels, which are executed by this Survey, and occasionally with Tidal Stations on the coasts of the Peninsula, at which direct determinations of the mean sea level have been made. The formula that was employed for many years in the calculation of differences of height is due to Colonel Everest, and is as follows :—

If $h$ be the difference of height of two stations A and B, $D'$ the depression of B at A and $D$ that of A at B, $H$ the height of A above mean sea level, $c$ the distance between A and B at that level, and $r$ the radius of curvature corresponding to the mean latitude of A and B, then the angle subtended at the lower station by the excess of height of the higher, or the so-called *subtended angle*, is $\frac{1}{2}(D-D')$, and the height of B above or below A is given by the expression

$$h = c\left(1 + \frac{H}{r}\right)\frac{\sin \frac{1}{2}(D-D')}{\cos D}$$

according as the result is *plus* or *minus*. If either of the angles is an elevation instead of a depression its value must be employed with the opposite sign to that here given.

In order to use this formula it is first necessary to correct the observed angles for the heights of the observing instrument and observed signal. A much less laborious process is to employ the uncorrected vertical angles, and then reduce the result thus obtained to the

levels of the stations by an algebraical combination of the heights of the instruments and signals. This procedure is as follows:—

If $i_a$, $i_b$ the heights in feet of the theodolites at A and B respectively

$s_a$, $s_b$ „ „ signals „ „

$D_a$, $D_b$ the observed vertical angles, both assumed to be depressions,

and we put

$$\delta = s_a - s_b + i_a - i_b$$

then

$$h = c\left(1 + \frac{H}{r}\right)\frac{\sin \frac{1}{2}(D_b - D_a)}{\cos D_b} + \frac{\delta}{2}.$$

This formula though not absolutely rigorous, holds good for all cases that have hitherto occurred or are likely to occur in this Survey.* If either of the angles is an elevation instead of a depression, its value must be employed with the opposite sign to that here given.

For $r$, the radius of curvature, the same formula is employed as in the calculation of the spherical excess, see page [8], $\rho$ and $\nu$ being here taken for the mean latitude of the stations.

In the preceding formula it is assumed that the reciprocal angles are equally affected by refraction, and in order that this may be as nearly the case as possible, the vertical angles in all the more modern operations are generally measured between the hours of 1 and 4 p.m., when the amount of refraction is usually a minimum. But in the earlier operations of the Survey it was thought that the lengths of the sides of the triangles should always be considerable, even in the plains, in order that the number of triangles in each series might be as few as possible; thus the stations were occasionally chosen at such distances from one another as to be only mutually visible when the amount of refraction was very considerable. The custom then was to take the observations at any time when mutual visibility obtained, and frequently during the night, when the refraction is usually greatest; reciprocal vertical angles at any two stations were generally measured at the same hour, as nearly as possible, of the day or night; and it was assumed that the refraction at both stations was then the same. This rule however does not seem to have been very closely adhered to in the case of the South Párasnáth Series: in the more modern South Malúncha Series there are also irregularities in the times of observation.

The reciprocal angles are also employed to determine the co-efficient of refraction, to be used in reducing unreciprocated vertical angles; for, putting $C$ for the arc between the stations A and B or the *contained arc* as it is usually called, and $\phi_a$, $\phi_b$ for the refraction at the respective stations, we have

$$C = D_a + \phi_a + D_b + \phi_b - \beta$$

---

* The calculations are performed logarithmically and $\log\left(1 + \frac{H}{r}\right)$ is replaced by Modulus $\frac{H}{r}$ which has been tabulated in the *Auxiliary Tables* for every degree of latitude from 5° to 36°.

in which expression

$$\beta = \frac{i_a - s_a + i_b - s_b}{c \sin 1''}.$$

Thus the mean refraction, $\phi$, is given by the expression

$$\phi = \tfrac{1}{2}\{ C - (D_a + D_b) + \beta \},$$

and $\frac{\phi}{C}$ gives the terrestrial refraction in decimals of contained arc—or in other words the *co-efficient of refraction*—for each pair of reciprocated observations. From the several values of the co-efficient thus determined, those which are deemed most suitable are selected for employment in the reduction of the vertical angles to secondary points, at which reciprocal observations have not been taken.

The formula for calculating the *contained arc* is

$$C'' = \frac{c}{r} \operatorname{cosec} 1''.$$

## 6.

### *The Final Values of Height.*

The heights of the initial and terminal stations of the South Párasnáth and South Malúncha Series having been finally determined at the time of the reduction of the South-East Quadrilateral, were available for employment for obtaining the final heights of these two series. After the heights of each series had been calculated in terms of the initial stations which lie in the Calcutta Longitudinal Series, the discrepancies, which shewed themselves at the closing stations in the East Coast Series, were dispersed throughout each series by simple proportion.

As the results in the case of the South Párasnáth Series were in many cases discordant and there was no information as to the height of signal, it has been thought sufficient to give the final values to the nearest 10 feet only. The heights of the South Malúncha Series have been given finally to the nearest foot.

## 7.

### *The Determination of Azimuth by Astronomical Observation.*

No astronomical azimuth was determined in the course of the South Párasnáth operations and but one was observed on the South Malúncha Series, *viz.*, at Kalsíbhánga.

Observations for azimuth consist of measures of the angle between a circumpolar star, when near either elongation, and a referring mark, which are made in accordance with the system

followed in observing the horizontal angles as regards the changes of zero, but with a large number of repetitions on each zero, as the observations are individually liable to greater error.

The time of each intersection being carefully noted, the azimuth of the star is subsequently calculated and applied to the observed angle between the referring mark and the star, and thus a measure of the azimuth of the referring mark is obtained.

The formula employed for the calculation has been

$$\delta A = \frac{(2 \sin^2 \tfrac{1}{2} \delta P. \operatorname{cosec} 1'') \tan A \cos^2 a}{1 - (2 \sin^2 a. \sin^2 \tfrac{1}{2} \delta P) \pm (\cot P. \sin \delta P)}*$$

in which $A$ is the azimuth of the star at elongation, $P$ the corresponding hour angle, $a$ the North Polar Distance of the star and $\delta A$ the difference in azimuth for the time $\delta P$ before and after elongation. The last term of the denominator is positive when the star is below and negative when above the position of maximum elongation.

At each station where the azimuth is observed the angle between the referring mark and one of the contiguous stations of the triangulation is also observed, just as any other horizontal angle; and the several measures are generally given in the Abstract of the Principal Angles. If omitted there they follow the Abstract of the Azimuthal Observations.

## 8.

### *Final Reduction of the Triangulation. Preliminary Remarks.*

So far the triangulation has only been made to fulfil those geometrical conditions which apply to single triangles, polygonal figures and net-works; it now becomes necessary to apply such conditions as will make the closing points of each chain take the positions already assigned them by the general reduction of the South-East Quadrilateral. In doing this all the angles of each chain should be treated simultaneously; but in the large general reductions which have hitherto been made this would have been so laborious an undertaking as to cause the solution to become practically impossible. It has therefore been the custom to select a chain of single triangles only from each series, choosing those, where a choice existed, which were most symmetrical, and to subject this chain to the required conditions. By this means the number of figural equations is reduced to one for each triangle of the simple form

$$x + y + z = 0$$

which permits of the elimination of one of the unknown quantities in each triangle, and thus enables all the triangular equations to be dispensed with. Thus the number of equations to be solved is eventually reduced to the number of new conditions to be satisfied, or in other words to the number of what are here called circuit equations, which are furnished by these new conditions. These conditions in the present case are:—

* The portions of the formula within brackets have been tabulated within the limits $\delta P = 30^m$ and $a = 10^\circ$, and are given in the *Auxiliary Tables*.

1. That the length of the closing side of each series should agree exactly with the length already fixed by the South-East Quadrilateral Reduction, and

2. That the latitude and longitude of one of the closing stations of each series and the azimuth of the closing side at that station should also agree exactly with the values previously determined.

After completing the Simultaneous Reduction of the chain of single triangles in each instance, the angles appertaining to the portions of the polygonal figures and net-works which had been excluded, are corrected in such a manner as to restore the consistency of each figure, without altering the values of the angles which have already been fixed.

## 9.

*The Final Reduction of the Triangulation. Formation of the Circuit Equations.*

The Simultaneous Reduction of each of the two series, the South Párasnáth and South Malúncha, was an independent operation, but the process was the same for each and may be generally described as follows :—

The triangles are numbered consecutively from north to south. The angle opposite the flank side of each triangle is known as $X$, that opposite the side of continuation as $Y$, and that opposite the base as $Z$, each being further distinguished by a numerical subscript, the same as the number of the triangle: $x$, $y$, $z$, with similar subscripts are the symbols employed to represent the errors of these angles, of which the most probable values that will satisfy the equations have to be found. These equations are respectively termed, *Linear* and *Geodetic*, the former taking cognizance of the errors in the ratios of the sides of the triangles, which are met with at the terminations of the chains, and the latter expressing the errors in latitude, longitude and azimuth at the closing stations.

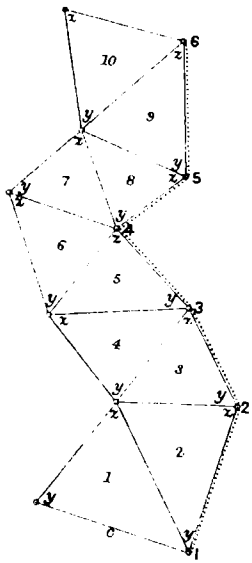
It is unnecessary here to repeat the deduction of the analytical expressions for the circuit equations. This has already been demonstrated in Volumes II, VI and VII of the *Account of the Operations of the Great Trigonometrical Survey of India*, to which reference can be made if necessary, it will be sufficient now to give the expressions themselves.

### *I. Linear Equations.*

Denoting for brevity the tabular difference (t. d.) of log sin $Y$ for 1″ by $\beta$ and of log sin $Z$ by $\gamma$, and by $E$ the error in the logarithmic value of the closing side of the chain, then

$$E = \beta_1 y_1 - \gamma_1 z_1 + \beta_2 y_2 - \gamma_2 z_2 + \ldots + \beta_m y_m - \gamma_m z_m$$

$m$ being the number of triangles in the chain. As in this equation $E$ as well as $\beta$ and $\gamma$ represent quantities in the 7th place of decimals, it is convenient to treat them as if both sides of the equation were multiplied by $10^7$, by which means $E$, $\beta$ and $\gamma$ become respectively the number of units in the 7th place of decimals.




If we employ brackets to denote summation the equation may be briefly written

$$E = {}_1^{m}\left[\beta y - \gamma z\right].$$

## *II. Geodetic Equations.*

The diagram in the margin represents the commencement of a chain of triangles in which station **1** is assumed to be the origin of geodetic co-ordinates, and **2**, **3**, . . . stations on the most direct route—indicated by the dotted line running parallel to the sides on one flank of the chain—which connects **1** with any station in advance. The side $c$ is the side of origin of the chain, and its azimuth at **1** the fundamental azimuth of the chain.

The following symbols are required to denote the differences of latitude, longitude and azimuth, the length of side, and the forward and back azimuths from station to station along the right flank of the chain:—

For the side **1** to **2**; $\Delta\lambda_1$, $\Delta L_1$, $\Delta A_1$, $c_1$, $A_1$ and $B_1$

. . . . . .

„ $n$ to $n+1$; $\Delta\lambda_n$, $\Delta L_n$, $\Delta A_n$, $c_n$, $A_n$ and $B_n$.

The errors in latitude, longitude and azimuth at the closing station, the $(n+1)th$, are denoted by $d\lambda_{n+1}$, $dL_{n+1}$, $dB_n$.

Now writing $\mu$ and $\phi$ for certain functions of $\Delta\lambda$, $\Delta L$, $\Delta A$ and $A$ as exhibited in the *Table of Substitutions* which follows, we have a general expression for each of the geodetic equations in which $E$ represents the error in latitude, longitude or azimuth, as the case may be, at the closing station, and $\beta$ and $\gamma$ have the same signification as in the linear equation, while $\alpha$ stands for t.d. log sin $X$ for a change of $1''$:—

$$\begin{aligned}
E = &+ (\mu_1\beta_1 - \phi_1)\, y_1 && + (-\mu_1\gamma_1 - \phi_1)\, z_1 \\
&+ \{(\mu_2 - \mu_1)\,\alpha_2 + \mu_2\beta_2 + \phi_1\}\, y_2 + \{(\mu_2 - \mu_1)\,\alpha_2 - \mu_1\gamma_2 + \phi_2\}\, z_2 \\
&+ \{(\mu_3 - \mu_2)\,\alpha_3 + \mu_3\beta_3 + \phi_2\}\, y_3 + \{(\mu_3 - \mu_2)\,\alpha_3 - \mu_2\gamma_3 + \phi_3\}\, z_3 \\
&+ (\mu_3\beta_4 - \phi_3)\, y_4 && + (-\mu_3\gamma_4 - \phi_3)\, z_4 \\
&+ \ . \ . \ . \ .
\end{aligned}$$

in which the $\mu$s and $\phi$s take their subscripts from the flank numbers of the stations and $\alpha$, $\beta$ and $\gamma$ from the triangles.

The general forms for the co-efficients of $y$ and $z$ are:—

*First.*—If the $p$th triangle have no side in the line of traverse, but only an angle at the station $m$,

$$(\mu_m \beta_p - \phi_m)\, y_p + (-\mu_m \gamma_p - \phi_m)\, z_p.$$

*Secondly.*—If the $q$th triangle have a side in the traverse between the stations $n$ and $n+1$,

$$\{(\mu_{n+1} - \mu_n)\, \alpha_q + \mu_{n+1}\, \beta_q + \phi_n\}\, y_q + \{(\mu_{n+1} - \mu_n)\, \alpha_q - \mu_n\, \gamma_q + \phi_{n+1}\}\, z_q.$$

Exceptions will appear to present themselves at the commencement and end of chains owing to the non-existence of some of the co-efficients. In all instances however it will be found that $\phi_m$ enters the co-efficients of all the errors at station $m$, and $\mu_m$ enters the co-efficients of the other angles of the same triangles, with a *plus* sign if looking from station $m$, the angle is the left-hand one of the triangle, and a *minus* sign if the right-hand.

The substitutions for $\mu$ and $\phi$ to render the general equation applicable to either latitude, longitude or azimuth are given in the following table.

*Table of Substitutions for $\mu$ and $\phi$.*

| | Latitude. | Longitude. | Azimuth. |
|---|---|---|---|
| For $E$ | $d\lambda_{n+1}$ | $dL_{n+1}$ | $dB_n$ |
| ,, $\mu$ | ${}_{\lambda}\mu$ | ${}_{L}\mu$ | ${}_{A}\mu$ |
| ,, $\phi$ | ${}_{\lambda}\phi$ | ${}_{L}\phi$ | ${}_{A}\phi$ |
| ,, $\mu_1$ | $+ {}^{n}_{1}\left[\frac{1}{\text{t.d.log}\,\Delta\lambda}\right]$ | $+ {}^{n}_{1}\left[\frac{1}{\text{t.d.log}\,\Delta L}\right]$ | $+ {}^{n}_{1}\left[\frac{1}{\text{t.d.log}\,\Delta A}\right]$ |
| ,, $\mu_2$ | $+ {}^{n}_{2}\left[\frac{1}{\text{t.d.log}\,\Delta\lambda}\right]$ | $+ {}^{n}_{2}\left[\frac{1}{\text{t.d.log}\,\Delta L}\right]$ | $+ {}^{n}_{2}\left[\frac{1}{\text{t.d.log}\,\Delta A}\right]$ |
| . . | . . . . . | . . . . . | . . . . . |
| ,, $\mu_n$ | $+ \frac{1}{\text{t.d.log}\,\Delta\lambda_n}$ | $+ \frac{1}{\text{t.d.log}\,\Delta L_n}$ | $+ \frac{1}{\text{t.d.log}\,\Delta A_n}$ |
| ,, $\phi_1$ | $+ {}^{n}_{1}\left[\frac{\text{t.d.log}\cos A}{\text{t.d.log}\,\Delta\lambda}\right]$ | $+ {}^{n}_{1}\left[\frac{\text{t.d.log}\sin A}{\text{t.d.log}\,\Delta L}\right]$ | $1 + {}^{n}_{1}\left[\frac{\text{t.d.log}\sin A}{\text{t.d.log}\,\Delta A}\right]$ |
| ,, $\phi_2$ | $+ {}^{n}_{2}\left[\frac{\text{t.d.log}\cos A}{\text{t.d.log}\,\Delta\lambda}\right]$ | $+ {}^{n}_{2}\left[\frac{\text{t.d.log}\sin A}{\text{t.d log}\,\Delta L}\right]$ | $1 + {}^{n}_{2}\left[\frac{\text{t.d.log}\sin A}{\text{t.d.log}\,\Delta A}\right]$ |
| . . | . . . . . | . . . . . | . . . . . |
| ,, $\phi_n$ | $+ \frac{\text{t.d.log}\cos A_n}{\text{t.d.log}\,\Delta\lambda_n}$ | $+ \frac{\text{t.d.log}\sin A_n}{\text{t.d.log}\,\Delta L_n}$ | $1 + \frac{\text{t.d.log}\sin A_n}{\text{t.d.log}\,\Delta A_n}$ |

The values of the absolute terms $E$ for the geodetic equations are the differences between the values of latitude, longitude and azimuth at the closing station as obtained by the calculation along the traverse and the final values as given by the Reduction of the South-East Quadrilateral; and if the subscripts $f$ and $t$ denote the *final* and *traverse* values at the closing station

$$E_\lambda = \lambda_t - \lambda_f$$
$$E_L = L_t - L_f$$
$$E_A = B_t - B_f$$

## 10.

*The Solution of the Equations.*

If we assume that the number of triangles entering the reduction is $t$ and that they furnish $n$ circuit equations, the latter may now be briefly written in order thus:—

$$\begin{aligned}
&{}_1\mathfrak{b}_1 y_1 + {}_1\mathfrak{c}_1 z_1 + \ldots + {}_1\mathfrak{b}_t y_t + {}_1\mathfrak{c}_t z_t = {}_1E \\
&{}_2\mathfrak{b}_1 y_1 + {}_2\mathfrak{c}_1 z_1 + \ldots + {}_2\mathfrak{b}_t y_t + {}_2\mathfrak{c}_t z_t = {}_2E \\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
&{}_n\mathfrak{b}_1 y_1 + {}_n\mathfrak{c}_1 z_1 + \ldots + {}_n\mathfrak{b}_t y_t + {}_n\mathfrak{c}_t z_t = {}_nE
\end{aligned}$$

in which equations the left-hand subscript in 'old face' type corresponds to the number of the equation and the right-hand subscript in ordinary type gives the number of the triangle.

The symbols employed for the indeterminate factors are ${}_1\Lambda$, ${}_2\Lambda$, ${}_3\Lambda$, &c., and the equations between them are*

$$\begin{aligned}
&{}'_1\left[{}_1\mathfrak{b}\,{}_1\mathfrak{B} + {}_1\mathfrak{c}\,{}_1\mathfrak{C}\right]{}_1\Lambda + {}'_1\left[{}_1\mathfrak{b}\,{}_2\mathfrak{B} + {}_1\mathfrak{c}\,{}_2\mathfrak{C}\right]{}_2\Lambda + \ldots + {}'_1\left[{}_1\mathfrak{b}\,{}_n\mathfrak{B} + {}_1\mathfrak{c}\,{}_n\mathfrak{C}\right]{}_n\Lambda = {}_1E \\
&{}'_1\left[{}_2\mathfrak{b}\,{}_1\mathfrak{B} + {}_2\mathfrak{c}\,{}_1\mathfrak{C}\right]{}_1\Lambda + {}'_1\left[{}_2\mathfrak{b}\,{}_2\mathfrak{B} + {}_2\mathfrak{c}\,{}_2\mathfrak{C}\right]{}_2\Lambda + \ldots + {}'_1\left[{}_2\mathfrak{b}\,{}_n\mathfrak{B} + {}_2\mathfrak{c}\,{}_n\mathfrak{C}\right]{}_n\Lambda = {}_2E \\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
&{}'_1\left[{}_n\mathfrak{b}\,{}_1\mathfrak{B} + {}_n\mathfrak{c}\,{}_1\mathfrak{C}\right]{}_1\Lambda + {}'_1\left[{}_n\mathfrak{b}\,{}_2\mathfrak{B} + {}_n\mathfrak{c}\,{}_2\mathfrak{C}\right]{}_2\Lambda + \ldots + {}'_1\left[{}_n\mathfrak{b}\,{}_n\mathfrak{B} + {}_n\mathfrak{c}\,{}_n\mathfrak{C}\right]{}_n\Lambda = {}_nE
\end{aligned}$$

* In these equations, although the corresponding co-efficients on opposite sides of the diagonal appear to differ, their values are in reality identical in each term of the summation. Both forms, however, have been made use of as a check on the calculations; and for a like reason the diagonal co-efficients have been obtained also by the formula

$$\frac{2}{3}\,{}'_1\left[(\mathfrak{b}^2 - \mathfrak{b}\mathfrak{c} + \mathfrak{c}^2)\right]$$

in which

$$\mathfrak{B} = \frac{1}{3}(2\mathfrak{b} - \mathfrak{c}) \text{ and } \mathfrak{C} = \frac{1}{3}(2\mathfrak{c} - \mathfrak{b}).\dagger$$

These equations having been solved, the values of the angular errors are given by the formulæ

$$y_p = {}_1\mathfrak{B}_p \, {}_1\Lambda + {}_2\mathfrak{B}_p \, {}_2\Lambda + \ldots + {}_n\mathfrak{B}_p \, {}_n\Lambda,$$
$$z_p = {}_1\mathfrak{C}_p \, {}_1\Lambda + {}_2\mathfrak{C}_p \, {}_2\Lambda + \ldots + {}_n\mathfrak{C}_p \, {}_n\Lambda,$$
$$x_p = -(y_p + z_p).$$

† As the factor $\frac{1}{3}$ enters all the co-efficients of all the equations its omission from the actual calculations can have no effect on the final values of the angular errors $x$, $y$ and $z$; it was accordingly omitted.

## CHAPTER III.

### THE DETAILS OF THE SIMULTANEOUS REDUCTION.

## 1.

*Preliminary Remarks.*

The general principles followed in the reduction of the triangulation, as described in the preceding chapter, apply equally to the South Párasnáth and South Malúncha Meridional Series; but in the present chapter which deals with the details of the reductions, it will be necessary, as the reductions are entirely independent, to keep these details apart, while it will be convenient to include them in the same sections. Where possible the same preamble for each section will be made to apply to both reductions, the details themselves being headed by the name of the series to which they belong.

## 2.

*The Figural Reductions Antecedent to the Final Simultaneous Reductions.*

The South Párasnáth Series consists of 6 single triangles and 2 compound figures, containing in all 59 observed angles.

The South Malúncha Series embraces 11 single triangles and 2 quadrilaterals and has 49 observed angles.

The figural conditions and reductions—excluding those of the single triangles, which are of so simple a form as not to require special exhibition, but will be found in the general data of the triangles—are given for each series, immediately after the Abstracts of the Ob-

served Angles; a diagram of each figure is also given in the plates for each series. These together afford the means of readily following the calculations appertaining to each figure.

The total number of geometrical equations of condition are:—for the South Párasnáth Series 29, and for the South Malúncha Series 19. The weights employed in the figural reductions were, as has been previously stated, in all cases unity.

## 3.

### *The Reduction Charts.*

The Reduction Chart at the end of the details of each series exhibits the whole of the Principal Triangulation in that series: where this triangulation is double, that is, does not consist of only a single chain of triangles, a portion of the angles are not introduced into the final reduction; but where the chain consists of single triangles the whole are introduced. The fixed data for the final reduction of each series are the lengths and positions of the sides of the Calcutta Longitudinal and East Coast Series on which each abuts. These sides are shewn on the charts by double lines, terminated by two concentric circles.

The so-called *circuit* triangles—the errors of whose angles are the unknown quantities in the reduction, and are all investigated simultaneously—are indicated by continuous lines. The *non-circuit* triangles, or those which are excluded from the simultaneous reduction, have their sides indicated by broken lines.

Along the flank on the right-hand side, looking south, of each chain a dotted line runs parallel to the sides of the triangles; this is the *line of the traverse.*

The principal stations are indicated on the charts by small circles, with their names and the serial numbers by which it has been found convenient to distinguish them for reference in the course of the reductions. These numbers are in Roman character and are progressive from north to south.

All the principal stations which fall on the lines of traverse have an additional number in block type assigned to them, called their traverse number, these numbers commence from the initial station.

The circuit triangles are numbered in the South Párasnáth Series Chart from 1 to 12, commencing from the side Chainpur–Tilabani, and the non-circuit triangles are numbered in succession in smaller type from 13 to 20. In the South Malúncha Series the circuit triangles are numbered from 1 to 14 commencing from the side Tilabani–Súsinia, and the non-circuit triangles are numbered 15 to 17 in smaller type.

Where polygonal figures or net-works occur, these are distinguished by figural numbers as Fig. 1, Fig. 2, and these distinctions are continued in the diagrams and reductions of figures.

# 4.

*General Outline of the Formation of the Linear and Geodetic Equations of Condition.*

**The South Parasnath Series.**

The triangulation having been first made consistent so far as all figural conditions were concerned, the linear calculations were commenced from the side Chainpur–Tilabani and carried southwards, through the circuit triangles only, until they closed on the side Megásini–Bolpál. The calculations of geodetic latitudes, longitudes and azimuths were then carried along the western flank of the chain, commencing and terminating with the linear calculations. The errors which form the absolute terms of the equations are the differences between the two sets of linear and geodetic values of the side Megásini–Bolpál and at the station Megásini, as obtained by the calculations just described and as already given finally by the Simultaneous Reduction of the South-East Quadrilateral. Thus there are four equations which may be symbolized as follows, if we employ S to denote the sum of the terms on the right-hand side of the linear equation—page [17]—and of the geodetic equation—page [18]—with the subscripts $c$ to denote the linear, $\lambda$ the latitudinal, $L$ the longitudinal, and $A$ the azimuthal equations; while $E$ with the corresponding subscript denotes the absolute term :—

$$(1)\quad {}_{c}S = {}_{c}E,$$

$$(2)\quad {}_{\lambda}S = {}_{\lambda}E,$$

$$(3)\quad {}_{L}S = {}_{L}E,$$

$$(4)\quad {}_{A}S = {}_{A}E.$$

**The South Maluncha Series.**

This Series having in like manner been first made consistent so far as the figural conditions were concerned, the linear calculations commenced from the side Tilabani–Súsinia and closed on the side Sátpautia–Dántún, the geodetic calculations being carried along the western flank. The errors are the two sets of values at the closing side Sátpautia–Dántún and at the closing station Sátpautia. The equations may be symbolized as before.

# 5.

*Formation of the Co-efficients of the Unknown Quantities.*

On page [20] the equations of condition are represented by a form of which the following may be taken as a general illustration :—

$$ {}_{m}b_1\, y_1 + {}_{m}c_1\, z_1 + {}_{m}b_2\, y_2 + {}_{m}c_2\, z_2 + \ldots = {}_{m}E$$

the left-hand subscript denoting the equation-number and the right-hand subscript the number of the triangle to which the errors appertain, and $\mathfrak{b}$ and $\mathfrak{c}$ being the co-efficients of $y$ and $z$ respectively.

For the *Linear* Equations we shall have generally, see page [17],

$$\mathfrak{b}_p = + \beta_p = + \text{t.d. log sin } Y_p \text{ for } 1'',$$
$$\mathfrak{c}_p = - \gamma_p = - \text{t.d. log sin } Z_p \quad ,, \quad .$$

For the *Geodetic* Equations we shall have, see page [18],

$$\mathfrak{b}_p = + (\mu_l \beta_p - \phi_l),$$
$$\mathfrak{c}_p = - (\mu_l \gamma_p + \phi_l),$$

or

$$\mathfrak{b}_p = + \{(\mu_{l+1} - \mu_l) \alpha_p + \mu_{l+1} \beta_p + \phi_l\},$$
$$\mathfrak{c}_p = + \{(\mu_{l+1} - \mu_l) \alpha_p - \mu_l \gamma_p + \phi_{l+1}\},$$

the former pair being applicable to any, the $p$th, triangle when it has only the angle $X$ in traverse at station $l$, and the latter when it has the side opposite $X$ in the traverse and lying between the stations $l$ and $l+1$.

*Exceptions to the General Expressions for* $\mathfrak{b}$ *and* $\mathfrak{c}$.

**The South Parasnath Series.**

Equation 1 has no exceptional co-efficients, but in equations 2, 3 and 4

$$\mathfrak{b}_{11} = - \mu_6 \alpha_{11} + \phi_6; \qquad \mathfrak{c}_{11} = - \mu_6 (\alpha_{11} + \gamma_{11})$$

with the exception of $\mathfrak{c}_{11}$ in Equation 4, in Azimuth, which needs the addition of unity to carry the calculations as far as the side Megásini–Murári; and the same equation has two extra co-efficients

$$\mathfrak{b}_{12} = - 1 \text{ and } \mathfrak{c}_{12} = - 1$$

to carry the calculations to the closing side Megásini–Bolpál.

**The South Maluncha Series.**

Equation 1 has no exceptional co-efficients; but in equations 2, 3 and 4

$$\mathfrak{b}_{13} = - \mu_7 \alpha_{13} + \phi_7; \qquad \mathfrak{c}_{13} = - \mu_7 (\alpha_{13} + \gamma_{13})$$

with the exception of $\mathfrak{c}_{13}$ in Equation 4, in Azimuth, which needs the addition of unity to carry the calculations as far as the side Sátpautia–Bánsgaria; and the same equation has two extra co-efficients

$$\mathfrak{b}_{14} = -1 \text{ and } \mathfrak{c}_{14} = -1$$

to carry the calculations to the closing side Sátpautia–Dántún.

## 6.

*Synoptical Exhibition of the Several Equations of Condition.*

For the sake of brevity let us put ${}_m\mathrm{k}_p$ for ${}_m\mathfrak{b}_p\, y_p + {}_m\mathfrak{c}_p\, z_p$ or, in other words, for the sum of the errors $y$ and $z$ of the angles $Y$ and $Z$ in any, the $p$th, triangle, respectively multiplied by their co-efficients $\mathfrak{b}$ and $\mathfrak{c}$ in any, the $m$th, equation of condition; and further, let us put ${}_m\mathrm{k}\Big|_p^q$ to represent the sum of the terms ${}_m\mathrm{k}$ for a series of triangles of which the first term is ${}_m\mathrm{k}_p$ and the last ${}_m\mathrm{k}_q$.

The equations will then be expressed as follows:—

| The South Parasnath Series. | The South Maluncha Series. |
|---|---|
| (1). *Linear.* ${}_1\mathrm{k}\Big|_1^{12} \ldots = {}_1E,$ | (1). *Linear.* ${}_1\mathrm{k}\Big|_1^{14} \ldots = {}_1E,$ |
| (2). *Latitude.* ${}_2\mathrm{k}\Big|_1^{11} \ldots = {}_2E,$ | (2). *Latitude.* ${}_2\mathrm{k}\Big|_1^{13} \ldots = {}_2E,$ |
| (3). *Longitude.* ${}_3\mathrm{k}\Big|_1^{11} \ldots = {}_3E,$ | (3). *Longitude.* ${}_3\mathrm{k}\Big|_1^{13} \ldots = {}_3E,$ |
| (4). *Azimuth.* ${}_4\mathrm{k}\Big|_1^{12} \ldots = {}_4E.$ | (4). *Azimuth.* ${}_4\mathrm{k}\Big|_1^{14} \ldots = {}_4E.$ |

## 7.

*The Numerical Values of the Fixed Data on which the Simultaneous Reductions of the South Párasnáth and South Malúncha Meridional Series are separately based.*

Both series emanate from the Calcutta Longitudinal Series and close on the East Coast Series. The fixed data furnished by these series are given in Vol. VI of the *Account*

*of the Operations, &c.*; but for the geodetic elements a third place of decimals of seconds has been obtained by reference to the calculations of the South-East Quadrilateral. The data are as follows:—

**South Parasnath Series.**

Volume VI page $160_{-B}$:—

Station of origin Chainpur or LVIII; side of origin Chainpur or LVIII to Tilabani or LXI.

At Chainpur.

| | | | | |
|---|---|---|---|---|
| Latitude North ... ... | ... | 23° | 33′ | 16″·512, |
| Longitude East of Greenwich ... | ... | 85 | 53 | 46 ·408, |
| Azimuth of Tilabani ... ... | ... | 281 | 56 | 37 ·17, |
| Distance ... ... ... | Log. Feet 5·3792092,2. | | | |

Volume VI pages $118_{-C}$ and $119_{-C}$:—

Closing Station Megásini or XXV; closing side Megásini or XXV to Bolpál or XXVI.

At Megásini.

| | | | | |
|---|---|---|---|---|
| Latitude North ... ... | ... | 21° | 37′ | 54″·997, |
| Longitude East of Greenwich ... | ... | 86 | 23 | 29 ·590, |
| Azimuth of Bolpál ... ... | ... | 337 | 42 | 5 ·10, |
| Distance ... ... ... | Log. Feet 5·0171495,6. | | | |

**South Maluncha Series.**

Volume VI page $160_{-B}$:—

Station of origin Tilabani or LXI, side of origin Tilabani or LXI to Súsinia or LXV.

At Tilabani.

| | | | | |
|---|---|---|---|---|
| Latitude North ... ... | ... | 23° | 24′ | 59″·866, |
| Longitude East of Greenwich ... | ... | 86 | 35 | 41 ·815, |
| Azimuth of Súsinia ... ... | ... | 272 | 58 | 26 ·960, |
| Distance ... ... ... | Log. Feet 5·1624568,7. | | | |

Volume VI page $118_c$:—

Closing Station Sátpautia or XVII; closing side Sátpautia or XVII to Dántún or XVI.

At Sátpautia.

| | | | |
|---|---|---|---|
| Latitude North ... ... | ... | 21° 56′ | 27″·662, |
| Longitude East of Greenwich ... | ... | 87 7 | 14 ·305, |
| Azimuth of Dántún ... ... | ... | 271 27 | 16 ·040, |
| Distance ... ... ... | | Log. Feet | 4·8286693,6. |

## 8.

*The Sides and Angles of the Circuit Triangles.*

The values of the Figurally Corrected Angles, and the logarithms of the side-lengths, computed (in feet) with these angles in terms of the fixed sides of origins furnished by the Calcutta Longitudinal Series, are exhibited in the following table. The given angles are the corrected plane angles, obtained by deducting the sum of the spherical excess and the figural error from the observed angles. Should it be desired to trace the formation of any corrected plane angle, reference must be made to the Abstract of the Observed Angles and to the final data of the Sides and Angles of the Triangles, which are given for each Series in this volume. The final data will be found to contain three columns of angular corrections, which are respectively headed by the words 'Figure', 'Circuit' and 'Non-Circuit',—'figure' being here taken to include single triangles as well as polygons and net-works; the corrections in the first column are what have been applied, with the spherical excess, to the observed angles, in order to obtain the figurally corrected plane angles; those in the second column are what have been derived from the Simultaneous Reduction; and those in the third column are what have been computed to satisfy the geometrical conditions of figures containing non-circuit triangles, which have to be adjusted to the fixed circuit triangles; the application of the correction in the second or the third column, as the case may be, to the figurally corrected plane angle gives the finally corrected plane angle.

In order that it may be readily ascertained—without reference to the Reduction Chart—whether any angle is a 'flank angle' or an 'angle of continuation', a column is inserted in the table which gives the symbolic error of the angle, either $x$, $y$, or $z$, but without the numerical subscript, as that may be inferred from the number of the triangle in the contiguous column. And since the stations on the right-hand flank of each chain are those at which the angles are the data for the formation of the values of the forward azimuth, and the side-lengths are the distances which were employed in the calculations of latitude, longitude and

back azimuth—see the next section—these stations are indicated by numbers in block type, shewing by their sequence the order in which the geodetic calculations were performed, as well as by their Serial-numbers.

The logarithm of the side* opposite any angle is given in the same horizontal line as the angle.

## South Parasnath Series.

*Sides and Angles of Circuit Triangles.*

| Triangle Number | Symbolic Error | Station Numbers: Serial | Station Numbers: Traverse | Corrected Plane Angle | Spherical Excess | Logarithm of side-length in Feet |
|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ″ | |
| | *y* | LVIII | 1 | 46 16 17·48 | 2·40 | 5·2389760,0 |
| 1 | *x* | LXI | | 47 19 18·14 | 2·41 | 5·2464525,1 |
| | *z* | I | 2 | 86 24 24·38 | 2·41 | 5·3792092,2 |
| | | LXI | | 76 3 29·95 | 1·53 | 5·2638996,5 |
| 2 | ,, | I | 2 | 37 32 5·02 | 1·53 | 5·0616755,2 |
| | | II | | 66 24 25·03 | 1·53 | 5·2389760,0 |
| | | I | 2 | 69 31 10·21 | 1·31 | 5·2430002,7 |
| 3 | ,, | II | | 31 4 5·91 | 1·30 | 4·9840572,9 |
| | | IV | 3 | 79 24 43·88 | 1·31 | 5·2638996,5 |
| | | II | | 38 3 36·20 | 1·46 | 5·0532883,1 |
| 4 | ,, | IV | 3 | 69 20 56·83 | 1·46 | 5·2345225,7 |
| | | V | | 72 35 26·97 | 1·46 | 5·2430002,7 |
| | | IV | 3 | 62 54 28·20 | 1·21 | 5·1526244,4 |
| 5 | ,, | V | | 71 59 57·33 | 1·21 | 5·1813047,5 |
| | | VIII | 4 | 45 5 34·47 | 1·20 | 5·0532883,1 |
| | | V | | 51 58 49·12 | 1·19 | 5·0854616,8 |
| 6 | ,, | VIII | 4 | 61 9 30·26 | 1·20 | 5·1315287,9 |
| | | IX | | 66 51 40·62 | 1·20 | 5·1526244,4 |

| Triangle Number | Symbolic Error | Station Numbers: Serial | Station Numbers: Traverse | Corrected Plane Angle | Spherical Excess | Logarithm of side-length in Feet |
|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ″ | |
| | *y* | VIII | 4 | 59 22 20·12 | 1·24 | 5·1368950,3 |
| 7 | *x* | IX | | 70 46 29·82 | 1·25 | 5·1772254,3 |
| | *z* | X | 5 | 49 51 10·06 | 1·24 | 5·0854616,8 |
| | | IX | | 49 32 56·25 | 1·07 | 5·0503694,1 |
| 8 | ,, | X | 5 | 62 12 50·04 | 1·08 | 5·1158004,0 |
| | | XI | | 68 14 13·71 | 1·08 | 5·1368950,3 |
| | | X | 5 | 27 41 59·43 | 0·42 | 4·7183783,3 |
| 9 | ,, | XI | | 65 33 56·59 | 0·42 | 5·0103248,0 |
| | | XII | 6 | 86 44 3·98 | 0·43 | 5·0503694,1 |
| | | XI | | 73 47 12·36 | 0·24 | 4·8277232,4 |
| 10 | ,, | XII | 6 | 57 55 30·37 | 0·23 | 4·7734135,4 |
| | | XIII | | 48 17 17·27 | 0·23 | 4·7183783,3 |
| | | XII | 6 | 69 43 4·18 | 0·41 | 4·9363297,7 |
| 11 | ,, | XIII | | 63 21 26·76 | 0·41 | 4·9153791,7 |
| | | XXV | | 46 55 29·06 | 0·41 | 4·8277232,4 |
| | | XIII | | 34 29 32·52 | 0·63 | 5·0171913,0 |
| 12 | ,, | XXV | | 117 28 2·66 | 0·63 | 5·2122049,6 |
| | | XXVI | | 28 2 24·82 | 0·63 | 4·9363297,7 |

* In calculating these values 7-place Logarithm Tables were employed, the 8th place here shewn being obtained by interpolation.

NOTE.—LVIII and LXI appertain to the Calcutta Longitudinal Series, and XXV and XXVI to the East Coast Series.

## South Maluncha Series.

*Sides and Angles of Circuit Triangles.*

| Triangle Number | Symbolic Error | Station Numbers: Serial | Station Numbers: Traverse | Corrected Plane Angle | Spherical Excess | Logarithm of side-length in Feet |
|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ″ | |
| | *y* | LXI | 1 | 57 36 26·19 | 1·77 | 5·2083171,8 |
| 1 | *x* | LXV | | 72 56 53·62 | 1·77 | 5·2622471,6 |
| | *z* | I | 2 | 49 26 40·19 | 1·77 | 5·1624568,7 |
| | | LXV | | 33 7 55·51 | 1·13 | 4·9663769,9 |
| 2 | ,, | I | 2 | 74 17 51·96 | 1·14 | 5·2122128,9 |
| | | II | | 72 34 12·53 | 1·14 | 5·2083171,8 |
| | | I | 2 | 73 8 39·84 | 0·42 | 4·9754441,9 |
| 3 | ,, | II | | 37 15 30·44 | 0·42 | 4·7765654.2 |
| | | III | 3 | 69 35 49·72 | 0·42 | 4·9663769,9 |
| | | II | | 51 49 34·15 | 0·41 | 4·8753188,2 |
| 4 | ,, | III | 3 | 46 17 35·42 | 0·40 | 4·8388886,0 |
| | | IV | | 81 52 50·43 | 0·41 | 4·9754441,9 |
| | | III | 3 | 78 33 50·81 | 0·36 | 4·9409064,7 |
| 5 | ,, | IV | | 44 0 11·57 | 0·36 | 4·7914116,5 |
| | | V | 4 | 57 25 57·62 | 0·36 | 4·8753188,2 |
| | | IV | | 58 55 8·09 | 0·34 | 4·8788926,1 |
| 6 | ,, | V | 4 | 40 0 21·97 | 0·33 | 4·7543195,2 |
| | | VI | | 81 4 29·94 | 0·34 | 4·9409064.7 |
| | | V | 4 | 51 7 40·07 | 0·27 | 4·7785985,5 |
| 7 | ,, | VI | | 50 7 7·23 | 0·27 | 4·7723205,2 |
| | | VII | 5 | 78 45 12·70 | 0·28 | 4·8788926,1 |
| | *y* | VI | | 59 26 39·22 | 0·20 | 4·7437728,6 |
| 8 | *x* | VII | 5 | 51 38 35·56 | 0·20 | 4·7031074,2 |
| | *z* | VIII | | 68 54 45·22 | 0·21 | 4·7785985,5 |
| | | VII | 5 | 50 3 18·07 | 0·14 | 4·6360647,9 |
| 9 | ,, | VIII | | 50 41 39·43 | 0·15 | 4·6400770,9 |
| | | IX | 6 | 79 15 2·50 | 0·15 | 4·7437728,6 |
| | | VIII | | 65 14 12·20 | 0·16 | 4·7095234,4 |
| 10 | ,, | IX | 6 | 64 42 3·83 | 0·16 | 4·7076274,7 |
| | | X | | 50 3 43·97 | 0·15 | 4·6360647,9 |
| | | IX | 6 | 64 13 25·98 | 0·37 | 4·9633234,1 |
| 11 | ,, | X | | 85 38 42·85 | 0·38 | 5·0075840,0 |
| | | XII | 7 | 30 7 51·17 | 0·37 | 4·7095234,4 |
| | | X | | 53 42 5·34 | 0·45 | 4·8867188,3 |
| 12 | ,, | XII | 7 | 52 16 2·63 | 0·44 | 4·8785223,0 |
| | | XIII | | 74 1 52·03 | 0·45 | 4·9633234,1 |
| | | XII | 7 | 76 59 32·90 | 0·42 | 4·9613969,6 |
| 13 | ,, | XIII | | 47 52 52·89 | 0·41 | 4·8429483,0 |
| | | XVII | | 55 7 34·21 | 0·42 | 4·8867188,3 |
| | | XIII | | 45 46 48·85 | 0·41 | 4·8286919,0 |
| 14 | ,, | XVII | | 57 36 48·06 | 0·41 | 4·8999479,9 |
| | | XVI | | 76 36 23·09 | 0·42 | 4·9613969,6 |

# 9.

*Preliminary Latitudes, Longitudes and Azimuths of the Stations on the Line of the Traverse.*

The following table gives the Geodetic Latitudes, Longitudes and Azimuths which have been obtained for all the stations and sides on the line of traverse by applying the values of the difference of latitude, longitude and azimuth—computed by the formulæ of Section 4 of the preceding chapter—first to the elements of the station of origin which are given on page [27] and then to the deduced elements of every subsequent station

NOTE.—LXI and LXV appertain to the Calcutta Longitudinal Series, and XVI and XVII to the East Coast Series.

in the order of succession which is indicated by the Traverse-numbers. Each station is thus regarded, first as the 'Deduced Station B' and afterwards as the 'Fixed Station A'.

In order to ascertain the differential values given by the geodetic calculations on which the tabulated elements are built up, we have for any, the $a$th, side on the flank of the chain

$$\Delta\lambda_a = (\lambda_{a+1} - \lambda_a); \qquad \Delta L_a = (L_{a+1} - L_a);$$

$$\Delta A_a = B_a - (\pi + A_a);$$

where $A_a$ stands for the forward azimuth at 'fixed station' $A_a$ of 'deduced station' $B_a$ and $B_a$ for the back azimuth of $A_a$ at $B_a$.

The three differential values depend on the length $c_a$ and forward azimuth $A_a$ of the side $a$, and also on the latitude $\lambda_a$. The logarithmic length is given in the preceding Section, on the same horizontal line as the angle at the Serial station which enters, in the table, between the stations numbered in block type $a$ and $(a + 1)$. The forward azimuth of the side $a$ may be deduced by adding all the spherical angles at $a$, as given in the table, to the back azimuth $B_{a-1}$. Thus the logarithmic length of flank-side 3 in the South Párasnáth Series is 5·1813047,5 which occurs in triangle 5 on the same line as Serial station V, entering between the flank stations 3 and 4; and the forward azimuth of this side is equal to the back azimuth of 2 at 3 and the sum of the spherical angles at 3, which occur in triangles 3, 4 and 5, the respective values of which are 79° 24′ 45″·19, 69° 20′ 58″·29 and 62° 54′ 29″·41, together amounting to 211° 40′ 12″·89.

## South Parasnath Series.

*Geodetic Elements of Traverse Stations.*

| Fixed Station A | | | | Deduced Station B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. in Traverse | Azimuth of B | | | No. in Traverse | Latitude North | | | Longitude East of Greenwich | | | Azimuth of A | | |
| | ° | ′ | ″ | | ° | ′ | ″ | ° | ′ | ″ | ° | ′ | ″ |
| 1 | 328 | 12 | 57·05 | 2 | 23 | 8 | 30·013 | 86 | 10 | 21·907 | 148 | 19 | 31·59 |
| 2 | 341 | 47 | 16·45 | 3 | 22 | 53 | 22·578 | 86 | 15 | 44·132 | 161 | 49 | 22·43 |
| 3 | 13 | 29 | 35·32 | 4 | 22 | 28 | 59·603 | 86 | 9 | 26·392 | 193 | 27 | 9·63 |
| 4 | 359 | 4 | 38·12 | 5 | 22 | 4 | 9·410 | 86 | 9 | 52·144 | 179 | 4 | 47·88 |
| 5 | 318 | 50 | 50·15 | 6 | 21 | 51 | 24·814 | 86 | 21 | 47·620 | 138 | 55 | 17·75 |
| 6 | 353 | 17 | 57·35 | | 21 | 37 | 54·770 | 86 | 23 | 29·412 | 173 | 18 | 35·06 |

### South Maluncha Series.

*Geodetic Elements of Traverse Stations.*

| Fixed Station A | | | | Deduced Station B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. in Traverse | Azimuth of B | | | No. in Traverse | Latitude North | | | Longitude East of Greenwich | | | Azimuth of A | | |
| | ° | ′ | ″ | | ° | ′ | ″ | ° | ′ | ″ | ° | ′ | ″ |
| 1 | 330 | 34 | 54·920 | 2 | 22 | 58 | 40·278 | 86 | 51 | 43·357 | 150 | 41 | 13·673 |
| 2 | 347 | 34 | 28·993 | 3 | 22 | 49 | 1·750 | 86 | 54 | 0·860 | 167 | 35 | 22·493 |
| 3 | 2 | 2 | 39·623 | 4 | 22 | 38 | 49·139 | 86 | 53 | 37·299 | 182 | 2 | 30·519 |
| 4 | 330 | 36 | 31·139 | 5 | 22 | 30 | 17·916 | 86 | 58 | 47·178 | 150 | 38 | 30·104 |
| 5 | 331 | 5 | 37·054 | 6 | 22 | 23 | 59·122 | 87 | 2 | 32·099 | 151 | 7 | 2·955 |
| 6 | 359 | 17 | 35·945 | 7 | 22 | 7 | 10·739 | 87 | 2 | 45·449 | 179 | 17 | 41·002 |
| 7 | 338 | 41 | 8·932 | | 21 | 56 | 27·598 | 87 | 7 | 14·408 | 158 | 42 | 49·818 |

# 10.

*Numerical Values of the Absolute Terms in the Primary Equations of Condition.*

The Lengths and Azimuths of the sides of the triangles, and the Latitudes and Longitudes of the Stations on the traverse flank of each chain, having been computed—as set forth in the two preceding sections—the values of the several Absolute Terms in the Primary Equations of Condition are indicated by the discrepancies between the computed values as here obtained at the junctions with the East Coast Series and the corresponding values given in Volume VI, and quoted in Section 7. The closing linear discrepancies are expressed logarithmically and the 7th place of decimals is treated as unity.

The Absolute Terms will now be particularized.

### South Parasnath Series.

Equation 1, *Linear*. Between the sides Chainpur–Tilabani and Megásini–Bolpál.

Log. computed length Megásini–Bolpál by Triangle No. 12 . . . . . 5·0171913,0
Log. final value from East Coast Series; see page [27] . . . . . 5·0171495,6

$_1E = +417{\cdot}4$ Logarithmic Error + ·0000417,4

Equations 2 to 4, *Geodetic.* Terminal Station, Megásini. Terminal side, Megásini–Bolpál.

| | *Latitude.* | *Longitude.* | *Azimuth.* |
|---|---|---|---|
| | ° ′ ″ | ° ′ ″ | ° ′ ″ |
| Computed values . . . . | 21 37 54·770 | 86 23 29·412 | 337 42 7·82 |
| Final values; see page [27] | 21 37 54·997 | 86 23 29·590 | 337 42 5·10 |
| Errors . . . . . | ${}_2E = -0{\cdot}227$ | ${}_3E = -{\cdot}178$ | ${}_4E = +2{\cdot}72$ |

**South Maluncha Series.**

Equation 1, *Linear.* Between the sides Tilabani–Súsinia and Sátpautia–Dántún.

Log. computed length Sátpautia–Dántún by triangle No. 14 . . . . . 4·8286919,0
Log. final value; see page [28] . . . . . 4·8286693,6

${}_1E = +225{\cdot}4$ Logarithmic Error + ·0000225,4

Equations 2 to 4, *Geodetic.* Terminal Station, Sátpautia. Terminal side, Sátpautia–Dántún.

| | *Latitude.* | *Longitude.* | *Azimuth.* |
|---|---|---|---|
| | ° ′ ″ | ° ′ ″ | ° ′ ″ |
| Computed values . . . . | 21 56 27·598 | 87 7 14·408 | 271 27 12·918 |
| Final values; see page [28] | 21 56 27·662 | 87 7 14·305 | 271 27 16·040 |
| Errors . . . . . | ${}_1E = -0{\cdot}064$ | ${}_2E = +0{\cdot}103$ | ${}_3E = -3{\cdot}122$ |

# 11.

*Numerical Values of the μs and φs.*

The Table of Substitutions at page [19] shews the general form of the factors $\mu$ and $\phi$. The numerical values are tabulated in this section: they were constructed in the opposite order to that in which they are now recorded, commencing at the closing side of the chain.*

* The values of the tabular log. differences of the first terms of $\Delta\lambda$, $\Delta L$ and $\Delta A$, in the expressions for them on page [12] were employed for t.d. log $\Delta\lambda$, t.d. log $\Delta L$ and t.d. log $\Delta A$.

## South Parasnath Series.

*Numerical Values of the $\mu$s and $\phi$s.*

| No. of Station in Traverse | Latitude | | Longitude | | Azimuth | |
|---|---|---|---|---|---|---|
| | ${}_{\lambda}\mu$ | ${}_{\lambda}\phi$ | ${}_{L}\mu$ | ${}_{L}\phi$ | ${}_{A}\mu$ | ${}_{A}\phi$ |
| 1 | − 15917 | − ·0081 | + 4131 | − ·0362 | + 1598 | + ·9859 |
| 2 | 12492 | 36 | 1805 | 283 | 681 | ·9890 |
| 3 | 10409 | 21 | 1064 | 236 | 389 | ·9909 |
| 4 | 7031 | 38 | 1934 | 159 | 728 | ·9939 |
| 5 | 3606 | 38 | 1874 | 81 | 705 | ·9969 |
| 6 | 1852 | 6 | 235 | 42 | 88 | ·9984 |

## South Maluncha Series.

*Numerical Values of the $\mu$s and $\phi$s.*

| No. of Station in Traverse | Latitude | | Longitude | | Azimuth | |
|---|---|---|---|---|---|---|
| | ${}_{\lambda}\mu$ | ${}_{\lambda}\phi$ | ${}_{L}\mu$ | ${}_{L}\phi$ | ${}_{A}\mu$ | ${}_{A}\phi$ |
| 1 | − 12227 | − ·0090 | + 4365 | − ·0279 | + 1704 | + ·9892 |
| 2 | 8591 | 46 | 2143 | 195 | 819 | ·9926 |
| 3 | 7258 | 39 | 1826 | 165 | 696 | ·9938 |
| 4 | 5850 | 39 | 1880 | 133 | 717 | ·9950 |
| 5 | 4674 | 25 | 1166 | 106 | 442 | ·9960 |
| 6 | 3797 | 14 | 648 | 86 | 246 | ·9967 |
| 7 | 1471 | 12 | 617 | 33 | 234 | ·9987 |

# 12.

*Numerical Values of the Coefficients* $\mathfrak{b}$ *and* $\mathfrak{c}$ *of the Unknown Quantities* y *and* z.

The following table gives the numerical values of the coefficients $\mathfrak{b}$ and $\mathfrak{c}$ of the unknown quantities $y$ and $z$ in each equation of condition. Should it be desired to reproduce any one of these coefficients, as the value of $\mathfrak{b}_p$ in the $q$th equation, it is first necessary to ascertain by reference to pages [25] and [26], whether the coefficient is one of those of an exceptional form for which symbolical expressions are there given. When not found in this list it will be understood to take one of the general forms on page [25].

*Examples.*

(1). To find the values of $\mathfrak{b}_6$ and $\mathfrak{c}_6$ in equation 1 of the South Párasnáth Series.

This is a linear equation, and the forms of the coefficients are normal,

$$ {}_1\mathfrak{b}_6 = + \text{t.d. log } 62^\circ\ 54'\ 28'' = + 11 $$

$$ {}_1\mathfrak{c}_6 = - \text{t.d. log } 45^\circ\ 5'\ 34'' = - 21 $$

(2). To find the values of $\mathfrak{b}_6$ and $\mathfrak{c}_6$ in equation 3 of the South Párasnáth Series.

The equation is longitudinal and the forms of the coefficients are normal,

$$ {}_3\mathfrak{b}_6 = + \{({}_L\mu_4 - {}_L\mu_3)\, a_6 + {}_L\mu_4\, \beta_6 + {}_L\phi_3\} $$

$$ = + \{870 \times \cdot0000007 + 1934 \times \cdot0000011 - \cdot0236\} $$

$$ = - \cdot0209 $$

$$ {}_3\mathfrak{c}_6 = + \{({}_L\mu_4 - {}_L\mu_3)\, a_6 - {}_L\mu_3\, \gamma_6 + {}_L\phi_4\} $$

$$ = + \{870 \times \cdot0000007 - 1064 \times \cdot0000021 - \cdot0159\} $$

$$ = - \cdot0175 $$

(3). To find the values of $\mathfrak{b}_{11}$ and $\mathfrak{c}_{11}$ in equation 4 of the South Párasnáth Series.

The equation is azimuthal and the forms of the coefficients are exceptional, see page [25].

$$ {}_4\mathfrak{b}_{11} = - {}_4\mu_6\, a_{11} + {}_4\phi_6 $$

$$ = - 88 \times \cdot0000011 + \cdot9984 $$

$$ = + \cdot9983 $$

$$ {}_4\mathfrak{c}_{11} = 1 - {}_4\mu_6\, (a_{11} + \gamma_{11}) $$

$$ = 1 - 88\ (\cdot0000011 + \cdot0000019) $$

$$ = + \cdot9997. $$

## South Parasnath Series.

*Numerical Values of the Coefficients.*

| No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $b$ | $c$ | | $b$ | $c$ | | $b$ | $c$ | | $b$ | $c$ |
| | 1*st Equation.* | *Linear.* | | 2*nd Equation.* | *Latitude.* | | 3*rd Equation.* | *Longitude.* | | 4*th Equation.* | *Azimuth.* |
| 1 | + 20 | − 2 | 1 | −0·0266 | + 0·0061 | 1 | −0·0370 | − 0·0335 | 1 | +0·9856 | + 0·9870 |
| 2 | 5 | 9 | 2 | ·0026 | ·0148 | 2 | + ·0292 | + ·0267 | 2 | − ·9887 | − ·9896 |
| 3 | 8 | 4 | 3 | ·0046 | ·0102 | 3 | − ·0300 | − ·0269 | 3 | + ·9883 | + ·9896 |
| 4 | 26 | 7 | 4 | ·0250 | ·0094 | 4 | + ·0264 | + ·0229 | 4 | − ·9899 | − ·9912 |
| 5 | 11 | 21 | 5 | ·0074 | ·0205 | 5 | − ·0209 | − ·0175 | 5 | + ·9919 | + ·9933 |
| 6 | 17 | 9 | 6 | ·0082 | ·0101 | 6 | + ·0192 | + ·0142 | 6 | − ·9927 | − ·9946 |
| 7 | 13 | 18 | 7 | ·0058 | ·0116 | 7 | − ·0135 | − ·0116 | 7 | + ·9948 | + ·9956 |
| 8 | 18 | 8 | 8 | ·0027 | ·0067 | 8 | + ·0115 | + ·0066 | 8 | − ·9956 | − ·9975 |
| 9 | 40 | 1 | 9 | ·0094 | ·0016 | 9 | − ·0088 | − ·0060 | 9 | + ·9967 | + ·9977 |
| 10 | 6 | 19 | 10 | ·0005 | ·0041 | 10 | + ·0043 | + ·0038 | 10 | − ·9983 | − ·9986 |
| 11 | 8 | 19 | 11 | + ·0014 | ·0055 | 11 | − ·0045 | − ·0007 | 11 | + ·9983 | + ·9997 |
| 12 | 31 | 40 | | | | | | | 12 | −1·0000 | − 1·0000 |

## South Maluncha Series.

*Numerical Values of the Coefficients.*

| No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $b$ | $c$ | | $b$ | $c$ | | $b$ | $c$ | | $b$ | $c$ |
| | 1*st Equation.* | *Linear.* | | 2*nd Equation.* | *Latitude.* | | 3*rd Equation.* | *Longitude.* | | 4*th Equation.* | *Azimuth.* |
| 1 | + 13 | − 18 | 1 | −0·0177 | + 0·0199 | 1 | −0·0267 | − 0·0290 | 1 | +0·9897 | + 0·9889 |
| 2 | 33 | 7 | 2 | ·0238 | ·0106 | 2 | + ·0266 | + ·0180 | 2 | − ·9899 | − ·9932 |
| 3 | 6 | 7 | 3 | ·0053 | ·0058 | 3 | − ·0193 | − ·0189 | 3 | + ·9927 | + ·9929 |
| 4 | 17 | 3 | 4 | ·0084 | ·0061 | 4 | + ·0196 | + ·0160 | 4 | − ·9926 | − ·9940 |
| 5 | 4 | 14 | 5 | ·0032 | ·0093 | 5 | − ·0156 | − ·0158 | 5 | + ·9941 | + ·9940 |

**South Maluncha Series.**

*Numerical Values of the Coefficients*—(Continued).

| No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | | No. of Circuit Triangle | Coefficients of $y$ and $z$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\mathfrak{b}$ | $\mathfrak{c}$ | | $\mathfrak{b}$ | $\mathfrak{c}$ | | $\mathfrak{b}$ | $\mathfrak{c}$ | | $\mathfrak{b}$ | $\mathfrak{c}$ |
| | 1*st Equation.* | *Linear.* | | 2*nd Equation.* | *Latitude.* | | 3*rd Equation.* | *Longitude.* | | 4*th Equation.* | *Azimuth.* |
| 6 | + 13 | − 3 | 6 | −0·0037 | + 0·0057 | 6 | +0·0157 | + 0·0127 | 6 | −0·9941 | − 0·9952 |
| 7 | 17 | 4 | 7 | ·0098 | ·0018 | 7 | − ·0125 | − ·0126 | 7 | + ·9953 | + ·9952 |
| 8 | 13 | 8 | 8 | ·0036 | ·0062 | 8 | + ·0121 | + ·0097 | 8 | − ·9954 | − ·9964 |
| 9 | 18 | 4 | 9 | ·0078 | ·0020 | 9 | − ·0103 | − ·0100 | 9 | + ·9961 | + ·9962 |
| 10 | 10 | 18 | 10 | ·0024 | ·0082 | 10 | + ·0092 | + ·0074 | 10 | − ·9965 | − ·9971 |
| 11 | 10 | 36 | 11 | ·0024 | ·0130 | 11 | − ·0080 | − ·0056 | 11 | + ·9969 | + ·9978 |
| 12 | 16 | 6 | 12 | ·0012 | ·0021 | 12 | + ·0043 | + ·0029 | 12 | − ·9983 | − ·9988 |
| 13 | 5 | 15 | 13 | + ·0016 | ·0050 | 13 | − ·0045 | − ·0021 | 13 | + ·9983 | + ·9992 |
| 14 | 21 | 5 | | | | | | | 14 | −1·0000 | − 1·0000 |

# 13.

*The Coefficients of the Indeterminate Factors in the Values of the Unknown Quantities.*

On reference to the equations on page [10] it will be seen that the general expression for the error $x_p$ of any angle $X_p$ appertaining to a trigonometrical figure, is, when the weight is unity,

$$x_p = (a_p \lambda_a + b_p \lambda_b + \ . \ . \ . \ + n_p \lambda_n)$$

so that the coefficients of $\lambda_a, \lambda_b, \ . \ . \ . \ \lambda_n$, the indeterminate factors, are the coefficients of $x_p$ in the several absolute geometrical equations to which the indeterminate factors are respectively related. But one of the three unknown quantities appertaining to every triangle having been eliminated, as a preliminary to the simultaneous reduction of each series, the coefficients of the indeterminate factors take a more complex form which is given on page [21]. The expressions are:—

$$y_p = {}_1\mathfrak{B}_p \, {}_1\Lambda + {}_2\mathfrak{B}_p \, {}_2\Lambda + \ . \ . \ . \ + {}_n\mathfrak{B}_p \, {}_n\Lambda$$
$$z_p = {}_1\mathfrak{C}_p \, {}_1\Lambda + {}_2\mathfrak{C}_p \, {}_2\Lambda + \ . \ . \ . \ + {}_n\mathfrak{C}_p \, {}_n\Lambda$$

where, see note to page [21],

$$ {}_1\mathfrak{B}_p = (2\ {}_1\mathfrak{b}_p - {}_1\mathfrak{c}_p); \qquad {}_2\mathfrak{B}_p = (2\ {}_2\mathfrak{b}_p - {}_2\mathfrak{c}_p); \qquad \ldots $$
$$ {}_1\mathfrak{C}_p = (2\ {}_1\mathfrak{c}_p - {}_1\mathfrak{b}_p); \qquad {}_2\mathfrak{C}_p = (2\ {}_2\mathfrak{c}_p - {}_2\mathfrak{b}_p); \qquad \ldots $$

the left-hand subscripts indicating the number of any one of the equations into which the errors $y$ and $z$ of any, the $p$th, triangle happen to enter.

The values of $\mathfrak{b}_p$ and $\mathfrak{c}_p$ for each equation into which the $y_p$ and $z_p$ enter, are given in the table in the preceding section.

*Examples.*

**From the South Parasnath Series.**

$$ {}_2\mathfrak{B}_6 = (2\ {}_2\mathfrak{b}_6 - {}_2\mathfrak{c}_6) = (2 \times - 0{\cdot}0082 - 0{\cdot}0101) = - 0{\cdot}0265 $$
$$ {}_2\mathfrak{C}_6 = (2\ {}_2\mathfrak{c}_6 - {}_2\mathfrak{b}_6) = (2 \times + 0{\cdot}0101 + 0{\cdot}0082) = + 0{\cdot}0284. $$

The following table gives the values of the significant coefficients $\mathfrak{B}$ and $\mathfrak{C}$ of the indeterminate factors ${}_1\Lambda$, ${}_2\Lambda$, ${}_3\Lambda$ and ${}_4\Lambda$ for the $y$ and $z$ of every triangle in each series separately.

**South Parasnath Series.**

*Numerical Values of the $\mathfrak{B}$s and $\mathfrak{C}$s.*

| No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ | No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ | No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ | No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1*st Equation.* | | *Linear.* | 2*nd Equation.* | | *Latitude.* | 3*rd Equation.* | | *Longitude.* | 4*th Equation.* | | *Azimuth.* |
| 1 | + 42 | − 24 | 1 | −0·0593 | + 0·0388 | 1 | −0·0405 | − 0·0300 | 1 | +0·9842 | + 0·9884 |
| 2 | 19 | 23 | 2 | ·0200 | ·0322 | 2 | + ·0317 | + ·0242 | 2 | − ·9878 | − ·9905 |
| 3 | 20 | 16 | 3 | ·0194 | ·0250 | 3 | − ·0331 | − ·0238 | 3 | + ·9870 | + ·9909 |
| 4 | 59 | 40 | 4 | ·0594 | ·0438 | 4 | + ·0299 | + ·0194 | 4 | − ·9886 | − ·9925 |
| 5 | 43 | 53 | 5 | ·0353 | ·0484 | 5 | − ·0243 | − ·0141 | 5 | + ·9905 | + ·9947 |
| 6 | 43 | 35 | 6 | ·0265 | ·0284 | 6 | + ·0242 | + ·0092 | 6 | − ·9908 | − ·9965 |
| 7 | 44 | 49 | 7 | ·0232 | ·0290 | 7 | − ·0154 | − ·0097 | 7 | + ·9940 | + ·9964 |
| 8 | 44 | 34 | 8 | ·0121 | ·0161 | 8 | + ·0164 | + ·0017 | 8 | − ·9937 | − ·9994 |
| 9 | 81 | 42 | 9 | ·0204 | ·0126 | 9 | − ·0116 | − ·0032 | 9 | + ·9957 | + ·9987 |
| 10 | 31 | 44 | 10 | ·0051 | ·0087 | 10 | + ·0048 | + ·0033 | 10 | − ·9980 | − ·9989 |
| 11 | 35 | 46 | 11 | ·0027 | ·0096 | 11 | − ·0083 | + ·0031 | 11 | + ·9969 | + 1·0011 |
| 12 | 102 | 111 | | | | | | | 12 | −1·0000 | − 1·0000 |

**South Maluncha Series.**

*Numerical Values of the $\mathfrak{B}$s and $\mathfrak{C}$s.*

| No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ | No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ | No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ | No. of Circuit Triangle | $\mathfrak{B}$ | $\mathfrak{C}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1*st Equation.* | *Linear.* | | 2*nd Equation.* | *Latitude.* | | 3*rd Equation.* | *Longitude.* | | 4*th Equation.* | *Azimuth.* |
| 1 | + 44 | − 49 | 1 | −0·0553 | + 0·0575 | 1 | −0·0244 | − 0·0313 | 1 | +0·9905 | + 0·9881 |
| 2 | 73 | 47 | 2 | ·0582 | ·0450 | 2 | + ·0352 | + ·0094 | 2 | − ·9866 | − ·9965 |
| 3 | 19 | 20 | 3 | ·0164 | ·0169 | 3 | − ·0197 | − ·0185 | 3 | + ·9925 | + ·9931 |
| 4 | 37 | 23 | 4 | ·0229 | ·0206 | 4 | + ·0232 | + ·0124 | 4 | − ·9912 | − ·9954 |
| 5 | 22 | 32 | 5 | ·0157 | ·0218 | 5 | − ·0154 | − ·0160 | 5 | + ·9942 | + ·9939 |
| 6 | 29 | 19 | 6 | ·0131 | ·0151 | 6 | + ·0187 | + ·0097 | 6 | − ·9930 | − ·9963 |
| 7 | 38 | 25 | 7 | ·0214 | ·0134 | 7 | − ·0124 | − ·0127 | 7 | + ·9954 | + ·9951 |
| 8 | 34 | 29 | 8 | ·0134 | ·0160 | 8 | + ·0145 | + ·0073 | 8 | − ·9944 | − ·9974 |
| 9 | 40 | 26 | 9 | ·0176 | ·0118 | 9 | − ·0106 | − ·0097 | 9 | + ·9960 | + ·9963 |
| 10 | 38 | 46 | 10 | ·0130 | ·0188 | 10 | + ·0110 | + ·0056 | 10 | − ·9959 | − ·9977 |
| 11 | 56 | 82 | 11 | ·0178 | ·0284 | 11 | − ·0104 | − ·0032 | 11 | + ·9960 | + ·9987 |
| 12 | 38 | 28 | 12 | ·0045 | ·0054 | 12 | + ·0057 | + ·0015 | 12 | − ·9978 | − ·9993 |
| 13 | 25 | 35 | 13 | ·0018 | ·0084 | 13 | − ·0069 | + ·0003 | 13 | + ·9974 | + 1·0001 |
| 14 | 47 | 31 | | | | | | | 14 | −1·0000 | − 1·0000 |

# 14.

*The Equations between the Indeterminate Factors, and their Solution.*

In the equations between the Indeterminate Factors, the coefficients of the factors are summations of terms of the form $(\mathfrak{b}\mathfrak{B} + \mathfrak{c}\mathfrak{C})$, such as are exhibited in the equations on page [20]. The coefficient of the $m$th $\Lambda$ in the $l$th equation is equal to that of the $l$th $\Lambda$ in the $m$th equation, and may therefore be expressed either as

$$\sum_{1}^{t}[{}_{m}\mathfrak{b}_{p}\,{}_{l}\mathfrak{B}_{p} + {}_{m}\mathfrak{c}_{p}\,{}_{l}\mathfrak{C}_{p}] \quad \text{or as} \quad \sum_{1}^{t}[{}_{l}\mathfrak{b}_{p}\,{}_{m}\mathfrak{B}_{p} + {}_{l}\mathfrak{c}_{p}\,{}_{m}\mathfrak{C}_{p}]$$

in which expressions the summations are taken for all the values of $p$, from 1 to $t$, corres-

ponding to the numbers of the triangles whose angular errors enter the $m$th and the $l$th equations as the case may be.

The coefficients of the Indeterminate Factors, and the Absolute Terms, in each of the 4 equations which were presented for simultaneous solution by either series are here given in a tabular form.

The table following each group of equations between the Indeterminate Factors, gives the first of each group of equations between certain of the indeterminate factors which remained after the other factors had been eliminated. These are the equations which were used in obtaining the numerical values of the factors by successive substitutions backwards from the last to the first.

### South Parasnath Series.

*The Equations between the Indeterminate Factors expressed in Natural Numbers.*

| No. of Equation | The Indeterminate Factors and their Coefficients | | | | The Absolute Terms |
|---|---|---|---|---|---|
| | $_1\Lambda$ | $_2\Lambda$ | $_3\Lambda$ | $_4\Lambda$ | |
| 1 | + 21438·0 | − 8·2691 | − 0·3439 | + 23·8608 | + 417·4 |
| 2 | − 8·2691 | + 0·0073 | + ·0004 | − 0·0028 | − 0·227 |
| 3 | − 0·3439 | + ·0004 | + ·0090 | − ·3722 | − ·178 |
| 4 | + 23·8608 | − ·0028 | − ·3722 | + 23·7118 | + 2·72 |

*The Equations between the Indeterminate Factors after the Successive Eliminations.*

| No. of Equation | The Indeterminate Factors and their Coefficients | | | | The Absolute Terms |
|---|---|---|---|---|---|
| | $_1\Lambda$ | $_2\Lambda$ | $_3\Lambda$ | $_4\Lambda$ | |
| 1 | + 21438·0 | − 8·2691 | − 0·3439 | + 23·8608 | + 417·4 |
| 2 | | + 0·0041 | + ·0003 | + 0·0064 | − 0·066 |
| 3 | | | + ·0090 | − ·3723 | − ·1665 |
| 4 | | | | + 8·2744 | − 4·5291 |

**South Maluncha Series.**

*The Equations between the Indeterminate Factors expressed in Natural Numbers.*

| No. of Equation | The Indeterminate Factors and their Coefficients | | | | The Absolute Terms |
|---|---|---|---|---|---|
| | $_1\Lambda$ | $_2\Lambda$ | $_3\Lambda$ | $_4\Lambda$ | |
| 1 | + 15646·0 | − 8·2327 | + 1·9686 | − 97·2513 | + 225·4 |
| 2 | − 8·2327 | + 0·0061 | − 0·0010 | + 0·0160 | − 0·064 |
| 3 | + 1·9686 | − ·0010 | + ·0060 | − ·3428 | + ·103 |
| 4 | − 97·2513 | + ·0160 | − ·3428 | + 27·7385 | − 3·122 |

*The Equations between the Indeterminate Factors after the Successive Eliminations.*

| No. of Equation | The Indeterminate Factors and their Coefficients | | | | The Absolute Terms |
|---|---|---|---|---|---|
| | $_1\Lambda$ | $_2\Lambda$ | $_3\Lambda$ | $_4\Lambda$ | |
| 1 | + 15646·0 | − 8·2327 | + 1·9686 | − 97·2513 | + 225·4 |
| 2 | | + 0·0018 | 0·0000 | − 0·0352 | + 0·0546 |
| 3 | | | + ·0058 | − ·3306 | + ·0746 |
| 4 | | | | + 7·6014 | + 3·5989 |

The following table gives the values of the factors to 4 places of decimals as deduced from the solution of the equations.

**South Parasnath Series.**

*Numerical Values of the Indeterminate Factors.*

| Factor | Numerical value |
|---|---|
| $_1\Lambda$ | + 0·0147 |
| $_2\Lambda$ | − 12·2439 |
| $_3\Lambda$ | − 41·1444 |
| $_4\Lambda$ | − 0·5474 |

### South Maluncha Series.

*Numerical Values of the Indeterminate Factors.*

| Factor | Numerical value |
|---|---|
| ${}_1\Lambda$ | + 0·0332 |
| ${}_2\Lambda$ | + 39·6111 |
| ${}_3\Lambda$ | + 39·8448 |
| ${}_4\Lambda$ | + 0·4735 |

## 15.

*The Angular Errors x, y and z.*

The following table gives the values of the errors of the angles of every triangle, the errors $y$ and $z$ having first been deduced for any, the $p$th, triangle by the formulæ.

$$y_p = {}_1\mathfrak{B}_p\,{}_1\Lambda + {}_2\mathfrak{B}_p\,{}_2\Lambda + \ . \ . \ .$$
$$z_p = {}_1\mathfrak{C}_p\,{}_1\Lambda + {}_2\mathfrak{C}_p\,{}_2\Lambda + \ . \ . \ .$$

the error $x_p$ was simply determined by finding the value of its equivalent, $-(y_p + z_p)$.

### South Parasnath Series.

*The Angular Errors.*

| No. of Triangle | $x$ | $y$ | $z$ | No. of Triangle | $x$ | $y$ | $z$ |
|---|---|---|---|---|---|---|---|
| | ″ | ″ | ″ | | ″ | ″ | ″ |
| 1 | − 2·34 | + 2·47 | − 0·13 | 7 | + 0·22 | + 1·02 | − 1·24 |
| 2 | + 1·43 | − 0·24 | − 1·19 | 8 | − 0·42 | + 0·66 | − 0·24 |
| 3 | − 1·21 | + 1·35 | − 0·14 | 9 | − 0·18 | + 1·37 | − 1·19 |
| 4 | + 0·51 | + 0·91 | − 1·42 | 10 | − 0·53 | + 0·87 | − 0·34 |
| 5 | − 0·18 | + 1·52 | − 1·34 | 11 | + 1·13 | + 0·34 | − 1·47 |
| 6 | + 0·20 | + 0·50 | − 0·70 | 12 | − 0·98 | + 2·07 | − 1·09 |

**South Maluncha Series.**

*The Angular Errors.*

| No. of Triangle | $x$ | $y$ | $z$ | No. of Triangle | $x$ | $y$ | $z$ |
|---|---|---|---|---|---|---|---|
| | ″ | ″ | ″ | | ″ | ″ | ″ |
| 1 | + 1·36 | − 1·22 | − 0·14 | 8 | − 0·19 | + 0·71 | − 0·52 |
| 2 | − 1·17 | + 1·06 | + 0·11 | 9 | − 0·37 | + 0·70 | − 0·33 |
| 3 | + 0·59 | − 0·32 | − 0·27 | 10 | + 0·32 | + 0·72 | − 1·04 |
| 4 | − 0·86 | + 0·79 | + 0·07 | 11 | + 0·04 | + 1·22 | − 1·26 |
| 5 | + 0·40 | − 0·02 | − 0·38 | 12 | + 0·29 | + 0·86 | − 1·15 |
| 6 | − 0·60 | + 0·73 | − 0·13 | 13 | − 0·62 | + 0·98 | − 0·36 |
| 7 | − 0·06 | + 0·40 | − 0·34 | 14 | + 0·41 | + 1·11 | − 1·52 |

# 16.

*Arbitrary Corrections.*

The values of the angular errors were first obtained to 4 places of decimals and then reduced to 2 places by rejecting the 3rd and 4th and increasing the 2nd place if the 3rd was not less than 5. This introduced certain closing errors, to eliminate which small arbitrary corrections had to be made: these are shewn in the following table:—

| South Parasnath Series | | | | South Maluncha Series | | | |
|---|---|---|---|---|---|---|---|
| $y$ | | $z$ | | $y$ | | $z$ | |
| Subscript | Correction | Subscript | Correction | Subscript | Correction | Subscript | Correction |
| | | | ″ | | ″ | | ″ |
| ... | ... | 3 | +·04 | 1 | +·01 | 1 | +·01 |
| ... | ... | 4 | ·04 | 2 | ·01 | 2 | ·01 |
| ... | ... | 7 | ·02 | 3 | ·01 | 3 | ·01 |
| ... | ... | 8 | ·02 | 4 | ·01 | 4 | ·01 |
| 12 | +″·02 | 12 | ·01 | 5 | ·01 | 5 | ·01 |
| | | | | 6 | ·01 | 6 | ·01 |
| | | | | 7 | ·01 | 7 | ·01 |
| | | | | 8 | ·01 | 8 | ·01 |
| | | | | 9 | ·02 | 9 | ·02 |
| | | | | 10 | ·01 | 10 | ·01 |
| | | | | 11 | ·01 | 11 | ·01 |
| | | | | 12 | ·02 | 12 | ·02 |
| | | | | 13 | ·02 | 13 | ·02 |
| | | | | 14 | ·02 | 14 | ·02 |

# 17.

*The Final Results of the Simultaneous Reduction.*

The errors above shewn were severally applied with changed signs to the values of the figurally corrected angles which are given in Section 8, and corresponding corrections were obtained to the logarithmic lengths of the sides of the circuit triangles which are given in that section. The corrections to the sides and angles were then introduced into the several geodetic calculations from which the values of latitude, longitude and azimuth for the stations on the line of traverse had been obtained, as given in Section 9.

After all the corrections had been applied the residual differences were as follows:—

**South Parasnath Series.**

At Megásini.

| | | |
|---|---|---|
| | | " |
| Latitude North ... ... ... | — | 0·002 |
| Longitude East of Greenwich ... ... | — | ·004 |
| Azimuth of Bolpál ... ... ... | | ·00 |
| Distance in the 7th place of logs. ... | + | ·3 |

**South Maluncha Series.**

At Sátpautia.

| | | |
|---|---|---|
| Latitude North ... ... ... | + | 0·002 |
| Longitude East of Greenwich ... ... | + | ·001 |
| Azimuth of Dántún ... ... ... | — | ·02 |
| Distance in the 7th place of logs. ... | | ·0 |

## CHAPTER IV.

### THE NON-CIRCUIT TRIANGLES AND THEIR FINAL FIGURAL ADJUSTMENTS.

Only a single chain of triangles having been selected from each series for reduction it followed that when each reduction was completed the remaining, or *non*-circuit triangles, had to be brought into accord with the reduced triangles, all the elements of the latter being maintained unaltered. This was effected in the same manner as the figural reductions, pages 15 and 45, the only difference being that

1. The sums of certain angles had to be made equal to fixed quantities.
2. The ratios of certain sides had to be maintained as given by the circuit reductions.
3. The algebraical sum of the corrections to each *non*-circuit triangle had to = o.

In certain cases it happened that a *non*-circuit triangle had two sides and the included angle already determined by the circuit triangles and the unknown quantities were the errors of the other two angles. Conditions 2 and 3 furnished two equations for determining these two unknown quantities, and the equations were solved as ordinary algebraical simultaneous equations.

The details of the reduction of the *non*-circuit triangles here follow :—

## South Parasnath Series.

### *Sides and Angles of the Non-Circuit Triangles.*

| Number of Figure | Number of Triangle | Figural No. of Angle | Number of Station | Corrected Plane Angle | Spherical Excess | Logarithm of Side-length in Feet | Number of Figure | Number of Triangle | Figural No. of Angle | Number of Station | Corrected Plane Angle | Spherical Excess | Logarithm of Side-length in Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ″ | | | | | | ° ′ ″ | ″ | |
| | | 4 | LXI | 55 4 48·46 | 1·23 | 5·1540069,9 | | | 26 | IV | 42 58 54·20 | ·95 | 5·0155803,8 |
| 1 | 13 | 6 | I | 39 15 2·52 | 1·23 | 5·0414257,5 | 1 | 17 | 25 | VII | 86 53 19·25 | ·96 | 5·1813049,7 |
| | | 5 | III | 85 40 9·02 | 1·24 | 5·2389760,0 | | | 27 | VIII | 50 7 46·55 | ·95 | 5·0670219,8 |
| | | 12 | I | 67 48 13·31 | 1·01 | 5·1420242,4 | | | 31 | VII | 70 30 12·28 | ·83 | 5·0854617,1 |
| ,, | 14 | 10 | III | 40 3 30·36 | 1·00 | 4·9840572,9 | ,, | 18 | 33 | VIII | 56 7 18·80 | ·83 | 5·0303019,3 |
| | | 11 | IV | 72 8 16·33 | 1·01 | 5·1540069,9 | | | 32 | IX | 53 22 28·92 | ·82 | 5·0155803,8 |
| | | 16 | III | 48 47 58·21 | ·82 | 5·0197199,3 | | | 4 | XIII | 44 8 17·19 | ·64 | 5·0877129,6 |
| ,, | 15 | 18 | IV | 45 31 51·33 | ·81 | 4·9967381,4 | 2 | 19 | 5 | XXVI | 23 55 13·39 | ·63 | 4·8528156,1 |
| | | 17 | VI | 85 40 10·46 | ·82 | 5·1420242,4 | | | 6 | XXIII | 111 56 29·42 | ·64 | 5·2122049,6 |
| | | 19 | VI | 70 59 42·19 | ·75 | 5·0670219,8 | | | 7 | XIII | 40 39 56·16 | 1·26 | 5·0396587,0 |
| ,, | 16 | 21 | IV | 51 1 7·52 | ·74 | 4·9819825,3 | ,, | 20 | 5+α | XXVI | 63 31 2·32 | 1·26 | 5·1775054,5 |
| | | 20 | VII | 57 59 10·29 | ·75 | 5·0197199,3 | | | 8 | XXIV | 75 49 1·52 | 1·26 | 5·2122049,6 |

### *Final Figural Adjustments of the Non-Circuit Triangles.*

*Figure* 1.

Triangles 13 to 18.

Constants (from pages 19 and 20).

| | | | | | Contained Angles. | | | |
|---|---|---|---|---|---|---|---|---|
| LXI to I | Log feet | 5·2389710,4 | } | ... | 6+12 | ... | 107° 3′ 15″·29 |
| I ,, IV | ,, | 4·9840555,5 | } | ... | 11+18+21+26 | ... | 211 40 11 ·00 |
| IV ,, VIII | ,, | 5·1812916,9 | } | ... | 27+33 | ... | 106 15 8 ·27 |
| VIII ,, IX | ,, | 5·0854453,8 | } | | | | |

NOTES.—1. Station LXI appertains to the Calcutta Longitudinal Series.
2. Stations XXIII, XXIV and XXVI appertain to the East Coast Series.
3. The symbol α here denotes an angle of the East Coast Series, already fixed by the Simultaneous Reduction of the South-East Quadrilateral.

## South Parasnath Series.

*Final Figural Adjustments of the Non-Circuit Triangles.*

*Figure* 1—(Continued).

| Equations to be satisfied. | | |

## South Parasnath Series.

*Final Figural Adjustments of the Non-Circuit Triangles.*

*Figure* 1—(Continued).

| Values of the Factors | | | | Adopted Errors | | |
|---|---|---|---|---|---|---|
| $\lambda_1 = -0\cdot993$ | $\lambda_7 = +1\cdot942$ | $x_4 = +0''\cdot10$ | $x_{16} = +0''\cdot89$ | $x_{25} = +0''\cdot09$ | | |
| $\lambda_2 = -\cdot894$ | $\lambda_8 = +0\cdot993$ | $x_5 = -1\cdot07$ | $x_{17} = -1\cdot03$ | $x_{26} = +1\cdot23$ | | |
| $\lambda_3 = -\cdot852$ | $\lambda_9 = +\cdot277$ | $x_6 = +0\cdot97$ | $x_{18} = +0\cdot14$ | $x_{27} = -1\cdot32$ | | |
| $\lambda_4 = -\cdot136$ | $\lambda_{10} = +\cdot074$ | $x_{10} = -1\cdot47$ | $x_{19} = +0\cdot53$ | $x_{31} = -0\cdot02$ | | |
| $\lambda_5 = +\cdot031$ | $\lambda_{11} = +\cdot098$ | $x_{11} = -0\cdot34$ | $x_{20} = -1\cdot39$ | $x_{32} = -\cdot17$ | | |
| $\lambda_6 = -\cdot064$ | $\lambda_{12} = +\cdot010$ | $x_{13} = +1\cdot81$ | $x_{21} = +0\cdot86$ | $x_{33} = +\cdot19$ | | |

*Figure* 2.

Triangle 19.

Constants (from pages 21 and III—$_C$*).

| | | | Contained Angle. |
|---|---|---|---|
| XIII to XXVI | Log feet | 5·2121684,9 | ... 5 23° 55′ 12″·93 |
| XXVI „ XXIII | „ | 5·0876711,8 | |

| Equations to be satisfied. | | | Adopted Errors. | | |
|---|---|---|---|---|---|
| $x_4 + x_6$ | = | $-1\cdot09$ | $x_4$ | = | $+4''\cdot68$ |
| $22x_4 + 9x_6$ | = | $+53\cdot1$ | $x_6$ | = | $-5\cdot77$ |

*Figure* 2—(Continued).

Triangle 20.

Constants (from pages 21 and III—$_C$*).

| | | | Contained Angle. |
|---|---|---|---|
| XIII to XXVI | Log feet | 5·2121684,9 | ... 5+a 63° 31′ 2″·49 |
| XXVI „ XXIV | „ | 5·0396168,6 | |

| Equations to be satisfied. | | | Adopted Errors. | | |
|---|---|---|---|---|---|
| $x_7 + x_8$ | = | $-1\cdot09$ | $x_7$ | = | $+1''\cdot61$ |
| $25x_7 - 5x_9$ | = | $+53\cdot7$ | $x_8$ | = | $-2\cdot70$ |

* Volume VI of the *Account of the Operations, &c.*, East Coast Series.

## South Maluncha Series.

*Sides and Angles of the Non-Circuit Triangles.*

| Number of Figure | Number of Triangle | Figural No. of Angle | Number of Station | Corrected Plane Angle | Spherical Excess | Logarithm of Side-length in Feet | Number of Figure | Number of Triangle | Figural No. of Angle | Number of Station | Corrected Plane Angle | Spherical Excess | Logarithm of Side-length in Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ″ | | | | | | ° ′ ″ | ″ | |
| | | 3 | I | 37 2 4·57 | ·50 | 4·8388887,1 | | | 3 | III | 32 14 50·58 | ·33 | 4·7543195,1 |
| 1 | 15 | 4+5 | II | 89 5 4·91 | ·51 | 5·0590224,1 | 2 | 16 | 4+5 | IV | 102 55 20·03 | ·33 | 5·0159828,8 |
| | | 6 | IV | 53 52 50·52 | ·50 | 4·9663769,9 | | | 6 | VI | 44 49 49·39 | ·33 | 4·8753188,2 |

*Final Figural Adjustments of the Non-Circuit Triangles.*

*Figure* 1.

Triangle 15.

Constants (from page 48).

| | | | | | Contained Angle. |
|---|---|---|---|---|---|
| I to II | Log feet | 4·9663750,0 | } | ... | 4+5 ... 89° 5′ 4″·04 |
| II „ IV | „ | 4·8388883,7 | | | |

| Equations to be satisfied. | | Adopted Errors. | |
|---|---|---|---|
| $x_3 + x_6 = -1{\cdot}38$ | | $x_3 = -″{\cdot}87$ | |
| $28\,x_3 - 15\,x_6 = -16{\cdot}5$ | | $x_6 = -{\cdot}51$ | |

*Figure* 2.

Triangle 16.

Constants (from pages 48 and 49).

| | | | | | Contained Angle. |
|---|---|---|---|---|---|
| III to IV | Log feet | 4·8753155,9 | } | ... | 4+5 ... 102° 55′ 19″·23 |
| IV „ VI | „ | 4·7543172,3 | | | |

| Equations to be satisfied. | | Adopted Errors. | |
|---|---|---|---|
| $x_3 + x_6 = -1{\cdot}13$ | | $x_3 = -″{\cdot}61$ | |
| $33\,x_3 - 21\,x_6 = -9{\cdot}5$ | | $x_6 = -{\cdot}52$ | |

# PART II.

# THE DETAILS OF THE OBSERVATIONS

AND

# THE FINAL RESULTS

OF

# THE S. PARASNATH MERIDL. SERIES

AND

# THE S. MALUNCHA MERIDL. SERIES

OF

# THE SOUTH-EAST QUADRILATERAL.

# SOUTH PARASNATH MERIDIONAL SERIES.

## ALPHABETICAL LIST OF PRIMARY STATIONS.


Amjhori . . . . . XII.

Badampahár . . . . . X.

Báglmuri . . . . . VIII.

Bári . . . . . III.

Bhandári . . . . . VI.

Bolpál . . . . . XXVI.
(Of the East Coast Series).

Chainpur . . . . . LVIII.
(Of the Calcutta Longitudinal Series).

Dalma . . . . . IV.

Gorgáburu . . . . . I.

Kimhíra . . . . . XXIII.
(Of the East Coast Series).

Kusumbani . . . . . XI.

Ledásál . . . . . V.

Megásini (*Meghásani*) . . . . XXV.
(Of the East Coast Series).

Murári . . . . . XIII.

Nilgiri . . . . . XXIV.
(Of the East Coast Series).

Parása . . . . . II.

Sátbakra . . . . . IX.

Sideshar . . . . . VII.

Tilabani . . . . . LXI.
(Of the Calcutta Longitudinal Series).

# SOUTH PARASNATH MERIDIONAL SERIES.

## NUMERICAL LIST OF PRIMARY STATIONS.

| | |
|---|---|
| LVIII | Chainpur. (Of the Calcutta Longitudinal Series). |
| LXI | Tilabani. (Of the Calcutta Longitudinal Series). |
| I | Gorgáburu. |
| II | Parása. |
| III | Bári. |
| IV | Dalma. |
| V | Ledásál. |
| VI | Bhandári. |
| VII | Sideshar. |
| VIII | Bághmuri. |
| IX | Sátbakra. |
| X | Badampahár. |
| XI | Kusumbani. |
| XII | Amjhori. |
| XIII | Murári. |
| XXIII | Kimhíra. (Of the East Coast Series). |
| XXIV | Nilgiri. (Of the East Coast Series). |
| XXV | Megásini. (Of the East Coast Series). |
| XXVI | Bolpál. (Of the East Coast Series). |

# SOUTH PARASNATH MERIDIONAL SERIES.

## DESCRIPTION OF PRIMARY STATIONS.

No descriptions of the primary stations of this Series having been furnished by the Executive Officer, endeavours have been made to supply this deficiency by means of the approximate descriptions which follow; in these however the usual detailed information regarding the structure of the pillar and platform, and the number and position of mark-stones cannot be supplied; but as the stations are all situated on hills it may be assumed that they were marked by platforms with a mark-stone at the top and one or more mark-stones placed within the structure. In some cases the stations were subsequently visited by the Ganjam Topographical Survey Party, whose descriptions of the localities are accordingly hereafter adopted, supplemented where practicable by the bearings and distances of surrounding villages from the Ganjam Topographical Survey Maps, and a statement of the condition of the stations at the time of the last visit. For the rest of the stations, their descriptions with the bearings and distances of the surrounding villages have been obtained from the Map of Western Bengal Sheets Nos. 13 and 14, compiled in the Surveyor General's Office, Calcutta, respectively in March 1871 and October 1874. In general some of the details, such as the name of a village or pargana within which a station is situated, have been extracted from the returns furnished by the civil authorities to whose care the stations have been committed.

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LVIII.—(*Of the Calcutta Longitudinal Series*). Chainpur Hill Station, lat. 23° 33′, long. 85° 54′—observed at in 1829, 1834, 1836 and 1867—is on the northern extremity of an extensive range of densely wooded flat hills running north and south; pargana Palamow, district Lohardugga.

The pillar is solid and contains two marks, the upper 2·88 feet above the lower which is engraved on the rock *in situ*, having been placed there in 1829. The station was revisited in 1834 and 1836 for the purpose of originating the South Párasnáth Meridional Series, but no record exists of any alteration in its construction at those times. On again visiting the station in 1867 the upper mark-stone of 1829 appeared undisturbed, but it diverged 4 inches to the north. A new pillar was built to the same height as before. The village of Chainpur lies about 4 miles N. E., that of Pitarbár about 2·5 miles N., and Kharkata about 1 mile N.

LXI.—(*Of the Calcutta Longitudinal Series*). Tilabani Hill Station, lat. 23° 25′, long. 86° 36′—observed at in 1829, 1834, 1836, 1837, 1845, 1846 and 1867—is on the eastern and higher of two isolated

peaks, about 1 mile N. W. of the village from which it derives its name; pargana Ludurka, district Manbhoom.

The pillar is solid and contains two marks, the upper 2·00 feet above the lower which is engraved on the rock *in situ*, having been placed there in 1829. The station was revisited in 1834, 1836 and 1837 for the purpose of originating the South Párasnáth Meridional Series, and in 1845 and 1846 for the purpose of originating the South Malúncha Meridional Series, but no record exists of any alteration in its construction at those times. On again visiting the station in 1867 the upper mark-stone of 1829 appeared undisturbed, and its height was adopted for the new station. The village of Kolabani lies about 1·5 miles S.E.

I. Gorgáburu Hill Station, lat. 23° 9′, long. 86° 10′—observed at in 1832, 1834, 1836 and 1837—is near the southern extremity of a range of hills which terminates near Mátha; pargana Mátha, district Manbhoom.

The bearings and estimated distances of the surrounding villages are as follows:—Mátha S. W., 3½ miles; Gherua S. E., 3½ miles; Ajudhia N., 4 miles.

II. Parása Hill Station, lat. 23° 7′, long. 86° 43′—observed at in 1836 and 1837—is on a detached hill to the E. of Kasai river; pargana Baráhabhum, district Manbhoom.

The bearings and estimated distances of the surrounding villages are as follows:—Mánbazar S. by W., 4 miles; Dhanaranghi E., 3½ miles; Poncha N. by W., 3½ miles.

III. Bári Hill Station, lat. 23° 7′, long. 86° 36′—observed at in 1836—is situated to the W. of the road from Purulia to Mánbazar; pargana Baráhabhum, district Manbhoom.

The bearings and estimated distances of the surrounding villages are as follows:—Mutulia E. by N., 1½ miles; Maragara N.W., 2 miles; Kadma S.W., 4 miles; Mánbazar S.E., 7 miles.

IV. Dalma Hill Station, lat. 22° 53′, long. 86° 16′—observed at in 1834 and 1837—is on a hill about 5 miles N. of Subarnrekha river; pargana Baráhabhum, district Manbhoom.

The bearings and estimated distances of the surrounding villages are as follows:—Rámgarh W. by S., 4 miles; Gondua S.E., 4 miles; Amjhor N. by W., 5 miles.

V. Ledásál Hill Station, lat. 22° 41′, long. 86° 31′—observed at in 1837—is on the broadest and highest part of a small range of hills running north and south; pargana Dhalbhum, district Singhbhoom.

This station was visited by the Ganjam Topographical Survey Party in the field season of 1858-59. The bearings and distances of the surrounding villages are as follows:—Rajabas W., 1½ miles; Borbil and Jorsa W., 2½ miles; Tikri S.E., 1½ miles; Kalajhori S.W., 2 miles.

VI. Bhandári Hill Station, lat. 22° 51′, long. 86° 34′—observed at in 1834 and 1837—is on a hill to the W. of the road from Purulia *viá* Baráhabhum to Phulkusama; pargana Baráhabhum, district Manbhoom.

The bearings and estimated distances of the surrounding villages are as follows:—Chunagura N.W., 1½ miles; Ghagra S.E., 3 miles; Sinradíh N.E., 6 miles.

VII. Sideshar Hill Station, lat. 22° 37′, long. 86° 26′—observed at in 1834 and 1837—is on a detached peak about 3 miles S. of the large village of Mahilia; pargana Dhalbhum, district Singhbhoom.

This station was visited by the Ganjam Topographical Survey Party in the field season of 1858-59 when the platform with its mark-stone was found undisturbed. The bearings and approximate distances of the surrounding villages are as follows:—Kendadíh S.E., 2 miles; Nitára W., 1 mile; Ghátsila on E. bank of the Subarnrekha river, S.E., 6½ miles.

VIII. Bághmuri Hill Station, lat. 22° 29′, long. 86° 9′—observed at in 1837—is on range of hills forming the boundary between the Singhbhoom district and the Mayurbhanja estate; pargana Dhalbhum, district Singhbhoom. The hill is approached from Barapalsa village situated about 3 miles to the south.

This station was visited by the Ganjam Topographical Survey Party in the field season of 1859-60 when the mark-stone was found undisturbed. The bearings and approximate distances of the surrounding villages are as follows:—Raghunáthpur N.W., 1½ miles; Siling N.E., 3½ miles; Kadam S.E., 3½ miles.

IX. Sátbakra Hill Station, lat. 22° 19′, long. 86° 28′—observed at in 1837 and 1838—is on the highest of a number of peaks rising out of two ranges of hills running nearly at right angles to each other, and is situated

near the boundary between the Singhbhoom district and the Mayurbhanja estate; pargana Dhalbhum, district Singhbhoom.

This station was visited by the Ganjam Topographical Survey Party in the field season of 1858-59 when the platform with its mark-stone was found undisturbed. The bearings and approximate distances of the surrounding villages are as follows:—Pitamohuli N., 2½ miles; Thidau S.E., 4 miles; Sano Bata S.W., 4½ miles.

X. Badampahár Hill Station, lat. 22° 4′, long. 86° 10′— observed at in 1838 and 1839—is on a range of hills running N.E. and S.W; pargana Kainsari of the Mayurbhanja estate. The high road from Midnapore to Sambalpur winds round the south-eastern side of the range, but the most easy approach to the hill is from Aharband village to the north about 4 miles in a direct distance.

This station was visited by the Ganjam Topographical Survey Party in the field season of 1859-60 when the upper mark-stone was found undisturbed. The bearings and approximate distances of the surrounding villages are as follows:—Govindapur N.W., 4 miles; Jamkasar S.W., 5 miles; Noagaon E. by S., 4½ miles.

XI. Kusumbani Hill Station, lat. 21° 57′, long. 86° 28′—observed at in 1838 and 1839—is on the N.W. extremity of the Meghásur hills in the Mayurbhanja estate. The village of Kusumbani is right out in the plains on the north side and the road from it goes through a pass to Bámankundi Ghát, from whence there is an easy road of about 7 miles to the summit.

This station was visited by the Ganjam Topographical Survey Party in the field season of 1858-59 when the platform with the centre mark-stone was found undisturbed. The bearings and approximate distances of the surrounding places are as follows:—Bamangaon N.W., 7 miles; Budhabalanga river W., 2 miles; Simlipahár S. by E., 8 miles.

XII. Amjhori Hill Station, lat. 21° 51′, long. 86° 22′—observed at in 1839—is on a ridge lying between the two confluents of the Puljera nadi, in the Mayurbhanja estate.

The bearings and approximate distances of the surrounding villages are as follows:—Simlipahár E., 4 miles; Amjhori W. by N., 4 miles; Baro Kasaria and Sano Kasaria nearly the same distance W. by S.

XIII. Murári Hill Station, lat. 21° 49′, long. 86° 33′—observed at in 1839—is on the Meghásur range of hills, about 10 miles W. by N. of the village of Murári; pargana Khunta Karkachia of the Mayurbhanja estate. The hill is ascended from Gobai Ghát which is directly below it on the eastern side.

This station was visited by the Ganjam Topographical Survey Party in the field season of 1858-59 when the platform with the station mark was found undisturbed. Satputia village lies at about 7 miles E. by S.

XXIII.—(*Of the East Coast Series*). Kimhíra Hill Station, lat. 21° 40′, long. 86° 41′—observed at in 1839, 1853 and 1854—is on a low detached rocky hill in an excessively wild and jungly tract, and takes its name from a remarkable rock at the top of the hill having the shape of an alligator; pargana Khunta Karkachia of the Mayurbhanja estate.

The station is marked on the rock *in sitú* and a platform has been built around it. The azimuths and perambulated distances of the circumjacent villages are:—Gúdia 133° 43′, miles 1·277 and Bálijora 154° 52′, miles 1·454.

XXIV.—(*Of the East Coast Series*). Nilgiri Hill Station, lat. 21° 28′, long. 86° 49′—observed at in 1838, 1853 and 1854—is on a well known hill about 11 miles west of Balasore, immediately at the southern foot of which lies the town of Nilgiri; pargana Nilgiri of the Nilgiri estate.

The pillar is solid and contains two marks, the upper 2·02 feet above the lower which is engraved on the rock *in sitú*.

XXV.—(*Of the East Coast Series*). Meghásani Hill Station, lat. 21° 38′, long. 86° 23′—observed at in 1839 and 1854—is on a lofty range of mountains of that name, clad with gigantic primeval forest in which the mango and jack abound; pargana Podadia of the Mayurbhanja estate. The station is approached from the village of Podadia lying at the eastern foot of the hill and about 8 miles from the station.

The station is marked on the rock *in sitú* and a platform has been built around it. Patámundái Rock is S.E. by E., about 6·4 miles.

XXVI.—(*Of the East Coast Series*). Bolpál or Barpál Hill Station, lat. 21° 22′, long. 86° 30′—observed at in 1838 and 1854—is approached from the village of Jugjuri which lies about 1½ miles east; pargana Nilgiri of the Nilgiri estate.

The station is marked on the rock *in situ*.

*October* 1878.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

# SOUTH PARASNATH MERIDIONAL SERIES.

## PRIMARY TRIANGULATION—OBSERVED ANGLES.

### At LVIII (Chainpur)

*December* 1836; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| LXI & I | 20·17 2 | 15·50 2 | 16·67 2 | 23·33 2 | 10·17 2 | 19·50 2 | 18·00 2 | 28·83 2 | 17·50 2 | 25·33 2 | 15·33 2 | 26·17 2 | 46° 16′ 19″·71 |

### At LXI (Tilabani)

*January* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| II & R.M. | 14·67 2 | 8·17 2 | 6·17 2 | 5·50 2 | 7·50 2 | 7·83 2 | 9·00 2 | 6·33 2 | 7·00 2 | 13·33 2 | 6·50 2 | 8·00 2 | 106° 49′ 8″·33 |
| III & I | 50·50 2 | 45·17 2 | 49·17 2 | 42·33 2 | 58·17 2 | 49·83 2 | 50·67 2 | 47·50 2 | 47·17 2 | 56·17 2 | 46·67 2 | 52·67 2 | 55° 4′ 49″·67 |
| I & R.M. | 31·00 2 | 35·33 2 | 30·83 2 | 38·00 2 | 32·83 2 | 37·17 2 | 41·33 2 | 39·67 2 | 39·17 2 | 37·00 2 | 33·00 2 | 37·50 2 | 30° 45′ 36″·07 |

NOTE.—Stations LVIII and LXI appertain to the Calcutta Longitudinal Series. R. M. denotes Referring Mark.

## At LXI (Tilabani)—(*Continued*).

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| R.M. & LVIII | 43·83 3 | 49·50 2 | 45·33 2 | 45·83 2 | 47·50 2 | 46·33 2 | 46·00 2 | 45·67 3 | 42·17 2 | 38·83 2 | 43·83 2 | 36·84 2 | 16° 33′ 44″·31 |

## At I (Gorgáburu)

*January and February* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| LVIII & R.M. | 75·50 3 | 70·83 2 | 63·33 3 | 64·50 2 | 76·33 2 | 59·83 2 | 72·17 2 | 67·00 2 | 76·00 2 | 74·33 2 | 67·17 2 | 58·50 2 | 123° 32′ 68″·79 |
| LXI & R.M. | 55·83 2 | 43·83 2 | 32·83 3 | 35·17 2 | 52·17 2 | 43·67 2 | 35·17 2 | 33·17 2 | 51·00 2 | 54·50 2 | 35·67 2 | 33·17 2 | 37° 8′ 42″·18 |
| R.M. & II | 20·67 2 | 29·83 2 | 20·67 2 | 31·17 2 | 19·00 2 | 32·33 2 | 22·17 2 | 28·50 2 | 15·67 2 | 30·50 2 | 22·83 2 | 33·83 2 | 0° 23′ 25″·60 |
| R.M. & III | 11·33 3 | 16·33 3 | 23·17 3 | 30·83 3 | 10·50 3 | 19·67 3 | 24·50 2 | 29·50 3 | 8·83 3 | 24·67 2 | 20·50 2 | 27·17 2 | 2° 6′ 20″·58 |
| R.M. & IV | 18·00 2 | 30·83 2 | 47·50 2 | 55·50 2 | 20·00 2 | 30·50 2 | 45·17 2 | 41·17 2 | 33·50 2 | 39·50 3 | 37·33 2 | 37·17 2 | 69° 54′ 36″·35 |

## At II (Parása)

*March* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| V & VI | 23·33 2 | 22·00 3 | 31·50 2 | 23·00 2 | 17·50 3 | 21·33 3 | 19·00 2 | 28·50 3 | 20·50 2 | 25·50 3 | 25·67 2 | 28·33 2 | 3° 8′ 23″·85 |
| VI & IV | 11·83 3 | 7·00 3 | 9·50 2 | 3·00 2 | 11·33 2 | 9·50 3 | 9·17 2 | 15·50 2 | 10·17 2 | 12·33 2 | 11·67 2 | 10·67 2 | 34° 55′ 10″·14 |
| VI & I | 25·67 2 | 18·67 2 | 23·67 3 | 17·17 3 | 18·83 2 | 10·50 2 | 18·50 2 | 19·67 2 | 19·50 3 | 24·00 3 | 18·16 3 | 22·83 3 | 65° 59′ 19″·76 |
| VI & LXI | 47·83 3 | 54·00 3 | 45·00 3 | 44·50 2 | 57·83 3 | 46·67 2 | 52·83 3 | 42·00 2 | 48·33 2 | 45·17 2 | 48·50 2 | 41·67 2 | 132° 23′ 47″·86 |

NOTE.—Stations LVIII and LXI appertain to the Calcutta Longitudinal Series. R. M. denotes Referring Mark.

## At III (Bári)

*April* 1836; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 220° | 40° | 230° | 50° | 240° | 60° | 250° | 70° | 260° | 80° | 270° | 90° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| VI & R.M. | 54·83 | 65·00 | 48·83 | 64·50 | 55·00 | 63·67 | 51·00 | 57·33 | 61·83 | 59·50 | 57·50 | 55·00 | 85° 3′ 57″·83 |
| IV & R.M. | 51·67 | 59·67 | 54·50 | 64·50 | 49·67 | 56·67 | 54·50 | 56·17 | 48·17 | 57·00 | 55·83 | 57·33 | 36° 15′ 55″·47 |
| R.M. & I | 42·67 | 26·00 | 33·33 | 30·00 | 30·67 | 34·33 | 38·00 | 39·00 | 35·50 | 28·83 | 35·84 | 42·17 | 3° 47′ 34″·70 |
| R.M. & LXI | 45·83 | 39·00 | 50·17 | 39·33 | 42·50 | 45·00 | 43·83 | 47·50 | 41·83 | 44·83 | 40·50 | 48·00 | 89° 27′ 44″·03 |

## At IV (Dalma)

*February* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| R.M. & I | 5·67 | 17·00 | 22·67 | 21·17 | 11·00 | 4·17 | 19·83 | 9·50 | 14·17 | 8·50 | 22·17 | 9·00 | 61° 9′ 13″·74 |
| R.M. & III | 18·33 | 25·50 | 39·83 | 41·33 | 16·00 | 29·50 | 33·50 | 41·83 | 21·67 | 26·33 | 36·83 | 34·00 | 133° 17′ 30″·39 |
| R.M. & II | 49·83 | 59·17 | 69·00 | 74·83 | 50·00 | 54·83 | 64·50 | 67·33 | 51·33 | 51·67 | 69·67 | 57·83 | 140° 33′ 60″·00 |
| R.M. & VI | 11·50 | 16·83 | 33·00 | 26·50 | 11·17 | 14·83 | 33·50 | 27·50 | 22·00 | 16·17 | 34·67 | 24·83 | 178° 49′ 22″·71 |
| VI & V | 41·83 | 34·83 | 36·50 | 36·33 | 39·50 | 35·67 | 36·17 | 35·50 | 30·50 | 41·00 | 30·50 | 34·00 | 31° 5′ 36″·03 |
| VII & R.M. | 38·50 | 31·67 | 19·83 | 20·83 | 33·17 | 25·83 | 22·67 | 22·50 | 37·33 | 25·83 | 20·00 | 21·00 | 130° 9′ 26″·60 |
| VIII & R.M. | 40·33 | 25·17 | 25·83 | 20·50 | 41·17 | 31·00 | 30·83 | 26·33 | 36·83 | 42·67 | 32·00 | 32·00 | 87° 10′ 32″·06 |

## At V (Ledásál)

*March and April* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IX & VI | 47·50 | 35·33 | 44·17 | 41·83 | 38·67 | 55·33 | 39·33 | 43·00 | 41·00 | 45·83 | 37·50 | 51·67 | 190° 31′ 43″·43 |

NOTE.—Station LXI appertains to the Calcutta Longitudinal Series. R.M. denotes Referring Mark.

## At V (Ledásál)—(*Continued*).

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| VIII & VI | 50.33 | 53.67 | 44.33 | 51.83 | 55.00 | 57.17 | 46.67 | 55.83 | 53.67 | 57.83 | 48.33 | 52.00 | 138° 32′ 52″·22 |
| IV & VI | 54.33 | 49.50 | 53.50 | 52.00 | 56.33 | 56.33 | 52.17 | 55.33 | 59.83 | 61.67 | 50.17 | 60.67 | 66° 32′ 55″·15 |
| VI & II | 33.50 | 31.00 | 31.33 | 36.17 | 37.17 | 35.00 | 39.33 | 33.00 | 34.33 | 34.00 | 29.67 | 29.00 | 6° 2′ 33″·63 |

## At VI (Bhandári)

*March* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| VII & IV | 46.67 | 45.33 | 48.17 | 44.17 | 46.33 | 39.67 | 46.17 | 47.33 | 43.67 | 52.83 | 49.83 | 54.50 | 70° 59′ 47″·06 |
| IV & III | 8.33 | 11.00 | 5.67 | 11.83 | 17.83 | 12.67 | 15.50 | 12.83 | 14.33 | 11.33 | 17.17 | 7.50 | 85° 40′ 12″·17 |

## At VII (Sideshar)

*April* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IX & VIII | 75.17 | 66.67 | 77.33 | 66.17 | 69.17 | 51.50 | 75.17 | 61.33 | 80.00 | 60.67 | 73.33 | 73.67 | 70° 29′ 69″·18 |
| VIII & IV | 18.67 | 21.50 | 15.50 | 16.17 | 19.17 | 20.00 | 18.33 | 21.67 | 21.33 | 22.67 | 25.67 | 19.33 | 86° 53′ 20″·00 |
| IV & VI | 18.33 | 9.33 | 18.50 | 15.33 | 15.83 | 11.83 | 7.50 | 13.50 | 9.67 | 12.00 | 4.50 | 16.33 | 57° 59′ 12″·72 |

## At VIII (Báglmuri)

*April* 1837; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IV & Dhoba H.M. | 39.17 | 41.50 | 27.83 | 30.83 | 40.17 | 37.50 | 35.67 | 34.17 | 38.67 | 34.67 | 29.50 | 31.50 | 5° 5′ 35″·10 |

NOTE.—H. M. denotes Hill Mark.

## At VIII (Bághmuri)—(*Continued*).

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IV & V | 41·17 | 43·50 | 28·17 | 36·00 | 32·00 | 33·50 | 34·50 | 33·33 | 33·83 | 31·83 | 40·50 | 32·50 | 45° 5′ 35″·07 |
| IV & VII | 48·00 | 55·83 | 45·17 | 48·83 | 46·50 | 45·50 | 46·33 | 49·67 | 52·67 | 39·83 | 51·83 | 39·83 | 50° 7′ 47″·50 |
| Dhoba H.M. & IX | 32·67 | 30·67 | 35·00 | 30·17 | 30·83 | 24·66 | 32·50 | 26·33 | 29·83 | 29·83 | 32·66 | 28·50 | 101° 9′ 30″·30 |
| Dhoba H.M. & X | 57·00 | 54·33 | 51·33 | 58·67 | 47·00 | 53·83 | 53·17 | 45·17 | 51·66 | 43·00 | 54·16 | 52·33 | 160° 31′ 51″·80 |

## At IX (Sátbakra)

**May* 1837 *and* †*February* 1838; *observed by Lieutenant A. H. E. Boileau with Cary's* 18*-inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| †XI & R.M. | 53·67 | 53·50 | 56·50 | 60·83 | 54·00 | 60·17 | 61·00 | 66·00 | 62·00 | 60·83 | 61·17 | 58·33 | 16° 10′ 59″·00 |
| †R. M. & X | 52·83 | 70·00 | 53·83 | 65·67 | 55·83 | 71·33 | 61·83 | 63·50 | 58·50 | 56·50 | 58·17 | 67·33 | 33° 21′ 61″·28 |
| *R. M. & VIII | 28·17 | 30·83 | 37·50 | 32·50 | 39·17 | 35·17 | 36·33 | 33·67 | 35·00 | 35·67 | 23·33 | 20·83 | 104° 8′ 32″·35 |
| *VIII & VII | 31·00 | 32·50 | 21·50 | 25·50 | 22·00 | 21·83 | 19·83 | 19·33 | 25·00 | 16·50 | 35·33 | 32·83 | 53° 22′ 25″·26 |
| *VIII & V | 47·33 | 52·33 | 36·50 | 47·33 | 36·17 | 35·67 | 41·33 | 41·83 | 50·83 | 36·00 | 45·67 | 48·50 | 66° 51′ 43″·29 |

## At X (Badampahár)

*February* 1838; *observed by Lieutenant A. H. E. Boileau with Cary's* 18*-inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| VIII & R.M. | 44·17 | 49·17 | 49·33 | 46·67 | 50·67 | 46·67 | 53·17 | 50·33 | 52·33 | 45·83 | 58·83 | 41·33 | 90° 16′ 49″·04 |
| IX & R.M. | 39·17 | 33·67 | 34·33 | 32·83 | 51·17 | 31·17 | 40·83 | 31·00 | 45·00 | 33·67 | 46·00 | 32·50 | 40° 25′ 37″·61 |

NOTE.—H. M. denotes Hill Mark. R. M. denotes Referring Mark.

## At X (Badampahár)—*(Continued).*

**February* 1838; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*
†*May* 1839; *observed by Mr. N. Kallonas with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| R.M.* & XI | 15·17 | 15·33 | 16·17 | 17·17 | 13·83 | 22·00 | 13·50 | 22·17 | 9·83 | 17·33 | 7·33 | 27·83 | 21° 47′ 16″·47 |
| Tree† & XI | 21·50 | 26·17 | 25·00 | 27·33 | 19·50 | 25·50 | 22·67 | 24·83 | 17·83 | 26·33 | 13·83 | 33·83 | 21° 47′ 23″·69 |
| Tree† & XII | 23·50 | 28·50 | 21·50 | 32·00 | 14·50 | 26·33 | 12·67 | 25·67 | 12·00 | 30·00 | 14·17 | 25·33 | 49° 29′ 22″·18 |

## At XI (Kusumbani)

‡*March* 1838; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*
§*May* 1839; *observed by Mr. N. Kallonas with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| §XIII & XII | 10·83 | 16·83 | 6·33 | 14·83 | 13·00 | 19·33 | 14·17 | 15·00 | 18·67 | 12·00 | 17·84 | 9·83 | 73° 47′ 14″·06 |
| §XII & X | 57·17 | 51·67 | 62·50 | 56·33 | 57·17 | 51·83 | 53·67 | 49·83 | 57·00 | 57·00 | 55·50 | 58·00 | 65° 33′ 55″·64 |
| ‡R.M. & X | 26·83 | 32·17 | 29·17 | 35·33 | 23·83 | 27·33 | 28·00 | 28·00 | 27·83 | 29·33 | 28·00 | 28·83 | 86° 14′ 28″·72 |
| ‡R.M. & IX | 48·83 | 48·33 | 49·33 | 48·50 | 47·00 | 49·83 | 53·17 | 42·50 | 44·66 | 43·50 | 44·16 | 39·66 | 154° 28′ 46″·62 |

## At XII (Amjhori)

*April and May* 1839; *observed by Mr. N. Kallonas with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| Dolki H.M. & X | 28·00 | 23·83 | 27·83 | 28·83 | 28·67 | 27·50 | 21·17 | 31·83 | 26·17 | 25·50 | 26·00 | 21·67 | 80° 56′ 26″·42 |
| Dolki H.M. & XI | 33·83 | 28·67 | 31·17 | 30·17 | 27·50 | 28·17 | 23·67 | 30·33 | 25·00 | 31·33 | 27·33 | 38·00 | 167° 40′ 29″·60 |
| Dolki H.M. & XIII | 66·17 | 64·00 | 61·83 | 64·17 | 61·50 | 60·83 | 57·83 | 57·33 | 60·00 | 62·50 | 62·67 | 61·00 | 225° 35′ 61″·65 |
| Dolki H.M. & XXV | 6·83 | 10·00 | 9·00 | 10·00 | 8·17 | 5·50 | 2·17 | 11·00 | 3·17 | 8·17 | 1·17 | 14·00 | 295° 19′ 7″·43 |

NOTE.—Station XXV appertains to the East Coast Series. R. M. denotes Referring Mark. H. M. denotes Hill Mark.

## At XIII (Murári)

*February and March* 1839; *observed by Mr. N. Kallonas with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XXIII & Rock | 9.17 | 14.50 | 6.67 | 17.33 | 11.33 | 15.67 | 13.67 | 9.33 | 15.67 | 13.50 | 16.33 | 15.83 | 49° 52′ 13″·25 |
| XXIV & Rock | 51.00 | 44.83 | 49.83 | 47.50 | 55.17 | 49.50 | 61.50 | 47.50 | 61.67 | 53.00 | 62.17 | 51.83 | 46° 23′ 52″·96 |
| XXVI & Rock | 54.17 | 48.67 | 59.33 | 54.83 | 53.50 | 57.17 | 55.17 | 54.67 | 57.83 | 58.33 | 58.83 | 52.83 | 5° 43′ 55″·44 |
| Rock & XXV | 39.17 | 45.50 | 39.33 | 51.00 | 42.00 | 43.17 | 34.50 | 41.83 | 34.67 | 45.67 | 32.17 | 43.50 | 28° 45′ 41″·04 |
| Rock & XII | 67.33 | 74.50 | 67.50 | 76.83 | 58.50 | 74.33 | 62.50 | 75.17 | 64.17 | 73.17 | 62.50 | 76.17 | 92° 6′ 69″·39 |
| Rock & XI | 26.00 | 33.00 | 30.83 | 30.83 | 29.00 | 35.00 | 23.50 | 25.83 | 21.00 | 33.17 | 16.33 | 35.67 | 140° 24′ 28″·35 |

## At XXIII (Kimhíra)

*February* 1839; *observed by Mr. N. Kallonas with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XXIV & XXVI | 27.50 | 17.33 | 26.67 | 21.83 | 26.83 | 23.00 | 26.50 | 30.84 | 23.33 | 26.50 | 11.67 | 25.34 | 61° 28′ 23″·95 |
| XXIV & XIII | 50.00 | 50.50 | 48.50 | 49.83 | 56.17 | 53.83 | 48.50 | 58.67 | 42.67 | 54.67 | 41.17 | 59.17 | 173° 24′ 51″·14 |

## At XXIV (Nilgiri)

*December* 1838; *observed by Lieutenant A. H. E. Boileau with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 180° | 0° | 190° | 10° | 200° | 20° | 210° | 30° | 220° | 40° | 230° | 50° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XXVI & R.M. | 52.33 | 31.17 | 53.33 | 31.17 | 43.50 | 35.33 | 52.17 | 33.00 | 52.00 | 38.50 | 47.83 | 32.67 | 132° 17′ 41″·92 |
| XIII & R.M. | 38.84 | 25.00 | 39.00 | 21.33 | 39.00 | 16.50 | 55.17 | 23.00 | 52.00 | 24.50 | 46.50 | 24.34 | 56° 28′ 33″·77 |

NOTE.—Stations XXIII, XXIV, XXV and XXVI appertain to the East Coast Series. R.M. denotes Referring Mark.

## At XXV (Megásini)

**January* 1839; †*March and April* 1839; *observed by Mr. N. Kallonas with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| † XII & R. M. | " 77·17 2 | " 56·17 2 | " 80·00 2 | " 63·67 2 | " 76·33 2 | " 64·17 2 | " 72·67 2 | " 61·50 2 | " 75·33 2 | " 57·50 2 | " 80·17 2 | " 60·00 2 | 119° 25′ 68″·72 |
| † XIII & R. M. | 41·00 2 | 33·00 2 | 43·00 2 | 35·00 2 | 42·00 2 | 30·33 2 | 50·17 2 | 30·67 2 | 44·17 2 | 28·17 2 | 50·67 2 | 28·67 2 | 72° 30′ 38″·07 |
| * XXIV & R. M. | 26·50 2 | 8·83 2 | 22·33 2 | 11·17 2 | 25·83 2 | 15·00 2 | 22·83 2 | 9·17 2 | 24·50 2 | 11·00 2 | 22·83 2 | 12·17 2 | 0° 42′ 17″·68 |

## At XXVI (Bolpál)

*December* 1838; *observed by *Lieutenant A. H. E. Boileau and †Mr. N. Kallonas with Cary's* 18-*inch Theodolite, G.*

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| * XXV & R. M. | " 70·67 2 | " 49·83 2 | " 57·17 2 | " 38·33 2 | " 62·00 2 | " 39·00 2 | " 55·17 2 | " 39·34 2 | " 81·50 2 | " 56·67 2 | " 82·17 2 | " 59·17 2 | 114° 27′ 57″·59 |
| † XIII & R. M. | 32·83 2 | 19·33 2 | 32·17 2 | 12·83 2 | 31·17 2 | 18·83 2 | 32·00 2 | 18·00 2 | 31·67 2 | 15·50 2 | 33·67 2 | 16·33 2 | 86° 25′ 24″·53 |
| † XXIII & R. M. | 68·33 2 | 67·33 2 | 71·17 2 | 57·17 2 | 73·83 2 | 62·50 2 | 69·33 2 | 59·83 2 | 75·00 2 | 63·33 2 | 75·00 2 | 62·33 2 | 62° 29′ 67″·10 |

NOTE.—Stations XXIII, XXIV, XXV and XXVI appertain to the East Coast Series. R. M. denotes Referring Mark.

*November* 1878.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

# SOUTH PARASNATH MERIDIONAL SERIES.

## PRIMARY TRIANGULATION. REDUCTION OF FIGURES.

*Figure No.* 1.

Observed Angles†

| No. | Value | No. | Value | No. | Value |
|---|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | | ° ′ ″ |
| 1 | 76 3 32·26 | 12 | 67 48 15·76 | 23 | 45 5 35·07 |
| 2 | 66 24 28·10 | 13 | 38 3 33·99 | 24 | 62 54 29·21 |
| 3 | 37 32 7·78 | 14 | 72 35 28·78 | 25 | 86 53 20·00 |
| 4 | 55 4 49·67 | 15 | 69 20 58·74 | 26 | 42 58 54·54 |
| 5 | 85 40 9·33 | 16 | 48 48 2·36 | 27 | 50 7 47·50 |
| 6 | 39 15 2·76 | 17 | 85 40 12·17 | 28 | 51 58 51·21 |
| 7 | 31 4 9·63 | 18 | 45 31 52·32 | 29 | 66 51 43·29 |
| 8 | 79 24 46·26 | 19 | 70 59 47·06 | 30 | 61 9 30·33 |
| 9 | 69 31 10·75 | 20 | 57 59 12·72 | 31 | 70 30 9·18 |
| 10 | 40 3 30·17 | 21 | 51 1 10·69 | 32 | 53 22 25·26 |
| 11 | 72 8 16·65 | 22 | 71 59 57·07 | 33 | 56 7 17·90 |

Equations to be satisfied

| | | | | | | | | | Factor |
|---|---|---|---|---|---|---|---|---|---|
| $x_1$ | $+x_2$ | $+x_3$ | ... | ... | ... | ... | ... | $= e_1 = +\ 3{\cdot}55,$ | $\lambda_1$ |
| $x_4$ | $+x_5$ | $+x_6$ | ... | ... | ... | ... | ... | $= e_2 = -\ 1{\cdot}94,$ | $\lambda_2$ |
| $x_7$ | $+x_8$ | $+x_9$ | ... | ... | ... | ... | ... | $= e_3 = +\ 2{\cdot}72,$ | $\lambda_3$ |
| $x_{10}$ | $+x_{11}$ | $+x_{12}$ | ... | ... | ... | ... | ... | $= e_4 = -\ 0{\cdot}44,$ | $\lambda_4$ |
| $x_{13}$ | $+x_{14}$ | $+x_{15}$ | ... | ... | ... | ... | ... | $= e_5 = -\ 2{\cdot}87,$ | $\lambda_5$ |
| $x_{16}$ | $+x_{17}$ | $+x_{18}$ | ... | ... | ... | ... | ... | $= e_6 = +\ 4{\cdot}40,$ | $\lambda_6$ |
| $x_{19}$ | $+x_{20}$ | $+x_{21}$ | ... | ... | ... | ... | ... | $= e_7 = +\ 8{\cdot}23,$ | $\lambda_7$ |
| $x_{22}$ | $+x_{23}$ | $+x_{24}$ | ... | ... | ... | ... | ... | $= e_8 = -\ 2{\cdot}27,$ | $\lambda_8$ |
| $x_{25}$ | $+x_{26}$ | $+x_{27}$ | ... | ... | ... | ... | ... | $= e_9 = -\ 0{\cdot}82,$ | $\lambda_9$ |
| $x_{28}$ | $+x_{29}$ | $+x_{30}$ | ... | ... | ... | ... | ... | $= e_{10} = +\ 1{\cdot}24,$ | $\lambda_{10}$ |
| $x_{31}$ | $+x_{32}$ | $+x_{33}$ | ... | ... | ... | ... | ... | $= e_{11} = -\ 10{\cdot}14,$ | $\lambda_{11}$ |
| $x_3$ | $-x_6$ | $+x_9$ | $-x_{12}$ | ... | ... | ... | ... | $= e_{12} = +\ 0{\cdot}01,$ | $\lambda_{12}$ |
| $x_6$ | $-x_{11}$ | $+x_{15}$ | $-x_{18}$ | $-x_{21}$ | $+x_{24}$ | $-x_{26}$ | ... | $= e_{13} = +\ 0{\cdot}01,$ | $\lambda_{13}$ |
| $x_{25}$ | $-x_{27}$ | $+x_{30}$ | $-x_{33}$ | ... | ... | ... | ... | $= e_{14} =\ 0{\cdot}00,$ | $\lambda_{14}$ |
| $+5x_1$ | $-9x_2$ | $+2x_5$ | $-15x_6$ | ... | ... | ... | ... | $= e_{15} = +\ 94,$ | $\lambda_{15}$ |
| $+35x_7$ | $-4x_8$ | $+7x_{11}$ | $-25x_{10}$ | | | | | | |
| $+8x_9$ | $-35x_7$ | $+25x_{10}$ | $-9x_{12}$ | $+27x_{13}$ | $-6x_{14}$ | $+x_{17}$ | ... | $= e_{16} = -302,$ | $\lambda_{16}$ |
| $-19x_{16}$ | $+13x_{20}$ | $-7x_{19}$ | $+7x_{22}$ | $-21x_{23}$ | $+17x_{27}$ | $-x_{25}$ | | | |
| $+11x_{24}$ | $-7x_{29}$ | $+x_{25}$ | $-23x_{26}$ | ... | ... | ... | ... | $= e_{17} = -\ 17,$ | $\lambda_{17}$ |
| $+16x_{28}$ | $-9x_{29}$ | $+16x_{32}$ | $-8x_{31}$ | | | | | | |

† These are treated hereafter with *equal* weights.

*Figure No.* 1—(Continued).

Equations between the factors

| No. of e | Value of e | Co-efficients of $\lambda_1$ | $\lambda_2$ | $\lambda_3$ | $\lambda_4$ | $\lambda_5$ | $\lambda_6$ | $\lambda_7$ | $\lambda_8$ | $\lambda_9$ | $\lambda_{10}$ | $\lambda_{11}$ | $\lambda_{12}$ | $\lambda_{13}$ | $\lambda_{14}$ | $\lambda_{15}$ | $\lambda_{16}$ | $\lambda_{17}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | + 3·55 | + 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | + 1 | ... | ... | − 4 | ... | ... |
| 2 | − 1·94 | | + 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | − 1 | ... | ... | − 13 | ... | ... |
| 3 | + 2·72 | | | + 3 | ... | ... | ... | ... | ... | ... | ... | ... | + 1 | + 1 | ... | + 31 | − 27 | ... |
| 4 | − 0·44 | | | | + 3 | ... | ... | ... | ... | ... | ... | ... | − 1 | − 1 | ... | − 18 | + 16 | ... |
| 5 | − 2·87 | | | | | + 3 | ... | ... | ... | ... | ... | ... | ... | + 1 | ... | ... | + 21 | ... |
| 6 | + 4·40 | | | | | | + 3 | ... | ... | ... | ... | ... | ... | − 1 | ... | ... | − 18 | ... |
| 7 | + 8·23 | | | | | | | + 3 | ... | ... | ... | ... | ... | − 1 | ... | ... | + 6 | ... |
| 8 | − 2·27 | | | | | | | | + 3 | ... | ... | ... | ... | + 1 | + 1 | ... | − 14 | + 4 |
| 9 | − 0·82 | | | | | | | | | + 3 | ... | ... | ... | − 1 | − 1 | ... | + 16 | − 22 |
| 10 | + 1·24 | | | | | | | | | | + 3 | ... | ... | ... | + 1 | .. | ... | + 7 |
| 11 | − 10·14 | | | | | | | | | | | + 3 | ... | ... | − 1 | ... | ... | + 8 |
| 12 | + 0·01 | | | | | | * | | | | | | + 4 | ... | ... | ... | + 17 | ... |
| 13 | + 0·01 | | | | | | | | | | | | | + 7 | ... | − 11 | ... | + 34 |
| 14 | 0·00 | | | | | | | | | | | | | | + 4 | ... | − 38 | ... |
| 15 | + 94 | | | | | | | | | | | | | | | + 2250 | − 1850 | ... |
| 16 | − 302 | | | | | | | | | | | | | | | | + 4120 | − 50 |
| 17 | − 17 | | | | | | | | | | | | | | | | | + 1357 |

Values of the Factors

| | | |
|---|---|---|
| $\lambda_1$ | = | + 1·054 |
| $\lambda_2$ | = | − 0·821 |
| $\lambda_3$ | = | + 0·028 |
| $\lambda_4$ | = | + 0 517 |
| $\lambda_5$ | = | − 0·378 |
| $\lambda_6$ | = | + 1·011 |
| $\lambda_7$ | = | + 3·264 |
| $\lambda_8$ | = | − 0·777 |
| $\lambda_9$ | = | − 0·308 |
| $\lambda_{10}$ | = | + 1·262 |
| $\lambda_{11}$ | = | − 4·115 |
| $\lambda_{12}$ | = | + 0·175 |
| $\lambda_{13}$ | = | + 0·829 |
| $\lambda_{14}$ | = | − 2·386 |
| $\lambda_{15}$ | = | − 0·054 |
| $\lambda_{16}$ | = | − 0·122 |
| $\lambda_{17}$ | = | − 0·023 |

Angular errors in seconds

| | | |
|---|---|---|
| $x_1$ = + 0·78 | $x_{12}$ = + 1·44 | $x_{23}$ = − 0·60 |
| $x_2$ = + 1·54 | $x_{13}$ = − 3·67 | $x_{24}$ = − 0·20 |
| $x_3$ = + 1·23 | $x_{14}$ = + 0·35 | $x_{25}$ = − 0·21 |
| $x_4$ = − 0·02 | $x_{15}$ = + 0·45 | $x_{26}$ = − 0·61 |
| $x_5$ = − 0·93 | $x_{16}$ = + 3·33 | $x_{27}$ = 0·00 |
| $x_6$ = − 0·99 | $x_{17}$ = + 0·89 | $x_{29}$ = + 0·90 |
| $x_7$ = + 2·42 | $x_{18}$ = + 0·18 | $x_{29}$ = + 1·47 |
| $x_8$ = + 1·07 | $x_{19}$ = + 4·12 | $x_{30}$ = − 1·13 |
| $x_9$ = − 0·77 | $x_{20}$ = + 1·68 | $x_{31}$ = − 3·93 |
| $x_{10}$ = − 1·19 | $x_{21}$ = + 2·43 | $x_{32}$ = − 4·48 |
| $x_{11}$ = − 0·69 | $x_{22}$ = − 1·47 | $x_{33}$ = − 1·73 |

$[wx^2] = 115·04$

* In the tables of the equations between the factors the co-efficients of the terms below the diagonal are omitted for convenience, the co-efficient of the $p$th term in the $q$th line being always the same as the co-efficient of the $q$th term in the $p$th line.

*Figure No. 2*

**Observed Angles‡**

| No. | Value | | |
|---|---|---|---|
| | ° | ′ | ″ |
| 1 | 34 | 29 | 36·49 |
| 2 | 71 | 48 | 20·39 |
| 3 | 28 | 2 | 33·06 |
| 4 | 44 | 8 | 17·81 |
| 5 | 23 | 55 | 17·43 |
| 6 | 111 | 56 | 27·19 |
| 7 | 40 | 39 | 57·51 |
| 8 | 75 | 49 | 8·15 |

**Fixed data†**

Log. Ratio of side *A* to *B* (see diagram) = − ·0705216,2
„ „ *A* to *C* „ = − ·0224673,0

Angle at XXVI between XXIV and XXIII = 39° 35′ 49″·56
„ XXVI „ XXIII „ XXV = 51 57 39 ·47
„ XXV „ XXVI „ XXIV = 45 39 46 ·78

**Equations to be satisfied**

| | | | | | Factor |
|---|---|---|---|---|---|
| $x_1$ | $+x_2$ | $+x_3$ | ... | $= e_1 = +14{\cdot}83,$ | $\lambda_1$ |
| $x_4$ | $+x_5$ | $+x_6$ | ... | $= e_2 = +0{\cdot}52,$ | $\lambda_2$ |
| $x_5$ | $+x_7$ | $+x_8$ | ... | $= e_3 = +8{\cdot}87,$ | $\lambda_3$ |
| $x_3$ | $+x_5$ | ... | ... | $= e_4 = +11{\cdot}02,$ | $\lambda_4$ |
| $-31x_1$ | $-11x_2$ | $+22x_4$ | $+8x_6$ | $= e_5 = -169{\cdot}7,$ | $\lambda_5$ |
| $-31x_1$ | $-11x_2$ | $+25x_7$ | $-5x_8$ | $= e_6 = -170{\cdot}8,$ | $\lambda_6$ |

**Equations between the factors**

| No. of e | Value of e | Co-efficients of | | | | | |
|---|---|---|---|---|---|---|---|
| | | $\lambda_1$ | $\lambda_2$ | $\lambda_3$ | $\lambda_4$ | $\lambda_5$ | $\lambda_6$ |
| 1 | + 14·83 | + 3 | ... | ... | + 1 | − 42 | − 42 |
| 2 | + 0·52 | | + 3 | + 1 | + 1 | + 30 | ... |
| 3 | + 8·87 | | | + 3 | + 1 | ... | + 20 |
| 4 | + 11·02 | | * | | + 2 | ... | ... |
| 5 | −169·7 | | | | | +1630 | +1082 |
| 6 | −170·8 | | | | | | +1732 |

**Values of the Factors**

$\lambda_1 = +4{\cdot}187$
$\lambda_2 = -4{\cdot}493$
$\lambda_3 = +4{\cdot}486$
$\lambda_4 = +3{\cdot}419$
$\lambda_5 = +0{\cdot}203$
$\lambda_6 = -0{\cdot}176$

**Angular errors in seconds**

$x_1 = +3{\cdot}34$ $x_5 = +3{\cdot}41$
$x_2 = +3{\cdot}88$ $x_6 = -2{\cdot}87$
$x_3 = +7{\cdot}61$ $x_7 = +0{\cdot}09$
$x_4 = -0{\cdot}02$ $x_8 = +5{\cdot}37$

$[wx^2] = 132{\cdot}83$

† The fixed data here given are obtained from Triangles Nos. 238, 239 and 426 of the East Coast Series, *vide* page 111—*c.* of Vol. VI of the *Account of the Operations, &c.* ‡ These are treated with *equal* weights.

*December* 1878.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

# SOUTH PARASNATH MERIDIONAL SERIES.

## PRIMARY TRIANGULATION. TRIANGLES.

| No. of Triangle | | Station | Spherical Excess | Corrections to Observed Angle | | | | Corrected Plane Angle | Distance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Circuit | Non-circuit | | | Figure | Circuit | Non-circuit | Total | | Log. feet | Feet | Miles |
| | | | " | " | " | " | " | ° ′ ″ | | | |
| 1 | | LVIII | 2·40 | + ·17 | −2·47 | | −2·30 | 46 16 15·01 | 5·2389710,4 | 173368·9 | 32·835 |
| | | LXI | 2·41 | + ·17 | +2·34 | | +2·51 | 47 19 20·48 | 5·2464569,8 | 176383·1 | 33·406 |
| | | I | 2·41 | + ·18 | + ·13 | | + ·31 | 86 24 24·51 | 5·3792092,2 | 239446·9 | 45·350 |
| | | | 7·22 | | | | + ·52 | 180 0 0·00 | | | |
| 2 | | LXI | 1·53 | − ·78 | + ·24 | | − ·54 | 76 3 30·19 | 5·2638937,4 | 183608·9 | 34·774 |
| | | I | 1·53 | −1·23 | −1·43 | | −2·66 | 37 32 3·59 | 5·0616655,9 | 115256·5 | 21·829 |
| | | II | 1·53 | −1·54 | +1·19 | | − ·35 | 66 24 26·22 | 5·2389710,4 | 173368·9 | 32·835 |
| | | | 4·59 | | | | −3·55 | 180 0 0·00 | | | |
| 3 | | I | 1·31 | + ·77 | −1·35 | | − ·58 | 69 31 8·86 | 5·2429932,2 | 174981·9 | 33·141 |
| | | II | 1·30 | −2·42 | +1·21 | | −1·21 | 31 4 7·12 | 4·9840555,5 | 96395·2 | 18·257 |
| | | IV | 1·31 | −1·07 | + ·14 | | − ·93 | 79 24 44·02 | 5·2638937,4 | 183608·9 | 34·774 |
| | | | 3·92 | | | | −2·72 | 180 0 0·00 | | | |
| | 13 | LXI | 1·23 | + ·02 | | − ·10 | − ·08 | 55 4 48·36 | 5·1540017,6 | 142561·3 | 27·000 |
| | | I | 1·23 | + ·99 | | − ·97 | + ·02 | 39 15 1·55 | 5·0414182,0 | 110006·5 | 20·835 |
| | | III | 1·24 | + ·93 | | +1·07 | +2·00 | 85 40 10·09 | 5·2389710,4 | 173368·9 | 32·835 |
| | | | 3·70 | | | | +1·94 | 180 0 0·00 | | | |
| | 14 | I | 1·01 | −1·44 | | −1·81 | −3·25 | 67 48 11·50 | 5·1420172,1 | 138681·1 | 26·265 |
| | | III | 1·00 | +1·19 | | +1·47 | +2·66 | 40 3 31·83 | 4·9840555,4 | 96395·2 | 18·257 |
| | | IV | 1·01 | + ·69 | | + ·34 | +1·03 | 72 8 16·67 | 5·1540017,6 | 142561·3 | 27·000 |
| | | | 3·02 | | | | + ·44 | 180 0 0·00 | | | |

NOTES.—1. The values of the side are given in the same line with the opposite angle.
2. Stations LVIII and LXI appertain to the Calcutta Longitudinal Series.

| No. of Triangle | | Station | Spherical Excess | Corrections to Observed Angle | | | | Corrected Plane Angle | Distance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Circuit | Non-circuit | | | Figure | Circuit | Non-circuit | Total | | Log. feet | Feet | Miles |
| | | | " | " | " | " | " | ° ′ ″ | | | |
| | | II | 1·46 | + 3·67 | − ·91 | | + 2·76 | 38 3 35·29 | 5·0532779,3 | 113051·9 | 21·411 |
| 4 | | IV | 1·46 | − ·45 | − ·51 | | − ·96 | 69 20 56·32 | 5·2345142,7 | 171598·8 | 32·500 |
| | | V | 1·46 | − ·35 | + 1·42 | | + 1·07 | 72 35 28·39 | 5·2429932,2 | 174981·9 | 33·141 |
| | | | 4·38 | | | | + 2·87 | 180 0 0·00 | | | |
| | | IV | 1·21 | + ·20 | − 1·52 | | − 1·32 | 62 54 26·68 | 5·1526095,8 | 142105·1 | 26·914 |
| 5 | | V | 1·21 | + 1·47 | + ·18 | | + 1·65 | 71 59 57·51 | 5·1812916,9 | 151807·0 | 28·751 |
| | | VIII | 1·20 | + ·60 | + 1·34 | | + 1·94 | 45 5 35·81 | 5·0532779,3 | 113051·9 | 21·411 |
| | | | 3·62 | | | | + 2·27 | 180 0 0·00 | | | |
| | | III | ·82 | − 3·33 | | − ·89 | − 4·22 | 48 47 57·32 | 5·0197111,4 | 104643·2 | 19·819 |
| | 15 | IV | ·81 | − ·18 | | − ·14 | − ·32 | 45 31 51·19 | 4·9967306,6 | 99250·0 | 18·797 |
| | | VI | ·82 | − ·89 | | + 1·03 | + ·14 | 85 40 11·49 | 5·1420172,1 | 138681·1 | 26·265 |
| | | | 2·45 | | | | − 4·40 | 180 0 0·00 | | | |
| | | IV | ·74 | − 2·43 | | − ·86 | − 3·29 | 51 1 6·66 | 4·9819704,8 | 95933·5 | 18·169 |
| | 16 | VI | ·75 | − 4·12 | | − ·53 | − 4·65 | 70 59 41·66 | 5·0670110,2 | 116683·9 | 22·099 |
| | | VII | ·75 | − 1·68 | | + 1·39 | − ·29 | 57 59 11·68 | 5·0197111,4 | 104643·2 | 19·819 |
| | | | 2·24 | | | | − 3·23 | 180 0 0·00 | | | |
| | | IV | ·95 | + ·61 | | − 1·23 | − ·62 | 42 58 52·97 | 5·0155642,8 | 103648·8 | 19·630 |
| | 17 | VII | ·96 | + ·21 | | − ·09 | + ·12 | 86 53 19·16 | 5·1812916,7 | 151807·0 | 28·751 |
| | | VIII | ·95 | ·00 | | + 1·32 | + 1·32 | 50 7 47·87 | 5·0670110,2 | 116683·9 | 22·099 |
| | | | 2·86 | | | | + ·82 | 180 0 0·00 | | | |
| | | V | 1·19 | − ·90 | − ·50 | | − 1·40 | 51 58 48·62 | 5·0854453,8 | 121743·4 | 23·057 |
| 6 | | VIII | 1·20 | + 1·13 | − ·20 | | + ·93 | 61 9 30·06 | 5·1315130,6 | 135367·1 | 25·638 |
| | | IX | 1·20 | − 1·47 | + ·70 | | − ·77 | 66 51 41·32 | 5·1526095,8 | 142105·1 | 26·914 |
| | | | 3·59 | | | | − 1·24 | 180 0 0·00 | | | |
| | | VII | ·83 | + 3·93 | | + ·02 | + 3·95 | 70 30 12·30 | 5·0854453,5 | 121743·4 | 23·057 |
| | 18 | VIII | ·83 | + 1·73 | | − ·19 | + 1·54 | 56 7 18·61 | 5·0302852,9 | 107222·3 | 20·307 |
| | | IX | ·82 | + 4·48 | | + ·17 | + 4·65 | 53 22 29·09 | 5·0155642,8 | 103648·8 | 19·630 |
| | | | 2·48 | | | | +10·14 | 180 0 0·00 | | | |
| | | VIII | 1·24 | − ·14 | − 1·02 | | − 1·16 | 59 22 19·10 | 5·1368752,6 | 137048·8 | 25·956 |
| 7 | | IX | 1·25 | − ·14 | − ·22 | | − ·36 | 70 46 29·60 | 5·1772067,2 | 150385·8 | 28·482 |
| | | X | 1·24 | − ·13 | + 1·24 | | + 1·11 | 49 51 11·30 | 5·0854453,8 | 121743·4 | 23·057 |
| | | | 3·73 | | | | − ·41 | 180 0 0·00 | | | |
| | | IX | 1·07 | − 2·96 | − ·66 | | − 3·62 | 49 32 55·59 | 5·0503482,6 | 112291·9 | 21·267 |
| 8 | | X | 1·08 | − 2·96 | + ·42 | | − 2·54 | 62 12 50·46 | 5·1157809,1 | 130551·2 | 24·726 |
| | | XI | 1·08 | − 2·97 | + ·24 | | − 2·73 | 68 14 13·95 | 5·1368752,6 | 137048·8 | 25·956 |
| | | | 3·23 | | | | − 8·89 | 180 0 0·00 | | | |
| | | X | ·42 | + 1·36 | − 1·37 | | − ·01 | 27 41 58·06 | 4·7183514,8 | 52281·9 | 9·902 |
| 9 | | XI | ·42 | + 1·37 | + ·18 | | + 1·55 | 65 33 56·77 | 5·0103036,1 | 102400·9 | 19·394 |
| | | XII | ·43 | + 1·37 | + 1·19 | | + 2·56 | 86 44 5·17 | 5·0503482,6 | 112291·9 | 21·267 |
| | | | 1·27 | | | | + 4·10 | 180 0 0·00 | | | |
| | | XI | ·24 | − 1·46 | − ·87 | | − 2·33 | 73 47 11·49 | 4·8276952,1 | 67250·5 | 12·737 |
| 10 | | XII | ·23 | − 1·46 | + ·53 | | − ·93 | 57 55 30·90 | 4·7733867,8 | 59345·4 | 11·240 |
| | | XIII | ·23 | − 1·46 | + ·34 | | − 1·12 | 48 17 17·61 | 4·7183514,8 | 52281·9 | 9·902 |
| | | | ·70 | | | | − 4·38 | 180 0 0·00 | | | |
| | | XII | ·41 | − 1·19 | − ·34 | | − 1·53 | 69 43 3·84 | 4·9362986,4 | 86357·2 | 16·356 |
| 11 | | XIII | ·41 | − 1·18 | − 1·13 | | − 2·31 | 63 21 25·63 | 4·9153470,8 | 82290·0 | 15·585 |
| | | XXV | ·41 | − 1·18 | + 1·47 | | + ·29 | 46 55 30·53 | 4·8276952,1 | 67250·5 | 12·737 |
| | | | 1·23 | | | | − 3·55 | 180 0 0·00 | | | |

NOTE.—Station XXV appertains to the East Coast Series.

| No. of Triangle | | Station | Spherical Excess | Corrections to Observed Angle | | | | Corrected Plane Angle | Distance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Circuit | Non-circuit | | | Figure | Circuit | Non-circuit | Total | | Log. feet | Feet | Miles |
| | | | " | " | " | " | " | ° ′ ″ | | | |
| | | XIII | ·63 | − 3·34 | − 2·07 | | − 5·41 | 34 29 30·45 | 5·0171495,9 | 104027·8 | 19·702 |
| 12 | | XXV | ·63 | − 3·38 | + ·98 | | − 2·90 | 117 28 3·64 | 5·2121684,9 | 162992·8 | 30·870 |
| | | XXVI | ·63 | − 7·61 | + 1·09 | | − 6·52 | 28 2 25·91 | 4·9362986,4 | 86357·2 | 16·356 |
| | | | 1·89 | | | | −14·83 | 180 0 0·00 | | | |
| | | XIII | ·64 | + ·02 | | − 4·68 | − 4·66 | 44 8 12·51 | 5·0876711,6 | 122368·9 | 23·176 |
| | 19 | XXVI | ·63 | − 3·41 | | − 1·09 | − 4·50 | 23 55 12·30 | 4·8527788,5 | 71249·0 | 13·494 |
| | | XXIII | ·64 | + 2·87 | | + 5·77 | + 8·64 | 111 56 35·19 | 5·2121684,9 | 162992·8 | 30·870 |
| | | | 1·91 | | | | − ·52 | 180 0 0·00 | | | |
| | | XIII | 1·26 | − ·09 | | − 1·61 | − 1·70 | 40 39 54·55 | 5·0396168,6 | 109551·1 | 20·748 |
| | 20 | XXVI | 1·26 | − 3·41 | | − 1·09 | − 4·50 | 63 31 1·23 | 5·1774664,1 | 150475·7 | 28·499 |
| | | XXIV | 1·26 | − 5·37 | | + 2·70 | − 2·67 | 75 49 4·22 | 5·2121684,9 | 162992·8 | 30·870 |
| | | | 3·78 | | | | − 8·87 | 180 0 0·00 | | | |

NOTE.—Stations XXIII, XXIV, XXV and XXVI appertain to the East Coast Series.

*December* 1878.

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*In charge of Computing Office.*

# SOUTH PARASNATH MERIDIONAL SERIES.

## SECONDARY TRIANGULATION. TRIANGLES.

### INTERSECTED POINTS.

Differences between the common sides of two triangles to intersected points, are shown by the small figures in the column for "Distance in Feet" between the data of the two triangles, the earlier of which in order has supplied the greater value: where the difference is small it has usually been apportioned between the triangles, but where it is large no adjustment has been made, as one or other of the two values must be erroneous.

| No. of Triangle | Station | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|
| | | | Log. feet | Feet | Miles | |
| | | ° ′ ″ | | | | Inch |
| | Tilabani, LXI | 71 3 37 | 5·038849 | 109358 | 20·712 | 18 |
| 21 | Parása, II | 23 27 58 | 4·663131 | 46040 | 8·720 | ,, |
| | Korochia Hill Mark | | 5·061666 | 115257 12 | 21·829 | |
| | Parása, II | 108 55 50 | 5·257955 | 181115 | 34·302 | ,, |
| 22 | Bhandári, VI | 34 49 48 | 5·038849 | 109358 | 20·712 | ,, |
| | Korochia Hill Mark | | 5·053810 * | 113191 | 21·438 | |
| | Gorgáburu, I | 90 9 49 | 5·253389 | 179221 | 33·943 | ,, |
| 23 | Bhandári, VI | 16 4 9 | 4·695553 | 49608 | 9·395 | ,, |
| | Rájpati Hill Peak | | 5·235723 * | 172077 4 | 32·590 | |
| | Parása, II | 80 27 54 | 5·253389 | 179221 | 33·943 | ,, |
| 24 | Bhandári, VI | 61 0 39 | 5·201295 | 158963 | 30·107 | ,, |
| | Rajpati Hill Peak | | 5·053810 * | 113191 | 21·438 | |
| | Parása, II | 40 12 51 | 5·061459 | 115202 | 21·819 | ,, |
| 25 | Dalma, IV | 61 3 56 | 5·193558 | 156156 | 29·575 | ,, |
| | Dúmarbera Hill Peak | | 5·242993 | 174982 | 33·141 | |

| No. of Triangle | Station | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|
| | | | Log. feet | Feet | Miles | |
| | | ° ′ ″ | | 1 | | Inch |
| | Dalma, IV | 99 19 20 | 5·224563 | 167711 | 31·764 | 18 |
| 26 | Bhandári, VI | 42 40 28 | 5·061459 | 115202 | 21·819 | ,, |
| | Dúmarbera Hill Peak | | 5·019711 | 104643 | 19·819 | |
| | Tilabani, LXI | 48 1 35 | 5·194592 | 156528 | 29·645 | ,, |
| 27 | Bhandári, VI | 48 52 11 | 5·200258 | 158583 | 30·035 | ,, |
| | Siringi Hill Peak | | 5·320185 * | 209019 13 | 39·587 | |
| | Dalma, IV | 106 6 57 | 5·194592 | 156528 | 29·645 | ,, |
| 28 | Bhandári, VI | 33 55 26 | 4·958708 | 90930 | 17·222 | ,, |
| | Siringi Hill Peak | | 5·019711 | 104643 | 19·819 | |
| | Dalma, IV | 124 51 1 | 5·249507 | 177626 | 33·641 | ,, |
| 29 | Bhandári, VI | 26 14 17 | 4·980872 | 95691 | 18·123 | ,, |
| | Digádi Hill Mark | | 5·019711 | 104643 31 | 19·819 | |
| | Gorgáburu, I | 83 3 59 | 4·980872 | 95691 | 18·123 | ,, |
| 30 | Dalma, IV | 7 10 51 | 4·080974 | 12050 | 2·282 | ,, |
| | Digádi Hill Mark | | 4·984056 | 96395 | 18·257 | |

NOTES.—1. Names followed by Roman numerals are those of Primary Stations. Tilabani, LXI appertains to the Calcutta Longitudinal Series. * Base deduced by two sides and included angle.
2. The values of the side are given in the same line with the opposite angle.

| No. of Triangle | Station | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|
| | | | Log. feet | Feet | Miles | |
| | | ° ′ ″ | | | | Inch |
| | Parása, II | 38 6 57 | 5·009216 | 102145 | 19·346 | 18 |
| 31 | Bhandári, VI | 98 43 37 | 5·213695 | 163567 | 30·979 | ,, |
| | Hill Peak No. 1 | | 5·053810 | 113191 | 21·438 | |
| | | | * | 2 | | |
| | Gorgáburu, I | 62 58 2 | 5·213695 | 163567 | 30·979 | ,, |
| 32 | Parása, II | 27 52 23 | 4·933735 | 85849 | 16·259 | ,, |
| | Hill Peak No. 1 | | 5·263894 | 183609 | 34·774 | |
| | Ledásál, V | 34 40 5 | 4·923323 | 83815 | 15·874 | ,, |
| 33 | Bághmuri, VIII | 40 0 0 | 4·976415 | 94714 | 17·938 | ,, |
| | Dhoba Hill Mark | | 5·152610 | 142105 | 26·914 | |
| | | | | 1 | | |
| | Sideshar, VII | 53 9 57 | 4·923323 | 83815 | 15·874 | ,, |
| 34 | Bághmuri, VIII | 45 2 12 | 4·869793 | 74096 | 14·033 | ,, |
| | Dhoba Hill Mark | | 5·015564 | 103649 | 19·630 | |
| | Dalma, IV | 63 30 30 | 5·001734 | 100400 | 19·015 | ,, |
| 35 | Bhandári, VI | 47 36 44 | 4·918320 | 82855 | 15·692 | ,, |
| | Rangámati Hill Mark | | 5·019711 | 104643 | 19·819 | |
| | | | | 7 | | |
| | Dalma, IV | 32 24 57 | 4·791654 | 61895 | 11·722 | ,, |
| 36 | Ledásál, V | 45 51 23 | 4·918320 | 82855 | 15·692 | ,, |
| | Rangámati Hill Mark | | 5·053278 | 113052 | 21·411 | |
| | Ledásál, V | 87 41 51 | 5·036269 | 108710 | 20·589 | ,, |
| 37 | Bhandári, VI | 59 31 19 | 4·972038 | 93764 | 17·758 | ,, |
| | Hill Mark No. 1 | | 4·770156 | 58906 | 11·156 | |
| | | | * | | | |

| No. of Triangle | Station | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|
| | | | Log. feet | Feet | Miles | |
| | | ° ′ ″ | | | | Inch |
| | Badampahár, X | 43 22 10 | 4·847450 | 70580 | 13·330 | 18 |
| 38 | Amjhori, XII | 49 1 25 | 4·888618 | 77378 | 14·655 | ,, |
| | Barágaon Hill Mark | | 5·010304 | 102401 | 19·394 | |
| | Badampahár, X | 53 30 43 | 4·972152 | 93789 | 17·763 | ,, |
| 39 | Kusumbani, XI | 52 12 33 | 4·964672 | 92188 | 17·460 | ,, |
| | Hill Mark No. 2 | | 5·050348 | 112292 | 21·267 | |
| | Badampahár, X | 23 19 16 | 4·621466 | 41828 | 7·922 | ,, |
| 40 | Amjhori, XII | 80 56 24 | 5·018445 | 104339 | 19·761 | ,, |
| | Dolki Hill Mark | | 5·010304 | 102401 | 19·394 | |
| | | | | 1 | | |
| | Badampahár, X | 51 1 14 | 4·971149 | 93573 | 17·722 | ,, |
| 41 | Kusumbani, XI | 60 5 25 | 5·018445 | 104339 | 19·761 | ,, |
| | Dolki Hill Mark | | 5·050348 | 112292 | 21·267 | |
| | Badampahár, X | 45 16 38 | 4·986994 | 97050 | 18·381 | ,, |
| 42 | Kusumbani, XI | 79 25 34 | 5·127980 | 134270 | 25·430 | ,, |
| | Ganpati Hill Mark | | 5·050348 | 112292 | 21·267 | |
| | | | | 1 | | |
| | Badampahár, X | 17 34 40 | 4·680830 | 47955 | 9·082 | ,, |
| 43 | Amjhori, XII | 122 15 55 | 5·127980 | 134270 | 25·430 | ,, |
| | Ganpati Hill Mark | | 5·010304 | 102401 | 19·394 | |
| | Amjhori, XII | 3 15 33 | 3·833937 | 6822 | 1·292 | ,, |
| 44 | Megásini, XXV | 40 2 5 | 4·887568 | 77191 | 14·620 | † |
| | Megásini, N. Hill Mark | | 4·915347 | 82290 | 15·585 | |

NOTE.—Station Megásini, XXV appertains to the East Coast Series. * Base deduced by two sides and included angle. † Instrument not known.

*April* 1879.

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*In charge of Computing Office.*

# SOUTH PARASNATH MERIDIONAL SERIES.

## AZIMUTHS OF SURROUNDING STATIONS AND POINTS AT PRIMARY STATIONS.

The following table contains, in the first column, the name of each Primary Station at which azimuths of surrounding Points have been measured; immediately followed by those azimuths. The second column contains the number of the triangle which gives the distance between the Station and the Point.

| Name of station with azimuths of surrounding points | | No. of triangle giving distance | Name of station with azimuths of surrounding points | | No. of triangle giving distance | Name of station with azimuths of surrounding points | | No. of triangle giving distance |
|---|---|---|---|---|---|---|---|---|
| AMJHORI, XII | ° ′ ″ | | BAGHMURI, VIII | ° ′ ″ | | BHANDARI, VI | ° ′ ″ | |
| Ganpati Hill Mark | 16 39 16 | 43 | Dalma, IV | 193 27 2·7 | 7 | Siringi Hill Peak | 133 32 2 | 27 |
| Dolki Hill Mark | 57 58 47 | 40 | Dhoba Hill Mark | 198 32 40 | 33 | Dúmarbera Hill Peak | 142 17 4 | 26 |
| Barágaon Hill Mark | 89 53 46 | 38 | Ledásál, V | 238 32 39·7 | 7 | Rájpati Hill Peak | 145 25 24 | 23 |
| Badampahár, X | 138 55 11·2 | 15 | Sideshar, VII | 243 34 51·5 | 10 | Korochia Hill Mark | 171 36 15 | 22 |
| Kusumbani, XI | 225 39 16·8 | 15 | Sátbakra, IX | 299 42 10·9 | 11 | Bári, III | 185 16 48·1 | 8 |
| Murári, XIII | 283 34 47·9 | 16 | Badampahár, X | 359 4 31·3 | 13 | Hill Mark No. 1 | 317 43 46 | 37 |
| Megásini, XXV* | 353 17 52·2 | 17 | | | | | | |
| Megásini, N. Hill Mark | 350 2 19 | 44 | BARI, III | | | BOLPAL, XXVI* | | |
| | | | Bhandári, VI | 5 17 26·3 | 8 | Megásini, XXV* | 157 44 38·2 | 18 |
| | | | Dalma, IV | 54 5 24·5 | 5 | Murári, XIII | 185 47 4·7 | 18 |
| BADAMPAHAR, X | | | Gorgáburu, I | 94 8 57·3 | 4 | Kimhíra, XXIII* | 209 42 17·6 | 19 |
| Barágaon Hill Mark | 2 12 54 | 38 | Tilabani, LXI† | 179 49 8·6 | 4 | Nilgiri, XXIV* | 249 18 7·2 | 20 |
| Bághmuri, VIII | 179 4 41·0 | 13 | | | | | | |
| Sátbakra, IX | 228 55 53·6 | 13 | BHANDARI, VI | | | CHAINPUR, LVIII† | | |
| Kusumbani, XI | 291 8 45·1 | 14 | Sideshar, VII | 28 36 53·4 | 9 | Tilabani, LXI† | 281 56 37·2 | 1 |
| Amjhori, XII | 318 50 43·6 | 15 | Rangámati Hill Mark | 51 59 52 | 35 | Gorgáburu, I | 328 12 54·6 | 1 |
| Ganpati Hill Mark | 336 25 23 | 42 | Dalma, IV | 99 36 35·8 | 8 | | | |
| Dolki Hill Mark | 342 10 0 | 40 | Hill Peak No. 1 | 107 42 26 | 31 | DALMA, IV | | |
| Hill Mark No. 2 | 344 39 28 | 39 | Digádi Hill Mark | 125 50 53 | 29 | Bághmuri, VIII | 13 29 28·3 | 7 |

* Of the East Coast Series. † Of the Calcutta Longitudinal Series.

| Name of station with azimuths of surrounding points | ° ′ ″ | No. of triangle giving distance |
|---|---|---|
| DALMA, IV | | |
| Digádi Hill Mark | 154 38 26 | 29 |
| Gorgáburu, I | 161 49 17·3 | 3 |
| Siringi Hill Peak | 173 22 30 | 28 |
| Dúmarbera Hill Peak | 180 10 7 | 25 |
| Bári, III | 233 57 35·0 | 5 |
| Parása, II | 241 14 2·7 | 3 |
| Bhandári, VI | 279 29 27·0 | 8 |
| Ledásál, V | 310 35 0·4 | 6 |
| Sideshar, VII | 330 30 34·4 | 9 |
| Rangámati Hill Mark | 342 59 57 | 35 |
| GORGABURU, I | | |
| Digádi Hill Mark | 64 51 10 | 30 |
| Chainpur, LVIII* | 148 19 29·1 | 1 |
| Rájpati Hill Peak | 219 2 9 | 23 |
| Tilabani, LXI* | 234 43 56·1 | 1 |
| Parása, II | 272 16 1·2 | 2 |
| Bári, III | 273 58 58·8 | 4 |
| Hill Peak No. 1 | 335 14 3 | 32 |
| Dalma, IV | 341 47 11·3 | 3 |
| KIMHIRA, XXIII† | | |
| Bolpál, XXVI† | 29 46 13·4 | 19 |
| Murári, XIII | 141 42 49·2 | 19 |
| KUSUMBANI, XI | | |
| Ganpati Hill Mark | 31 50 8 | 42 |
| Amjhori, XII | 45 41 45·0 | 15 |
| Dolki Hill Mark | 51 10 17 | 41 |
| Hill Mark No. 2 | 59 3 9 | 39 |

| Name of station with azimuths of surrounding points | ° ′ ″ | No. of triangle giving distance |
|---|---|---|
| KUSUMBANI, XI | | |
| Badampahár, X | 111 15 42·2 | 14 |
| Sátbakra, IX | 179 29 57·2 | 14 |
| Murári, XIII | 331 54 33·3 | 16 |
| LEDASAL, V | | |
| Sátbakra, IX | 6 42 7·1 | 11 |
| Bághmuri, VIII | 58 40 56·9 | 7 |
| Rangámati Hill Mark | 84 49 33 | 36 |
| Dhoba Hill Mark | 93 21 2 | 33 |
| Dalma, IV | 130 40 55·6 | 6 |
| Parása, II | 203 16 25·5 | 6 |
| Hill Mark No. 1 | 284 55 44 | 37 |
| MEGASINI, XXV† | | |
| Amjhori, XII | 173 18 29·9 | 17 |
| Megásini, N. Hill Mark | 213 20 35 | 44 |
| Murári, XIII | 220 14 0·8 | 17 |
| Bolpál, XXVI† | 337 42 5·1 | 18 |
| MURARI, XIII | | |
| Bolpál, XXVI† | 5 48 8·9 | 18 |
| Megásini, XXV† | 40 17 40·0 | 17 |
| Amjhori, XII | 103 39 6·0 | 16 |
| Kusumbani, XI | 151 56 23·8 | 16 |
| Kimhíra, XXIII† | 321 39 55·7 | 19 |
| Nilgiri, XXIV† | 325 8 13·1 | 20 |
| NILGIRI, XXIV† | | |
| Bolpál, XXVI† | 69 24 43·5 | 20 |
| Murári, XIII | 145 13 49·0 | 20 |

| Name of station with azimuths of surrounding points | ° ′ ″ | No. of triangle giving distance |
|---|---|---|
| PARASA, II | | |
| Ledásál, V | 23 21 8·2 | 6 |
| Dalma, IV | 61 24 44·9 | 3 |
| Hill Peak No. 1 | 64 36 30 | 31 |
| Gorgáburu, I | 92 28 53·4 | 2 |
| Dúmarbera Hill Peak | 101 37 36 | 25 |
| Rájpati Hill Peak | 106 57 27 | 24 |
| Korochia Hill Mark | 135 25 23 | 21 |
| Tilabani, LXI* | 158 53 21·1 | 2 |
| SATBAKRA, IX | | |
| Badampahár, X | 49 2 49·3 | 13 |
| Bághmuri, VIII | 119 49 20·2 | 11 |
| Sideshar, VII | 173 11 50·1 | 12 |
| Ledásál, V | 186 41 2·7 | 11 |
| Kusumbani, XI | 359 29 52·7 | 14 |
| SIDESHAR, VII | | |
| Bághmuri, VIII | 63 41 11·4 | 10 |
| Dhoba Hill Mark | 116 51 8 | 34 |
| Dalma, IV | 150 34 31·5 | 9 |
| Bhandári, VI | 208 33 43·9 | 9 |
| Sátbakra, IX | 353 10 58·3 | 12 |
| TILABANI, LXI* | | |
| Korochia Hill Mark | 49 54 2 | 21 |
| Siringi Hill Peak | 50 26 25 | 27 |
| Gorgáburu, I | 54 53 56·7 | 1 |
| Chainpur, LVIII* | 102 13 19·6 | 1 |
| Parása, II | 338 50 25·0 | 2 |
| Bári, III | 359 49 7·1 | 4 |

* Of the Calcutta Longitudinal Series. † Of the East Coast Serics.

*April* 1879.

J. B. N. HENNESSEY,

*In charge of Computing Office.*

# SOUTH PARASNATH MERIDIONAL SERIES.

## PRIMARY TRIANGULATION. HEIGHTS ABOVE MEAN SEA LEVEL.

The following table gives, first, the usual data of the observed vertical angles and the heights of the signal (where forthcoming) and instrument, &c., in pairs of horizontal lines, the first line of which gives the data for the 1st or the fixed station, and the second line the data for the 2nd or the deduced station. This is followed by the arc contained between the two stations, and then by the terrestrial refraction, and the height of the 2nd station above or below the 1st, as computed from the vertical angles in the usual manner. This difference of height applied to the given height above mean sea level of the fixed station, gives that of the deduced station. Usually there are two or three independent values of the height of the deduced station; the details are so arranged as to show these consecutively and their mean in the columns of "Trigonometrical Results". The mean results thus obtained are however liable to receive corrections for the errors generated in the trigonometrical operations, which are shown up by the spirit leveling operations, whenever a junction between the two has been effected. The spirit leveled determinations, when available, are always accepted as final, and the trigonometrical heights of stations, lying between other stations fixed by the leveling operations, are adjusted—usually by simple proportion—to accord with the latter.

The heights of the South Párasnáth Meridional Series have been adjusted between the final values of Chainpur and Tilabani, the fixed points of the Calcutta Longitudinal Series, and those of the fixed stations of Kimhíra, Nilgiri, Megásini and Bolpál of the East Coast Series. The heights of the fixed points are as follows:—

LVIII, Chainpur ... 2085
LXI, Tilabani, ... 1329
} feet above Mean Sea Level as brought down from Karáchi.

XXIII, Kimhíra ... 582
XXIV, Nilgiri ... 1788
XXV, Megásini ... 3823
XXVI, Bolpál ... 1652
} Points. „ „ as determined at Balarámgarhi and Vizagapatam Tide

Excepting the above fixed points, the heights in the column "Final Result" are given only to the nearest tenth foot, because these results are not more trustworthy on this series.

| Astronomical Date 1836-37 | Mean of Times of observation | Station | Observed Vertical Angle | Number of observations | Height in feet: Signal | Height in feet: Instrument | Contained Arc | Terrestrial Refraction: In seconds | Terrestrial Refraction: Decimals of Contained Arc | Height of 2nd Station − 1st Station in feet | Height in feet of 2nd Station above Mean Sea Level: Trigonometrical Results: By each deduction | Trigonometrical Results: Mean | Final Result | Height of Pillar or Tower |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *h m* | | ° ′ ″ | | | | ″ | | | | | | | *feet* |
| Dec. 9 | 2 0 | LVIII | D 0 10 50 | 4 | Not forthcoming | 5·5 | 1743 | 76 | ·043 | + 130 | 2215 | 2211 | 2220 | Not forthcoming |
| Jan. 18 | 2 48 | I | D 0 15 55 | 4 | | 5·5 | | | | | | | | |
| „ 3 | 22 26 | LXI | E 0 4 48 | 4 | | 5·5 | 1713 | 107 | ·062 | + 878 | 2207 | | | |
| „ 31 | 0 46 | I | D 0 30 0 | 4 | | 5·5 | | | | | | | | |
| „ 6 | 4 53 | LXI | D 0 21 37 | 4 | | 5·5 | 1139 | 41 | ·036 | − 424 | 905 | 907 | 920 | |
| Mar. 13 | 2 53 | II | E 0 3 41 | 4 | | 5·5 | | | | | | | | |
| Jan. 26 | 2 10 | I | D 0 37 58 | 4 | | 5·5 | 1814 | 97 | ·054 | −1301 | 910 | | | |
| Mar. 14 | 0 53 | II | E 0 10 46 | 4 | | 5·5 | | | | | | | | |

| Astronomical Date | | Station | Observed Vertical Angle | Number of observations | Height in feet | | Contained Arc | Terrestrial Refraction | | Height of 2nd Station − 1st Station in feet | Height in feet of 2nd Station above Mean Sea Level | | | Height of Pillar or Tower |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1836-37 | Mean of Times of observation | | | | Signal | Instrument | | In seconds | Decimals of Contained Arc | | Trigonometrical Results: By each deduction | Trigonometrical Results: Mean | Final Result | |
| 1837 | *h m* | | ° ′ ″ | | | | ″ | | | | | | | *feet* |
| Jan. 3 | 22 26 | LXI | D 0 27 40 | 4 | | 5·5 | 1087 | 47 | ·044 | − 615 | 714 | | | |
| 1836 Apr. 19 | 5 30 | III | E 0 10 47 | 4 | | 5·5 | | | | | | 721 | 730 | |
| 1837 Jan. 22 | 3 8 | I | D 0 46 24 | 4 | | 5·5 | 1409 | 73 | ·052 | −1483 | 728 | | | |
| 1836 Apr. 19 | 5 30 | III | E 0 25 6 | 4 | | 5·5 | | | | | | | | |
| 1837 Feb. 9 | 3 32 | I | E 0 22 37 | 4 | | 5·5 | 952 | 49 | ·052 | + 840 | 3051 | | | |
| „ 19 | 21 25 | IV | D 0 37 15 | 4 | | 5·5 | | | | | | | | |
| Mar. 14 | 21 40 | II | E 0 29 49 | 4 | | 5·5 | 1729 | 163 | ·095 | +2118 | 3025 | 3041 | 3060 | |
| Feb. 25 | 22 0 | IV | D 0 53 24 | 4 | | 5·5 | | | | | | | | |
| 1836 Apr. 19 | 5 30 | III | E 0 47 13 | 4 | | 5·5 | 1370 | 67 | ·049 | +2326 | 3047 | | | |
| 1837 Feb. 22 | 1 44 | IV | D 1 8 5 | 4 | | 5·5 | | | | | | | | |
| Mar. 13 | 2 52 | II | E 0 2 41 | 4 | | 5·5 | 1696 | 49 | ·029 | + 805 | 1712 | | | |
| „ 31 | 0 14 | V | D 0 29 33 | 4 | | 5·5 | | | | | | 1696 | 1720 | |
| Feb. 16 | 4 15 | IV | D 0 49 18 | 4 | | 5·5 | 1117 | 92 | ·082 | −1360 | 1681 | | | |
| Mar. 28 | 6 16 | V | E 0 33 25 | 4 | | 5·5 | | | | | | | | |
| 1836 Apr. 19 | 5 30 | III | E 0 17 12 | 4 | Not forthcoming | 5·5 | 981 | 48 | ·049 | + 715 | 1436 | | | Not forthcoming |
| 1837 Mar. 4,7 | * | VI | D 0 32 19 | 4 | | 5·5 | | | | | | 1438 | 1460 | |
| Feb. 15 | 2 42 | IV | D 1 0 10 | 4 | | 5·5 | 1034 | 72 | ·069 | −1600 | 1441 | | | |
| Mar. 2 | 2 42 | VI | E 0 44 58 | 4 | | 5·5 | | | | | | | | |
| Feb. 22 | 1 14 | IV | D 0 55 21 | 4 | | 5·5 | 1153 | 82 | ·071 | −1594 | 1447 | | | |
| Apr. 3 | 5 38 | VII | E 0 38 33 | 4 | | 5·5 | | | | | | 1437 | 1460 | |
| Mar. 3 | 2 22 | VI | D 0 5 58 | 4 | | 5·5 | 948 | 152 | ·160 | − 11 | 1427 | | | |
| Apr. 3 | 5 38 | VII | D 0 5 10 | 4 | | 5·5 | | | | | | | | |
| Feb. 21 | 23 49 | IV | D 0 34 33 | 4 | | 5·5 | 1500 | 120 | ·080 | −1056 | 1985 | | | |
| Apr. 10 | 23 16 | VIII | E 0 13 18 | 4 | | 5·5 | | | | | | | | |
| „ 1 | 22 37 | V | D 0 2 12 | 4 | | 5·5 | 1404 | 100 | ·071 | + 329 | 2025 | 1994 | 2020 | |
| „ 10 | 23 16 | VIII | D 0 18 8 | 4 | | 5·5 | | | | | | | | |
| „ 3 | 5 38 | VII | E 0 9 56 | 4 | | 5·5 | 1024 | 52 | ·051 | + 536 | 1973 | | | |
| „ 10 | 23 16 | VIII | D 0 25 38 | 4 | | 5·5 | | | | | | | | |
| Mar. 28 | 4 42 | V | D 0 2 7 | 4 | | 5·5 | 1338 | 85 | ·063 | + 305 | 2001 | | | |
| May 1 | 1 12 | IX | D 0 17 37 | 4 | | 5·5 | | | | | | | | |
| Apr. 3 | 5 38 | VII | E 0 8 8 | 4 | | 5·5 | 1059 | 46 | ·044 | + 511 | 1948 | 1971 | 2000 | |
| May 1 | 1 12 | IX | D 0 24 36 | 4 | | 5·5 | | | | | | | | |
| Apr. 14 | 22 31 | VIII | D 0 9 51 | 4 | | 5·5 | 1203 | 71 | ·059 | − 31 | 1963 | | | |
| May 1 | 1 12 | IX | D 0 8 8 | 4 | | 5·5 | | | | | | | | |

* The mean of observations taken on 4th and 7th March 1837 at $2^h\ 22^m$ and $23^h\ 39^m$ respectively.

| Astronomical Date | | Station | Observed Vertical Angle | Number of observations | Height in feet | | Contained Arc | Terrestrial Refraction | | Height of 2nd Station − 1st Station in feet | Height in feet of 2nd Station above Mean Sea Level | | | Height of Pillar or Tower |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1837—39 & 1854 | Mean of Times of observation | | | | Signal | Instrument | | In seconds | Decimals of Contained Arc | | Trigonometrical Results: By each deduction | Trigonometrical Results: Mean | Final Result | |
| 1837 | | | ° ′ ″ | | | | ″ | | | | | | | *feet* |
| Apr. 15 | 2 14 | VIII | E 0 4 22 | 4 | | 5·5 | 1486 | 43 | ·029 | + 708 | 2702 | | | |
| 1838 Feb. 24 | 0 52 | X | D 0 27 58 | 4 | | 5·5 | | | | | | 2698 | 2730 | |
| „ 9 | 0 49 | IX | E 0 7 20 | 4 | | 5·5 | 1354 | 38 | ·028 | + 722 | 2693 | | | |
| „ 24 | 0 52 | X | D 0 28 54 | 4 | | 5·5 | | | | | | | | |
| „ 10 | 1 34 | IX | E 0 23 20 | 4 | | 5·5 | 1290 | − 3 | ·003 | +1302 | 3273 | | | |
| Mar. 24 | 23 58 | XI | D 0 45 14 | 2 | | 5·5 | | | | | | 3277 | 3320 | |
| Feb. 27 | 1 49 | X | E 0 9 3 | 4 | | 5·5 | 1110 | 38 | ·034 | + 582 | 3280 | | | |
| Mar. 23 | 20 54 | XI | D 0 26 37 | 4 | | 5·5 | | | | | | | | |
| 1839 May 9 | 4 10 | X | E 0 19 13 | 4 | Not forthcoming | 5·5 | 1012 | 56 | ·055 | + 801 | 3499 | | | Not forthcoming |
| „ 2 | 4 59 | XII | D 0 34 36 | 4 | | 5·5 | | | | | | 3506 | 3550 | |
| „ 29 | 1 15 | XI | E 0 12 7 | 4 | | 5·5 | 517 | 74 | ·143 | + 236 | 3513 | | | |
| „ 2 | 1 58 | XII | D 0 18 59 | 4 | | 5·5 | | | | | | | | |
| „ 29 | 1 15 | XI | D 0 15 39 | 4 | | 5·5 | 586 | 20 | ·033 | − 186 | 3091 | | | |
| Mar. 10 | 22 55 | XIII | E 0 5 53 | 4 | | 5·5 | | | | | | 3098 | 3150 | |
| May 2 | 1 58 | XII | D 0 26 18 | 4 | | 5·5 | 665 | 1 | ·001 | − 401 | 3105 | | | |
| Mar. 10 | 22 55 | XIII | E 0 14 41 | 4 | | 5·5 | | | | | | | | |
| May 2 | 1 58 | XII | E 0 4 20 | 4 | | 5·5 | 813 | 14 | ·017 | + 266 | 3772 | | | |
| Apr. 2 | 22 58 | XXV | D 0 17 53 | 4 | | 5·5 | | | | | | 3771 | 3823 | † |
| Mar. 10 | 22 55 | XIII | E 0 20 8 | 4 | | 5·5 | 853 | 44 | ·052 | + 671 | 3769 | | | |
| Jan. 13 1854 | 23 0 | XXV | D 0 35 19 | 4 | | 5·5 | | | | | | | | |
| Feb. 22,23,24 | 2 8 | XXV | D 1 19 17 | 12 | 1·1 | 5·1 | 1028 | 66 | ·064 | −2170 | 1601 | 1601 | 1652 | † |
| Mar. 1,2 | 2 16 | XXVI | E 0 4 5 | 8 | 1·1 | 5·0 | | | | | | | | |
| 1839 Mar. 14 | 4 45 | XIII | D 2 12 38 | 4 | | 5·5 | 704 | −87 | ·123 | −2594 | 504 | | | |
| Feb. 5 1854 | 3 5 | XXIII | E 1 57 29 | 4 | | 5·5 | | | | | | 518 | 582 | † |
| Mar. 1,2 | 2 28 | XXVI | D 0 38 59 | 8 | 1·2 | 5·0 | 1209 | 74 | ·061 | −1069 | 532 | | | |
| Feb. 17,18 1839 | 2 42 | XXIII | E 0 21 3 | 8 | 1·1 | 5·1 | | | | | | | | |
| Mar. 15 | 19 45 | XIII | D 0 42 41 | 4 | | 5·5 | 1487 | 69 | ·047 | −1371 | 1727 | | | |
| 1838 Dec. 15 1854 | 4 35 | XXIV | E 0 19 58 | 4 | | 5·5 | | | | | | | | |
| Feb. 22,23,24 | 2 21 | XXV | D 0 56 41 | 12 | 1·5 | 5·1 | 1513 | 103 | ·068 | −2036 | 1735 | | | |
| „ 8,9,10 | 2 38 | XXIV | E 0 34 43 | 12 | 1·1 | 5·1 | | | | | | 1730 | 1788 | 2 |
| Mar. 1,2 | 2 40 | XXVI | D 0 3 42 | 8 | 1·2 | 5·0 | 1083 | 73 | ·067 | + 135 | 1736 | | | |
| Feb. 8,9,10 | 2 32 | XXIV | D 0 12 12 | 12 | 1·1 | 5·1 | | | | | | | | |
| (1) | 2 39 | XXIII | E 0 46 16 | 12 | 2·9 | 5·1 | 785 | 50 | ·064 | +1204 | 1722 | | | |
| (2) | 2 49 | XXIV | D 0 57 58 | 18 | 1·1 | 5·1 | | | | | | | | |

NOTE.—Stations XXIII, XXIV, XXV and XXVI appertain to the East Coast Series. (1) The mean of observations taken on 25th March 1863 and 17th, 18th February 1854. (2) The mean of observations taken on 30th, 31st March 1853 and 6th, 7th, 10th February 1854. † Mark cut on the rock *in situ*.

*May* 1879.

J. B. N. HENNESSEY,

*In charge of Computing Office.*

# SOUTH PARASNATH MERIDIONAL SERIES.

## CO-ORDINATES AND DESCRIPTIONS OF ALL STATIONS AND POINTS.

The following table gives the co-ordinates of all the stations and other fixed points, arranged in alphabetical order, and references to the preceding pages where the descriptions of the primary stations are given. In certain instances numbers are added which have reference to the given data of the triangles by which the station or point has been fixed; when these numbers are omitted it is to be understood that no triangles are given.

Note.—λ stands for Latitude North; L for Longitude East of Greenwich; H for Height of station in feet above mean sea level determined trigonometrically, and *h* for Height of station tower or pillar. The trigonometrical heights always refer to the upper mark-stone or to the upper surface of the pillar on which the theodolite stood. For visited stations and for other points of superior accuracy the values of λ and L are given to two places of decimals; for well determined objects to one place, and for the remaining points to the nearest second. Primary stations are distinguished by the Roman numerals I, II, &c. The names in italics are those of the territories, states or districts in which the stations or points are situated.

| Name of station, district, description, co-ordinates &c. | Name of station, district, description, co-ordinates &c. | Name of station, district, description, co-ordinates &c. |
|---|---|---|
| Amjhori, XII. (*Vide page* 5) | Barágaon Hill Mark. (*Mayurbhanja Estate*) | Bolpál, XXVI*. (*Vide page* 6) |
| λ 21 51 24·98 | λ 21 51 23·24 | λ 21 22 0·94 |
| L 86 21 47·78 | L 86 9 20·56 | L 86 30 27·25 |
| H 3550 | No. 38 | H 1652 |
| *h* *Not forthcoming* | | *h* 0 |
| No. 15 | | No. 18 |
| Badampahár, X. (*Vide page* 5) | Bári, III. (*Vide page* 4) | Chainpur, LVIII†. (*Vide page* 3) |
| λ 22 4 9·51 | λ 23 6 49·84 | λ 23 33 16·51 |
| L 86 9 52·31 | L 86 35 45·55 | L 85 53 46·41 |
| H 2730 | H 730 | H 2085 |
| *h* *Not forthcoming* | *h* *Not forthcoming* | *h* 3 |
| No. 13 | No. 4 | No. 1 |
| Bághmuri, VIII. (*Vide page* 4) | Bhandári, VI. (*Vide page* 4) | Dalma, IV. (*Vide page* 4) |
| λ 22 28 59·64 | λ 22 50 30·54 | λ 22 53 22·59 |
| L 86 9 26·51 | L 86 34 7·70 | L 86 15 44·19 |
| H 2020 | H 1460 | H 3060 |
| *h* *Not forthcoming* | *h* *Not forthcoming* | *h* *Not forthcoming* |
| Nos. 7, 10 | No. 8 | Nos. 3, 5 |

* Of the East Coast Series. † Of the Calcutta Longitudinal Series.

Name of station, district, description, co-ordinates &c.

Dhoba Hill Mark.
(*Singhbhoom*)

| | ° | ′ | ″ |
|---|---|---|---|
| λ | 22 | 42 | 7·03 |
| L | 86 | 14 | 11·22 |

Nos. 33, 34

Digádi Hill Mark.
(*Manbhoom*) On higher peak.

| | | | |
|---|---|---|---|
| λ | 23 | 7 | 39·26 |
| L | 86 | 8 | 25·07 |

Nos. 29, 30

Dolki Hill Mark.
(*Mayurbhanja Estate*)

| | | | |
|---|---|---|---|
| λ | 21 | 47 | 45·07 |
| L | 86 | 15 | 31·42 |

Nos. 40, 41

Dúmarbera Hill Peak.
(*Manbhoom*)

| | | | |
|---|---|---|---|
| λ | 23 | 12 | 24·1 |
| L | 86 | 15 | 47·8 |

Nos. 25, 26

Ganpati Hill Mark.
(*Mayurbhanja Estate*)

| | | | |
|---|---|---|---|
| λ | 21 | 43 | 49·64 |
| L | 86 | 19 | 21·99 |

Nos. 42, 43

Gorgáburu, I.
(*Vide page 4*)

| | | | |
|---|---|---|---|
| λ | 23 | 8 | 30·01 |
| L | 86 | 10 | 21·94 |
| H | 2220 | | |
| *h* | *Not forthcoming* | | |

No. 1

Hill Mark No. 1.
(*Midnapore*) On small peak.

| | | | |
|---|---|---|---|
| λ | 22 | 37 | 12·87 |
| L | 86 | 47 | 8·25 |

No. 37

Hill Mark No. 2.
(*Mayurbhanja Estate*) West station.

| | | | |
|---|---|---|---|
| λ | 21 | 49 | 28·41 |
| L | 86 | 14 | 11·21 |

No. 39

Hill Peak No. 1,
(*Manbhoom*) Conical.

| | | | |
|---|---|---|---|
| λ | 22 | 55 | 37·5 |
| L | 86 | 16 | 46·7 |

Nos. 31, 32

Hill Peak No. 2.
(*Manbhoom*)

| | | | |
|---|---|---|---|
| λ | 22 | 51 | 10 |
| L | 86 | 42 | 15 |

Name of station, district, description, co-ordinates &c.

Hill Peak No. 3,
(*Singhbhoom*) Low.

| | ° | ′ | ″ |
|---|---|---|---|
| λ | 22 | 41 | 49 |
| L | 86 | 37 | 12 |

Kimhíra, XXIII*.
(*Vide page 6*)

| | | | |
|---|---|---|---|
| λ | 21 | 39 | 34·01 |
| L | 86 | 41 | 10·16 |
| H | 582 | | |
| *h* | 0 | | |

No. 19

Korochia Hill Mark.
(*Manbhoom*)

| | | | |
|---|---|---|---|
| λ | 23 | 20 | 5·91 |
| L | 86 | 29 | 23·91 |

Nos. 21, 22

Kusumbani, XI.
(*Vide page 5*)

| | | | |
|---|---|---|---|
| λ | 21 | 57 | 27·01 |
| L | 86 | 28 | 25·01 |
| H | 3320 | | |
| *h* | *Not forthcoming* | | |

No. 14

Ledásál, V.
(*Vide page 4*)

| | | | |
|---|---|---|---|
| λ | 22 | 41 | 13·05 |
| L | 86 | 31 | 1·13 |
| H | 1720 | | |
| *h* | *Not forthcoming* | | |

No. 6

Megásini (Meghásani), XXV*.
(*Vide page 5*)

| | | | |
|---|---|---|---|
| λ | 21 | 37 | 55·00 |
| L | 86 | 23 | 29·59 |
| H | 3823 | | |
| *h* | 0 | | |

No. 17

Megásini N. Hill Mark.
(*Mayurbhanja Estate*)

| | | | |
|---|---|---|---|
| λ | 21 | 38 | 51·48 |
| L | 86 | 24 | 9·35 |

No. 44

Murári, XIII.
(*Vide page 5*)

| | | | |
|---|---|---|---|
| λ | 21 | 48 | 48·08 |
| L | 86 | 33 | 21·60 |
| H | 3150 | | |
| *h* | *Not forthcoming* | | |

No. 16

Name of station, district, description, co-ordinates &c.

Nilgiri (Nílgirí), XXIV*.
(*Vide page 5*)

| | ° | ′ | ″ |
|---|---|---|---|
| λ | 21 | 28 | 23·72 |
| L | 86 | 48 | 32·40 |
| H | 1788 | | |
| *h* | 2 | | |

No. 20

Parása, II.
(*Vide page 4*)

| | | | |
|---|---|---|---|
| λ | 23 | 7 | 14·64 |
| L | 86 | 43 | 7·55 |
| H | 920 | | |
| *h* | *Not forthcoming* | | |

No. 2

Rájpati Hill Peak.
(*Manbhoom*)

| | | | |
|---|---|---|---|
| λ | 23 | 14 | 51·7 |
| L | 86 | 15 | 57·0 |

Nos. 23, 24

Rangámati Hill Mark.
(*Singhbhoom*)

| | | | |
|---|---|---|---|
| λ | 22 | 40 | 17·36 |
| L | 86 | 20 | 2·87 |

Nos. 35, 36

Sáthakra, IX.
(*Vide page 4*)

| | | | |
|---|---|---|---|
| λ | 22 | 19 | 0·75 |
| L | 86 | 28 | 12·86 |
| H | 2000 | | |
| *h* | *Not forthcoming* | | |

Nos. 11, 12

Sideshar, VII.
(*Vide page 4*)

| | | | |
|---|---|---|---|
| λ | 22 | 36 | 35·80 |
| L | 86 | 25 | 57·30 |
| H | 1460 | | |
| *h* | *Not forthcoming* | | |

No. 9

Siringi Hill Peak.
(*Manbhoom*)

| | | | |
|---|---|---|---|
| λ | 23 | 8 | 17·6 |
| L | 86 | 13 | 51·8 |

Nos. 27, 28

Tilabani LXI†.
(*Vide page 3*)

| | | | |
|---|---|---|---|
| λ | 23 | 24 | 59·87 |
| L | 86 | 35 | 41·82 |
| H | 1329 | | |
| *h* | 2 | | |

No. 1

* Of the East Coast Series. † Of the Calcutta Longitudinal Series.

*May* 1879.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

SOUTH PARASNATH MERIDIONAL SERIES.

Fig. No. 1

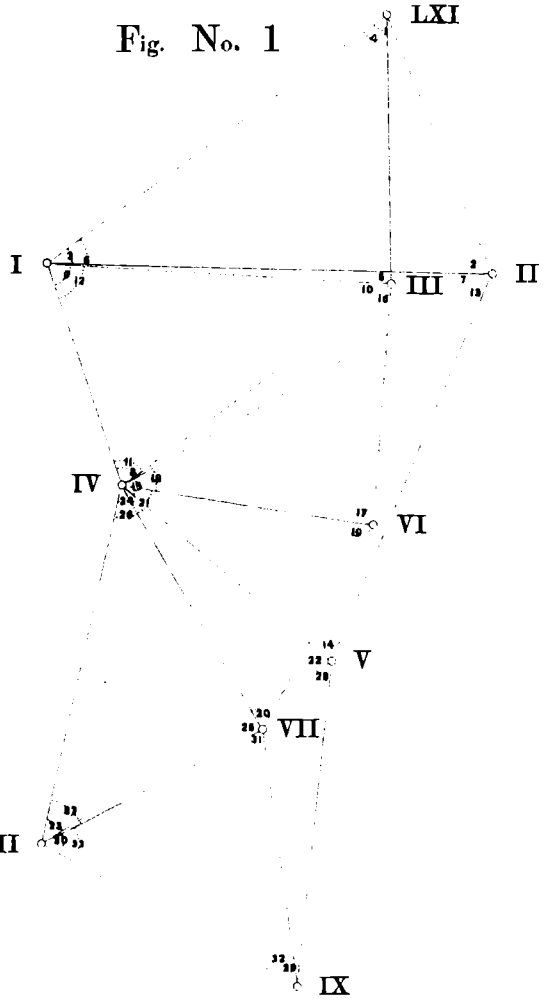
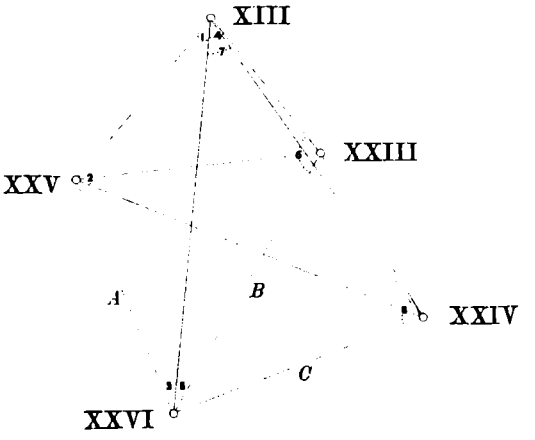



Fig. No. 2




Scale 1 Inch = 12 Miles or $\frac{1}{760320}$

Photomacrographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, January 1865

C. Dyson, Photo.

C. G. Offenbach, Zinco.

# SOUTH MALUNCHA MERIDIONAL SERIES.

# SOUTH MALUNCHA MERIDIONAL SERIES.

## ALPHABETICAL LIST OF PRIMARY STATIONS.


| | | | |
|---|---|---|---|
| Bánsgaria | XIII. | Kalsíbhánga | X. |
| Báuljori | VII. | Kukurmuri | VIII. |
| Dántún (Dántan) (Of the East Coast Series). | XVI. | Kundába | II. |
| Dháusola | VI. | Mauliákhál | XII. |
| Gop | XI. | Sátpautia (Of the East Coast Series). | XVII. |
| Hátiári | V. | Súsinia (Of the Calcutta Longitudinal Series). | LXV. |
| Jalhári | I. | Tilabani (Of the Calcutta Longitudinal Series). | LXI. |
| Káema | IV. | Tura | III. |
| Kalábani | IX. | | |

# SOUTH MALUNCHA MERIDIONAL SERIES.

## NUMERICAL LIST OF PRIMARY STATIONS.

| | | | |
|---|---|---|---|
| LXI | Tilabani. (Of the Calcutta Longitudinal Series). | VIII | Kukurmuri. |
| LXV | Súsinia. (Of the Calcutta Longitudinal Series). | IX | Kalábani. |
| I | Jalhári. | X | Kalsíbhánga. |
| II | Kundába. | XI | Gop. |
| III | Tura. | XII | Mauliákhál. |
| IV | Káema. | XIII | Bánsgaria. |
| V | Hátiári. | XVI | Dántún (Dántan). (Of the East Coast Series). |
| VI | Dhánsola. | | |
| VII | Báuljori. | XVII | Sátpautia. (Of the East Coast Series). |

## SOUTH MALUNCHA MERIDIONAL SERIES.

### DESCRIPTION OF PRIMARY STATIONS.

The Primary Stations of this Series, when on hills or high mounds, consist of circular masonry pillars for the large theodolites to rest on, surrounded by a platform from 10 to 16 feet square on which the observatory tent was pitched. Being almost invariably on the highest accessible points they rarely required to be raised more than 2 or 3 feet. The pillars contain mark-stones placed vertically over one another, the uppermost being generally flush with the surface. When in the plains, and mounds were not available, towers had to be built; these in some cases consisted of a solid, central pillar of masonry, with mark-stones at top and bottom, and in other cases of perforated pillars of masonry with mark-stones placed in the basement; in both cases they were surrounded by a mass of either stones and earth or sundried bricks to the level of their surface for the observatory tent to rest on. Access to the ground level mark in the perforated pillars was obtained by a passage constructed for the purpose: for a full description of such towers, see pages 44 to 46 of Volume II of the *Account of the Operations, &c.*

The following descriptions have been compiled from those given by the Officers who executed the Series. A few details, such as the name of a village or pargana within which a station is situated, have been obtained from the returns furnished by the civil authorities to whose charge the stations have been committed.

LXI.—(*Of the Calcutta Longitudinal Series*). Tilabani Hill Station, lat. 23° 25′, long. 86° 36′—observed at in 1829, 1834, 1836, 1837, 1845, 1846 and 1867—is on the eastern and higher of two isolated peaks, about 1 mile N.W. of the village from which it derives its name; pargana Ludurka, district Manbhoom.

The pillar is solid and contains two marks, the upper 2·00 feet above the lower which is engraved on the rock *in situ*, having been placed there in 1829. The station was revisited in 1834, 1836 and 1837 for the purpose of originating the South Párasnáth Meridional Series, and in 1845 and 1846 for the purpose of originating the South Malúncha Meridional Series, but no record exists of any alteration in its construction at those times. On again visiting the station in 1867, the upper mark-stone of 1829 appeared undisturbed, and its height was adopted for the new station. The village of Kolabani lies about 1½ miles to S. E.

LXV.—(*Of the Calcutta Longitudinal Series*). Súsinia Hill Station, lat. 23° 24′, long. 87° 2′—observed at in 1830, 1846 and 1867—is on the highest point of a long isolated hill, about a mile in extent, at the base

of which to the S.W. are extensive quarries of sandstone belonging to the Burdwan Stone Co.; pargana Chhátna, district Bankoora.

The pillar is solid and contains two marks, the upper 2·00 feet above the lower which is engraved on the rock *in situ*, having been placed there in 1830. The station was revisited in 1846 for the purpose of originating the South Malúncha Meridional Series, but no record exists of any alteration in its construction at that time. The station was again visited in 1867, when the upper mark-stone of the station of 1830 was found undisturbed, but the mark was not truly in the normal of that below. A new pillar was built to the same height as before. The village of Súsinia lies about ¾ of a mile to W.

I. Jalhári Hill Station, lat. 22° 59′, long. 86° 52′—observed at in 1846—is about 1 mile S.W. of the village so called; pargana Supur, district Manbhoom.

The pillar is solid and contains two marks, the upper 1·5 feet above the lower which is engraved on the rock *in situ*. Khatra village lies 2 miles to E.

II. Kundába Tower Station, lat. 22° 57′, long. 87° 8′—observed at in 1846—is on a slight elevation in the jungle, about 1¼ miles N.E. from the little village so called; pargana Ráipur, district Manbhoom.

There is a mound of stones 12·6 feet high with mark-stones at top and bottom.

III. Tura Hill Station, lat. 22° 49′, long. 86° 54′—observed at in 1846—is on a low hill 1·88 miles S.W. of the village of Sonagara; pargana Shyámsundarpur, district Manbhoom. The ascent to the station is easy and practicable for bullocks or camels.

The pillar is solid and isolated. It is 1·83 feet high and has a mark-stone at top and another at bottom. Shyámsundarpur village lies 2¼ miles to S. E.

IV. Káema Tower Station, lat. 22° 46′, long. 87° 7′—observed at in 1846—is on a slightly elevated spot in the jungle, about ½ a mile S.E. of the little village so called; pargana Ráipur, district Manbhoom.

The pillar is solid and isolated. It is 11·06 feet high and has a mark-stone at top, another at the surface of the ground and a third 8 inches below the latter. Saringa village lies 3 miles to W.

V. Hátiári Hill Station, lat. 22° 39′, long. 86° 54′—observed at in 1846 and 1847—is on a low hill or mound about ½ a mile S.E. of the village of Hijra; pargana Jhatibani, district Midnapore. The little river Tarapini flows at the northern base of the hill.

The pillar is solid and 2·84 feet high with mark-stones at top and bottom. Silda village lies about 4 miles to W.

VI. Dhánsola Tower Station, lat. 22° 37′, long. 87° 7′—observed at in 1846 and 1847—is on a slight elevation in thick tree jungle, about 1½ miles S.W. of the village so called; pargana Sakakulia, district Midnapore.

The pillar is solid and isolated. It is 15·48 feet high and has a mark-stone buried in the ground, another at the surface of the ground, a third at the height of 8·57 feet and a fourth at the top. Lálgarh village (the residence of the zamíndár) is about 3 miles to S. W.

VII. Báuljori Tower Station, lat. 22° 30′, long. 86° 59′—observed at in 1847—is on a ridge of jungly ground about ¾ of a mile N. of the village so called; pargana Jambani, district Midnapore.

The pillar is solid and isolated. It is 12·5 feet high and has mark-stones at top and bottom.

VIII. Kukurmuri Tower Station, lat. 22° 29′, long. 87° 8′—observed at in 1847—is on the S.E. corner of the embankment of a tank about ¼ of a mile N. of the little village so called; pargana Bahádurpur, district Midnapore.

The pillar is solid and 42·46 feet high with mark-stones at top and bottom. The large village of Dherua lies 1 mile to N. and the river Kosi flows about ¾ of a mile to W.

IX. Kalábani Tower Station, lat. 22° 24′, long. 87° 3′—observed at in 1847, 1852 and 1853—is on a slightly elevated ridge in very thick high jungle, about ½ a mile S.W. of the village so called; pargana Jhargrám, district Midnapore.

The pillar is solid and 18·5 feet high with mark-stones at top and bottom. Jhargrám village (the residence of the Rája) lies 2¼ miles to N. E.

X. Kalsíbhánga Tower Station, lat. 22° 20′, long. 87° 11′—observed at in 1847, 1849-50, 1852 and 1853—is on slightly rising ground near the edge of the jungle, ½ a mile N.E. of the village so called; pargana Digparui, district Midnapore.

The pillar is solid and 24 feet high with mark-stones at top and bottom. The road from Midnapore to Nágpur passes about 3½ miles to N.

XI. Gop Tower Station, lat. 22° 25′, long. 87° 19′—observed at in 1846 and 1847—is on a spur of the ridge of high land immediately above the Kosi river and a few yards W. of the northern entrance to Gop house; pargana Bhanjabhum, district Midnapore.

No description of the construction of the pillar is forthcoming. The village of Lepura lies about ¼ of a mile to S. W; Jansol, about the same distance to N.; and the Collector's Kachahri at Midnapore, about 2 miles east.

XII. Mauliákhál Tower Station, lat. 22° 7′, long. 87° 3′—observed at in 1853—is on the densely wooded ridge which skirts the Subarnrekha river on the S. and is named after a stream about a mile N. of the station; pargana Nayagrám, district Midnapore.

The pillar is perforated and 25 feet in height. It has a mark-stone in the ground floor. The village of Chandbela lies about 2½ miles to S.; and the secondary station of Jagannáthpur about 2½ miles to N.

XIII. Bánsgaria Tower Station, lat. 22° 9′, long. 87° 16′—observed at in 1853—is near the small village of this name; pargana Náráyangar, district Midnapore.

The pillar is 32·42 feet high having its upper portion perforated, so as to admit of plumbing over the station mark which is imbedded about 19 feet above the base. The azimuths and distances of the circumjacent villages are as follows:—Deogaria 5° 44′, mile 0·409; Relagaria 62° 51′, mile 0·431; Bánsgaria No. 1 280° 11′, mile 0·129; and Bánsgaria No. 2 329° 5′, mile 0·209.

XVI.—(*Of the East Coast Series*). Dántún or Dántan Tower Station, lat. 21° 56′, long. 87° 19′—observed at in 1852 and 1853—is on the bank of a tank at the southern extremity of the large village of Dántan, on the high road from Midnapore to Balasore; pargana Dántan, district Midnapore.

The tower is solid, 30·00 feet high, and has a central pillar of masonry in which the mark-stones have been placed. The azimuths and perambulated distances of the circumjacent villages are:—Chaulia 248° 13′, mile 0·743; Gunduria 306° 34′, miles 1·362; Jamua 326° 25′, miles 2·024; Tákínagar 19° 30′, mile 0·975; and Bencha-Bágara 97° 25′, miles 1·253.

XVII.—(*Of the East Coast Series*). Sátpautia Tower Station, lat. 21° 56′, long. 87° 7′—observed at in 1853—is situated on the thickly wooded flats to the west of the Subarnrekha river and 0·67 of a mile east of the well known temple of Sástarni, where a religious fair is held annually. Chandrekhagarh, a well known ruined fort, lies about 2 miles N. of the station. It is in pargana Nayagrám, district Midnapore.

The pillar is perforated, 35·17 feet high, and has a mark-stone at the ground level. The azimuths and perambulated distances of the circumjacent villages are:—Sátpautia 91° 4′, mile 0·489; Bishwanáthpur 101° 6′, miles 1·614; Chandrekhagarh 133° 34′, miles 1·578; Sástarni 138° 33′, mile 0·714; and Neguria 168° 23′, mile 0·898.

*May* 1879.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## PRIMARY TRIANGULATION—OBSERVED ANGLES.

### At LXI (Tilabani)

**December* 1845; *and* †*June* 1846; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| * R.M. & LXV | 30·87 | 32·79 | 36·94 | 32·79 | 37·97 | 26·42 | 32·31 | 36·91 | 35·35 | 38·05 | 35·92 | 37·40 | 187° 38′ 34″·48 |
| † R.M. & I | 59·64 | 62·81 | 62·67 | 65·72 | 63·62 | 59·90 | 63·56 | 61·79 | 63·07 | 58·58 | 60·18 | 59·75 | 245° 15′ 1″·77 |

### At LXV (Súsinia)

*June* 1846; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| II & I | 51·95 | 51·75 | 61·13 | 52·17 | 58·77 | 56·80 | 59·80 | 57·81 | 58·87 | 55·67 | 52·91 | 57·20 | 33° 7′ 56″·24 |
| I & LXI | 57·62 | 60·61 | 51·97 | 55·07 | 52·74 | 58·87 | 52·62 | 55·38 | 51·02 | 49·27 | 54·42 | 57·08 | 72° 56′ 54″·72 |

NOTE.—Stations LXI and LXV appertain to the Calcutta Longitudinal Series. R.M. denotes Referring Mark.

## At I (Jalhári)

**April*; *and* †*May* 1846; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| †LXI & LXV | 41·42 | 40·97 | 38·35 | 36·14 | 41·46 | 41·67 | 41·09 | 41·68 | 38·90 | 44·74 | 42·64 | 46·30 | 49° 26′ 41″·30 |
| LXV* & III | 38·62 | 39·25 | 41·29 | 36·93 | 35·32 | 39·07 | 31·18 | 31·83 | 30·10 | 31·60 | 36·35 | 32·70 | 147° 26′ 35″·35 |
| II* & III | 47·50 | 49·17 | 42·54 | 42·93 | 42·22 | 42·23 | 40·45 | 36·69 | 40·09 | 42·02 | 43·70 | 42·43 | 73° 8′ 42″·66 |
| †IV & III | 34·45 | 35·79 | 40·17 | 40·35 | 36·02 | 38·95 | 32·30 | 41·29 | 37·07 | 37·59 | 35·05 | 35·85 | 36° 6′ 37″·07 |

## At II (Kundába)

*April* 1846; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IV & III | 32·32 | 31·15 | 38·07 | 32·57 | 34·51 | 31·94 | 34·88 | 31·18 | 31·56 | 32·95 | 33·99 | 26·50 | 51° 49′ 32″·64 |
| IV & I | 59·87 | 61·30 | 63·89 | 59·58 | 64·04 | 55·07 | 67·77 | 69·10 | 67·25 | 67·48 | 66·85 | 68·02 | 89° 5′ 4″·17‡ |
| IV & LXV | 16·13 | 14·61 | 16·10 | 13·74 | 21·50 | 15·21 | 19·51 | 20·66 | 22·25 | 18·05 | 14·81 | 16·65 | 161° 39′ 17″·43 |

## At III (Tura)

*May* 1846; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| I & II | 48·87 | 49·54 | 55·73 | 48·90 | 53·35 | 51·00 | 54·29 | 53·90 | 53·89 | 51·46 | 50·52 | 51·61 | 69° 35′ 51″·92 |
| II & IV | 35·29 | 35·85 | 29·97 | 36·07 | 39·60 | 34·90 | 38·62 | 39·15 | 35·10 | 34·88 | 32·56 | 30·70 | 46° 17′ 35″·22 |

NOTE.—Stations LXI and LXV appertain to the Calcutta Longitudinal Series.
‡ This value should be 4·19; the error was not detected until after completion of the calculations.

## At III (Tura)—(*Continued*).

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IV & VI | 50·84 | 51·42 | 51·19 | 52·06 | 47·24 | 48·04 | 51·39 | 49·39 | 52·95 | 52·30 | 56·45 | 51·50 | 32° 14′ 51″·23 |
| VI & V | 60·05 | 61·08 | 63·98 | 55·82 | 63·46 | 59·00 | 57·23 | 58·22 | 59·32 | 56·62 | 55·75 | 61·79 | 46° 18′ 59″·36 |

## At IV (Káema)

*April* 1846; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| VI & V | 12·28 | 5·62 | 10·37 | 9·10 | 14·22 | 5·04 | 8·41 | 8·25 | 11·70 | 8·92 | 8·25 | 9·76 | 58° 55′ 9″·33 |
| V & III | 12·25 | 11·80 | 11·19 | 12·38 | 8·62 | 20·22 | 14·78 | 12·89 | 8·19 | 9·99 | 9·73 | 9·17 | 44° 0′ 11″·77 |
| III & I | 56·41 | 57·37 | 61·86 | 53·65 | 54·11 | 52·27 | 61·67 | 64·53 | 60·90 | 61·02 | 62·80 | 61·84 | 27° 59′ 59″·04 |
| I & II | 54·45 | 48·37 | 44·95 | 53·87 | 52·27 | 51·92 | 44·79 | 45·89 | 49·12 | 50·70 | 46·38 | 47·72 | 53° 52′ 49″·20 |

## At V (Hátiári)

**May* 1846; *and* †*January* 1847; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| * | " | " | " | " | " | " | " | " | " | " | " | " | |
| III & IV | 58·28 | 57·91 | 59·27 | 57·95 | 60·68 | 51·47 | 55·04 | 62·32 | 55·77 | 60·02 | 53·08 | 56·77 | 57° 25′ 57″·38 |
| * IV & VI | 20·40 | 17·19 | 19·52 | 20·62 | 18·97 | 24·99 | 22·62 | 24·57 | 21·92 | 22·30 | 26·41 | 25·77 | 40° 0′ 22″·11 |
| * VI & VII | 40·30 | 42·09 | 36·80 | 41·59 | 37·27 | 36·67 | 38·18 | 43·25 | 42·23 | 40·77 | 43·95 | 39·09 | 51° 7′ 38″·81 |
| † VI & VII | 35·95 | 37·41 | 41·39 | 38·02 | 38·40 | 35·23 | 43·82 | 38·45 | 33·07 | 36·99 | 32·47 | 37·77 | |

## At VI (Dhánsola)

‡*May* 1846; *and* §*January* 1847; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| §VIII & VII | 34·36 | 42·64 | 44·55 | 44·53 | 39·84 | 33·96 | 36·60 | 38·00 | 32·87 | 39·45 | 32·09 | 34·17 | 59° 26′ 37″·76 |
| §VII & V | 62·58 | 61·70 | 65·75 | 70·18 | 64·80 | 68·07 | 71·50 | 68·84 | 69·59 | 63·77 | 71·27 | 67·85 | 50° 7′ 5″·97 |
| ‡VII & V | 65·80 | 65·52 | 61·60 | 59·12 | 64·73 | 59·66 | 67·75 | 63·67 | 67·69 | 65·45 | 68·60 | 67·62 | |
| ‡V & III | 42·18 | 44·13 | 42·45 | 41·47 | 34·63 | 40·07 | 37·64 | 40·12 | 41·53 | 41·99 | 41·13 | 42·66 | 36° 14′ 40″·83 |
| ‡III & IV | 50·68 | 49·74 | 50·39 | 52·72 | 51·12 | 54·21 | 54·70 | 49·94 | 45·64 | 46·69 | 50·06 | 48·03 | 44° 49′ 50″·33 |

## At VII (Báuljori)

*January* 1847; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| V & VI | 14·01 | 8·43 | 16·36 | 5·19 | 11·75 | 10·06 | 10·27 | 5·22 | 10·97 | 12·80 | 12·44 | 18·94 | 78° 45′ 11″·44 |
| V & VI | 16·75 | 11·94 | 12·64 | 5·45 | 9·00 | 10·69 | 12·95 | 10·35 | 8·82 | 14·54 | 11·07 | 13·77 | |
| VI & VIII | 30·91 | 34·25 | 36·32 | 33·68 | 32·09 | 37·80 | 32·45 | 31·65 | 31·91 | 35·00 | 36·25 | 37·05 | 51° 38′ 34″·11 |
| VIII & IX | 15·64 | 18·67 | 16·88 | 20·42 | 20·34 | 13·14 | 20·97 | 19·39 | 16·92 | 18·09 | 17·25 | 20·32 | 50° 3′ 18″·17 |

## At VIII (Kukurmuri)

*January and February* 1847; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XI & X | 14·97 | 17·02 | 17·29 | 16·13 | 20·45 | 11·25 | 14·04 | 14·89 | 14·45 | 13·52 | 10·23 | 9·18 | 56° 57′ 14″·45 |

## At VIII (Kukurmuri)—(*Continued*).

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| X & IX | 12·45 | 17·78 | 11·07 | 10·92 | 7·90 | 19·23 | 8·97 | 12·24 | 7·22 | 14·54 | 16·22 | 12·25 | 65° 14′ 12″·57 |
| IX & VII | 37·46 | 34·62 | 40·97 | 41·63 | 42·69 | 34·94 | 45·69 | 41·42 | 40·12 | 38·22 | 35·82 | 40·94 | 50° 41′ 39″·54 |
| VII & VI | 47·87 | 50·22 | 42·87 | 43·39 | 37·87 | 43·15 | 45·37 | 43·62 | 44·36 | 43·17 | 41·90 | 41·50 | 68° 54′ 43″·77 |

## At IX (Kalábani)

**February* 1847; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.
† *January* 1853; *observed by Mr. J. Peyton with Troughton and Simms'* 24-*inch Theodolite No.* 1.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| VII & VIII* | 62·57 | 65·53 | 65·90 | 67·68 | 64·93 | 62·75 | 57·43 | 67·50 | 58·72 | 63·41 | 57·35 | 57·45 | 79° 15′ 2″·60 |
| VIII & X* | 70·33 | 68·39 | 63·97 | 65·94 | 61·48 | 59·69 | 65·02 | 66·94 | 59·79 | 58·50 | 66·12 | 64·22 | 64° 42′ 4″·20 |
| X & XII† | 25·83 | 27·48 | 27·66 | 27·11 | 30·23 | 26·83 | 23·53 | 24·94 | 28·70 | 27·14 | 28·17 | 25·17 | 64° 13′ 26″·90 |

## At X (Kalsíbhánga)

‡*February* 1847; *observed by Captain C. T. Hill with Troughton and Simms'* 18-*inch Theodolite No.* 2.
§*January* 1853; *observed by Mr. J. Peyton with Troughton and Simms'* 24-*inch Theodolite No.* 1.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XIII & XII§ | 8·97 | 2·38 | 5·13 | 4·05 | 4·04 | 6·18 | 7·02 | 5·22 | 5·54 | 6·24 | 4·52 | 6·10 | 53° 42′ 5″·45 |
| XII & IX§ | 42·62 | 43·90 | 42·80 | 42·04 | 46·48 | 44·05 | 43·84 | 45·24 | 43·70 | 45·60 | 52·87 | 42·37 | 85° 38′ 43″·79 |
| IX & VIII‡ | 42·92 | 42·37 | 47·00 | 44·15 | 46·07 | 40·42 | 50·09 | 41·81 | 41·59 | 43·80 | 40·55 | 51·02 | 50° 3′ 44″·32 |
| VIII & XI‡ | 41·65 | 45·17 | 36·35 | 43·45 | 43·50 | 47·32 | 37·54 | 43·09 | 40·67 | 45·99 | 39·15 | 41·73 | 74° 2′ 42″·13 |

## At X (Kalsíbhánga)—(*Continued*).

*January* 1850; *observed by Mr. R. Clarkson with Troughton and Simms' 24-inch Theodolite No.* 1.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 20° | 200° | 40° | 220° | 60° | 240° | 80° | 260° | 100° | 280° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IX & R.M. | 59·03 | 57·93 | 61·06 | 59·53 | 66·54 | 59·69 | 61·30 | 59·45 | 60·71 | 59·62 | 61·37 | 60·29 | 49° 50′ 0″·56 |

## At XI (Gop)

*July* 1847; *observed by Captain C. T. Hill with Troughton and Simms' 18-inch Theodolite No.* 2.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| X & VIII | 1·99 | 5·73 | 7·12 | 8·32 | 8·45 | 6·54 | 9·00 | 9·90 | 7·11 | 7·95 | 2·30 | 4·15 | 49° 0′ 6″·55 |

## At XII (Mauliákhál)

*January* 1853; *observed by Mr. J. Peyton with Troughton and Simms' 24-inch Theodolite No.* 1.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| IX & X | 52·99 | 50·79 | 51·87 | 53·27 | 53·33 | 52·08 | 52·27 | 52·21 | 49·57 | 51·52 | 52·90 | 52·30 | 30° 7′ 52″·09 |
| X & XIII | 58·16 | 61·55 | 64·05 | 67·00 | 65·92 | 57·92 | 60·82 | 66·17 | 66·31 | 59·09 | 64·74 | 61·04 | 52° 16′ 2″·73 |
| XIII & XVII | 37·35 | 30·44 | 34·80 | 30·20 | 29·14 | 37·32 | 41·20 | 35·17 | 31·06 | 35·00 | 34·57 | 31·67 | 76° 59′ 33″·99 |

## At XIII (Bánsgaria)

*January* 1853; *observed by Mr. J. Peyton with Troughton and Simms' 24-inch Theodolite No.* 1.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40′ | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XVI & XII | 42·71 | 45·34 | 42·21 | 45·02 | 44·94 | 44·23 | 46·37 | 43·89 | 42·35 | 43·35 | 41·70 | 42·94 | 93° 39′ 43″·75 |

NOTE.—Stations XVI and XVII appertain to the East Coast Series. R.M. denotes Referring Mark.

## At XIII (Bánsgaria)—(*Continued*).

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XVII & XII | 57·35 | 57·47 | 50·97 | 54·17 | 51·97 | 56·37 | 54·49 | 55·45 | 56·07 | 52·38 | 50·92 | 50·05 | 47° 52′ 53″·97 |
| XII & X | 56·52 | 53·65 | 51·74 | 50·72 | 52·44 | 50·30 | 51·65 | 53·10 | 49·06 | 50·15 | 52·15 | 54·07 | 74° 1′ 52″·13 |

## At XVI (Dántún)

*February* 1853; *observed by Mr. J. Peyton with Troughton and Simms'* 24-*inch Theodolite No.* 1.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XVII & XIII | 24·00 | 24·40 | 23·71 | 25·32 | 25·45 | 25·85 | 25·49 | 24·04 | 25·95 | 19·27 | 22·60 | 22·41 | 76° 36′ 24″·04 |

## At XVII (Sátpautia)

*January and February* 1853; *observed by Mr. J. Peyton with Troughton and Simms'* 24-*inch Theodolite No.* 1.

| Angle between | Seconds of Observed Angles at each Zero | | | | | | | | | | | | General Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0° | 180° | 10° | 190° | 20° | 200° | 30° | 210° | 40° | 220° | 50° | 230° | |
| | " | " | " | " | " | " | " | " | " | " | " | " | |
| XII & XIII | 35·60 | 38·27 | 35·90 | 35·15 | 35·29 | 33·37 | 35·62 | 34·37 | 33·74 | 36·77 | 35·21 | 34·35 | 55° 7′ 35″·30 |
| XII & XVI | 24·45 | 25·75 | 23·85 | 22·48 | 22·09 | 23·37 | 21·90 | 22·67 | 27·63 | 25·07 | 25·64 | 26·56 | 112° 44′ 24″·29 |

NOTE.—Stations XVI and XVII appertain to the East Coast Series.

*May* 1879.

J. B. N. HENNESSEY,

*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## PRIMARY TRIANGULATION. REDUCTION OF FIGURES.

*Figure No.* 1.

**Observed Angles†**

| No. | Value | | |
|---|---|---|---|
| | ° | ′ | ″ |
| 1 | 69 | 35 | 51·92 |
| 2 | 36 | 6 | 37·07 |
| 3 | 37 | 2 | 5·59 |
| 4 | 37 | 15 | 31·53 |
| 5 | 51 | 49 | 32·64 |
| 6 | 53 | 52 | 49·20 |
| 7 | 27 | 59 | 59·04 |
| 8 | 46 | 17 | 35·22 |

**Equations to be satisfied**

| | | | | | Factor |
|---|---|---|---|---|---|
| $x_1$ | $+x_2$ | $+x_3$ | $+x_4$ | $= e_1 = +4{\cdot}85,$ | $\lambda_1$ |
| $x_3$ | $+x_4$ | $+x_5$ | $+x_6$ | $= e_2 = -2{\cdot}55,$ | $\lambda_2$ |
| $x_5$ | $+x_6$ | $+x_7$ | $+x_8$ | $= e_3 = -5{\cdot}12,$ | $\lambda_3$ |
| | $-8x_1$ | $+7x_2$ | $-21x_3$ | $= e_4 = -45{\cdot}9,$ | $\lambda_4$ |
| | $+13x_6$ | $-3x_7$ | $+21x_8$ | | |

**Equations between the Factors**

| No. of e | Value of e | Co-efficients of $\lambda_1$ | $\lambda_2$ | $\lambda_3$ | $\lambda_4$ |
|---|---|---|---|---|---|
| 1 | +4·85 | +4 | +2 | ... | −22 |
| 2 | −2·55 | | +4 | +2 | −8 |
| 3 | −5·12 | | * | +4 | +31 |
| 4 | −45·9 | | | | +1173 |

**Values of the Factors**

$\lambda_1 = +1{\cdot}834$

$\lambda_2 = -1{\cdot}162$

$\lambda_3 = -0{\cdot}756$

$\lambda_4 = +0{\cdot}007$

**Angular errors in seconds**

$x_1 = +1{\cdot}78$ $\quad x_5 = -1{\cdot}92$

$x_2 = +1{\cdot}88$ $\quad x_6 = -1{\cdot}82$

$x_3 = +{\cdot}52$ $\quad x_7 = -{\cdot}78$

$x_4 = +{\cdot}67$ $\quad x_8 = -{\cdot}60$

$[wx^2] = 15{\cdot}41$

* In the tables of the equations between the factors the co-efficients of the terms below the diagonal are omitted for convenience, the co-efficient of the $p$th term in the $q$th line being always the same as the co-efficient of the $q$th term in the $p$th line. † These are treated hereafter with *equal* weights.

*Figure No. 2.*

**Observed Angles†**

| No. | Value | | |
|---|---|---|---|
| | ° | ′ | ″ |
| 1 | 57 | 25 | 57·38 |
| 2 | 46 | 18 | 59·36 |
| 3 | 31 | 14 | 51·23 |
| 4 | 44 | 0 | 11·77 |
| 5 | 58 | 55 | 9·33 |
| 6 | 44 | 49 | 50·33 |
| 7 | 36 | 14 | 40·83 |
| 8 | 40 | 0 | 22·11 |

**Equations to be satisfied**

| | | | | | Factor |
|---|---|---|---|---|---|
| $x_1$ | $+x_2$ | $+x_3$ | $+x_4$ | $= e_1 = -1\cdot34,$ | $\lambda_1$ |
| $x_3$ | $+x_4$ | $+x_5$ | $+x_6$ | $= e_2 = +1\cdot67,$ | $\lambda_2$ |
| $x_5$ | $+x_6$ | $+x_7$ | $+x_8$ | $= e_3 = +1\cdot59,$ | $\lambda_3$ |
| | $-14\,x_1$ | $+4\,x_2$ | $-29\,x_3$ | $= e_4 = +0\cdot9,$ | $\lambda_4$ |
| | $+18\,x_6$ | $-3\,x_7$ | $+25\,x_8$ | | |

**Equations between the Factors**

| No. of e | Value of e | Co-efficients of | | | |
|---|---|---|---|---|---|
| | | $\lambda_1$ | $\lambda_2$ | $\lambda_3$ | $\lambda_4$ |
| 1 | $-1\cdot34$ | $+4$ | $+2$ | ... | $-39$ |
| 2 | $+1\cdot67$ | | $+4$ | $+2$ | $-11$ |
| 3 | $+1\cdot59$ | | * | $+4$ | $+40$ |
| 4 | $+0\cdot9$ | | | | $+2011$ |

**Values of the Factors**

$\lambda_1 = -0\cdot835$

$\lambda_2 = +0\cdot678$

$\lambda_3 = +0\cdot223$

$\lambda_4 = -0\cdot016$

**Angular errors in seconds**

| | |
|---|---|
| $x_1 = -0\cdot60$ | $x_5 = +0\cdot90$ |
| $x_2 = -0\cdot90$ | $x_6 = +0\cdot61$ |
| $x_3 = +0\cdot32$ | $x_7 = +0\cdot27$ |
| $x_4 = -0\cdot16$ | $x_8 = -0\cdot19$ |

$[wx^2] = 2\cdot59$

† These are treated hereafter with *equal* weights.

*June* 1879.

J. B. N. HENNESSEY,

*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## PRIMARY TRIANGULATION. TRIANGLES.

| No. of Triangle | | Station | Spherical Excess | Corrections to Observed Angle | | | | Corrected Plane Angle | Distance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Circuit | Non-circuit | | | Figure | Circuit | Non-circuit | Total | | Log. feet | Feet | Miles |
| | | | " | " | " | " | " | ° ′ ″ | | | |
| 1 | | LXI | 1·77 | + ·67 | +1·22 | | +1·89 | 57 36 27·41 | 5·2083185,5 | 161554·3 | 30·597 |
| | | LXV | 1·77 | + ·67 | −1·36 | | − ·69 | 72 56 52·26 | 5·2622460,4 | 182913·6 | 34·643 |
| | | I | 1·77 | + ·66 | + ·14 | | + ·80 | 49 26 40·33 | 5·1624568,7 | 145364·0 | 27·531 |
| | | | 5·31 | | | | +2·00 | 180 0 0·00 | | | |
| 2 | | LXV | 1·13 | + ·40 | −1·06 | | − ·66 | 33 7 54·45 | 4·9663750,0 | 92549·7 | 17·528 |
| | | I | 1·14 | + ·41 | +1·17 | | +1·58 | 74 17 53·13 | 5·2122150,4 | 163010·3 | 30·873 |
| | | II | 1·14 | + ·41 | − ·11 | | + ·30 | 72 34 12·42 | 5·2083185,5 | 161554·3 | 30·597 |
| | | | 3·41 | | | | +1·22 | 180 0 0·00 | | | |
| 3 | | I | ·42 | −2·40 | + ·32 | | −2·08 | 73 8 40·16 | 4·9754422,2 | 94502·3 | 17·898 |
| | | II | ·42 | − ·67 | − ·59 | | −1·26 | 37 15 29·85 | 4·7765615,9 | 59780·8 | 11·322 |
| | | III | ·42 | −1·78 | + ·27 | | −1·51 | 69 35 49·99 | 4·9663750,0 | 92549·7 | 17·528 |
| | | | 1·26 | | | | −4·85 | 180 0 0·00 | | | |
| 4 | | II | ·41 | +1·92 | − ·79 | | +1·13 | 51 49 33·36 | 4·8753155,9 | 75043·9 | 14·213 |
| | | III | ·40 | + ·60 | + ·86 | | +1·46 | 46 17 36·28 | 4·8388883,7 | 69006·2 | 13·069 |
| | | IV | ·41 | +2·60 | − ·07 | | +2·53 | 81 52 50·36 | 4·9754422,2 | 94502·3 | 17·898 |
| | | | 1·22 | | | | +5·12 | 180 0 0·00 | | | |
| | 15 | I | ·50 | − ·52 | | + ·87 | + ·35 | 37 2 5·44 | 4·8388883,8 | 69006·2 | 13·069 |
| | | II | ·51 | +1·25 | | −1·38 | − ·13 | 89 5 3·53 | 5·0590196,0 | 114556·5 | 21·696 |
| | | IV | ·50 | +1·82 | | + ·51 | +2·33 | 53 52 51·03 | 4·9663750,0 | 92549·7 | 17·528 |
| | | | 1·51 | | | | +2·55 | 180 0 0·00 | | | |
| 5 | | III | ·36 | + ·58 | + ·02 | | + ·60 | 78 33 50·83 | 4·9409027,2 | 87277·6 | 16·530 |
| | | IV | ·36 | + ·16 | − ·40 | | − ·24 | 44 0 11·17 | 4·7914070,5 | 61859·6 | 11·716 |
| | | V | ·36 | + ·60 | + ·38 | | + ·98 | 57 25 58·00 | 4·8753155,9 | 75043·9 | 14·213 |
| | | | 1·08 | | | | +1·34 | 180 0 0·00 | | | |

NOTES.—1. The values of the side are given in the same line with the opposite angle.
2. Stations LXI and LXV appertain to the Calcutta Longitudinal Series.

| No. of Triangle | | Station | Spherical Excess | Corrections to Observed Angle | | | | Corrected Plane Angle | Distance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Circuit | Non-circuit | | | Figure | Circuit | Non-circuit | Total | | Log. feet | Feet | Miles |
| | | | " | " | " | " | " | ° ′ ″ | | | |
| | | IV | ·34 | − ·90 | − ·73 | | −1·63 | 58 55 7·36 | 4·8788978,7 | 75663·7 | 14·330 |
| 6 | | V | ·33 | + ·19 | + ·60 | | + ·79 | 40 0 22·57 | 4·7543172,3 | 56795·9 | 10·757 |
| | | VI | ·34 | − ·88 | + ·13 | | − ·75 | 81 4 30·07 | 4·9409027,2 | 87277·6 | 16·530 |
| | | | 1·01 | | | | −1·59 | 180 0 0·00 | | | |
| | | III | ·33 | − ·32 | | + ·61 | + ·29 | 32 14 51·19 | 4·7543172,1 | 56795·9 | 10·757 |
| | 16 | IV | ·33 | − ·74 | | −1·13 | −1·87 | 102 55 18·90 | 5·0159791,3 | 103747·9 | 19·649 |
| | | VI | ·33 | − ·61 | | + ·52 | − ·09 | 44 49 49·91 | 4·8753155,9 | 75043·9 | 14·213 |
| | | | ·99 | | | | −1·67 | 180 0 0·00 | | | |
| | | V | ·27 | +1·53 | − ·40 | | +1·13 | 51 7 39·67 | 4·7785929,9 | 60061·1 | 11·375 |
| 7 | | VI | ·27 | +1·53 | + ·06 | | +1·59 | 50 7 7·29 | 4·7723157,4 | 59199·2 | 11·212 |
| | | VII | ·28 | +1·54 | + ·34 | | +1·88 | 78 45 13·04 | 4·8788878,7 | 75663·7 | 14·330 |
| | | | ·82 | | | | +4·60 | 180 0 0·00 | | | |
| | | VI | ·20 | +1·66 | − ·71 | | + ·95 | 59 26 38·51 | 4·7437660,1 | 55432·7 | 10·499 |
| 8 | | VII | ·20 | +1·65 | + ·19 | | +1·84 | 51 38 35·75 | 4·7031017,8 | 50478·0 | 9·560 |
| | | VIII | ·21 | +1·66 | + ·52 | | +2·18 | 68 54 45·74 | 4·7785929,9 | 60061·1 | 11·375 |
| | | | ·61 | | | | +4·97 | 180 0 0·00 | | | |
| | | VII | ·14 | + ·04 | − ·70 | | − ·66 | 50 3 17·37 | 4·6360566,1 | 43257·0 | 8·193 |
| 9 | | VIII | ·15 | + ·04 | + ·37 | | + ·41 | 50 41 39·80 | 4·6400707,4 | 43658·7 | 8·269 |
| | | IX | ·15 | + ·05 | + ·33 | | + ·38 | 79 15 2·83 | 4·7437660,1 | 55432·7 | 10·499 |
| | | | ·44 | | | | + ·13 | 180 0 0·00 | | | |
| | | VIII | ·16 | − ·21 | − ·72 | | − ·93 | 65 14 11·48 | 4·7095127,7 | 51228·6 | 9·702 |
| 10 | | IX | ·16 | − ·21 | − ·32 | | − ·53 | 64 42 3·51 | 4·7076172,0 | 51005·5 | 9·660 |
| | | X | ·15 | − ·20 | +1·04 | | + ·84 | 50 3 45·01 | 4·6360566,1 | 43257·0 | 8·193 |
| | | | ·47 | | | | − ·62 | 180 0 0·00 | | | |
| | | VIII | ·22 | − ·83 | | | − ·83 | 56 57 13·40 | 4·7531906,8 | 56648·8 | 10·729 |
| | 17 | X | ·22 | − ·83 | | | − ·83 | 74 2 41·08 | 4·8127660,1 | 64978·0 | 12·306 |
| | | XI | ·21 | − ·82 | | | − ·82 | 49 0 5·52 | 4·7076172,0 | 51005·5 | 9·660 |
| | | | ·65 | | | | −2·48 | 180 0 0·00 | | | |
| | | IX | ·37 | − ·55 | −1·22 | | −1·77 | 64 13 24·76 | 4·9633069,8 | 91898·2 | 17·405 |
| 11 | | X | ·38 | − ·56 | − ·04 | | − ·60 | 85 38 42·81 | 5·0075687,8 | 101758·0 | 19·272 |
| | | XII | ·37 | − ·55 | +1·26 | | + ·71 | 30 7 52·43 | 4·7095127,7 | 51228·6 | 9·702 |
| | | | 1·12 | | | | −1·66 | 180 0 0·00 | | | |
| | | X | ·45 | + ·34 | − ·86 | | − ·52 | 53 42 4·48 | 4·8867003,9 | 77037·2 | 14·590 |
| 12 | | XII | ·44 | + ·34 | − ·29 | | + ·05 | 52 16 2·34 | 4·8785047,1 | 75597·0 | 14·318 |
| | | XIII | ·45 | + ·35 | +1·15 | | +1·50 | 74 1 53·18 | 4·9633069,8 | 91898·2 | 17·405 |
| | | | 1·34 | | | | +1·03 | 180 0 0·00 | | | |
| | | XII | ·42 | − ·67 | − ·98 | | −1·65 | 76 59 31·92 | 4·9613774,9 | 91490·8 | 17·328 |
| 13 | | XIII | ·41 | − ·67 | + ·62 | | − ·05 | 47 52 53·51 | 4·8429305,0 | 69651·5 | 13·192 |
| | | XVII | ·42 | − ·67 | + ·56 | | − ·31 | 55 7 34·57 | 4·8867003,9 | 77037·2 | 14·590 |
| | | | 1·25 | | | | −2·01 | 180 0 0·00 | | | |
| | | XIII | ·41 | − ·52 | −1·11 | | −1·63 | 45 46 47·74 | 4·8286593,6 | 67401·5 | 12·765 |
| 14 | | XVII | ·41 | − ·52 | − ·41 | | − ·93 | 57 36 47·65 | 4·8999271,9 | 79419·5 | 15·042 |
| | | XVI | ·42 | − ·53 | +1·52 | | + ·99 | 76 36 24·61 | 4·9613774,9 | 91490·8 | 17·328 |
| | | | 1·24 | | | | −1·57 | 180 0 0·00 | | | |

NOTE.—Stations XVI and XVII appertain to the East Coast Series.

*June* 1879.

J. B. N. HENNESSEY,

*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## SECONDARY TRIANGULATION. TRIANGLES.

### PRIMARY-AUXILIARY STATIONS, AND INTERSECTED POINTS.

Differences between the common sides of two triangles to stations and intersected points, are shown by the small figures in the column for "Distance in Feet" between the data of the two triangles, the earlier of which in order has supplied the greater value: where the difference is small it has usually been apportioned between the triangles, but where it is large no adjustment has been made, as one or other of the two values must be erroneous.

| No. of Triangle | Station | | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|---|
| | | | | Log. feet | Feet | Miles | |
| | | | ° ′ ″ | | | | Inch |
| | Jalhári, I | | 27 51 51 | 4·520855 | 33178 | 6·284 | 18 |
| 18 | Tura, III | | 29 30 2 | 4·543534 | 34957 | 6·621 | „ |
| | Bámunípahár | h.s. | 122 38 7 | 4·776562 | 59781 | 11·322 | 12 |
| | Tura, III | | 27 49 11 | 4·441606 | 27644 | 5·236 | 18 |
| 19 | Bámunípahár | h.s. | 118 6 59 | 4·718041 | 52245 | 9·895 | 12 |
| | Pora | „ | 34 3 50 | 4·520855 | 33178 | 6·284 | „ |
| | | | | | 5 | | |
| | Jalhári, I | | 16 24 13 | 4·441606 | 27644 | 5·236 | 18 |
| 20 | Bámunípahár | h.s. | | 3·887197 | 7713 | 1·461 | |
| | Pora | „ | 159 4 39 | 4·543534 | 34957 | 6·621 | 12 |
| | Jalhári, I | | 132 17 18 | 4·025567 | 10606 | 2·009 | 18 |
| 21 | Pora | h.s. | 15 10 8 | 3·574218 | 3752 | 0·711 | 12 |
| | Supur Temple | | | 3·887197 | 7713 | 1·461 | |
| | Jalhári, I | | | 4·390651 | 24584 | 4·656 | |
| 22 | Bámunípahár | h.s. | 84 54 48 | 4·611874 | 40914 | 7·749 | „ |
| | Bhutádungri | „ | 58 19 27 | 4·543534 | 34957 | 6·621 | „ |

| No. of Triangle | Station | | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|---|
| | | | | Log. feet | Feet | Miles | |
| | | | ° ′ ″ | | 1 | | Inch |
| | Tura, III | | 47 36 13 | 4·390651 | 24584 | 4·656 | 18 |
| 23 | Bámunípahár | h.s. | 37 43 19 | 4·308932 | 20367 | 3·857 | 12 |
| | Bhutádungri | „ | 94 40 28 | 4·520855 | 33178 | 6·284 | „ |
| | Bámunípahár | h.s. | 59 30 38 | 4·379767 | 23975 | 4·541 | „ |
| 24 | Bhutádungri | „ | 58 24 39 | 4·374751 | 23700 | 4·489 | „ |
| | Mátiála Factory | | | 4·390651 | 24584 | 4·656 | |
| | Bámunípahár | h.s. | 43 30 49 | 4·236982 | 17258 | 3·268 | „ |
| 25 | Bhutádungri | „ | 57 43 32 | 4·326174 | 21192 | 4·014 | „ |
| | Bárgaon House | | | 4·390651 | 24584 | 4·656 | |
| | Tura, III | | 25 17 50 | 4·095079 | 12447 | 2·357 | „ |
| 26 | Bhutádungri | h.s. | 19 3 56 | 3·978414 | 9515 | 1·802 | „ |
| | Sonágarh House | | | 4·308932 | 20367 | 3·857 | |
| | Tura, III | | 128 23 19 | 4·609706 | 40710 | 7·710 | „ |
| 27 | Bámunípahár | h.s. | | 4·030119 | 10718 | 2·030 | |
| | Torábánd | „ | 39 42 8 | 4·520855 | 33178 | 6·284 | „ |

NOTES.—1. Names followed by Roman numerals are those of Primary Stations.
2. The values of the side are given in the same line with the opposite angle.

| No. of Triangle | Station | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|
| | | | Log. feet | Feet | Miles | |
| | | ° ′ ″ | | | | Inch |
| | Tura, III | 32 19 21 | 4·024840 | 10589 | 2·005 | 12 |
| 28 | Torábánd h.s. | 114 54 38 | 4·254333 | 17961 | 3·402 | ,, |
| | Shyámsundarpur House | | 4·030119 | 10718 | 2·030 | |
| | Tura, III | 29 22 24 | 4·037598 | 10904 | 2·065 | ,, |
| 29 | Torábánd h.s. | 121 48 9 | 4·276313 | 18894 | 3·578 | ,, |
| | Shyámsundarpur Factory | | 4·030119 | 10718 | 2·030 | |
| | Tura, III | 20 57 42 | 4·544803 | 35059 | 6·640 | 18 |
| 30 | Káema, IV | 109 3 54 | 4·966731 | 92626 | 17·543 | ,, |
| | Rámgar Hill Mark (heliotrope) | | 4·875316 | 75044 | 14·213 | |
| | Hátiári, V | 37 27 2 | 4·733128 | 54091 | 10·245 | ,, |
| 31 | Dhánsola, VI | | 4·500027 | 31625 | 5·990 | |
| | Báinpur s. | 121 43 28 | 4·878888 | 75664 | 14·330 | 7 |
| | Hátiári, V | 14 38 5 | 4·454753 | 28494 | 5·397 | 18 |
| 32 | Báuljori, VII | 17 1 41 | 4·518854 | 33026 | 6·255 | ,, |
| | Báinpur Scaffold (heliotrope) | | 4·772316 | 59199 | 11·212 | |
| | Báuljori, VII | 16 11 54 | 4·135914 | 13675 | 2·590 | ,, |
| 33 | Kalábani, IX | 100 50 51 | 4·682537 | 48143 | 9·118 | ,, |
| | Ándharisol Pillar (heliotrope) | | 4·640071 | 43659 | 8·269 | |

| No. of Triangle | Station | Corrected Plane Angle | Distance | | | Theodolite used |
|---|---|---|---|---|---|---|
| | | | Log. feet | Feet | Miles | |
| | | ° ′ ″ | | | | Inch |
| | Kukurmuri, VIII | 79 50 31 | 4·703453 | 50519 | 9·568 | 18 |
| 34 | Kalsíbhánga, X | 16 32 15 | 4·164615 | 14609 | 2·767 | ,, |
| | Dudhiákháli s. | | 4·707617 | 51006 | 9·660 | |
| | Kukurmuri, VIII | 40 33 5 | 3·977615 | 9498 | 1·799 | ,, |
| 35 | Dudhiákháli s. | 49 24 12 | 4·045034 | 11093 | 2·101 | 12 |
| | Ámgauri ,, | 90 2 43 | 4·164615 | 14609 | 2·767 | ,, |
| | Kalsíbhánga, X | 6 33 56 | 4·015674 | 10368 | 1·964 | 18 |
| 36 | Gop, XI | 134 46 11 | 4·808700 | 64372 | 12·192 | ,, |
| | Midnapore Park House (helio.) | | 4·753191 | 56649 | 10·729 | |
| | Kalsíbhánga, X | | 4·080957 | 12049 | 2·282 | |
| 37 | Gop, XI | 121 10 19 | 4·804310 | 63725 | 12·069 | ,, |
| | Nazargauj s. | 49 31 4 | 4·753191 | 56649 | 10·729 | 12 |
| | Kalsíbhánga, X | 59 55 35 | 4·906089 | 80554 | 15·257 | 24 |
| 38 | Bánsgaria, XIII | | 4·928829 | 84885 | 16·077 | |
| | Jagannáthpur t.s. | 54 18 15 | 4·878505 | 75597 | 14·318 | ,, |
| | | | | ° | | |
| | Kalábani, IX | 66 52 10 | 4·928829 | 84885 | 16·077 | ,, |
| 39 | Kalsíbhánga, X | 79 25 13 | 4·957779 | 90736 | 17·185 | ,, |
| | Jagannáthpur t.s. | 33 42 37 | 4·709513 | 51229 | 9·702 | ,, |

*June* 1879.

J. B. N. HENNESSEY,

*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## AZIMUTHS OF SURROUNDING STATIONS AND POINTS, AT PRIMARY, PRIMARY-AUXILIARY, AND SECONDARY STATIONS.

The following table contains, in the first column, the name of each Primary, Primary-Auxiliary, or Secondary Station, at which azimuths of surrounding Points have been measured; immediately followed by those azimuths. The second column contains the number of the triangle which gives the distance between the Station and the Point.

| Name of station with azimuths of surrounding points | | ° ′ ″ | No. of triangle giving distance |
|---|---|---|---|
| ÁMGAURI s. | | | |
| Kukurmuri, VIII | | 44 47 10 | 35 |
| Dudhiákháli | s. | 314 44 27 | 35 |
| BAINPUR s. | | | |
| Hátiári, V | | 136 57 27 | 31 |
| Dhánsola, VI | | 258 40 55 | 31 |
| BAMUNIPAHAR h.s. | | | |
| Jalhári, I | | 195 25 44 | 18 |
| Pora | h.s. | 199 56 52 | 19 |
| Mátiála Factory | | 220 49 54 | 24 |
| Bárgaon House | | 236 49 43 | 25 |
| Bhutádungri | ,, | 280 20 32 | 22 |
| Tura, III | | 318 3 51 | 18 |
| Torábánd | ,, | 329 58 24 | 27 |
| BANSGARIA, XIII | | | |
| Sátpautia, XVII* | | 33 55 51·4 | 16 |
| Mauliákhál, XII | | 81 46 45·3 | 15 |

| Name of station with azimuths of surrounding points | | ° ′ ″ | No. of triangle giving distance |
|---|---|---|---|
| BANSGARIA, XIII | | | |
| Jagannáthpur | t.s. | 90 2 29 | 38 |
| Kalsíbhánga, X | | 155 48 38·9 | 15 |
| Dántún (Dántan), XVI* | | 348 7 3·2 | 17 |
| BAULJORI, VII | | | |
| Hátiári, V | | 150 38 34·7 | 9 |
| Báinpur Scaffold (heliotrope) | | 167 40 16 | 32 |
| Dhánsola, VI | | 229 23 48·0 | 9 |
| Kukurmuri, VIII | | 281 2 23·9 | 10 |
| Kalábani, IX | | 331 5 41·4 | 11 |
| Ándhárisol Pillar (heliotrope) | | 347 17 35 | 33 |
| BHUTADUNGRI h.s. | | | |
| Tura, III | | 5 41 45 | 23 |
| Bámunípahár | h.s. | 100 22 13 | 22 |
| Bárgaon House | | 158 5 45 | 25 |
| Jalhári, I | | 158 41 40 | 22 |
| Mátiála Factory | | 158 46 52 | 24 |

| Name of station with azimuths of surrounding points | | ° ′ ″ | No. of triangle giving distance |
|---|---|---|---|
| BHUTADUNGRI h.s. | | | |
| Sonágarh House | | 346 37 49 | 26 |
| DANTUN (DANTAN), XVI* | | | |
| Sátpautia, XVII* | | 91 31 43·5 | 17 |
| Bánsgaria, XIII | | 168 8 8·5 | 17 |
| DHANSOLA, VI | | | |
| Báuljori, VII | | 49 26 54·7 | 9 |
| Báinpur | s. | 78 44 32 | 31 |
| Hátiári, V | | 99 34 2·3 | 7 |
| Tura, III | | 135 48 42·4 | 8 |
| Káema, IV | | 180 38 32·7 | 7 |
| Kukurmuri, VIII | | 350 0 16·0 | 10 |
| DUDHIAKHALI s. | | | |
| Kalsíbhánga, X | | 1 43 28 | 34 |
| Kukurmuri, VIII | | 85 20 42 | 34 |
| Ámgauri | s. | 134 44 54 | 35 |

* Of the East Coast Series.

| Name of station with azimuths of surrounding points | | ° ′ ″ | No. of triangle giving distance |
|---|---|---|---|
| **Gop, XI** | | | |
| Kalsíbhánga, X | | 59 17 6·1 | 13 |
| Kukurmuri, VIII | | 108 17 11·9 | 13 |
| Midnapore Park House (helio.) | | 284 30 55 | 36 |
| Nazarganj | s. | 298 6 47 | 37 |
| **Hatiari, V** | | | |
| Tura, III | | 182 2 34·5 | 6 |
| Káema, IV | | 239 28 32·9 | 6 |
| Dhánsola, VI | | 279 28 55·8 | 7 |
| Báinpur Scaffold (heliotrope) | | 315 58 31 | 32 |
| Báinpur | s. | 316 55 58 | 31 |
| Báuljori, VII | | 330 36 35·7 | 9 |
| **Jagannathpur** t.s. | | | |
| Kalábani, IX | | 181 56 12 | 39 |
| Kalsíbhánga, X | | 215 38 49 | 38 |
| Bánsgaria, XIII | | 269 57 4 | 38 |
| **Jalhari, I** | | | |
| Bámunípahár | h.s. | 15 26 23 | 18 |
| Tilabani, LXI* | | 150 41 14·9 | 1 |
| Súsinia, LXV* | | 200 7 57·0 | 1 |
| Supur Temple | | 226 44 52 | 21 |
| Kundába, II | | 274 25 51·3 | 2 |
| Káema, IV | | 311 27 57·2 | 5 |
| Bhutádungri | h.s. | 338 40 38 | 22 |
| Tura, III | | 347 34 31·8 | 3 |
| Pora | ,, | 359 2 10 | 20 |
| **Kaema, IV** | | | |
| Dhánsola, VI | | 0 38 35·3 | 7 |
| Hátiári, V | | 59 33 43·0 | 6 |
| Tura, III | | 103 33 54·5 | 4 |
| Jalhári, I | | 131 33 53·8 | 5 |
| Kundába, II | | 185 26 45·3 | 4 |
| Rámgar Hill Mark (heliotrope) | | 354 30 1 | 30 |
| **Kalabani, IX** | | | |
| Jagannáthpur | t.s. | 1 56 24 | 39 |
| Ándhárisol Pillar (heliotrope) | | 50 16 16 | 33 |

| Name of station with azimuths of surrounding points | | ° ′ ″ | No. of triangle giving distance |
|---|---|---|---|
| **Kalabani, IX** | | | |
| Báuljori, VII | | 151 7 7·3 | 11 |
| Kukurmuri, VIII | | 230 22 10·3 | 11 |
| Kalsibhánga, X | | 295 4 14·0 | 12 |
| Mauliákhál, XII | | 359 17 39·1 | 14 |
| **Kalsibhanga, X** | | | |
| Mauliákhál, XII | | 29 28 38·9 | 14 |
| Jagannáthpur | t.s. | 35 42 9 | 38 |
| Kalábani, IX | | 115 7 22·1 | 12 |
| Kukurmuri, VIII | | 165 11 7·3 | 12 |
| Dudhiákháli | s. | 181 43 22 | 34 |
| Gop, XI | | 239 13 48·6 | 13 |
| Midnapore Park House (helio.) | | 245 47 45 | 36 |
| Nazarganj | s. | 248 32 26 | 37 |
| Bánsgaria, XIII | | 335 46 34·0 | 15 |
| **Kukurmuri, VIII** | | | |
| Kalábani, IX | | 50 24 25·9 | 11 |
| Báuljori, VII | | 101 6 5·9 | 10 |
| Dhánsola, VI | | 170 0 51·8 | 10 |
| Ámgauri | s. | 224 46 38 | 35 |
| Dudhiákháli | ,, | 265 19 43 | 34 |
| Gop, XI | | 288 13 0·7 | 13 |
| Kalsíbhánga, X | | 345 10 14·3 | 12 |
| **Kundaba, II** | | | |
| Káema, IV | | 5 27 12·5 | 4 |
| Tura, III | | 57 16 46·3 | 3 |
| Jalhári, I | | 94 32 16·6 | 2 |
| Súsinia, LXV* | | 167 6 30·1 | 2 |
| **Mauliakhal, XII** | | | |
| Kalábani, IX | | 179 17 44·2 | 14 |
| Kalsíbhánga, X | | 209 25 37·0 | 14 |
| Bánsgaria, XIII | | 261 41 39·8 | 15 |
| Sátpautia, XVII† | | 338 41 12·1 | 16 |
| **Nazarganj** s. | | | |
| Kalsíbhánga, X | | 68 36 27 | 37 |
| Gop, XI | | 118 7 31 | 37 |

| Name of station with azimuths of surrounding points | | ° ′ ″ | No. of triangle giving distance |
|---|---|---|---|
| **Pora** h.s. | | | |
| Bámunípahár | h.s. | 19 57 32 | 19 |
| Jalhári, I | | 179 2 11 | 20 |
| Supur Temple | | 194 12 19 | 21 |
| Tura, III | | 345 53 42 | 19 |
| **Satpautia, XVII†** | | | |
| Mauliákhál, XII | | 158 42 53·0 | 16 |
| Bánsgaria, XIII | | 213 50 28·0 | 16 |
| Dántún (Dántan), XVI† | | 271 27 16·0 | 17 |
| **Susinia, LXV*** | | | |
| Jalhári, I | | 20 11 52·0 | 1 |
| Tilabani, LXI* | | 93 8 46·1 | 1 |
| Kundába, II | | 347 3 56·5 | 2 |
| **Tilabani, LXI*** | | | |
| Súsinia, LXV* | | 272 58 27·0 | 1 |
| Jalhári, I | | 330 34 56·1 | 1 |
| **Toraband** h.s. | | | |
| Bámunípahár | h.s. | 149 59 49 | 27 |
| Tura, III | | 189 41 57 | 27 |
| Shyámsundarpur House | | 304 36 35 | 28 |
| Shyámsundarpur Factory | | 311 30 6 | 29 |
| **Tura, III** | | | |
| Hátiári, V | | 2 2 43·6 | 6 |
| Torábánd | h.s. | 9 42 4 | 27 |
| Bámunípahár | ,, | 138 5 23 | 18 |
| Pora | ,, | 165 54 34 | 19 |
| Jalhári, I | | 167 35 25·3 | 3 |
| Bhutádungri | ,, | 185 41 36 | 23 |
| Sonágarh House | | 210 59 26 | 26 |
| Kundába, II | | 237 11 15·7 | 3 |
| Káema, IV | | 283 28 52·4 | 4 |
| Rámgar Hill Mark (heliotrope) | | 304 26 34 | 30 |
| Dhánsola, VI | | 315 43 43·9 | 8 |
| Shyámsundarpur House | | 337 22 43 | 28 |
| Shyámsundarpur Factory | | 340 19 40 | 29 |

* Of the Calcutta Longitudinal Series. † Of the East Coast Series.

*June* 1879.

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*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## PRIMARY TRIANGULATION. HEIGHTS ABOVE MEAN SEA LEVEL.

The following table gives, first, the usual data of the observed vertical angles and the heights of the signal and instrument, &c., in pairs of horizontal lines, the first line of which gives the data for the 1st or the fixed station, and the second line the data for the 2nd or the deduced station. This is followed by the arc contained between the two stations, and then by the terrestrial refraction, and the height of the 2nd station above or below the 1st, as computed from the vertical angles in the usual manner. This difference of height applied to the given height above mean sea level of the fixed station, gives that of the deduced station. Usually there are two or three independent values of the height of the deduced station; the details are so arranged as to show these consecutively and their mean in the columns of "Trigonometrical Result". The mean results thus obtained are however liable to receive corrections for the errors generated in the trigonometrical operations, which are shown up by the spirit leveling operations, whenever a junction between the two has been effected. The spirit leveled determinations, when available, are always accepted as final, and the trigonometrical heights of stations, lying between other stations fixed by the leveling operations, are adjusted—usually by simple proportion—to accord with the latter.

The heights of the South Malúncha Meridional Series have been adjusted between the final values of Tilabani and Súsinia, the fixed points of the Calcutta Longitudinal Series, and those of the fixed stations of Dántún (Dántan) and Sátpautia of the East Coast Series. The heights of the fixed points are as follows:—

LXI, Tilabani .. 1329·0
LXV, Súsinia .. 1443·8
} feet above Mean Sea Level as brought down from Karáchi.

XVI, Dántún (Dántan) 115·8
XVII, Sátpautia .. 219·5
} " " as determined at Kejiri (or Bedford Station) and Balarámgarhi Tide Points.

| Astronomical Date 1846 | Mean of Times of observation | Station | Observed Vertical Angle | Number of observations | Height in feet: Signal | Height in feet: Instrument | Contained Arc | Terrestrial Refraction: In seconds | Terrestrial Refraction: Decimals of Contained Arc | Height of 2nd Station − 1st Station in feet | Height in feet of 2nd Station above Mean Sea Level: Trigonometrical Results: By each deduction | Trigonometrical Results: Mean | Final Result | Height of Pillar or Tower |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *h m* | | ° ′ ″ | | | | ″ | | | | | | | *feet* |
| June 9 | 3 35 | LXV | D o 26 20·1 | 4 | 4·50 | 5·43 | 1596 | 89 | ·056 | − 681·7 | 762·1 | 762·1 | 763 | 2 |
| April 15 | 8 37 | I | E o 2 36·2 | 4 | 1·03 | 5·30 | | | | | | | | |
| June 16 | 3 44 | LXI | D o 23 39·4 | 4 | 4·50 | 5·38 | 1807 | 109 | ·060 | − 552·9 | 776·1* | | | |
| May 24 | 3 11 | I | D o 2 56·3 | 4 | 1·13 | 5·30 | | | | | | | | |
| June 9 | 4 0 | LXV | D o 35 40·9 | 4 | 1·11 | 5·43 | 1611 | 95 | ·059 | −1126·3 | 317·5 | | | |
| April 11 | 8 50 | II | E o 11 49·0 | 4 | 1·03 | 5·40 | | | | | | 320·8 | 322 | 13 |
| „ 15 | 8 20 | I | D o 23 19·0 | 4 | 1·03 | 5·30 | 914 | 44 | ·048 | − 438·0 | 324·1 | | | |
| „ 12 | 8 12 | II | E o 9 13·4 | 4 | 1·17 | 5·40 | | | | | | | | |

* Rejected.

| Astronomical Date 1846 | Mean of Times of observation | Station | Observed Vertical Angle | Number of observations | Height in feet: Signal | Height in feet: Instrument | Contained Arc | Terrestrial Refraction: In seconds | Terrestrial Refraction: Decimals of Contained Arc | Height of 2nd Station – 1st Station in feet | Height in feet of 2nd Station above Mean Sea Level: Trigonometrical Results: By each deduction | Height in feet of 2nd Station above Mean Sea Level: Trigonometrical Results: Mean | Height in feet of 2nd Station above Mean Sea Level: Final Result | Height of Pillar or Tower |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *h. m.* | | ° ′ ″ | | | | ″ | | | | | | | *feet* |
| April 14 | 8 48 | I | D 0 9 15·4 | 4 | 1·11 | 5·30 | 591 | 21 | ·036 | − 77·2 | 684·9 | | | |
| May 3 | 4 4 | III | D 0 0 23·0 | 4 | 1·05 | 5·37 | | | | | | | | |
| April 11 | 8 3 | II | E 0 5 58·0 | 6 | 1·11 | 5·40 | 934 | 47 | ·050 | + 360·8 | 681·6 | 683·7 | 685 | 2 |
| May 8 | 3 6 | III | D 0 20 13·5 | 4 | 2·61 | 5·37 | | | | | | | | |
| April 22 | 3 5 | IV | E 0 9 11·9 | 4 | 1·11 | 5·78 | 742 | 39 | ·053 | + 326·4 | 684·6 | | | |
| May 3 | 3 19 | III | D 0 20 31·4 | 4 | 4·63 | 5·37 | | | | | | | | |
| „ 23 | 3 21 | I | D 0 20 38·0 | 6 | 4·98 | 5·30 | 1132 | 51 | ·045 | − 401·4 | 360·7 | | | |
| April 24 | 3 23 | IV | E 0 3 26·1 | 4 | 4·69 | 5·78 | | | | | | | | |
| „ 11 | 8 24 | II | D 0 3 57·0 | 4 | 1·22 | 5·40 | 682 | 13 | ·019 | + 34·8 | 355·6 | 357·7 | 359 | 11 |
| „ 29 | 3 15 | IV | D 0 7 26·1 | 6 | 1·15 | 5·78 | | | | | | | | |
| May 3 | 3 19 | III | D 0 20 31·4 | 4 | 4·63 | 5·37 | 742 | 39 | ·053 | − 326·4 | 356·9 | | | |
| April 22 | 3 5 | IV | E 0 9 11·9 | 4 | 1·11 | 5·78 | | | | | | | | |
| May 3 | 3 44 | III | D 0 18 46·3 | 4 | 4·59 | 5·37 | 611 | 28 | ·046 | − 253·7 | 430·0 | | | |
| „ 10 | 3 34 | V | E 0 9 16·7 | 4 | 2·10 | 5·39 | | | | | | | | |
| April 25 | 3 1 | IV | D 0 3 53·4 | 4 | 1·03 | 5·78 | 862 | 31 | ·036 | + 75·1 | 432·8 | 432·1 | 434 | 3 |
| May 11 | 2 58 | V | D 0 9 39·1 | 4 | 4·63 | 5·39 | | | | | | | | |
| „ 18 | 3 18 | VI | D 0 0 29·0 | 4 | 4·52 | *1·53 | 748 | 29 | ·039 | + 109·9 | 433·6 | | | |
| „ 11 | 3 18 | V | D 0 11 5·7 | 4 | *2·33 | 5·39 | | | | | | | | |
| „ 4 | 3 42 | III | D 0 19 56·4 | 4 | *5·68 | 5·37 | 1025 | 53 | ·052 | − 359·9 | 323·8 | | | |
| „ 16 | 3 38 | VI | E 0 4 23·5 | 4 | 2·10 | *1·53 | | | | | | | | |
| April 25 | 3 34 | IV | D 0 7 20·4 | 4 | *2·21 | 5·78 | 561 | − 6 | ·011 | − 34·4 | 323·3 | 322·9 | 325 | 15 |
| May 18 | 3 35 | VI | D 0 2 18·9 | 4 | 4·63 | *1·53 | | | | | | | | |
| „ 11 | 3 18 | V | D 0 11 5·7 | 4 | *2·33 | 5·39 | 748 | 29 | ·039 | − 109·9 | 321·5 | | | |
| „ 18 | 3 18 | VI | D 0 0 29·0 | 4 | 4·52 | *1·53 | | | | | | | | |
| 1847 | | | | | | | | | | | | | | |
| Jan. 24 | 3 46 | V | D 0 9 54·8 | 4 | 1·27 | 5·45 | 585 | 29 | ·050 | − 91·0 | 341·1 | | | |
| „ 16 | 3 50 | VII | E 0 0 46·6 | 4 | 3·17 | 5·33 | | | | | | 340·7 | 343 | 13 |
| „ 22 | 3 21 | VI | D 0 3 30·0 | 4 | 1·27 | 5·39 | 593 | 41 | ·069 | + 17·4 | 340·3 | | | |
| „ 16 | 3 32 | VII | D 0 5 28·5 | 4 | 1·61 | 5·33 | | | | | | | | |
| „ 22 | 3 35 | VI | D 0 13 26·0 | 4 | 2·70 | 5·39 | 499 | 10 | ·020 | − 136·0 | 186·9 | | | |
| Feb. 1 | 3 31 | VIII | E 0 5 13·2 | 4 | 4·73 | 5·42 | | | | | | 187·8 | 191 | 42 |
| Jan. 16 | 3 14 | VII | D 0 13 59·1 | 4 | 1·04 | 5·33 | 548 | 16 | ·029 | − 152·0 | 188·7 | | | |
| „ 31 | 3 10 | VIII | E 0 4 52·4 | 4 | 1·27 | 5·42 | | | | | | | | |
| „ 19 | 3 35 | VII | D 0 1 17·2 | 4 | 24·57 | 5·33 | 431 | 19 | ·044 | + 6·1 | 346·8 | | | |
| Feb. 13 | 3 40 | IX | D 0 5 37·4 | 4 | 1·39 | 25·13 | | | | | | 347·4 | 351 | 19 |

* These heights are to be combined with negative signs, because the pillar at VI had a permanent addition of 6·02 feet made to it subsequently.

| Astronomical Date 1847 | Mean of Times of observation | Station | Observed Vertical Angle | Number of observations | Height in feet: Signal | Height in feet: Instrument | Contained Arc | Terrestrial Refraction: In seconds | Terrestrial Refraction: Decimals of Contained Arc | Height of 2nd Station − 1st Station in feet | Height in feet of 2nd Station above Mean Sea Level: Trigonometrical Results: By each deduction | Height in feet of 2nd Station above Mean Sea Level: Trigonometrical Results: Mean | Height in feet of 2nd Station above Mean Sea Level: Final Result | Height of Pillar or Tower |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *h. m.* | | ° ′ ″ | | | | ″ | | | | | | | *feet* |
| Jan. 30 | 3 28 | VIII | E o 10 27·9 | 4 | 20·66 | 5·42 | 427 | 5 | ·012 | + 160·1 | 347·9 | | | |
| Feb. 11,13 | 3 30 | IX | D o 18 4·8 | 10 | 1·43 | 25·13 | | | | | | | | |
| „ 1 | 3 10 | VIII | E o 4 0·3 | 4 | 14·58 | 5·42 | 504 | 11 | ·022 | + 110·0 | 297·8 | | | |
| „ 18 | 3 10 | X | D o 11 46·4 | 4 | 1·43 | 6·46 | | | | | | 298·9 | 303 | 24 |
| (1) | 3 1 | IX | D o 7 50·9 | 8 | 9·62 | 15·50 | 506 | − 3 | ·006 | − 47·5 | 299·9 | | | |
| (2) | 3 9 | X | D o o 33·8 | 8 | 13·51 | 5·78 | | | | | | | | |
| Feb. 18 | 3 44 | X | D o 9 50·4 | 4 | 13·38 | 6·46 | 560 | 1 | ·002 | − 92·4 | 206·5 | 206·5 | 211 | † |
| July 13 | 3 47 | XI | E o o 47·9 | 4 | 2·48 | 5·06 | | | | | | | | |
| 1852 Dec. 29 | 2 48 | IX | D o 9 14·3 | 4 | 4·54 | 5·86 | 1006 | 43 | ·043 | − 44·6 | 302·8 | | | |
| 1853 Jan. 25 | 2 29 | XII | D o 6 10·3 | 4 | 5·39 | 5·04 | | | | | | 302·9 | 307 | 25 |
| „ 6 | 2 48 | X | D o 6 54·0 | 4 | 4·48 | 5·10 | 908 | 33 | ·036 | + 4·0 | 302·9 | | | |
| „ 25 | 2 21 | XII | D o 7 11·5 | 4 | 4·71 | 5·04 | | | | | | | | |
| „ 6 | 2 58 | X | D o 11 29·8 | 4 | 4·51 | 5·10 | 747 | 17 | ·022 | − 121·2 | 177·7 | | | |
| „ 9 | 2 9 | XIII | D o o 27·9 | 4 | 4·71 | 5·04 | | | | | | 177·0 | 182 | 32 |
| „ 24 | 2 21 | XII | D o 11 45·4 | 4 | 2·39 | 5·04 | 761 | 20 | ·027 | − 126·6 | 176·3 | | | |
| „ 11 | 2 31 | XIII | D o o 21·0 | 4 | 4·74 | 5·04 | | | | | | | | |
| „ 26 | 2 56 | XII | D o 10 24·4 | 4 | 4·72 | 5·04 | 688 | −10 | ·014 | − 90·9 | 212·0 | | | |
| „ 30 | 2 24 | XVII | D o 1 27·0 | 4 | 4·51 | 5·06 | | | | | | 215·0 | 220 | 35 |
| „ 15 | 6 1 | XIII | D o o 31·8 | 4 | 19·58 | 5·04 | 904 | 296 | ·327 | + 40·9 | 217·9 | | | |
| „ 30 | 5 4 | XVII | D o 3 35·4 | 4 | 19·98 | 5·06 | | | | | | | | |
| „ 11 | 2 10 | XIII | D o 9 18·0 | 4 | 4·50 | 5·04 | 785 | 5 | ·007 | − 64·8 | 112·2 | | | |
| Feb. 14 | 2 47 | XVI | D o 3 41·3 | 4 | 4·51 | 5·06 | | | | | | 110·2 | 116 | 30 |
| Jan. 31 | 3 5 | XVII | D o 11 2·4 | 22 | 4·50 | 5·06 | 666 | − 1 | ·002 | − 106·8 | 108·2 | | | |
| Feb. 1,2,3,4,12 | | | | | | | | | | | | | | |
| „ 14,15 | 3 2 | XVI | D o o 8·9 | 8 | 4·50 | 5·06 | | | | | | | | |

NOTE.—Stations XVI and XVII appertain to the East Coast Series.
(1) The mean of observations taken on 9th February 1847 and 31st December 1852. (2) The mean of observations taken on 18th February 1847 and 6th January 1853. † Not forthcoming.

*June* 1879.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## CO-ORDINATES AND DESCRIPTIONS OF ALL STATIONS AND POINTS.

The following table gives the co-ordinates of all the stations and other fixed points, arranged in alphabetical order, also the descriptions of the secondary and intersected (or unvisited) points, and references to the preceding pages where the descriptions of the primary stations are given. In certain instances numbers are added which have reference to the given data of the triangles by which the station or point has been fixed; when these numbers are omitted it is to be understood that no triangles are given.

Note.—λ stands for Latitude North; L for Longitude East of Greenwich; H for Height of station in feet above mean sea level determined trigonometrically, and *h* for Height of station tower or pillar. For visited stations and for other points of superior accuracy the values of λ and L are given to two places of decimals; for well determined objects to one place, and for the remaining points to the nearest second. Primary stations are distinguished by the Roman numerals I, II, &c.; secondary stations by the letters h.s., s. and t.s. The names in italics are those of the territories, states or districts in which the stations or points are situated.

| Name of station, district, description, co-ordinates &c. | Name of station, district, description, co-ordinates &c. | Name of station, district, description, co-ordinates &c. |
|---|---|---|
| Álampur Tree Flag.<br>(*Midnapore*) In centre of village.<br>° ′ ″<br>λ 22 26 36<br>L 87 10 12 | Ándápál Tree Flag.<br>(*Midnapore*) On a high round tree in centre of village.<br>° ′ ″<br>λ 22 24 53<br>L 87 19 7 | Báinpur s.<br>(*Midnapore*) On N. W. bund of tank close to and W. of village; pargana Sildah.<br>° ′ ″<br>λ 22 35 0·16<br>L 86 57 27·72<br>No. 31 |
| Ámdahi s.<br>(*Midnapore*) N. of village; pargana Dharindah.<br>λ 22 24 45·44<br>L 87 17 23·67 | Ándhárisol Pillar (heliotrope).<br>(*Midnapore*)<br>λ 22 22 32·50<br>L 87 0 39·97<br>No. 33 | Bálgoma Palm Tree.<br>(*Midnapore*) In village.<br>λ 22 25 48<br>L 87 11 19 |
| Ámdahi Tree Flag.<br>(*Midnapore*) On high tree in N. W. corner of village.<br>λ 22 24 28<br>L 87 17 11 | Ástora Tree Flag.<br>(*Midnapore*) On a high mango tree in S.W. corner of village.<br>λ 22 25 44<br>L 87 12 16 | Bámtia s.<br>(*Midnapore*) S. W. of village; pargana Bahádurpur.<br>λ 22 24 43·29<br>L 87 15 5·81 |
| Ámgauri s.<br>(*Midnapore*) On a slightly elevated spot in the jungle about a mile N.W. of the village of that name; pargana Bahádurpur.<br>λ 22 29 50·46<br>L 87 9 50·63<br>No. 35 | Báinpur Scaffold (heliotrope).<br>(*Midnapore*) On tree in N.W. corner of village.<br>λ 22 34 53·77<br>L 86 57 42·20<br>No. 32 | Bámunípahár h.s.<br>(*Manbhoom*)<br>λ 22 53 6·37<br>L 86 50 3·81<br>No. 18 |

Name of station, district, description, co-ordinates &c.

**Búnsgaria, XIII.**
(*Vide page* 37)

| | ° ′ ″ |
|---|---|
| λ | 22 9 0·51 |
| L | 87 16 16·36 |
| H | 182 |
| *h* | 32 |

No. 15

**Bánsol s.**
(*Midnapore*) About 2·05 miles S.E. of Káchera village which lies on the W. bank of the river turn.

| | |
|---|---|
| λ | 22 26 58·51 |
| L | 87 10 23·11 |

**Bánsol Tree Flag.**
(*Midnapore*) On a conspicuous pípal tree in S.W. corner of village.

| | |
|---|---|
| λ | 22 26 51 |
| L | 87 10 28 |

**Bárakuria Village.**
(*Midnapore*)

| | |
|---|---|
| λ | 22 25 24 |
| L | 87 10 6 |

**Báresini s.**
(*Midnapore*) On W. bund of tank about 80 yards N. of Indigo vats; pargana Bahádurpur.

| | |
|---|---|
| λ | 22 25 29·16 |
| L | 87 12 31·70 |

**Bárgaon House.**
(*Manbhoom*) Western of two thatched houses in village.

| | |
|---|---|
| λ | 22 55 1 |
| L | 86 53 14 |

No. 25

**Basantapur s.**
(*Midnapore*) N. of village; pargana Dharindah.

| | |
|---|---|
| λ | 22 24 2·86 |
| L | 87 18 54·36 |

**Basantapur Tree No. 1.**
(*Midnapore*) Flag, in N.W. corner of village.

| | |
|---|---|
| λ | 22 23 57 |
| L | 87 18 52 |

**Basantapur Tree No. 2.**
(*Midnapore*) Trunk of remarkable tree at bend on left bank of Kánsái river.

| | |
|---|---|
| λ | 22 24 22 |
| L | 87 18 43 |

**Báuljori, VII.**
(*Vide page* 36)

| | |
|---|---|
| λ | 22 30 17·92 |
| L | 86 58 47·13 |
| H | 343 |
| *h* | 13 |

No. 9

Name of station, district, description, co-ordinates &c.

**Bhátsásni Village.**
(*Midnapore*)

| | ° ′ ″ |
|---|---|
| λ | 22 25 46 |
| L | 87 11 34 |

**Bhikunpur Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 27 59 |
| L | 87 9 31 |

**Bhorábani Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 25 57 |
| L | 87 10 38 |

**Bhutádungri h.s.**
(*Manbhoom*)

| | |
|---|---|
| λ | 22 52 22·59 |
| L | 86 54 22·44 |

Nos. 22, 23

**Bínpur s.**
(*Midnapore*) S.W. of village on the road to Bárakuria; pargana Bahádurpur.

| | |
|---|---|
| λ | 22 27 24·36 |
| L | 87 10 11·14 |

**Bínpur Tree Flag.**
(*Midnapore*) On a high conspicuous mango tree on the S. side of village.

| | |
|---|---|
| λ | 22 27 25 |
| L | 87 10 29 |

**Birbiria Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 27 38 |
| L | 87 9 59 |

**Briddhakola s.**
(*Midnapore*)

| | |
|---|---|
| λ | 22 25 32·99 |
| L | 87 11 45·86 |

**Briddhakola Tree Flag No. 1.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 25 25 |
| L | 87 12 2 |

**Briddhakola Tree Flag No. 2.**
(*Midnapore*) On a high mango tree in tope.

| | |
|---|---|
| λ | 22 25 31 |
| L | 87 12 7 |

**Chaipur Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 28 16 |
| L | 87 9 30 |

Name of station, district, description, co-ordinates &c.

**Chándábíla Tree Flag.**
(*Midnapore*) S. of village.

| | ° ′ ″ |
|---|---|
| λ | 22 29 18 |
| L | 87 9 41 |

**Chándra Tree Flag.**
(*Midnapore*) S.W. of village.

| | |
|---|---|
| λ | 22 27 38 |
| L | 87 11 24 |

**Chhagharia s.**
(*Midnapore*)

| | |
|---|---|
| λ | 22 28 18·11 |
| L | 87 10 14·52 |

**Chhagharia Tree Flag.**
(*Midnapore*) On a large pípal tree N. of road running through the village.

| | |
|---|---|
| λ | 22 28 5 |
| L | 87 10 14 |

**Chholádhán s.**
(*Midnapore*)

| | |
|---|---|
| λ | 22 27 7·90 |
| L | 87 9 50·87 |

**Chilgora Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 28 4 |
| L | 87 10 56 |

**Chubka s.**
(*Midnapore*) S.W. of village; pargana Bahádurpur.

| | |
|---|---|
| λ | 22 23 59·28 |
| L | 87 14 12·37 |

**Dángrám Tree Flag No. 1.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 24 57 |
| L | 87 10 4 |

**Dángrám Tree Flag No. 2.**
(*Manbhoom*) On a pípal tree in village.

| | |
|---|---|
| λ | 22 48 1 |
| L | 86 53 23 |

**Dántún (Dántan), XVI.***
(*Vide page* 37)

| | |
|---|---|
| λ | 21 56 10·27 |
| L | 87 19 10·07 |
| H | 116 |
| *h* | 30 |

No. 17

**Deulidánga Tree Flag.**
(*Midnapore*) On a solitary mango tree near the Indigo factory vats.

| | |
|---|---|
| λ | 22 28 20 |
| L | 87 10 4 |

* Of the East Coast Series.

Name of station, district, description, co-ordinates &c.

Dhádki Village.
(*Midnapore*)

| | ° | ′ | ″ |
|---|---|---|---|
| λ | 22 | 26 | 26 |
| L | 87 | 11 | 49 |

Dhánsola, VI.
(*Vide page* 36)

| | | | |
|---|---|---|---|
| λ | 22 | 36 | 45·08 |
| L | 87 | 6 | 53·87 |
| H | 325 | | |
| *h* | 15 | | |

Nos. 7, 8

Dharmadánga Village.
(*Midnapore*)

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 2 |
| L | 87 | 10 | 58 |

Distant Peak.
(*Manbhoom*)

| | | | |
|---|---|---|---|
| λ | 22 | 48 | 48 |
| L | 86 | 57 | 4 |

Dudhiákháli s.
(*Midnapore*) On a height in the jungle S.W. of village; pargana Bahádurpur.

| | | | |
|---|---|---|---|
| λ | 22 | 28 | 44·21 |
| L | 87 | 11 | 2·57 |

No. 34

Dudhpátia Village.
(*Midnapore*)

| | | | |
|---|---|---|---|
| λ | 22 | 25 | 41 |
| L | 87 | 10 | 35 |

Faridchak Tree Flag.
(*Midnapore*) In centre of village.

| | | | |
|---|---|---|---|
| λ | 22 | 24 | 58 |
| L | 87 | 13 | 5 |

Goáldánga Tree Flag.
(*Midnapore*) In centre of village.

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 5 |
| L | 87 | 10 | 11 |

Gop, XI.
(*Vide page* 37)

| | | | |
|---|---|---|---|
| λ | 22 | 25 | 10·77 |
| L | 87 | 19 | 25·20 |
| H | 211 | | |
| *h* | *Not forthcoming* | | |

[No. 13

Gurgurápál s.
(*Midnapore*) Half a mile W. of village; pargana Bahádurpur.

| | | | |
|---|---|---|---|
| λ | 22 | 25 | 36·46 |
| L | 87 | 14 | 45·55 |

Name of station, district, description, co-ordinates &c.

Hátiári, V.
(*Vide page* 36)

| | ° | ′ | ″ |
|---|---|---|---|
| λ | 22 | 38 | 49·15 |
| L | 86 | 53 | 37·26 |
| H | 434 | | |
| *h* | 3 | | |

No. 6

Hill East Peak.
(*Manbhoom*)

| | | | |
|---|---|---|---|
| λ | 22 | 58 | 35 |
| L | 86 | 55 | 18 |

Illábani Village.
(*Midnapore*)

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 0 |
| L | 87 | 11 | 57 |

Jagannáthpur t.s.
(*Midnapore*)

| | | | |
|---|---|---|---|
| λ | 22 | 9 | 0·46 |
| L | 87 | 1 | 59·36 |

Nos. 38, 39

Jalhári, I.
(*Vide page* 36)

| | | | |
|---|---|---|---|
| λ | 22 | 58 | 40·28 |
| L | 86 | 51 | 43·34 |
| H | 763 | | |
| *h* | 2 | | |

No. 1

Jalhári Peak Tree.
(*Manbhoom*) On W. termination of the Jalhári range.

| | | | |
|---|---|---|---|
| λ | 22 | 57 | 32 |
| L | 86 | 49 | 34 |

Jámni s.
(*Midnapore*) On a rise, E. of village; pargana Bahádurpur.

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 21·50 |
| L | 87 | 12 | 15·59 |

Jámni Village.
(*Midnapore*)

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 24 |
| L | 87 | 12 | 4 |

Jámsali s.
(*Midnapore*) About ¼ of a mile W. of village in the jungle; pargana Bhanjabhum.

| | | | |
|---|---|---|---|
| λ | 22 | 25 | 23·43 |
| L | 87 | 16 | 57·66 |

Jhunjhuni Tree Flag.
(*Midnapore*) On a conspicuous tamarind tree N. of village.

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 40 |
| L | 87 | 11 | 12 |

Name of station, district, description, co-ordinates &c.

Joba Tree Flag.
(*Midnapore*) On the higher of two mango trees in village.

| | ° | ′ | ″ |
|---|---|---|---|
| λ | 22 | 26 | 0 |
| L | 87 | 11 | 57 |

Káchora s.
(*Midnapore*) On a rise in jungle, ¼ of a mile W. of village; pargana Bahádurpur.

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 2·60 |
| L | 87 | 8 | 30·88 |

Káema, IV.
(*Vide page* 36)

| | | | |
|---|---|---|---|
| λ | 22 | 46 | 7·86 |
| L | 87 | 7 | 0·67 |
| H | 359 | | |
| *h* | 11 | | |

Nos. 4, 5

Kalábani, IX.
(*Vide page* 36)

| | | | |
|---|---|---|---|
| λ | 22 | 23 | 59·13 |
| L | 87 | 2 | 32·04 |
| H | 351 | | |
| *h* | 19 | | |

No. 11

Kalsíbhánga, X.
(*Vide page* 37)

| | | | |
|---|---|---|---|
| λ | 22 | 20 | 23·80 |
| L | 87 | 10 | 46·37 |
| H | 303 | | |
| *h* | 24 | | |

No. 12

Kanchia Tree Flag.
(*Midnapore*) On N. side of village.

| | | | |
|---|---|---|---|
| λ | 22 | 25 | 21 |
| L | 87 | 12 | 56 |

Kankabati Tree Flag.
(*Midnapore*) On the higher of two tamarind trees in village S. side of road to Nágpur.

| | | | |
|---|---|---|---|
| λ | 22 | 24 | 51 |
| L | 87 | 17 | 55 |

Khatra Tree Flag.
(*Manbhoom*) In village.

| | | | |
|---|---|---|---|
| λ | 22 | 58 | 47 |
| L | 86 | 53 | 45 |

Kíliámára s.
(*Midnapore*)

| | | | |
|---|---|---|---|
| λ | 22 | 26 | 36·44 |
| L | 87 | 11 | 29·90 |

Name of station, district, description, co-ordinates &c.

**Kukurmuri, VIII.**
(*Vide page* 36)

| | o ′ ″ |
|---|---|
| λ | 22 28 32·44 |
| L | 87 8 27·30 |
| H | 191 |
| *h* | 42 |

No. 10

**Kukurmuri Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 28 22 |
| L | 87 8 41 |

**Kundábá, II.**
(*Vide page* 36)

| | |
|---|---|
| λ | 22 57 28·57 |
| L | 87 8 10·75 |
| H | 322 |
| *h* | 13 |

No. 2

**Lepara Tree Flag.**
(*Midnapore*) On highest tree in S.W. part of village.

| | |
|---|---|
| λ | 22 24 29 |
| L | 87 18 32 |

**Lodhásái s.**
(*Midnapore*) On height N. of village; pargana Bhanjabhum.

| | |
|---|---|
| λ | 22 26 1·70 |
| L | 87 17 45·82 |

**Lodhásái Tree Flag.**
(*Midnapore*) On cotton tree about the centre of village; pargana Bhanjabhum.

| | |
|---|---|
| λ | 22 25 20 |
| L | 87 17 41 |

**Lohátikri s.**
(*Midnapore*) At the W. extremity of village, near the boundary and 0·1 of a mile S. of Sálkia bazar; pargana Bhanjabhum.

| | |
|---|---|
| λ | 22 25 19·80 |
| L | 87 15 52·00 |

**Lohátikri Tree Flag.**
(*Midnapore*) On the E. boundary of village; pargana Bhanjabhum.

| | |
|---|---|
| λ | 22 25 9 |
| L | 87 16 39 |

**Madhádánga s.**
(*Midnapore*) At the N.E. extremity of village; pargana Bahádurpur.

| | |
|---|---|
| λ | 22 25 18·45 |
| L | 87 9 56·71 |

**Máguria Tree Flag.**
(*Midnapore*) In S.E. corner of village.

| | |
|---|---|
| λ | 22 25 32 |
| L | 87 13 19 |

Name of station, district, description, co-ordinates &c.

**Maheshpur Tree Flag.**
(*Midnapore*) In centre of village.

| | o ′ ″ |
|---|---|
| λ | 22 26 26 |
| L | 87 10 10 |

**Málíkhál s.**
(*Midnapore*)

| | |
|---|---|
| λ | 22 25 23·57 |
| L | 87 10 40·04 |

**Málíkhál Village.**
(*Midnapore*)

| | |
|---|---|
| λ | 22 25 10 |
| L | 87 10 44 |

**Mandho Tree Flag.**
(*Midnapore*) On a remarkable tree on S.E. side of village.

| | |
|---|---|
| λ | 22 24 43 |
| L | 87 14 1 |

**Masak Hill Tree.**
(*Manbhoom*)

| | |
|---|---|
| λ | 22 58 34 |
| L | 86 55 17 |

**Mátiála Factory,**
(*Manbhoom*) Chimney.

| | |
|---|---|
| λ | 22 56 4·1 |
| L | 86 52 49·6 |

No. 24

**Mauliákhál, XII.**
(*Vide page* 37)

| | |
|---|---|
| λ | 22 7 10·78 |
| L | 87 2 45·37 |
| H | 307 |
| *h* | 25 |

No. 14

**Maydádánga Village.**
(*Midnapore*)

| | |
|---|---|
| λ | 22 25 17 |
| L | 87 9 56 |

**Midnapore Park House (heliotrope).**
(*Midnapore*) The residence of the judge, Mr. Raikes. The centre mark is on roof.

| | |
|---|---|
| λ | 22 24 45·01 |
| L | 87 21 12·18 |

No. 36

**Mujrápál s.**
(*Midnapore*) N. of village; pargana Dharindah.

| | |
|---|---|
| λ | 22 24 39·85 |
| L | 87 16 27·72 |

Name of station, district, description, co-ordinates &c.

**Mujrápál Tree Flag.**
(*Midnapore*) At N. extremity of village.

| | o ′ ″ |
|---|---|
| λ | 22 24 33 |
| L | 87 16 30 |

**Nazarganj s.**
(*Midnapore*) On the Indigo factory (Mr. Young's house) belonging to the firm of Cockerell & Co. The centre mark is on the western part of roof.

| | |
|---|---|
| λ | 22 24 14·49 |
| L | 87 21 18·47 |

No. 37

**Nichintápur Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 26 49 |
| L | 87 10 9 |

**Nimdángra Tree Flag.**
(*Midnapore*) At S.E. corner of village.

| | |
|---|---|
| λ | 22 25 25 |
| L | 87 14 5 |

**Padima Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 26 38 |
| L | 87 12 2 |

**Páiraguri Tree Flag.**
(*Midnapore*) At the eastern extremity of village on W. bank of the Kánsái river.

| | |
|---|---|
| λ | 22 28 6 |
| L | 87 7 39 |

**Paláshbani Tree Flag.**
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 27 45 |
| L | 87 10 18 |

**Pora h.s.**
(*Manbhoom*)

| | |
|---|---|
| λ | 22 57 23·87 |
| L | 86 51 44·73 |

Nos. 19, 20

**Púrnapáni Tree Flag.**
(*Midnapore*) In village.

| | |
|---|---|
| λ | 21 57 54 |
| L | 87 8 28 |

**Raghunáthpur Tree Flag.**
(*Midnapore*) In village, on tamarind tree on bank of river.

| | |
|---|---|
| λ | 22 25 1 |
| L | 87 17 21 |

**Rámgar Hill Mark (heliotrope).**
(*Midnapore*)

| | |
|---|---|
| λ | 22 40 22·04 |
| L | 87 7 36·55 |

No. 30

Name of station, district, description, co-ordinates &c.

Renrápál s.
(*Midnapore*) W. of village; pargana Bahádurpur.

| | ° ′ ″ |
|---|---|
| λ | 22 25 10·13 |
| L | 87 14 5·87 |

Renrápál Tree Flag.
(*Midnapore*) On a high mango tree S. side of village.

| | |
|---|---|
| λ | 22 25 7 |
| L | 87 14 27 |

Sálpatra Tree Flag.
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 28 32 |
| L | 87 9 0 |

Sátpautia, XVII*.
(*Vide page* 37)

| | |
|---|---|
| λ | 21 56 27·66 |
| L | 87 7 14·31 |
| H | 220 |
| *h* | 35 |

No. 16

Shanka Tree Flag.
(*Midnapore*) On a conspicuous pípal tree in centre of village.

| | |
|---|---|
| λ | 22 26 43 |
| L | 87 10 43 |

Shibpur s.
(*Midnapore*)

| | |
|---|---|
| λ | 22 25 41·50 |
| L | 87 12 14·80 |

Shibpur Tree Flag.
(*Midnapore*) In middle of village.

| | |
|---|---|
| λ | 22 25 50 |
| L | 87 12 3 |

Shyámkishorpur Palm Tree.
(*Midnapore*) Taller of the two in village.

| | |
|---|---|
| λ | 22 24 22 |
| L | 87 12 20 |

Name of station, district, description, co-ordinates &c.

Shyámkishorpur s.
(*Midnapore*) At N.E. extremity of village; pargana Bahádurpur.

| | ° ′ ″ |
|---|---|
| λ | 22 24 23·27 |
| L | 87 12 22·53 |

Shyámsundarpur Factory,
(*Manbhoom*) Chimney.

| | |
|---|---|
| λ | 22 46 5·5 |
| L | 86 55 8·8 |

No. 29

Shyámsundarpur House.
(*Manbhoom*) N. W. corner of staircase of Rája's house.

| | |
|---|---|
| λ | 22 46 17·5 |
| L | 86 55 14·7 |

No. 28

Simla Tree Flag.
(*Midnapore*) In centre of village.

| | |
|---|---|
| λ | 22 27 4 |
| L | 87 10 33 |

Sonágarh House.
(*Manbhoom*) N.W. corner of thatched house.

| | |
|---|---|
| λ | 22 50 23 |
| L | 86 54 53 |

No. 26

Sukhjora Tree Flag.
(*Midnapore*) On only palm tree in centre of village.

| | |
|---|---|
| λ | 22 24 33 |
| L | 87 15 21 |

Supur Temple,
(*Manbhoom*) Kalas.

| | |
|---|---|
| λ | 22 59 5·8 |
| L | 86 52 12·6 |

No. 21

Name of station, district, description, co-ordinates &c.

Súsinia, LXV†.
(*Vide page* 35)

| | ° ′ ″ |
|---|---|
| λ | 23 23 42·97 |
| L | 87 1 40·31 |
| H | 1444 |
| *h* | 2 |

No. 1

Tilabani, LXI†.
(*Vide page* 35)

| | |
|---|---|
| λ | 23 24 59·87 |
| L | 86 35 41·82 |
| H | 1329 |
| *h* | 2 |

No. 1

Torábánd h.s.
(*Manbhoom*)

| | |
|---|---|
| λ | 22 47 17·06 |
| L | 86 53 41·54 |

No. 27

Tree.
(*Midnapore*) Centre of tree on ridge in jungle.

| | |
|---|---|
| λ | 22 33 30 |
| L | 87 8 36 |

Tungchára Palm Tree.
(*Manbhoom*) In village.

| | |
|---|---|
| λ | 22 52 10 |
| L | 86 53 15 |

Tura, III.
(*Vide page* 36)

| | |
|---|---|
| λ | 22 49 1·75 |
| L | 86 54 0·84 |
| H | 685 |
| *h* | 2 |

No. 3

Upardánga Village.
(*Midnapore*)

| | |
|---|---|
| λ | 22 25 44 |
| L | 87 11 22 |

* Of the East Coast Series. † Of the Calcutta Longitudinal Series.

*June* 1879.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

# SOUTH MALUNCHA MERIDIONAL SERIES.

## PRIMARY TRIANGULATION. AZIMUTHAL OBSERVATIONS.

### At X (Kalsíbhánga)

Lat. N. 22° 20′ 23″·80; Long. E. 87° 10′ 46″·37 = 5 h 48 m 43·1 s; Height above Mean Sea Level, 303 feet.
December 1849; observed by Mr. R. Clarkson with Troughton and Simms' 24-inch Theodolite No. 1.

Star observed — δ Ursæ Minoris (East and West)
Mean Right Ascension 1849·0 — 18h 21m 3s
Mean North Polar Distance 1849·0 — 3° 24′ 11″·83
Local Mean Times of Elongation, Dec. 23 — Eastern 18h 20m; Western 6 11

| Astronomical Date | Elongation | Zeros (Circle Readings of Referring Mark) | FACE LEFT: Observed Horizontal Angle: Diff. of Readings Ref. Mark – Star | FACE LEFT: Interval in Time from Elongation | FACE LEFT: Reduction in Arc to Time of Elongation | FACE LEFT: Reduced Observation Ref. Mark – Star at Elongation | FACE RIGHT: Observed Horizontal Angle: Diff. of Readings Ref. Mark – Star | FACE RIGHT: Interval in Time from Elongation | FACE RIGHT: Reduction in Arc to Time of Elongation | FACE RIGHT: Reduced Observation Ref. Mark – Star at Elongation |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ ″ | m s | ′ ″ | ° ′ ″ | ° ′ ″ | m s | ′ ″ | ° ′ ″ |
| Dec. 23 | E. | 0 1 | − 18 41 27·46 | 28 38 | − 1 42·59 | − 18 43 10·05 | − 18 42 41·17 | 16 29 | − 0 34·06 | − 18 43 15·23 |
| | | & | 41 49·07 | 25 51 | 1 23·71 | 12·78 | 42 50·43 | 13 48 | 0 23·90 | 14·33 |
| | | 180 1 | 42 57·43 | 11 15 | 0 15·93 | 13·36 | 43 14·34 | 2 40 | 0 0·89 | 15·23 |
| | | | 42 48·74 | 14 9 | 0 25·23 | 13·97 | 43 13·66 | 0 9 | 0 0·00 | 13·66 |
| „ 24 | E. | 20 2 | − 18 42 46·00 | 15 54 | − 0 31·69 | − 18 43 17·69 | − 18 41 24·33 | 30 9 | − 1 53·79 | − 18 43 18·12 |
| | | & | 42 53·07 | 12 54 | 0 20·89 | 13·96 | 41 47·87 | 26 51 | 1 30·27 | 18·14 |
| | | 200 2 | 43 16·53 | 2 57 | 0 1·09 | 17·62 | 43 6·00 | 9 33 | 0 11·49 | 17·49 |
| | | | 43 16·27 | 0 6 | 0 0·00 | 16·27 | 42 56·44 | 12 5 | 0 18·37 | 14·81 |
| „ 25 | W. | 40 3 | − 11 24 37·47 | 33 56 | + 2 24·97 | − 11 21 72·50 | − 11 22 45·94 | 18 21 | + 0 42·40 | − 11 21 63·54 |
| | | & | 24 15·10 | 32 20 | 2 11·65 | 63·45 | 22 31·94 | 15 46 | 0 31·32 | 60·62 |
| | | 220 3 | 22 26·23 | 12 50 | 0 20·67 | 65·56 | 22 6·06 | 1 54 | 0 0·45 | 65·61 |
| | | | 22 38·07 | 15 34 | 0 30·37 | 67·70 | 22 0·94 | 0 55 | 0 0·11 | 60·83 |
| „ 25 | E. | 40 3 | − 18 41 37·77 | 28 19 | − 1 40·36 | − 18 43 18·13 | − 18 42 50·60 | 14 26 | − 0 26·15 | − 18 43 16·75 |
| | | & | 41 52·37 | 25 31 | 1 21·60 | 13·97 | 42 53·56 | 11 50 | 0 17·55 | 11·11 |
| | | 220 3 | 42 8·83 | 23 15 | 1 8·06 | 16·89 | 43 18·77 | 0 14 | 0 0·01 | 18·78 |
| | | | 41 36·10 | 28 10 | 1 39·93 | 16·03 | 43 11·26 | 2 21 | 0 0·70 | 11·96 |
| „ 26 | E. | 60 4 | − 18 42 38·56 | 18 8 | − 0 41·23 | − 18 43 19·79 | − 18 40 36·90 | 35 39 | − 2 38·86 | − 18 43 15·76 |
| | | & | 42 44·73 | 15 45 | 0 31·14 | 15·87 | 40 59·47 | 32 44 | 2 14·08 | 13·55 |
| | | 240 4 | 43 14·53 | 6 8 | 0 4·72 | 19·05 | 43 6·90 | 6 55 | 0 6·03 | 12·93 |
| | | | 43 15·30 | 3 45 | 0 1·77 | 17·07 | 43 1·84 | 9 7 | 0 10·45 | 12·29 |

| Astronomical Date | Elongation | Zeros (Circle Readings of Referring Mark) | FACE LEFT: Observed Horizontal Angle: Diff. of Readings Ref. Mark—Star | FACE LEFT: Interval in Time from Elongation | FACE LEFT: Reduction in Arc to Time of Elongation | FACE LEFT: Reduced Observation Ref. Mark—Star at Elongation | FACE RIGHT: Observed Horizontal Angle: Diff. of Readings Ref. Mark—Star | FACE RIGHT: Interval in Time from Elongation | FACE RIGHT: Reduction in Arc to Time of Elongation | FACE RIGHT: Reduced Observation Ref. Mark—Star at Elongation |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ ″ | m s | ′ ″ | ° ′ ″ | ° ′ ″ | m s | ′ ″ | ° ′ ″ |
| Dec. 27 | W. | 80 6 | − 11 23 24·17 | 25 23 | + 1 21·14 | − 11 21 63·03 | − 11 22 20·20 | 12 28 | + 0 19·56 | − 11 21 60·64 |
| | | & | 23 5·50 | 21 25 | 0 57·72 | 67·78 | 22 10·84 | 9 50 | 0 12·19 | 58·65 |
| | | 260 6 | 22 36·87 | 14 38 | 0 26·85 | 70·02 | 22 0·94 | 3 2 | 0 1·16 | 59·78 |
| | | | 22 39·80 | 16 53 | 0 35·77 | 64·03 | 22 2·93 | 5 33 | 0 3·87 | 59·06 |
| „ 27 | E. | 80 5 | − 18 40 57·27 | 33 44 | − 2 22·23 | − 18 43 19·50 | − 18 42 18·33 | 21 39 | − 0 58·80 | − 18 43 17·13 |
| | | & | 41 18·27 | 31 3 | 2 0·63 | 18·90 | 42 29·63 | 18 44 | 0 44·00 | 13·63 |
| | | 260 5 | 43 12·36 | 6 41 | 0 5·62 | 17·98 | 43 11·17 | 7 20 | 0 6·75 | 17·92 |
| | | | 43 4·06 | 9 18 | 0 10·87 | 14·93 | 43 12·37 | 4 33 | 0 2·61 | 14·98 |
| „ 28 | W. | 100 6 | − 11 22 16·60 | 9 57 | + 0 12·47 | − 11 21 64·13 | − 11 23 0·10 | 22 30 | + 1 3·79 | − 11 21 56·31 |
| | | & | 22 8·36 | 7 36 | 0 7·26 | 61·10 | 22 45·60 | 19 26 | 0 47·54 | 58·06 |
| | | 280 6 | 22 4·24 | 1 36 | 0 0·32 | 63·92 | 22 28·14 | 14 27 | 0 26·19 | 61·95 |
| | | | 22 4·50 | 3 41 | 0 1·71 | 62·79 | 22 34·50 | 16 44 | 0 35·16 | 59·34 |
| „ 28 | E. | 100 6 | − 18 43 18·63 | 3 23 | − 0 1·44 | − 18 43 20·07 | − 18 42 38·00 | 17 19 | − 0 37·61 | − 18 43 15·61 |
| | | & | 43 19·30 | 0 50 | 0 0·09 | 19·39 | 42 44·86 | 14 48 | 0 27·51 | 12·37 |
| | | 280 6 | 43 8·87 | 8 54 | 0 9·97 | 18·84 | 42 12·13 | 22 2 | 1 1·13 | 13·26 |
| | | | 43 1·90 | 11 24 | 0 16·34 | 18·24 | 41 56·60 | 24 35 | 1 16·07 | 12·67 |
| „ 29 | W. | 0 2 | − 11 22 52·26 | 18 55 | + 0 45·05 | − 11 21 67·21 | − 11 22 0·03 | 4 58 | + 0 3·10 | − 11 21 56·93 |
| | | & | 22 35·93 | 15 58 | 0 32·12 | 63·81 | 22 3·60 | 2 12 | 0 0·60 | 63·00 |
| | | 180 2 | 23 31·40 | 26 8 | 1 25·54 | 65·86 | 22 20·44 | 11 29 | 0 16·37 | 63·87 |
| | | | 23 46·20 | 28 30 | 1 41·66 | 64·54 | 22 27·37 | 14 9 | 0 25·13 | 62·24 |
| „ 30 | W. | 20 2 | − 11 22 4·80 | 2 4 | + 0 0·54 | − 11 21 64·26 | − 11 22 14·10 | 11 48 | + 0 17·55 | − 11 21 56·55 |
| | | & | 22 4·13 | 0 34 | 0 0·04 | 64·09 | 22 11·56 | 9 16 | 0 10·80 | 60·76 |
| | | 200 2 | 22 19·13 | 10 38 | 0 14·20 | 64·93 | 22 58·97 | 21 31 | 0 58·07 | 60·90 |
| | | | 22 26·80 | 12 57 | 0 21·03 | 65·77 | 23 10·50 | 23 50 | 1 11·18 | 59·32 |
| „ 31 | W. | 60 4 | − 11 22 13·77 | 9 51 | + 0 12·20 | − 11 21 61·57 | − 11 21 55·73 | 0 57 | + 0 0·11 | − 11 21 55·62 |
| | | & | 22 19·63 | 11 58 | 0 17·99 | 61·64 | 21 57·17 | 2 59 | 0 1·11 | 56·06 |
| | | 240 4 | 22 57·23 | 20 30 | 0 52·67 | 64·56 | 24 13·50 | 32 1 | 2 8·23 | 65·27 |
| | | | 23 3·00 | 22 40 | 1 4·43 | 58·57 | 24 25·13 | 34 3 | 2 24·91 | 60·22 |

## Abstract of Astronomical Azimuth observed at X (Kalsíbhánga) 1849.

### 1. By Eastern Elongation of δ Ursæ Minoris.

| Face | L | R | L | R | L | R | L | R | L | R | L | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zero | 0° | 180° | 20° | 200° | 40° | 220° | 60° | 210° | 80° | 260° | 100° | 280° |
| Date | December 23 | | December 24 | | December 25 | | December 26 | | December 27 | | December 28 | |
| Observed difference of Circle-Readings, Ref. M.—Star reduced to Elongation | 10″·05 | 15″·23 | 17″·69 | 18″·12 | 18″·13 | 16″·75 | 19″·79 | 15″·76 | 19″·50 | 17″·13 | 20″·07 | 15″·61 |
| | 12·78 | 14·33 | 13·96 | 18·14 | 13·97 | 11·11 | 15·87 | 13·55 | 18·90 | 13·63 | 19·39 | 12·37 |
| | 13·36 | 15·23 | 17·62 | 17·49 | 16·89 | 18·78 | 19·05 | 12·93 | 17·98 | 17·92 | 18·84 | 13·26 |
| | 13·97 | 13·66 | 16·27 | 14·81 | 16·03 | 11·96 | 17·07 | 12·29 | 14·93 | 14·98 | 18·24 | 12·67 |
| Means | 12·54 | 14·61 | 16·39 | 17·14 | 16·26 | 14·65 | 17·95 | 13·63 | 17·83 | 15·92 | 19·14 | 13·48 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Means of both faces | − 18° 43′ 13″·58 | 16″·77 | 15″·46 | 15″·79 | 16″·88 | 16″·31 |
| Az. of Star fr. S., by W. | 183 40 35·78 | 36·05 | 36·38 | 36·70 | 37·19 | 37·46 |
| Az. of Ref. M. „ | 164 57 22·20 | 19·28 | 20·92 | 20·91 | 20·31 | 21·15 |

Abstract of Astronomical Azimuth observed at X (Kalsíbhánga) 1849—(*Continued*).

2. By Western Elongation of δ Ursæ Minoris.

| Face | L | R | L | R | L | R | L | R | L | R | L | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zero | 0° | 180° | 20° | 200° | 40° | 220° | 60° | 240° | 80° | 260° | 100° | 280° |
| Date | December 29 | | December 30 | | December 25 | | December 31 | | December 27 | | December 28 | |
| | " | " | " | " | " | " | " | " | " | " | " | " |
| Observed difference of Circle-Readings, Ref. M.—Star reduced to Elongation | 67·21 | 56·93 | 64·26 | 56·55 | 72·50 | 63·54 | 61·57 | 55·62 | 63·03 | 60·64 | 64·13 | 56·31 |
| | 63·81 | 63·00 | 64·09 | 60·76 | 63·45 | 60·62 | 61·64 | 56·06 | 67·78 | 58·65 | 61·10 | 58·06 |
| | 65·86 | 63·87 | 64·93 | 60·90 | 65·56 | 65·61 | 64·56 | 65·27 | 70·02 | 59·78 | 63·92 | 61·95 |
| | 64·54 | 62·24 | 65·77 | 59·32 | 67·70 | 60·83 | 58·57 | 60·22 | 64·03 | 59·06 | 62·79 | 59·34 |
| Means | 65·36 | 61·51 | 64·76 | 59·38 | 67·30 | 62·65 | 61·59 | 59·29 | 66·22 | 59·53 | 62·99 | 58·92 |
| | ° ′ ″ | | " | | " | | " | | " | | " | |
| Means of both faces | − 11 22 3·44 | | 2·07 | | 4·98 | | 0·44 | | 2·88 | | 0·96 | |
| Az. of Star fr. S., by W. | 176 19 22·25 | | 21·94 | | 23·78 | | 21·49 | | 23·01 | | 22·69 | |
| Az. of Ref. M. „ | 164 57 18·81 | | 19·87 | | 18·80 | | 21·05 | | 20·13 | | 21·73 | |

| | | ° ′ ″ |
|---|---|---|
| Astronomical Azimuth of Referring Mark | by Eastern Elongation ... ... ... | 164 57 20·80 |
| | by Western „ ... ... ... | „ 20·07 |
| | Mean ... ... ... | „ 20·44 |
| Angle Referring Mark and IX (Kalábani) *see* page 43 ... ... ... ... | | − 49 50 0·56 |
| Astronomical Azimuth of Kalábani by observation ... ... ... ... ... | | 115 7 19·88 |
| Geodetical Azimuth of „ by calculation from that adopted (*Vol.* II, page 141) at Kaliánpur, *see* page 53 *ante* ... ... ... ... ... ... | | 115 7 22·1 |
| Astronomical—Geodetical Azimuth at X (Kalsíbhánga) ... ... ... ... | | − 2·2 |

*June* 1879.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

## NOTE TO CHART.

*Alphabetical List of Stations and Points omitted in the Chart for want of space on which to project them.*

| | | | | | |
|---|---|---|---|---|---|
| Ándápál | Tree Flag. | Dángrám | Tree Flag No. 1. | Maydádánga | Village. |
| Bálgoma | Palm Tree. | Deulidánga | Tree Flag. | Mujrápál | s. |
| Bánsol | Tree Flag. | Dudhpátia | Village. | Do. | Tree Flag. |
| Báresini | s. | Jámni | s. | Nichintápur | ,, |
| Bhátsásni | Village. | Do. | Village. | Padima | ,, |
| Bhikunpur | Tree Flag. | Jhunjhuni | Tree Flag. | Paláshbani | ,, |
| Bhorábani | ,, | Joba | ,, | Raghunáthpur | ,, |
| Bínpur | s. | Kanchia | ,, | Renrápál | s. |
| Do. | Tree Flag. | Kankabati | ,, | Do. | Tree Flag. |
| Birbiria | ,, | Kíliámára | s. | Sálpatra | ,, |
| Briddhakola | s. | Kukurmuri | Tree Flag. | Shanka | ,, |
| Do. | Tree Flag No. 1. | Lepara | ,, | Shibpur | s. |
| Do. | do. No. 2. | Lohátikri | s. | Do. | Tree Flag. |
| Chaipur | Tree Flag. | Do. | Tree Flag. | Shyámkishorpur | Palm Tree. |
| Chándra | ,, | Madhádánga | s. | Do. | s. |
| Chhagharia | s. | Máguria | Tree Flag. | Simla | Tree Flag. |
| Do. | Tree Flag. | Maheshpur | ,, | Sukhjora | ,, |
| Chholádhán | s. | Málíkhál | s. | Upardánga | Village. |
| Chilgora | Tree Flag. | Do. | Village. | | |

*July* 1879.

J. B. N. HENNESSEY,
*In charge of Computing Office.*

# SOUTH PARASNATH AND SOUTH MALUNCHA MERIDIONAL SERIES.

## ADDENDUM TO DESCRIPTION OF STATIONS.

NOTE.—Consequent on modern alterations of district and other boundaries, the sites occupied by the stations are in some instances now included in civil divisions of territory which differ from the district, pargana, or village, recorded in the descriptions of stations, given on pages 3 to 6 and 35 to 37: a complete list of all the primary stations of the two series including a suitably modified statement of the altered sub-divisions in question is accordingly given in the following table, and is derived chiefly from the annual reports, up to 1884, made by the Civil Officials to whose care the stations have been committed. The statement also gives additional information as to position and condition of certain of the stations; where no entry regarding present condition is made against a station it is to be assumed that when last reported on by the district Official it was in good order.

The spelling of names is in accordance with that given in the lists of more important places in Bengal published by the Government of India in June 1876.

### SOUTH PÁRASNÁTH MERIDIONAL SERIES.

| No. of Station | Local name | District | Pargana, &c. | Village in which the Station lies | Remarks on the Condition of the Station |
|---|---|---|---|---|---|
| LVIII* | Bulbul | Lohardugga (Lohárdága) | P. Palamow (Palámu), Thá. Daltonganj | Chainpur | |
| LXI* | Tilabani | Manbhoom (Mánbhúm) | P. Ludurka, Thá. Purulia | Tilabani | Reported in 1884. "The pillar is out of repair." |
| I | ... | „ | P. Máhta, Thá. Bághmundi | Doasaka | Reported in 1875. "Greatly damaged." |
| II | ... | „ | P. and Thá. Baráhabhúm | Bundi | Reported in 1878. "Greatly injured." |
| III | ... | „ | P. Baráhabhúm, Thá. Mánbazar | ... | |
| IV | ... | „ | P. and Thá. Baráhabhúm | Bundi | |
| V | Lodhashol Pahár | Singhbhoom (Singhbhúm) | P. Dhalbhúm, Thá. Kálikapur | Kálikapur | |
| VI | ... | Manbhoom | P. and Thá. Baráhabhúm | Jabuagarh | |
| VII | Sidasir Pahár | Singhbhoom | P. Dhalbhúm, Thá. Kálikapur | Kálikapur | |
| VIII | Bághmuri Pahár | „ | P. Dhalbhúm, Thá. Ghátsila | Bághmuri | |
| IX | Satbakhra Pahár | „ | „ „ | Kálikapur | |
| X | Badam Pahár | Balasore (Báleshwar) | K. Mayurbhanja, Zillah Kaisari | Badam Pahár | |

* Of the Calcutta Longitudinal Series.
NOTE.—P. stands for pargana, Thá. for thána, and K. for killah.

# SOUTH PARASNATH AND SOUTH MALUNCHA MERIDIONAL SERIES.

## ADDENDUM TO DESCRIPTION OF STATIONS.

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|---|---|---|---|---|---|
| LVIII* | Bulbul | Lohardugga (Lohárdága) | P. Palamow (Palámu), Thá. Daltonganj | Chainpur | |
| LXI* | Tilabani | Manbhoom (Mánbhúm) | P. Ludurka, Thá. Purulia | Tilabani | Reported in 1884. "The pillar is out of repair." |
| I | ... | ,, | P. Málta, Thá. Bághmundi | Doasaka | Reported in 1875. "Greatly damaged." |
| II | ... | ,, | P. and Thá. Baráhabhúm | Bundi | Reported in 1878. "Greatly injured." |
| III | ... | ,, | P. Baráhabhúm, Thá. Mánbazar | ... | |
| IV | ... | ,, | P. and Thá. Baráhabhúm | Bundi | |
| V | Lodhashol Pahár | Singhbhoom (Singhbhúm) | P. Dhalbhúm, Thá. Kálikapur | Kálikapur | |
| VI | ... | Manbhoom | P. and Thá. Baráhabhúm | Jabuagarh | |
| VII | Sidasir Pahár | Singhbhoom | P. Dhalbhúm, Thá. Kálikapur | Kálikapur | |
| VIII | Bághmuri Pahár | ,, | P. Dhalbhúm, Thá. Ghátsila | Bághmuri | |
| IX | Satbakhra Pahár | ,, | ,, ,, | Kálikapur | |
| X | Badam Pahár | Balasore (Báleshwar) | K. Mayurbhanja, Zillah Kaisari | Badam Pahár | |

* Of the Calcutta Longitudinal Series.
NOTE.—P. stands for pargana, Thá. for thána, and K. for killah.

| No. of Station | Local name | District | Pargana, &c. | Village in which the Station lies | Remarks on the Condition of the Station |
|---|---|---|---|---|---|
| XI | ... | Balasore | K. Mayurbhanja | ... | |
| XII | Ambjhari | ,, | ,, | ... | |
| XIII | Báligarh | ,, | K. Mayurbhanja, Zillah Khunta Karkachia | Báligarh or Murári | Reported in 1871. "Present height of the pillar is 5 feet." |
| XXIII* | Kimbhiria | ,, | K. Mayurbhanja, Zillah Khunta Karkachia | ... | |
| XXIV* | Sunichot | ,, | K. Nilgiri | Nilgiri | |
| XXV* | Meghásan | Mayurbhanja | K. Mayurbhanja, Zillah Porádiha | Meghásani | |
| XXVI* | Boulpál | ,, | K. Nilgiri | Gudsahi | |

## SOUTH MALÚNCHA MERIDIONAL SERIES.

| | | | | | |
|---|---|---|---|---|---|
| LXI† | Tilabani | Manbhoom | P. Ludurka, Thá. Purulia | Tilabani | Reported in 1884. "The pillar is out of repair." |
| LXV† | Shushunia | Bankoora (Bánkura) | P. Chhátna, Thá. Bankoora | Shushunia | Reported in 1884. "Partly broken down." |
| I | ... | Bankoora | P. Supur | ... | Reported in 1875. "Greatly injured." |
| II | ... | ,, | P. and Thá. Ráipur | ... | Reported in 1883. "Partly fallen down." |
| III | Jura | ,, | P. Ráipur, Thá. Khatra | Jura | |
| IV | ... | ,, | P. and Thá. Ráipur | ... | |
| V | Etalia | Midnapore (Medinípur) | P. Silda, Thá. Bínpur | Etalia | |
| VI | Dhánsola | ,, | P. Rámgar, Thá. Bínpur | Dhánsola | Reported in 1870. "In a totally ruined state." |
| VII | Bálijori | ,, | P. Jambani, Thá. Jhargrám | Bálijori | |
| VIII | Kukurmuri | ,, | P. Bahádurpur, Thá. Midnapore | Kukurmuri | |
| IX | Kalábari | ,, | P. and Thá. Jhargrám | Kalábari | ,, ,, |
| X | Kalshibhánga | ,, | ,, | Kalshibhánga | |

* Of the East Coast Series. † Of the Calcutta Longitudinal Series.
NOTE.—P. stands for pargana, Thá. for thána and K. for killah.

| No. of Station | Local name | District | Pargana, &c. | Village in which the Station lies | Remarks on the Condition of the Station |
|---|---|---|---|---|---|
| XI | Gop | Midnapore | P. and Thá. Midnapore | Gop | |
| XII | Chandbela | ,, | P. Nayagrám, Thá. Gopiballabhpur | Chandbéla | |
| XIII | Bánsgaria | ,, | P. and Thá. Náráyangarh | Bánsgaria | |
| XVI* | Bidyádhari | ,, | P. and Thá. Dántan | Near Bidyádhari tank in Sarai bazar | |
| XVII* | Sátpatia | ,, | P. and Thá. Gopiballabhpur | Sátpatia | |

* Of the East Coast Series.
NOTE—P. stands for pargana and Thá. for thána.

*January, 1885.*

W. H. COLE,
*In charge of Computing Office.*

Fig. No. 1

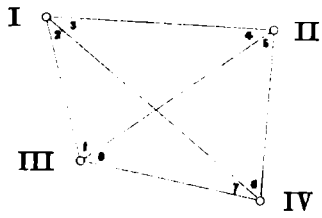
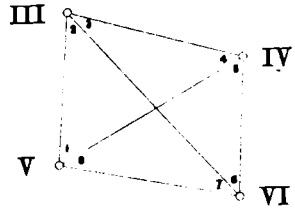


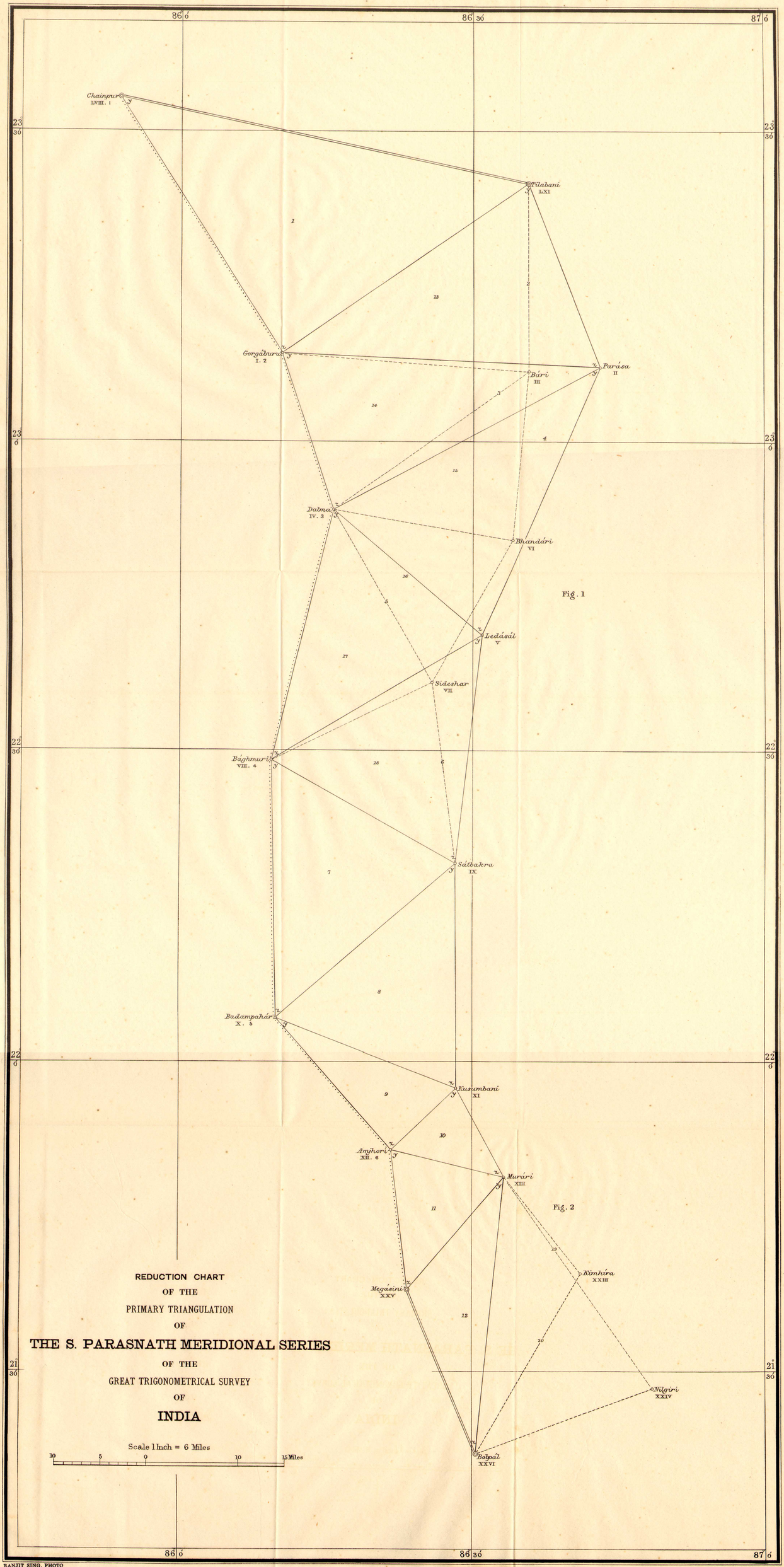

Fig. No. 2




Scale 1 Inch = 12 Miles or $\frac{1}{760320}$

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, May 1885

C. G. Ollenbach, Zinco




**REDUCTION CHART**

**OF THE**

**PRIMARY TRIANGULATION**

**OF**

# THE S. PARASNATH MERIDIONAL SERIES

**OF THE**

**GREAT TRIGONOMETRICAL SURVEY**

**OF**

# INDIA

Scale 1 Inch = 6 Miles

10 5 0 10 15 Miles

RANJIT SING, PHOTO

C. DYSON, ZINCO.

*Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, July 1880.*

23° 30′ | 87° 0′ | 23° 30′

Tilabani
LXI . 1

Súsinia
LXV

1

2

23° 0′

Jalhári
I . 2

Kundábá
II

3

15

Fig . 1

4

Tura
III . 3

Káema
IV

5

16

Fig . 2

6

Hátiári
V . 4

Dhánsola
VI

7

8

22° 30′

Báuljori
VII . 5

Kukurmuri
VIII

9

Gop
XI

10

17

Kalábani
IX . 6

Kalsíbhánga
X

11

12

Bánsgaria
XIII

Mauliákhál
XII . 7

13

14

22° 0′

Sátpautia
XVII

Dántún
XVI

# REDUCTION CHART
OF THE
PRIMARY TRIANGULATION
OF
# THE S. MALUNCHA MERIDIONAL SERIES
OF THE
GREAT TRIGONOMETRICAL SURVEY
OF
# INDIA

Scale 1 Inch = 6 Miles

10 5 0 10 15 Miles

86° 30′ | 87° 0′ | 87° 30′

RANJIT SING, PHOTO.

C. DYSON, SINGO.

*Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, July* 1880.

85° 30′ | 86° 0′ | 86° 30′ | 87° 0′

23° 30′ | 23° 0′ | 22° 30′ | 22° 0′ | 21° 30′ | 21° 0′

Chainpur H. S.
LVIII

Tilabani H. S.
LXI

Korochiá h.m.

Rájpatí h.p.

Dúmarberá h.p.

I Gorgáburú H. S.

Siringí h.p.

Digádí h.m.

Parásá H. S.
II

III Bárí S.

Nº1 h.p.

Dalma H. S.
IV

Bhandárí H. S.
VI

Nº2 h.p.

Dhobá h.m.

Nº3 h.p.

Ledásál H. S.
V

Rangamatí h.m.

Nº1 h.m.

Sideshar H. S.
VII

Bághmurí H. S.
VIII

Sátbakrá H. S.
IX

Badampahár H. S.
X

Kusumbaní H. S.
XI

Barágaon h.m.

Amjhorí H. S.
XII

Nº2 h.m.

Murárí H. S.
XIII

Dolkí h.m.

Ganpatí h.m.

Megásiní (Meghásani) H. S.
XXV

Megásiní (Meghásani) N. h.m.

Kimhírá H. S.
XXIII

Nilgirí H. S.
XXIV

Bolpál H. S.
XXVI

# Chart

OF THE

# SOUTH PARASNATH MERIDIONAL SERIES

*Compiled and photozincographed under the orders of*

COLONEL J. T. WALKER, C. B., R. E., F. R. S., &C.,

*Superintendent of the Great Trigonometrical Survey of India*

At the Office of the Survey, Dehra Dun, February 1878.

Scale 1 inch = 8 miles or $\frac{1}{506880}$

8 4 0 8 16 24 Miles

EXPLANATION OF SYMBOLS USED ON THIS CHART.

| | | |
|---|---|---|
| H.S. | Signifies | Hill Station (Principal) |
| S. | „ | Station (Principal, in the plains) |
| h. | „ | Hill |
| m. | „ | Mark |
| p. | „ | Peak |

C. DYSON, PHOTO.

C. G. OLLENBACH, ZINCO.

# Chart

OF THE

# SOUTH MALUNCHA MERIDIONAL SERIES

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At the Office of the Survey, Dehra Dun, February 1878.

Scale 1 inch = 8 miles or $\frac{1}{506880}$

8 4 0 8 16 24 Miles

## EXPLANATION OF SYMBOLS USED ON THIS CHART.

| | | |
|---|---|---|
| H.S. | Signifies | Hill Station (Principal) |
| S. | ,, | Station (Principal, in the plains) |
| T.S. | ,, | Tower Station (Principal) |
| h.s. | ,, | Hill Station (Secondary) |
| s. | ,, | Station (Secondary, in the plains) |
| t.s. | ,, | Tower Station (Secondary) |
| fl. | ,, | Flag |
| h. | ,, | Hill |
| hel. | ,, | Heliotrope |
| ho. | ,, | House |
| m. | ,, | Mark |
| p. | ,, | Peak |
| t. | ,, | Temple |
| tr. | ,, | Tree |
| v. | ,, | Village |

C. DYSON. PHOTO.

C. G. OLLENBACH, ZINCO.

*List of Published Works of the Great Trigonometrical Survey of India.*

---

An Account of the Measurement of an Arc of the meridian between the parallels of 18° 3′ and 24° 7′, being a continuation of the Grand Meridional Arc of India as detailed by the late Lieutenant-Colonel Lambton in the Volumes of the Asiatic Society of Calcutta. By Captain George Everest, of the Bengal Artillery, F.R.S., &c. London, 1830.

An Account of the Measurement of two Sections of the Meridional Arc of India, bounded by the parallels of 18° 3′ 5″; 24° 7′ 11″; and 29° 30′ 18″. By Lieutenant-Colonel Everest, F.R.S., &c., late Surveyor General of India, and his Assistants. London, 1847.

---

Account of the Operations of the Great Trigonometrical Survey of India.

Volume I. The Standards of Measure and the Base-Lines, also an Introductory Account of the early Operations of the Survey, during the period of 1800-1830. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey. Dehra Dún, 1870.

Do. II. History and General Description of the Principal Triangulation and of its Reduction. By Colonel J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Survey, and his Assistants. Dehra Dún, 1879.

Do. III. The Principal Triangulation, the Base-Line Figures, the Karáchi Longitudinal, N.W. Himalaya, and the Great Indus Series of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1873.

Do. IV. The Principal Triangulation, the Great Arc (Section 24°-30°), Rahún, Gurhágarh and Jogí-Tíla Meridional Series, and the Sutlej Series of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1876.

Do. V. Details of the Pendulum Operations by Captain J. P. Basevi, R.E., and W. J. Heaviside, R.E., and of their Reduction. Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Trigonometrical Survey. Dehra Dún and Calcutta, 1879.

Do. VI. The Principal Triangulation of the South-East Quadrilateral including the Great Arc—Section 18° to 24°, the East Coast Series, the Calcutta and the Bider Longitudinal Series, the Jabalpur and the Biláspur Meridional Series, and the Details of their Simultaneous Reduction. Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Trigonometrical Survey. Dehra Dún, 1880.

*List of Published Works of the Great Trigonometrical Survey of India—(Continued).*

Account of the Operations of the Great Trigonometrical Survey of India—(*Continued*).

Volume VII. General Description of the Principal Triangulation of the North-East Quadrilateral including the Simultaneous Reduction and the Details of Five of the Component Series, the North-East Longitudinal, the Budhon Meridional, the Rangír Meridional, the Amua Meridional, and the Karára Meridional. Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Trigonometrical Survey. Dehra Dún, 1882.

Do. VIII. Details of the Principal Triangulation of Eleven of the Component Series of the North-East Quadrilateral, including the following Series; the Gurwáni Meridional, the Gora Meridional, the Huríláong Meridional, the Chendwár Meridional, the North Párasnáth Meridional, the North Malúncha Meridional, the Calcutta Meridional, the East Calcutta Longitudinal, the Brahmaputra Meridional, the Eastern Frontier—Section 23° to 26°, and the Assam Longitudinal. Prepared under the directions of Lieut.-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Trigonometrical Survey. Dehra Dún, 1882.

Do. IX. Electro-Telegraphic Longitude Operations executed during the years 1875-77 and 1880-81, by Lieut.-Colonel W. M. Campbell, R.E., and Major W. J. Heaviside, R.E. Prepared under the directions of Lieut.-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Trigonometrical Survey. Dehra Dún, 1883.

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Synopses of the Results of the Great Trigonometrical Survey of India, comprising Descriptions, Co-ordinates, &c., of the Principal and Secondary Stations and other Fixed Points, of the Several Series of Triangles, as follows;—

Volume I. The Great Indus Series, or Series *D* of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1874.

Do. II. The Great Arc—Section 24° to 30°, or Series *A* of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1874.

Do. III. The Karáchi Longitudinal Series, or Series *B* of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1874.

Do. IV. The Gurhágarh Meridional Series, or Series *F* of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1875.

Do. V. The Rahún Meridional Series, or Series *E* of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1875.

Do. VI. The Jogí-Tíla Meridional Series, or Series *G*, and the Sutlej Series, or Series *H* of the North-West Quadrilateral. By Colonel J. T. Walker, R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1875.

Do. VII. The North-West Himalaya Series, or Series *C* of the North-West Quadrilateral, and the Triangulation of the Kashmir Survey. By Major-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Survey, and his Assistants. Dehra Dún, 1879.

Synopses of the Results of the G. T. Survey of India, &c.—(*Continued*).

Volume VIII. The Great Arc—Section 18° to 24°, or Series *A* of the South-East Quadrilateral. By Colonel J. T. Walker, C.B., R.E., F.R.S., &c., &c., Superintendent of the Survey, and his Assistants. Dehra Dún, 1878.

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Do. XI. The Biláspur Meridional Series, or Series *F* of the South-East Quadrilateral. By Major-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Survey, and his Assistants. Dehra Dún, 1880.

Do. XII. The Calcutta Longitudinal Series, or Series *B* of the South-East Quadrilateral. By Major-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Survey, and his Assistants. Dehra Dún, 1880.

Do. XIII. The East Coast Series, or Series *C* of the South-East Quadrilateral. By Major-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Survey, and his Assistants. Dehra Dún, 1880.

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Do. XV. The Rangír Meridional Series, or Series *K* of the North-East Quadrilateral. By Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Survey, and his Assistants. Dehra Dún, 1883.

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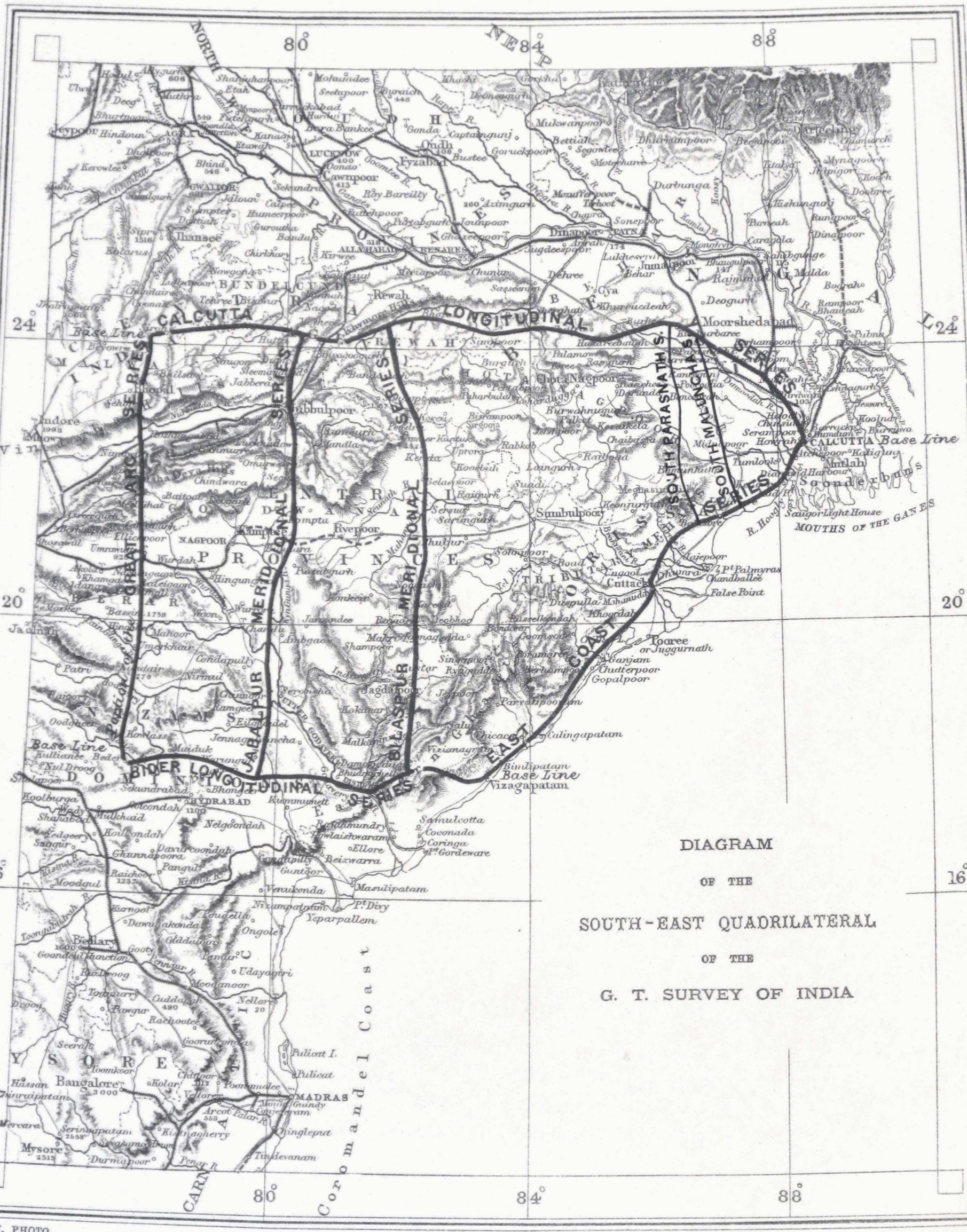
Do. XVIII. The Huríláong Meridional Series, or Series *P*, and the Chendwár Meridional Series, or Series *Q* of the North-East Quadrilateral. By Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., &c., &c., Surveyor General of India and Superintendent of the Survey, and his Assistants. Dehra Dún, 1883.

Do. XIX. The North Párasnáth Meridional Series, or Series *R*, and the North Malúncha Meridional Series, or Series *S* of the North-East Quadrilateral. Prepared by J. B. N. Hennessey, Esq., M.A., F.R.S., &c., &c., Offg. Deputy Surveyor General, in charge of Trigonometrical Surveys, and his Assistants, and published under the orders of Colonel G. C. DePrée, S.C., Offg. Surveyor General of India. Dehra Dún, 1883.

Do. XX. The Calcutta Meridional Series, or Series *T*, and the Brahmaputra Meridional Series, or Series *V* of the North-East Quadrilateral. Prepared by J. B. N. Hennessey, Esq., M.A., F.R.S., &c., &c., Offg. Deputy Surveyor General, in charge of Trigonometrical Surveys, and his Assistants, and published under the orders of Colonel G. C. DePrée, S.C., Offg. Surveyor General of India. Dehra Dún, 1883.

Do. XXI. The East Calcutta Longitudinal Series, or Series *U*, and the Eastern Frontier Series—Section 23° to 26°, or Series *W* of the North-East Quadrilateral. Prepared by J. B. N. Hennessey, Esq., M.A., F.R.S., &c., &c., Offg. Deputy Surveyor General, in charge of Trigonometrical Surveys, and his Assistants, and published under the orders of Colonel G. C. DePrée, S.C., Offg. Surveyor General of India. Dehra Dún, 1883.




DIAGRAM

OF THE

SOUTH-EAST QUADRILATERAL

OF THE

G. T. SURVEY OF INDIA

C. DYSON, PHOTO.

C. G. OLLENBACH, ZINCO.

*Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, August* 1880.