Library ... Calcutta

Received (without plates) from the Library of the Geological Survey on condition that the copy for the Great Trig. Survey expected from England, be supplied in its' place.–

J. T. Walker

March 1862.

[illegible]
28

SCIENTIFIC MISSION

TO

INDIA AND HIGH ASIA.

VOLUME I.

RESULTS

OF A SCIENTIFIC MISSION TO

INDIA AND HIGH ASIA,

UNDERTAKEN BETWEEN THE YEARS MDCCCLIV. AND MDCCCLVIII.,

BY ORDER OF THE COURT OF DIRECTORS OF THE HONOURABLE EAST INDIA COMPANY,

BY

HERMANN, ADOLPHE, AND ROBERT DE SCHLAGINTWEIT.

WITH AN ATLAS OF PANORAMAS, VIEWS, AND MAPS.

VOLUME I.

LEIPZIG: F. A. BROCKHAUS. LONDON: TRÜBNER & CO.

MDCCCLXI.

ASTRONOMICAL DETERMINATIONS

OF

LATITUDES AND LONGITUDES

AND

MAGNETIC OBSERVATIONS

DURING A SCIENTIFIC MISSION TO INDIA AND HIGH ASIA,

BY

HERMANN, ADOLPHE, AND ROBERT DE SCHLAGINTWEIT.

PRECEDED BY

GENERAL INTRODUCTORY REPORTS.

WITH THREE PLATES.

LEIPZIG: F. A. BROCKHAUS.

LONDON: TRÜBNER & CO.

MDCCCLXI.

TO

THE ROYAL SOCIETY,

WHICH BY ITS UNTIRING ENDEAVOURS FOR THE

ADVANCEMENT OF PHYSICAL SCIENCE IN GENERAL,

AND MORE ESPECIALLY BY THE LABOURS OF MANY OF ITS DISTINGUISHED MEMBERS,

HAS SO ESSENTIALLY AND ENERGETICALLY PROMOTED THE SCIENCE OF MAGNETISM.

THIS VOLUME

IS MOST RESPECTFULLY DEDICATED

BY

THE AUTHORS.

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ERRATA.

Page 30 line 19, *for* X *read* XI

" 69 " 22, *insert* between (bh) and d *ch*

" 87 " 13, *for* $\begin{array}{l} \;\;\;\;{}^{\circ}\;\;{}'\;\;{}'' \\ +\ 7\ 46\ 10 \\ +\ 7\ 26 \end{array}$ *read* $\begin{array}{l} \;\;\;\;{}^{\circ}\;\;{}'\;\;{}'' \\ +\ 7\ 46\ 10 \\ +\ \;\;\;\;\ 7\ 26 \end{array}$

" 125 " 6, *for b read c*

" 126 " 20, *for* 113 *read* 112, line 23, *for* Lambert *read* Lambton.

" 190 " 23, *for* 1856 *read* 1855

" 191 " 29, *for* 214° 10′·0 *read* 214° 14′·0

" 250 " 19, *for* $4^h\ 17^m\ 28^s$ *read* $4^h 17^m\ 18^s$

" 288 " 8, *for m* to three and *X* to four *read m* to four and *X* to three.

" 343 " 11, *for* 36° 34′ 35″ *read* 26° 34′ 35″

" 344 " 16, *for* 0·4399 *read* 0·4409

" 346 " 14, *for* 5·653 *read* 5·719

" 348 " 13, *for* 9·449 *read* 9·541

" 353 " 32, *for* 2° 21′·1 *read* 2° 21′·9

" 354 " 25, *for* log *m read m*

" 355 " 6, *for* 4·247 *read* 4·294, line 7 *for* 9·011 *read* 9·033

Page 356 line 21, *for* 6·203 *read* 4·190, line 22, *for* 9·132 *read* 7·904

" 361 " 7, *for* 5·095 *read* 5·113, line 8, *for* 9·230 *read* 9·242

" 371 " 19, *for* 0.22063 *read* 0·22539, line 30, *for* 0·2226 *read* 0·2239, line 30, *for* 7·464 *read* 7·505

" 372 " 3, *for* Needle 3 *read* Needle 4, line 12, *for* 7·845 *read* 7·889, line 13, *for* 10·830 *read* 10·889

" 376 " 22, *for* 2·286 *read* 3·286

" 381 " 21, *for* 0·31665 *read* 0·33275

" 384 " 3, *for* 229° 34′·5 *read* 229° 24′·5, line 16, *for* 0·29984 *read* 0·31536

" 468 " 12, *for* Tomb *read* Tomb on the coast

" 477 last line, *for* southern ones in 1800; *read* southern ones; in 1800

" 478 line 20, *for* declinations *read* curves, line 21, *for* 8,000,000; for the equator *read* 8,000,000 for the equator;

" 479 " 24, *for* the forces *read* force, line 26, *for* every degree *read* every full degree.

ALPHABET USED FOR TRANSCRIPTION.

a (ā ă a̲ ã); ä; b (bh); ch (chh); d (dh); e (ē ĕ ẽ); f; g (gh); h; i (ī ĩ); j (jh); k (kh), k̲h̲; l (lh); m; n; o (ō õ), ö; p (ph); r (rh); s; sh; t (th); u (ū ũ), ü; v; y; z.

RULES OF PRONUNCIATION.

Vowels.

1. a, e i, o, u, as in German and Italian.
2. ä, ö, ü, as in German.
3. Diphthongs give the sound of the two component vowels combined. Diæresis is marked by the accent falling on the second of the two vowels.
4. ‾ above the vowel makes the vowel long.

   In general we considered it unnecessary to add this sign when the accent coincided with it, and the omission would not influenc the correctness of the pronunciation.

   Short vowels are not separately distinguished.
5. ˘ above a and e (ă, ĕ) is a sign of imperfect phonetic formation, similar to the open *u* in *but*, and *e* in *herd*.
6. ‗ below a indicates the deep sound, like *a* in *wall*.
7. ˜ above a and o indicates a nasal sound, like *a* and *o* in the French words *gant* and *son*; also ẽ, ĩ, and ũ had to be introduced for marking the nasal sound of e, i, and u; in the nasal diphthongs aũ and aĩ, we make the sign over one only, though both vowels have the nasal sound.

Consonants.

1. b, d, f, g, h, k, l, m, n, p, r, s, t, are pronounced as in German and English [the variations occuring in the pronunciation of g, and h (in English) excepted].
2. h, after a consonant is an audible aspiration, except in ch, sh, and k̲h̲.
3. ch, as in English (*church*).
4. sh, as in English (*shade*).
5. k̲h̲ as *ch* in German (*hoch*).
6. j, as in English (*just*).
7. v, as the *w* in German (*Wasser*), being different from *v* in *very*, and *w* in *water*.
8. y, as *y* in the English word *yes*, or *j* in the German *ja*.
9. z, soft, as in English.

Accents.

ʹ marks the syllable on which the accent falls, whether the syllable be long or short.

Alphabetical Registers.

In our alphabetical registers the letters follow the order of the alqhabet, irrespective of the signs attached to them.

GENERAL REMARKS.

The measurements of heights and distances are given in English feet, and the miles also are English.

The readings of the barometer are given in millimetres and English inches.

The longitudes are referred to the meridian of Greenwich. Adopted longitude of the Madras Observatory: 80° 13′ 56″ East Green.

The magnetic elements are given in English units.

The sign △ before a name indicates an uninhabited place.

L. a. L. S. = Little above the level of the sea.

PART I.

GENERAL INTRODUCTORY REPORTS.

GENERAL INTRODUCTORY REPORTS.

I. ADDRESS TO SIR CHARLES WOOD, BART., SECRETARY OF STATE FOR INDIA.

II. ITINERARY, WITH AN APPENDIX ABOUT THE ESTABLISHMENT.

III. LAST JOURNEYS AND DEATH OF OUR BROTHER ADOLPHE.

IV. TRANSCRIPTION.

I. ADDRESS TO SIR CHARLES WOOD, BART., SECRETARY OF STATE FOR INDIA.

I.

It is not without a lively sense of the great difficulties of the work we have undertaken, that we endeavour, in the following volumes, to present the results of the scientific mission with which we were entrusted in the years 1854-8.

The flattering interest which His Majesty, Frederick William IV., King of Prussia, so eminent a patron and protector of science and art, graciously condescended to take in our former researches, on the physical geography and the geology of the Alps, gave the first impulse which resulted in our mission to India.

It was in February, 1854, when our late friend, Baron Humboldt, and the distinguished Prussian Minister, Baron Bunsen, then at London, officially communicated His Majesty's intentions to the Court of Directors of the East India Company. Soon after this, our late brother, Adolphe, left Munich for London, where he received from Baron Cetto, the Bavarian Minister, the kindest reception, who gave him at the same time most valuable advice in furtherance of our plans.

Supported by the energetic assistance of Colonel Sykes, on the part of the Court of Directors, and of General Sabine and Sir Roderick Murchison, on the part of the Royal Society, all the official arrangements were made without any delay.

One of the chief objects of our researches was the completion of the Magnetic Survey of India, which had been commenced in 1846 by the late Captain Elliot, in the Eastern Archipelago.[1] At the same time, in consequence of the high interest evinced in science by the distinguished Court then at the head of Indian affairs, our mission assumed a very general and extensive character.

[1] Magnetic Survey of the Eastern Archipelago, by Captain C. M. Elliot. Philosophical Transactions, 1851.

On the 20th of September, 1854, we left England, under conditions most favourable for the researches with which we had the honour to be charged, and we arrived in Bombay on the 26th October, 1854. In India, as in England, every official assistance was most kindly given to us, and we found ourselves liberally provided with the necessary orders to the respective civil and military authorities, and with diplomatic introductions to the Courts of the Native States.[1] These documents were of the most essential importance in enabling us to extend our mission into countries, which, otherwise, we could never have hoped to reach, and which, indeed, were far beyond the limits of our original intention.

Notwithstanding, in the independent territories north of the Himálaya, and especially amongst tribes whose hostile disposition often obliged us to travel in disguise and conceal our instruments, our progress was not without many and unexpected difficulties—difficulties which most unhappily ended in the lamentable death of our dear brother, Adolphe, who was killed at Káshgar, in August, 1857.[2]

We met on our way home in Egypt, Hermann having come down from Tíbet, by the easterly route, viâ Calcutta, Robert by the westerly route, viâ Bombay. We arrived at Trieste on the 8th of June, 1857.

Our assistants had been allowed by the Government to continue their observations in the special branches of physical geography until March, 1858. To about this date also extends the information received from those of our brother's establishment, who returned after his death, from Turkistán.[3]

[1] Lord Dalhousie and Lord Canning at Calcutta, Lord Harris at Madras, and Lord Elphinstone at Bombay, most materially contributed to the uninterrupted and successful progress of our observations by their never failing official assistance.

We are also indebted to the numerous friends, met with during our travels in India, for much valuable advice, support, and scientific information. Amongst others we may mention Sir John Lawrence and Lord W. Hay, in the Pánjáb and the Himálaya, Colonel Waugh and Major Thuillier, in Calcutta, and the Honourable Walter Elliot, in Madras, and though we must refrain in this place from completing the list of names, we shall gladly avail ourselves of the many opportunities which will occur in the course of our work for mentioning them in connection with the objects of our researches.

[2] See No. III. of the General Introductory Reports.

[3] During our travels "Reports on the proceedings of the Officers engaged in the Magnetic Survey of India" were from time to time forwarded by us to the Government, who ordered them to be printed. With the exception of the last Report, they were all written upon the march, and contain but the general outlines of the routes followed and of the objects observed.

Their titles are:

II.

Upon our return to Europe, the working out of our scientific materials, and their publication, was immediately commenced. The kind assistance which we were fortunate enough to receive from Lord Stanley, then Secretary of State for India, greatly facilitated the preliminary preparations for our intended work.

It was not without some anxiety in reference to the results we might obtain, that we took in hand the elaboration of our various observations; but though we often found many difficulties presented by the intimate and complicated connection of the various physical laws in nature, yet the progress of our labours, of which we here present the first volume, has, if we may venture an opinion, developed results, for which we may hope to find an indulgent reception.

It has been a circumstance peculiarly encouraging that Her Majesty, your most gracious Sovereign, has been pleased to confer upon us the high honour of accepting the dedication of the artistic parts of our publications. This portion of our work consists of an Atlas in three folio volumes (containing 80 views and panoramas, and from 20 to 30 maps and profiles), and also of a plastic series of 275 ethnographical heads.

Our scientific publications, in eight quarto volumes, contain the details of the observations, together with the general results which we endeavoured to obtain by the comparative and mutual application of the related branches in physical science and natural history, our principal object being to present a general physical tableau of the various countries explored.

1. Observations made during the sea voyage from Southampton to Bombay, by Hermann, Adolphe, and Robert.
2. Bombay to Madras, through Southern India, by Hermann, Adolphe, and Robert. These two Reports were published in Madras, May, 1855, and reprinted in Calcutta, June, 1855.
3. Síkkim, Khássia Hills, and Assám, by Hermann. Calcutta, February, 1856.
4. Kămáon, Tíbet, and Gărhvál, by Adolphe and Robert. Ágra, December, 1855.
5. Upper Assám, Bhután, and Bengál, by Hermann. Lahór, 1856.
6. Central India, Madras Presidency, and Nílgiris, by Adolphe. Lahór, 1856.
7. Central India and North West Provinces, by Robert. Lahór, 1856.
8. Ladák and Turkistán, by Hermann and Robert. Ágra, 1857.
9. Western Himálaya and Bálti, by Adolphe. Lahór, 1857.
10. Pănjáb, through Sindh, to Bombay, by Robert. Calcutta, 1857.
11. On the last journeys and death of Adolphe, by Hermann and Robert. Berlin, 1859.

To these volumes will be added another descriptive one, forming No. 9 of the series. This will not be a narrative of the travels in their chronological order, such being given in the first volume[1] in a condensed tabular form, but, on the contrary, a general and comparative representation of what we consider to be the characteristics of the natural scenery of the different regions examined.[2]

The area over which our operations were carried on, every facility being given us to follow independently different routes as often as circumstances allowed it, was extended from Ceylón to Káshgar in Turkistán (Lat. N. 6° to Lat. N. 38°), and from Sindh to Assám (Long. E. Gr. 67° to 95°); and all along these various routes we were enabled to collect, in addition to our own observations, materials very valuable for the work we had to publish.

III.

In working out our observations, the well known labours of numerous scientific predecessors[3] have proved of the greatest importance to us.

The materials collected by us are comprised under the following heads:

A. MANUSCRIPTS, DRAWINGS, MAPS.

1. 45 manuscript volumes, containing the observations made by ourselves and our respective establishments.

2. 172 unreduced stations of meteorological observations, part of which were made previously to our arrival in India, and communicated to us, at our request, by the Government.

[1] See No. II. of the General Introductory Reports.

[2] The titles of the nine volumes are:

I. *Astronomical* and *Magnetic Observations.*
II. *Hypsometry, Barometrical* and *Trigonometrical* Observations.
III. *Topical Geography,* and Route Book of the Himálaya and Tibet.
IV. & V. *Meteorology* and *Climate* in general.
VI. *Geology.*
VII. *Botany* and *Zoology,* particularly with reference to geographical distribution.
VIII. *Ethnography,* comparative researches based on measurements, casts, and photographs.
IX. *Geographical Aspects* of India, the Himálaya, Tibet, and Turkistán.

[3] Amongst many others, who have laboured in the various branches of physical geography and ethnography, are to be named: Buist, Cautley, Cunningham, Eastwick, Elliot, Everest, Falconer, Gerard, Griffith, Hodgson, Hooker, Latham, Oldham, Prinsep, Thomson, the Stracheys, Sykes, Thuillier, Waugh, and Wilson.

3. 750 views and panoramas by Hermann and Adolphe, including some photographs of landscapes by Robert.

4. Various maps and profiles in connection with the geological and geographical observations.[1]

B. COLLECTIONS.

a. GEOLOGY AND NATURAL HISTORY.

1. *The Geological Collections* consist of about 2000 specimens of rocks and fossils, and of 1400 specimens of soils and deposits now filled in glass cylinders. The setting up of the latter, which are in the museum of the India House, is now nearly complete, and the labelling and arrangement of the remaining part of the collection is in active progress.

2. *The Herbarium* was formed principally with a view to represent the geographical distribution of plants, and is particularly complete for Tíbet, from Gnári Khórsum to Hasóra, and for the routes from Ladák to Turkistán.

3. *The Zoological Collections* contain skeletons, skins, and animals preserved in spirits of wine, many of which are already placed in the India House museum.

b. ETHNOGRAPHY.

In illustration of this branch of science we have collected various articles of native dress, manufactures and weaving, 351 specimens of which have been delivered to the India House museum, whose ethnographical collection for the Eastern Empire is unrivalled in Europe. The more important portion, however, consists, besides the skulls and skeletons, and numerous photographs, of a collection of 275 facial casts and 38 casts of hands and feet.

The complete series, published in metallic casts since May, 1859, by J. A. Barth, at Leipzig, is in the sculpture room of the India House.

We particularly mention our obligations to the late Dr. Horsfield, and also to Dr. Forbes Watson, the present superintendent, for their kind and valuable assistance in arranging our contributions.

[1] The important maps, published in India by the Great Trigonometrical Survey, and those also by the Revenue Department, were most liberally placed at our disposal by Colonel Waugh and Major Thuillier, whom we have already had the pleasure of mentioning.

IV.

The Royal Society, to whom, as has been already stated, we are under deep obligation for their active interest in our mission, have highly honoured us by accepting the dedication of this volume, the first of the series, which contains the results of our researches on terrestrial magnetism, as well as the determinations of latitudes and longitudes, connected with these observations.

The details of the astronomical and magnetic observations are preceded by an itinerary in a tabular form, by the communications received in reference to the fate of our late brother, Adolphe, and by explanatory notes on the mode of transcription adopted.

Berlin, 1st March, 1860.

II. ITINERARY, WITH AN APPENDIX ABOUT THE ESTABLISHMENT.

A. ROUTES.

I. Europe to Bombay, viâ Egypt. II. Bombay to Madras. III. Calcutta to Nainitál, and Calcutta to Darjíling. IV. Himálaya and Central Tibet. V. Bengál, territories of the North-East Frontier, and Hindostán. VI. Central and Southern India. VII. Western Tibet. VIII. Chains of the Karakorúm and Kuenlúen. IX. Tíbet and Himálaya. X. Pánjáb to Calcutta, with a visit to Central Nepál. XI. Pănjáb to Bombay, and visit to Ceylón. XII. Return to Europe, viâ Egypt. XIII. Adolphe's last journeys. XIV. Routes of Adolphe's establishment: *a.* in the Himálaya; *b.* in Central Asia.

The routes are laid down on Map No. 1 of the Geographical Atlas.

B. ESTABLISHMENT.

I. Observers. II. Interpreters. III. Collectors. IV. Servants.

The detail of the transcription used forms the object of No. IV. of the General Introductory Reports.

A. ROUTES.

In the Tables, in which we present the different routes[1] taken by ourselves and by our assistants, we give the detail in such a form, as to render it possible minutely to follow them on the Route Map, which is contained in the geographical part of our Atlas.

We have formed our routes in 14 groups, arranged in chronological order.

The sign $\triangle$ indicates an uninhabited place, where a halt had been made. Such places along commercial routes are also the halting places of caravans.

The different routes are preceded by explanatory remarks, having reference principally to the mode of travelling and to the general character of the climate.

[1] As stated in our evidence before the Select Committee on Colonization and Settlement in India (Fourth Report, published July 23rd, 1858, p. 2), the total length of the various routes, along which our researches were carried on, in India and to the north of it, amounts to about 18,000 miles.

In writing these notes, we ever experienced the most lively conviction of their incompleteness. If, however, for the present, we have limited ourselves to the delineation of a few descriptive outlines, we have done so only with the hope of being able hereafter to present the details in a form better adapted for scientific and descriptive purposes than the chronological arrangement appears to be. This enumeration of our routes in a condensed form may at least be found useful in facilitating the general geographical connection of the objects of our researches.

In the second part of this chapter, we give an enumeration of the establishment we had engaged, in which all the detail about the persons, occasionally mentioned in our itinerary, will be found. The routes they took are only given when they were separated from us.

I. EUROPE TO BOMBAY, VIÂ EGYPT.

1. Hermann, Adolphe, Robert.

1854.

September 20th, left Southampton, per steamer "Indus".
" 25th, Gibraltar.
" 30th, Malta.
October 5th, Alexandria.
October 8th, left Suez, per steamer "Oriental".
" 14th, Aden, per steamer "Auckland", for Bombay.
" 26th, Bombay.

Adolphe remained at Bombay till December 2nd, Hermann and Robert till December 31st.

They visited:

November 19th to 22nd, Bassáin, Sálsette, and Tánna.
December 16th and 17th, Elephanta.

II. BOMBAY TO MADRAS.

During our journey through the southern parts of the Peninsula of India we had engaged a camel proprietor. The men keeping camels ready for hire are called mokadáms in Bombay, cháudris in Bengál. This man supplied 20 camels (dromedaries) and six servants for the transport of our tents, collections, and our heavy luggage in general. All the delicate instruments were carried by kúlis on long bamboo sticks; the chronometers, throughout the journey, were carefully packed up in bags, thickly stuffed with cotton, as well to prevent the ill effects of unavoidable shaking, as to reduce as much as possible the variations of temperature. The kúlis were changed every three or four marches.

Our mode of travelling was as follows:—In the evening the mokadám, with his kúlis and the greater part of the dromedaries, used to leave the encampment which had sheltered us during the day, and push forward in advance of us during the cool hours of the night. Early in the morning, between three or four o'clock, we ourselves set off on horseback, reaching the new halting place, already prepared by the party preceding us, at about ten o'clock. In the afternoon, when the sun's rays were somewhat tempered, we made our usual exploration of the immediate vicinity. In jungly districts we occasionally rode dromedaries, instead of horses.

In the Dékhan the mornings were generally cool, 7° to 11° C. (44°·6 to 51°·8 Fahr.); and during the hours preceding sunrise a well marked haze, considerably affecting the transparency of the air, was regularly observed when the temperature reached its maximum of heat. At about three o'clock in the afternoon the thermometer ranged between 23° to 27° C. (73°·4 to 80°·6 Fahr.). In Maissúr, the southernmost point of this journey, heavy morning dews were a characteristic feature. The temperature also was considerably higher, the morning minimum being on an average 14° to 18° C. (57°·2 to 64°·4 Fahr.), the maximum 25° to 29° C. (77° to 84°·2 Fahr.). The only wet day was the 19th February on Robert's route, the rain being heavy, though of short duration, and quite local in its effects.

The periodical setting in of the sea breeze in the afternoon was distinctly felt 50 miles inland.

2. Hermann, Adolphe, Robert: Western Ghāts.

1854-5.

A. Adolphe.	*B.* Hermann, Robert.
December 2nd, left Bombay by boat.	December 31st, left Bombay by steamer.
„ 6th, Mahár.	January 2nd, across the Bhor Ghāt.
„ 9th to 15th, Mahabuléshvar.	„ 4th, Púna, where they joined Adolphe.
„ 20th to January 4th, 1855, Púna.	

From Púna he visited. December 28th to 31st, Singárh.

3. Through the Dékhan and Maissúr to Madras.

A. Hermann, Adolphe, Robert.

1855.

January 5th, left Púna.	January 18th and 19th, Kāládghi.
„ 9th, Sattára.	„ 22nd, Gădjăntergárh.
„ 15th, Ánapur.	„ 27th to 30th, Bellári.

1855.

B. Adolphe.	*C.* Hermann, Robert.
January 31st, left Bellári.	January 31st, left Bellári.
February 5th, Banganpílli.	February 4th, Paulasamúdrăm.
„ 9th, Kádapa.	„ 8th, Bangalúr.
„ 14th, Tirpúti.	Hermann, by carriage dāk.
„ 16th, Nellatúr.	„ 12th, Madras.
„ 18th, Madras.	Robert.
	„ 11th, Kistnaghérri.
	„ 15th, Vellúr.
	„ 19th, Madras.

We remained in Madras till March 2nd, arrived at Calcutta per steamer "Bengal", March 5th. Quarter Master General's Guide, Salmónji, returned round Ceylón to Bombay.

III. CALCUTTA TO NAINITÁL AND CALCUTTA TO DARJÍLING.

One mode of rapid travelling in Bengál is by palanquin or pálki, with relays of bearers previously posted at the different stations along the line of route. The luggage (reduced in our case chiefly to instruments) is conveyed at the same speed with the traveller. A large pálki train travelling during the night, accompanied by torches and kept at a uniform rate by a peculiar monotonous chant of the bearers, is a characteristic peculiar to Indian travelling. The pálki dāk has the advantage of being practicable even along bad roads, and over the hilly districts, in fact on nearly every kind of route where bearers can be procured. In Bengál the office of pálki bearer is confined exclusively to one particular caste, named the Kahárs.

Another mode of travelling is by carriage dāk, which, however, can be used along but very few roads, and even on these its progress is often interrupted by the swollen state of the rivers, nearly all of which must be crossed without the help of proper bridges. These carriages are four-wheeled, of the same make as a palanquin, and drawn by one horse, which is changed about every six miles.

A part of our journeys was performed during the setting in of the hot season; the maximum temperature reached 36° C. (96°·8 Fahr.), but during our later journeys we had still higher temperatures. Though in the morning the thermometer usually reached 20° C. (68° Fahr.), yet the air was very pleasant to the feelings of the traveller.

At Farrukhabád, on the 11th of April, 1855, there was a heavy dust storm, from which we defended ourselves as well as we could by putting wetted tattis before our doors. These tattis are mats of grass, and, when kept wet, lower considerably the temperature of the room by the process of evaporation. Some people consider them unhealthy; though for our own parts we never experienced any bad effects from their use.

The ascent to the top of the first ridges of the Himálaya, which are more than 6000 feet high, is very steep, and the climate, in consequence, extremely varied. Indeed, the very first evening, after leaving the heated plains, we found it desirable to have fires.

4. Adolphe, Robert: Bengál and Hindostán.

1855.

March 24th, left Calcutta by rail.	April 6th and 7th, Allahabád by carriage dák.
„ 29th, Pátna by pálki dák.	„ 10th and 11th, Fatigárh „ „ „
April 4th, Benáres { Adolphe, viâ Báksar. / Robert, viâ Sherghótti. }	„ 13th, Baréli by pálki dák.
	„ 16th, Nainitál.

We remained at Nainitál till May 16th, making occasional excursions: to Chíner peak, 27th and 28th April, to Lária Kánta, May 7th to 9th, and in the environs of the lake at Nainitál.

Assistants: Mr. Daniel and guide Eleazar travelled along the Grand Trunk Road, March 15th to May 9th, from Calcutta to Nainitál. They made a stay of several days at Allahabád, Benáres, and Fatigárh.

They had their luggage carried by the Government bullock train. This consists of a number of strong carts, with solid wooden wheels; they are drawn by bullocks, which are changed at every six or eight miles. This train is used chiefly for the carriage of Government stores, merchandize, and heavy luggage in general to the upper provinces, and travelling, as it does, day and night, reaches Lahór, during the dry season, in about from 24 to 26 days after leaving Calcutta.

5. Hermann: Bengál to Síkkim.

1855.

April 5th, left Calcutta by pálki dák.	April 14th, Siligóri.
„ 8th, Bĕrhampúr.	„ 16th, Pankabári.
„ 11th, Dínajpur.	„ 18th, Darjíling.

Remained at Darjíling till May 7th, making occasional excursions.

Assistant: Lieutenant Adams left Calcutta, March 30th, went by steamer up the Ganges, and reached Darjíling, viâ Párnea, April 23rd.

IV. HIMÁLAYA AND CENTRAL TÍBET.

6. HERMANN: Síkkim, Himálaya.

My researches in Síkkim were made along the Singhalíla ridge. The hostile disposition of the Síkkim Government since Dr. Hooker's and Dr. Campbell's travels utterly frustrated all attempts to obtain permission to travel in the lower parts of Síkkim. Even on the route which, at first, I thought it possible to follow unobserved, since it lay along a jungly and uninhabited ridge, I soon found that my kúlis and workmen, of whom I had a great number for clearing paths and making tree sections for the collection, gradually disappeared. This seems to have been a device on the part of the Nepalese to make it impossible for me to continue my journey. But in spite of this and all other difficulties I succeeded, partially at least, in effecting my purpose. Three weeks later a Nepalese guard presented itself, and, after allowing me to make a few marches forward, forced me to return.

Up to Tónglo I had the pleasure of being accompanied by Lieutenants Congreve and Goddard, and Dr. Dominichetti. Lieutenant Congreve, who returned by the Nepalese fort Ilám, had the kindness to communicate to me his route.

In the southern parts of Síkkim, and particularly in the environs of Darjíling, the rainy season is very heavy; the amount of rain very often exceeding, during this period, 120 inches. Farther to the north the rains were not quite so violent, nevertheless they offered very serious obstacles. During my travels in Síkkim, my tent was wet through for three weeks continuously, and everything inside, as may be well imagined, in a state of excessive moisture.

1855.

May	7th, left Darjíling.	June	2nd, last camp Singhalíla.
„	9th, Saimonbóng.	„	12th, returned from Falút.
„	10th, Tónglo.	„	17th, reached Darjíling.
„	20th, Changtábu.	July	1st, coal mines on the Ratiáng.
„	22nd, Fălút.	August	12th, left Darjíling.
„	30th, Góza.	„	14th, Siligóri, foot of Himálaya.

Assistants: Lieutenant Adams marched with Hermann; Ábdul, being a native, was able to visit the valleys of the Ramám, and Răngit.

7. Adolphe, Robert: Kămáon, Himálaya.

The Traill's pass was the first high pass which Adolphe had to cross in the Himálaya.

This pass had been first discovered by Mr. Traill[1]: we therefore kept his name connected with it. It offered great difficulties, as well from the enormous quantities of snow, which still covered its flanks at this season, as from the religious superstitions with which it is regarded by the Hindus, to whom these stupendous mountains are objects of a particular worship.

Its height exceeds 17,000 feet; but on account of its being impassable for horses, it has never been, like many high passes in the Alps, of practical use. The men whom Adolphe had succeeded in engaging were, with the exception of one, entirely ignorant of the direction to be taken; they could only be induced to follow him by his promising to sacrifice three goats on the top of the pass. Though this was done by them with strict observance of all religious ceremonies, some of the men were so frightened as suddenly to fall into fits, from which, however, they soon recovered.

The route which Robert took, with the tents and the greatest part of the instruments, is at the same time the route of trade between the plains and the higher parts of Kămáon. The road, as far as Bágeser, is excellent; but between Munshári and Mílum the valleys are generally so narrow, and the slopes so steep and rugged, that great difficulties were experienced in bringing up the horses, even without their loads. The only time that horses can be brought up and down with safety is early in the spring, when the remains of the winter avalanches form solid snow bridges, exactly similar to those in the higher parts of the Alps.

The influence of the rainy season was felt in the higher valleys of Johár only in the beginning of July, when there were heavy showers of rain for three consecutive days.

1855.

A. Adolphe.	*B.* Robert.
May 20th, left Nainitál.	May 17th, left Nainitál.
„ 22nd, Almóra.	„ 21st, Bágeser.
„ 27th, Káthi.	„ 25th to 27th, Munshári.
„ 31st, Traill's pass.	„ 29th, Rilkŏt.
June 4th, Mílum.	„ 31st, Mílum.

Adolphe and Robert both remained at Mílum till July 4th, and visited:

June 9th to 12th, environs of Nánda Dévi.	June 16th to 21st, the glaciers near Mílum.

[1] Mr. Traill is well known by his publications on Kămáon. See Asiatic Researches, Vol. XVI., 1831, p. 137, and Vol. XVIII., 1832, p. 1.

8. ADOLPHE, ROBERT: Gnári Khórsum, Tíbet.

The only chance we had of crossing the Tibetan frontier was to pass it in disguise. Notwithstanding all our precautions, we were soon recognised as Europeans by the Chinese authorities, and peremptorily ordered to return. To prevent our entering their territories, from which Europeans are so jealously and successfully excluded, a Chinese guard was ordered to bring us back. But we were able to escape their vigilance, and, late in a dark night, to cross the Sakh pass. Though soon traced and overtaken by our guard, we nevertheless succeeded, by a liberal use of money, in making arrangements with the Chinese to allow us to proceed to the north as far as the Sátlej. With the assistance of the Bára Máni, the head of the Máni family, we were able to penetrate as far as Gártok.

This important trading station in Central Tíbet was first made known by Moorcroft's visit in 1812[1]. At that time Moorcroft was also accompanied by members of Máni's family.

On this journey, in our ascent of the Íbi Gámin, we attained an elevation of 22,260 feet, the greatest height, as far as we know, that has yet been reached on any mountain.

Even here the influence of the Indian rainy season was still appreciable; it manifested itself in sudden thunder-storms, for the most part accompanied by hail and sleet. Occasionally we had to suffer very much from cold.

1855.

July 4th, left Mílum.
" 6th, Úta Dhúra pass.
" 8th and 9th, Jánti pass.
" 11th, Kiúnger pass.
" 15th, Sakh pass.
" 18th to 20th, environs of Dába.
" 26th Cháko La pass.

July 28th, environs of Gártok.
" 29th, Gunchankár peak.
August 5th to 8th, Mángnang.
" 13th to 19th, Ibi Gămin.
" 22nd, Ibi Gămin pass.
" 25th to 31st, Bádrinath and Mána.

9. ADOLPHE, ROBERT: Himálaya and Tíbet.

Adolphe managed to complete his second journey into Gnári Khórsum without the disguise he had assumed being detected. But, besides difficulties of a political nature, he had to contend with natural impediments, in the shape of a very rough road with three high passes.

[1] See Moorcroft's Travels, edited by H. H. Wilson. 2 Volumes. London, 1841.

Robert examined the territory in which are situated the sources of the Ganges and the Jámna with their principal tributaries. The surface of the country is extremely precipitous and rugged, difficult of access, and quite impassable for horses. At the same time, the great number of fakírs travelling as pilgrims over these regions gives to them a very peculiar character.

1855.

A. ADOLPHE.

Second journey to Tíbet and return to Gărhvál.

September 2nd, left Bádrinath.
„ 5th, Mána pass.
„ 10th, Phóko La pass.
„ 16th, Púling.
„ 19th, Nélong pass.
„ 27th to 30th, Múkba.
October 6th to 9th, Usílla.
„ 12th, Kidarkánta.
„ 17th, Măssúri.

B. ROBERT.

Gărhvál.

September 7th, left Bádrinath.
„ 9th, Jhósimath.
„ 15th, Ókimath.
„ 19th to 22nd, Kídarnath and glaciers near it.
24th, Tríjugi Naráin.
October 1st, Masertál.
„ 6th, Úri.
„ 13th, Khărsáli.
„ 21st, Măssúri.

Separate routes of assistants:

In May: from Nainitál to Mílum, viâ Námik; in July: from the Sakh pass, viâ Níti to Bádrinath; in October: from Masertál, viâ Sálu to Khărsáli, by two different routes.

V. BENGÁL, TERRITORIES OF THE NORTH-EAST FRONTIER, AND HINDOSTÁN.

10. HERMANN: Bengál and Khássia Hills.

Notwithstanding the unfavourable season for travelling in the plains during and after the rains, a boat journey through the Jhīls, nearly across country, was undertaken from Síkkim to the foot of the Khássia Hills, since it had become impracticable to make any further exploration in the interior of Síkkim.

I had two large native boats, called bánders, and a smaller one besides. The first was for the assistant and myself, and also carried the instruments; the second was for the servants and for cooking operations; the smaller one conveyed our two horses, which we found very useful in exploring the neighbourhood of our halting places, which we did every evening, as far as the state of the country allowed. Similar boats were also sometimes used in Assám. In the Khássia Hills and in Bhután I travelled with horses and kúlis.

The climate in Eastern Bengál is exceedingly dangerous at this season, particularly for a party like ours who had come down so recently from the cooler regions of the Himálaya. The temperature, which keeps nearly the same range both day and night, is not excessively hot, but very oppressive from the great moisture and almost entire absence of winds. The greatest danger, however, proceeds from the malarious gases, which affected us severely, though we should not otherwise have noticed their existence. Lieutenant Adams was the first attacked by a brain fever, and shortly afterwards I was myself taken dangerously ill and laid up for a fortnight with a severe intermittent fever.

In the Khássia Hills I could still observe the last traces of the rainy season, which is the heaviest as yet known in the world, the total amount of rain exceeding 600 inches a year.

The climate of Assám during the cold season is a most agreeable one, though, on account of the latitude, the insolation is still very powerful.

1855.

August	15th, Siligóri, on elephant
"	17th, Bariadángi, by boat.
"	22nd, Málda.
"	25th to 30st, Rámpur Bólea, by boat.
September	8th, to 10th, Dháka.
"	18th, Káttia.
"	22nd to 24th, Silhét.
September	29th to November 5th, Chérra Púnji.
November	9th and 10th, Máirong.
"	11th, Kúlong Rock.
"	12th and 13th, Nánklau.
"	14th, Jáirong.
"	15th, Ranigodáun.
"	16th, Gohátti.

Draughtsman Ábdul came down the river Tísta from Titalía and joined me by Silhét at Chérra Púnji. Mr. Monteiro, the zoological assistant, left Síkkim, August 24th, and descended by the lateral branches of the Ganges to Calcutta, where he remained till April 4th, 1856.

11. Hermann: Assám, outer ranges of the Bhután Himálaya, and the Delta of the Ganges.

1855-6.

November	16th to December 21st, at Gohátti.
December	28th, Mangeldái, by boat.
December	30th to January 5th, Udelgúri, on elephant.
January	7th, Bogagáun.
"	10th to 13th, Närigún.
"	23th to 30th, Tézpur, by river steamer "Thames".
February	2nd, Salamára.
"	5th to 7th, Dibrugárh.
February	7th, left Dibrugárh, by river steamer ["Thames".
"	10th, Tézpur.
"	12th, by canoe to Gohátti, steamer sticking fast in the mud below Kúlang.
"	13th, 14th, Gohátti.
"	17th, Serajgáng, by river steamer "Thames".
"	21st, Dháka.
"	24th, Kúlna.
"	29th, Calcutta. Remained here till March 30th.

Assistants: Lieutenant Adams and draughtsman Ábdul left Hermann at Măngeldái, January 2nd, 1856. They went up the Bóri Dihíng, and on the 28th of May reached the place where the Nōh Dihíng branches; then following the Nōh Dihíng to Sádia, on the Brahmapútra, they descended thence to Calcutta, where they arrived on the 28th of June, 1856.

This was one of the most difficult expeditions which they had undertaken alone. Only the smallest canoes could be used, and even these, on account of the rapids, had often to be carried over jungly ground.

The chief objects of their researches were: the coal strata, the petroleum springs along the foot of the Nága Hills, and more especially the rare hydrographical phenomenon offered by the Dihíng. This river divides itself, even in the upper part of its course, into two great branches, which afterwards discharge themselves into the Brahmapútra.

12. Hermann: Bengál, Audh and Hindostán.

As far as Ambála by horse dāk.

1856.

March 31st, left Calcutta.	April 17th, Déhli.
April 4th, Benáres.	„ 18th, Mírăth.
„ 7th to 9th, Lăkhnáu.	„ 22nd, Ambála.
„ 15th, Ágra.	„ 25th, Símla.

Mr. Monteiro, the zoological collector, left Calcutta, April 4th, and marched to Símla, where he arrived, May 20th.

VI. CENTRAL AND SOUTHERN INDIA.

The following route of Adolphe, to Southern India and thence up to Símla, extended over a much larger area than any of our others in one season. Along the Godáveri, in particular, where he had to march with fifteen camels, the natural obstacles were very great; but his experience in Indian travelling, together with the assistance of a well trained establishment, enabled him to overcome them without material loss of time.

A part of Robert's journeys led through the jungles and mountain systems of Central India—unhealthy countries, inhabited by the wild aboriginal tribes of the Gōds, Bhils, and Kols. The road was for the most part stony, and altogether so bad that the camels could scarcely follow. Buffaloes, procurable in large quantities in Jáblpur, would have been decidedly more useful.

Amarkántak is, for the physical geographer and ethnographer, a most interesting country. It has been only once examined, by Dr. Spilsbury.[1] Though its height is only 3580 feet (instead of 7000 or 8000 feet, as had generally been supposed)[2], the maximum of temperature did not exceed, in January, 24° C. (75°·2 Fahr.), and a sky, almost continually overcast, sensibly mitigated the effects of the insolation.

Adolphe, during his extensive journeys, had to pass through such a variety of climates that we find it impossible to give the general characteristics, without entering too much into the details of his observations.

13. Adolphe, Robert: Hindostán and Băndelkhánd.

From Déra to Ágra by horse dāk; thence with camels.

1855.

November 8th, left Mássúri by pálki dāk.
" 10th to 14th, Déra.
" 19th, Mírăth.
" 21th to 29th, Ágra.

December 2nd, Gválior.
" 7th, Jhánsi.
" 11th, Bamóri.
" 15th to 19th, Ságer.

Guide Eleazar went alone by way of Déhli to Ágra, thence with Adolphe and Robert to Ságer.

14. Adolphe: Central and Southern India and Nílgiris.

From Ságer to Rajamándri with camels; Madras to the Nílgiris by pálki dāk; Calcutta to Ambála by horse dāk.

1855-6.

December 19th, left Ságer.
" 22nd to 26th, Jáblpur.
" 31st, Seúni.
January 4th to 8th, Nágpur.
" 11th, Nágri.
" 17th, Bíbberi.
" 24th, Rajupétta.
February 1st to 7th, Rajamándri.
" 19th, Madras by sailing vessel "Trafalgar".
" 24th, left Madras.
" 27th, Pondishérri.

March 4th, Utatúr.
" 7th, Trichinópali.
" 11th to 16th, Utakamánd and Nílgiris.
" 20th, Bangalúr.
" 22nd to 31st, Madras.
April 5th, Calcutta per steamer "Oriental".
" 14th, left Calcutta.
" 19th, Káuhpur (Cawnpore).
" 22nd, Déhli.
" 24th, Ambála.
" 26th, Símla.

[1] See Journal of the Asiatic Society, Vol. IX. 1840, pp. 889 to 903. A letter of Mr. O. P. M'Leod, printed in the Transactions of the Agricultural Society, Vol. VIII., p. 144, contains only some general remarks about the possibility of its being the site of a sanitarium.

[2] See Dr. Hooker's well known "Himalayan Journals", Murray, London, 1854. Vol. I., p. 32.

At Símla we all three met, and took advantage of our stay in that place to make a general comparison of our instruments and observations.

Assistants: Guide Eleazar accompanied Adolphe through Central and Southern India as far as Madras; from that place he was sent by a different route to Pondishérri; somewhat later he accompanied Adolphe to Calcutta. From Calcutta he marched to Símla, April 5th to May 20th.

15. Robert: Málva and Hindostán (N.W. Prov.).

1855-6.

December	19th, left Ságer.	February	4th to 6th, Sohágpur.
"	22nd, Bĕrmhán.	"	12th, Ríma (Rewah).
"	25th, Nărsínghpur.	"	15th to 18th, Allahabád.
"	30th to January 5th, Jáblpur.	"	21st to March 8th, Ágra by horse dāk.
January	9th, Mándla, on elephant.	March	9th to 11th, Déhli.
"	13th, Ramgárh.	"	13th to 14th, Sahárаnpur.
"	18th, Gorákhpur.	"	18th, Nahán.
"	20th to 26th, Amarkántak.	"	25th to May 28th, Símla and environs.
"	31st, Múnda.		(May 6th to 10th, hot springs at Súni.)

The native doctor Hărkíshen marched from Allahabád to Símla, March 8th to 26th.

VII. WESTERN TIBET.

16. Hermann, Robert: Símla to Leh.

On each of the routes leading from Símla to the interior of Western Tíbet, the road, for eight or ten days, lies through high, uninhabited countries, where shepherds only are to be met with, and occasionally caravans of salt traders, who employ sheep for the transport of their goods.

Passes, exceeding 17,000 feet, increase the difficulties of the road. Hermann's route, which lay quite across the country, was chosen chiefly with a view of visiting as many of the salt lakes as possible.

Soon after crossing the ridge of the Himálaya Proper the characteristics of the Tibetan climate become decidedly prominent, viz., an excessive dryness of the atmosphere, a cloudless sky, and very powerful insolation.

In Ladák, a peculiar dry haze is very remarkable during the latter part of summer; in valleys of an elevation of 11,000 or 12,000 feet the temperature is still remarkably high.

1856.

A. Hermann. Bissér, Spíti and Pangkóng.	*B.* Robert. Kúlu, Lahṓl, and Rúpchu.
May 29th, left Símla.	May 29th, left Símla.
„ 30st, Kotgárh.	„ 31st, Shulái.
June 2nd, Rámpur.	June 2nd, Rissálu.
„ 5th to 7th, Vángtu bridge.	„ 5th to 7th, Sultánpur.
„ 8th, Tári pass.	„ 9th, Rotáng pass.
„ 12th and 13th, Mūd.	„ 13th to 15th, Kárdong.
„ 18th, Párang pass.	„ 19th, Bára Lácha pass.
„ 21st to 24th, Lake Tsomoríri.	„ 23rd, Lácha Lung pass.
„ 26th to July 2nd, Lake Tsomognalarí.	„ 26th, Táklang pass.
July 6th to 23rd, Leh.	„ 30th to July 23rd, Leh.

17. Adolphe: Śímla to Skárdo, viâ Kúlu, Lahṓl, and Tsánskar.

Adolphe's journey in Bálti included one of the largest groups of glaciers, as well as some peaks remarkably high for this longitude. He examined carefully the most western part of the Karakorúm range; but his attempts to cross it into Turkistán were frustrated by the hostile attitude of the predatory tribes infesting its northern foot.

In Bálti, the principal valleys being at a lower elevation than those of Ladák, and at the same time more generally cultivated, the climate becomes mild enough to allow of the cultivation of fruits, chiefly apricots, which form here an important article of trade.

1856.

May 29th, left Símla, } accompanied by Robert, and making the same stages.	July 24th to 29th, Chorkónda glaciers.
June 13th to 15th, Kárdong, }	August 1st, Háldi.
„ 19th, Shínko La pass.	„ 5th, Shígar.
„ 23rd to 26th, Pádum.	„ 8th, Chutrón.
„ 29th, Péntse La pass.	„ 12th, Braháldo.
July 4th to 7th, Dah.	„ 14th, Áskoli.
„ 8th, Chórbat pass.	„ 17th, Shúrshing.
„ 12th, Khápalu.	„ 20th to 23rd, Musták glaciers and pass.
„ 14th and 15th, Húshe.	„ 29th, Skóra La pass.
„ 16th to 19th, Sóspor glaciers.	„ 31st, Shígar.
„ 21st, Chorkónda.	Sept. 2nd to 5th, Skárdo.

VIII. CHAINS OF THE KARAKORÚM AND KUENLÚEN.

18. Hermann, Robert: Ladák, Núbra, Turkistán.

We are fortunate enough to have been the first Europeans that ever crossed the chains of the Karakorúm and of the Kuenlúen; Dr. Thomson had proceeded so far as to reach the Karakorúm pass,[1] but the Kuenlúen, erroneously considered as the watershed between Central Asia and India, had hitherto remained a perfectly unknown and unvisited territory. Marco Polo, in the 13th century, only penetrated in these parts as far south as Káshgar.

The success attained by ourselves, though scarcely anticipated, may be ascribed, in a great measure, to the precautions we took to keep all our arrangements for this journey as secret as possible. It was very important, for the purpose of avoiding immediate discovery, to follow a route not generally taken by caravans trading to Yárkand. Mohámmad Amin, our chief guide,[2] therefore, proposed to us a direction, which we followed, and along which we travelled, without any trace of a road, from the Karakorúm pass as far as Búshia.

The countries we passed are certainly some of the highest of our globe. At these great elevations (14,800 to 17,600 feet, with passes above 18,000 feet) we very rarely found wood, and scarcely sufficient food for our horses; even water, though generally plentiful in summer, by reason of the melting of the snows, is occasionally obtainable only with great difficulty, when the days are more than usually cold.

On leaving Ladák, we had nineteen horses with us, of which, however, we lost seven between Leh and △ Súmgal. On the 13th August, while crossing the Élchi pass, we were overtaken by a violent snow storm. The cold was intense during the night, and two of the horses, which were lying close to our very feet, died from the effects of it. Before our return from Khótan we succeeded in making purchases of fresh horses,[3] together with six yaks and two Bactrian camels.

As far as the southern foot of the Kuenlúen the climate is always very dry, and, as must be expected from the great elevations, exceedingly cold and bleak. In these regions the rarefied air frequently became the cause of severe suffering for all our party, even the horses and our two Bactrian camels being decidedly affected by it.

[1] Western Himálaya and Tibet. London, 1852.

[2] For details about him, see *B.* Establishment.

[3] Two of these horses we brought with us to Europe, as well as the two camels; the latter we presented to the zoological garden at Berlin.

We were surprised to find how much the effect of the rarefaction of the air was increased when winds sprang up.

1856.

July	24th, left Leh.	August	24th, △ Oitásh.
„	29th, Panamik.	„	25th and 26th, Búshia.
August	2nd, Sásser pass.	„	28th, recrossed the Kuenlúen.
„	3rd, Sásser peak.	„	31st, △ Súget.
„	6th, △ Púllak.	September	2nd, △ Váliksha.
„	8th, △ Dáulat Beg Úlde.	„	4th, recrossed Karakorúm pass.
„	9th, crossed Karakorúm pass.	„	6th, △ Súltan Chúskun.
„	12th to 14th, Salt Lake Kiúk-Kiöl.	„	8th, Sásser pass.
„	16th to 18th, to △ Sikánder Mokám.	„	10th, Kársar.
„	19th to 22nd, Karakásh valley to △ Súmgal.	„	12th, Leh.
„	23rd, crossed the Kuenlúen by the Élchi pass.		

Assistants: Hărkíshen and observer Nain Singh remained at Leh in charge of a corresponding magnetic observatory; plant collectors and shooters collected in the Indus valley from Dah to Hánle, and in Tsánskar and Núbra.

IX. TÍBET AND HIMÁLAYA.

19. Adolphe: Hasóra and Kashmír.

Adolphe selected this route chiefly with the view of examining the large peaks and glacier groups surrounding the Diámer, which attains a height of 26,629 feet.[1] Kinnibári and Nunnivári peak were important stations for his geographical surveys.

1856.

September	6th, Búrge pass.	September	27th to 29th, Kinibári peak.
„	9th, Naugáum.	October	1st, Dorikón pass.
„	12th, Hasóra.	„	3rd, Gurés.
„	15th, Táshing.	„	6th, Nunnivári peak.
„	17th to 19th, Diámer glaciers.	„	9th to November 2nd, Srinágger.
„	20th to 23rd, Táshing.		

His plant collectors and shikáris (shooters) chiefly explored the country west of Skárdo.

20. Hermann, Robert: Ladák to Kashmír.

The Súru pass, being already covered with snow, was crossed with difficulty so late in the season. In general, both the roads followed are comparatively easy.

[1] See Memorandum on the Nanga Parbat, by Captain T. G. Montgomerie, in the Journal of the Asiatic Society of Bengal, No. IV., 1857, p. 266.

1856.

A. HERMANN.—Southern route.	*B.* ROBERT.—Northern route.
October 4th, left Leh.	October 4th, left Leh.
„ 6th, Láma Yúru.	„ 6th, Lama Yúru.
„ 8th, Kárgil.	„ 8th to 10th, Kárgil.
„ 11th, Súru pass.	„ 12th, Dras.
„ 15th, Pashmín.	„ 14th, Tsóji pass.
„ 17th, Islamabád.	„ 16th, Núnner.
„ 19th to November 2nd, Srinágger.	„ 17th to November 2nd, Srinágger.

21. Separate routes of the establishment:

A. Mr. Monteiro and guide Eleazar.

From Símla Mr. Monteiro and guide Eleazar took the route to Kashmír, viâ Kángra and Jámu. This journey was performed during the rainy season, which is not only the unhealthiest time of the year for travelling, but has such effect upon the roads as to render rapid movement an impossibility.

1856.

June 2nd, left Símla.	September 11th to 14th, Rajáuri.
„ 27th to July 9th, Kángra.	„ 17th, Pir Pánjal.
August 22nd to 25th, Jasrótha.	„ 23rd, Srinágger.
„ 29th to September 4th, Jámu.	

B. Plant collectors:

The plant collectors Daiádher and Johár Singh went by the following route to Kashmír, after leaving Adolphe and Robert at Kárdong:

1856.

June 16th, left Kárdong.	July 26th to 30th, Kishtvár.
„ 22nd, Triloknáth.	August 7th to 10th, Islamabád.
July 6th to 8th, Chámba.	„ 12th, Srinágger.
„ 18th to 23rd, Bhadrár.	

22. HERMANN, ADOLPHE, ROBERT: Kashmír to the Pănjáb.

During our stay in Srinágger, the capital of Kashmír, where we all met together for the second time, we occupied the large house built by the late Rájah Guláb Singh[1] for the reception of Government missions. It is situated close to the banks of the Jhílum, in a large garden, and though not so richly ornamented as the Rájah's own palace is much better adapted to European purposes.

[1] Guláb Singh died in August, 1857, and was succeeded by his son, Rámbir Singh, the present ruler of Kashmír.

The different routes from Kashmír to the Pănjáb offer in themselves no particular obstacles; but as all the collections which we had made during the summer, and which had already been forwarded from time to time to await our arrival at Kashmír, had accumulated in large quantities, we found great difficulty in procuring the necessary means of transport, though we divided our luggage between three caravans and sent them off before us at several days' interval from each other.

During our stay, in October, the climate was mild and agreeable, the minimum, 2° to 3° C. (35°·6 to 37°·4 Fahr.); the maximum, 19° to 22° C. (66°·2 to 71°·6 Fahr.). The season at the end of autumn is one of the finest in the world. In summer the heat is much greater than is generally supposed, though it is often interrupted by rains.

In the annual distribution of rains, summer rains, decidedly prevail, coinciding with the period of the rainy season in the plains; but occasional falls occur in every month. Snow falls in the middle of winter only, and then lasts but for a short time.

The climate of Kashmír is generally considered to be very healthy; but a year after our departure, in the summer of 1857, cholera raged to a fearful extent in its somewhat thickly populated districts.

A. HERMANN, ADOLPHE.—Southern route, viâ Márri.

1856.

November 2nd, left Srinágger.
" 5th, Úri.
" 8th, Hátti.
" 9th, Chikár.
November 12th to 16th, Márri.
" 17th to Dec. 13th, Adolphe: Raulpíndi.
" 17th to Dec. 18th, Hermann: Raulpíndi.

B. ROBERT.—Northern route, viâ Mozăferabád.

1856.

November 2nd, left Srinágger.
" 4th, Naushéra.
" 8th, Hátian.
November 10th to 12th, Mozăferabád.
" 13th, Abottabád.
" 16th to December 18th, Raulpíndi.

Assistants: Máni and Nain Singh went across the Pũch pass by Thimáli to Raulpíndi.

X. PANJÁB TO CALCUTTA, WITH A VISIT TO CENTRAL NEPÁL.

It had been the intention of Adolphe and Robert to visit Nepál in the summer of 1855. But not only was the permission for a regular journey refused, but my (Hermann's) first attempt, even, to proceed in the same year along the frontier between Síkkim and Nepál, resulted in being turned back by force.[1]

It was only after two years' diplomatic negociations, very kindly entered into upon our behalf by the Governor General and Colonel Ramsay, British Resident in Kathmándu, that the Court of Nepál allowed me to visit a portion of its territories.

Upon arriving at the frontier I had quite an official reception, and a guard of sepoys constituted themselves my constant companions, partly in the capacity of guides, but more especially for keeping watch upon my operations. No restriction, however, was placed upon the use of my instruments, and I was allowed to take measurements, and also to draw without let or hinderance, a privilege of which I availed myself by making drawings of the beautiful peaks of Central Nepál from different heights in the environs of Kathmándu.

The Tarái, the unhealthy belt of forests and jungles at the foot of the Himálaya, was crossed on elephants, kindly provided by Major Holmes, who, to the great regret of his numerous friends, was killed a few months later in the Indian mutiny.

The climate of the valley of Kathmándu will hereafter be the object of a detailed treatment based on a most valuable series of observations taken at the Residency. These observations had their origin in Mr. H. B. Hodgson's ardent love for science, and have been lately taken up again by the medical gentlemen attached to the Residency.

Kathmándu has very warm summers, a well marked rainy season, and mild winters. Snow is exceedingly rare; but a few isolated occasions of its appearance are known, and then it fell in the night only, and disappeared with the earliest rays of the sun.

23. HERMANN: *A.* Pănjáb and Hindostán to Nepál.

As far as Ambála by pálki dāk, then to Pátna by horse dāk.

1856-7.

December 18th, left Raulpíndi.
,, 20th, Gujrát.
,, 27th to January 8th, Lahór.
January 13th, Ludhiána.
,, 15th, Ambála.

January 18th, Aligárh.
,, 20th to 26th, Ágra.
February 5th to 11th, Pátna.
,, 14th, Sigáuli.

[1] See p. 16.

B. Nepál.

1857.

February 14th, left Sigáuli.
„ 16th, Chíria Ghāt.
„ 18th, Kathmándu.
„ 28th, Kåkani peak.
March 1st, Káulea peak.
„ 4th, Kathmándu.
„ 6th, Chandragíri pass.
„ 10th, Fírfing.
„ 13th, Sigáuli.

C. Bengál.

Partly by pálki, partly by horse dāk.

1857.

March 14th, left Sigáuli.
„ 15th, Chápra.
„ 19th to 22nd, Pátna.
March 24th, Parisnáth peak.
„ 27th to April 22nd, Calcutta; left per steamer "Bengal", for Europe.

Assistants: Lieutenant Adams and draughtsman Ábdul, after their return from Assám, left Calcutta per river steamer, March 10th, reached Pátna, February 1st, travelling thence with Hermann.

After the departure of Hermann to Europe, Lieutenant Adams remained still attached to the Survey, for scientific observations, which he carried on successfully till March, 1858, chiefly in Bengál, Bahár, and the Rajmahál Hills.

X. PĂNJÁB TO BOMBAY, AND VISIT TO CEYLÓN.

The greatest part of this journey might have been performed by water, viz., on the tributaries of the Indus as far as Multán, on the Indus itself from Multán to Kărráchi, and by sea from Kărráchi to Bombay. However, I (Robert) preferred to go by land as a mode of travelling better suited for the examination of the country. Before arriving at the Gulf of Kambay I had to march nearly 1500 miles, on horse-back almost all the way, except in Sindh, where I made use of camels. My caravan of baggage-camels had to be changed three times before I reached Bhūj; subsequently, however, I engaged bullock carts.

There is no part in the plains of India which presents greater extremes of temperature than the Pănjáb. In winter it enjoys a cold season in the true sense of the word, the thermometer from November to the end of February scarcely rising above 19° C. (66°·2 Fahr.); in summer the heat, accompanied by fearful dust-storms and hot winds, is excessive. The varieties of climate which I passed through on my route, nearly due south, were most striking, the difference of temperature fully corresponding to a change produced by a descent of from 6000 to 7000 feet in the Himálaya.

In Lower Sindh heavy fogs were not unfrequent. The sea breeze was felt nearly 60 miles inland. In March, during my travels across the sterile delta of the Indus, in Kăch, and Kattivár, the heat was very oppressive, and especially so in the close atmosphere of the tents.

24. ROBERT: *A.* Pănjáb and Síndh.

1856-7.

December	18th, left Raulpíndi.	January	22nd, Mithánkōt.
"	21st to 24th, salt mines at Kiúra.	"	25th, Nausléra.
"	27th to 29th, Sháhpur.	"	30th to February 4th, Sákker.
January	1st, Jhăng.	February	9th, Nári.
"	5th to 12th, Multán.	"	13th, Sévan.
"	15th, Bháulpur.	"	19th, Mánchar lake.
"	20th, Khánpur.	"	22nd to 29th, Kărráchi.

B. Kăch and Gujrát.

1857.

March	1st, left Kărráchi.	March	19th, Gulf of Kăch.
"	3rd, Thátha (Tátta).	"	21st and 22nd, Rajkót.
"	9th and 10th, Lăkhpút.	April	2nd, Súrat.
"	15th and 16th, Bhŭj.	"	4th, Bombay, per steamer "Lowjee Family".

C. Ceylón.

1857.

April 4th to 17th, Bombay.	April 29th to 30th, Kándi.
" 17th to 21st, Bombay to Gálle, per steamer "Norna".	May 3rd to 4th, Nurélia.
" 24th to 26th, Kolómbo.	" 11th to 14th, Gálle; left per steamer "Nubia", for Europe.

Mr. Monteiro accompanied Robert only so far as Pind Dádan Khan; from this place he took boats, and went to Multán; thence by river steamer to Kărráchi, where he remained during the month of March. Arrived by steamer in Bombay, April 5th. During Robert's visit to the interior of Ceylón he remained at Gálle.

XII. RETURN TO EUROPE, VIÂ EGYPT.

25. Hermann, Robert: Overland route.

1857.

A. Hermann.	*B.* Robert.
April 23rd, left Calcutta per steamer "Bengal".	May 14th, left Gálle per steamer "Nubia".
„ 26th, Madras,	„ 23rd, Áden.
May 1st to 4th, Gálle,	„ 28th, Suez.
„ 13th, Áden,	„ 31st, left Kairo.
„ 20th, Suez,	
„ 22nd to 30th, Kairo,	

June 2nd, Hermann and Robert left Alexandria per steamer "Bombay", for Trieste.
„ 8th, arrived at Trieste.

XIII. ADOLPHE'S LAST JOURNEYS.

On the 17th December, 1856, at Raulpíndi, we took leave of each other, and set out on separate routes. This was the last time we saw our unfortunate brother.

His plans were, at one time, to go to Bombay by a more easterly route than Robert, after revisiting the fossiliferous outer ranges of the Himálaya. He determined, however, again to examine the Karakorúm chain and to visit the Kuenlúen and the countries to the north of it.

The details of his last journeys, and their fatal termination, are given separately in No. III. of the General Introductory Reports.

26. Adolphe: Pănjáb and outer ranges of the Himálaya.

1856-7.

December 13th, left Raulpíndi.	February 1st to 5th, Kohát.
„ 16th, Átak.	„ 10th to 14th, Kalabágh.
December 18th to January 30th, Pesháur with excursions.	„ 16th, Musakél.
January 31st, visit to Dost Mohámmad and environs of the Kháiber pass.	„ 23rd to 28th, Déra Ismáel Khan.
	March 9th to 20th, Lahór.
	April 5th to 20th, Kángra.

In Pesháur he was invited to accompany Sir John Lawrence to Jămrúd, on his official interview with Dost Mohámmad, the ruler of Kábul.

27. Adolphe: Himálaya, Tíbet, and Turkistán.

The data for this journey are less precise than those for the preceding ones.

1857.

April 20th, left Kángra.
May 5th, Sultánpur, Kúlu.
„ 15th to 26th, Kárdong, Lahól.
„ 31st, Bára Lácha pass.
June 14th, Changchénmo, avoiding Leh, for greater facility of crossing in disguise the Tibetan frontier.

July 9th, crossed the Karakorúm chain by the pass north of Aksáë Chīn, which lies three marches south-east of the Karakorúm pass, by a new and entirely unfrequented road.
„ 20th, crossed the Kuenlúen, near △ Karangolák.
August 1st to 5th, environs of Yárkand, Shámla Khója, Négsăr.

During the month of August,
- △ Kokiár.
- △ Késseli.
- △ Chámelung.
- Yángsar.
- Káshgar, where he was killed.

XIV. ADOLPHE'S ESTABLISHMENT.

Before starting for Turkistán, Adolphe despatched the different parties of his establishment upon the following routes:—

a) A party of plant collectors was discharged by him in Lahól and went viâ Kishtvár to Kashmír, thence to India.

b) A second party returned from Ladák, by Lahól and Kúlu, to their native villages near Kángra.

c) The native doctor, Hărkíshen, was left by Adolphe in Lahól, and was ordered to visit at a later period Spíti, Kănáur, and Bissér. When, after some time, no news of Adolphe had reached him, he returned to Déra and Almóra.

After Adolphe's death, his followers were partly dispersed; two of his chief servants some time afterwards communicated to us, amongst other information, the routes they had respectively taken after the sad catastrophe. As they had been for a long period in our service, as well as his, they had gained some experience in travelling, and were better able to define and give an account of their marches, than natives in general would have been able to do.[1]

[1] It is well known that this was the same way in which, some years ago, valuable information was obtained by Mir Ízzet Úllah, a native servant of Moorcroft, of the same countries, first explored at a later period by our brother Adolphe and ourselves.

28. Hărkíshen's route.

1857-8.

May	31st to June 9th, glacier group round the southern flanks of the Bára Lácha pass.	October	6th, Khálsi on the Jámna.
June	14th to July 25th, Kárdong, the chief place of Lahól and its environs.	„	11th to December 11th, Déra, in the Déra Dūn.
August	11th to 21st, Tránkar in Spíti.	December	14th, Tíri, } in Gărhvál.
„	25th, Shálkar.	„	18th, Srínăgger, } in Gărhvál.
September	2nd, Nísang in Bissér.	„	25th to March 2nd, Almóra.
„	3rd to 31st, down the Báspa valley, along Puári and across the Gunáss pass.	March	5th, Srinágger, in Gărhvál.
		„	17th, Déra.

29. Route from Káshgar to Kókand, made by the guide Ábdul, native of Pesháur, after our brother's death.

Ábdul, before proceeding on this journey, had been taken prisoner and sold as a slave. For details, see p. 62.

1858, May to July.

Káshgar.
△ Karaúl,[1] Chinese post station.
Minggiál, tents inhabited by Kirghises.
△ Khansuvalák.
△ Kargashímkane.
△ Ókhsalur.
△ Yáskechik.
△ Irin or Yérin.
△ Íkisak, foot of Térek Deván.[2]
across the Térek Deván o
△ Sófi, or Álsüge.
△ Árchalik.
△ Súpeneke.

Kissilgorgán, Gúlsha, Kablankál, Karvankál, } Tents inhabited by Kirghises.
△ Sáukechuk.
△ Mádu.
Ōsh or Takht-i-Sulimán.
Áravan, Tólmasar, Margelón, (Naphtha and petroleum springs are in the environs,) Karaúl Dípa, Kókand, } Towns inhabited by Kokandis.

[1] The sign △ indicates halting places, generally uninhabited.

[2] A pass (Deván) east of it is called the Shert Deván, and is crossed by the following road:

△ Írin or Yérin.
△ Tokái páshi.
△ Cher ka tal.
△ Yeballakárcha.
Akhtásh, foot of Shert Deván, in the Sáyan Shan, across the Shert Deván to △ Kurokhkálla.
△ Sófi or Álsüge, and thence by the ordinary road to Kókand.

30. Kókand, viâ Samarkánd to Bokhára, by the guide Ábdul.

1858, July to end of September.

Kókand.
Lévi Deriau.
Ksékos.
Khúchand.
Nau.
Kísseli.
Ůritpa.
Tsómum.
Jísak.
Yákorgan.
Khisbobrúk.
Samarkánd.
Kåressu.
Kătegorgán.
Kármina.
Bokhára.

Good road; inhabited places all the way.

31. Bokhára, viâ Kundúz and Badakhshán to Kábul and Pesháur, by the guide Ábdul.

1859, end of September to December 15th.

October, Bokhára.
" Kásan.
" Koshmugórak.
" Kárchi.
" Bálkh.
" Shahimárdan.
October, Khulm.
November, Kundúz.
" Faizabád, chief place of Badakhshán.
December 1st, Kábul.
" 10th, Jellalabád.
" 15th, Pesháur.

32. Guide Mohámmad Amín's previous journey from Ösh to Táshkend, 1855.

For completing the routes in Central Asia, we annex a very interesting route which was traversed by Mohámmad Amín (our chief guide during our travels in Turkistán) in the summer of 1855, from Ōsh to Táshkend, the most northern military frontier post of Kókand, on the Russian frontier.

Ösh.
Káshgar Kshlak, village.
Andishán, } towns on the
Námangan, } Sir Deriau.
△ Taiták, foot of a pass in the Kindirtáu range.
△ Raváte Abdúllah Khan.
△ Tóitipa.
△ Biskát.
△ Teláu.
△ Kúrruma.
△ Chíkchik, } on the Sir Deriau.
Táshkend, }

B. ESTABLISHMENT.

We had been authorized by the Government of India to engage the establishment required for our mission immediately upon our arrival; and as the selection of the assistants, both as to number and qualifications, was entirely left to our own discretion, we found ourselves at liberty to engage those persons best suited for our purposes. Accordingly we found that, after sufficient training, we could entrust some of them, even in our absence, with magnetic and meteorological observations at fixed stations, corresponding with those made by ourselves during our journeys in the neighbouring countries.

The assistant Lieutenant Adams and the draughtsman Ábdul remained permanently attached to Hermann; the others used to travel, sometimes with one, sometimes with the other of us; very often they were sent out on lateral routes, and even performed journeys of considerable extent by themselves.

The ethnographical remarks, which we give about the tribes and the countries they belong to, may tend at the same time, we think, to a clearer apprehension of our general mode of travelling.

I. OBSERVERS.

1. Mr., afterwards Lieutenant Adams.

This gentleman was engaged by Hermann, at Calcutta, and from March, 1855, was head assistant to him throughout his travels. After Hermann's departure to Europe, he continued still engaged with observations till March, 1858.

In him we found a most talented and energetic coadjutor, who very materially contributed to the progress of our mission. His important journey in Upper Assám, as well as his observations in the Rajmahál Hills, are deserving of particular mention.

2. Ábdul, a Mussălmán from Madras, but of Hindu origin.

This native held an appointment as draughtsman and assistant surveyor in the office of the Quarter Master General of that Presidency, who was kind enough to place him officially at our disposal in February, 1855. He became Hermann's second assistant, and continued so till nearly the completion of the travels, when he died, at Calcutta, in April, 1857.

Ábdul had travelled alone on several routes in Síkkim, made the boat voyage from Síkkim to Assám by an independent route (along the Tísta), and was attached to Lieutenant Adams during the latter's examination of the Dihíng. His death is a subject of sincere regret to us.

3. Hărkíshen, Bráhman from Almóra in Kămáon (Himálaya).

Before entering our service in April, 1855, he had been attached as a native doctor to the hospital at Almóra. He was our (Adolphe and Robert's) chief assistant, and rendered us important services by his zeal and diligence in general, as well as by the accuracy of his observations. He was also superintendent of our plant-collectors. He could write, but not speak, English, and labelled, in Hindostání and English, our ethnographical collections.

During our travels in Turkistán, in 1856 (Hermann and Robert), he remained at Leh in charge of our magnetic and meteorological observatory. In Raulpíndi he again became attached to our late brother Adolphe's establishment, and accompanied him as far as Lahól, when he was instructed to follow a separate route through Tíbet and the Himálaya. In the different provinces of these mountainous countries—where he spent nine months, from June, 1857, to March, 1858—he made a series of observations deserving of all praise.

On all occasions we found him to be a very honest, trustworthy, and intelligent native. As a medical attendant he was also very valuable to us, from his knowledge of surgery and of the use of simple remedies.

4. Mr. Daniel, an Indo-Briton (Eurasian), accompanied us (Adolphe and Robert) only from Calcutta to Kămáon and Gárhvál, between March and September, 1855. We discharged him at his own request.

5. Eleazar, a guide in the Quarter Master General's Department, of Bombay, was ordered to join us at the commencement of our journeys.

This man was a Jew of the black tribe,[1] which is known to have been settled for a long time in India. He was with us (Adolphe and Robert) till Robert's return to Europe, May, 1857. He acted as an excellent guide during our travels in India Proper, and even in the Himálaya we could safely entrust him with the superintendence of the transport of our instruments and collections. He was also frequently engaged

[1] See: Ritter, Erdkunde von Asien. Vol. IV., p. 598.

with success in surveys of a less difficult character, and could read correctly the meteorological and minor surveying instruments.

6. Salmónji, from the same office as Eleazar, also a coloured Jew from Bombay, accompanied us from Púna as far as Madras; he then obtained leave to return round Ceylón to Bombay.

7. Ramchánd, a Hindu múnshi from Pesháur, seems to have been but a short time with Adolphe, who took him into his service at that place, about the end of December, 1857.

8. Mohámmad Hássan, was a native of Lahór or Pesháur, whom Adolphe had engaged as a múnshi nearly at the same time with Ramchánd. He could write English, Hindostáni, and Persian, and doubtless proved useful on many occasions, though his character must certainly be considered as a questionable one. He travelled with Adolphe as far as the frontier of Turkistán, where he treacherously left him, just at a time when our brother was in a most precarious situation. Several witnesses stated that he took with him one of Adolphe's horses. (See p. 48 and p. 60.)

II. INTERPRETERS.

During our travels in Tíbet and Turkistán, and also in some parts of Síkkim, we had to engage different men, who knew Hindostáni as well as the languages of the countries which we were traversing. Besides filling their office as interpreters, they occasionally gave us valuable geographical information about the countries bordering upon our line of route, and proved of great use in our linguistic inquiries about dialects and geographical names.

9. Máni (full name Man Singh), a Bhot-Rajpút, the member of an influential and wealthy family from Johár, in northern Kămáon (Himálaya), was charged, during two summers, with the difficult arrangements of our travels in Tíbet, during which he proved of the most essential service to us by his excellent behaviour. He was the only one of our establishment whom we trusted sufficiently to take with us to Turkistán. Máni is also well known as a faithful servant to the British Government, who have made him the Pătvári, or head man, of Johár, a district of Kámáon.

His father, Dévi Singh, who is still alive, was the companion of Moorcroft, in 1812; and he himself had once been engaged by the Stracheys, during their travels in Tíbet.

10. Dólpa, Máni's cousin, a subordinate attendant during our travels in Gnári Khórsum, was made, by Adolphe, his interpreter and chief guide for Bálti. He was rather a rough kind of man, but full of courage, energy, and devotedness.

11. Nain Singh, another relative of Máni, a well disposed and intelligent native, went with us (Hermann and Robert) to Ladák, in 1856. He took a great interest in our operations, and though at first unacquainted with instruments was soon taught their use, as he showed a very great desire to be able to read off the scales and write the readings in English numbers. He could also read and write Tibetan. During our travels in Turkistán he remained at Leh, where he acted as assistant to Härkíshen.

We had proposed, and with apparent acquiescence on his part, to take him with us to Europe; but, like all hill men, he was too much attached to his native mountains to bring himself to leave them, and he unexpectedly went away from us at Raulpíndi, leaving behind a long letter of apologies.

12. Mohámmad Amín, a rather aged Turkistáni, from Yárkand, rendered us most faithful and important services during our expedition to Turkistán. He had formerly carried on extensive trading operations between Tíbet and the Russian frontier, which seemed to have brought him into great trouble with the Chinese Government.

His manner of treating the natives, and the cordial reception every where given to him, plainly showed that amongst his countrymen he was a well known personage, and considered as a man of great respectability and influence. It is principally owing to his excellent arrangements, carried on under difficulties which seemed at first insurmountable, that we found it possible to penetrate to the north of the Kuenlúen.

He was also Adolphe's chief guide during his last and fatal journey to Yárkand and Káshgar. As far as we are able to judge, no blame whatever can be attached to him in connection with the murder of our brother.

Few persons have travelled more in the western part of Central Asia, or are better acquainted with the different routes of that region, than Mohámmad Amín.

13. MAKSHÚT, an Indian Mussălmán from Déhli, who had been settled for a long time in Ladák, was our Turkish interpreter in Turkistán, as Mohámmad Amín knew no Hindostáni and very little Tibetan, and Máni was acquainted with Tibetan and Hindostáni only.

Makshút was decidedly wanting in energy; so much so, that when difficulties, physical or political, arose, he would try his utmost to induce us to return. This, however, must in some measure be excused on the score of his delicate health, which rendered him incapable of bearing up against the fatigues and hardships of the journey.

14. CHÉJI, a Lépcha from Tassidíngin, in the Síkkim Himálaya, afterwards a settler in British Síkkim, was originally engaged as a plant collector; but he soon distinguished himself so well that I (Hermann) made him my chief interpreter for Bhútia and Lépcha. He was with me a whole year, and from Assám accompanied me to Bhután, where again he was most useful in my interview with the head Láma of Nărigún. When sent forward with two Bhútia companions towards Táuong, however, he did not succeed in making more than a few marches.

III. COLLECTORS.

The number of the people employed for assisting in the collection of natural history varied much according to circumstances. A few only were attached to our establishment at a fixed salary; but we occasionally engaged a greater number, when we remained a longer time than usual in one place.

In general we met with great difficulties in bringing together the number of people required. Prejudices of caste, real and fictitious, and the want of energy, which is so general a characteristic of the natives of India, obliged us to make frequent changes; at a later period of our travels, however, we succeeded in making a fair selection of the most active and intelligent amongst them, and some, as mentioned below, remained with us a considerable time, and worked very well.

15. MR. MONTEIRO, an Indo-Portuguese, of Calcutta, was general superintendent of the collectors, besides having the special charge of the zoological collections.

As far as possible, we always arranged for him to remain stationary at those places where we could send him down materials to be worked. He knew his business thoroughly, and always evinced great activity. He entered our establishment in April, 1855, and was engaged on the zoological preparations a year after our departure from India.

16. 17. DÁBLONG, a Bhútia, who had formerly travelled with Dr. Hooker, and CHÁGI, a Lépcha, who went with Hermann over Assám and Bhután to Calcutta, were plant collectors. Dáblong died 1857.

18 to 22. Amongst the people engaged by Adolphe and Robert for longer periods of time, between 1855 and 1857, we especially name, as having been very useful and active persons, the shooters,

LÚRI and JOHÁR SINGH, from Almóra in Kămáon and the plant collectors,

KRÍSHNA and MÓHON SINGH, from the same place, and SÚKHA, from Gválior in Băndelkhănd.

IV. SERVANTS.

For completing the sketch of the establishment which accompanied us, we add yet a few words more about the servants. We will not go into detail upon what has been already so often described, and is so well known in England, as to the great number of personal and office servants required in an Indian establishment.

In a fixed residency, a numerous retinue is not inconvenient, as the wages are pretty low, but when travelling in mountainous districts, or thinly inhabited countries, it becomes a matter of serious importance, on account of the difficulty of moving with large bodies of people.

We made many attempts, with but partial success, to get our servants to do a greater amount and variety of work for a higher rate of wages, and thus reduce their number. It was impossible, however, to do with less than eight or ten in India Proper, since many more servants are absolutely necessary for the Indian mode of travelling than are ordinarily required in Europe: such as Kălássis (or Laskárs), for tent pitching; Bhístis, for fetching water; Ghasválas, for cutting grass; Saises, for attending to the horses; Chaprássis (or Piŭns), for procuring supplies; Chaukedárs, for guarding the camp at night; Dhóbis, for washing, &c.

As one instance, connected with caste, which seriously interferes with work, we may mention that nearly every one of our establishment thought it necessary to prepare his own food, a process which materially reduced the time available for our purposes in the case of nearly every one of the attendants.

In the Himálaya, where the native races, particularly those of the higher valleys, are not so prejudiced and much more active, we were enabled to get on with comparatively few men, especially where we could procure horses or yaks (bos grunniens) for the transport of our luggage. When we travelled in disguise we messed together with the people of our caravan, who were on such expeditions always very few in number.

On one occasion our camp presented a most interesting variety of tribes and creeds, and for the time being might almost be said to form an ethnographical museum of living specimens. This happened upon our return from separate travels in different parts, when we all three met at Kashmír with our several establishments charged with one summer's collections. Besides the many divisions of Indian castes, the following religions were represented: Christians, Mr. Monteiro, and one native Christian, a laskár from Madúra, in Southern India; Hindus from different parts of India and the Himálaya, Buddhists from Tíbet; Mussălmán Túrks from Yárkand, and Mussălmáns from India and Bálti; a Jew (Eleazar), and a Parsí (fire-worshipper), both from Bombay. The languages spoken by these natives were, Hindostáni, Bengáli, Guzeráti, Maharáti, Pănjábi, Kashmíri, Persian, Tibetan, Turkish, and Portuguese and English.

Of all our private servants we here name only the Parsí, DHÁMJI, who was Hermann's chief servant. Dhámji was the only one who remained with us from the beginning to the end of our travels, and was absent during those expeditions only when we were obliged to travel in disguise. A few months after my (Hermann's) departure to Europe, he nearly lost his life, and was severely wounded, in attempting to give assistance to Europeans at the fearful massacre at Kánhpur (Cawnpore). He proved an excellent butler, honest and trustworthy in all the various transactions with which he was charged, and distinguished himself by the care which he always took to maintain a general friendly spirit in the camp.

III. LAST JOURNEYS AND DEATH OF OUR BROTHER ADOLPHE.

1. Verbal statement of the native doctor Hàrkishen. 2. Statement made by Bhútias from Johár. 3. Information contained in the *Delhi Gazette*, and general remarks of Capt. Strachey. 4. Report from Máni and Náin Singh. 5. Verbal Statement of Kăttah Áli Shah from Yárkand. 6. Statement of Gosht Mohámmad, one of Adolphe's servants. 7. Letter from Mr. Vardouguine, Russian Consul at Chúguchak. 8. Second report from Mr. Vardouguine, forwarded to Baron Budberg by Mr. George Kowalewski. 9. Letter to R. Temple, Esq., Secretary to the Chief Commissioner of the Pănjáb. 10. Verbal statement given by the Kashmíri, Abdúllah, an attendant on Adolphe. 11. Letter from Mohámmad Amín of Yárkand to Colonel Edwardes. 12. Concluding remarks.

We have to fulfil the melancholy duty of presenting here in a collected form the reports in reference to the unhappy fate of our beloved brother Adolphe. He fell a victim to his scientific zeal at Káshgar, in Turkistán, August, 1857. In him we lost a dear brother, in the prime of his youth[1] and activity, a companion in travels, the recollection of which, notwithstanding all hardships and difficulties, would be a cheerful one, if it were not also connected with this sad event. The numerous friends he found wherever he passed will know how to appreciate our loss.

The important share which he took in all our scientific and artistic labours will be apparent in the course of these publications, and prove the most lasting memorial that can be erected in order to preserve his name.

The various reports which we received from India and Russia, collected from natives by European officers of the adjoining districts, do not all agree as to the immediate cause and particulars of his death; yet it is evident from all of them that the political condition of these countries, and the circumstance of the deceased's being recognized as an officer of the Indian Government, in spite of every precaution he took, essentially contributed to his tragic end. Even with the lively sympathy always

[1] He was born at Munich, the 9th January, 1829.

so energetically evinced by England for the fate of scientific travellers, it will scarcely be possible to succeed in bringing the murderers of our brother to account. According to some reports, he perished through taking up the cause of some captive Bhot-Rajpúts, British subjects, and from using his influence to prevent them from being put to death, or sold as slaves. Other accounts state the immediate cause of his death to have been, that he was recognised as a European by some fanatic Mussălmáns, and put to death by their hands.

Many very important geographical communications have been made to us by his followers, and we are not without hope that, from the active sympathy which the Indian government has always displayed in our scientific mission to India and High Asia, no efforts will be left untried which may tend to the recovery of the papers that were in his possession at the time of his death. Up to the present time, March, 1860, we have, however, only received a parcel of his drawings, but no letters and no manuscripts.

We owe the reports[1] respecting the fate of our brother Adolphe to the exertions of the following gentlemen:

I. Captain Henry Strachey, 66th Górkhas, of Almóra (Himálaya), who, in consequence of his scientific journeys in the Himálaya, and in Western Tíbet, was in a position to select the persons on whose reports the most reliance could be placed, and was thus enabled critically to elucidate their statements, as he has done with the greatest attention.[2]

II. G. Knox, Esq., and Sir Alexander Lawrence, Assistant Commissioners of Kúlu and Kángra (Himálaya).

Mr. Knox found an opportunity of making inquiries of the Yarkándi, Káttah Áli Shah, at Någger, a place at a very great distance from Yárkand; Sir Alexander was also fortunate in obtaining information from a servant of our late brother.

III. Mr. Vardouguine, Russian Consul at Chúguchack (Central Asia), whose reports we have received through the kind offices of Baron Budberg at Berlin. Notwithstanding

[1] We had already printed these reports for private distribution in May, 1859.

[2] The reports collected by Captain Strachey were communicated by him to the Asiatic Society of Bengal, and are printed in No. IV., 1858, pp. 374 to 388, and in No. II., 1859, pp. 166 to 170, of the Asiatic Society's Journal. A part of these reports is also contained in the Proceedings of the Royal Geographical Society, London, 1858-9, Vol. III., pp. 144 and 172.

the distance, these reports have reached us in a remarkably short time, a circumstance for which we are indebted to the active sympathy of Prince Gortschakoff.

IV. Lieutenant Colonel Edwardes, C.B., in whom Adolphe, when at Pesháur, had already found a warm friend. This energetic officer, by making use of the influence of his important political position, has recently been exerting himself to the utmost to obtain the latest definite information relating to our ill fated brother.

In addition to the above, we had repeatedly received general accounts of Adolphe, accompanied with expressions of the most cordial sympathy, both through the medium of the Indian press, and also from the private communications of the following gentlemen:

The Rev. H. Jäschke, Missionary at Lahól (Himálaya),

A. C. Gumpert, Esq., Consul for Hamburg and Oldenburg at Bombay, and F. Schiller, Esq., Austrian Consul at Calcutta,

Lord Elphinstone, Lord W. Hay, Major Ramsay, the Hon. W. Elliot, E. Bowring, Esq., Private Secretary to Lord Canning, W. Russell, Esq., Correspondent of the *Times* during the Indian rebellion, and others.

We have further to acknowledge the important assistance we have received, in collecting information respecting our deceased brother, from Lord Stanley, Colonel Sykes, and Sir Roderick Murchison, in England, and from our kind and venerable friend, the late Baron Humboldt.

Our own observations are included in brackets, [ ], and are also given in foot notes. The verbal statements of native witnesses are distinguished by inverted commas. " ".

I. REPORTS COLLECTED BY CAPTAIN HENRY STRACHEY.

1. Verbal Statement of the native Doctor Hărkíshen.[1] Almóra, August, 1858.

"Adolphe Schlagintweit crossed the Bára Lácha pass from Dárche, in Lahól, into "Rúpchu, a province of Ladák, *i. e.*, from India to Tíbet, on the 31st of May, 1857. "taking with him:

[1] For detail about the persons here mentioned, see the general list of our establishment, given as an Appendix to the Itinerary, p. 36.

In consequence of our giving the statements of the native witnesses literally and almost without any alteration we could not of course avoid the occasional repetition of the expressions of the deponents, nor the opinions that they gave of the character of the attendants of Adolphe.

A reference to the general list of our establishment will, however, show discrepancies existing between their opinions and ours.

"1. Mohámmad Amín, native of Yárkand, chief guide,
"2. A Yahúdi (Jew), engaged as second guide,
"3. Mohámmad Hássan, of Pesháur, múnshi,
"4. Ábdul, of Kashmír, } domestic servants, &c.,
"5. Ghost Mohámmad, of Muradabád, }
"6. Múrli, of Bhágsu in Kángra, } chaprássis.
"7. Máula Baksh, of Muradabád, and others }

"The first of these, Mohámmad Amín, was a person of questionable antecedents, "nominally a merchant, trading between Yárkand and Leh, but said also to have "acted in the capacity of a gang-robber on the road between those places.

"Being at Leh, in 1856, he was arrested by the Dógra thanadár, Básti Ram, for "debt, at the suit of sundry merchants, or for other reasons, and released on the "application of Hermann and Robert de Schlagintweit, who engaged him to act as "guide for their journey towards Khótan, in the summer of that year, the account "of which is on record.[1] On their return to India, in the autumn, he was discharged, "and remained at Leh, where he soon got into trouble again with the Dógra Government.

"Some say that the agents of the Chinese Government in Yárkand having heard "of his bringing European travellers across their frontier (which is high treason in "their code), offered a reward of 1000 rupis for his apprehension, and perhaps coerced "some of the Kashmíri residents at Yárkand to work upon their friends in Ladák "and Kashmír for the same object, which Guláb Singh and Básti Ram possibly also "turned to a mercantile transaction.

"However this may be, Guláb Singh having ordered his arrest and threatened "to hang him soon after the Schlagintweits' (Hermann and Robert's) departure, he fled "from Ladák into Kúlu, where Adolphe found him, at Sultánpur, in April, 1857.

"There had possibly been some previous arrangement between them. Any way, "he was again entertained as interpreter, guide, and baggage master for another "journey into Turkistán.

"As a specimen of his veracity, it may be mentioned that he informed me that he "was to have a monthly salary of 2000 rupis whilst travelling with Mr. Schlagintweit, "and a monthly pension of 1000 rupis after he had brought him back safe to India.

[1] Hárkishen alludes to our official Report, No. 8, Ágra, Secundra Orphan Press, 1856; see p. 7.

"Major Hay, Assistant Commissioner of Kúlu, probably knows more of Mohámmad "Amín's history."

[So far Hărkíshen. We have already given our very favourable opinion about Mohámmad Amín at p. 39.

The name of the Yahúdi, the Jew, mentioned as the second guide, was not known to Hărkíshen. This is not so surprising as it may appear. It sometimes happens, that natives go only by the name of their caste or their native place. The name of the Yahúdi is Murád; he is a native of Bokhára. We saw him first in Ladák, after our return from Turkistán, when he gave us much valuable information about the various routes in Central Asia, and have always found him to be a very trustworthy, respectable native.

Hărkíshen says about him:] "He was commonly called 'Yahúdi', *i. e.* 'the Jew', "was a native of Yárkand and dependent of Mohámmad Amín: they had some baggage "ponies with them, and four Turkish grooms or baggage-men, all of whom were en-"gaged for the journey. The third man, Mohámmad Hássan, of Pesháur, was engaged "by my master as a múnshi, when he was at that place, in December, 1856, and he "assisted him also in scientific observations and accounts."

[To this statement of Hărkishen, Captain Strachey adds:] The last documentary evidence of Adolphe's movements written by himself is a letter to Hărkíshen, dated from Changchénmo, in Ladák, June 14th, 1857, a postscript to the same, stating that it was not sent till the 24th inst., and one or two notes for sundry payments of money, of the latter date. The letter consists chiefly of instructions to Hărkíshen, and of himself Adolphe only says: "I am quite well, and at present all things seem to go on pretty right," but as it also mentions two dăk parcels, one for Lieutenant Charles Hall (Assistant Commissioner of Bhágsu), sent by the same dispatch for transmission to Kángra, I think other persons may have no doubt received letters from him, and also particulars of his history up to that time.

[But no letter has as yet reached us. The Rev. H. Jäschke also, missionary at Lahól, who about the same time received letters from our brother (copies of which he had the kindness to send us), could not give us any other information about his later movements.]

These letters to Jäschke and Hărkíshen were brought from Ladák by the chaprássis, Múrli and Máula Baksh (Nos. 6 and 7 of the above list), who joined Hărkíshen at Kárdong, in Lahól, on the 20th of July, 1857.

It appeared from the statement of these men (made to Hărkíshen) that, "before "they left Adolphe, the múnshi, Mohámmad Hássan, had gone off, taking with him "one of his master's (or Mohámmad Amín's) horses, some little money, and other "articles belonging to Adolphe. The chaprássis were directed to overtake him if "they could, recover the property, and make it over to Hărkíshen in Kúlu. This "they succeeded in doing, but left the múnshi himself in Ladák, whence he probably "made his way to Kashmír and Pesháur." He gave them a letter for his master, which they brought to Hărkíshen, and which is still extant among his papers, written in pencil in broken English, excusing his sudden departure on the score of inability to endure the hardship of such a journey any longer, and admitting a balance of 72 rupis, of which he gave the chaprássis the account, but did not pay the money.

[This letter we now have in our possession.]

It must be observed that Adolphe makes no allusion to all this in his letter to Hărkíshen; from which it may perhaps be inferred, that he did not attach much importance to the múnshi's desertion.

Hărkíshen, when at Déra, in November, 1857, gathered from Captain Montgomerie, an officer of the Great Trigonometrical Survey, and his native doctor, that they had been in Ladák during the past summer, and that Adolphe had left Leh[1] or its environs before their arrival there, and that they knew nothing more of him.

From the locality of Adolphe's last dispatch, Changchénmo, at the north-east end of Ladák, I [Captain Strachey] infer that he crossed the Turkish watershed to the east of the Karakorúm pass, properly speaking perhaps to Súget, thence following approximatively the route taken by his brothers the year before, towards Kílian and Khótan. It appears that he had laid in a stock of merchandize in India, with the view of facilitating his journey by trade, or the appearance of it.

[We also carried with us merchandize instead of money, chiefly rich Indian cloth, silks, &c.]

[1] Adolphe had not been in Leh during this journey.

2. Statement made by Bhútias, from Johár. Almóra, August, 1858.

From the Bhútias of Johár, who obtained their information from Kashmíris of Ladák at the fair in the autumn of 1857, I [Capt. Strachey] have heard, that Adolphe had succeeded in reaching the margin of the inhabited country at the foot of the mountains north of the Kuenlúen. "There," they said, "he went out from his camp some way "to reconnoitre, and in his absence the múnshi Mohámmad Hássan absconded, with most "of the baggage and cattle,[1] towards Yárkand. Adolphe Schlagintweit, being left helpless, "sent back some of the Ladáki baggage men he had brought with him with a letter "or message to the thanadár of Leh, requesting him to send assistance in men, cattle, "provisions, and money." Whether for the purpose of continuing his attempt to penetrate into Turkistán, or merely to return to Ladák with less hardship, does not appear.

When his messengers arrived at Leh, they found Básti Ram's son in authority there, the thanadár himself being away in Kashmír. The son is said to have refused the required assistance. More probably, he was too silly and timid to act upon his own responsibility, and referred for instructions to his father, or Guláb Singh the Rájah of Kashmír, at the expense of great delay and danger to Adolphe.

3. Information contained in the "Dehli Gazette", and General Remarks of Captain Strachey. Summer, 1858.

The following accounts are derived from letters, which were published during the summer of 1858 in the *Dehli Gazette*, from a correspondent of that paper, apparently at Símla, and obtaining his information from merchant travellers from Ladák.

From these letters it may be gathered that Adolphe passed the winter of 1857-8 at the foot of the mountains [of the Kuenlúen] on the border of Khótan, on this side of the Chinese outposts, among the same tribe of shepherds, perhaps, who gave his brothers a friendly reception the year before. On his arrival there the provinces of Káshgar and Yárkand were in a very disturbed state, in consequence of one of those invasions of the Turks from Kókand which have been recurring periodically every ten or twenty years during the past century.

[1] Besides the animals of burden, such as horses and yaks, travellers in these regions are always obliged to take with them a living stock of sheep, goats, &c. for their support.

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[1] Besides the animals of burden, such as horses and yaks, travellers in these regions are always obliged to take with them a living stock of sheep, goats, &c. for their support.

On these occasions, the foreign invaders being joined by the Turks of the country, they usually succeed in driving the Chinese garrisons into their forts and subverting their government for a time, till reinforcements come from the Chinese provinces further east, when the rabble of Turks soon becomes disorganized, the Kokándis retire to their own country, and the people of Yárkand and Káshgar are left to settle their own accounts with the Chinese, which is sometimes done by wholesale massacres of the Turks of those cities.

The invaders are commonly headed by one of the Khójahs of Andishán,[1] a family who ruled at Káshgar before the Chinese conquest, about 100 years ago, and who still aspire to the recovery of their former dominions.

An unsuccessful invasion and rebellion of the Turks, as here described, occurred when I (Captain Strachey) was in Ladák in 1847-8. On the present occasion the result is said to have been the same.

So long as the Chinese were in the ascendant, Adolphe Schlagintweit would have had little chance of penetrating the inhabited country to so great a distance, as they have outposts on all the roads across their frontier, and from the rarity of population and traffic, individuals are easily marked, and moreover he would hardly have been able to disguise himself enough to bear scrutiny.

A European traveller attempting to pass any of these outposts would probably be stopped and turned back, and extra precautions taken against him all along the frontier, but if detected after penetrating the inhabited country to any distance he would more probably be murdered.

The English and Kokándis are, generally speaking, in no hostile relations, and from his brothers' and his own successful antecedents in the Yárkand country, Adolphe might possibly have met with a friendly reception there. On the other hand, the Kokándis, as is usual with the Turks of this country, are on bad terms with all their neighbours, including the Russians, who are steadily encroaching on their north-west frontier. All this again would have added to his difficulties in getting away from their country.

[1] Andishán is a large town to the east of Kókand; its connection with other places is given p. 35, route 32.

4. Reports of Máni and Nain Singh. Almóra, January, 1859.

Máni and Nain Singh, from Mílum in Johár, had left Adolphe at Pesháur, in January, 1857, and had returned to their own country during the next three months, making a few observations by the way. After this they had no further communication with him, except by a message sent in March, 1857, through me, which requested Máni to join Adolphe again either at Kángra, in April, or later in Ladák. This, however, Máni did not attempt.

Going as usual to the Gártok fair in the summer of 1857, Máni heard only some vague reports about Adolphe from traders of Ladák, the substance of which is already given (see No. 2, p. 49).

In September, 1858, Máni, being again at the Gártok fair, obtained some further information about Adolphe, chiefly from Núrpur, a native of Súnam in Kănáur, trading to Ladák and Yárkand. This person was himself at Yárkand in 1857. Núrpur said: "When Adolphe Schlagintweit arrived in that quarter, the Turks of Kókand "were already at or near the city. He himself did not enter the town, but his chief "guide, Mohámmad Amín,[1] did so, and left it again, either before, or during the siege, "though under what relations with his own master or the insurgent Turks is not "known to me.

"As the siege continued and the Chinese were shut up in their citadel, they "obliged the inhabitants of the place to take part in the fighting, and also a lot of "foreign merchants, including about forty five of the Bisséris, of whom fifteen only "returned, I (Núrpur) being one of them; the rest were either killed or made prisoners "by the Turks.

"After the siege was raised, I heard that the Sáhib (Adolphe) had joined the "camp of the Turks, and had been at first well received by them; on their retreat "towards Kókand, he accompanied them as far as Káshgar. As the hordes of Turks "were carrying off with them a lot of their prisoners, to be kept or sold for slaves "(according to their custom) some of the Bisséris[2] being among the number, the "Sáhib tried to assist them, remonstrated that they were British subjects and should

[1] According to the more probable information of Ábdul (see No. 10, p. 61), it was not Mohámmad Amín, but Murád, who entered the city to get information.

[2] We had travelled a great deal in the country of the Bisséris.

"be released. On this arose a dispute: the Turks accused him of taking part with "their enemies, and ended by killing him."

Máni also said that Núrpur had certificates from the Chinese authorities of Yárkand, testifying his services in the siege, and promising him some reward at a future opportunity.

The above account of the Bisséri, Núrpur, was confirmed by Ómar, an Árgon[1] of Ladák, who had received letters from his friends at Yárkand to the same effect.

II. INFORMATION RECEIVED FROM G. KNOX, ESQ., ASSISTANT COMMISSIONER OF KÚLU, AND FROM SIR ALEXANDER LAWRENCE, ASSISTANT COMMISSIONER OF KÁNGRA.

5. Verbal Statement of Káttah Áli Shah, from Yárkand. Examined at Nágger in Kúlu, September 28th, 1858.[2]

"Last year in the month of Sévan (July, 1857), viz. 14 months ago, the Àndishánis "came to Yárkand to fight with the Chinese, and I went to Kárgalik, two days' journey "south of Yárkand. The Andishánis took me and all the Pănjábis, Kábulis, Kashmíris "and Hindostánis, in all some 40 or 50 persons, prisoners; at that time two Andishánis "and a múnshi were accompanying a Sáhib who was coming from the Ladák side; "these three men ran away with the Sáhib's property and came to Kárgalik; there "they stopped in the house of one Kurbán, and they said to him: 'We have some "property for sale, do you take it?' When he had sent for the property and examined "it, he found it to consist of 12 or 14 yards of valuable embroidered cloth, a quantity "of ordinary cloth and some other property also, but I did not see it with my own "eyes. Kurbán having seen the things, went and reported the fact to Háji Mísser, "Kardár of the Andishánis, saying that these men were poor and had nothing of their "own, and that they must have robbed somebody of this. Háji Mísser sent for them "and intimidated them, questioning as to where they got the property, and whose "it was.

[1] Árgon is the name of the mixed races of Yarkándis and Ladákis.

[2] In this, as in the other statements, we have not made any alteration in the language, which often presents a faithful picture of the native mode of expressing ideas.

Káttah Áli Shah's statement is printed in the Journal of the Asiatic Society of Bengal; No. I., 1859; p. 57, &c.

"They at first asserted the property was their own, but when threatened severely, "they stated that Mohámmad Amín had brought a Feringhi,[1] and that they had stolen "these articles and were escaping with them. Háji Mísser asked where the Feringhi "was; they replied: 'God knows, he was on his way to Yárkand; if he was gone "there, he will have arrived at the village of Kílian.' Háji Mísser therefore sent two "or three of his own men, and told them to go and fetch the Sáhib; they, therefore, "went to Kílian and brought the Sáhib from thence to Kárgalik, and Mohámmad Amín "was also with him."

[It may be surprising, that Mohámmad Amín should not have been selected as interpreter at the following interview; but we, as well as Adolphe, could only speak through interpreters with Mohámmad Amín, who, in addition to Turkish, his native language, knew only a little Tibetan and somewhat more of Persian, but no Hindostáni whatever. Máni and Makshút were our interpreters. Our brother's interpreter seems to have been the runaway múnshi; Abdúllah is not mentioned here.]

"Nobody understood the Sáhib's speech in the country; they searched therefore "for somebody who could understand him, in hope of finding some one who could "understand Hindostáni or Pănjábi. I was in confinement, and they took me to the "place. Háji Mísser told me to ask the Sáhib why he had come there. I asked the "Sáhib; he replied that there was Shazádah, son of Mohámmad Shah, living in the "Andishán country, and he had visited him (Adolphe) in Lahór, and had said: 'Do "you come to Andishán, Sáhib, and I will establish friendly relations between the Naváb "of Andishán and the Sáhibs.' It was on this account that he was on his way to "Andishán. Háji Mísser confiscated all the Sáhib's property, and put the Sáhib in "confinement, and sent him to Zúllah Khan, a principal Sirdár. When they put the "Sáhib in confinement he said to me: 'No one here understands my language, and "my belief is, that these people will kill me. Should you go to that side of the "country, by Kúlu, tell this matter to Hay Sáhib; if you go by Kashmír, tell it to "whatever Sáhib you meet.' After this the Sáhib went away. On the day that the "Sáhib went to Sirdár Zúllah Khan, on the same day the Chinese force came to fight "with the Andishánis; and the Andishánis fought for half an hour, and then ran away "and took the Sáhib with them. When the Chinese force came, all the Andishán

[1] Feríngbi is, in India and Central Asia, the general designation of a European, the term being a modification of the word Frank.

"Kardárs ran away, and we 40 or 50 men who were in confinement got free. I "afterwards heard that Dil Khan, the great chief of the Andisháni, had taken the "Sáhib's property and put him to death, but I only heard this from report of travellers "from Káshgar and Yárkand; I did not see it with my own eyes."

[When Kăttah Ali Shah was asked by Mr. Knox, whether he knew any thing of the property of the Sáhib or his servants, he said:] "No, I do not know any thing about them. I only saw the Sáhib and Mohámmad Amín Móghul."[1]

6. Statement of Gosht Mohámmad, Adolphe's Servant. Examined at Kángra, July 10th, 1859.

"Besides me and several chaprássis, my master had with him the following múnshis, "who could all write English:—

"1. Ramchánd, whose house is near the city of Lahór. He was engaged at "Pesháur; in reaching Kárdong the Sáhib sent him to Kashmír, saying, he would rejoin "him viâ Yárkand. I do not know where this múnshi is now, I have not heard of "him since.

"2. Hărkíshen, native doctor from Almóra. He left us at the foot of the Bára "Lácha pass, and went by Lahól, Spíti, Bissér and Găhrvál to Déra, where he gave "over all the instruments he had to the office of the Surveyor General of India.

"3. Mohámmad Hássan, a native of Pesháur, accompanied us nearly as far as "Ladák, but had to return, as he suffered a good deal from ophthalmia.[2]

"We left Bhágsu about the end of April and marched on through Kúlu to Rúpchu. In "Kúlu my master met Mohámmad Amín Móghul, who had accompanied his brothers to "Turkistán, and Murád, the Jew, who knew his brothers from Ladák. As the Sáhib "intended to personate a merchant, he bought in Kúlu 40 horses and some cloth, and "at the same time mounted three of his servants. After completing all his prepara-"tions, he set out with the intention of going to Kókand. When we came to Rúpchu, "Mohámmad Amín said he would take my master by the ordinary route to Kókand; this, "however, he did not wish. Mohammád Amín therefore took another route, and after

[1] Móghul is the general designation of the Turks in Central Asia.

[2] All the other reports most positively state that he absconded; but it may be quite true that he suffered from ophthalmia, a very general complaint, caused by the glare of the vast snow fields.

"marching for some days we reached, after great difficulties, a place where the water "was very salt; 15 horses died here. About this time, I, who continued to remain "with the Sáhib, fell sick, and he wished to send me back with Múrli,[1] but I said "I would rather remain. Here we had considerable difficulty in finding the road; at "last we discovered a pass, on which lay a heap of stones, for marking the place "where a murder had been committed. This pass is not far from Súget, whence the "road branches off to Karakásh.

"After proceeding two marches from Súget, we halted; the Sáhib always occupied "one tent, his servants another, and the camp followers encamped all round. "During the night, three men who had been engaged in Kúlu walked off with "21 horses and other property; a fruitless search was instituted after the thieves: of "the 21 stolen horses, 11 had such sore backs and were so lame that the thieves "abandoned them.

"From this point my master again returned to the pass above Súget, where he "remained some days, and then proceeded in the direction of Yárkand; but in the road "he fell in with three men who told him, that there was a good deal of fighting going "on in Yárkand, and advised him not to proceed any further. He accordingly "again returned to the pass, in the neighbourhood of which he remained about "a month, and then, being still very anxious to reach Yárkand, if he could possibly "do so, he again set out. I, however, got very ill, and as we happened to meet a "caravan of merchants proceeding from Yárkand to Ladák, he entrusted me and "some of his collections to the care of these people, who should take me back as far "as Ladák. He gave the merchants a bill for 50 rupis, and to me one for 30 rupis, "both drawn on the thanadár of Ladák. Moreover, he gave me a draft of 250 rupis, "on Kángra, and a horse for my use. I received orders to proceed from Ladák to "Bhágsu. On reaching Ladák, I presented the first bills to the thanadár, who refused "to cash them. I therefore remained in Ladák three months, and as the merchants "became very importunate on account of not receiving the 50 rupis, for which my "master had given them a bill, I sold my horse for 54 rupis, and out of the money "thus realized, paid the merchants their 50 rupis. The caravan belonged to Rúpa Shah "from Yárkand.

"I have not heard anything more about my master."

[1] This chaprássi was sent back with Máulu Baksh to Lahól. See p. 48.

III. INFORMATION RECEIVED FROM THE "DEPARTEMENT ASIATIQUE" OF ST. PETERSBURGH, THROUGH BARON BUDBERG, RUSSIAN MINISTER AT BERLIN.

7. Letter from Mr. Vardouguine, Russian Consul at Chúguchak.[1]

Chúguchak, December 31st, 1858. / January 11th, 1859.

Although the following information must tend to increase the general sympathy which is felt in the fate of the renowned and universally respected traveller, Adolphe Schlagintweit, they unfortunately offer no consolation to his brothers.

In the autumn of 1857, at the time of the insurrection against the Chinese in Turkistán, which was headed by Búzruk Khan, a nephew of Jehángir Háji, a Feringhi (European) came to Turkistán from India[2], giving himself out for a merchant.

Having received the permission of the Chinese authorities to proceed to Káshgar, the traveller unfortunately arrived on the day when Búzruk Khan made his entrance into the town. The next day he presented himself before the latter to obtain his permission to extend his journey into Kókand; Búzruk Khan, however, taking him for a Chinese spy, caused him to be murdered. It has been asserted that he declared to Búzruk Khan before his death, that his murder should not remain unpunished, as no means would be neglected to find him. This report has occasioned a belief in the country that "this European was a person of high importance, belonging to the Feringhis who govern India", *i. e.* that he was an Indian officer. It is also asserted that the four Europeans composing his retinue[3] were also murdered. The person, through whose agency I obtained these details, did not know whether he was also accompanied by Mussălmáns. All the effects of this traveller are said to have been taken by Búzruk Khan on his return to Kókand.

It is further reported that this traveller came from India, intending to proceed through Tíbet to Kókand, or, in the event of being prevented from doing so, to return as he had come. His name is unknown. All that I can learn respecting him is that he was very tall [at least in comparison with the much smaller races of Central Asia]. I obtained these statements on inquiring of the head man of a large caravan from

[1] Chúguchak, in 46° 9′ N. Lat., 83° 7′ Long. E. from Greenwich, is a Russian station, south of the Záisang lake.

[2] The name Sikemarata, given in Mr. Vardouguine's original letter as the name of a little town from which he is supposed to have come, must refer to the country of the Sikhs, the Pănjáb. We are unacquainted with any town bearing this or a similar name.

[3] This appears to be an error. He had no Europeans with him.

that place, whether any Europeans had fallen in the rebellion in Turkistán. Unfortunately the statements I received, especially as to the routes[1], agree but too well with the points to which my attention was directed, as being essential ones in reference to the person about whose identity I was commissioned by the Asiatic Department, in November, to make investigations.

8. Second Report from Mr. Vardouguine, forwarded to Baron Budberg by Mr. George Kowalewski, St. Petersburgh, March $\frac{2nd}{14th}$, 1859.

Prince Gortschakoff has already communicated, in his dispatch to your Excellency (Baron Budberg) of the $\frac{10th}{22nd}$ of February, some information which Mr. Vardouguine, acting as our Consul at Chúguchak, had forwarded to him, and which appears to have some bearing on the fate of Mr. Schlagintweit. According to a fresh report, dated $\frac{\text{January 24th}}{\text{February 25th}}$, from the same official, it would appear that this ill-fated traveller had not four, but only three companions, who did not share his fate, but saved themselves. Mr. Vardouguine brings forward a circumstance which, however indefinite it appears, may still not be without weight for those who personally knew Mr. Schlagintweit, in establishing his identity. The traveller, who is said to have been killed, is described as having a mole (*tâche naturelle*) under his right eye.

[Our brother certainly had no such mole, but it is not impossible that some scarred wound, of which we know nothing, might be meant.]

In communicating this information, I consider it useless to observe how little credence should be attached to it. The inhabitants of those distant regions where it was collected, generally speaking, make no scruple of modifying their reports at pleasure, especially when Europeans are concerned.

[1] Our letters, in consequence of which Prince Gortschakoff had the kindness to institute inquiries, contained details about our brother's possible routes to Turkistán, and also about those which he might have adopted in order to reach the Russian territories.

IV. REPORTS COLLECTED BY LIEUTENANT COLONEL H. B. EDWARDES, C.B., COMMISSIONER AND SUPERINTENDENT, PESHÁUR DIVISION.

9. Letter of Colonel Edwardes to R. Temple, Esq., Secretary to the Chief Commissioner of the Pănjáb. Pesháur, December 18th, 1858. — Political Department.

I am not aware whether the Chief Commissioner has yet received a reliable account of the circumstances attending the death of the German traveller, Mr. Adolphe Schlagintweit; but, at any rate, it will be satisfactory to the Government, as well as to his friends, to be able to compare the enclosed narratives of the sad events.

The first [No. 10] is the verbal statement of one of his followers, a Kashmíri named Abdúllah[1], who arrived here viâ Bokhára and Kábul three days ago, December 15th, 1858.

The second [No. 11] is the written report of a native of Yárkand, named Mohámmad Amín, who appears to have been provided by Lord William Hay, as a kind of agent, or chief guide, to Mr. Adolphe Schlagintweit. He writes from Kókand, and Abdúllah is the bearer of his letter.

From these statements, which appear to me substantially trustful, it seems that Mr. Schlagintweit was impelled by a desire to find a road to Yárkand which need not pass through Ladák; that he reached Yárkand; found that country harried by fanatic Mussălmáns from Kókand; and passed on to Káshgar, where the same fanatical raids where going on, and the leader of one of them, a Sáyad, named Váli Khan, seized him and barbarously caused him to be beheaded, without any other offence, apparently, than that of being a foreigner.

If anything could soothe the distress of Mr. Schlagintweit's friends in Europe, it would surely be the noble contrast between the enlightened purpose and humane search for knowledge which bore him into those wilds, with his life in his open hand, and the barbarians' frenzy for the propagation of error by the blood of his fellow men.

I have sent by separate parcel a slip of paper, and a broken pocket telescope, which were the only relics Abdúllah could bring away with him.

[1] His full name is Abdúllah Mohámmad.

[We have received these articles. The handwriting on the slip of paper is certainly that of our brother; but it is beyond all doubt that it had not been written during his travels in Ṭurkistán; it is dated "Pesháur", and was probably written in December, 1856. It seems to be a rejected label, belonging to a specimen of his ethnographical collections.

The telescope, which Abdullah says had been bought of one of the people who stole our brother's property, was certainly not his; it looks as if it had been purchased in a native bazár of Pesháur, and is of such rude external appearance that our brother cannot even have taken it with him as a present for natives; it only magnifies once and a half, and gives the images very badly defined.

We have communicated to Colonel Edwardes our strong doubts as to whether these articles were actually found amongst our brother's property in Turkistán, and we have requested him again to cross-examine Abdúllah, and at the same time to keep in mind the improbability of his statements, at least in reference to these alleged relics.]

10. Verbal Statement given by the Kashmíri, Abdúllah.

"About two years ago, when the Amír of Kábul came to pay a visit[1] to Pesháur, "my master was in Pesháur, and I was employed under him as a sepáhi of the guard. "After much travelling in the Pănjáb, he went to Sultánpur in Kúlu, where he got "acquainted with Mohámmad Amín of Yárkand, whom Lord William Hay had sent "for the purpose.

"Mohámmad Amín was obliged to go for protection to Lord William Hay, to be "safe from Guláb Singh's prosecution.[2]

"Also the officer, named Básti Ram, who was posted at Ladák, as a thanadár, by "Maharájah Guláb Singh, bore very ill feelings towards Mohámmad Amín, because he "had shown to Europeans, the brothers of my master, the way to Yárkand.

"At Sultánpur, the chief place of Kúlu, the Sáhib stopped for some days, with "a view to arrange with Mohámmad Amín for the journey. He then sent his baggage, "under the care of Mohámmad Amín, by the direct road to Kárdong, and he, with

[1] This official visit took place at the end of December, 1856. Our brother, Adolphe, was in the suite of Sir John Lawrence, when he had his interview with Dost Mohámmad Khan, at Jamrúd, near Pesháur. See Itinerary, p. 32.

[2] See p. 46.

"myself, the native doctor Hărkíshen, and Gosht Mohámmad, the butler, went there viâ "the Bánghal pass. In Kárdong he halted five days, sent his múnshi, Ramchánd, and "two chaprássis to Kashmír, purchased 60 horses and provisions, and with the múnshi, "Mohámmad Hássan, a native of Pesháur, Hărkíshen, Gosht Mohámmad, myself, and "Mohámmad Amín of Yárkand with his three followers, proceeded to Ladák. When "we reached a place three days' journey from Leh, Mohámmad Amín pointed out to "the Sáhib a road, viâ Sirikúl to Kókand, which he proposed to follow. The master "consented to this proposal, ordered Hărkíshen, two chaprássis, and two other men "employed in the survey office to return to Hindostán, sent one chaprássi with his "heavy baggage to Ladák, and he with myself, Mohámmad Amín, and some other "followers, went to Chúsel [near the Tsomognalarí, the great salt lake of Pangkóng]. "There he hired sixty porters and with them set out.

"After three days' journey, múnshi Mohámmad Hássan of Pesháur, having taken "away at night one of the Sáhib's horses, ran away and carried off with him his book "of accounts. The Sáhib sent a man named Ráhiman, a native of Bálti, to search for "him and lent him a horse to ride on; but he also never returned. We halted three days "in the same uninhabited country, and then, taking Mohámmad Amín and two natives "of Tíbet, the master went away alone to discover the way. By means of a telescope "he at last found a way, and started with his baggage; but we soon missed the proper "route, and after a weary journey came by the side of two small lakes, the water in "one of which was reddish and in the other greenish, but both bitter [saline], so that "all his followers, through despair, began to lament and sigh to return.

[The difficulties of travelling, here described, perfectly agree with what we also had to experience during our passage over the chains of the Karakorúm and the Kuenlúen.]

"Upon this my master dismissed some Tibetans, together with one chaprássi, by "name Múrli. He then with myself, Mohámmad Amín, and his three followers, Gosht "Mohámmad, and two Tíbetans, resumed his journey, and on his way met with only "a single house, situated in a desert tract of country, from which the city of Élchi, "the capital of Khótan, was distant by three days' journey.

"All our way had hitherto lain through an uninhabited country; for our master "had selected a new route, marked it with stones as he went along, and made a sketch "of it. This was a way which led straight to Yárkand, without passing through Leh;

"but with the exception of a few inhabited huts [on the Tibetan (southern) side of the "Karakorúm] in some places, the whole of the tract was an entire wilderness. We, "however, did not proceed from this single house, situated at three days marches from "Élchi, in the direction of this city, but turned towards Súget, where we stayed three "days. Mohámmad Amín here again urged upon the Sáhib not to proceed to Yárkand, "but to Sirikúl, and thence on to Kókand. We consequently set out for Sirikúl.

"On the third day we arrived at the summit of a pass where, the same night, "snow fell to a great extent; here the horses we had were all taken away by the "servants of Mohámmad Amín, but we next morning went in pursuit of the robbers, "and Mohámmad Amín with one of his servants, who was a Jew, also accompanied us. [This must have been Murád.]

"We at last recovered seven horses from the thieves, and sent Mohámmad Amín "and his servant ahead to search for the rest. Mohámmad Amín had not instigated "his men to rob our Sáhib of his horses, but they, of their own accord, had done the "deed. On our return, we asked the Sáhib to retire down the pass in order to be "safe from the severity of the cold, and to get provisions. He accordingly descended "from the pass, and reached △ Sáyad-úlla Khója, where Mohámmad Amín also came up "with the three remaining horses which had been stolen, and despatched his servant, "by name Murád, the Jew, to Yárkand, to bring information of the wars that were "then going on there. The Jew returned, and reported that it was the Khan of Kókand "who had been making war. We therefore, without hesitation, set out for Yárkand; "Gosht Mohámmad, under the protection of a caravan, was sent back to Kángra[1].

"After his departure, we passed through Kárgalik and Bozgán[2], and arrived at the "camp of Dil Khan, Sáyad of Kókand, who had come with an armed multitude to "make a religious war with Yárkand. His camp lay outside the city, and about an "hour after our arrival, the army of the Khatáis[3], which formed the garrison of the "city, came out to encounter the besiegers on the open field, and routed them, and "obliged Dil Khan to fly. Mr. Schlagintweit, likewise leaving all his baggage there, "fled with his followers to Négsăr, and thence went to Káshgar. Here another Sáyad "of Kókand, named Váli Khan, who had likewise come on a religious expedition had

[1] See p. 55 and p. 64.

[2] These places are respectively two days' and one day's march distant from Yárkand.

[3] Khatái is the name given to the Chinese in Turkistán.

"succeeded in getting the throne of Káshgar; Mr. Schlagintweit desired an interview "with him, but it was refused, and a guard was sent to apprehend us.

"They accordingly carried us prisoners into the presence of Váli Khan, who ordered "Mr. Schlagintweit to be beheaded, and so the order was instantly carried out. Váli "Khan did not ask any question of Mr. Schlagintweit before his murder, and he was "executed outside the city of Káshgar. He was allowed no burial, but a man, named "Átta Báhi, a native of Yárkand, had collected his bones, and Mohámmad Amín assured "me that he would send them over to India, viâ Ladák. This tragedy occurred about "seventeen months ago [August, 1857].

"Váli Khan then sent me and Mohámmad Amín of Yárkand, and Murád, the Jew, "and a native of Tíbet to prison; and afterwards sold me as a slave to a man called "Túzăk, for 25 rupis, by reason of my being a native of India.

"A month after, an army of Khatáis came and expelled Sáyad Váli Khan of "Kókand, together with the inhabitants of Káshgar, who took refuge in Kókand. I "also accompanied the fugitives, and on my arrival at Kókand, a Sáyad of Pesháur, by "name Mián Khalíl, procured me freedom by paying to my master, Túzăk, the amount "which he had paid for me.

"After I was set at liberty, I stopped in Kókand for ten months, during which "time I sent three petitions to the King intimating that Mr. Schlagintweit had been "murdered, and praying that justice might be done to him. But the King of Kókand, "without giving me any reply, tore up all my petitions. When I was in Kókand, it "was the season of winter, and, consequently, I never went out to see the country. "I met Mohámmad Amín of Yárkand at Kókand who advised me to return to "India, and said that he would again apply to the King of Kókand for justice in the "case of Mr. Schlagintweit. Meanwhile the King of Bokhára prepared to make an "inroad on Kókand, upon which, fearing bad consequences from a longer stay at Kókand, "I went to Bokhára. On my departure from Kókand, Mohámmad Amín gave me a "Persian letter for delivery to Colonel Edwardes, in Pesháur, which I now present. "From Bokhára I came to Bálkh, from Bálkh to Kábul, and from Kábul to Pesháur.

11. Letter from Mohámmad Amín of Yárkand, to Colonel Edwardes. Kókand. July 29th, 1858.

I met Mr. Schlagintweit at Sultánpur in Kúlu, then went with him to Lahṓl, and over a pass reached Rúpchu.

Here two roads diverge, one leading to Leh, and the other to Chúsel. My master asked me to direct the way to Aksáe Chīn, we consequently proceeded thither, and passed through Changchénmo, and having crossed a high ridge [this is the Karakorúm chain], we came up to the road leading to Aksáe Chīn[1]. We arrived at a place, whereabout two forts were situated. The one was said to have belonged to Sikánder, and was situated on the flanks of the Yurungkásh pass. [We ourselves also passed, with Mohámmad Amín, through Sikánder Mokám, on the 18th of August, 1856. It is a small fort and now deserted; it seems never to have been anything else but a fortified place, and was never permanently inhabited. The name of Alexander the Great, after whom it is called, is well known to the inhabitants of Turkistán, partly in historical, partly in more fabulous form, and appears several times without any real connection, and quite unexpectedly, in geographical terminology.] The other fort lay on the banks of the Karakásh, which is one of the streams that flow through Khótan.

Travelling along the Karakásh river [and after having crossed the Kuenlúen], we came down the main stream of Khótan, and passed through Sáyad-úlla Khója which was intersected by two roads, one connecting Yárkand with Tíbet, and the other leading to Tashkorgán, Ósh and Kókand.

We halted at Sáyad-úlla Khója for five days. It was twenty days' journey from this to Osh, viâ Tashkorgán, and five days' journey to Yárkand.

My Sáhib told me that the way through Tashkorgán and Osh was very long, and that to Yárkand comparatively short, and that he would take the latter. I remonstrated that the latter was a dangerous, and the former a safe, way. He then sent Murád, the Jew, to bring information from Yárkand. The Jew returned after eight days in the company of eight caravans, and reported that the Khan of Kókand

[1] It is a characteristic of Mohámmad Amín that he complains very little about the difficulties of the road, in comparison with Ábdul.

had wrested from the people of Khatáis [Chinese] the provinces of Káshgar and Yárkand.

I, however, discredited the report, and said that the real Khan of Kókand would never undertake such a distant expedition; but that within the last twelve years some of the Bára Sáhibs [great men] of Kókand, who were Sáyads by birth, having collected vagabond outlaws and all sorts of rabble, made frequent inroads on Káshgar, sometimes succeeded in defeating its governors and occupying their throne, and at other times were repulsed by the Chinese army and obliged to retreat, and that one of them, Chíkchik Khója, had once fallen into the hands of the army of Khatáis, and was since in confinement. If wars were going on at Káshgar, I added, they must have been waged by these Sáyad fanatics, and not by the Khan of Kókand.

My master nevertheless persisted in going to Yárkand [evidently,—because the road to Káshgar and Kókand was equally dangerous on account of the disturbances in this direction, and because the distance to these places was also much greater]. He sent back Gosht Mohámmad the butler, in company with a caravan, to Kángra.

We then set out for Yárkand; on our approach, the inhabitants of that place treated us with great courtesy, and furnished us with provisions; Mr. Schlagintweit also gave them presents suitable to their several ranks and deserts.

From thence we proceeded to Káshgar which was then occupied by a Khója of Kókand, who had defeated the original governor and wrested from him his provinces, but the army of Khatáis was also encamped outside the city, and laid siege to a fort, called Gul-Bágh, situated about a mile from the town.

The Mussălmáns of the garrison every day came out and gave them battle. The fight was going on when we arrived; the Mussălmáns asked who we were, Mr. Schlagintweit replied that he was the Honourable East India Company's envoy, and was going to the Khan of Kókand. Upon this they got into a rage, and ordered Mr. Schlagintweit to be beheaded, and me with my followers to be thrown into prison, and plundered of all our property. During the thirty five days of our confinement, my two servants died and the third was missing.

Meanwhile the army of Khatáis, having been reinforced from Máha Chīn,[1] overpowered the Khója, and obliged him to fly. I consequently got my release, placed

[1] Máha Chīn, *i. e.* Great China or China Proper, as distinguished from the Chinese province of Turkistán.

the remains of Mr. Schlagintweit in charge of Murád, for safe custody, and proceeded to Kókand.

I have been eight months in Kókand; and as the way to Káshgar remained blockaded during that time, and no traveller could pass to and fro, I could send no message to you; however, lately envoys have been sent to, and received from, Káshgar, and peace restored; and the Khan of Kókand has deputed a man, named Áka Sikál, to Káshgar to bring about the state of affairs on the old footing. I shall, therefore, shortly leave for Káshgar and proceed to Pesháur with the remains of my unfortunate master.

12. Concluding Remarks.

The latest news which we have received from India about Adolphe, is contained in a letter of the 27th November, 1859, from the Rev. H. Jäschke, missionary at Lahól. He derived his information from a man, recently returned, whom he had prevailed upon Hári Chand to despatch in August, 1858, to Yárkand, for the purpose of making inquiries about our brother's fate. This man confirms most positively the general correctness of the former sad intelligence. He found out that our name had been transformed by the Turkistánis into *Sáladin.*

Mr. Jäschke's communication allows us also to hope, that we may still receive some of our brother's manuscripts, instruments, and collections.

From Russia we hear quite recently (end of April), through the kind exertions of the Imperial Geographical Society of St. Petersburgh, that the son of a Kirghis chief, by name Vanikoff, has just returned to St. Petersburgh from Káshgar, and given an account of his journeys to the Society. He most positively confirms the accounts as to Adolphe's sad fate, who, according to his statement, was killed by Háji Mísser.

IV. TRANSCRIPTION.

System adopted. *A.* Vowels. *B.* Diphthongs. *C.* Consonants. *D.* Phonetic Accents—Linguistic Experiments.—Alphabet used for Transcription.

THE transcription of words from the different languages of India, including Tibetan and Turkish for High Asia, has, throughout our journeys, been an object to which we have always endeavoured to give an attention proportionate to its difficulties. Our principal object has been to define, to the best of our ability, the *phonetic* sound of the words. Whenever it was possible, we followed the native orthography; but in cases where this orthography was indeterminate as to the vowels, or too complicated in the system of consonants, we have always deviated from it.

Where the provincial forms were found to be well defined or modernized, we kept them unaltered, in conformity with the rule adopted in geographical works. For a few of the familiar and most generally used names, such as Calcutta, Ganges, Indus, Madras, &c., we have retained the established European mode of spelling.

We are not Oriental scholars ourselves, but had acquired a sufficient knowledge of Hindostáni to converse with the natives—such an amount of acquaintance with the language being in itself indispensable, both in India, to facilitate intercourse with followers and servants, and in the territories beyond English influence, which are generally inacessible to Europeans, to enable the traveller to assume disguise with more chance of success. Though we could never have hoped to pass as natives in a country where Hindostáni was the native language, the difficulty was far less in Tíbet or Turkistán, where the chief requisite in speaking with our interpreters was fluency, and not correctness.

The systems adopted for the transcription of Indian languages are very numerous. Our researches referring almost exclusively to physical geography and natural history, we thought it important to adopt a system as little complicated as possible, and at the same time to preserve an alphabet, not differing too widely from the letters generally used in typography. For writing the names on maps also, it is very convenient not to have too many distinctive signs added to the letters; for they are easily overlooked, when they happen to coincide with the lines of shading on the map. Besides, a simple method makes it so much easier for the general reader in following our researches and in remembering the names connected with them [1].

A. VOWELS.

As will be seen from our Alphabet, we generally write the vowels on the German or Italian system of pronunciation, a system already introduced by Sir William Jones, and, with some slight modifications, now almost universally adopted.

Amongst many others who write in accordance with similar principles, we need only mention: Wilson, Hooker, Thomson, Müller, and Eastwick [2], in England; Bopp, Lepsius [3], Lassen, and Weber, in Germany. In the Presidency of Madras, it has also been officially introduced of late [4].

B. DIPHTHONGS.

This class requires particular notice here. In modern European languages there are instances in which the spelling of diphthongs is phonetically incorrect, as will be seen when we dissolve the diphthongs into their two component vowels, by pronouncing the latter very slowly, as in singing, an experiment which we found exceedingly valuable in many doubtful cases. By doing so, it is easy to perceive that, if we wish to write phonetically, the German words "*heute* (to-day)", "*Eigenschaft* (quality)", sound like, "*háüte*", "*Áigenschaft*"; the diphthongs in the English words, "*loudly*", "*silently*", sound like, "*láudli*", "*sáilentli*". [5]

These examples, at the same time, serve to show that, if the accentuated syllable

[1] A simple mode of writing also much facilitates the printing of translations, and of abstracts in scientific periodicals.

[2] Eastwick. Handbooks for India. 2 vols., Murray, London, 1859. We take this opportunity of acknowledging the valuable information contained in these volumes, which have proved of essential service to us, especially in what relates to Southern India.

[3] In the details of transcription, his well known researches in connection with a general alphabet (Standard Alphabet, London, 1855) have been very important to us.

[4] Allen's Indian Mail, November 28th, 1859.

[5] We add, not to be misunderstood, that we are far from alluding to alterations, as little desirable in English as in the German, in cases where orthography is based on history and firmly established by universal usage.

contains a diphthong, the accent, contrary to the adopted mode of writing it in Greek, aways lies on the first vowel, even when the diphthong is in the antepenult. When placed otherwise, the two vowels no longer form a diphthong, but are separated by diæresis.

C. CONSONANTS.

In reference to the consonants, simplicity could not be obtained without entirely omitting many distinctions of the Oriental alphabets.

In the Geographical Glossary, which will be embodied in the third volume of our publications, we have endeavoured to transcribe, with greater accuracy, the different native consonants. We retained, however, as far as was possible, the English alphabet, since for most general purposes it is sufficiently complete, and has besides for centuries been intimately associated with Indian geography.

D. PHONETIC ACCENTS.

To each word of more than one syllable we have given a phonetic accent.

Although signs for distinguishing the accented syllable are generally considered unnecessary in a complete system of transcription, where the quantity is marked in full, yet in the more simple system here adopted, we have thought it advisable to ensure correctness and facility in the pronunciation of the names by the regular employment of the phonetic accent.

When the accent falls upon a diphthong, we place the sign over the first vowel, in accordance with the principles explained above.

In rapid conversational utterance there is seldom any difficulty in distinguishing the syllable upon which the principal accent lies. In compound words, indeed, some embarrassment arises as to the disposal of the accent when one only is to be used; for several syllables may here be pronounced with equal stress, or nearly so, as is often the case with many German words. However, though but one accent is used in our system, this will at least serve to exclude the possibility of a wrong syllable being accentuated, and, what is more important, obviate the danger of a misapprehension, or total misunderstanding, of the word.

Before our departure from India, we had made an engagement with Sáyad Mohámmad Said, an intelligent múnshi, from Calcutta, who was recommended to us by the well known orientalist, Professor Sprenger, as one of his best scholars. He accompanied us to Europe, and remained in our service a year and a half. The múnshi was well versed in Bengáli, Úrdu, Persian, and Arabic; but English he had yet to acquire after his arrival in Europe. In consequence of his unacquaintance with European languages, we were at some loss how to dispose of him at Berlin, during our first short visit to England, immediately upon our return from the East; but Doctor Dieterici, Professor of Arabic and Persian at the University of Berlin, came forward and most kindly offered to take charge of him. The múnshi evinced great interest for the work in which he was engaged under our superintendence. The results will be given in the glossary.

As an instance of the important assistance we were enabled to derive from the native articulation of Indian names, we may mention the following: On our return, viâ Trieste (June, 1857), we took the múnshi with us on a visit to Professor Brücke, in Vienna, who proposed to us several very successful experiments. One of these trials was to determine, whether the glottis remained open or shut in the pronunciation of certain consonants without an accompanying vowel. This was easily ascertained by applying the concave end of an acoustic tube to the outer side of the larynx, while the other end rested in the ear of the observer. Other experiments were made, in reference to the pronunciation of aspirated tenues and aspirated mediae. The results have been recently published by Professor Brücke[1].

We conclude by giving the alphabet employed throughout our publications:—

ALPHABET USED FOR TRANSCRIPTION.

a (ā ă a̲ ã), ä; b (bh); d (dh); e (ē ĕ ẽ); f; g (gh); h; i (ī ĭ); j (jh); k (kh), k̲h̲; l (lh); m; n; o (ō ŏ), ö; p (ph); r (rh); s, sh; t (th); u (ū ŭ), ü; v; y; z.

VOWELS.

1. a, e, i, o, u, as in German and Italian.

2. ä, ö, ü, as in German.

3. Diphthongs give the sound of the two component vowels combined. Diæresis is marked by the accent falling on the second of the two vowels.

4. – above the vowel makes the vowel long.

[1] Ueber die Aussprache der Aspiraten im Hindostáni. Sitzungsberichte der philosophisch-historischen Classe der Wiener Akademie, April, 1859.

In general we considered it unneccessary to add this sign when the accent coincided with it, and the omission would not influence the correctness of the pronunciation.

Short vowels are not separately distinguished.

5. ˘ above a and e is a sign of imperfect phonetic formation, similar to the open *u* in *but*, and *e* in *herd*.

6. ‾ below a indicates the deep sound, like *a* in *wall*.

In Hindostáni this sound occurs only in local dialects; in Tíbetan and Turkish it is more prevalent.

7. ~ above a and o indicates a nasal sound, like *a* and *o* in the French words *gant* and *son*; also ẽ, ĩ, and ũ had to be introduced for marking the nasal sound of e, i, and u; in the nasal diphthongs aũ and aĩ, we make the sign over one only, though both vowels have the nasal sound.

CONSONANTS.

1. b, d, f, g, h, k, l, m, n, p, r, s, t, are pronounced as in German and English [the variations occurring in the pronunciation of g, and h (in English) excepted].

2. h, after a consonant, is an audible aspiration, except in ch, sh, and kh.

3. ch sounds as in English (*church*).

4. sh, as in English (*shade*).

5. kh, as *ch* in German (*hoch*).

6. j, as in English (*just*).

7. v, as the *w* in German (*Wasser*), being different from *v* in *very*, and *w* in *water*.

8. y, as *y* in the English word *yes*, or *j* in the German *ja*.

9. z, soft, as in English.

ACCENTS.

′ marks the syllable on which the accent falls, whether the syllable be long or short.

ALPHABETICAL REGISTERS.

In our alphabetical registers the letters follow the order of the alphabet, irrespective of the signs attached to them. This arrangement has the advantage of coinciding, as nearly as possible, with the system adopted in dictionaries of European languages.

PART II.

ASTRONOMICAL DETERMINATIONS

OF LATITUDES AND LONGITUDES.

SECTION I.

METHODS OF OBSERVATION AND CALCULATION.

I. INSTRUMENTS.

a. THEODOLITES.

The instruments for angular measurements which we used were the following: *Theodolite 1, Jones.*[1] It had a horizontal circle of 5, and a vertical circle of $4^1/_2$ inches diameter. The horizontal circle had three verniers, reading 30 seconds; the two verniers of the vertical circle gave the minutes.[2] There was also a tangential screw, which allowed of repetitions being made. For surveying purposes, as well as for an approximate determination of the declination, a magnet could be screwed upon the telescope. The levels were large and always remained in very good order.

[1] Jones, 4, Rupert Street, London.

[2] The mean of the verniers and the use of the repetition apparatus allowed of 10 seconds being estimated with sufficient accuracy. In some cases, even 5 seconds or less were noted, being then the mean of several readings. This remark also applies to our other theodolites.

On account of the great length of the telescope, altitudes could only be taken up to 55°; and the telescope could not be inverted, without lifting the axis of the vertical circle.

We received this instrument in Madras, 1856, through the kindness of Major Jacob, and it was chiefly used by Robert.

Theodolite 2, Jones. This theodolite formed a part of the set of magnetic and astronomical instruments, which were made for us in England under the kind superintendence of General Sabine. Diameter of both circles 5 inches. The verniers, two for each circle, gave direct readings of 30 seconds. It had no apparatus for repetition, but a needle could be connected with the telescope.

Till May, 1856, it was used by Adolphe and Robert, later by Hermann. It remained in perfect order till August 9th, 1856, when the horse that carried the instrument tumbled down a ravine. The upper level was unfortunately broken; however, we managed to replace it by a spare level, which after many trials we succeeded in connecting with the telescope better than could at first have been expected.[1] When arrived in Kashmír, where clever workmen are to be met with, we were able to get the spare level properly reset.

Theodolite 3, Troughton.[2] This was a very fine instrument; the diameter of both circles was 5 inches, and the verniers read off 20 seconds. The horizontal circle was provided with a very good repetition screw. The theodolite also contained in its lower parts a large, delicate needle, with an independent horizontal circle belonging to it.[3]

We received this instrument from the stores of the Surveyor General's Office in Calcutta, March, 1855. It was used by Hermann till May, 1856, and afterwards by Adolphe, who had it with him during his last journeys. It was lost with his other instruments at Káshgar.

We found the construction of this instrument particularly well adapted for astronomical and magnetic observations, as well as for topographical surveys. Every part of it was very solid, but at the same time most minutely and carefully worked.

[1] See stations △ Kiúk-Kiöl and △ Súget, in Turkistán.

[2] Troughton and Simms, London.

[3] The needle could be easily removed when we observed the collimator for magnetic declination; but it could also be used for an independent determination of the declination. See the comparisons made at Gohátti; Part. III., Station 4.

Theodolite 4, Pistor.[1] This was one of their "universal instruments", most delicately executed, and light enough to be easily carried by one man. The dimensions of the horizontal and vertical circle were 5 Paris inches, with two reading microscopes belonging to each circle. Screw micrometers connected with the microscopes gave readings of 10 seconds.

The instrument could not be combined with a collimator magnet, on account of its having steel axes, but we used it very often for topographical measurements. The reading microscopes, however, easily got out of order, and they then required a considerable time for re-adjustment.

Theodolite 5, Ertel.[2] A most accurate description of this "universal instrument" is contained in "Sawitsch",[3] p. 156.

This was the largest of our theodolites, with a diameter of 6½ Paris inches for the horizontal, and of 5 Paris inches for the vertical circle. Two verniers, reading 10 seconds, were connected with the horizontal, and four verniers, also reading 10 seconds, with the vertical circle. Repetitions could be made, and to the lower part of the instrument a second telescope was attached for controlling its position, whether it remained unchanged or not during the observations. As there was much steel in its construction, we used it only for topographical surveys, and chiefly in Síkkim. Its great weight, and the size of the two boxes in which it was packed, prevented us from taking it with us as often as we otherwise could have wished.

Besides these theodolites, we had *pocket sextants* by Troughton and Simms, which were used principally for minor topographical operations,[4] as we could always manage to carry a theodolite with us.[5] The great altitudes of the sun, during many hours of the day in these latitudes, somewhat limited the use of sextants, and, indeed, in working the theodolites we were often obliged to take prisms. Those by Jones and Troughton originally had no prisms; but we easily succeeded in applying to them the prisms of the

[1] Pistor and Martins, Berlin.

[2] Ertel und Sohn, Munich.

[3] "Sawitsch, Abriss der praktischen Astronomie." Translated from the Russian, by W. C. Goetze. Hamburg, 1850.

[4] As an instance of the exceptional use of sextants for latitude and longitude, see the stations Gártok and Rámpur, in Section II.

[5] In reference to the detail of the construction of surveying instruments and their use, we draw attention to the "Manual of Revenue Surveying", by H. L. Thuillier and R. Smyth. London, 1855. It also contains much valuable information for the carriage and management of instruments in Indian travelling.

theodolites by Pistor and Ertel. The great altitudes of the sun at the same time considerably increase the difficulties of such observations, in consequence of the powerful, and often dangerous, insolation to which the observer is exposed.

b. CHRONOMETERS.

Their description and their rates are given in detail, in connection with the materials from which we have deduced our longitudes, in No. IV. of this section.

c. METEOROLOGICAL INSTRUMENTS.

In this volume we give barometer readings, in millimetres and inches, corrected already for error of instruments, and reduced to 32° Fahr. The temperatures of the air are also corrected for the error of the thermometers. A detailed description and comparison will be contained in Vol. II.

As meteorological elements for the calculation of our astronomical and magnetic observations, we have selected, in each case, one or two readings, which best represent the mean values during the time of the observations. As far as relates to these calculations it is unnecessary to enter further into detail.[1]

Mode of packing.

All our larger instruments were packed in strong wooden cases, light enough for one man to carry easily, and with leather covers fitted to them. The idea of such an arrangement had already occurred to us before we started, and upon actual trial the covers proved to be of the greatest use. We found them to add materially to the strength of the box; they limited the shrinking of the wood during the hot season, both in the tropics and in the dry climate of Tíbet, and also served as an excellent protection against the effects of dampness and moisture. In countries such as Tíbet and Turkistán, no large pieces of wood are procurable, and consequently the greatest difficulty would have been experienced in effecting the slightest repairs.

In this manner we succeeded in keeping our instruments in very good order, although we found the screws frequently loosened by the unavoidable shaking. Indeed, we were surprised to see how great was the effect produced by a constant succession

[1] Meteorology in general will be the special object of Vols. IV. and V.

of little shocks during the course of a long journey. However, a cursory examination of the different screws, and a little attention in seeing that they were all properly fastened before making an observation, took up but a short time, and proved amply sufficient to keep the instruments in good working order.

II. INTRODUCTORY CALCULATIONS.

The materials of the observations are: Apparent Altitudes of the Limbs of the Sun, in some instances of the Centre of the Sun, and Differences of Azimuths; and in other cases similar observations for the Moon and Stars. The observations of the Sun form by far the greater part.

In all our calculations the numerical elements are taken from the "Nautical Almanac", with a few isolated exceptions, which we have taken care to mention.

The first object of the calculation is the reduction of the values, observed from the surface of the earth, to true and geocentric values: viz. the application of refraction and parallax.

a. REFRACTION.

The refractions are taken from "Ivory's Tables of Astronomical Refractions", in which 34′ 32″ is given as the Constant for refraction. They are originally published in the Philosophical Transactions of the Royal Society for 1838.

Bessel's Tables refer only to variations of the barometer between 30 and 20 French inches; consequently, they could not be used, as the lowest barometric pressure in connection with our astronomical observations is as low as 14·6 English inches.

We had the advantage of using the detailed tables, based on Ivory's values, as extended by General Boileau. They are contained in the latter's valuable "Collection of Tables, Astronomical, Meteorological, and Magnetical", printed at Ambála, 1850, and to the kindness of the author we are indebted for a copy. His logarithms of correction extend from 32 to 14 inches, and from 10° to 130° Fahr.

The very convenient arrangement of the tables may best be seen from the following example:—

Station No. 91. SKÁRDO IN BÁLTI.

Observed Altitude of the Sun's Upper Limb	25° 15′ 0″		
Barom.[1] { 583·2 millim. / 22·961 inches. — Temp. of Air { 22°·9 C. / 73°·2 Fahr.			
Logarithm of correction for	22·961 inches	=	9·885
Logarithm of correction for	73°·2	=	9·980
Logarithm of mean refraction for the Apparent Altitude of	25° 15′ 0″ . .	=	2·090
Sum = Logarithm of true refraction		=	1·955
	nat. num	=	90″
Apparent Altitude of Sun's Upper Limb	25° 15′ 0″		
Refraction	— 1′ 30″		
True Altitude of the Sun	25° 13′ 30″		

For altitudes of the sun below 20°, and particularly for those of the moon, another correction depending on refraction must be applied.

Since the refraction is a different one for every point of the sun's or the moon's discs which differs in altitude, it follows that the sun and the moon do not present themselves as regular circles, but as transcendental curves. For our observations of the sun, which were always taken above 20°, this correction was never required. At 20° it only amounts to 2″, but between 30° and 40° becomes 0.

The tables to be used for low altitudes are Nos. XIV., XV., and XVI. in "Bremiker's nautisches Jahrbuch."

b. PARALLAX,

in reference to the System of Co-ordinates of Altitudes.

Taking the earth as a perfect sphere, the parallax alters the altitudes only, and not the azimuths. This consideration is quite accurate enough for our calculations.

For the sun and the planets, the parallax of altitudes may be found either by a simple multiplication of the horizontal equatorial parallax with the cos of altitude, or by using the formulæ which have been lately developed for parallax. In general, the first term of the series gives the correct values, but, for the moon, it is necessary to introduce the ellipticity of the earth and the second term of the infinite series.[2]

[1] The barometer readings are already reduced to 32° Fahr., and corrected for the instrumental error. Compare, p. 76.

[2] Compare, Brünnow, sphärische Astronomie. Berlin 1851, p. 94.

The ellipticity of the earth is also the cause of the azimuthal parallax of the moon, which need not be taken into account for the sun and the stars. "Bremiker's nautisches Jahrbuch", which we constantly use, gives the azimuthal parallax as a function of latitude and azimuth.

Besides the parallax, another correction, as function of the moon's altitude, must be applied to observations of the moon, the object of this correction being the variation of its apparent semidiameter, which depends upon its altitude. This correction in some instances may amount to 18″; it is proportional (Const. sin h).

c. METHODS OF INTERPOLATION.

Quantities depending on the Yearly Motion, or on the Anomalies of the Orbit.

For the quantities depending on anomalies, the "Nautical Almanac" contains for every Mean Noon of Greenwich Time, for the Sun: Right Ascension, Declination, and Equation of Time.

For the Moon, the "Nautical Almanac" gives, for each hour: Right Ascension and Declination, and, from 12 to 12 hours, equatorial and horizontal Parallax and Semi-diameter.

These values must be interpolated for the moments of observation. The first differences already give a sufficient accuracy for all that must be considered as a function of the anomalies of the orbits. But it is necessary to know approximatively the Greenwich Time corresponding with the moments of observation.

This can be done by a transformation of the well known formula:

$$\sin h = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos t, \qquad (1)$$

which, if we give to it the form required, becomes:

$$\cos t = \frac{\sin h - \sin \varphi \sin \delta}{\cos \varphi \cos \delta}. \qquad (1a)$$

In these formulæ:

φ = Latitude of the place of observation, which must be known within ten minutes for obtaining the Time with sufficient accuracy;

δ = the Sun's Declination, for which the Declination at Greenwich Noon can be taken for the first approximation;

h = the true Altitude of the Sun's Centre, corrected for parallax and refraction;

t = the Apparent Local Time, sought for, which must be reduced by the Equation of Time to the Mean Local Time, and by the difference of Longitude (which must be known within half or a quarter of a degree) to Greenwich Time.

The differentiation of formula (1a) shows, that we must take for h the lowest observed altitude.

The following is an example of the mode of calculating:

Station No. 21. RAULPÍNDI IN THE PĂNJÁB.

1856, December 3.

Time by Chron. 3	$8^h\,48^m\cdot7$
Lowest Altitude reduced to the Sun's Centre . .	26° 0′·0
Refraction	— 1′·9
Parallax	+ 0′·1
True Altitude of Sun's Centre	25° 58′·2
Approximate Latitude North	33° 6′
Approximate Longitude E. Green. . . . 73°·1 =	$4^h\,52^m$
δ at Greenwich Mean Noon	— 22° 12′

$\log \sin h = 9\cdot641$. $\log \sin \varphi = 9\cdot743$ $\log \cos \varphi = 9\cdot921$

$\sin h = 0\cdot437$ $\log \sin \delta = 9\cdot577_n$ $\log \cos \delta = 9\cdot967$

$-\sin\varphi \sin\delta = +0\cdot209$ $9\cdot320_n$ $9\cdot888$

$0\cdot646$ . . . . $\log = 9\cdot810$

$\log \cos t = 9\cdot922$

$t = 33°\cdot2 = 2^h\,12^m\cdot8$

Time of observation by Chron. 3	$8^h\,48^m\cdot7$
Apparent Noon by Chron. 3	$6^h\,35^m\cdot9$

The observations used for the determination of

	h m
Latitudes were made at	4 38·9
Mean Noon	6 45·8
Mean Local Time of the observations . . .	—2 6·9
Longitude E. Green.	4 52·1
Mean Greenwich Time	—6 59·0

Sun's Declination at Greenwich, Mean Noon, Dec. 3, — 22° 11′ 32″

Horary Variation . . . . — 21″·2

log of Horary Variation . . . . . $1\cdot326_n$

log of $6^h\,59^m$ expressed in hours $0\cdot844_n$

$2\cdot170$

nat. num = + 148″ = + 2′ 28″

Sun's Declination at the moment of the observation — 22° 9′ 4″

We find the Apparent Noon:

	h m
With the Declination at the moment of observation .	6 36·6
With the Declination at Greenwich Noon	6 35·9

Therefore there exists an error of $0^m \cdot 7$ in the determination of time, as it was made for interpolating the sun's declination. The horary variation of this value is $21''$, and, therefore, the error of declination which was used in the calculation $= 0' \, 0'' \cdot 2$, a value which we consider by a calculation with 5 decimals in log to be equal to 0.

Quantities depending on the Daily Motion.

The motion of the sun, as well in reference to altitude as to azimuth, forms a series of differences of higher orders. If we have a series of observations of altitudes or azimuths, in which the times of observations shall be

$$t, t', t'' \text{ \&c.},$$

and the readings of the vertical circle, which alone are to be taken into the calculation, expressed in zenith distances

$$z, z' z'' \text{ \&c.},$$

then the errors in the readings involve the probability of being partly positive, partly negative, and thus of compensating themselves.

If we were simply to take the arithmetical mean, we should get a probable error, about equal to, or greater than, the errors eliminated, since the motion of the sun is not a series of differences of the first order.

For, if the time of observation obtained by the arithmetical mean $= T$,
if the zenith distance obtained in the same manner . . . . . . $= Z$,
and if

$$t - T = \tau,$$
$$t' - T = \tau',$$
$$t'' - T = \tau'',$$

we get as results from Taylor's theorem[1]:

$$Z = z + \frac{dZ}{dT} \cdot \tau + \frac{1}{2} \frac{d^2 Z}{dT^2} \cdot \tau^2 + \text{\&c.}$$

$$Z = z' + \frac{dZ}{dT} \cdot \tau' + \frac{1}{2} \frac{d^2 Z}{dT^2} \cdot \tau'^2 + \text{\&c.}$$

$$Z = z'' + \frac{dZ}{dT} \cdot \tau'' + \frac{1}{2} \frac{d^2 Z}{dT^2} \cdot \tau''^2 + \text{\&c.}$$

[1] Brünnow, sphärische Astronomie, 1851, p. 226.

The second differences can be taken into account either by developing the formulæ for the zenith distances, including the higher differences, or by correcting the time found by the arithmetical mean of the zenith distances with reference to the higher differences.

In order to develope the formulæ for the zenith distances, including the higher differences, we know

$$\tau + \tau' + \tau'' + \&c. = 0;$$

we therefore obtain by a summation of the single equations, for Z,

$$Z = \frac{z + z' + z'' + z''' + \&c.}{n} + \tfrac{1}{2} \frac{d^2 Z}{d T^2} \cdot (\tau^2 + \tau'^2 + \tau''^2 + \&c.),$$

where n signifies the number of the observations.

By the well known formulæ of reduction we can also write the formula:

$$Z = \frac{z + z' + z'' + z''' + \&c.}{n} + \frac{d^2 Z}{d T^2} \cdot \frac{\Sigma\, 2 \sin^2 \tfrac{1}{2} \tau}{n}.$$

The double differentiation of the elementary equations (1) for the zenith distance gives

$$\frac{d^2 z}{d t^2} = + \frac{\cos \delta \cos \varphi}{\sin z} \cdot \cos A \cos p,$$

p signifying in this and also the following formulæ, the parallactic angle.

The final equation then becomes:

$$Z = \frac{z + z' + z'' + z''' \ldots}{n} + \frac{\cos \delta \cos \varphi}{\sin Z} \cdot \cos A \cos p \cdot \frac{\Sigma\, 2 \sin^2 \tfrac{1}{2} \tau}{n}. \tag{2}$$

The correction of the time, deduced from the mean of the zenith distances, is, if we transform the above equations, obtained as follows:

$$\frac{d T}{d Z} = \tfrac{1}{15} \cdot \frac{\sin Z}{\cos \delta \cos \varphi} \cdot \frac{1}{\sin T},$$

which must be introduced in the formula

$$+ \frac{d T}{d Z} \cdot \frac{\cos \delta \cos \varphi}{\sin Z} \cdot \cos A \cos p \cdot \frac{\Sigma\, 2 \sin^2 \tfrac{1}{2} \tau}{n}.$$

Since, besides

$$\sin p = \frac{\sin T}{\sin Z} \cdot \cos \varphi, \quad \text{and } \sin A = \frac{\sin T}{\sin Z} \cdot \cos \delta,$$

we get as corrections of the Hour Angle

$$+ \frac{\tfrac{1}{15} \cos p \cos A}{\sin T} \cdot \frac{\Sigma\, 2 \sin^2 \tfrac{1}{2} \tau}{n}. \tag{3}$$

This method might have been applied as the principal one to our observations, but we have preferred to use in its place another mode of calculation based on the principles of Equations of Condition, which have recently been used very successfully in calculating astronomical observations, particularly after the precedent of Gauss, who first collected them. We employ this method for the calculations of latitudes and longitudes, especially as it has the great advantage of at once detecting accidental errors of observations, and of determining the weight of each single observation.

At the same time, it is in general not affected by the higher terms of infinite series,—terms which are neglected in the method communicated above. Lastly, it makes, as final result, the value to agree with the principles of probability, and with the method of least squares. In division V. of this section, this method is given in detail, especially with reference to its application to latitudes and longitudes.

III. METHODS FOR CALCULATING LATITUDE AND TIME.

1. OBSERVATIONS OF STARS.

The observations of the planets and stars in general, when not combined with lunar observations, were considered only as a control for the results obtained from the observations of the sun. But observations of polar stars were preferred to observations of the sun for calculating the latitude, in those cases where, for obtaining as correctly as possible time and longitude, the sun had been observed at some distance from the meridian. Such solar observations are not well adapted for calculating the latitude, since the differential of latitude is a multiple of the differential of altitude.

In calculating the latitude, the mean local time (reduced from the observation of the sun) was introduced to find declination and right ascension from the tables of the "Nautical Almanac".

If U = the time of Mean Noon by chronometer,

u = the time of the observation by chronometer,

λ = Longitude East of Greenwich,

$9^{s}{\cdot}86$ = the Acceleration of Stars compared to the mean Sun,

we get the sidereal time of the observation:

$$s = (u - U - \lambda) + U + (u - U - \lambda)^{\text{hor}} . 9^{s}{\cdot}86 + \lambda + S.$$

In this formulæ, S denotes the Sidereal Time at Mean Noon at Greenwich; the co-efficient of $9^s \cdot 86$ is to be expressed in hours; δ is the Declination of the Star, $R.A.$ its Right Ascension—both corrected for precession, nutation, and aberration. Then $s - R.A.$ is the Hour Angle of the Star. This being found, the latitude is obtained by the formula given in Method II.; we, therefore, give no special example. For Polaris, the "Nautical Almanac" contains tables for obtaining the latitude by a simple arithmetical operation.

2. OBSERVATIONS OF THE SUN.

For all stations of particular importance, such as those in India, unconnected with the Great Trigonometrical Survey, and those in the mountain systems of High Asia, the formulæ generally used were only taken for the first approximation. The preliminary results, so obtained, served to give the latitude and time by applying, in a second series of calculations, the method communicated in division V. of this section, in a form satisfying all conditions of the calculations of probability.

In every case where one method only was used, controls have been applied.

METHOD I

The greater number of the observations form two groups, situated in different Azimuths, separated by an interval of several hours.

Method of unequal Altitudes.

The variations of the sun's declination in the intervals have already been introduced in the first series of calculations.

When the observations succeed each other at intervals so short that it is possible to take the arithmetical means,

u being = mean of Times by Chronometer,
h ,, = mean of the Altitudes observed,
δ ,, = Declination of the Sun,
$R.A.$,, = Right Ascension,

we get for the mean of one group u', h', δ', $R.A.'$, the same data as for the mean of the second group, either on the same or on the opposite side of the meridian. We then obtain latitude and time by the following system of formulæ:

$$\lambda = \frac{24^h}{23^h\,56^m\,4^s{\cdot}1}(u'-u)-(R.A.'-R.A.);$$

or in a more simple form:

$$\lambda = (u'-u) - (9^s{\cdot}86 - \triangle\,R.A.)\,(u'-u)^{hor},$$

where $\triangle\,R.A.$ signifies the Horary Motion of the Sun in Right Ascension.

Then, if we put

$$\sin\delta\,\sin\delta' + \cos\delta\,\cos\delta'\,\cos\lambda = \cos D$$
$$\cos\delta\,\sin\delta' - \sin\delta\,\cos\delta'\,\cos\lambda = \sin D\,\cos s$$
$$\cos\delta'\,\sin\lambda = \sin D\,\sin s,$$

and

$$\cos(s+p) = \frac{\sin h' - \cos D\,\sin h}{\sin D\,\cos h},$$

we get

$$\sin\varphi = \sin h\,\sin\delta + \cos h\,\cos\delta\,\cos p \qquad (1\,1)$$
$$\sin t = \frac{\cos h\,\sin p}{\cos\varphi}, \qquad (1\,2)$$

t being = the Hour Angle of the True Sun, to which must be applied the respective equation of time for obtaining the mean local time, φ being the latitude, and D, and s, the well known auxiliary quantities, used in calculating spherical triangles.

These equations can be somewhat simplified, and transformed into a system of 13 single equations, two of which combined give the tangent of an unknown auxiliary quantity. These equations are:

$$\sin\delta' = \sin f\,\sin F$$
$$\cos\delta'\,\cos\lambda = \sin f\,\cos F$$
$$\cos\delta'\,\sin\lambda = \cos f$$

$$\cos D = \sin f\cos(F-\delta)$$
$$\sin D\,\cos s = \sin f\,\sin(F-\delta)$$
$$\sin D\,\sin s = \cos f$$

$$S = \frac{D+h+h'}{2}$$

$$\tan^2 \tfrac{1}{2}(s+p) = \frac{\cos S\,\sin(S-h)}{\cos(S-D)\,\sin(S-h')}$$

$$\sin g\,\sin G = \sin h$$
$$\sin g\,\cos G = \cos h\,\cos p$$
$$\cos g = \cos h\,\sin p$$

$$\sin\varphi = \sin g\,\cos(G-\delta)\quad \ldots\ldots \qquad (13)$$
$$\cos\varphi\,\sin t = \cos g$$
$$\cos\varphi\,\cos t = \sin g\,\sin(G-\delta).$$

Where observations of the sun are taken, no doubt can remain about the meaning of cos $(s+p)$ and of $\tan^2 \frac{1}{2}(s+p)$. It is also evident that this system of equations represents a continuous series of controls.

By differentiation of the final equations, and if we make the possible error in time equal to the possible error in latitude (since they can both be reduced to the altitude), and if, for giving a more simple form to the differential equations, the azimuths are introduced after differentiation instead of the hour angles, we obtain

$$dh = -\cos A\, d\varphi - \cos\varphi \sin A\, dt$$
$$dh' = -\cos A' d\varphi - \cos\varphi \sin A' dt,$$

or

$$\cos\varphi\, dt = -\frac{\cos A'}{\sin(A'-A)}\, dh - \frac{\cos A}{\sin(A'-A)}\, dh'$$

$$d\varphi = -\frac{\sin A'}{\sin(A'-A)}\, dh + \frac{\sin A}{\sin(A'-A)}\, dh'.$$

For the *observer* these equations show that, for obtaining results as accurate as possible, the sun must be observed in azimuths 90 degrees distant from each other, since $\sin(A'-A)$ is the number by which the error is divided. The details of the observations, communicated later, will show that a similar arrangement had already been made in most of the cases to which this method is applied.

For the *calculation* they show the following: If the sun has been taken in low altitudes, viz., if A' has been nearly equal to 90°, where $\sin(A'-A)$ becomes nearly 1, then

$$\cos\varphi\, dt = \cos A'\, dh - \cos A\, dh',$$

and

$$d\varphi = -\sin A'\, dh + \sin A\, dh'.$$

Now if A' (for low altitudes) is nearly $= \pm 90°$, A (for great altitudes) nearly $= 0$, or 180°, we have, for dt, the influence of $dh =$ a minimum, the influence of dh' $=$ a maximum, and vice versâ for $d\varphi$, the influence of $dh =$ a maximum, the influence of $dh' =$ a minimum.

It results that, in calculating, we must use the greatest altitude for latitude, and the lowest altitude for time.

Example for Method I.

Station No. 91. Skárdo, 1856, September 2.

Compare the detail of the observations in Section II., Group XI.

Means from the two series of the observations:

		h m s	° ′
Sun's Upper Limb	u =	3 58 30	45 42·3
	u' =	10 51 37	25 15·0

h corrected = 45° 25′·8

h' corrected = 24 57·7

Approximated Noon for finding the Sun's Decl. calculated from h' by formula (1 a) = $6^h·46$

	h	h
	6·46	6·46
Time of Observations	3·97	10·85
Local Time	− 2·5	+ 4·4
Approximate Longitude	5·6	5·6
Greenwich Time, September 2 . . .	− 8·1	− 1·2

Sun's Declination at Greenwich, Mean Noon:

	° ′ ″	° ′ ″
	+ 7 46 10	+ 7 46 10
Reduction to the Time of Observation	+ 7 26	+ 1 6
	δ = + 7 53·6	δ′ = + 7 47·3

		h m s
Time by Chronometer	= u' =	10 51 37
	u =	3 58 30
Intermediate Time	= $u' - u$ =	6 53 7
Acceleration of Stars	=	+ 1 8
Variation of Sun's Right Ascension, $(u'-u)\triangle R.A.$	=	− 1 3
λ in Time	=	. . 6 53 12
λ in Arc	=	103° 17′·9

log sin δ = 9·13777   log cos δ = 9·99587
log sin δ′ = 9·13199   log cos δ′ = 9·99597
log cos λ = $9·36177_n$

8·26976 $9·35361_n$

nat. num + 0·01861
− 0·22574
− 0·20713   log = $9·31624_n$ = log cos D

log cos δ = 9·99587   log sin δ = 9·13777
log sin δ′ = 9·13199   log cos δ′ = 9·99597
log cos λ = $9·36177_n$

9·12786 $8·49551_n$

nat. num + 0·13423
+ 0·03130
+ 0·16553   log = 9·21888 = log sin D cos s

log cos δ′ = 9·99597
log sin λ = 9·98819

9·98416 = log sin D sin s

log sin D sin s = 9·98416
log sin D cos s = 9·21888
log tan s = 0·76528

arc = 80° 15′·5 . . . . log sec = 0·00631
log sin D sin s = 9·98416
log sin D = 9·99047

Control of the calc., arc D from cos = 180—78° 2′·6
arc D from sin = 180—78 2·6

log sin h' = 9·62533   log sin h = 9·85272   log cos h = 9·84620
log cos D = $9·31624_n$ log sin D = 9·99047
$9·16896_n$ 9·83667

sin h' . . . . . . = + 0·42202
sin h cos D . . = + 0·14756 . . . . log. = 9·75555
0·56958   log. cos $(s+p)$ = 9·91888
$s+p$ = 33° 56′·4

arc s = 80° 15′·5
arc $(s+p)$ = 33° 56′·4
p = — 46° 19′·1

log sin h = 9·85272   log cos h = 9·84620
log sin δ = 9·13777   log cos δ = 9·99587
log cos p = 9·83926
8·99049   9·68133

nat. num
0·48010
0·09783
0·57793 . . . . log = 9·76187 = log sin φ
φ = Latitude North 35° 18′·3

log cos h = 9·84620
log sin p = 9·85925
9·70545
log cos φ = 9·91173 t = 38° 27′·3
9·79372

	h	m	s
Hour Angle in Time . . .	— 2	33	49
Equation of Time	—		31
Mean Local Time	— 2	34	20
Time by Chronometer . .	3	58	30
Mean Noon	6	32	50

METHOD II.

The observations form two groups on both sides of the meridian and in approximatively equal azimuths and altitudes.

Method of corresponding Altitudes.

If we have two series of observations, in which h signifies the altitude, u the time by chronometer,

before culmination	after culmination
u h	$u_{,}$ $h_{,}$
u' h'	$u_{,}'$ $h_{,}'$
u'' h''	$u_{,}''$ $h_{,}''$
. .	. .
. .	. .
. .	. .
u^{n} h^{n}	$u_{,}^{n}$ $h_{,}^{n}$,

and if the intervals between the single observations are not too great, and the azimuths in both groups not too different in reference to their distance from the meridian, the following formula can be applied, where h is considered the lowest altitude observed, and the time of chronometer, $u_{,}^{n} + x$, corresponds to an altitude after culmination, which is equal to the lowest altitude, h, observed before culmination.

Then

$$x = \frac{(u_{,}^{n} - u_{,}^{n-1})\ (h_{,}^{n} - h)}{(h_{,}^{n-1} - h_{,}^{n})}. \qquad \text{(II 1)}$$

The two altitudes being exactly equal at both these times, viz. at u, and at $u_{,}^{n} + x$, the moment of the true noon would be the exact mean of these times, were not the declination of the sun changed during the time between the two observations.

If this change of the declination is considered as a differential quantity $= d\,\delta$, we get the correction in time by the well known formula (correction for noon):

$$-\ {}^{1}/_{30}\ d\,\delta \left(\frac{\tan\varphi}{\sin t} - \tan\delta\ \text{cotan}\ t\right). \qquad \text{(II 2)}$$

Tables for finding this correction for noon, calculated by Gauss, are contained in "Schuhmacher's Hülfstafeln", Altona, 1845, p. 100. Log μ required in these tables is annually published in "Encke's Berliner astronomisches Jahrbuch".

As soon as the time of the true noon is found by this method, the hour angle of the sun for the respective times by chronometer can easily be calculated;

if $\triangle z$ = the Equation of Time for the Noon of the place of observation,

$\triangle z'$ = the Equation of Time for the moment of the observation, then the Hour Angle of the Sun (u_0 being the apparent local noon) is

$$t = u - (u_0 - \triangle z) - \triangle z'. \tag{II 3}$$

For obtaining the most favourable determination of latitude, the greatest altitude has been combined with the hour angle, and the latitude is then obtained by the following formulæ:

$$\left.\begin{array}{c} \tan N = \dfrac{\tan \delta}{\cos t} \\ \cos(\varphi - N) = \dfrac{\sin h}{M}, \quad \text{where} \quad M = \dfrac{\sin \delta}{\sin N} = \dfrac{\cos \delta \cos t}{\cos N} \end{array}\right\}. \tag{II 4}$$

Example for Method II.

Station No. 21. RAULPÍNDI, IN THE PĂNJÁB.

1856, December 3.

Compare the detail of the observations in Section II., Group IV.

u = Time by Chronometer; h = Appar. Altitude of Sun's Centre.

	h m s		° ′ ″
u =	4 36 18	h =	27 20 36
$u_{,}^{n-1}$ =	8 37 51	$h_{,}^{n-1}$ =	27 13 24
$u_{,}^{n}$ =	8 43 16	$h_{,}^{n}$ =	26 37 29
	5 25		35 55

$$h - h_{,}^{n-1} = 7' \, 12'',$$

and x is therefore to be found by the equation:

$$x = \frac{5^m \, 25^s \times 7' \, 12''}{35' \, 55''} = 65^s.$$

The time P.M., corresponding to the Altitude, h, is therefore:

	h m s
P. M.	8 36 45
A. M.	4 36 18
Uncorrected Appar. Noon	6 36 32
Correction for Noon . . +	4
Apparent Noon	6 36 36
Equation of Time . . .	9 56
Mean Noon	6 46 32
Time of observation . .	4 42 17
Mean Local Time . . .	21 55 45

With the approximate longitude = $4^h \, 52^m \, 24^s$, we get

		h m s		
the Local Sidereal Time	=	14 44 36		
the *R.A.* of the Sun	=	16 38 56		
therefore the Hour Angle in Time . . .	= —	1 54 20	=	28° 34′·9 in Arc
δ interpolated for the time of observation is			—	22 9·1
the corrected Altitude is				20 56·6.

The remaining calculation is the following:

	$\log \sin \delta = 9 \cdot 57641_n$	$\log \cos \delta = 9 \cdot 96670$	
	$\log \cos \delta \cos t = 9 \cdot 91031$	$\log \cos t = 9 \cdot 94361$	
	$\log \tan N = 9 \cdot 66610_n$	$9 \cdot 91031$	
arc N	$= -24^\circ\, 52' \cdot 2$	$\log \sec$	$= 0 \cdot 04227$
		$\log \cos \delta \cos t$	$= 9 \cdot 91031$
		$\log M$	$= 9 \cdot 95258$
		$\log \sin h$	$= 9 \cdot 67081$
		$\log \cos (\varphi - N)$	$= 9 \cdot 71823$
arc $(\varphi - N)$	$=$ 58 29·4		
Latitude North:	33 37·2.		

Of the two formulæ for M (p. 90, II 4), we select the one, as in all formulæ of this kind, for which the angular function of N can most easily be interpolated.

In order to make it possible to calculate the latitude from different combinations of observations (taken for determining latitudes), it was necessary in a few instances somewhat to modify method No. II.

1. In some stations, as No. 44, Nărigún, observations of the sun's altitude are combined with altitudes of stars.

When the latter observations gave either of the elements (latitude or mean local time) more accurately than the altitudes of the sun alone, the mean local time was calculated from the lowest, the latitude from the highest altitude, either of the sun or of the star.

2. Where observations of different stars only were taken, having different declinations, as in No. 20, Lahór, the mean local noon was calculated from the star with the greatest polar distance, the latitude from the star with the least polar distance.

METHOD III.

Circum-meridian Altitudes.

The changes of the altitude near the culmination are proportional to the squares of the hour angles. On this principle the following method is based. If, not too distant from the meridian, the altitudes be

$$h, \quad h', \quad h'',$$

and the times by chronometer

$$u, \quad u', \quad u'',$$

and if $d\delta$ be the change in the sun's declination in the unity of time, then

$$\left.\begin{aligned} m &= \frac{h'' - h}{u - u''} + d\delta \\ m' &= \frac{h'' - h'}{u' - u''} + d\delta \end{aligned}\right\} \qquad \text{(III 1)}$$

$$\alpha = \frac{\dfrac{h'' - h}{u - u''} - \dfrac{h'' - h'}{u' - u''}}{u - u'}. \qquad \text{(III 2)}$$

We find u_0, the time of apparent noon, by

$$\left.\begin{aligned} u_0 &= \frac{u + u''}{2} - \frac{m}{2\alpha} \\ u_0 &= \frac{u' + u''}{2} - \frac{m'}{2\alpha}. \end{aligned}\right\} \qquad \text{(III 3)}$$

The identity of the numerical values for u_0 from both equations must be exact, and gives a control for the calculation.

The altitude of culmination, h_0, is obtained, h^n being the observation least distant from the meridian, by the formula:

$$h_0 = h^n + \alpha\,(u^n - u_0)^2 + d\delta\,(u^n - u_0). \qquad \text{(III 4)}$$

and the latitude

$$\varphi = 90 - (h^0 - \delta).$$

Example for Method III.

Station No. 95. △ SÚGET, IN TURKISTÁN.

1856, September 1.

Compare the detail of the observations in Section II., Group XII.

		° ′ ″			° ′ ″
h''	=	62 14 30	h''	=	62 14 30
h	=	62 16 40	h'	=	62 18 15
$h''-h$	= —	2 10	$h''-h'$	= —	3 45
	= —	130		= —	225

		h m s			h m s			h m s
u	=	6 28 33·0	u'	=	6 32 22·2	u	=	6 28 33·0
u''	=	6 36 40·2	u''	=	6 36 40·2	u'	=	6 32 22·2
$u-u''$	= —	8 7·2	$u'-u''$	= —	4 18·0	$u-u'$	= —	3 49·2

Variation of the Sun's Declination in one second of time = $d\delta$ = — 0″. 01520.

log nat. num — 130	=	$2·11394_n$	log nat. num — 225	=	$2·35218_n$
log nat. num — 487·2	=	$2·68771_n$	log nat. num — 258·0	=	$2·41162_n$
log m_0	=	9·42623	log m'_0	=	9·94056
nat. num	=	+ 0·26682	nat. num	=	+ 0·87208
$d\delta$	=	— 0·01520	$d\delta$	=	— 0·01520
m	=	+ 0·25162	m'	=	+ 0·85688

$$m_0 = 0{\cdot}26682$$
$$m'_0 = 0{\cdot}87208$$
$$m_0 - m'_0 = -0{\cdot}60526.$$

$$\log m_0 - m'_0 = 9{\cdot}78194_n$$
$$\log \text{nat. num} - 229{\cdot}2 = 2{\cdot}36021_n$$
$$\log \alpha = 7{\cdot}42173$$
$$\log \text{nat. num} + 2 = 0{\cdot}30103$$
$$\log 2\alpha = 7{\cdot}72276$$

$$\log m = 9{\cdot}40074 \qquad \log m' = 9{\cdot}93292$$
$$\log 2\alpha = 7{\cdot}72276 \qquad \log 2\alpha = 7{\cdot}72276$$
$$1{\cdot}67798 \qquad 2{\cdot}21016.$$

$$\text{nat. num} \quad -\ {}^{\text{h}}\ {}^{\text{m}}\ 47{\cdot}6^{\text{s}} \qquad \text{nat. num} - 2^{\text{h}}\ 42^{\text{m}}\ 2^{\text{s}}{\cdot}2$$
$$\frac{u + u''}{2} = 6\ 32\ 36{\cdot}6 \qquad \frac{u' + u''}{2} = 6\ 34\ 31{\cdot}2$$
$$\text{Apparent Noon} = 6\ 31\ 49{\cdot}0 \qquad 6\ 31\ 49{\cdot}0.$$

The coincidence of these two results gives a control for the calculation.

Observation 2 being the one nearest to the meridian, we use it for carrying out our final calculations:

		h m s	
Apparent Noon	$= u_0 =$	6 31 49·0	
u of observation 2	=	6 32 22·2	
$u - u_0$	=	33·2	
log	=		1·5211
$\log (u - u_0)^2$	=		3·0423
$\log \alpha$	=		7·4217
log red.	=		0·4640
nat. num	=		2″·91.

It is merely accidental in this case, that the value of the reduction of the observation 2 to the culmination is extremely small.

		°	′	″
Observed Apparent Altitude of the Sun's Upper Limb		62	18	5
Semidiameter	—		15	54
Refraction	—			18
Parallax	+			4
Reduction to the Meridian as above	+			3
Calculated true Altitude of the Sun's Centre at its Culmination . .		62	2	0
Sun's Declination	+	8	12	54
Elevation of the Equator		53	49	6
Latitude North		36	10	54

3. DETERMINATION OF THE TRUE MERIDIAN

in reference to the Position of the Theodolite.

From our astronomical observations, the true meridian is deduced for method I. by the application of the strict formulæ, for methods II. and III. generally by an interpolation analogous to formula (II 1.)

The strict formulæ which we use for the determination of the meridian are:

$$\sin \frac{1}{2} A = \sqrt{\frac{\cos s \cos (s - \sigma)}{\cos \varphi \cos h}}, \qquad \text{(a)}$$

where

$$A = \text{Azimuth}$$
$$s = \frac{1}{2}(\varphi + h + \sigma)$$
$$\sigma = 90° - \delta;$$

or,

$$\cot A = - \frac{\cos \varphi \tan \delta - \sin \varphi \cos t}{\sin t}. \qquad \text{(b)}$$

Very often we made direct observations, in connection with the magnetic declination, either by taking the corresponding altitudes of the sun at low elevations, or by observing the passage of stars, both with the theodolite.

When remaining a whole day at one place, the observations of the sun at low corresponding altitudes are the most simple for determining the meridian line. These observations, with a very small correction for the sun's declination, give the meridian line and the apparent noon as immediate result.

IV. METHODS FOR CALCULATING THE LONGITUDE.

The longitude, *i. e.* the second angle of the polar co-ordinate ρ, cannot be obtained by so simple and easy a way as the latitude.

Much more accurate observations, as well as more detailed calculations, are required for the longitude than for the latitude, when the same limits of accuracy are sought for.

Longitudes can be determined by transportation of chronometers, by observation of celestial phenomena, and by the use of signals.

Our observations of longitudes are chiefly based on chronometers, to which method we give the preference[1] even in those cases where we have also deduced the longitude from celestial phenomena.

1. LONGITUDES BY CHRONOMETERS.

Rates of the Chronometers.

During our journeys we used the following chronometers, marked in our journals of observations with the initial signs as in the annexed list:

Chron. 1, by Parkinson and Frodsham, original No. 2942, one day chronometer.
Chron. 2, by Parkinson and Frodsham, original No. 1864, „
Chron. 3, by Parkinson and Frodsham, original No. 3420, „

These three chronometers we took with us from London, their rate having been previously ascertained at the Greenwich Observatory.

Chron. 4, box chronometer (two day chronometer) by Parkinson and Frodsham, original No. 2295.
Chron. 5, by Grant, one day chronometer.

These two chronometers were handed over to us from the Madras Observatory, 1856, March 28.

We soon found that the latter (No. 5) did not keep its rate well enough for astronomical purposes.

The best of our chronometers was No. 3;[2] we, therefore, used it as often as possible, and we have deduced from it the greatest part of our longitudes.

During all our journeys, each chronometer was packed in a large bag, stuffed with cotton, and carried by a separate kúli (bearer). This seemed to us the best arrangement to obviate any bad effects, as well from insolation, as from shaking. The very satisfactory rates of our chronometers, in spite of our travelling nearly always by land, and not by water, may be attributed, in a great measure, to this precaution.

The rates for our chronometers were ascertained with the greatest possible care, as may be seen from the following details. We give first the data on which the rate of chronometer 3 is based, then those for our other chronometers.

[1] See Raper, On Longitudes, Nautical Magazine, 1839; Daussy, Sur la marche des chronomètres, Paris, 1840; Lieussou, Recherches sur les pendules et les chronomètres, Paris, 1854; Shadwell, On chronometers and meridian distances, London, 1855.

[2] This chronometer had been used, previous to our journeys, in one of the Arctic expeditions, as we were told at Parkinson's and Frodsham's office, where it was recommended us a particularly good one.

a. CHRONOMETER 3; 1854 TO 1857.

1. London.

1854, September 10 to 18.

Determined by comparison with Parkinson and Frodsham's standard pendulum clock:

Mean rate, communicated September 18: Gaining $1^s\cdot0$.

2. Voyage from Southampton to Bombay.

1854, September 20 to November 24.

We had arrived at Bombay the 26th of October.

	h	m	s	
Southampton, at Noon Greenwich Time, September 20, Chron. 3	0	0	33·5	P.M.
Bombay Observatory, at Noon Bombay Time, November 24, Chron. 3	7	7	52·5	
Difference of Longitude between Bombay and Greenwich, in Time	4	51	16·3	
Chron. 3, referred to Bombay Noon, Mean Time	11	59	8·8	
Chron. 3, Bombay, November 24, slow	0	0	51·2	
Greenwich Time (Southampton), September 20, fast			33·5	
Lost from September 20 to November 24 (65 days)			82·7	

Mean daily rate: Losing $1^s\cdot27$.

When on board the steamers, the chronometers were kept in as uniform a temperature as possible, and secured from the effects of the ship's motion, by being placed in a thick wrapping of cotton.

3. Bombay Observatory.

1854, November 24 to December 8.

Mean daily rate: Losing $0^s\cdot61$.

The comparisons were made by Lieutenant E. F. T. Fergusson, I. N.

The following table contains the detail of the comparisons and the variation of the daily rate, which may be considered as very uniform.

[1] Bombay is freed from error of clock. Longitude Bombay Observatory, 72° 49′ 5″, as contained in the Bombay Magnetical Observations, 1856, p. III., and based on Taylor's Longitude of Madras = 80° 13′ 56″.

Year, 1854.		Mean Time by Standard Clock.	Bombay Mean Time corrected for Error and Rate of Clock.	Time by Chronometer 3.	Difference of Chronometer 3 from Bombay Mean Time corr.	Daily Rate.	
Month.	Day.					Gaining.	Losing.
		h m	h m s	h m s	h m s		s
Nov.	24	11 52	11 52 47·5	7 0 40·0	4 52 7·5	...	0·50
,,	25	11 56	56 52·0	7 4 44·0	4 52 8·0	...	0·75
,,	26	...	...	...	...	...	0·75
,,	27	11 51	52 1·5	6 59 52·0	4 52 9·0	...	0·00
,,	28	11 51	52 6·5	6 59 57·0	4 52 9·0	...	1·50
,,	29	11 51	51 12·0	6 59 1·0	4 52 11	...	0·75
,,	30	...	...	...	...	...	0·75
Dec.	1	11 34	34 18·0	6 48 5·5	4 52 12·5	...	1·00
,,	2	11 53	53 21·5	7 2 8·0	4 53 13·5	...	0·33
,,	3	...	...	...	...	...	0·33
,,	4	...	...	...	...	...	0·33
,,	5	11 47	47 33·5	6 55 19·0	4 52 14·5	...	0·00
,,	6	11 51	51 38·5	6 59 24·0	4 52 14·5	...	0·75
,,	7	...	...	...	...	...	0·75
,,	8	11 49	49 49·0	6 59 33·0	4 52 16·0	...	...

4. Bombay to Madras.

1844-5, December 8 to February 27.

	h m s
Madras Observatory, Chron. 3 at Madras Noon, Mean Time, February 27	6 37 40·6
Difference of Longitude between Madras and Greenwich, in Time	5 20 57·3
Mean Time at Madras by Chron. 3	11 58 37·9
Chron. 3, slow at Madras	0 1 22·1
,, slow at Bombay	0 0 51·2
,, lost from December 8 to February 27 (81 days)	0 0 30·9

Mean daily rate: Losing 0·38

The observations were made by Major Worcester and Adolphe.

Our (H. and R.) short stay in Madras made it impossible to rate Nos. 2 and 3 at the Observatory itself, but Adolphe's Chronometer 1 was rated; see p. 104.

5. Madras to Calcutta.

1855, February 27 to March 8.

	h m s
Surveyor General's Office: Chron. 3 at Calcutta Noon, Mean Time, March 8	6 5 11·3
Difference of Longitude between Calcutta[1] and Greenwich in Time	5 53 22·1
Mean Time at Calcutta by Chron. 3	11 58 33·4

[1] Referred, as all our longitudes, to Taylor's longitude of Madras.

	h	m	s
Chron. 3, slow at Calcutta	0	1	26·6
„ slow at Madras	0	1	21·4
„ lost from February 27 to March 8 (9 days)	0	0	5·2

Mean daily rate: Losing $0^s \cdot 58$

Between Madras and Calcutta, by the Peninsular and Oriental Company's steamer "Bengal", the chronometers were secured in the same manner as during the preceding voyage.

6. Calcutta Observatory, 35, Park-street.

1855, March 8 to 22.

Mean daily rate: Losing $0^s \cdot 65$.

The daily comparisons were made by Bábu Rádhanath Sikdár.

The detail of the comparisons and the variation of the daily rate is given in the following table. The readings are referred to Mean Noon Calcutta (already corrected for error and rate of standard clock, by Thwaites).

Year, 1855.		Time at Calcutta, Mean Noon, by Chronometer 3.	Daily Rate, Chron. 3.	
Month.	Day.		Gaining.	Losing.
		h m s	s	s
March	8	6 5 11·30	. . .	0·27
„	9	6 5 11·03	. . .	1·43
„	10	6 5 9·60	. . .	0·735
„	11	. . .	. . .	0·735
„	12	6 5 8·13	. . .	4·98[1]
„	13	6 5 3·15	3·75[1]	
„	14	6 5 6·90	. . .	0·31
„	15	6 5 6·59	. . .	
„	16	. . .	. . .	
„	17	. . .	. . .	0·925 (15–18)
„	18	. . .	. . .	
„	19	6 5 3·89	0·76	
„	20	6 5 3·65	. . .	0·70
„	21	6 5 2·95	. . .	0·78
„	22	6 5 2·17	. . .	. . .

[1] These readings are evidently wrong, though they do not affect the mean of the daily rate.

7. Goháтti to Calcutta.

1855-6, December 13 to March 26.

a. Gohátti, December 13.

	h m s
Noon, Mean Time at Gohátti, deduced from the observations by Chron. 3 . . .	5 44 15
Longitude of Gohátti, from the G. T. S.,[1] East of Greenwich, 91° 43′ 45″ =	6 6 55
Therefore Mean Greenwich Time at Mean Noon, Gohátti	5 53 5
Chron. 3, slow at Gohátti	0 8 50

b. Calcutta, March 26.

	h m s
Calcutta uncorrected Time by Chronometer Thwaites	2 12 0 P.M.
Error of Thwaites, at Noon, fast	0 51 43·08
Rate of Thwaites (in 24^h gaining $10^s{\cdot}44$) in 2 hours	0·8
Error of Thwaites at the time of comparison	0 51 43·9
Corrected Time of comparison	1 20 16·1
Chronometer 3	7 20 23·5 A.M.
	h m s
Time by Chronometer 3, at Mean Noon, Calcutta (Thw. — Ch. 3)	6 0 7·4
Mean Greenwich Time, at Calcutta, Noon	6 6 38·4
Chronometer 3, slow at Calcutta	0 6 31·0

Gohátti to Calcutta. (a. — b.)

	h m s
Chron. 3, slow at Gohátti, 1855, December 13	0 8 50·0
„ slow at Calcutta, 1856, March 26	0 6 31·0
„ gained in 104 days	2 19·0

Mean daily rate: Gaining $1^s{\cdot}34$.

8. Símla to Raulpíndi.

1856, May 15 to October 24.

In the dāk carriage, the chronometer was carefully packed away to mitigate the effects of the shaking. It was not wound up before reaching Símla. Between this place and Raulpíndi, it was kept regularly going.

a. Símla.

	h m s
Noon, Mean Time at Símla, deduced from the observations, May 15, Chron. 3	6 28 21
Longitude of Símla, near General Boileau's former Observatory . . . . =	5 8 30·4
Therefore Mean Greenwich Time at Mean Noon, Símla	6 51 29·6
Chron. 3, slow at Símla	0 23 8·6

[1] G. T. S. = Great Trigonometrical Survey.

b. Srinágger in Kashmír.

	h m s
Noon, Mean Time at Srinágger, deduced from the observations, October 24, Chron. 3	6 40 20
Longitude of Srinágger, fixed for the Shēkh Bagh by measuring its distance from Lánka Island and Takt-i-Sulaimán, Stations of the G. T. S.[1]: 74° 48′ 30″ =	4 59 14
Therefore Mean Greenwich Time at Mean Noon, Srinágger	7 0 46
Chron. 3, slow at Srinágger	0 20 26

c. Símla to Srinágger.

	h m s
Chron. 3, slow at Símla, May 15	0 23 8·6
„ slow at Srinágger, October 24	0 20 26
„ gained in 162 days	2 43
	= 163^s

Mean daily rate: Gaining $1^s \cdot 01$.[2]

d. Leh in Ladák.

1856, July 11 to September 17.

	h m
Noon, Mean Time at Leh, deduced from the observations, July 11, Chron. 3.	6 29 24
Noon, Mean Time at Leh, deduced from the observations, September 17, after our return from Turkistán, Chron. 3	6 29 27
Gained in 68 days	0 0 3

The determination of Noon, July 11, is not precise enough to allow an alteration in the general rate between Símla and Kashmír. But it shows, at all events, that the chronometer had been going uninterruptedly during our journey in Turkistán.

9. Ágra to Calcutta.

1857, January 20 to April 1.

At Ágra the comparisons were made with Parkinson and Frodsham's box chronometer 2325, at the Chief Engineer's Office, by General Boileau's head assistant, Mr. Nutall.

[1] See the detail at the station Srinágger, Section II., Group VIII., No. 61.

[2] The Time of the Raulpíndi observation, December 3, was referred by direct comparison to Adolphe's Chronometer 1, for which the rate had been ascertained with particular accuracy for this period.

The comparison gave, Raulpíndi 1856, December 3:

	h m s
Adolphe's Chronometer 1	6 8 53·0
Hermann's Chronometer 3	5 36 19·2
Chron. 1 — Chron. 3	32 33·8

	h m s
Readings of Chronometer 2325, Ágra Mean Time, January 20	10 35 0
	10 41 0
	10 38 0
2325 fast on Mean Time	0 0 4
2325 corrected Mean Time Ágra	10 37 56
Corresponding readings of Chron. 3	6 57 37
	7 3 37
Mean	7 0 37

April 1. Reading of Thwaites, Calcutta Mean Time. h m s	April 1. Corresponding Readings of Chron. 3 h m s
4 3 0 P. M.	9 46 59·4 A. M.
4 6 0	9 49 59·0
4 7 0	9 50 59·0
4 8 0	9 51 59·0
4 9 0	9 52 59·0
4 17 0	10 0 59·0
4 18 50	10 1 49·2
Mean 4 9 50·2	Mean 9 53 40·7

Error of Thwaites at 4h 12m P.M.: fast 1h 56m 59s·9	h m s
Corr. Mean Time at Calcutta	2 12 50·3
Chron. 3, slow at Calcutta	4 19 9·6
Longitude, E. Green., of Calcutta, in Time	5 53 22·0
„ „ of Ágra „	5 12 6·6
Difference of Time by Longitude	0 41 15·4
Chron. 3, slow at Calcutta	4 19 9·6
„ slow at Ágra	3 37 19·0
Difference of Time by Chron. 3	0 41 50·6
Therefore, Chron. 3 lost from January 20 to April 1 (71 days)	0 0 35·2

Mean daily rate: Losing 0s·49.

10. Calcutta.

1857, April 2 to April 18.

By direct comparison with the clock of the Calcutta Observatory was found:

Mean daily rate: Losing 0s·57.

The details are:

Year, 1857.		Time at Calcutta Mean Noon by Chron. 3.	Chron. 3, Daily Rate.	
Month.	Day.		Gaining.	Losing.
		h m s	s	s
April	2	7 40 56·23	. . .	0·72
,,	4	7 40 54·79	. . .	0·60
,,	6	7 40 53·60	. . .	0·04
,,	7	7 40 53·56	. . .	0·27
,,	8	7 40 53·29	1·59	
,,	9	7 40 53.80	. . .	0·52
,,	15	7 40 50.70	. . .	1·08
,,	16	7 40 49·62	. . .	0·93
,,	17	7 40 49·69	. . .	1·56
,,	18	7 40 47·13	. . .	. . .

11. Calcutta to Madras.

1857, April 1 to 27.

Comparisons of the Chronometer Arnold 392, of the Madras Observatory, with Chron. 3.

	Arnold 392. Madras Mean Time.		Chron. 3.
	h m s		h m s
	4 29 30		12 35 14
	4 30 30		12 36 14·4
	4 31 30		12 37 14·4
	4 32 30		12 38 14·4
	4 36 30		12 42 14·4
Mean	4 32 6	Mean	12 37 50·3

Error of Arnold 392 at 4^h 30^m P.M.: fast 7^m $13^s·2$

	h m s
Corr. Mean Time at Madras	4 24 52·8
Chron. 3 slow	3 47 2·5
Longitude, E. Green., of Calcutta, in Time	5 53 22·0
,, ,, of Madras ,,	5 20 57·0
Difference of Time by Longitude	0 32 25·0
Chron. 3, slow at Calcutta	4 19 9·6
,, slow at Madras	3 47 2·5
Difference of Time by Chron. 3	0 32 7·1
Therefore Chron. 3 lost from April 1 to April 27 (26 days)	0 0 17·9

Mean daily rate: Losing $0^s·69$.

The rates adopted for this chronometer, as well as for the others, during the different periods of our travels are contained in the General Table of Rates, p. 109.

The rate varied very little and with a certain regularity. The chronometer was gaining or losing, according to the changes of temperature, a fact which was ascertained by us, and afterwards corroborated by Professor Bruhns, in two extensive series of ratings, made at the Berlin Observatory from June to August, 1857, and from October, 1857, to January, 1858.

b. CHRONOMETERS 1 AND 2; 1854 TO 1856.

1. London.

1854, September 18.

London, compared with Parkinson and Frodsham's standard clock:

Chron. 1 (Or. No. 2942).	Chron. 2 (Or. No. 1864).
Stand: slow $12^{s}\cdot0$	Stand: slow $57^{s}\cdot5$
Rate: Losing $2\cdot0$	Rate: Losing $2\cdot3$.

2. Voyage from Southampton to Bombay.

1854, September 20 to November 24.

Southampton Noon, Greenwich Time, September 20:

Chron. 1: $11^{h}\ 59^{m}\ 44^{s}\cdot0$ Chron. 2: $11^{h}\ 58^{m}\ 57^{s}\cdot9$.

Bombay Observatory at Noon, Bombay Time, November 24:

Chron. 1: $7^{h}\ 5^{m}\ 35^{s}\cdot5$ A.M. Chron. 2: $7^{h}\ 3^{m}\ 36^{s}\cdot5$ A.M.

Chron. 1.	Chron. 2.
Rate: Losing $2^{s}\cdot65$	Rate: Losing $3^{s}\cdot77$.

Bombay Observatory at Noon, Bombay Time, November 24 to December 8.

Chron. 1.	h m s	Chron. 2.	h m s
November 24	7 5 35·5 A.M.	November 24	7 3 36·5 A.M.
December 8	7 5 2 A.M.	December 8	7 3 1 A.M.
Rate: Losing 2·39		Rate: Losing 2·54.	

The rate obtained for each day is shown in the following table; the numbers united by braces are mean results for this group of days, without including direct observations on the single days:

Chronometer 1.						Chronometer 2.					
Month.	Day.	Losing.	Month.	Day.	Losing.	Month.	Day.	Losing.	Month.	Day.	Losing.
Nov.	25	s 2·50	Dec.	2	s 2·50	Nov.	25	s 2·0	Dec.		s 2·5
„	26	2·75	„	3	2·00	„	26	2·5	„	3	2·5
„	27	2·75	„	4	2·00	„	27	2·5	„	4	2·5
„	28	2·00	„	5	2·00	„	28	2·0	„	5	2·5
„	29	3·50	„	6	2·00	„	29	3·5	„	6	2·5
„	30	2·50	„	7	2·25	„	30	2·7	„	7	2·5
Dec.	1	2·50	„	8	2·25	Dec.	1	2·7	„	8	2·5

3. Bombay to Madras.

1854-5, December 8 to February 27.

Madras Observatory, at Madras Noon M. T., 1855, February 27.

Chron. 1.	Chron. 2.
$6^h\ 31^m\ 41^s{\cdot}8$ A.M.	$6^h\ 29^m\ 48^s{\cdot}5$ A.M.

Bombay Observatory, at Bombay Noon M. T., 1854, December 8.

Chron. 1.	Chron. 2.
$7^h\ 5^m\ 2^s$ A. M.	$7^h\ 3^m\ 1^s$ A. M.
Rate: Losing $3^s{\cdot}12$	Rate: Losing $3^s{\cdot}05$.

At the Madras Observatory the daily rate of Chron. 1 was determined from February 12 to 26; the following results were obtained:

Chronometer 1.

		Losing.			Losing.			Losing.
February	13	s 3·17	February	18	s 2·70	February	23	s 2·73
„	14	2·84	„	19	2·82	„	24	2·48
„	15	3·50	„	20	3·07	„	25	2·40
„	16	2·46	„	21	2·00	„	26	2·70
„	17	2·37	„	22	2·73			

Mean Rate: Losing $2^s{\cdot}71$.

4. Madras to Calcutta.

1855, February 27 to March 8.

Surveyor General's Office, Park-street, Calcutta Noon M. T., March 8.

Chron. 1.	Chron. 2.
$5^h\ 58^m\ 40^s{\cdot}8$	$5^h\ 57^m\ 0^s{\cdot}3$

Madras, Noon M. T. February 27:

	Chron. 1.	Chron. 2.
	$6^h\ 31^m\ 41^s\cdot8$ A.M.	$6^h\ 29^m\ 48^s\cdot5$ A.M.
	Mean Rate: Losing $1^s\cdot4$.	Mean Rate: Losing $2^s\cdot60$.

At the Surveyor General's Office at Calcutta the daily rates obtained by direct comparison were:

Chron. 1.	Losing.		Losing.	Chron. 2.	Losing.		Losing.
	s		s		s		s
March 9,	4·77	March 14,	2·25	March 9,	4·27	" 14,	3·25
" 10,	2·43	" 15,	2·81	" 10,	3·43	" 15,	2·31
" 12,	2·49	" 19,	3·05	" 12,	3·49	" 19.	3·70
" 13,	4·48	" 20,	4·28	" 13,	4·48	" 20,	2·78
		Mean Rate	3·32			Mean Rate	3·46

Chron. 1 was purposely allowed to run down, since we wished to take one chronometer with us, carefully packed away, in order to see how far this plan would avail in keeping the rate uniform.

Chron. 2 stood, when last compared at Calcutta, a day before our departure:

1855, March 22: $5^h\ 56^m\ 17^s\cdot2$ at Calcutta Mean Noon.

1855, March, to 1856, April.

During this period, chron. 1 could be used only for the determination of intervals of time, when observations of latitude or of horizontal magnetic intensity by vibrations were made; the time read must be considered as arbitrary; for on the way from Calcutta to Nainitál we had packed it away in a large stuffed bag, in order to prevent alterations in its rate by the heavy shaking of the dāk carriages.

Both chronometers were also taken with us on our journey to Gnári Khórsum; but both got injured.

a. First period. Chron. 1. While we were crossing the Sakh pass on the night of July 16, in secrecy and disguise, this chronometer fell off a little stone, on which it had been deposited with other luggage during a short halt. An alteration of the rate ensued, the amount of which was again determined at the Massúri Observatory, 1855, Nov.

The rate, ascertained by J. H. Hennesser, Assistant G. T. S., was found to be:

Chron. 1, Losing $1^s\cdot2$.

Chron. 2 was kept going from March to July 13, 1855. At △ Laptél we found that it had stopped, though we were unable to assign any reason for its so doing; comparisons with chron. 1 showed, however, that it had kept its rate. We set it afresh at Laptél, and it continued going till after we had reached △ Díra, August 12. When set again, it kept the rate as before, till △ Úlla Tingdíng, 1855, September 7.

Chron. 2, 1855, July 14, Mean Noon, $6^h\ 21^m\ 57^s$.

We adopt, as rates for the periods detailed above, the mean of all the preceding rates, viz., for

Chron. 1.	Chron. 2.
Losing $2^s \cdot 46$.	Losing $2^s \cdot 85$.

Frequent mutual comparisons of the two chronometers were made during the journey, and they showed that both chronometers kept their rates. Chron. 1 had been keyed and compared with Chron. 2 at Nainitál.

β. *Second period.* Chron. 2. When Adolphe was the second time out in Gnári Khórsum, the Bhútia, Rámu, who carried the instrument, fell down a precipice near △ Úlla Tingdíng, 1855, September 7, and was dashed to pieces. Singularly enough the chronometer was not stopped by this accident, its rate, however, was much altered, and became very variable. The chronometer was partly repaired at Símla, in April, 1856, but we did not find it advisable to use it again as a chronometer after this catastrophe.

γ. *Third period.* Chron. 1. 1856 and 1857. The rate of chron. 1 was found at Símla to be losing $1^s \cdot 7$, and this rate has been adopted in the calculations as far as Dāh.

At Símla, May 15, Mean Noon Símla Time, we had

	h	m	s	
Chron. 3.	6	28	21	A.M.
Chron. 1.	6	25	21	A.M.

When Adolphe passed through the Chetánga valley, the kúli with the chronometer remained behind, and the chronometer ran down.

It was wound up at Húshe, 1856, July 14, and from then gave arbitrary time.

A similar accident took place again near Táshing, September 22.

From this date, up to the period to which our brother's observations, as far as they have been recovered, extend, the chronometer appears to have kept going without stoppage.

From 1856, July, to 1856, October, the rate adopted was $= 0^s \cdot 0$, which also agrees with comparisons at Srinágger with chron. 3, the rate of the latter being $= 1^s \cdot 01$ gaining. The observations of chronometric longitudes, as far as Dāh, were referred to Símla;

from 1856, September 20, Srinágger was the place of reference. But for the short isolated period from 1856, July 8 to September 20, we were obliged to take Shígar as the starting point. We adopt as longitude of Shígar, from the most careful computation of various distances, 75° 45′ 30″.

For Srinágger Mean Noon we obtained:

		h	m	s
October 24,	by Chron. 3,	6	40	20
„	by Chron. 1,	7	14	22.

1856-7.

For the observations during the last period of our brother's journey we deduced the rates of chron. 1 from the observations at Márri and at Déra Ismáel Khan. The longitudes of these places are taken from the G. T. S. as detailed below, where our own observations are given.

Márri.	Déra Ismáel Khan.
Long. E. Gr. 73° 22′·7 in arc	Long. E. Gr. 70° 56′·5 in arc
„ „ $4^h\ 53^m\ 31^s$ in time	„ „ $4^h\ 43^m\ 46^s$ in time
Mean Noon . . $7^h\ 19^m\ 30^s$ Nov. 13, 1856.	Mean Noon . . $7^h\ 23^m\ 10^s$ Feb. 25, 1857.

	m	s
Difference of Longitude	9	45
„ of the Mean Noons	3	36
Lost in 104 days		369

Mean Rate: Losing $3^s·55$.

c. CHRONOMETER 4; 1856 TO 1857.

Chron. 4 is a box chronometer by Parkinson and Frodsham, with the original number 2295.

We received this instrument through the kindness of Major Jacob, the Government Astronomer in Madras, March, 1856.

Its rate was large, but it remained pretty uniform when the chronometer was left undisturbed for some days in one place.

The rates determined are:

			s
at Madras,	March 1856,	Gaining	11·7
at Leh,	July 1856,	Gaining	14·0
at Bombay,	April 1857,	Gaining	13·0.

A series of careful comparisons with chron. 3, during our journeys between Símla and Kashmír, has, however, shown that its rate increased considerably, and sometimes became irregular, when the instrument was carried about.

The following table shows the result of the different comparisons. They are formed into two groups, in consequence of chronometer 4 having run down during our ascent of the Élchi pass, when we were obliged to leave the chronometer, together with our other luggage, behind on the glacier.

Year, 1856.	Chron. 3. Corr. for Rate XIII = Gain 1s·01.	Chron. 4. Reading.	Rate of Chron. 4. Interval of Time.	Rate: Gain.
	h m s	h m s		s
Símla, ... May 18	3 58 37	3 58 31		
			May 18 to July 12	19·9
Leh, ... July 12	6 27 41	6 45 50		
			July 12 „ July 16	14·0
Leh, ... July 16	8 13 20·2	8 32 25		
			July 16 „ August 2	(43·1)
Sásser pass, . . . August 2	11 33 57	12 5 15		
			August 2 „ August 14	13·8
Kiúk—Kiöl, . . . August 14	2 39 13·2	3 13 15		
			August 14 „ August 21	17·2
Above △Súmgal, August 21	8 15 13·4	8 51 15		

On the rugged ascent up the southern slopes of the Sásser pass, chron. 4 seemed evidently to have been affected by the heavy shaking, and the rate obtained by the comparison on the Sásser pass is therefore quite an exceptional one. Later, the original rate very nearly returned.

When travelling together (Hermann and Robert) from Leh to Turkistán, we never had occasion to use chron. 4, chron. 3 being always in perfect order. But at Kárgil, before we separated, it was set and compared again with chron. 3. The comparison was subsequently repeated at Srinágger and Raulpíndi.

Year, 1856.	Chron. 3. Corr. for Rate XIII = Gain 1s·01.	Chron. 4. Reading.	Rate of Chron. 4. Interval of Time.	Rate: Gain.
	h m s	h m s		s
Kárgil, . . October 9	1 56 15	2 13 40		
			October 9 to October 30	17·6
Srinágger, October 30	3 39 51	4 3 25		
			October 30 „ December 3	13·4
Raulpíndi. December 3	3 0 25	3 31 35		

On the way from Kárgil to Bombay, from October, 1856, to March, 1857, where I (Robert) had only this chronometer with me, I used it also for the determination of longitudes, adopting as mean rate: Gaining 15s·0. This rate it seemed to keep on an average tolerably well for longer periods of time.

TABLE OF RATES

ADOPTED IN CALCULATING THE CHRONOMETRIC LONGITUDES.

Epochs and Periods.		Routes.	Observer.	Chronometer.	Mean Local Noon.			Rate.		No. of Rate.
Year.	Month and Day.				Station.	Date.	Time by Chron.	Gaining.	Losing.	
							h m s	s	s	
1854-5	Dec. 8 to Feb. 27	Bombay to Madras	H. A. R.	1	Bombay	Dec. 8	7 5 2 A.M.	. . .	2·39	I.
,,	,, ,,	,, ,,	,,	2	,,	,,	7 3 1 ,,	. . .	2·54	II.
,,	,, ,,	,, ,,	,,	3	,,	,,	7 7 52·5 ,,	. . .	0·38	III.
1855	March 22 to July 16	Calcutta to Sakh pass	A. R.	1	*Arbitrary time*			. . .	2·46	IV.
1855	March 22 to Sept. 7	Calcutta to △ Úlla Tingdíng	A. R.	2	Calcutta Laptél	March 22 July 14	5 56 17·2 ,, 6 21 57 ,,	. . .	2·85	V.
1855	March 8 to April 16	Calcutta to the foot of Síkkim, Himálaya	H.	3	Calcutta	March 8	6 5 11·3 ,,	. . .	0·58	VI.
1855	April 17 to July 29	Síkkim, Himálaya	H.	3	Calcutta	March 8	6 5 11·3 ,,	0·5	. . .	VII.
1855-6	November to May 15	Southern India to Símla	A.	1	*Arbitrary time*			. . .	1·2	VIII.
1855	July to October	Bengál to Khássia Hills	H.	3	*Arbitrary time*			. . .	0·17	
1855-6	Oct. 20 to Jan. 10	Khássia Hills, Assám	H.	3	Gohátty	Dec. 13	5 44 15 ,,	. . .	0·17	IX.
1856	Feb. 26 to March 26	Bengál	H.	3	Calcutta	March 26	6 0 7 ,,	. . .	0·17	
1856	May 15 to July 6	Símla to Dāh	A.	1	Símla	May 15	6 25 21 ,,	. . .	1·7	X.
1856	July 8 to Sept. 20	Húshe to Táshing	A.	1	Shígar	August 5	6 32 44 ,,	0	0	XI.
1856	Sept. 21 to Oct. 24	Kinibári to Srinágger	A.	1	Srinágger	Oct. 24	7 14 22 ,,	0	0	XII.
1856	March to May	Bengál to Símla	H.	3	*Arbitrary time*			1·01	. . .	
1856	May 15 to Oct. 24	Símla to Srinágger	H. R.	3	Símla	May 15	6 28 21 ,,	- 1·01		XIII.
1856	May to December	Símla, Khótan to Raulpíndi	R.	4	*Arbitrary time*			15·0	. . .	
1856-7	Dec. 17 to Feb. 24	Raulpíndi to Kărráchi	R.	4	Raulpíndi	Dec. 17	7 18 21 ,,	15·0		XIV.
1856-7	Nov. 13 to	Márri to Turkistán	A.	1	Márri	Nov. 13	7 19 30 ,,	. . .	3·55	XV.
1857	January to April	Lahór to Calcutta	H.	3	Ágra	Jan. 20	8 22 41 ,,	. . .	0·49	XVI.

2. LONGITUDES BY CELESTIAL PHENOMENA.

Longitudes can be deduced from celestial phenomena that are affected by parallax, as:

Eclipses of the Sun, Transits of Mercury and Venus through the disc of the Sun, Occultations of Stars by the Moon, Lunar Distances, either from the Sun or from Stars,[1] Altitudes of the Moon;

and from celestial phenomena without parallax, as:

Eclipses of the Moon, Immersions and Emersions of the Satellites of Jupiter,[2] and Culminations of the Moon.[3]

The observations of Jupiter's satellites have only recently acquired an unexpected accuracy by the nice calculations of Damoiseau.

Argelander, Pogson, and Julius Schmidt have calculated the epochs of the maximum and minimum intensity of more than twenty variable stars. But though in theory such observations would give very easy determinations of longitude, they cannot be practically used.

a. LUNAR DISTANCES.

We used theodolites only, not sextants, for lunar distances, a method to which also all the formulæ given below are referred.

For calculating longitudes from lunar distances, u = the Mean Local Time, must be known. We have deduced it from altitudes of the sun (see p. 84 et seq.).

φ = Latitude of the place, needs only to be known within one degree, to be able to find, with sufficient accuracy, the correction for parallax (see p. 79).

From observations with the theodolite, we do not obtain, as we do with the sextant, the co-ordinates of both celestial bodies at exactly the same time, but with a short space of time intervening; an interpolation, therefore, in reference to one of the celestial bodies is required for reducing it to the exact time of the other.

The various modes for the interpolation are given in detail (p. 79 et seq.); generally, however, we have only employed an interpolation with reference to the terms of the

[1] Professor Hansen's detailed tables, published only in 1859, have superseded Burckardt's former calculations, in which the error (gradually increasing every year) now exceeds 5 seconds.

[2] Immersions and emersions of the satellites of Uranus cannot be observed with portable instruments of the size used by travellers. It is but recently that Professor Lamont, the well known astronomer at Munich, has published very detailed and elaborate elements in reference to two satellites of Saturn.

[3] The appearance of Hansen's tables, 1859, renders the calculation of these observations much more accurate.

first order, the terms of the second order being below the limits of our calculations and observations.

The co-ordinates of both celestial bodies having been first reduced to the same exact moment of time, the apparent altitudes have been transformed by the application of the respective values of parallax and refraction into true and geocentric altitudes (see p. 77 et seq.).

The azimuthal parallax produced by the ellipticity of the earth has been taken into consideration, but quite approximatively, since it never exceeded, for our observations, the tenth of a minute.

If h and h' = the geocentric Altitudes of the two celestial bodies.
A = the arc of the Almucantarat of both,
D = the true geocentric distance,

we find D from the simple formula:

$$\cos D = \sin h \sin h' + \cos h \cos h' \cos A.$$

The Greenwich time corresponding to this distance is found by the aid of proportional logarithms. (For lunar distances taken by a sextant the formulæ are much more complicated; moreover, in this case, the geocentric distance can only be found by the process of several approximations.)

The difference between the observed mean local time and the mean Greenwich time, which is deduced from the observed lunar distances themselves, gives as immediate result the difference of longitude between Greenwich and the place of observation. Lunar distances can only give a satisfactory result for the determination of longitude, when observed with the greatest possible accuracy. The distance of the moon from another celestial body changes in three hours' time only to the extent of one and a half degree. It is evident that if there be an error of but 30 seconds in arc in the observation of distance, this slight deviation from the true distance will result in an error of 15 minutes in arc for the longitude.

Example for calculating Longitude by Lunar Distances.

Station No. 21. RAULPÍNDI. 1856, December 2.

Moon's Lower Limb.

1856, December 2.	Horizontal Circle.	Vertical Circle.
h m s	° ′ ″	° ′ ″
u 1 29 4	H 250 49 40	h 20 57 25
u' 1 51 39	H' 255 9 25	h' 17 57 15

Jupiter.

$u_{\prime}$ 1^h 44^m 17^s $H_{\prime}$ 204° 10′ 30″ $h_{\prime}$ 54° 39′ 45″

Barom. { 721·4 millim. / 28·402 inches.   Temp. of Air { 13°·2 C. / 55·8 Fahr.

I. Interpolation (preliminary calculation).

$$u' - u = 22^m\ 35^s$$
$$u_{\prime} - u = 15\ 13$$
$$H' - H = 4^\circ\ 19'\cdot 7$$
$$h' - h = -\ 3\ \ 0\cdot 1$$

We obtain with these values the following two equations:

1. for ΔH

$$22^m\ 35^s : 15^m\ 13^s = 4^\circ\ 19'\cdot 7 : \Delta H;$$

2. for Δh

$$22^m\ 35^s : 15^m\ 13^s = 3^\circ\ 0'\cdot 1 : \Delta h.$$

These equations give

$$\Delta H = 2^\circ\ 55'\cdot 0$$
$$\Delta h = 2\ \ 1\cdot 3,$$

and with these values, we obtain the following interpolated observation for the moon:

$$1^h\ 44^m\ 17^s \qquad 253^\circ\ 44'\cdot 7 \qquad 18^\circ\ 56'\cdot 1.$$

II. Reduction of apparent altitudes to true geocentric altitudes.

Horizontal Equatorial Parallax of the Moon for the time of observation = 57′·2 log . . . . =	1·757
log cos of the approximatively corrected Altitude[1]	9·974
log of Parallax in Altitude	1·731
Parallax in Altitude	53′·9

	Moon.	Jupiter.
	° ′	° ′
Apparent Altitude	18 56·1	54 39·7
Parallax	+ 53·9	0·0
Refraction	— 2·6	— 0·6
Semidiameter of the Moon	+ 15·6	. . .
True geocentric Altitude	20 3·0	54 39·1

[1] This value is obtained by a rough application of semidiameter, refraction, and parallax to the observed altitude (see p. 77 et seq.).

III. Calculation of the geocentric distance.

	H =	253° 44′·7
	$H_{,}$ =	204 10·5
Arc of the Almucantarat[1] . . .	=	49 34·2 = A

log sin h	9·91150	log cos h	9·76234
log sin $h_{,}$	9·53509	log cos $h_{,}$	9·97285
		log cos A	9·81192
	9·44659		9·54711

0·27963
0·35246
0·63209

log = 9·80078
Arc = 50° 47′·7.

IV. Determination of the longitude.

Lunar Distance for the Meridian of Greenwich.

1856, December 2.

0^h Greenwich.	3^h Greenwich.
51° 58′·6	50° 19′·5.

	° ′
Variation of the Moon within 3 hours	1 39·1
Distance at 0^h — observed distance	1 10·9.

These two values give the following equation:

$$99'\cdot 1 : 70'\cdot 9 = 180^m : x;$$

therefore $x = 2^h\ 8^m\ 48^s$ = the corresponding Greenwich Time.

	h	m	s
Time by Chronometer	13	44	17
Mean Local Noon by Chronometer .	6	46	25
Mean Local Time	6	57	52
Greenwich Time	2	8	48
Longitude East of Greenwich	4	49	4

b. LONGITUDES BY ECLIPSES OF THE MOON.

Eclipse observed at Pashmín in Kishtvár. 1856, October 13 to 14.

Latitude North.	Longitude East Green.	Height.
33° 57′	75° 41′ 30″	8,350 feet.

[1] The Azimuthal parallax has been neglected in the calculation.

The latitude and longitude of Pashmín is deduced approximatively from our itineraries; but this eclipse could be referred by chron. 3 directly to Srinågger, the rate of the chronometer being very well known, and the time being determined soon after our arrival in Kashmír, October 24 and 25.

Though from eclipses of the moon longitudes cannot be deduced with the greatest precision, on account of the phenomena to be observed not being sufficiently well defined, these observations were nevertheless of particular interest from the nature of the physical phenomena attending this present eclipse.

In eclipses, the atmosphere produces, besides the shadow of the earth itself, another secondary shadow, which veils, as it were, the shadow proper of the earth in forms often indistinct and diffused, and modified by atmospherical phenomena, such as clouds, haze, &c.

According to circumstances, the forms of this atmospheric shadow are variable in each eclipse, being sometimes spherical, and at other times of very irregular curvatures. The magnitude also of this shadow is extremely variable, on some observed occasions extending over a space of three minutes of arc, as in the year 1772, on others of one minute, as in 1773, and sometimes even less. The magnitude of the penumbra itself is also subject to similar variations. It was observed to precede the nucleus of the shadow from 2 to 10 minutes of time; in April, 1818, it even preceded the nucleus by 15 minutes.

For 1856, when I (Hermann) had occasion to observe the moon's eclipse, no such observations by others of the magnitude of the penumbra are known to me.

I found the magnitude of the penumbra equal to the semi-minor axis of the Mare crisium. According to various observations, the shadow of the earth itself required the following times for passing through the whole breadth of Mare crisium:

Observer.	Time. m s
Neumayr	6 22
Niebour	7 0
Rümker	5 41
Schmidt	7 10
Mean	6 34

Half the value of this time is $3^m\ 17^s$, and this value of the magnitude of the penumbra I adopted for the calculation of longitude from occultations of Tycho and Mare crisium.

Observed Ingress of Various Objects on the Surface of the Moon.

a. *Circellus Tycho.*

This high circellus forms, on account of its radiated and extremely ramified system, the most conspicuous object on the surface of the moon, and is very favourable for observations of ingress. It is situated in the south-east quadrant of the moon.

The following observations of the ingress of Tycho have been made in Europe. For convenience of direct comparison we have reduced the observed local times to Greenwich time:

Place of Observation.	Observer.	Ingress of Tycho.		
		First Limb.	Centrum.	Second Limb.
		h m s	h m s	h m s
Hamburgh.	Neumayr	9 39 28	. . .	9 40 55
"	Niebour	9 39 31	9 40 26	9 41 2
Altona	Peters	9 39 3	. . .	9 41 0
Hamburgh	Rümker	9 39 49	9 40 27	9 41 1
"	Schmidt.	9 40 1	9 40 46	9 41 21
Hoya in Hanover . .	Winnecke . . .	9 38 33	9 39 45	9 40 15
	Mean	9 39 24	9 40 21	9 40 56

At Pashmín I had:

Ingress of the Centre of Tycho in the Nucleus, Mean Local Time of Srinágger	h m s 14 44 58	
Observed Magnitude of the Penumbra	3 17	
First Contact	14 41 41	
Ingress at Greenwich	9 40 10	(Mean from first and second Limb of Tycho)
Srinágger East of Greenwich in Time	5 1 31	
" " in Arc =	75° 22′ 40″.	

b. *First Limb of Mare crisium.*

This Mare is an extensive and well defined circular depression, which to the eye appears to make an ellipse in the north-west quadrant of the moon.

15*

Place of Observation.	Observer.	Ingress of the first Limb.
		h m s
Hamburgh	Neumayr . .	10 22 0
	Niebour . .	10 23 36
	Rümker . .	10 24 24
	Schmidt . .	10 23 51
	Mean . . .	10 23 28

These are, as far as I know, the only observations of Mare crisium taken in Europe. The great variations in the observed time show that the observations are extremely difficult.

I observed at Pashmín:

	h m s
Ingress of the first Limb of Mare crisium at	15 30 11 (Srinágger Time)
Observed Magnitude of Penumbra	3 17
First Contact	15 26 54
Ingress by Greenwich Time	10 23 28
Srinágger, East of Greenwich in Time	5 3 26
" " in Arc	= 75° 51′ 30″.[1]

Explanation of the Plate.

The first part of the plate represents the motion of the moon through the shadow of the earth. The horizontal line represents a part of the ecliptic. It is intersected by a second line at an angle of 5° 40′, which is the angle formed by the relative orbit of the moon with the ecliptic.

The hor. mot. of the Moon is: In Latitude	$= \Delta\beta = + \; 3' \; 31''$
" " In Longitude	$= \Delta\lambda = + \; 38 \;\; 5$
For the Sun, the hor. mot. is	$= \Delta\lambda' = + \;\; 2 \; 39$
The relative motion of the Moon in reference to the shadow of the Earth is therefore	$= \Delta L = \; 35 \; 26$,
and the Angle of the relative orbit of the Moon	$\text{arc tan} \frac{\Delta\beta}{\Delta L} = 5° \; 40'$.
Latitude of the Full Moon	+ 29′ 44″ North
Full Moon at	$10^h \; 59^m$ Green. Time.

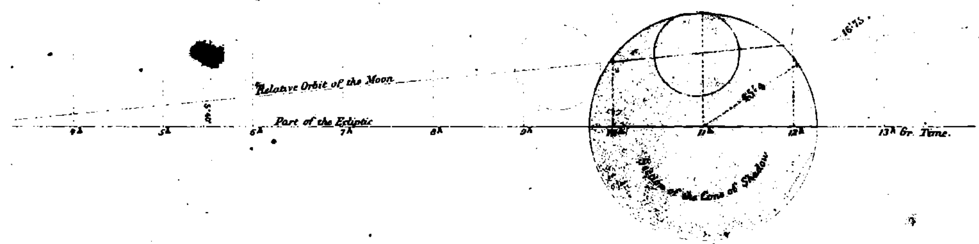
Starting with this time, the ecliptic has been divided into hours. The figure

[1] For details in reference to the longitude we adopt, see Srinágger, station 61.

DIAGRAMS

to illustrate the Eclipse of the Moon 1856, October 13 to 14,
observed at Pashmín, in Kishtvár, by Hermann de Schlagintweit.

1. Position of the Moon in relation to the Shadow of the Earth.



2. Selenocentrical Aspect of the Earth during the Eclipse of the Moon.

Radius of the Earth 61'.4

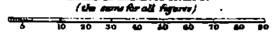
A
At the Beginning of the Eclipse
Centre 8°6' N. 32°41' E.F. (35°7' E. Gr.).

B
At the Middle of the Eclipse
Centre 8°31' N. 30°21' E.F.? (12°41' E. Gr.)

C
At the End of the Eclipse
Centre 9°1' N. 7°36' E.F.? (9°44' W. Gr.)

For the three moments here represented, the Moon rises on all the points of the western side, and sets on all the points of the eastern side of the periphery. — The dotted ring round the Earth represents the terrestrial atmosphere, which, as seen from the Moon during the Eclipse, has probably a reddish appearance. The height of this ring is about the 40th part of the Earth's radius.

Scale of Minutes in Arc.
(the same for all figures)



Leipzig: F. A. Brockhaus. Engraved by L. Kraatz, Berlin.

shows for every moment the position of the moon in reference to the shadow of the earth.

The second part of the plate contains three figures, which show the three parts of the earth as selenocentrically seen at the beginning, at the middle, and at the end of the eclipse.

By these three figures, which are purely mathematical, without regard to the refraction, it can, at the same time, be seen through which parts of the atmosphere surrounding the earth the sun's rays were refracted before reaching the moon.

Physical Remarks.

The beginning of the eclipse took place October 14 at about $2^h\ 24^m$ A.M. local time; the atmosphere being perfectly clear, and the sky without a cloud in any direction.

Particular attention was directed to the appearance of the milky way. The part of the heavens where it was expected to appear was pointed out to Máni, one of my people, who was told to call out as soon as he could observe it.

The milky way became visible at $3^h\ 57^m$, or $1^h\ 33^m$ after the beginning of the eclipse, singularly enough precisely coinciding with the maximum of the eclipse. At Santiago in Chili, Director Moesta[1] also saw the milky way appear in the moment of the greatest darkness,—in this agreeing more exactly than could have been expected with my own observation.

I also directed my attention to the changes of darkness during the progress of the eclipse. The obscured limb of the moon remained perfectly visible through the telescope from first to last. The darkness of the shadow was decidedly greatest at the beginning; for the first five minutes I could not distinguish any forms on the surface of the moon; but even during this period the limb remained visible in the telescope. The colour of the obscured part was that of Chinese ink, with a faint yellowish lustre, very similar to thick Chinese ink, when dried upon porcelain. But by degrees the darkness became less intense; the colour changed into a violet tint, and gradually became less and less dark.

Ten minutes after the beginning ($2^h\ 34^m$), the larger forms already appeared, but just distinguishable, as if drawn with ink on smoky paper.

[1] Astronomische Nachrichten, 1857, No. 1066.

Soon after the nucleus had reached the Mare crisium, the penumbra was no longer visible, since the general intensity of the shadow had decreased.

During the middle of the eclipse, the obscurity had so much diminished, that in the telescope all the chief forms on the moon's surface could be seen; Mare crisium could be distinguished even with the naked eye.[1] The colour had now become a reddish violet.

As to the intensity of the darkness at this time, I can best give an idea of it by comparing it with the result of an experiment made by myself the following morning: The surface of a rotatory cyanometer[2], I found, best represented the colour of the moon, when 65 per cent. of its surface was covered with cobalt blue of the colour of the cake, with 5 per cent. of white, and 30 per cent. of carmine red. The resulting intensity of colour, compared with the white surface of paper, also seemed to me approximatively to represent the difference of intensity in the light between the illuminated and obscured part of the moon.

Later I could not observe any increase in the darkness. 26 minutes after the last observations in Mare crisium, at 3^h 53^m A.M., Srinágger time, the moon disappeared behind mountains; though, independently of this, the end of the eclipse would not have been visible, on account of the setting of the moon. A red, similar to that observable at sunset was not seen, the tint that appeared being rather comparable to the colour below the antecrepuscular arc on a very fine day.

In reference to the phenomena of light and colour observed, particular attention may be directed to the distribution of atmospheric moisture and rain in the marginal zone. There is scarcely any other month in the year, when, in the actual position of the earth towards the moon, the probability of a clear sky, or at least the absence of rain-clouds in the torrid and temperate zones, is greater than in the month of October. Besides, in by far the greatest part of the northern half of the periphery the atmospheric zone rests upon land.

The latitude of the moon being northerly, the atmospheric conditions of this part are those which chiefly influence the colour of the moon, and the reddish tint

[1] A similar appearance was observed by Maedler, 1833, December 26. Compare also previous observations of Helfenzrieder, 1776, Schröter, 1790. "Der Mond, von Beer und Maedler", Berlin, 1837, p. 140.

[2] As figured Plate X., fig. 1, in our "Untersuchungen über die physikalische Geographie der Alpen". Leipzig, 1850.

being considered principally as the effect of atmospheric moisture, the circumstances above mentioned must have considerably modified its intensity and colour.

To complete the methods which can be used for the determination of longitudes, we have yet to mention the use of terrestrial signals.

Such observations can only be taken, when the distance of two respective stations does not exceed a certain amount. Heliotropes are to be used during the day time, and strong disappearing lights for the night. Among the latter, we name Argand's reverberatory lights, and especially the Drummond lights, which are visible, even in hazy weather, at a distance of from 60 to 80 miles. They are very generally used by the Great Trigonometrical Survey of India.[1]

For greater distances, telegraphic signals have been used with great success for verifying the longitude of different observatories in Europe. In India also Sir W. B. O'Shaughnessy has recently commenced such experiments.[2]

We employed lunar distances (example, Raulpíndi, station No. 21), and in one case the eclipse of the moon at Pashmín.

V. METHOD OF EQUATIONS OF CONDITION.

This method was employed for stations, for which the nature of their position, or the material of the observations, made it desirable to enter more into detail, the values of φ and T having previously been ascertained by a first approximation, according to one of the methods explained above.[3]

The first approximation is based on two or three values, but it is insufficient in itself to take into consideration the values of the other observations.

The application of the method of equations of condition offers the advantage, that it does not deduce the values of φ and T from two or three single observations only, but from the entire series of the altitudes, representing each single observation with the least possible error; and that it is also possible by this means to detect the

[1] Thuilliers "Manual of Surveying". London, 1855, p. 370.

[2] Allen's Indian Mail, 1859, December 30, p. 1065.

[3] Compare methods I., II., III.

accidental errors of the observations. It shows, moreover, in general, the weight which can be assigned to each single observation.

The method of "equations of condition" is based upon the principle, that the probability of small errors is greater than that of large ones. It must be further supposed that the values of φ_0 and T_0 be known with such a degree of exactness, as to render it possible to consider the remaining deviations of the single observations as the first differentials.

Such equations of condition can be employed either for latitude or longitude.

a. DETERMINATION OF LATITUDE.

For each single observation we use the following equation:

$$\sin h = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos t. \tag{1 a}$$

This equation gives, when φ_0 and t_0 have been substituted for φ and t, a comparison of each single observation, so that

$$h = \text{arc} \sin (\sin \varphi_0 \sin \delta + \cos \varphi_0 \cos \delta \cos t_0) + dh.$$

T is considered so far known as not to alter δ; and it is necessary that the values of the parallax and of the refraction are applied, so that dh indicates the true differential of the altitude.

The method is entirely based on the relation of dh to the two differential elements $d\varphi_0$ and dt_0.

By the differentiation of the equation for sin h we obtain

$$\cos h \, dh = (\cos \varphi \sin \delta - \sin \varphi \cos \delta \cos t) \, d\varphi - \cos \varphi \cos \delta \sin t \, dt. \tag{A}$$

The products of the values $\sin \varphi \sin \delta$, $\cos \varphi \cos \delta \cos t$, having already been formed during the process of comparing the observations, it is much more expedient to alter the formula in a manner which allows of the values of these products being used again.

The formula then becomes:

$$\cos h \, dh = (\sin \varphi \sin \delta \cot\text{an} \varphi - \cos \varphi \cos \delta \cos t \tan \varphi) \, d\varphi - \cos \varphi \cos \delta \cos t \tan t \, dt. \tag{A α}$$

This is the formula usually adopted by us for calculating latitudes by equations of condition.

The equation (A) contains the two unknown values $d\varphi$ and dt, for the determination of which two values dh would be sufficient; but the values of $d\varphi$ and dt can be determined from all the existing values of dh.

1. If the observations divide themselves into two groups, the mean of the corresponding values of dh can be taken for each of the two groups, and we are at the same time enabled to find out any error in the observations, which is then excluded from the mean.

For example:

The values of dh for the two groups at Chérra (station No. 5) are as follows:

	t	dh
	°	′
I. Group	3·1	— 3·7
	6·1	— 3·7
	8·1	(— 0·5)
	9·2	— 2·9
II. Group	39·7	— 2·4
	41·0	— 2·6

According to their positions, the observations of the first group and those of the second could be used for the means, but, as the third observation shows a great deviation, it has been excluded from the mean. The first approximation alone would not have sufficed to show the errors of this observation.

In this particular case the principle of probability could be still more strictly applied, especially if each differential equation were multiplied with the number of observations from which it is derived.

2. If the observations arrange themselves in more than two groups, a corresponding number of differential equations must be formed. The application of the method of least squares is then indispensable. We select as example Gohátti:

In Gohátti (station No. 4), five groups must be formed on account of the very different values of t.

Gohátti:

	t	dh
	°	′
I. Group	— 36·3	+ 9·4
	— 34·7	+ 8·6
II. Group	— 14·2	+ 1·9
III. Group	— 3·7	+ 0·3
IV. Group	+ 14·7	— 5·2
V. Group	+ 37·0	— 8·0
	+ 38·3	— 8·3

If in such a manner any number of equations have been obtained as:

$$0 = dh + a\ d\varphi + b\ dt$$
$$0 = dh' + a'\ d\varphi + b\ dt$$
$$0 = dh'' + a''\ d\varphi + b''\ dt$$
$$\cdot \quad \cdot\cdot \quad \cdot\cdot\cdot \quad \cdot\cdot\cdot$$
$$\cdot \quad \cdot\cdot \quad \cdot\cdot\cdot \quad \cdot\cdot\cdot$$
$$\cdot \quad \cdot\cdot \quad \cdot\cdot\cdot \quad \cdot\cdot\cdot$$

and if $\Sigma\ (a)^2$ . . . . be the sum of the squares of the co-efficients of $d\varphi$,
$\Sigma\ (b)^2$ . . . . the sum of the squares of the co-efficients of dt,
$\Sigma\ (ab)$ . . . . . . the sum of the products of the co-efficients of $d\varphi$ and dt,
$\Sigma\ (adh)\ \Sigma\ (bdh)$ . . . . the sum of the products of a and b in dh,

then the two final equations are:

$$0 = \Sigma\ (a)^2\ d\varphi + \Sigma\ (ab)\ dt + \Sigma\ (adh)$$
$$0 = \Sigma\ (ab)\ d\varphi + \Sigma\ (b)^2\ dt + \Sigma\ (bdh),$$

from which $d\varphi$ and dt are deduced, so as best to be adapted to the entire series of observations.

If, in this second case, the weight of the different equations of condition is taken into consideration, the corresponding equation must be multiplied with the radix of the number of the observations from which the equation has been deduced.

b. EXAMPLE FOR THE CALCULATION OF LATITUDE: MÁRRI (STATION No. 64.)

1856, November 13.

Approximative values: $\varphi_0 = 33°\ 51'{\cdot}4$. $T_0 = 7^h\ 19^m\ 34^s$.

	1.	2.	3.	4.	5.	6.	7.
Time by Chronometer . . .	$6^h\ 42^m\ 1^s$	$6^h\ 48^m\ 25^s$	$6^h\ 57^m\ 41^s$	$10^h\ 20^m\ 29^s$	$10^h\ 27^m\ 14^s$	$10^h\ 34^m\ 51^s$	$10^h\ 39^m\ 10^s$
Mean Local Noon	$7^h\ 19^m\ 34^s$	$7^h\ 19^m\ 34^s$	$7^h\ 19^m\ 34^s$	$7^h\ 19^m\ 34^s$	$7^h\ 19^m\ 34^s$	$7^h\ 19^m\ 34^s$	$7^h\ 19^m\ 34^s$
Mean Local Time	$-\ 0^h\ 37^m\ 33^s$	$-\ 0^h\ 31^m\ 9^s$	$-\ 0^h\ 21^m\ 53^s$	$+\ 3^h\ 0^m\ 55^s$	$+\ 3^h\ 7^m\ 40^s$	$+\ 3^h\ 15^m\ 17^s$	$+\ 3^h\ 19^m\ 36^s$
Equation of Time	$15^m\ 32^s$	$15^m\ 32^s$	$15^m\ 32^s$	$15^m\ 31^s$	$15^m\ 31^s$	$15^m\ 31^s$	$15^m\ 31^s$
Hour Angle in Time	$-\ 0^h\ 22^m\ 1^s$	$-\ 0^h\ 15^m\ 37^s$	$-\ 0^h\ 6^m\ 21^s$	$+\ 3^h\ 16^m\ 26^s$	$+\ 3^h\ 23^m\ 11^s$	$+\ 3^h\ 30^m\ 48^s$	$+\ 3^h\ 35^m\ 7^s$
Hour Angle in Arc = t . .	5° 30′·3	3° 54′·3	1° 35′·3	49° 6′·5	50° 47′·3	52° 42′·0	53° 46′·8
δ (Sun's Declination) . . .	− 18° 3′·0	− 18° 3′·0	− 18° 3′·1	− 18° 5′·5	− 18° 5′·5	− 18° 5′·6	− 18° 5′·6
log sin φ	9·74594	9·74594	9·74594	9·74594	9·74594	9·74594	9·74594
log sin δ	9·49115$_n$	9·49115$_n$	9·49119$_n$	9·49211$_n$	9·49211$_n$	9·49215$_n$	9·49215$_n$
log sin φ sin δ	9·23709$_n$	9·23709$_n$	9·23713$_n$	9·23805$_n$	9·23805$_n$	9·23809$_n$	9·23809$_n$
log cos φ	9·91930	9·91930	9·91930	9·91930	9·91930	9·91930	9·91930
log cos δ	9·97808	9·97808	9·97808	9·97798	9·97798	9·97798	9·97798
log cos t	9·99899	9·99899	9·99983	9·81600	9·80084	9·78246	9·77150
. . .	9·89537	9·89637	9·89721	9·71328	9·69812	9·67974	9·66878
sin φ sin δ	− 0·17262	− 0·17263	− 0·17264	− 0·17300	− 0·17300	− 0·17301	− 0·17302
cos φ cos δ	+ 0·78590	+ 0·78772	+ 0·78924	+ 0·51675	+ 0·49902	+ 0·47835	+ 0·46642
sin h	0·61328	0·61509	0·61660	0·34375	0·32602	0·30524	0·29340
h (True Altit. of Sun's Centre)	53° 49′·6	37° 57′·5	38° 4′·1	20° 6′·3	19° 1′·7	17° 46′·7	17° 3′·7
Refraction + Parallax . .	+ 0′·9	+ 0′·9	+ 0′·9	+ 1′·9	+ 2′·0	+ 2′·2	+ 2′·3
± Sun's Semidiameter . . .	+ 16′·2	+ 16′·2	+ 16′·2	+ 16′·2	+ 16′·2	+ 16′·2	+ 16′·2
Calculated Observation . . .	38° 6′·7	38° 14′·6	38° 21′·2	20° 24′·4	19° 19′·9	18° 5′·1	17° 22′·2
Direct Observation	38° 7′·5	38° 15′·2	38° 21′·2	20° 24′·2	19° 19′·7	18° 2′·5	17° 22′·2
Calc.—Obs.	− 0′·8	− 0′·6	∓ 0′·0	+ 0′·2	+ 0′·2	+ 2′·6	± 0′·0

From these deviations two groups were formed, corresponding to the position of the different observations:

First Group.

	dh
	$'$
	$-0\cdot8$
	$-0\cdot6$
	$-0\cdot0$
mean dh	$-0\cdot5$
$\log\sin\varphi\sin\delta$ . . =	$9\cdot24_n$
$\log\cot\text{an}\,\varphi$ . . . . =	$0\cdot17$
	$9\cdot41_n$
$\log\cos\varphi\cos\delta\cos t$ =	$9\cdot90$
$\log\tan\varphi$ . . . . . =	$9\cdot83$
	$9\cdot73$
	nat. num
	$-0\cdot26$
	$-0\cdot54$
co-effic. of $d\varphi$. =	$-0\cdot80$
log =	$9\cdot90$
$\log\cos\varphi\cos\delta\cos t$ =	$9\cdot90$
$\log\tan t$ . . . . . =	$8\cdot90_n$
log co-effic. of dt . =	$8\cdot80$
$\log dh$ . . . . =	$9\cdot70$
$\log\cos h$ . . . . . . =	$9\cdot89$
$\log\cos h\,dh$ . . . =	$9\cdot59$

Second Group.

	dh
	$'$
	$+0\cdot2$
	$+0\cdot2$
	$(+2\cdot6)$
	$+0\cdot0$
mean dh $+0\cdot1$ (dh No. 6 being excluded)	
$\log\sin\varphi\sin\delta$ . . . . =	$9\cdot24_n$
$\log\cot\text{an}\,\varphi$ . . . . =	$0\cdot17$
	$9\cdot41_n$
$\log\cos\varphi\cos\delta\cos t$ . . . . =	$9\cdot70$
$\log\tan\varphi$ . . . . =	$9\cdot83$
	$9\cdot53$
	nat. num
	$-0\cdot26$
	$-0\cdot34$
co-effic. of $d\varphi$ . . . . =	$-0\cdot60$
log =	$9\cdot78$
$\log\cos\varphi\cos\delta\cos t$ . . . . . . =	$9\cdot70$
$\log\tan t$ . . . . =	$9\cdot81$
log co-effic. of dt . . . . =	$9\cdot51_n$
$\log dh$ . . . . =	$9\cdot00$
$\log\cos h$ . . . . =	$9\cdot98$
$\log\cos h\,dh$ . . . . =	$8\cdot98$

These values give the two logarithmic equations of condition:

$$0 = -\,9\cdot59 - 9\cdot90\,d\varphi + 8\cdot80\,dt$$
$$0 = +\,8\cdot98 - 9\cdot78\,d\varphi - 9\cdot51\,dt.$$

The solution of these two equations gives:

$$d\varphi = -\,0'\cdot4$$
$$dt = +\,1'\cdot1;\ \text{therefore}\ dT = -\,4^s\cdot4$$
$$\varphi = 33^\circ\ 51'\cdot0$$
$$T = 7^h\ 19^m\ 30^s.$$

In order to show the greater precision resulting from the application of this method, each single observation has been compared with the last definitively resulting elements. This, however, was effected, not in the direct way, but by the corresponding differential equations. The errors are:

Observations 1.	$-0'{\cdot}3$	Observations 4.	$+0'{\cdot}1$
" 2.	$-0{\cdot}1$	" 5.	$+0{\cdot}1$
" 3.	$+0{\cdot}5$	" 7.	$-0{\cdot}1$

The final correction is not very considerable, as the observations have already been very well represented by the first approximation.

b. CALCULATION OF THE LONGITUDE BY EQUATIONS OF CONDITION.

We limit ourselves to showing, in a general way, the application of this method also to longitude. The method can be successfully applied only, when there are two variables.

For the latitude, these two variables were $d\varphi$ and dt. For the longitude, φ and T are considered to be exactly known, the variables being here, $\delta =$ the declination, and $R.A. =$ the right ascension of the moon.

The longitudes are then calculated in the same way as the latitudes, but instead of the equation $(A\,\alpha)$

$$\cos h\, dh = (\sin\varphi \sin\delta \cot\varphi - \cos\varphi \cos\delta \cos t \tan\varphi)\, d\varphi - \cos\varphi \cos\delta \cos t \tan t\, dt,$$

the following, formed according to the same principles, is used:

$$\cos h\, dh = (\sin\varphi \sin\delta \cot\delta - \cos\varphi \cos\delta \cos t \tan t)\, d\delta - \cos\varphi \cos\delta \cos t \tan t\, dt. \qquad (A\,\beta)$$

On the supposition of great correctness in the observations, the resulting values of dt and $d\delta$ will both give the same differential of longitude, thus allowing of a very minute control of the observations.

Besides this, it would be possible to express the differential of longitude in functions of time; but this operation is best reserved for the numeric process.

SECTION II.

OBSERVATIONS FOR THE DETERMINATION OF GEOGRAPHICAL CO-ORDINATES.

In India, the operations of the Great Trigonometrical Survey, under men so distinguished as Lambert, Hodgson, Everest, and the present able superintendents, Colonel A. S. Waugh and Major H. L. Thuillier, are well known to be executed with as perfect accuracy and fulness of detail as the best existing. In places, therefore, the positions of which have been previously fixed by the general triangulation, we give their determinations as definitive results. But even in such stations our own observations were indispensable for obtaining Time and Meridian.

In some few places, however, our time, limited by the difficulties of travelling, only allowed us to make observations of magnetic intensity. In quoting the determinations of the Great Trigonometrical Survey, we mark them G. T. S. Some of the determinations, contained in the Appendix of the "Manual of Surveying", by Smyth and Thuillier, London, 1855, p. xcvi., are marked Thuill. App. We adopt as longitude of the Madras Observatory: 80° 13′ 56″ East Green.

In countries not yet properly surveyed, such as many parts of the Himálaya and of Tíbet, we had no other material for comparison than maps, the nature of which did not allow of so accurate and direct a comparison. In general, we give no latitudes or longitudes taken from maps. At the end of this part, in the "Concluding General Remarks and Results", we have drawn up a general list of the principal original maps of the Himálaya and of Tíbet for comparison.

In the Himálaya, where the operations of the Great Trigonometrical Survey extend only to the determination of single peaks, and in the as yet unsurveyed countries of Tíbet and Turkistán, the determination of the geographical positions became of equal importance with the magnetic observations. In these territories, when difficulties presented themselves, as they did occasionally, for extending our observations, we considered it desirable to determine latitudes and longitudes in preference to magnetic observations.

The following groups, therefore, contain all the stations where latitudes and longitudes have been determined by us, as well as those where magnetic observations only have been made.[1]

In India, the stations generally follow each other[2] from East to West and from South to North. Every station is preceded by a short topographical explanation, having reference chiefly to the position of the instruments.

The heights refer to the place where our magnetic instruments were put up, and are given in English feet; the observations on which they are based will be given in detail in the second volume.

[1] The materials of our observations are contained in Vols. 5, 9, 10, 11, and 12 of the manuscripts quoted p. 8. We give, as will be seen, all the detail of the observations, even including readings, which are occasionally affected by (comparatively small) errors of observation.

[2] The chronological order is a matter of comparative indifference, and may be seen in the itinerary, pp. 11 to 35.

A.M. and P.M. will be seen to refer to apparent local time, and not to time by chronometer.

We were authorized to engage a computer, Mr. Charles Linsser, to assist us in the publication of this volume, and we profit by this occasion to make particular mention of his zeal and activity.

A. INDIA.

GROUP I.

ASSÁM AND KHÁSSIA HILLS.

STATIONS 1 TO 5.

Dibrugárh.—Tézpur.—Udelgúri.—Gohátti.—Chérra Púnji.

No. 1. Dibrugárh, in Upper Assám.

This is a permanent military station on the Brahmapútra, farthest removed from its mouth. Sádia, though still higher up the river, is only temporarily occupied by an officer and his escort.

The observations were made on the left side of the Brahmapútra, near an open shed erected for the free use of Bhútias and of neighbouring hill tribes, when coming for trading purposes to the station. Such sheds are called "namgárh", and are to be seen in many of the villages of Assám.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 32′ 0″	94° 57′ 35″	395 feet.

Observations: 1856, February 5.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude.

Sun, Upper Limb.

1856, February 5.	Horizontal Circle.	Vertical Circle.
	P. M.	
h m s	° ′ ″	° ′ ″
1) 3 0 39	263 44 0	46 32 55
2) 3 9 41	266 52 20	46 20 0
3) 4 19 42	285 4 10	41 16 18
4) 7 23 40	325 8 10	11 26 40

Barom. { 754·6 millim. / 29·709 inches. Temp. of Air { 19°·2 C. / 66·6 Fahr.

Calculated by Method I., from observations 1 and 4.

	1.	4.
	′ ″	′ ″
Refraction	— 0 52	— 4 28
Parallax	+ 0 6	+ 0 8
Semidiameter	— 16 15	— 16 15
Sum of Corr. . . .	— 17 1	— 20 35

1) h corr. = 46° 15′ 54″ δ = — 16° 9′ 10″

4) h' corr. = 11 6 5 δ' = — 16 5 53

Latitude N. . . . . 27° 32′·0.

The latitude by a preliminary determination of the G. T. S. (Thuill. App.) is 27° 31′ 45″, based on Wilcox and Bedford's Survey of Upper Assám. It perfectly agrees with our results.

Time.

	h m s
Apparent Noon, deduced from the Altitude of the Sun, from observ. 1	2 52 5
" " " observ. 4	2 52 6

We give the preference to the latter, on account of the altitude being 35° lower; but the values, being identical, also serve as a control of the observations.

	h m s
Apparent Noon, adopted	2 52 6
Equation of Time	+ 0 14 15
Mean Noon	2 37 51

Longitude.

Our Chronometer giving in Upper Assám arbitrary time only, we adopt the

Longitude of Thuill. App. . . . . = 94° 57′ 35″ East Green.

Meridian.

Meridian, deduced from the observations of the Sun . . . . 260° 47′·1.

No. 2. Tézpur, in Assám.

Coming from Bhután, this was the first station I reached. It is situated on the right side of the Brahmapútra, and has during the last few years become a very important place for the manufacture of lac, and for the cultivation of tea and indigo.

Tea ought to be particularly mentioned in connection with Tézpur, on account of Mr. Bruce, a resident of this station, having first found it growing wild in Assám.

My instruments were placed near the circuit bángalo, a government building erected on a slight eminence for the temporary residence of officers while travelling.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 34′ 35″	92° 46′ 45″	239 feet.

Observations: 1856, January 25.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude.

1856, January 25.	Horizontal Circle.	Vertical Circle.
	A. M.	
	Sun, Lower Limb.	
h m s	° ′ ″	° ′ ″
1) 1 32 33	269 10 35	43 40 58
2) 1 39 42	271 49 45	43 51 45
3) 1 46 41	273 50 5	43 56 38
4) 1 52 40	275 28 0	43 59 18
	P. M.	
	Sun, Upper Limb.	
h m s	° ′ ″	° ′ ″
5) 2 4 10	279 35 40	44 28 15
6) 2 16 40	280 40 45	44 12 45

Barom. { 755·3 millim. / 29·737 inches. Temp. of Air { 27°·4 C. / 81·3 Fahr.

Calculated by Method III. from the Altitude nearest the Meridian.

		′	″
Refraction	—	0	56
Parallax	+	0	6
Semidiameter	+	16	18
Sum of Corr.	+	15	28

		°	′
True Altitude of Sun's Centre at Culmination, calculated . . .	=	44	16·4
Declination = δ	=	— 19	9·0
Latitude N.	=	26	34·6

Latitude N. (Thuill. App.) . . . 26° 36′ 45″.

Time.

		h	m	s
Apparent Noon, deduced from obs. 2 and 3, and 3 and 4	=	2	1	22
Equation of Time	=	+	12	28
Mean Noon		1	48	54

Longitude.

The adopted longitude, as given above, is taken from Thuill. App.

Meridian.

From observations of the Sun . . . . . 278° 11′·3.

No. 3. Udelgúri, in Assám.

Situated at the southern end of the road from Lhássa to Assám, viâ Táuong and Nărigún, through the country of the wandering Kámpo-Bhútias, it is an important trading station, with extensive bazars much used at periodical fairs.

The instruments were put up near a government house, constructed of bambu and cane, in charge of the daróga of the place.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 45′ 40″	91° 56′ 30″	352 feet.

Observations: 1856, January 2.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

1856, January 2.	Horizontal Circle.	Vertical Circle.
	A. M. Sun, Centre.	
h m s	° ′ ″	° ′ ″
1) 2 26 29	306 33 20	20 32 20
2) 2 41 52	309 12 30	23 1 55

Sun, Upper Limb.

	h m s	° ′ ″	° ′ ″
3)	2 51 23	310 16 50	24 50 55
4)	2 59 41	312 18 5	25 59 10
5)	5 2 44	342 20 20	39 22 50
6)	5 11 14	344 49 30	39 46 5
		P. M.	
	h m s	° ′ ″	° ′ ″
7)	5 48 57	356 6 35	40 31 44
		Sun, Lower Limb.	
	h m s	° ′ ″	° ′ ″
8)	6 32 39	9 5 10	38 47 20
9)	6 39 48	10 30 15	38 27 20

Barom. { 754·3 millim. / 29·697 inches. Temp. of Air { 23°·0 C. / 73·4 Fahr.

At Udelgúri, the observations were calculated more in detail, in consequence of the greater number of observations, and on account of this place being well situated as a starting point for some longitudes by chronometer.

First Approximation.

For the first approximation, the mean of observations 3 and 4 = I., and observation 7 = II., are chosen, as they are nearest the meridian. They are calculated by Method I.

The usual corrections for these series are:

	I.	II.
	′ ″	′ ″
Refraction	— 1 58	— 1 6
Parallax	+ 7	+ 7
Semidiameter	— 16 18	— 16 18
Sum of Corr. . .	— 18 9	— 17 17

I. h corr. = 25° 6′·9 δ = — 22° 52′·8

II. h' corr. = 40 14·4 δ' = — 23 0·5

Latitude N. . . . . 26° 45′·0

Mean Noon (corr. for Equation of Time) $5^h\ 44^m\ 1^s$

Second Approximation.

Comparison of the single observations with the elements obtained by the first approximation.

Formulæ: *Aα* (p. 120).

	Group I.				Group II.		Group III.	
	1.	2.	3.	4.	5.	6.	7.	8.
Time of Observation by Chron.	$2^h 26^m 29^s$	$2^h 41^m 52^s$	$2^h 51^m 23^s$	$2^h 59^m 41^s$	$5^h 2^m 44^s$	$5^h 11^m 14^s$	$6^h 32^m 39^s$	$6^h 39^m 48^s$
Mean Noon } from 1st	$5^h 44^m 1^s$	$5^h 44^m 1^s$	$5^h 44^m 1^s$	$5^h 44^m 1^s$	$5^h 44^m 1^s$	$5^h 44^m 1^s$	$5^h 44^m 1^s$	$5^h 44^m 1^s$
Mean Local Time } Approx.	$-3^h 17^m 32^s$	$-3^h 2^m 9^s$	$-2^h 52^m 38^s$	$-2^h 44^m 20^s$	$-0^h 41^m 17^s$	$-0^h 32^m 47^s$	$+0^h 48^m 38^s$	$+0^h 55^m 47^s$
Equation of Time	$-$ $3^m 54^s$	$-$ $3^m 54^s$	$-$ $3^m 54^s$	$-$ $3^m 54^s$	$-$ $3^m 56^s$	$-$ $3^m 56^s$	$-$ $3^m 58^s$	$-$ $3^m 58^s$
Hour Angle in Time	$-3^h 21^m 26^s$	$-3^h 6^m 3^s$	$-2^h 56^m 32^s$	$-2^h 48^m 14^s$	$-0^h 45^m 13^s$	$-0^h 36^m 43^s$	$+0^h 44^m 40^s$	$+0^h 51^m 49^s$
Hour Angle in Arc $= t$	$-50° 21'·5$	$-46° 30'·7$	$-44° 8'·0$	$-42° 3'·5$	$-11° 18'·3$	$-9° 10'·7$	$+11° 10'·0$	$+12° 57'·5$
δ (Sun's Declination)	$-23° 0'·4$	$-23° 0'·4$	$-23° 0'·3$	$-23° 0'·3$	$-22° 59'·9$	$-22° 59'·9$	$-22° 59'·6$	$-22° 59'·6$
$\sin\varphi \sin\delta$	$-0·17592$	$-0·17592$	$-0·17590$	$-0·17590$	$-0·17586$	$-0·17586$	$-0·17582$	$-0·17582$
$\cos\varphi \cos\delta \cos t$	$+0·52440$	$+0·56567$	$+0·58994$	$+0·61029$	$+0·80604$	$+0·81148$	$+0·80648$	$+0·80107$
Sum $= \sin h$	0·34848	0·38975	0·41404	0·43439	0·63018	0·63562	0·63066	0·62525
h (True Altit. of the Sun's Centre)	$20° 23'·7$	$22° 56'·3$	$24° 27'·5$	$25° 44'·8$	$39° 3'·8$	$39° 28'·0$	$39° 5'·9$	$38° 42'·0$
Refraction	$+$ $2'·5$	$+$ $2'·2$	$+$ $2'·0$	$+$ $1'·9$	$+$ $1'·1$	$+$ $1'·1$	$+$ $1'·2$	$+$ $1'·2$
Parallax	$-$ $0'·1$	$-$ $0'·1$	$-$ $0'·1$	$-$ $0'·1$	$-$ $0'·1$	$-$ $0'·1$	$-$ $0'·1$	$-$ $0'·1$
Apparent calc. Altitude of Centre	$20° 26'·1$	$22° 58'·4$	$24° 29'·4$	$25° 46'·6$	$39° 4'·8$	$39° 29'·0$	$39° 7'·0$	$38° 43'·1$
$\pm$ Sun's Semidiameter	. . .	. . .	$+$ $16'·3$	$+$ $16'·3$	$+$ $16'·3$	$+$ $16'·3$	$-$ $16'·3$	$-$ $16'·3$
Calculated Observation	$20° 26'·1$	$22° 58'·4$	$24° 45'·7$	$26° 2'·9$	$39° 21'·1$	$39° 45'·3$	$38° 50'·7$	$38° 26'·8$
Direct Observation	$20° 32'·3$	$23° 1'·9$	$24° 50'·9$	$25° 59'·2$	$39° 22'·2$	$39° 46'·1$	$38° 47'·3$	$38° 27'·3$
Calc.—Obs.	$-$ $6'·2$	$-$ $3·5$	$-$ $5'·2$	$+$ $3'·7$	$-$ $1'·1$	$-$ $0'·8$	$+$ $3'·4$	$-$ $0'·5$
	Group A.				Group B.			

The mean of the deviations (Calc.—Obs.) in Group A is $= - 4'\cdot 9$, excluding observation 4 at $2^h\ 59^m$, and the mean of Group $B = - 0'\cdot 9$.

We obtain the following differential equations for reducing the errors to their minimum:

$$1)\quad 0 = - 0\cdot 68 - 9\cdot 84\, d\varphi - 9\cdot 81\, dt$$
$$2)\quad 0 = - 9\cdot 85 - 9\cdot 99\, d\varphi - 9\cdot 23\, dt,$$

the co-efficients being logarithmical.

The solution of these equations gives:

$$dt = - 10'\cdot 1 \text{ in Arc} \qquad dT = + 40^s\cdot 4 \text{ in Time}$$
$$d\varphi = + 0'\cdot 7;$$

therefore,

$$\text{Latitude N.} = \varphi = 26^\circ\ 45'\cdot 7$$
$$\text{Mean Noon} = T = 5^h\ 43^m\ 21^s.$$

The following table shows the remaining errors after these new elements are introduced:

No. of Observ.	Calc.—Obs.
	′
1	— 1·3
2	+ 1·4
3	— 0·3
5	— 0·2
6	+ 0·1

Longitude.

	h	m	s
Mean Noon by Chron. 3, at Gohátti, 1855, December 13 .	5	44	15
Mean Noon by Chron. 3, at Udelgúri, 1856, January 2 . .	5	43	21
Rate for this period = IX. = losing 0ˢ·17			
Correction of the Udelgúri Noon for 20 days	+ 0	0	3·4
Meridional Difference between Gohátti and Udelgúri	0	0	51

Therefore,

	°	′	″
Udelgúri East of Gohátti	0	12	45
Gohátti East of Greenwich	91	43	45
Udelgúri East of Greenwich	91	56	30

For this station the G. T. S. could not supply us with data of latitude and longitude for comparison.

Meridian.

Calculated from the second approximation . . . . 355° 36′·9.

No. 4. Gohátti, in Assám.

Besides containing a large native population, this is the principal British Station of Assám, and the seat of the Governor General's Agent for the provinces of the north-east frontier. The Brahmapútra flows by on the right. My instruments were put up near the house of Major Vetch, who gave me the most friendly and cordial reception.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 5′ 50″	91° 43′ 45″	134 feet.

Observations: 1855, November 19 and December 13.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

	1855, December 13.	Horizontal Circle.	Vertical Circle.
		A. M.	
		Sun, Lower Limb.	
	h m s	° ′ ″	° ′ ″
1)	3 12 17	318 0 55	29 8 10
2)	3 18 45	319 23 45	30 2 35
3)	4 40 41	349 53 20	38 37 5
		Sun, Upper Limb.	
	h m s	° ′ ″	° ′ ″
4)	5 22 35	355 7 30	40 55 35
		P. M.	
	h m s	° ′ ″	° ′ ″
5)	6 36 18	14 8 0	39 7 25
		Sun, Lower Limb.	
	h m s	° ′ ″	° ′ ″
6)	8 5 31	36 7 40	28 59 55
7)	8 10 34	37 10 10	28 17 0

Barom. { 754·2 millim. / 29·693 inches. Temp. of Air { 18°·5 C. / 65·3 Fahr.

First Approximation.

Calculated by Method I., from observations 4 and 7.

The corrections are:

	4.	7.
	′ ″	′ ″
Refraction	− 1 5	− 1 44
Parallax	+ 0 7	+ 0 7
Semidiameter	− 16 17	+ 16 17
Sum of Corr. . .	− 17 15	+ 14 40

4) h corr. $= 40° 38′ 20″$ $\delta = -23° 8′·0$

7) h' corr. $= 28\ 31\ 40$ $\delta' = -23\ 8·4$

Latitude N. 26° 5′·8

Mean Noon (corr. for Equation of Time) $5^h\ 43^m\ 17^s$.

Second Approximation.

Calculated by formula $A\alpha$ (p. 120), which is used throughout in calculating the second approximations.

	A.M.				P.M.		
	Group I.		Group II.		Group III.	Group IV.	
	1.	2.	3.	4.	5.	6.	7.
Time of Observ. by Chron.	$3^h\ 12^m\ 17^s$	$3^h\ 18^m\ 45^s$	$4^h\ 40^m\ 41^s$	$5^h\ 22^m\ 35^s$	$6^h\ 36^m\ 18^s$	$8^h\ 5^m\ 31^s$	$8^h\ 10^m\ 34^s$
Mean Noon } from 1st	$5^h\ 43^m\ 17^s$	$5^h\ 43^m\ 17^s$	$5^h\ 43^m\ 17^s$	$5^h\ 43^m\ 17^s$	$5^h\ 43^m\ 17^s$	$5^h\ 43^m\ 17^s$	$5^h\ 43^m\ 17^s$
Mean Local Time } Approx.	$-\ 2^h\ 31^m\ 0^s$	$-\ 2^h\ 24^m\ 32^s$	$-\ 1^h\ 2^m\ 36^s$	$-\ 0^h\ 20^m\ 42^s$	$+\ 0^h\ 53^m\ 1^s$	$+\ 2^h\ 22^m\ 14^s$	$+\ 2^h\ 27^m\ 17^s$
Equation of Time.	$+\ 5^m\ 53^s$	$+\ 5^m\ 53^s$	$+\ 5^h\ 51^s$	$+\ 5^m\ 51^s$	$+\ 5^m\ 49^s$	$+\ 5^m\ 47^s$	$+\ 5^m\ 47^s$
Hour Angle in Time. . . .	$-\ 2^h\ 25^m\ 7^s$	$-\ 2^h\ 18^m\ 39^s$	$-\ 0^h\ 56^m\ 45^s$	$+\ 0^h\ 14^m\ 51^s$	$+\ 0^h\ 58^m\ 50^s$	$+\ 2^h\ 28^m\ 1^s$	$+\ 2^h\ 33^m\ 4^s$
Hour Angle in Arc $= t$ . .	36° 16′·8	− 34° 39′·8	− 14° 11′·3	− 3° 42′·8	+ 14° 42′·5	+ 37° 0′·8	+ 38° 16′·0
δ (Sun's Declination)	− 23° 7′·6	− 23° 7′·6	− 23° 7′·7	− 23° 7′·8	− 23° 8′·3	− 23° 8′·5	− 23° 8′·5
$\sin\varphi\sin\delta$.	− 0·17278	− 0·17278	− 0·17279	− 0·17280	− 0·17286	− 0·17289	− 0·17289
$\cos\varphi\cos\delta\cos t$	+ 0·66579	+ 0·67930	+ 0·80070	+ 0·82414	+ 0·79875	+ 0·65939	+ 0·64837
Sum $= \sin h$	0·49301	0·50652	0·62791	0·65134	0·62589	0·48650	0·47548
h (True Altit. of Sun's Centre)	29° 32′·3	30° 26′·0	38° 53′·8	40° 38′·6	38° 44′·8	29° 6′·6	28° 23′·4
Refraction	+ 1′·7	+ 1′·6	+ 1′·6	+ 1′·1	+ 1′·2	+ 1′·7	+ 1′·7
Parallax	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1
Apparent calc. Altitude of Centre	29° 33.·9	30° 27′·5	38° 55′·3	40° 39′·6	38° 45′·9	29° 8′·2	28° 25′·0
± Sun's Semidiameter . .	− 16′·3	− 16′·3	− 16′·3	+ 16′·3	+ 16′·3	− 16·3	− 16′·3
Calculated Observation. . .	29° 17′·6	30° 11′·2	38° 39′·0	40° 55′·9	39° 2′·2	28° 51′·9	28° 8′·7
Direct Observation	29° 8′·2	30° 2′·6	38° 37′·1	40° 55′·6	39° 7′·4	28° 59′·9	28° 17′·0
Calc. — Obs.	+ 9′·4	+ 8′·6	+ 1′·9	+ 0′·3	− 5′·2	− 8′·0	− 8′·3
	Group *A.*		Group *B.*		Group *C.*	Group *D.*	

In the preceding table, we separated by vertical lines those observations, the differentials of which could not be considered identical; we thus obtain the four following groups:

Groups.	Calc.—Obs.	t
	′	°
A.	+ 9·0	− 35·5
B.	+ 1·1	− 8·8
C.	− 5·2	+ 18·2
D.	− 8·2	+ 37·6

This shows that, in accordance with the observation No. 4, we may consider $d\varphi = 0$, and that all the corrections of the elements consist in a correction of the mean noon.—Therefore, in the following equations we have put, $d\varphi = 0$:

$$0 = + 0{\cdot}89 - 9{\cdot}84\, d\varphi + 9{\cdot}68\, dt$$
$$0 = - 0{\cdot}86 - 9{\cdot}84\, d\varphi - 9{\cdot}69\, dt.$$

These equations are referred to the groups *A* and *D*, and give:

$$dt = - 15'{\cdot}5 \text{ in Arc} \qquad dT = + 1^{m}\, 2^{s} \text{ in Time.}$$

The corrected elements, therefore, are:

Latitude N. . . . $= \varphi = 26°\ 5'{\cdot}8$
Mean Noon . . . $= T = 5^{h}\ 44^{m}\ 19^{s}$.

A comparison, after introducing the new elements, shows the following errors still remaining:

No. of Observ.	Calc.—Obs.
	′
1	+ 0·4
2	− 0·4
3	+ 0·8
4	− 0·8
5	0·0
6	+ 0·2
7	− 0·1

The latitude from Thuill. App. is: 26° 11′ 15″ N.

Longitude.

Observations of the Moon and Jupiter.

1855. November 19.	Horizontal Circle.	Vertical Circle.
	P. M.	
	Moon, Centre.	
$3^{h}\ 21^{m}\ 13^{s}$	213° 56′ 50″	56° 3′ 30″.

Jupiter.

h m s	° ′ ″	° ′ ″
3 10 47	234 44 20	24 42 45
3 29 44	238 4 25	21 0 50

Barom. { 757·1 millim. / 29·808 inches   Temp. of Air { 18°·5 C. / 65·3 Fahr.

Co-ordinates of Jupiter, interpolated for the time of the lunar observation:

$3^h\ 21^m\ 13^s$ 236° 34′·4   22° 40′·6.

Corrections for reducing the apparent altitudes of the Moon and Jupiter to true geocentric altitudes:

	for Jupiter	for Moon
Refraction	— 2′·2	— 0′·6
Parallax	0′·0	+ 33′·2

Jupiter, true Altitude	22° 38′·4
Moon „ „	56 36·1
Arc of the Almucantarat	22 46·8
Reduced Distance of Centres	37 50·8
to which corresponds a Mean Greenwich Time of	3h 30m 20s P.M.
Mean Local Time (referred to December 13, the Rate I. = losing 0s·17 would give a correction of — 3s, which, however, does not affect the result within the 10s adopted as limit for our longitudes).	9 36 50
Meridional Difference in Time	6 6 30

therefore,

Longitude East Green. . . . . . 91° 37′ 30″

This result happens to agree, beyond the limits which could have been expected, with the longitude of the G. T. S. = 91° 43′ 45″ East Green.

Meridian.

Calculated from Observations of the Sun by the second approximation . . 0° 3′·8.

No. 5. Chérra Púnji, in the Khássia Hills.

This station has been made the chief place for the political superintendence of the Khássia Hills and of Kachár. It is situated on the eastern margin of the Khássia

Hills, which terminate here very abruptly toward the plains. All the eastern border of the Khássia and Jáintia Hills is particularly remarkable for excessive precipitation of rain, often exceeding 600 inches in a year. Soon after the rains the climate becomes dry and very healthy, during which period it is found to be an excellent place for a sanitarium.

My instruments were set up in an open situation, not far from the house of Captain Byng, who, unfortunately, was killed during the time of the rebellion, in an expedition against the Kacháris.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
25° 14′ 15″	91° 40′ 30″	4,164 feet.

Observations: 1855, November 4.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

a. Observations of the Sun.

	1855, November 4.	Horizontal Circle. Sun, Upper Limb. P. M.	Vertical Circle.
	h m s	° ′ ″	° ′ ″
1)	5 40 23	2 24 10	49 43 0
2)	5 52 21	6 39 50	49 23 40
3)	6 0 14	9 31 30	49 1 10
4)	6 4 50	11 9 15	48 49 50
5)	8 6 30	45 26 15	34 19 55
6)	8 11 50	46 27 55	33 25 50

Barom. { 660·0 millim. / 25·985 inches. Temp. of Air { 20°·3 C. / 68·5 Fahr.

First Approximation.

Calculated by Method I., from Observations 1 and 6.

	1.	6.
	′ ″	′ ″
Refraction	— 0 41	— 1 17
Parallax	+ 5	+ 5
Semidiameter	— 16 10	— 16 10
Sum of Corr.	— 16 46	— 17 22

1. h corr. $= 49^\circ\ 26'\cdot3$ $\delta = -15^\circ\ 10'\cdot6$
6. h' corr. $= 33^\circ\ 8'\cdot4$ $\delta' = -15^\circ\ 12'\cdot6$

Latitude N. 25° 16′·2
Mean Noon (corr. for Equation of Time) 5^h 44^m 11^s.

In this first approximation, δ is referred to a wrong date, where magnetic observations were made, but no declination. In the second approximation, the correction which exactly corresponds to the time of observation has been introduced, so that the final result is not in the least altered.

Second Approximation.

The equation of time may be considered as constant, during the observations. The latitude, as obtained from the first approximation, is assumed in round number = 25° 17′ N.

	Group I.				Group II.	
Time of Obs. by Chron. 3.	5^h 40^m 22^s	5^h 52^m 21^s	6^h 0^m 14^s	6^h 4^m 49^s	8^h 6^m 30^s	8^h 11^m 50^s
Apparent Noon	5^h 27^m 53^s	5^h 27^m 53^s	5^h 27^m 53^s	5^h 27^m 53^s	5^h 27^m 53^s	5^h 27^m 53^s
Hour Angle in Time . .	0^h 12^m 29^s	0^h 24^m 28^s	0^h 32^m 21^s	0^h 36^m 56^s	2^h 38^m 37^s	2^h 43^m 57^s
Hour Angle in Arc = t	3° 7′·3	6° 7′·0	8° 5′·3	9° 14′·0	39° 39′·3	40° 59′·3
δ (Sun's Declination) . .	— 15° 13′·8	— 15° 13′·8	— 15° 13′·8	— 15° 13′·8	— 15° 15′·5	— 15° 15′·5
sin φ sin δ	— 0·11219	— 0·11219	— 0·11219	— 0·11219	— 0·11240	— 0·11240
cos φ cos δ cos t	+ 0·87118	+ 0·86750	+ 0·86380	+ 0·86118	+ 0·67163	+ 0·65849
Sum = sin h . . .	0·75899	0·75531	0·75161	0·74899	0·55923	0·54609
h (True Altitude of the Sun's Centre)	49° 22′·5	49° 3′·2	48° 43′·9	48° 30′·1	34° 0′·2	33° 5′·9
Refraction	+ 0′·7	+ 0′·7	+ 0′·7	+ 0′·7	+ 1′·2	+ 1′·2
Parallax	— 0′·1	— 0′·1	— 0′·1	— 0′·1	— 0′·1	— 0′·1
± Sun's Semidiameter.	+ 16′·2	+ 16′·2	+ 16′·2	+ 16′·2	+ 16′·2	+ 16′·2
Calculated Observation	49° 39′·3	49° 20′·0	49° 0′·7	48° 46′·9	34° 17′·5	33° 23′·2
Direct Observation . . .	49° 43′·0	49° 23′·7	49° 1′·2	48° 49′·8	34° 19′·9	33° 25′·8
Calc.—Obs.	— 3′·7	— 3′·7	(— 0′·5)	— 2′·9	— 2′·4	— 2′·6
	Group *A* (excluding — 0′·5)				Group *B*.	

For forming the differential equations, the mean of the errors of Groups *A* and *B* have been used, the observation No. 3 being excluded from Group *A*.

Group *A*, Calc.—Obs. = $-3'\cdot4$
Group *B*, Calc.—Obs. = $-2\cdot5$.

The differential equations are:

$$0 = -0\cdot44 - 9\cdot81\, d\varphi - 9\cdot19\, dt$$
$$0 = -0\cdot32 - 9\cdot74\, d\varphi - 9\cdot78\, dt,$$

the co-efficients being logarithmical.

The solution of these equations gives:

$$d\varphi = -4'\cdot5$$
$$dt = +0'\cdot6 \text{ in Arc} \qquad dT = -2^s\cdot4 \text{ in Time};$$

therefore,

Latitude N. . . . $= \varphi = 25° \; 12' \; 30''$
Mean Noon . . . $= T = 5^h \; 44^m \; 9^s$.

The remaining errors, after introducing the new elements, are:

No. of Observ.	Calc.—Obs.
1	$-0'\cdot3$
2	$-0\cdot3$
4	$+0\cdot5$
5	$+0\cdot1$
6	$-0\cdot1$

b. Circumpolar Star.

Observations of the Circumpolar Star 4^m, in the constellation Ursus Minor, close to the foot of Cepheus. Its co-ordinates are:

for 1855·0 *R.A.* = $0^h \; 49^m \; 43^s$
" " $\delta = +85° \; 28'\cdot6$

1855. November 4.	Horizontal Circle.	Vertical Circle.
$13^h \; 19^m \; 27^s$	180° 53′ 20″	28° 56′ 0″

Barom. { 659·8 millim. / 25·977 inches. Temp. of Air { 17·1 °C. / 62·8 Fahr.

	h m s
Time by Chronometer	13 19 27
Mean Noon (2nd Approximation)	5 44 9
Mean Local Time	7 35 18
Long. E. Green. in Time	6 6 42
Mean Green. Time of the Observation	1 28 36
Acceleration of Fixed Stars	+ 15
Mean Time reduced to Sidereal Time	1 28 51
Long. E. Green. in Time	6 6 42
Sidereal Time at Mean Noon at Green., Nov. 4	14 52 40
Sidereal Time at Chérra Púnji	22 28 13
R. A. of Circumpolar Star	0 49 43
Hour Angle in Time	21 38 30
Hour Angle in Arc	35° 22′·5
Latitude N. by the Circumpolar Star	25° 11′ 50″.

c. Jupiter.

1855, November 4. h m s	Horizontal Circle. ° ′ ″	Vertical Circle. ° ′ ″
12 43 21	0 46 40	49 47 50
12 48 57	6 32 10	49 27 20

	h m s
Time by Chronometer (Mean of the two Observations)	12 51 4
Mean Noon (2nd Approximation)	5 44 9
Mean Local Time	7 6 55
Long. E. Green. in Time	6 6 42
Mean Green. Time of the Observation	1 0 13
Acceleration of Fixed Stars	+ 10
Mean Time reduced to Sidereal Time	1 0 23
Long. E. Green. in Time	6 6 42
Sidereal Time at Mean Noon at Green., Nov. 4	14 52 40
Sidereal Time at Chérra Púnji	21 59 45
R. A. of Jupiter	21 43 39
Hour Angle in Time	0 16 6
Hour Angle in Arc	4° 1·5
Latitude N. by Jupiter	25° 18′ 25″.

Mean of Latitude.

	° ′ ″
a) Latitude N. by Sun	25 12 30
b) Latitude N. by Circumpolar Star	25 11 50
c) Latitude N. by Jupiter	25 18 25
Mean = Latitude N.	25 14 15

(Latitude N.: Thuill. App. = 25° 16′ 35″).

Longitude.

We adopt as longitude from Thuill. App. = 91° 40′ 30″ East Green.

Meridian.

Meridian, deduced from the Observations of the Sun, 1855, November 4 . . . . 357° 55′·6.

GROUP II.

DELTA OF THE GANGES AND BRAHMAPÚTRA.

STATIONS 6 TO 9.

Surajgánj.—Dháka.—Kúlna.—Calcutta.

No. 6. Surajgánj, in Eastern Bengál.

This is a station north of Dháka, on the right bank of the Konái, with several large factories. Here observations of the dip only were made. (Observer: Hermann.)

The latitude and longitude are taken from Tassin's Map of Central Bengál, Calcutta, 1841.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
24° 22′ 50″	89° 43′ 20″	L. a. L. S.[1] (20 feet).

Surajgánj lies in the Ganges-Brahmapútra Delta; the height mentioned above refers only to the height of the instruments above the level of the Konái.

No. 7. Dháka, in Eastern Bengál.

This is a large station, situated on the Bára Gánga, one of the ramifications in the upper part of the Ganges Delta. It is 150 miles north-east of Calcutta.

I (Hermann) put up the dip circle at a short distance from the principal ghāt or landing place. When I first passed Dháka, in going up to Assám, I was seriously ill and confined to my boat; and when returning, my stay was so limited, that I could

[1] L. a. L. S. = Little above the level of the sea.

only make a few magnetic observations. The latitude and longitude of this place were furnished me by the kindness of Mr. Brennand.

Latitude obtained from three series (*A*, *B*, *C*) of observations of Polaris by Mr. Brennand, 1855:

	Latitude N.
	° ′ ″
A,	23 42 26·9
B,	46·3
C,	57·24
Mean Lat. N.	23 42 43·5

Longitude East Green., determined by the officers of the Great Trigonometrical Survey, and communicated to Mr. Brennand, 1855:

90° 20′ 15″.

(Thuill. App. gives latitude N.: 23° 43′ 10″.)

Height: A few feet above the level of the sea.

Meridian.

Deduced from corresponding low Altitudes of the Sun . . . . 161° 25′·2.

No. 8. Kúlna, in Eastern Bengál.

This small town, in the district of Jăssór, is situated on the right bank of the Bháirab, one of the numerous ramifications in the Ganges Delta, and is about 75 miles east of Calcutta. The river steamers between Calcutta and Dháka pass by regularly. The instruments were placed close to the river, 10 feet above the water.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
22° 45′ 55″	89° 36′ 55″	L. a. L. S.
		(25 feet above the level of the Bháirab.)

Observations: 1856, February 24.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude.

1856, February 24.	Horizontal Circle.	Vertical Circle.
	A. M.	
	Sun, Lower Limb.	
h m s	° ′ ″	° ′ ″
1) 5 11 6	357 57 15	54 20 0
2) 5 47 3	13 24 20	56 49 35
3) 6 3 14	20 25 10	57 12 50

Barom. { 758·0 millim. / 29·843 inches. Temp. of Air { 26°·6 C. / 79·9 Fahr.

Calculated by Method I., from observations 1 and 3.

Refraction	— 0′·6
Parallax	+ 0·1
Semidiameter	+ 16·2
Sum of Corr.	+ 15·7

1) h corr. = 54° 35′·7

3) h' corr. = 57 28·5

$\delta = \delta' = -9° 44'·0$

Latitude N. . . . . . . 22° 45′·9.

Time.

	h	m	s
Apparent Noon, deduced from the Altitude of the Sun, from observation 1	6	8	33
Equation of Time		13	36
Mean Noon	5	54	57

Control for Latitude and Time.

Calculated Apparent Altitude at $5^h\ 47^m\ 3^s$ =		56° 49′·0
Observation		56 49·6
Calc.—Obs.	—	0·6

Longitude.

	h	m	s
Mean Noon by Chron. 3, at Calcutta, 1856, March 26	6	0	7
Mean Noon by Chron. 3, at Kúlna, $5^h\ 54^m\ 57^s$			
Rate = IX. = Losing $0^s·17$			
Mean Noon Kúlna, corrected for rate	5	55	2
Meridional Difference in Time	0	5	5
„ „ in Arc	1°	16′	20″
Longitude of Calcutta, E. Green.	88	20	34
Longitude of Kúlna, E. Green.	89	36	54

For this place we have no other determination of latitude and longitude for comparison with ours.

Meridian.

Deduced from a bearing to the Sun with the prismatic compass, in the early morning 22° 52′·6.

No. 9. Calcutta, in Bengál.

The observations were made in the Botanical Garden, south-west of the town. Mr. Grote, C. S., and Dr. Thomson, who at that time had charge of this well known scientific institution, most kindly allowed me (Hermann) to make use of it for the observations. The Calcutta Observatory, under the direction of Colonel Waugh, Surveyor General, and Major Thuillier, Deputy Surveyor, which we so often have occasion to mention, on account of corresponding observations and other scientific materials supplied, is at No. 35, Park-street.

The following are the Observatory's

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
22° 33′ 1″	88° 20′ 34″	18 feet.

(My instruments stood 12 feet above the Húgli at mean height.)

One series was made in March, 1856; the second in April, 1857. At Calcutta, I was kindly assisted by Baron George Liebig, M.D., then Assay Master of the Mint.

A. *Observations: 1856, March 23.*

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

Sun, Lower Limb.

1856, March 23.		Horizontal Circle.	Vertical Circle.
		A. M.	
	h m s	° ′ ″	° ′ ″
1)	6 2 52	343 20 25	68 18 10
2)	6 6 35	346 9 10	68 20 25
		P. M.	
	h m s	° ′ ″	° ′ ″
3)	6 11 10	349 11 20	68 19 5
4)	6 18 39	354 7 15	68 10 55

Barom. { 756·7 millim. / 29·792 inches. Temp. of Air { 31·2° C. / 88·2 Fahr.

Calculated by Method III., from observations 1, 2, 3.

True Altitude of Sun's Centre at Apparent Noon	68° 36′·4
Latitude North	22 31·7
Mean Noon (corrected for Equation of Time)	6h 0m 32s

Control.

	° ′
Calculated Apparent Altitude at $6^h\ 18^m\ 39^s$ . .	68 11·1
Observation	68 11·0
Calc.—Obs.	+ 0·1

Meridian.

The considerable Altitude of the Sun being unfavourable for the calculation of the Meridian (though very good for Latitude), the Meridian was determined directly by observing the passage of η *Argus* and *Alphard*, and was found to be . . . . 346° 47′·6.

B. *Observations: 1857, April 13.*

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 9, Pistor. Observer: Hermann.

Meridian.

Sun, Upper Limb.

1857, April 13.	Horizontal Circle.	Vertical Circle.
$3^h\ 13^m\ 1^s$	292° 41′ 10″	24° 25′ 50″

Barom. { 760·0 millim. / 29·922 inches. Temp. of Air { 33°·1 C. / 91·6 Fahr.

	° ′
Hour Angle of Sun in Arc	67 30·5
Meridian	207 12·1

GROUP III.

VALLEY OF THE GANGES AND ITS TRIBUTARIES.

STATIONS 10 TO 18.

Rámpur Bólea.—Kissengánj (Bariadángi).—Pátna.—Sigáuli.—Benáres.—Lăkhnáu.—Aligárh.—Ágra.—Mírăth.

No. 10. Rámpur Bólea, in Eastern Bengál.

This is a small town on the left side of the Ganges, situated on its great eastern branch Pódda. My observations were made in the civil station, near Mr. Herschel's house, at a short distance from the river.

Lieutenant Adams being taken very ill at this place, my (Hermann's) observations were limited to the determination of magnetic intensity. Mr. Herschel gave me his friendly assistance in putting up the instruments.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
24° 21′ 46″	88° 34′ 20″	54 feet.

Latitude and longitude are taken from Thuill. App.

No. 11. Kissengánj, or Bariadángi, in Western Bengál.

This town is situated in the district of Párnea, close to the Mahanáddi.

I here made a stay of two days, before beginning the boat voyage to the foot of the Khássia Hills. The cloudy state of the sky, the rains during this season being still very heavy, allowed only of evening observations for determining the meridian required for the magnetic declination. (Observer: Hermann, 1855, August 18.)

The latitude and longitude is taken from the Revenue Map of Messrs. Fitzpatrick and Pemberton.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 6′ 0″	87° 56′ 8″	140 feet.

Determination of the Meridian.

Deduced from the Transit of *Antares* in the Scorpion, in the early evening hours 258° 10′·4.

No. 12. Pátna, in Western Bengal.

This important place, situate on the right bank of the Ganges, is 377 miles by land N. W. of Calcutta. Besides being a large native city with numerous suburbs, it contains extensive cantonments, and is remarkable for its antiquity and for the history connected with it.

I had my instruments put up in the garden of Mr. Woodcock, then collector of the district.—The dip was made in the shade of fine mango trees.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
25° 37′ 12″	85° 7′ 32″	170 feet.

Observations: 1857, February 6.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 9, Pistor. Observer: Hermann.

Latitude and Time.

Sun, Lower Limb.

	1857, February 6.	Horizontal Circle.	Vertical Circle.
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	7 54 49	214 39 45	48 21 35
2)	8 1 46	217 34 0	48 27 5
		P.M.	
	h m s	° ′ ″	° ′ ″
3)	8 15 10	222 25 27	48 27 40
4)	8 23 40	229 8 58	48 41 13

Barom. { 751·2 millim. / 29·575 inches. Temp. of Air { 30°·2 C. / 86·4 Fahr.

Calculated by Method III., from observations 1, 2, 3.

Apparent Noon deduced from 1 and 2	$8^h\ 9^m\ 5^s$
Apparent Noon deduced from 2 and 3	$8^h\ 9^m\ 5^s$
True Altitude of the Sun at the Culmination	48° 44′·9
Sun's Declination	15° 36′·0
Elevation of the Equator	64° 20′·9
Latitude North	25° 39′·1

For the Gola (Round House) at Pátna, not very far from the place of observation, the G. T. S. gives:

	° ′ ″
Latitude North	25 37 12
Longitude East Green.	85 7 32

Our own observations, being very near the meridian, are not well situated for a chronometric determination of longitude.

Meridian.

Calculated from corresponding Altitudes of the Sun . . 221° 51′·1.

No. 13. Sigáuli, in Western Bengál.

This important military frontier station of Bengál, towards Nepál, is 24 miles distant from the southern border of the Tarái, an unhealthy tract of country at the base of the Himálaya.

My time being fully occupied with preparations for the journey to Nepál, I (Hermann) could only determine the magnetic dip. My instrument was put up in the compound of my friend Major Holmes, who, to my great regret, was murdered a few months later by the troop of irregular cavalry under his command.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 46′ 41″	84° 44′ 26″	260 feet.

Latitude and longitude are taken from the G. T. S.

No. 14. Benáres, in Hindostán (N.W. Prov.).

Benáres, very beautifully situated on the left bank of the Ganges, is celebrated all over the world as one of the most sacred places for Hindu worship. It contains a remarkable number of religious monuments and institutions, and, amongst its population, proportionally more Bráhmans, Pándits and Fakírs, than any other town of India.

It is also distinguished for possessing a native observatory, built in the middle of the 17th century by Rája Jai Singh of Jaianágger, minister to Mohámmad Shah, Emperor of Déhli, who reigned from 1719 to 1748. It is now in a state of decay.[1] Similar observatories, also constructed by Rája Jai Singh, were formerly in existence at Déhli, at Máthra on the Jámna, and at Újen (Oojein) in Málva. The following are the observatory's

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
25° 18′ 26″	82° 59′ 47″	325 feet.

Latitude and longitude from G. T. S.

My (Hermann's) magnetic instruments were put up on a spot not very far from the English church at Benáres. On this day (1856, April 4), a heavy dust-storm unfortunately made it quite impossible to take proper observations of the sun from an unsheltered place.

[1] The instruments of this observatory have been described by Hunter in the Asiatic Society's Researches, by Sir R. Barker in Phil. Trans. Vol. 67, 1777, p. 608, and by J. S. Williams in Phil. Trans. Vol. 83, 1793, p. 43. In Hooker's Himálayan Journals (London, 1854), pp. 74 to 77, the principal instruments are very well represented in woodcuts.

Meridian.

When the dust-storm had somewhat subsided, the passage of *Spica* (α Virginis) was observed late in the night.

Meridian . . . . 101° 1′·9.

No. 15. Lăkhnáu, in Audh.

This town, the capital of Audh, with a very large native population, estimated, before its annexation, at 300,000, is situated on the right side of the river Gúmti.

Its geographical position, given below, has been minutely determined by Major Wilcox, who had charge, under the preceding native dynasty, of an astronomical observatory.

My instruments were placed one mile S. S. E. of the observatory.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 51′ 10″	80° 55′ 32″	520 feet.

Observations: 1856, April 9.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

Sun, Lower Limb.

	1856, April 9.	Horizontal Circle.	Vertical Circle.
		A. M.	
	h m s	° ′ ″	° ′ ″
1)	4 52 56·0	266 32 20	59 27 40
2)	4 59 28·4	268 43 20	60 39 45
		P. M.	
	h m s	° ′ ″	° ′ ″
3)	8 58 17·0	29 34 40	50 1 0

Barom. { 742·2 millim. / 29·221 inches. Temp. of Air { 32°·2 C. / 90·0 Fahr.

Calculated by Method I., from Observations 1 and 3.

	1.	2 (Control).	3.
	′ ″	′ ″	′ ″
Refraction	— 0 32	— 0 30	— 0 44
Parallax	+ 0 5	+ 0 5	+ 0 5
Semidiameter	+ 16 0	+ 16 0	+ 16 0
Sum of Corr. . . .	+ 15 33	+ 15 35	+ 15 21

1) h corr.	= 59° 43′ 13″	δ	= 7° 38′ 55″
3) h' corr.	= 50 16 21	δ′	= 7 42 41

Latitude North . . . . 26° 54′·8
Time: Mean Noon (corr. for Equation of Time) 6ʰ 29ᵐ 54ˢ

Control.

Calculated Apparent Altitude		60° 38′·3
Observation	+	60 39·7
Calc.—Obs.	—	1·4

Meridian.

Deduced from the Observations of the Sun . . . . . 321° 29′·4.

No. 16. Aligárh, in Hindostán (N.W. Prov.).

A town of considerable importance, and a civil station, 84 miles south-east of Déhli.

Mr. Charles Gubbins had the kindness to communicate to me (Hermann) his observations of latitude and longitude, as well as the position of his meridian marks, all based upon a series of most careful and often repeated operations. The meridian marks consisted of delicate lines traced upon glass, and were fixed in solid walls.

The G. T. S. gives for the Fort:	Lat. N.	27° 55′ 41″
„ „	Long. E. Green.	78 2 48

The latitude and longitude, given below, referring to the place of observation itself, are those determined by Mr. Gubbins.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 53′ 50″	78° 3′ 55″	760 feet.

No. 17. Ágra, in Hindostán (N.W. Prov.).

Latitude and longitude, as determined by the G. T. S., are referred to the Taj Mahál Dome. The observations of equal altitudes for determining meridian and declination were made near the house of General Boileau, who had kindly invited me to stay with him.

Observer: Hermann. 1856, April 15.

The declination was ascertained here by comparison with the meridian deduced from low corresponding altitudes of the sun, 1856, April 15:

Meridian thus found . . . . 100° 2′·9.

Geographical Co-ordinates.

Referred to the Taj, G. T. S.

Latitude North.	Longitude East Green.	Height.
27° 10′ 26″	78° 1′ 39″	657 feet.

No. 18. Míräth, in Hindostán (N.W. Prov.).

A large town, and very important military station, 25 miles west of the Ganges, and 30 miles east of the Jámna. It is one of the finest stations in Upper India.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
29° 0′ 41″	77° 41′ 48″	865 feet.

Latitude and longitude from G. T. S.

Though staying but a short time during the hottest hours of the day, I (Hermann) determined the magnetic declination, making use of Mr. Gubbins' previous meridional marks.

GROUP IV.

PÁNJÁB, SINDH, AND KĂCH.

STATIONS 19 TO 30.

Ambála.—Lahór.—Raulpíndi.—Pesháur Sháhpur.—Déra Ismáel Khan.—Multán.—Shikárpur.—Sĕvan.—Kărráchi.—Bhūj.—Rajkót.

No. 19. Ambála, in Sărhínd (Pănjáb).

This large station, in the Cis-Sátlej division, contains extensive barracks and cantonments. It is situated 40 miles distant from the southern foot of the Himálaya, in a highly cultivated, level plain.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
30° 21′ 25″	76° 48′ 49″	1,026 feet.

Observations: 1857, January 15.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 9, Pistor. Observer: Hermann.

Latitude and Time.

1857, January 15.	Sun, Upper Limb. Horizontal Circle.	Vertical Circle.
	A.M.	
1) 7h 28m 35s	146° 6′ 30″	36° 17′ 15″
	P.M.	
2) 10h 7m 35s	31° 43′ 20″	34° 39′ 27″
3) 10 13 2	33 6 40	34 8 5

Barom. { 740·9 millim. / 29·170 inches. Temp. of Air { 34°·0 C. / 93·2 Fahr.

Calculated by Method I., from the Observations 1 and 3.

	1.	3.	2. (Control).
Refraction	— 1′ 13″	— 1′ 18″	— 1′ 21″
Parallax	+ 7	+ 6	+ 6
Semidiameter	— 16 17	— 16 17	— 16 17
Sum of Corr. . . .	— 17 23	— 17 29	— 17 32

h corr. = 35° 59′ 52″ δ = — 21° 7′ 51″

h' corr. = 33 50 37 δ' = — 21 6 39

Latitude North . . . . 30° 12′·7

Time: Mean Noon (corrected for Equation of Time) . . . 8h 28m 25s

Control.

Calculated Altitude corresponding to obs. 2 . . .	34° 38′·9
Observed Altitude	34 39·5
Calc.—Obs.	— 0·6

Latitude and longitude given above are G. T. S. values.

Meridian.

Deduced from the Observations of the Sun . . . 6° 4′·3.

No. 20. Lahór, in the Pănjáb.

This famous city was formerly the principal seat of the Sikh Empire, and even now is the capital of the Pănjáb. It is situated in the Bári Duáb, about one mile east of the Rávi, the smallest of the Pănjáb rivers.

The European quarter, a little south of the native town, is called Anarkálli; it was here that the instruments were put up.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 34′ 5″	74° 14′ 37″	790 feet.

Observations: 1857, January 9.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 9, Pistor. Observer: Hermann.

Latitude.

1857, January 9.	Horizontal Circle.	Vertical Circle.
	Saturn.	
	(The ring being distinctly divided into two equal parts by the central wire.)	
$4^h\ 20^m\ 14^s$	265° 54′ 10″	39° 50′ 55″
	Polaris.	
$4^h\ 43^m\ 43^s$		32° 52′ 45″

Barom. { 746·4 millim. / 29·386 inches. Temp. of Air { 16·0 C. / 60·8 Fahr.

The corresponding mean local time was deduced from the observations of Saturn, an approximate latitude being introduced. By the second approximation we obtain from Polaris:

Latitude North . . . . 31° 42′ 30″.

Time.

	h m
Sidereal Time at $4^h\ 20^m\ 14^s$, Chron. 3, by first Approximation . . .	2 59·4
" " " by second Approximation . .	2 59·3

Meridian.

Deduced from the Observations of Saturn . . . 0° 6′·0.

No. 21. Raulpíndi, in the Pănjáb.

A large military station, situated in the northern part of the Sindh Ságer Dúab, about half way distant from the Indus and the Jhílum.

We staid here a little longer than usual, in order to make a general comparison of our chronometers and magnetic instruments.

The instruments were put up at a considerable distance from the native town, in the cantonment.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
33° 36′ 30″	72° 59′ 49″	1,674 feet.

Observations: 1856, December 2 and 3.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 6, Adie. Observer: Robert.

Latitude and Time.

1856, December 3.		Horizontal Circle.	Vertical Circle.
		A. M.	
		Sun, Upper Limb.	
	h m s	° ′ ″	° ′ ″
1)	4 27 58	177 35 20	26 41 45
		Sun, Lower Limb.	
	h m s	° ′ ″	° ′ ″
2)	4 36 18	179 31 15	27 4 20
3)	4 38 45	180 4 45	27 20 20
4)	4 42 15	180 55 5	27 42 0
5)	4 45 33	181 41 40	28 3 5
6)	4 48 35	182 24 0	28 21 15
		P. M.	
		Sun, Upper Limb.	
	h m s	° ′ ″	° ′ ″
7)	8 21 10	238 45 25	29 13 15
8)	8 25 24	239 45 45	28 47 15
9)	8 27 45	240 19 45	28 33 45
10)	8 37 51	242 39 40	27 29 40
11)	8 43 16	243 54 35	26 53 45
12)	8 48 39	245 6 50	26 16 15

Barom. { 719·0 millim. / 28·308 inches. Temp. of Air { 17·8° C. / 64·0 Fahr.

Calculated by Method II.

As the first data of observations, the mean of 2, 3, 4, 5, and 6 was taken; the corresponding altitude, after the culmination, is interpolated from observations 10 and 11.

Latitude North . . . . 33° 37′·2

Time: Mean Noon, taking into the calculation the variation of the Sun's Declination during the period of the observations . . . . $6^h\ 46^m\ 25^s$

Second Approximation.

Comparison of the Different Single Observations with the Elements deduced from the First Approximation.

	Group I.						Group II.						
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	
Time by Chronometer	$4^h 27^m 58^s$	$4^h 36^m 18^s$	$4^h 38^m 45^s$	$4^h 42^m 15^s$	$4^h 45^m 33^s$	$4^h 48^m 35^s$	$8^h 21^m 10^s$	$8^h 25^m 24^s$	$8^h 27^m 45^s$	$8^h 37^m 51^s$	$8^h 43^m 16^s$	$8^h 48^m 39^s$	Time by Chronometer.
Mean Noon (from 1st Approx.)	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	$6^h 46^m 25^s$	Mean Noon (from 1st Approx.)
Mean Local Time	$-2^h 18^m 27^s$	$-2^h 10^m 7^s$	$2^h 7^m 40^s$	$-2^h 4^m 10^s$	$-2^h 0^m 52^s$	$-1^h 57^m 50^s$	$+1^h 34^m 45^s$	$+1^h 38^m 59^s$	$+1^h 41^m 20^s$	$+1^h 51^m 26^s$	$+1^h 56^m 51^s$	$+2^h 2^m 14^s$	Mean Local Time
Equation of Time	$+9^m 56^s$	$+9^m 56^s$	$+9^m 56^s$	$+9^m 56^s$	$+9^m 56^s$	$+9^m 56^s$	$+9^m 55^s$	$+9^m 55^s$	$+9^m 54^s$	$+9^m 54^s$	$+9^m 54^s$	$+9^m 54^s$	Equation of Time.
Hour Angle in Time	$-2^h 8^m 31^s$	$-2^h 0^m 11^s$	$-1^h 57^m 44^s$	$-1^h 54^m 14^s$	$-1^h 50^m 56^s$	$-1^h 47^m 54^s$	$+1^h 44^m 40^s$	$+1^h 48^m 54^s$	$+1^h 51^m 14^s$	$+2^h 1^m 20^s$	$+2^h 6^m 45^s$	$+2^h 12^m 8^s$	Hour Angle in Time.
Hour Angle in Arc $= t$	−32° 7′·8	−30° 2′·8	−29° 26′·0	−28° 33′·5	−27° 44′·0	−26° 58′·5	+26° 10′·0	+27° 13′·5	+27° 48′·5	+30° 20′·0	+31° 41′·3	+33° 2′·0	Hour Angle in Arc $= t$.
δ (Sun's Declination)	−22° 9′·4	−22° 9′·4	−22° 9′·4	−22° 9′·4	−22° 9′·4	−22° 9′·4	−22° 9′·5	−22° 9′·5	−22° 9′·5	−22° 9′·5	−22° 9′·5	−22° 9′·5	δ = Sun's Declination.
sin φ sin δ	−0·20881	−0·20881	−0·20881	−0·20881	−0·20881	−0·20881	−0·20882	−0·20882	−0·20882	−0·20882	−0·20882	−0·20882	sin φ sin δ.
cos φ cos δ cos t	+0·65311	+0·66757	+0·67152	+0·67739	+0·68262	+0·68732	+0·69217	+0·68577	+0·68215	+0·66563	+0·65623	+0·64654	cos φ cos δ cos t.
Sum = sin h	0·44430	0·45876	0·46271	0·46858	0·47381	0·47851	0·48335	0·47695	0·47333	0·45681	0·44741	0·43772	Sum = sin h.
h (True Altitude of the Sun's Centre)	26° 22′·7	27° 18′·4	27° 33′·8	27° 56′·5	28° 17′·0	28° 35′·3	28° 54′·2	28° 29′·2	28° 15′·1	27° 10′·9	26° 34′·7	25° 57′·6	h (True Altitude of the Sun's Centre).
Refraction	+ 1′·9	+ 1′·8	+ 1′·7	+ 1′·7	+ 1′·7	+ 1′·6	+ 1′·6	+ 1′·7	+ 1′·7	+ 1′·8	+ 1′·8	+ 1′·9	Refraction.
Parallax	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	Parallax.
Apparent calcul. Altitude of the Sun's Centre	26° 24′·5	27° 20′·1	27° 35′·4	27° 58′·1	28° 18′·6	28° 36′·8	28° 55′·7	28° 30′·8	28° 16′·7	27° 12′·6	26° 36′·4	25° 59′·4	Apparent calcul. Altitude of the Sun's Centre.
± Sun's Semidiameter	+ 16′·3	− 16′·3	− 16′·3	− 16′·3	− 16′·3	− 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	± Sun's Semidiameter.
Calculated Observation	26° 40′·8	27° 3′·8	27° 19′·1	27° 41′·8	28° 2′·3	28° 20′·5	29° 12′·0	28° 47′·1	28° 33′·0	27° 28′·9	26° 52′·7	26° 15′·7	Calculated Observation.
Direct Observation	27° 41′·7	27° 4′·3	27° 20′·3	27° 42′·0	28° 3′·1	28° 21′·3	29° 13′·2	28° 47′·3	28° 33′·7	27° 29′·7	26° 53′·7	26° 16′·2	Direct Observation.
Calc.—Obs.	− 0′·9	− 0′·5	− 1′·2	− 0′·2	− 0′·8	− 0′·8	− 1′·2	− 0′·2	− 0′·7	− 0′·8	− 1′·0	− 0′·5	Calc.—Obs.
	Group *A*.						Group *B*.						

The preceding table shows very small errors: this, consequently, allows of as accurate a result being obtained (and in a shorter way), as by the application of the method of least squares. The mean of errors is:

for Group A . . . . — 0′·7
for Group B . . . . — 0·7
and the sum of the squares of errors . . . . 8′·10.

Since the mean error is equally great, and has the same sign before and after the culmination, the meridian remains unaltered; besides, the observations being near the meridian, the differential of latitude is equal to the differential of altitude.

Therefore a decrease of latitude for 0′·7 appears to give the best result:

Latitude North . . . . 33° 36′ 30″.

With this corrected latitude (33° 36′ 30″), and the noon, as obtained above, the remaining differences between calculated and direct observation are:

No. of Observ.	Calc.—Obs.	No. of Observ.	Calc.—Obs.
	′		′
1	— 0·2	7	— 0·5
2	+ 0·2	8	+ 0·5
3	— 0·5	9	— 0·0
4	+ 0·5	10	— 0·1
5	— 0·1	11	— 0·3
6	— 0·1	12	+ 0·2

The sum of the squares of errors is now diminished from 8′·10 to 1′·11.

Thuill. App. gives latitude 33° 34′ 40″ N.

Longitude.

A. By Lunar Distances.

1856. December 2.	Horizontal Circle.	Vertical Circle.
	Jupiter.	
1ʰ 44ᵐ 17ˢ	204° 10′ 30″	54° 39′ 45″
	Moon, Lower Limb.	
h m s	° ′ ″	° ′ ″
1 29 4	250 49 40	20 57 25
1 51 39	255 9 25	17 57 15

Barom. { 721·4 millim. / 28·402 inches. Temp. of Air { 13°·2 C. / 55·8 Fahr.

The two observations of the moon have been used in order to interpolate her apparent co-ordinates for the time when Jupiter was observed. We obtain for the moon

at 1ʰ 44ᵐ 17ˢ 253° 44′·7 18° 56′·1.

Reduction to geocentric and true Altitudes.

(Compare the more detailed calculations pp. 112 and 113.)

	Moon	Jupiter.
	′	′
Refraction	− 2·6	− 0·6
Parallax	+ 53·9	0·0
Semidiameter	+ 15·6	. . .
Sum of Corr. . .	+ 66·9	− 0·6

Arc of the Almucantarat . . . . 49° 34′·2

Therefore:

True geocentric Distance between the Moon and Jupiter 50° 47′·7

	h	m	s
Corresponding Green. Time	2	8	48
Corresponding Mean Local Time	6	57	52
Longitude in Time	4	49	4

By calculating the Altitudes of the Moon, we obtain the Longitude in Time East of Green. $4^h\ 48^m{\cdot}3$.

B. By Chronometer 1.

The short interval of time between the observations at Raulpíndi and at Pesháur was very favourable for the determination of the difference of longitude by chron. 1, the rate of which (XV.) had been very accurately ascertained. Pesháur, at the same time, had the advantage of being a station fixed by the G. T. S. in direct connection with its minute operations of the measurement of arc in Sindh.

	h	m	s
Mean Noon at Raulpíndi, by Chron. 1, from a comparison, December 3, with Chron. 3 (see p. 100)	7	18	58·8
The rate (XV.) of Chron. 1 has been found to be, from Márri, November 13, to Adolphe's last Observations = Losing $3^s{\cdot}5$			
Mean Noon at Raulpíndi for December 22, corrected for rate	7	17	52
Mean Noon at Pesháur, December 22	7	23	44
Meridional Difference in Time		5	52
	°	′	″
„ „ in Arc	1	28	0
Pesháur, East of Green.	71	33	19
Raulpíndi, East of Green.	73	1	19

This result of chronometric longitude, which we adopt, only differs from the approximate value (73° 1″ 55′) given in Thuill. App. by 0′ 36″ in arc.

Meridian.

Deduced from Altitudes of the Sun . . . . 211° 37′·0.

No. 22. Peshâur, in the Pănjâb.

On account of its position, west of the Indus and near the frontier of Kábul, this is one of the most important military and political stations of north-western India, with very large cantonments.

The instruments were set up near the lower end of the Sâdder bazar (principal bazar), in a large open space before the mess house of the European Infantry barracks.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
34° 3′ 10″	71° 33′ 19″	1,250 feet.

Observations: 1856, December 22.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 11, Pistor. Observer: Adolphe.

Latitude and Time.

Sun, Upper Limb.

	1856, December 22.	Horizontal Circle.	Vertical Circle.
		A. M.	
	h m s	° ′ ″	° ′ ″
1)	6 49 22	281 35 33	32 12 10
2)	7 4 22	285 38 10	32 36 0
3)	7 12 8	287 44 20	32 44 20
4)	7 21 44	290 23 0	32 46 50
		P. M.	
	h m s	° ′ ″	° ′ ″
5)	7 28 29	292 12 20	32 46 45
6)	7 39 6	295 3 20	32 40 15
7)	7 58 39	300 20 55	32 11 26

Barom. { 734·1 millim. / 28·902 inches. Temp. of Air { 15·6° C. / 60·1 Fahr.

First Approximation.

Circum-meridional altitudes, calculated from 3, 4, and 5, by Method III.

	° ′ ″
Apparent Altitude of Sun's Upper Limb, when culminating	32 46 59
Refraction	— 1 26
Parallax	+ 0 7
Semidiameter	— 16 18
Sum of Corr.	— 17 37
Calculated true Altitude	32 29 22
Sun's Declination	— 23 27 28
Latitude N.	34 3 10
Time: Mean Noon (corr. for Equation of Time)	$7^h\,25^m\,47^s$

Second Approximation.

	A. M.				P. M.		
	Group I.				Group II.		
	1.	2.	3.	4.	5.	6.	7.
Time of Observ. by Chron. 1	$6^h\ 49^m\ 22^s$	$7^h\ 4^m\ 22^s$	$7^h\ 12^m\ 8^s$	$7^h\ 21^m\ 44^s$	$7^h\ 28^m\ 29^s$	$7^h\ 39^m\ 6^s$	$7^h\ 58^m\ 39^s$
Apparent Noon (from 1st Approximation)	$7^h\ 24^m\ 44^s$	$7^h\ 24^m\ 44^s$	$7^h\ 24^m\ 44^s$	$7^h\ 24^m\ 44^s$	$7^h\ 24^m\ 44^s$	$7^h\ 24^m\ 44^s$	$7^h\ 24^m\ 44^s$
Hour Angle in Time . . .	$-\ 0^h\ 35^m\ 22^s$	$-\ 0^h\ 20^m\ 22^s$	$-\ 0^h\ 12^m\ 36^s$	$-\ 0^h\ 3^m\ 0^s$	$+\ 0^h\ 3^m\ 45^s$	$+\ 0^h\ 14^m\ 22^s$	$+\ 0^h\ 33^m\ 55^s$
Hour Angle in Arc = *t* .	— 9° 20′·5	— 5° 5′·5	— 3° 9′·0	— 0° 45′·0	+ 0° 56′·3	+ 3° 35′·3	+ 8° 28′·8
δ = Sun's Declination . . .	— 23° 27′·5	— 23° 27′·5	— 13° 27′·5	— 23° 27′·5	— 23° 27′·5	— 23° 27′·5	— 23° 27′·5
sin φ sin δ	— 0·22291	— 0·22291	— 0·22291	— 0·22291	— 0·22291	— 0·22291	— 0·22291
cos φ cos δ cos *t*	+ 0·74997	+ 0·75706	+ 0·75890	+ 0·75998	+ 0·75994	+ 0·75856	+ 0·75173
Sum = sin *h*	0·52706	0·53415	0·53599	0·53707	0·53703	0·53565	0·52882
h = true Altitude of the Sun's Centre	31° 48′·4	32° 17′·1	32° 24′·6	32° 29′·0	32° 28′·9	32° 23′·2	31° 55′·6
Refraction	+ 1·4	+ 1′·4	+ 1′·4	+ 1′·4	+ 1′·4	+ 1′·4	+ 1′·4
Parallax	— 0·1	— 0′·1	— 0′·1	— 0′·1	— 0′·1	— 0′·1	— 0′·1
Apparent calc. Altitude of Centre	31° 49′·7	32° 18′·4	32° 25′·9	32° 30′·3	32° 30′·2	32° 24′·5	31° 56′·9
± Sun's Semidiameter . .	+ 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	+ 10′·3	+ 16′·3	+ 16′·3
Calculated Observation . .	32° 6′·0	32° 34′·7	32° 42′·2	32° 46′·6	32° 46′·5	32° 40′·8	32° 13′·2
Direct Observation	32° 12′·2	32° 36′·0	32° 44′·3	32° 46′·7	32° 46′·6	32° 40′·3	32° 11′·4
Calc.—Obs.	— 6′·2	— 1′·3	— 2′·1	— 0′·1	— 0′·1	+ 0′·5	+ 1′·8
	Group *A*.				Group *B*.		

The mean of errors

from Group A (Observation 1 being excluded) $= - 1'\cdot 4$
from Group B . . . . $= + 1'\cdot 3$

These numbers being very nearly equal, but with opposite signs, it results, as can be directly seen, that

$$d\varphi = 0,$$

and dt can be deduced directly from the equation

$$0 = + 0\cdot 16 - 8\cdot 97\ dt.$$

the co-efficients being logarithmical.

$$dt = + 15'\cdot 0 \qquad dT = - 1^{m}\ 0^{s}$$

therefore:

Latitude N. . . $= \varphi = 34° 3' 10''$, remaining unaltered;
Apparent Noon $= T = 7^{h}\ 23^{m}\ 44^{s}$.

The direct readings are obtained within a few tenths of the minute by introducing these elements.

(The latitude of Pesháur as given by the G. T. S. is

Latitude North 34° 4′ 44″

referred to the fort.)

Longitude.

The G. T. S. gives Longitude East Green. . . . . 71° 33′ 19″.

Meridian.

Deduced from Observations of the Sun . . . . . . 290° 56′·8.

No. 23. Sháhpur, in the Pánjáb.

This small town has been recently selected as a military and civil station. It is situated in the Jĕch Duáb, about two miles distant from the left bank of the Jhílum.

I had my theodolite placed near the commanding officer's house.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
32° 14′ 0″	72° 32′ 30″	680 feet.

Observations: 1856, December 28.

Instruments: Theodolite 1, Jones; Chron. 4; Barom. 8, Pistor. Observer: Robert.

Latitude and Time.

1856, December 28.		Horizontal Circle.	Vertical Circle.
		A. M.	
		Sun, Lower Limb.	
	h m s	° ′ ″	° ′ ″
1)	4 17 51	71 4 33	18 21 20
2)	4 26 47	72 46 47	19 46 0
3)	4 32 8	73 46 30	20 30 0
4)	4 37 33	74 50 33	21 15 10
5)	4 46 35	76 37 50	22 29 55
6)	4 59 33	79 19 50	24 13 10
		P. M.	
		Sun, Upper Limb.	
	h m s	° ′ ″	° ′ ″
7)	9 54 27	153 39 30	24 14 25
8)	10 2 38	135 19 10	23 7 10
9)	10 18 31	158 26 45	20 57 10
10)	10 23 10	159 20 40	20 14 55
11)	10 29 57	160 35 43	19 16 40
12)	10 37 8	161 56 45	18 15 15

Barom. { 751·0 millim. / 29·567 inches. Temp. of Air { 11°·8 C. / 53·2 Fahr.

First Approximation.

Calculated by Method I., from Observations 6 and 12.

	6.	12.
	′ ″	′ ″
Refraction	— 2 14	— 2 59
Parallax	+ 0 8	+ 0 8
Semidiameter	+ 16 18	— 16 18
Sum of Corr. . .	+ 14 12	— 19 9

6) h corr. = 24° 27′·4 δ = — 23° 17′·7

12) h' corr. = 17 56·1 δ' = — 23 17·0

Latitude N. . . . . 32° 18′·5

Time: Mean Noon (corr. for Equation of Time) 7h 23m 1s.

Second Approximation.

Comparison of the Single Observations with the Elements obtained by the First Approximation.

	Group I. A.M.					Group II. P.M.					
	1.	2.	3.	4.	5.	7.	8.	9.	10.	11.	
Time of Observation by Chron. 4	$4^h 17^m 51^s$	$4^h 26^m 47^s$	$4^h 32^m 8^s$	$4^h 37^m 33^s$	$4^h 46^m 35^s$	$9^h 54^m 27^s$	$10^h 2^m 38^s$	$10^h 18^m 31^s$	$10^h 23^m 10^s$	$10^h 29^m 57^s$	Time of Observation by Chron. 4.
Mean Noon } from 1st Approx.	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	$7^h 23^m 1^s$	Mean Noon } from 1st Approx.
Mean Local Time }	$-\ 3^h 5^m 10^s$	$-\ 2^h 56^m 14^s$	$-\ 2^h 50^m 53^s$	$-\ 2^h 45^m 28^s$	$-\ 2^h 36^m 26^s$	$+\ 2^h 31^m 26^s$	$+\ 2^h 39^m 37^s$	$+\ 2^h 55^m 30^s$	$+\ 3^h 0^m 9^s$	$+\ 3^h 6^m 56^s$	Mean Local Time }
Equation of Time	$-\ 1^m 54^s$	$-\ 1^m 54^s$	$-\ 1^m 54^s$	$-\ 1^m 54^s$	$-\ 1^m 54^s$	$-\ 2^m 0^s$	$-\ 2^m 0^s$	$-\ 2^m 0^s$	$-\ 2^m 0^s$	$-\ 2^m 0^s$	Equation of Time.
Hour Angle in Time	$-\ 3^h 7^m 4^s$	$-\ 2^h 58^m 8^s$	$-\ 2^h 52^m 47^s$	$-\ 2^h 47^m 22^s$	$-\ 2^h 38^m 20^s$	$+\ 2^h 29^m 26^s$	$+\ 2^h 37^m 37^s$	$+\ 2^h 53^m 30^s$	$+\ 2^h 58^m 9^s$	$+\ 3^h 4^m 56^s$	Hour Angle in Time.
Hour Angle in Arc = t	− 46° 46′·0	− 44° 32′·0	− 43° 11′·7	− 41° 50′·5	− 39° 35′·0	+ 37° 21′·5	+ 39° 24′·2	+ 43° 22′·5	+ 44° 32′·2	+ 46° 14′·0	Hour Angle in Arc = t.
δ = Sun's Declination	− 23° 17′·4	− 23° 17′·4	− 23° 17′·4	− 23° 17′·4	− 23° 17′·4	− 23° 16′·7	− 23° 16′·7	− 23° 16′·7	− 23° 16′·7	− 23° 16′·7	δ = Sun's Declination.
$\sin\varphi \sin\delta$	− 0·21133	− 0·21133	− 0·21133	− 0·21133	− 0·21133	− 0·21122	− 0·21122	− 0·21122	− 0·21122	− 0·21122	$\sin\varphi \sin\delta$.
$\cos\varphi \cos\delta \cos t$	+ 0·53175	+ 0·55339	+ 0·56596	+ 0·57835	+ 0·59830	+ 0·61710	+ 0·59990	+ 0·56432	+ 0·55340	+ 0·53703	$\cos\varphi \cos\delta \cos t$.
Sum = $\sin h$	0·32042	0·34206	0·35463	0·36702	0·38697	0·40588	0·38868	0·35310	0·34218	0·32581	Sum = $\sin h$.
h (True Altitude of the Sun's Centre)	18° 41′·3	20° 0′·2	20° 46′·3	21° 31′·9	22° 46′·0	23° 56′·9	22° 52′·3	20° 40′·7	20° 0′·7	19° 0′·9	h (True Altitude of the Sun's Centre).
Refraction	+ 2′·9	+ 2′·7	+ 2′·5	+ 2′·4	+ 2′·3	+ 2′·2	+ 2′·4	+ 2′·5	+ 2′·6	+ 2′·8	Refraction.
Parallax	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	− 0′·1	Parallax.
Apparent calc. Altitude of Centre	18° 44′·1	20° 2′·8	20° 48′·7	21° 34′·2	22° 48′·2	23° 59′·0	22° 54′·6	20° 43′·1	20° 3′·2	19° 3′·6	Apparent calc. Altitude of Centre.
± Sun's Semidiameter	− 16′·3	− 16′·3	− 16′·3	− 16′·3	− 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	+ 16′·3	± Sun's Semidiameter.
Calculated Observation	18° 27′·8	19° 46′·5	20° 32′·4	21° 17′·9	22° 31′·9	24° 15′·3	23° 10′·9	20° 59′·4	20° 19′·5	19° 19′·9	Calculated Observation.
Direct Observation	18° 21′·3	19° 46′·0	20° 30′·0	21° 15′·2	22° 29′·9	24° 14′·4	23° 7′·2	20° 57′·2	20° 14′·9	19° 16′·7	Direct Observation.
Calc.—Obs.	+ 6′·5	+ 0′·5	+ 2′·4	+ 2′·7	+ 2′·0	+ 0′·9	+ 3′·7	+ 2′·2	+ 4′·6	+ 3′·2	Calc.—Obs.
	Group *A*.					Group *B*.					

The mean of the deviations (Calc.—Obs.) is:

$$\text{in Group } A = +2'\cdot 5$$
$$\text{in Group } B = +2'\cdot 4.$$

We obtain the following differential equations for reducing the errors to their minimum:

$$1) \quad 0 = +0\cdot 39 - 9\cdot 84\, d\varphi + 9\cdot 72\, dt$$
$$2) \quad 0 = +0\cdot 42 - 9\cdot 84\, d\varphi - 9\cdot 72\, dt,$$

the co-efficients being logarithmical.

The solution of these equations gives:

$$d\varphi = -4'\cdot 5$$
$$dt = \pm 0'\cdot 0;$$

therefore,

$$\text{Latitude N.} = \varphi = 32^\circ\ 14'\cdot 0$$
$$\text{Mean Noon} = T = 7^h\ 23^m\ 1^s.$$

The following table shows the remaining errors after the new elements are introduced:

No. of Observ.	Calc.—Obs.
1	+ 4'·0
2	— 2·0
3	— 0·1
4	+ 0·2
5	— 0·5
6	— 2·5
7	— 1·5
8	+ 1·3
9	— 0·2
10	+ 2·2
11	+ 0·8
12	— 2·4

Longitude.

	h	m	s
Mean Noon at Sháhpur, by Chron. 4, deduced from Observations of the Sun, 1856, December 28	7	23	1
Mean Noon at Sháhpur, corrected for rate since the last comparison at Raulpíndi, December 17, Rate = XIV. = gaining 15ˢ	7	20	10
Mean Noon at Raulpíndi, December 17, by Chron. 4	7	18	21
Meridional Difference in Time		1	49

= 27′ 15″ in Arc.

	°	′	″
Raulpíndi East of Greenwich	72	59	49
Sháhpur West of Raulpíndi		27	15
Sháhpur East of Greenwich	72	32	34

We have no other data of latitude and longitude exact enough for comparison.

Meridian.

Deduced from the Apparent Noon, as obtained by the second Approximation 102° 18′·0.

No. 24. DÉRA ISMÁEL KHAN, IN THE PĂNJÁB.

This station is situated on the right (western) side of the Indus, but its position was changed after being entirely destroyed by the floods of this large river. Even now it is not quite secured against the dangerous effects produced by a sudden rise of the Indus.

Déra Ismáel Khan is an important commercial place on one of the great routes which lead from the Pănjáb to the northern parts of Sindh.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 39′ 35″	70° 56′ 30″	478 feet.

Observations: 1857, February 25.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 11, Pistor. Observer: Adolphe.

Latitude and Time.

a. Observations of the Sun.

	1857, February 25.	Horizontal Circle. Sun, Upper Limb.	Vertical Circle.
	A.M.		
	h m s	° ′ ″	° ′ ″
1)	5 10 48	2 32 20	36 29 25
2)	5 17 19	4 6 40	37 28 30
3)	5 25 16	6 5 30	38 39 40
	P.M.		
	h m s	° ′ ″	° ′ ″
4)	10 32 4	102 37 5	31 50 10
5)	10 38 47	104 1 0	30 39 45
6)	10 44 24	105 9 20	29 40 45

Barom. { 739·8 millim. / 29·127 inches. Temp. of Air { 23°·8 C. / 74·8 Fahr.

I. = Mean A.M.

$5^h\ 17^m\ 48^s$ 37° 32′ 32″

II. = Mean P.M.

$10^h\ 38^m\ 25^s$ 30° 43′ 33″

Calculated by Method I.

	I.	II.
	′	′
Refraction	− 1·2	− 1·5
Parallax	+ 0·1	+ 0·1
Semidiameter	− 16·2	− 16·2
Sum of Corr.	− 17·3	− 17·6

I.	h corr. = 37° 15′·3	δ = − 9° 6′·5
II.	h' corr. 30 25·9	δ′ = − 9 1·8

Latitude N. . . . . 31° 38′·5

Time: Mean Noon (corr. for Equation of Time) $7^h\ 23^m\ 10^s$

A comparison of the single observations is not necessary, as the altitudes interpolated from the single observations, corresponding to the times of Mean I. and II., are nearly identical with these means.

b. Observations of *Alnitak*, in the girdle of Orion.

A second determination of latitude was made as follows:

1857, February 25. Alnitak.

Altitude.

h m s			° ′
17 23 10	Chron. 1.	Vertical Circle	37 46·0
= 10 0 0	Mean Local Time P.M.	Refraction . . .	− 1·2
		Corr. Altitude .	− 37 44·8

Barom. { 740·4 millim. / 29·150 inches. Temp. of Air { 15°·1 C. / 59·2 Fahr.

R.A. and δ taken from the British Association Catalogue and reduced to the time of observation:

$R.A. = 5^h\ 33^m\ 32^s$ δ = − 2° 1′·8.

Latitude N. 31° 40′·7.

As definitive result we adopt the mean:

Latitude N. 31° 39′ 35″.

Longitude.

We have no very exact data of latitude for comparison, the maps here differing very considerably, but not so for longitude. The value given above is the mean of the best maps which our brother had the opportunity of examining and comparing.

He adopted:

Longitude E. Green. . . . . 70° 56′ 30″.

The resulting rate XV., giving very good chronometric longitudes for the other stations, is another proof of the adopted longitude being correct.

Meridian.

Deduced from Altitudes of the Sun . . . . . . 49° 24′·0.

No. 25. Multán, in the Pănjáb.

This ancient city, the Malitán, or place of Mális, known since the time of Alexander the Great's expeditions in the Pănjáb, is situated in the Jĕch Duáb, three miles east of the Chináb. The station is surrounded by gardens and groves of very beautiful trees, which form a striking contrast to the general barrenness and aridity of the adjacent country.

The instruments were placed in the large open compound which is attached to the Government dăk bángalo.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
30° 10′ 10″	71° 34′ 34″	480 feet.

Observations: 1857, January 8.

Instruments: Theodolite 1, Jones; Chron. 4; Barom. 8, Pistor. Observer: Robert.

Latitude and Time.

1857, January 8.		Horizontal Circle.	Vertical Circle.
		A.M.	
		Sun, Lower Limb.	
	° ′ ″	° ′ ″	° ′ ″
1)	4 53 35	77 20 30	24 17 12
2)	4 57 36	77 58 50	24 54 27
(I.) 3)	5 1 0	78 38 33	25 21 42

P. M.

Sun, Upper Limb.

(II.)	4)	10° 11′ 31″	158° 58′ 50″	26° 0′ 22″
	5)	10 16 52	159 58 30	25 16 17
	6)	10 22 30	161 8 30	24 32 27
	7)	10 25 48	161 46 53	24 5 27

Barom. { 755·2 millim. / 29·733 inches. Temp. of Air { 19°·8 C. / 67·6 Fahr.

First Approximation.

Calculated by Method I., from Observations 3 and the mean of 4, 5, 6, and 7.

	I.	II.
Refraction	− 2′·0	− 2′·0
Parallax	+ 0·1	+ 0·1
Semidiameter	+ 16·3	− 16·3
Sum of Corr.	+ 14·4	− 18·2

I. h corr. = 25° 36′·1
II. h' corr. = 24 40·3

$\delta = \delta' = -\ 22°\ 14'\cdot5$

Latitude N. . . . . 30° 10′·8
Time: Mean Noon (corr. for Equation of Time) . . . $7^h\ 29^m\ 44^s$

Second Approximation.

Comparison of the single observations.

	Group I.		Group II.			
	1.	2.	4.	5.	6.	7.
Time of Obs. by Chron. 4.	$4^h 53^m 35^s$	$4^h 57^m 36^s$	$10^h 11^m 31^s$	$10^h 16^m 52^s$	$10^h 22^m 30^s$	$10^h 25^m 48^s$
Mean Noon . . } from 1st	$7^h 29^m 44^s$	$7^h 29^m 44^s$	$7^h 29^m 44^s$	$7^h 29^m 44^s$	$7^h 29^m 44^s$	$7^h 29^m 44^s$
Mean Local Time } Approx.	$-2^h 36^m 9^s$	$-2^h 32^m 8^s$	$+2^h 41^m 47^s$	$+2^h 47^m 8^s$	$+2^h 52^m 46^s$	$-2^h 56^m 4^s$
Equation of Time	$-\ 6^m 58^s$	$-\ 6^m 58^s$	$-\ 7^m 4^s$	$-\ 7^m 4^s$	$-\ 7^m 4^s$	$-\ 7^m 4^s$
Hour Angle in Time . .	$-2^h 43^m 7^s$	$-2^h 39^m 6^s$	$+2^h 34^m 43^s$	$+2^h 40^m 4^s$	$+2^h 45^m 42^s$	$+2^h 49^m 0^s$
Hour Angle in Arc $= t$	$-40° 46'·8$	$-39° 46'·5$	$+38° 40'·8$	$+40° 1'·0$	$+41° 25'·5$	$+42° 15'·0$
δ (Sun's Declination) . .	$-22° 15'·5$	$-22° 15'·5$	$-22° 13'·7$	$-22° 13'·7$	$-22° 13'·7$	$-22° 13'·7$
$\sin\varphi \sin\delta$	$-\ 0·19042$	$-\ 0·19042$	$-\ 0·19018$	$-\ 0·19018$	$-\ 0·19018$	$-\ 0·19018$
$\cos\varphi \cos\delta \cos t$	$+\ 0·60580$	$+\ 0·61489$	$+\ 0·62470$	$+\ 0·61286$	$+\ 0·60001$	$+\ 0·59234$
Sum $= \sin h$ . .	0·41538	0·42447	0·43452	0·42268	0·40983	0·40216
h (True Altitude of the Sun's Centre)	$24° 32'·6$	$25° 7'·0$	$25° 45'·3$	$25° 0'·2$	$24° 11'·7$	$23° 42'·8$
Refraction	$+\ 2'·0$	$+\ 2'·0$	$+\ 1'·9$	$+\ 1'·9$	$+\ 2'·0$	$+\ 2'·0$
Parallax	$-\ 0'·1$	$-\ 0'·1$	$-\ 0'·1$	$-\ 0'·1$	$-\ 0'·1$	$-\ 0'·1$
Apparent Calc. Altitude of Centre	$24° 34'·5$	$25° 8'·9$	$25° 47'·1$	$25° 2'·0$	$24° 13'·6$	$23° 44'·7$
$\pm$ Sun's Semidiameter .	$-\ 16'·3$	$-\ 16'·3$	$+\ 16'·3$	$+\ 16'·3$	$+\ 16'·3$	$+\ 16'·3$
Calculated Observation .	$24° 18'·2$	$24° 52'·6$	$26° 3'·4$	$25° 18'·3$	$24° 29'·9$	$24° 1'·0$
Direct Observation . . .	$24° 17'·2$	$25° 54'·4$	$26° 0'·4$	$25° 16'·3$	$24° 32'·4$	$24° 5'·4$
Calc.—Obs.	$+\ 1'·0$	$-\ 1'·8$	$+\ 3'·0$	$+\ 2'·0$	$-\ 2'·5$	$-\ 4'·4$
	Group *A*.		Group *B*.			

The mean of the deviations (Calc.—Obs.), including all observations is:

$$\text{in Group } A. = -0'·3,$$
$$\text{in Group } B. = -0·5.$$

We obtain the following differential equations for reducing the errors to their minimum:

$$1)\quad 0 = -9·44 - 9·90\, d\varphi - 9·82\, dt$$
$$2)\quad 0 = -9·67 - 9·84\, d\varphi + 9·70\, dt,$$

the co-efficients being logarithmical.

The solution of these equations gives:

$$d\varphi = -0'\cdot 6$$
$$dt = +0'\cdot 3,\ dT = -1^s\cdot 2$$

Therefore,

$$\text{Latitude N.} = \varphi = 30^\circ\ 10\cdot 2$$
$$\text{Mean Noon} = T = 7^h\ 29^m\ 43^s$$

The following table shows the remaining errors, after the new elements are introduced:

No. of Observ.	Calc.—Obs.
	′
1	+ 1·3
2	— 1·5
3	+ 0·3
4	+ 3·5
5	+ 2·5
6	— 2·0
7	— 3·9

Longitude.

	h	m	s
Mean Noon at Multán, by Chron. 4, deduced from Observations of the Sun, 1857, January 8	7	29	43
Corr. for rate since December 17, Rate = XIV. = gaining 15ˢ	7	24	2
Mean Noon at Raulpíndi, December 17, by Chron. 4	7	18	21
Meridional difference in Time		5	41

	°	′	″
Raulpíndi, East of Green.	72	59	49
Multán, West of Raulpíndi	1	25	15
Multán, East of Green.	71	34	34

Thuillier's App. gives as approximate values:

	°	′	″
Latitude N.	30	10	40
Longitude E. Green.	71	30	0

Meridian.

Deduced from Altitudes of the Sun . . . . 118° 55′·3.

No. 26. Shikárpur, in Sindh.

Situated in a low and level plain of rich alluvial soil, 21 miles west of the Indus, this station is one of the most important commercial places of Upper Sindh.

The bankers at Shikárpur, chiefly Hindús, are famous for the credit and the extent of their húndis (bills of exchange), which are accepted in every part of India, and even in the principal markets of Central Asia.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 55′ 10″	68° 51′ 50″	60 feet.

Observations: 1857, February 5.

Instruments: Theodolite 1, Jones; Chron. 4; Barom. 7, Pistor. Observer: Robert.

Latitude and Time.

1857, February 5.	Horizontal Circle.	Vertical Circle.
	A. M.	
	Sun, Lower Limb.	
h m s	° ′ ″	° ′ ″
1) 4 56 1	153 54 40	27 38 5
2) 5 0 19	154 45 10	28 23 7
3) 5 4 4	155 28 30	29 0 55
4) 5 8 10	156 15 53	29 46 25
5) 5 12 9	157 5 23	30 24 25

Barom. { 759·3 millim. / 29·894 inches. } Temp. of Air { 17·2° C. / 63·0 Fahr. }

Calculated by Method I., from Observations 1 and 5.

	1.	5.
	′ ″	′ ″
Refraction	— 1 46	— 1 35
Parallax	+ 0 8	+ 0 8
Semidiameter	+ 16 15	+ 16 15
Sum of Corr.	+ 14 37	+ 14 48

I. h corr. = 27° 52′·2
II. h' corr. = 30° 39′·2

$\delta = \delta' = -15° 56'{\cdot}1$

Latitude N. . . . . 27° 55′·2
Mean Noon (corr for Equation of Time) . . . . . . $7^h 43^m 29^s$.

The comparison of the single observations with the elements thus found gives as errors:

No. of Observ.	Calc. – Obs.
	′
2	— 0·8
3	— 1·1
4	— 5·2

The mean of Calc.—Obs. (including 1 and 5, used for the calculation and giving half the weight to 4)

$$= -1'\cdot 0.$$

and is reduced to a minimum, either by diminishing the latitude for 1′·7, or by diminishing the noon for 4ˢ in time; if the error is divided equally between both, we get:

Latitude N.	27° 54′·4
Mean Noon (corr. for Equation of Time)	7ʰ 43ᵐ 27ˢ

Longitude.

	h m s
Mean Noon at Shikárpur, by Chron. 4, deduced from Observations of the Sun, February 5	7 43 29
Mean Noon at Kárráchi, by Chron. 4, February 24	7 55 38
Difference of Time uncorrected for Rate	12 9
Rate for 19 days (Chron. 4 gaining 15ˢ)	— 4 45
Corrected difference of Time	7 24

	° ′ ″
Meridional Difference in Arc	1 51 0
Kărráchi. East of Green.	67 0 51
Shikárpur, East of Green.	68 51 51

We have no data of other direct observations for comparison.

No. 27. Sévan, in Sindh.

This is at the present day a comparatively small town, though, both from history and the still existing evidences of decayed grandeur, as shown by the large masses of fallen houses and ruined mosques, it must formerly have been a place of no inconsiderable extent and importance.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 25′ 0″	67° 56′ 40″	140 feet.

Latitude and longitude are taken from the Kărráchi Collectorate Map, 1851 (scale of map: 2 miles to the inch.)

Meridian.

It was found for the magnetic declination by observations of the sun in the morning and evening.

Instruments: Theodolite 1, Jones; Chron. 4; Barom. 7, Pistor; Observer: Robert.

1857, February 13.	Horizontal Circle.	Vertical Circle.
	° ′ ″	° ′ ″
1) 4h 27m 5s	178 54 0	23 27 32
2) 4 30 21	179 24 10	24 4 42

Barom. { 756·1 millim. / 29·768 inches. Temp. of Air { 25°·4 C. / 77·7 Fahr.

Sum of Corrections for these 2 Altitudes . .	+ 0° 14′·0
δ	— 13 22·8
Apparent Noon deduced from 1	8h 5m 28s
" " 2	8 5 31
Meridian of the Theodolite	238° 55′ 9″.

No. 28. KĂRRÁCHI, IN SINDH.

Situated at the western end of the Delta of the Indus, close to the sea, this is an important sea port for the Pănjáb, and for Western India in general.

The cantonment where my observations were made is about three miles to the north of the harbour.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
24° 45′ 30″	67° 0′ 51″	Little above the level of the sea.

Observations: 1857, February 24.

Instruments: Theodolite 1, Jones; Chron. 4; Barom. 7, Pistor. Observer: Robert.

Latitude and Time.

1857, February 24.	Horizontal Circle.	Vertical Circle.
	A. M.	
	Sun, Lower Limb.	
	° ′ ″	° ′ ″
1) 4h 2m 53s	233 27 33	20 43 45
2) 4 7 21	234 3 50	21 39 30
3) 4 13 21	234 57 10	22 58 15
	P. M.	
	Sun, Upper Limb.	
	° ′ ″	° ′ ″
4) 12h 18m 14s	10 25 25	20 42 0
5) 12 24 18	11 16 30	19 26 45
6) 12 29 13	11 56 40	18 26 0
7) 12 36 9	12 46 45	17 28 0

Barom. { 759·0 millim. / 29·882 inches.   Temp. of Air { 26°·0 C. / 78·8 Fahr.

Calculated by Method II.

Time.

	h	m	s
Apparent Noon, deduced from corresponding Altitudes (1, 2, and 5) . . .	8	9	2
Equation of Time	+	13	24
Mean Noon	7	55	38

Latitude.

For calculating the latitude, the mean was used of 1, 2, and 3 . . . . $= 4^h\ 10^m\ 38^s$

$h = 22°\ 21'\ 37''$

Corrections.

Refraction	—	2'·5
Parallax	+	0·1
Semidiameter	+	16·2
Sum of Corr.	+	13·8

h corr. = 22° 35'·5

δ . . . = — 9 30·4

Latitude N. . . . . 24° 45'·5.

For comparison, I add the latitude given on the chart of the coast of Sindh and Kăch, by Lieut. A. M. Grieve, 1848-50, 24° 50'·5 N.

The longitude on the same chart, which we also adopt, is 67° 0' 51" East Green.

Meridian.

Deduced from corresponding Altitudes of the Sun . . . . . 301° 32'·0.

No. 29. Bhūj, in Kăch.

Bhūj is the capital of the native state of Kăch, a country geologically remarkable for the frequent occurrence of earthquakes. A hill, crowned with a strong native fort, lies close to the town.

After leaving Kărráchi, the level of my theodolite getting out of order, I was obliged to replace it by another level, which could not be very accurately connected with the vertical circle. Consequently, I could only use my observations for calculating the meridian required for the declination. The value obtained may, however, be considered as sufficiently exact, since I purposely took the altitudes of the sun at very low elevations.

My instruments were put up not far from the British Resident's house. Latitude and longitude are taken from information communicated to me from the Quarter Master General's Office at Bombay.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
23° 17′	69° 40′	283 feet.

Observations: 1857, March 16.

Instruments: Theodolite 1, Jones; Chron. 4; Barom. 7, Pistor. Observer: Robert.

Meridian.

1857, March 16.	Sun, Upper Limb. Horizontal Circle.	Vertical Circle.
at $4^h\ 50^m$ P.M. Local Time.	252° 18′·5	18° 26′ 30″

Barom. { 750·6 millim. / 29·552 inches. Temp. of Air { 31°·5 C. / 88·7 Fahr.

	°	′
Corrected Altitude of the Sun's Centre	18	7·7
Sun's Declination	— 1	38·5
Meridian	172	18·7

No. 30. Rajkót, in Kattivár.

It is situated 150 miles west of Baróda, and though the principal station of Kattivár, is not by any means a large place.

I had my instruments put up near the church.

Here, as in Bhūj, I could only determine the meridian.

Latitude and longitude are derived from information received at the Quarter Master General's Office at Bombay.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
22° 13′	71° 7′	325 feet.

Observations: 1857, March 22.

Instruments: Theodolite 1, Jones; Chron 4; Barom. 7, Pistor. Observer: Robert.

Meridian.

1857, March 22.	Horizontal Circle.	Vertical Circle.
	Sun, Lower Limb.	
at 7h 20m A.M. Local Time.	292° 18′ 26″	16° 13′ 15″
	Sun, Upper Limb.	
at 4h 50m P.M. Local Time.	99° 38′ 20″	17° 58′ 0″
	100° 6′ 33″	16° 54′ 15″

Barom. { 750·8 millim. / 29·560 inches. Temp. of Air { 33°·2 C. / 91·8 Fahr.

Meridian, deduced from corresponding Altitudes . . . . 16° 13′·7.

GROUP V.

CENTRAL AND SOUTHERN INDIA.

STATIONS 31 TO 43.

Ságer.—Jáblpur.—Nágri.—Rajamándri.—Madras.—Bombay.—Púna.—Mahabaléshvar.—Kaládghi.—Bellári.—Utakamánd.—Utatúr.—Gálle.

The Great Trigonometrical Survey having been already extended in detail over these countries, we were, consequently, supplied with accurate materials for latitudes and longitudes.

These determinations were the more valuable for us, since the considerable distances we had to traverse, and the important variety of objects relating to physical geography to be observed, greatly limited our time.

In general, besides the magnetic intensity and dip, we only determined the true meridian for its comparison with the magnetic meridian.

In Central and Southern India we made magnetic observations at 13 stations (Nos. 31 to 43); also the heights of the different places above the level of the sea were calculated from our own observations.

No. 31. Ságer, in Málva.

Latitude North.	Longitude East Green.	Height.
23° 50′ 9″	78° 43′ 26″	1,880 feet.

A civil and military station, on the Béssi river, in a hilly country.

Observer: Adolphe. 1855, December 18.

No. 32. Jáblpur, in Málva.

Latitude North.	Longitude East Green.	Height.
23° 9′ 39″	79° 56′ 18″	1,480 feet.

This station is situated one mile north of the Nărbáda river, at the base of trap hills. The population is, for the most part, composed of Hindus, but is considerably mixed with elements of the aboriginal tribes of the Gōds and Bhīls.

Observer: Adolphe. 1855, December 23.

Meridian.

Deduced from the passage of *Achernar* . . . . 349° 50′·0.

No. 33. Nágri, in Oríssa.

Latitude North.	Longitude East Green.	Height.
20° 25′ 25″	78° 52′ 50″	850 feet.

A small village, 82 miles south-east of Nágpur.

Observer: Adolphe. 1856, January 11.

No. 34. Rajamándri, in Oríssa.

Latitude North.	Longitude East Green.	Height.
17° 10′ 30″	81° 46′ 35″	35 feet above the level of the sea.

A considerable town, with a mixed population of high caste Hindus and various tribes of Southern India, situated at the upper end of the Godáveri Delta, on the left bank of the principal branch of the river.

Observations: 1856, February 6.

Instruments: Theodolite 2, Jones; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1856, February 6.	Horizontal Circle.	Vertical Circle.
Sun, Lower Limb.		
A. M.		
h m s	° ′	° ′
1) 11 14 44	213 45·2	55 48
2) 11 37 38	223 9·5	56 44
P. M.		
h m s	° ′	° ′
3) 12 14 18	239 19·0	56 16
4) 12 36 30	248 16·0	54 45
5) 12 45 39	251 49·5	53 51

Barom. { 759·3 millim. / 29·894 inches. Temp. of Air { 30°·0 C. / 86·0 Fahr.

Calculated by Method I., from Observations 1 and 5.

	1.	5.
	′	′
Refraction	— 0·6	— 0·7
Parallax	+ 0·1	+ 0·1
Semidiameter	+ 16·3	+ 16·3
Sum of Corr.	+ 15·8	+ 15·7

1. h corr. = 56° 3′·8
5. h' corr. = 54 6·7

$\delta = \delta' = -15° 47'·4$

Latitude N. . . . . 17° 10′ 30″
Time: Mean Noon . . . . $11^h 33^m 14^s$

As we have no special data, the longitude, 81° 46′ 35″ East Green. (corrected for Madras), is taken from Wyld's map, which gives at the same time for Rajamándri a latitude of 17° 2′ N.

Meridian.

Deduced from Altitudes of the Sun . . . . 227° 59′·7.

No. 35. MADRAS.

Latitude North.	Longitude East Green.	Height of the Barom.
13° 4′ 11″	80° 13′ 56″.	21 feet above the level of the sea.

The geographical co-ordinates refer to the Madras Observatory.

The longitude as mentioned above is Taylor's determination.

The magnetic observations were made by Adolphe, 1856, March.

The Government Astronomers, Colonel Jacob, and, in his absence, Major Worcester, most kindly supplied us, during our travels, with corresponding materials of observations, both magnetical and meteorological.

No. 36. BOMBAY.

Latitude North.	Longitude East Green.	Height of the Barom.
18° 53′ 30″	72° 49′ 5″	38 feet above the level of the sea.

The geographical co-ordinates refer to the Bombay Observatory.

This observatory, which is directed by Lieutenant Fergusson, I. N., is situated at Colaba, at the southern extremity of the island; it is also furnished with an extensive set of instruments for magnetic and meteorological observations, which, together with astronomical observations, are annually published at Bombay.[1]

We here made a detailed series of comparisons of our magnetic instruments.

No. 37. PÚNA.

Latitude North.	Longitude East Green.	Height.
18° 30′ 23″	73° 52′ 8″	1,819 feet.

Latitude and longitude refer to St. Mary's Church.

This is the principal military station of the Dékhan, situated on the western Ghāts, in an open plain, which is intersected by the Múta and Múla rivers.[2]

Magnetic Observations: 1855, January. Observer: Hermann.

[1] See "Bombay Magnetical and Meteorological Observations", published since April, 1845.

[2] Its vicinity to Bombay and connection with it by a railway considerably increase its importance. Its native population consists chiefly of Maharátas.

No. 38. MAHABALÉSHVAR, IN THE DÉKHAN.

Latitude North.	Longitude East Green.	Height.
17° 55′ 25″	73° 38′ 42″	4,396 feet.

Though an important sanitarium during the dry part of the year, this station is scarcely habitable during the rains.

Magnetic Observations: 1854, December. Observer: Adolphe.

No. 39. KĂLÁDGHI, IN THE DÉKHAN.

Latitude North.	Longitude East Green.	Height.
16° 12′ 55″	75° 29′ 55″	1,720 feet.

This was formerly a large military station, in the district of Belgáum. Having been given up, the cantonments are rapidly falling to ruin, like many other military stations now deserted in Southern India.

Observer: Adolphe.

Meridian.

Deduced from the passage of *Sirius*, 1855, January 19, late in the night 220° 10′·7

No. 40. BELLÁRI, IN MAISSÚR.

Latitude North.	Longitude East Green.	Height.
15° 8′ 57″	76° 53′ 45″	1,580 feet.

The principal place of Maissúr, with a large cantonment and hill-fort.

Observer: Adolphe.

Meridian.

Deduced from low Altitudes of the Sun . . . . 26° 19′·0

No. 41. UTAKAMÁND, IN THE NÍLGIRIS.

Latitude North.	Longitude East Green.	Height.
11° 23′ 40″	76° 43′ 10″	7,278 feet.

Latitude and Longitude are referred to Major Jacob's former Observatory; my (Adolphe's) tent was considerably to the north of it.

For Southern India this is the most important sanitarium, and is situated on one of the higher parts of the Nílgiris.

Observations: 1856, March 14.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1856, March 14.	Horizontal Circle. Sun's Centre. P.M.	Vertical Circle.
h m s	° ′ ″	° ′ ″
1) 3 7 15	125 25 0	75 56 15
2) 3 10 52	129 5 0	75 44 30
3) 3 38 40	152 38 40	72 26 20

Barom. { 586·5 millim. / 23·091 inches. Temp. of Air { 22°·2 C. / 72·0 Fahr.

Calculated by Method I., from Observations 1 and 3.

	1.	3.
	′ ″	′ ″
Refraction	— 0 11	— 0 13
Parallax	+ 0 3	+ 0 3
Sum of Corr.	— 0 8	— 0 10

1. h corr. = 75° 56′ 7″
3. h' corr. = 72 26 10

$\delta = \delta' = -2^\circ\ 15'\ 0''$

Latitude N. . . . . 11° 29′·1
Time: Mean Noon (corr. for Equation of Time) . . . $3^h\ 4^m\ 25^s$

Control.

	° ′
Calculated Apparent Altitude (Obs. 2)	75 43·7
Observation 2	75 44·5
Calc.—Obs.	— 0·8

Meridian.

Deduced from Observations of the Sun . . . . . 122° 30′·6.

No. 42. Utatúr, in the Karnátik.

Latitude North.	Longitude East Green.	Height.
11° 4′ 40″	78° 51′ 40″	280 feet.

A small place, 22 miles north of Trichinópalli, but well situated as an intermediate magnetic station between Madras and the Nílgiris.

Magnetic Observations: 1856.

No. 43. GÁLLE, IN CEYLÓN.

Latitude North.	Longitude East Green.	Height.
6° 2′ 30″	80° 10′ 45″	Little above the level of the sea.

This is the most important harbour of Ceylón for the Overland Route to India, China, and Australia.[1]

Magnetic observations of Intensity were made 1857, May 2, in the native town, north of the fort.

Meridian.

From low corresponding Altitudes of the Sun . . . 33° 25′·5.

[1] Recently, the Peninsular and Oriental Company's Steamers go by way of Mauritius to Australia.

B. HIGH ASIA.

a. HIMÁLAYA.

GROUP VI.

BHUTÁN TO NEPÁL.

STATIONS 44 TO 49.

Nărigún.—Darjíling.—Răngít Bridge.—Tónglo.—Fălút.—Kathmándu.

No. 44. NĂRIGÚN, IN BHUTÁN.

This place is the residency of a Láma Governor, and is the most southern outpost on the route from Lhássa, viâ Táuong to Assám. The houses of the Láma are surrounded by a large village, built quite close to the banks of the river Ri-ju, and not, as most Himálayan villages, upon the flanks of a mountain.

The country does not belong to Bhután Proper, but is a direct dependency of Lhássa.

I experienced great difficulties in getting to Nărigún with my instruments. The observations were made half a mile south of the village, in a grove of trees which allowed of my remaining unobserved.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
26° 53′ 50″	92° 6′ 0″	3,615 feet.

Observations: 1856, January 10 and 12.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

1856, January 10.		Vertical Circle.
$10^h\ 19^m\ 33^s$	*a.* Jupiter.	25° 28′ 20″

b. Sun's Centre.

1856, January 12.	Horizontal Circle.	Vertical Circle.
$3^h\ 1^m\ 28^s$	123° 42′ 40″	40° 0′ 5″

Barom. { 671·6 millim. / 26·441 inches. Temp. of Air { 26°·9 C. / 80·4 Fahr.

	Jupiter.	Sun.
Sum of Refraction + Parallax	— 0° 1′·8	— 0° 0′·9
Declination	— 11 29·0	— 21 46·1
R.A.	$22^h\ 19^m\ 59^s$	. . .

Time: Mean Noon from Jupiter . . . . $3^h\ 57^m\ 28^s$

Latitude from the Sun (calculated by one Approximation) 26° 53′ 50″

Longitude.

The chronometer could not be keyed January 6, the kúli remaining behind. Time is therefore arbitrary. The above longitude is based on a series of bearings connecting a peak close to Nărigún with Udelgúri; the result was a difference of longitude of 10′, Nărigún being east of Udelgúri.

I have no other data for comparison.

Meridian.

Deduced from low Altitudes of the Sun . . . . 138° 10′·0.

No. 45. Darjíling, in Síkkim.

This important sanitarium for Eastern Bengál is the chief place of British Síkkim under the charge of the Superintendent and Political Agent, Dr. Campbell, a gentleman well known for the active personal part he took in Dr. Hooker's travels in Síkkim, and to whom I too am greatly indebted for the kind assistance he gave me.

My instruments were placed on a little hill, called at the station, "Observatory

Hill", where a well-constructed shed for the meteorological observations, in charge of the medical officer of the station, then Dr. Withecombe, is erected.

This point was selected principally because it allowed of the theodolites being used very favourably for measuring the gigantic snow peaks to the north.

The rainy season, and my long absence to the north of the station, preventing a regular series of astronomical observations, the latitude and longitude were taken from the G. T. S.

The magnetic intensity was determined twice, in April and July. Observer: Hermann.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 3′ 0″	88° 15′ 15″	7,168 feet.

Meridian.

Deduced from Observations of *Polaris*.

		h	m	s
Mean Noon at Calcutta, 1855, March 8, by Chron. 3		6	5	11
Darjíling, West of Calcutta	+	0	0	20
Mean Noon at Darjíling		6	5	31
Rate of Chron. 3 (VI. and VII.) = 0				
		°	′	″
Latitude N. of Darjíling		27	3	10
Azimuth of Polaris, 1855, July 23, 4^h 18^m P.M. Green. Time (1° 36′ west of the Meridian)		310	2	10
Meridian		311	38	10

No. 46. Răngít Bridge, in Síkkim.

This spot, which owes its considerable depression partially to the erosion of the Răngít river, is situated on the road between Darjíling and Tónglo, in a straight line five miles north-west of Darjíling.

The latitude and longitude of this place were easily deduced from bearings to the surrounding peaks; astronomical observations, however, could not be made, the malarious condition of the air making a longer stay dangerous.

For the magnetic observations, Răngít Bridge was an interesting station, on account of its unusually low elevation, and its situation in the most rainy part of Síkkim.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 4′ 50″	88° 10′ 15″	3,130 feet.

No. 47. Tónglo, in Síkkim.

The southernmost peak of the Singhalíla ridge.

I (Hermann) had to cut down some of the trees of a beautiful rhododendron grove (so dense it was) in order to clear a view for my trigonometrical observations.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 1′ 50″	88° 3′ 55″	10,080 feet.

Determined by the G. T. S., from a private communication by Colonel Waugh.

Meridian.

From low corresponding Altitudes of the Sun . . . . 111° 11′ 10″.

No. 48. Fălŭt, in Síkkim.

The summit of this peak was the second point of my observations on the Singhalíla ridge. Fogs and rain made it very difficult to select the proper moments for good observations of the sun; the very early hours of the morning, however, were in general perfectly clear.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 6′ 20″	87° 59′.0″	12,042 feet.

Observations: 1856, May 22.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude.

1855, May 22.		Vertical Circle.
$3^h\ 20^m\ 53^s$	Polaris.	25° 42′ 5″

Barom. { 496·6 millim. / 19·552 inches.   Temp. of Air { 10°·0 C. / 50·0 Fahr.

	h	m	s
Mean Noon at Calcutta, 1855, March 8, by Chron. 3 .	6	5	11
Fălút, West of Calcutta	+ 0	1	6
Mean Noon at Fălút.	6	6	17

The Rate VII. of the Chronometer, gaining: $0^s \cdot 5$.

Calculation.

	h	m	s
Time by Chron. 3	15	20	53
Mean Noon by Chron. 3	6	6	17
Mean Local Time	9	14	36
Fălút East of Green.	5	51	56
Mean Green. Time	3	22	40
Acceleration of the Fixed Stars	+ 0	0	33
Fălút East of Green.	5	51	56
Sidereal Time at Mean Green Noon	3	58	12
Sidereal Time at Fălút	13	13	21

	°	′
Observed Altitude of Polaris	25	42·1
Refraction	—	1·4
First Term of the Series	1	27·1
Second Term „ „	+ 0	0·0
Third Term „ „	+ 0	0·4
Latitude N.	27	8·2

We have, however, adopted as latitude, 27° 6′ 20″ N., being, as well as the longitude, the result based upon the Calcutta meridional series.

Meridian.

	h	m	s
Sidereal Time	13	13	21
R.A. of Polaris	1	5	40
Hour Angle in Time	12	7	41

	°	′
Latitude N.	27	8·2
Azimuth of Polaris	0	4
Bearing to Polaris	214	10·0
Meridian	214	16·0

No. 49. Kathmándu, in Nepál.

The broad valley, in which Kathmándu, the capital of Nepál, lies, is intersected by many rivers. Its lacustrine deposits, which originally presented an almost level surface, are now much cut up into channels by former water-courses, and the more or less isolated banks, which are called "Tars", form a predominant feature of the valley.

My instruments stood on the Residency's "Tar", south of the central parts of the town. Colonel Ramsay, Political Agent to the Governor General, most kindly allowed me to erect some huts in his park for a continued series of observations.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
27° 42′ 5″	85° 11′ 59″	4,350 feet.

Observations: 1857, March 4.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 9, Pistor. Observer: Hermann.

Latitude and Time.

1857, March 11.	Horizontal Circle.	Vertical Circle.
	Sun, Upper Limb.	
	A.M.	
h m s	° ′ ″	° ′ ″
1) 6 55 49	43 12 0	51 58 19
2) 7 1 9	45 53 5	52 44 39
3) 7 6 47	47 59 55	53 18 6
4) 7 27 21	56 11 55	54 55 24
5) 7 33 50	58 55 15	55 17 4
6) 7 39 10	61 13 55	55 32 9
7) 7 45 7	63 45 3	55 48 54
8) 7 52 26	66 58 57	56 0 7
9) 8 4 43	72 24 5	56 8 54
	P.M.	
h m s	° ′ ″	° ′ ″
10) 8 8 46	74 11 52	56 8 29
11) 8 17 27	78 2 25	56 1 44
12) 8 32 49	84 41 25	55 31 12
13) 8 45 12	89 56 25	54 49 39
14) 9 20 55	103 41 25	51 37 4
15) 9 27 13	105 53 10	50 52 0
16) 9 31 51	107 27 0	50 18 0

Barom. { 651·1 millim. / 25·634 inches. Temp. of Air { 20°·0 C. / 68·0 Fahr.

First Approximation.

Calculated by Method III., from Observations 8, 9, and 11.

		° ′
Calculated Apparent Altitude of Sun's Upper Limb, when culminating		56 8·9
Refraction	—	0·5
Parallax	+	0·1
Semidiameter	—	16·1
Calculated True Altitude of Sun's Centre		55 52·4
Sun's Declination	—	6 25·9
Latitude N.		27 41·7
Mean Noon (corrected for Equation of Time)		7^h 53^m 46^s.

Second Approximation.

Comparison of the single observations with the elements obtained by the first approximation. φ has been adopted in round number $= 27° 42'$.

	A. M.						
	1.	2.	3.	4.	5.	6.	7.
Time of Observation, by Chron. 3	$6^h 55^m 49^s$	$7^h 1^m 9^s$	$7^h 6^m 47^s$	$7^h 27^m 21^s$	$7^h 33^m 50^s$	$7^h 39^m 10^s$	$7^h 45^m 7$
Mean Noon . . . } from 1st Approx.	$7^h 53^m 46^s$	$7^h 53^m 46^s$	$7^h 53^m 46^s$	$7^h 53^m 46^s$	$7^h 53^m 46^s$	$7^h 53^m 46^s$	$7^h 53^m 46$
Mean Local Time } from 1st Approx.	$-0^h 57^m 57^s$	$-0^h 52^m 37^s$	$-0^h 46^m 59^s$	$-0^h 26^m 25^s$	$-0^h 19^m 56^s$	$-0^h 14^m 36^s$	$-0^h 8^m 39$
Equation of Time	$- 11^m 58^s$	$- 11^m 58^s$	$- 11^m 58^s$	$- 11^m 58^s$	$- 11^m 58^s$	$- 11^m 58^s$	$- 11^m 57$
Hour Angle in Time . . .	$-1^h 9^m 55^s$	$-1^h 4^m 35^s$	$-0^h 58^m 57^s$	$-0^h 38^m 23^s$	$0^h 31^m 54^s$	$0^h 26^m 34^s$	$-0^h 20^m 36$
Hour Angle in Arc $= t$.	$-17°28'\cdot 8$	$-16° 8'\cdot 8$	$-14°44'\cdot 3$	$- 9°35'\cdot 8$	$-7°58'\cdot 5$	$-6°38'\cdot 5$	$-5° 9'\cdot 0$
δ (Sun's Declination) . .	$- 6°26'\cdot 7$	$- 6°26'\cdot 6$	$- 6°26'\cdot 5$	$- 6°26'\cdot 2$	$-6°26'\cdot 1$	$-6°26'\cdot 0$	$-6°25'\cdot 9$
$\sin\varphi \sin\delta$	$-0\cdot 05218$	$-0\cdot 05217$	$-0\cdot 05215$	$-0\cdot 05211$	$-0\cdot 05210$	$-0\cdot 05208$	$-0\cdot 05207$
$\cos\varphi \cos\delta \cos t$	$+0\cdot 83918$	$+0\cdot 84510$	$+0\cdot 85086$	$+0\cdot 86752$	$+0\cdot 87132$	$+0\cdot 87394$	$+0\cdot 87628$
Sum $= \sin h$ . .	$0\cdot 78700$	$0\cdot 79293$	$0\cdot 79871$	$0\cdot 81541$	$0\cdot 81922$	$0\cdot 82186$	$0\cdot 82421$
h (True Altitude of the Sun's Centre) . .	$51°54'\cdot 3$	$52°27'\cdot 5$	$53° 0'\cdot 4$	$54°37'\cdot 7$	$55° 0'\cdot 5$	$55°16'\cdot 3$	$55°30'\cdot 5$
Refraction + Parallax . .	$+ 0'\cdot 5$	$+ 0'\cdot 5$	$+ 0'\cdot 5$	$+ 0'\cdot 5$	$+ 0'\cdot 5$	$+ 0'\cdot 5$	$+ 0'\cdot 4$
Calcul. Appar. Altitude of Sun's Centre	$51°54'\cdot 8$	$52°28'\cdot 0$	$53° 0'\cdot 9$	$54°38'\cdot 2$	$55° 1'\cdot 0$	$55°16'\cdot 8$	$55°30'\cdot 9$
± Sun's Semidiameter . .	$+ 16'\cdot 1$	$+ 16'\cdot 1$	$+ 16'\cdot 1$	$+ 16'\cdot 1$	$+ 16'\cdot 1$	$+ 16'\cdot 1$	$+ 16'\cdot 1$
Calculated Observation .	$52°10'\cdot 9$	$52°44'\cdot 1$	$53°17'\cdot 0$	$54°54'\cdot 3$	$55°17'\cdot 1$	$55°32'\cdot 9$	$55°47'\cdot 0$
Direct Observation	$51°58'\cdot 3$	$52°44'\cdot 7$	$53°18'\cdot 1$	$54°55'\cdot 4$	$55°17'\cdot 1$	$55°32'\cdot 2$	$55°48'\cdot 9$
Calc.—Obs.	. . .	$- 0'\cdot 6$	$- 1'\cdot 1$	$- 1'\cdot 1$	$0'\cdot 0$	$+ 0'\cdot 7$	$- 1'\cdot 9$
	Group *A*.						

Observation 9, p. 192, was left laid down A. M., as we found it in our original manuscripts

		P. M.						
8.	9.	10.	11.	12.	13.	14.	15.	16.
$7^h52^m26^s$	$8^h\ 4^m43^s$	$8^h\ 8^m46^s$	$8^h17^m27^s$	$8^h32^m49^s$	$8^h45^m12^s$	$9^h20^m55^s$	$9^h27^m13^s$	$9^h31^m51^s$
$7^h53^m46^s$	$7^h53^m46^s$	$7^h53^m46^s$	$7^h53^m46^s$	$7^h53^m46^s$	$7^h53^m46^s$	$7^h53^m46^s$	$7^h53^m46^s$	$7^h53^m46^s$
$-0^h\ 1^m20^s$	$+0^h10^m57^s$	$+0^h15^m\ 0^s$	$+0^h23^m41^s$	$+0^h39^m\ 3^s$	$+0^h51^m26^s$	$+1^h27^m\ 9^s$	$+1^h33^m27^s$	$+1^h38^m\ 5^s$
$-\ 11^m57^s$	$-\ 11^m57^s$	$-\ 11^m57^s$	$-\ 11^m57^s$	$-\ 11^m56^s$	$-\ 11^m56^s$	$-\ 11^m56^s$	$-\ 11^m56^s$	$-\ 11^m56^s$
$-0^h13^m17^s$	$-0^h\ 1^m\ 0^s$	$+0^h\ 3^m\ 3^s$	$+0^h11^m44^s$	$+0^h27^m\ 7^s$	$+0^h39^m30^s$	$+1^h15^m13^s$	$+1^h21^m31^s$	$+1^h26^m\ 9^s$
−3° 19′·3	− 0° 15′·0	+ 0° 45′·8	+ 2° 56′·0	+ 6° 46′·8	+ 9° 52′·5	+ 18° 48′·3	+ 20° 22′·8	+ 21° 32′·3
−6° 25′·8	− 6° 25′·7	− 6° 25′·6	− 6° 25′·5	− 6° 25′·2	− 6° 25′·0	− 6° 24′·4	− 6° 24′·3	− 6° 24′·2
−0·05206	−0·05204	−0·05203	−0·05202	−0·05198	−0·05195	−0·05187	−0·05186	−0·05184
+0·87836	+0·87984	+0·87975	+0·87868	+0·87370	+0·86682	+0·83290	+0·82480	+0·81844
0·82630	0·82780	0·82772	0·82666	0·82172	0·81487	0·78103	0·77294	0·76660
55° 43′·3	55° 52′·5	55° 51′·9	55° 45′·5	55° 15′·3	54° 34′·3	51° 21′·3	50° 37′·1	50° 3′·0
+ 0′·4	+ 0′·4	+ 0′·4	+ 0′·4	+ 0′·4	+ 0′·4	+ 0′·5	+ 0′·5	+ 0′·5
55° 43′·7	55° 52′·9	55° 52′·3	55° 45′·9	55° 15′·7	54° 34′·7	51° 21′·8	50° 37′·6	50° 3′·5
+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1
55° 59′·8	56° 9′·0	56° 8′·4	56° 2′·0	55° 31′·8	54° 50′·8	51° 37′·9	50° 53′·7	50° 19′·6
56° 0′·1	56° 8′·9	56° 8′·5	56° 1′·7	55° 31′·2	54° 49′·7	51° 37′·1	50° 52′·0	50° 18′·0
− 0′·3	+ 0′·1	− 0′·1	+ 0′·3	+ 0′·6	+ 1′·1	+ 0′·8	+ 1′·7	+ 1′·6
		Group *B*.						

though it is easily seen by the calculation, that it was made after the culmination.

The mean of the deviations (Calc.—Obs.), including all observations, except No. 1, is:

$$\text{in Group } A \; - \; 0'{\cdot}5$$
$$\text{in Group } B \; + \; 0{\cdot}7$$

We obtain the following differential equations for reducing the errors to their minimum:

$$1) \quad 0 = -\, 9{\cdot}47 - 9{\cdot}72\, d\varphi + 9{\cdot}18\, dt$$
$$2) \quad 0 = +\, 9{\cdot}62 - 9{\cdot}72\, d\varphi - 9{\cdot}18\, dt,$$

the co-efficients being logarithmical.

The solution of these equations gives:

$$d\varphi = +\, 0'{\cdot}1$$
$$dt = +\, 2{\cdot}3; \quad dT = 9^{s}{\cdot}2$$

therefore,

$$\text{Latitude N.} = \varphi = 27^{\circ}\ 42'{\cdot}1$$
$$\text{Mean Noon} = T = 7^{h}\ 53^{m}\ 37^{s}.$$

Longitude.

a. By Lunar Altitudes.

1857, March 4.	Altitudes of the Moon, Upper Limb.
h m s	° ′ ″
1) 11 21 30	41 22 20
2) 11 30 30	43 13 3

Barom. { 655·3 millim. / 25·8 inches Temp. of Air { 20°·0 C. / 68·0 Fahr.

In the present case it happens that the change of declination of the moon is absolutely 0, so that the accuracy of the longitude thus obtained is somewhat lessened.

	Hypothesis *A*. Longitude adopted: $5^{h}\ 40^{m}$.		Hypothesis *B*. Longitude adopted: $5^{h}\ 45^{m}$.	
	Altitude 1.	Altitude 2.	Altitude 1.	Altitude 2.
	° ′	° ′	° ′	° ′
Calc. True Altitude of the Moon's Centre	41 45·9	43 36·8	41 48·5	43 39·4
Parallax	— 43·1	— 42·0	— 43·1	— 42·0
Moon's Semidiameter	+ 15·8	+ 15·8	+ 15·8	+ 15·8
Refraction	+ 0·9	0·9	+ 0·9	+ 0·9
Calculated Observation	41 19·5	43 11·5	41 22·1	43 14·1
Direct Observation	41 22·3	43 13·0	41 22·3	43 13·0
Calc.—Obs.	— 2·8	— 1·5	— 0·2	+ 1·1

	h m	
Longitude from Altitude 1	5 44·6	
„ „ Altitude 2	5 42·7	
Mean Longitude	5 43·7	= 85° 56′ in arc.

b. By Chronometer.

	h m s
Mean Noon at Ágra, 1857, January 20 . .	8 22 41
Rate = X. = Losing: $0^s{\cdot}5$	— 22
Mean Noon referred to March 4	8 22 19
Mean Noon at Kathmándu	7 53 37
Meridional Difference in Time	0 28 42
	° ′ ″
Ágra, East of Green.	78 1 39
Kathmándu, East of Ágra	7 10 30
Kathmándu, East of Green.	85 12 9

We give the preference to the longitude by chronometer.[1] We have no other direct observations for comparison.

Meridian.

From Altitudes of the Sun, March 4 . . . 72° 46′·7.

GROUP VII.

KĂMÁON AND GĂRHVÁL.

STATIONS 50 TO 55.

Nainitál.—Mílum.—Mána.—Mána pass.—Ussílla.—Măsúri.

No. 50. NAINITÁL, IN KĂMÁON.

This sanitarium in the outer ranges of the Himálaya, is situated on one of the few fresh-water lakes which are to be found in the Himálaya Proper.

The lake filling up nearly the whole basin of the valley, many of the houses are built on the steep slopes of the mountains.

Our instruments were put up near the southern end of the lake, about 100 feet above the level of the water.

[1] In the preceeding sheet (p. 192), the longitude is given, less accurately, 85° 11′ 59″. This was the result obtained by a different grouping of the observations, which proved to give the resulting errors less favourable.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height of the lake.
29° 23′ 34″	79 30 55	6,409 feet.

(From Captain Vanrenen's observations, Revenue Survey.)

Observations: 1855, April 28 and May 5.

Instruments: Theodolite 2, Jones; Chron. 1; Barom. 2, Pistor. Observer: Adolphe.

a. 1855, April 28.

1855, April 28.	Horizontal Circle.	Vertical Circle.
	Sun, Lower Limb.	
h m s	° ′ ″	° ′ ″
6 22 30	82 5 30	74 17 50
7 5 1	118 45 0	72 22 0

Barom. { 605·2 millim. / 23·827 inches. Temp. of Air { 20°·1 C. / 68·2 Fahr.

h corr. = 74° 33′·4
h' corr. = 72 21·6
δ = δ′ = + 13° 59′·6

Latitude N., by Method I. . . . . 29° 23′·3

b. 1855, May 5.

Observed Transit of the Sun through the Meridian (Chron. 1, Arbitrary Time) 7h 33m 38s

Observed Altitude, Sun's Centre = h = 76° 41′·0 . . . . at 7 39 18

Barom. { 604·3 millim. / 23·792 inches. Temp. of Air { 22°·4 C. / 72·3 Fahr.

h = 76° 41′·0
h corr. = 76 40·7
δ = + 16 6·6

Latitude N. . . . . 29° 22′·2.

Meridian.

From low corresponding Altitudes of the Sun, May 4 . . . . 138° 1′·2.

No. 51. Mílum, in Johár.

The chief village of the district of Johár, situated on a high alluvial terrace at the left side of the Gúri river.

This place corresponds with what is called in the western Alps "Sommerdörfer";[1]

[1] Neue Untersuchungen über die Alpen, von H. & A. Schlagintweit, Vol. II., p. 582.

it is inhabited only in summer by Bhot-Rajpúts, active and enterprising people, who carry on an extensive trade with the Tibetans, their neighbours to the north.

We found unexpected difficulties in collecting provisions sufficient for our large establishment during our stay of nearly a month.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
30° 34′ 35″	79° 54′ 49″	11,640 feet.

Observations: 1855, June 24 and June 26.

Instruments: Theodolite 4, Pistor, and Theodolite 2, Jones; Chron. 2; Barom. 2, Pistor. Observer: Adolphe.

Latitude and Time.

a. June 24. Theodolite 4, Pistor.

1855, June 24.	Horizontal Cirle. Sun's Centre.	Vertical Circle.
	A.M.	
h m s	° ′ ″	° ′ ″
1) 6 12 58	107 52 0	82 5 50
2) 6 24 3	130 20 0	82 49 29
	P.M.	
3) 6 33 50	150 1 45	82 42 35
4) 6 46 18	167 20 30	81 53 25

Barom. { 505·0 millim. 19·882 inches. Temp. of Air { 23°·8 C. 74·8 Fahr.

Calculated by Method III.

We use for the calculation Observations 1, 2, 3.

Apparent Noon	$6^h\ 27^m\ 22^s$
Calculated culminating Altitude of the Sun, corrected for Refraction and Parallax	82° 51′·9
δ	+ 23 26·5
Elevation of the Equator	59 25·4
Latitude N.	30 34·6
Mean Noon (corrected for Equation of Time)	$6^h\ 25^m\ 27^s$

Latitude and Time.

b. June 26. Theodolite 2, Jones.

1855, June 26.	Horizontal Circle. Sun's Centre.	Vertical Circle.
	A.M.	
h m s	° ′ ″	° ′ ″
1) 6 1 56	306 32 0	80 43 25
2) 6 11 55	319 16 57	82 34 30

P.M.

3) $7^h\ 5^m\ 11^s$ 38° 17′ 30″ 78° 57′ 20″

Barom. { 504·9 millim. / 19·878 inches. Temp. of Air { 24·2 C. / 75·6 Fahr.

Calculated by Method I.

We use for the calculation Observations 1 and 3.

1) h corr. = 80° 43′·4
3) h' corr. = 78 57·2
$\delta = \delta' = + 23° 23'·9$

Latitude N. 30° 40′·2
Mean Noon (corr. for Equation of Time). . . $6^h\ 25^m\ 29^s$.

Control.

Calculated Apparent Altitude at $6^h\ 11^m\ 55^s$	82° 36′·0
Observed	82 34·5
Calc.—Obs.	+ 1·5

We prefer, as resulting latitude, the first series, taken with theodolite 4, Pistor, on account of its more delicate graduation.

Longitude.

	h	m	s
Mean of the two determinations of Noon (June 24 and June 26) = June 25	6	25	28
Rate = V. = Losing: 2s·85, for 95 days		4	32
Corrected Mean Noon reduced to March 22	6	30	0
Mean Noon at Calcutta, March 22	5	56	17
Meridional Difference in Time	0	33	43
	°	′	″
Calcutta, East of Green.	88	20	34
Milum, West of Calcutta.	8	25	45
Milum, East of Green.	79	54	49

Meridian.

True Meridian, from Altitudes of the Sun . . . . 347° 12′·9.

No. 52. MÁNA, IN GÁRHVÁL.

This is the highest village in the Vishnugánga valley, situated two miles to the north of the celebrated Hindu temples of Bádrinath.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
30° 47′ 0″	79° 20′ 50″	10,670 feet.

The longitude we adopt is based on our itinerary distances; the Indian Atlas (sheet 66) gives the longitude (corrected for Madras): 79° 28′ 55″ East Green.

Observations: 1855, September 1.

Instruments: Theodolite 2, Jones; Chron. 2; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1855, September 1.	Horizontal Circle. Sun's Centre.	Vertical Circle.
	A.M.	
1) 6h 12m 39s	41° 45′ 5″	67° 39′ 37″
	P.M.	
2) 6h 35m 53s	56° 57′ 30″	67° 33′ 45″
3) 6 43 4	61 44 45	67 20 0

Barom. { 523·4 millim. / 20·607 inches. Temp. of Air { 20°·6 C. / 69·1 Fahr.

Calculated by Method I., from Observations 1 and 3.

Latitude N. . . . . 30° 47′·0

Meridian.

Deduced from the Altitudes of the Sun . . . 48° 19′·5

No. 53. Mána Pass, in Gărhvál.

This pass, the highest on the commercial route between Gărhvál and Gnári Khórsum, is situated two days' journey north of Mána. It is passable for horses.

The Indian Atlas (sheet 65) gives as longitude: 79° 23′ 25″ East Green.; the longitude we adopt is referred to Mána.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 5′ 0″	79° 15′ 20″	18,852 feet.

Observations: 1855, September 5.

Instruments: Theodolite 2, Jones; Chron. 2; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1855, September 5.	Horizontal Circle. Sun's Centre.	Vertical Circle.
	A.M.	
	° ′ ″	° ′ ″
1) 5h 54m 40s	293 14 52	65 8 12
2) 6 29 33	314 29 45	66 3 0
	P.M.	
3) 6h 37m 5s	319 11 15	65 50 10
4) 6 59 28	332 30 0	64 22 0

Barom. { 388·4 millim. / 15·292 inches. Temp. of Air { 3°·1 C. / 37·6 Fahr.

Calculated by Method I., from Observations 1 and 4.

Latitude N. . . . . 31° 5′·0

Mean Noon (corrected for Equation of Time) $6^h\ 22^m\ 58^s$

No. 54. Ussílla, in GăRhvál.

This is the highest village in the valley of the Tons, and was in former years chiefly the abode of predatory tribes from Gnári Khórsum.

It is now inhabited by peaceful Bhot-Rajpúts, who are generally poor. Here observations of magnetic intensity only were made. We deduce the latitude and longitude of this place from its position on the maps of the Indian Atlas (sheet 47), altering, however, the longitude for 14 minutes in arc, which will include the difference of longitude for Madras and the relative distance in longitude from other places of our observations near it.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 7′ 40″	78° 18′ 10″	8,940 feet.

No. 55. Măssúri, in Gărhvál.

A hill station, and sanitarium of great importance for the north-western provinces. Banóg Hill, to which the co-ordinates given below must be referred, lies close to Măssúri, and is one of the principal stations of the Himálayan part of the G. T. S. We therefore limited ourselves to magnetic observations only. The co-ordinates of Banóg Hill[1] were kindly communicated to us by Colonel Waugh.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
30° 28′ 30″	77° 59′ 58″	7,549 feet.

GROUP VIII.

SÍMLA TO HAZÁRA.

STATIONS 56 TO 64.

Vángtu bridge.—Rámpur.—Símla.—Sultánpur.—Kárdong.—Srinágger.—Dáver.—Mozáferabád.—Márri.

No. 56. VÁNGTU, IN THE PROVINCE OF SÍMLA.

Here the Sátlej is crossed by a permanent bridge on the way from Bissér to Tíbet. I was detained at this place a few days, on account of a slight accident. A pack-horse, bulkily laden with tentage, stumbled and hurt my foot as it was rolling down the cud; on the last day of my involuntary rest, however, I was enabled to determine the dip.

Observer: Hermann.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 37′ 0″	77° 54′ 0″	4,210 feet.

These are referred to itinerary distances from Rámpur.

No. 57. RÁMPUR, IN THE PROVINCE OF SÍMLA.

A large native place on the left side of the Sátlej, where I (Hermann) took the opportunity of a few hours' halt to determine the latitude by means of a sextant and a

[1] The geographical co-ordinates of Gracemount, where a series of barometrical corresponding observations was made, at our request, by Colonel Waugh, are as follows:

Latitude North.	Longitude East Green.	Height.
30° 27′ 35″	78° 3′ 0″	6,590 feet.

duplex watch by Dent. The longitude is estimated by distance from Símla; Chron. 3 being with the kúlis who were in advance.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 31′ 0″	77° 37′ 0″	3,215 feet.

	1856, June 2, Approximate Local Time.	Vertical Angle of Sun's Centre, by Sextant.
	h m s	° ′ ″
1)	12 46 0 P.M.	80 18 0
2)	1 18 42 „	76 14 0

Calculated by Method I.

$\delta = \delta'$ . . . . + 22° 13′·4

Latitude N. . . . . 31° 31′ 0″

No. 58. Símla, in the Province of Símla.

This well known sanitarium is situated on the flanks of the outer ranges of the Himálaya, 40 miles distant from its southern foot.

Meeting as we did here, all three, after a long separation, we made a general comparison of our magnetic instruments[1] and chronometers; Lord Hay, the Superintendent of the protected Hill States, very kindly gave us every assistance in putting up our temporary observatories.

The observations were made three miles south-west of the native bazar, on a ridge, where General Boileau's observatory had formerly been placed.[2]

Geographical Co-ordinates.

	Latitude North.	Longitude East Green.	Height.
	° ′ ″	° ′ ″	
Church	31 6 13	77 9 14	
Magnetic Observatory	31 6 6	77 7 36	7,091 feet.

The latitude and longitude of the church is determined by the G. T. S., those of the second point by General Boileau; the height was determined by us barometrically.

Observations: 1856, May 15.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 1, Greiner. Observer: Adolphe.

[1] See the comparison of the chronometers, p. 106, and the comparison of the magnetic instruments, Section III.

[2] His observations, already prepared for publication, were unhappily destroyed at Ágra during the Indian mutiny of 1857.

Latitude and Time.

1856, May 15.	Horizontal Circle.	Vertical Circle.
	Sun, Lower Limb.	
	A. M.	
h m s	° ′ ″	° ′ ″
1) 4 48 13	303 39 40	64 51 10
2) 4 58 31	306 58 50	66 51 22
	Sun, Upper Limb.	
	P. M.	
h m s	° ′ ″	° ′ ″
3) 9 20 23	94 4 20	48 55 30

Barom. { 587·9 millim. / 23·146 inches. Temp. of Air { 22°·2 C. / 72·0 Fahr.

Calculated by Method I., from Observations 2 and 3.

2) h corr. = 67° 7′·0 δ = + 18° 55′·0

3) h' corr. = 48 40·2 δ' = + 18 57·6

	′ ″	′ ″
Refraction	— 19	— 37
Parallax	+ 4	+ 4
Sun's Semidiameter	+ 15 51	— 15 51
Sum of Corr.	+ 15 36	— 16 24

Latitude N. 31° 1′·3

Mean Noon, deduced from Observation 3 . . $6^h\ 28^m\ 52^s$

Control.

Calculated Apparent Altitude of the Sun's Lower Limb at $4^h\ 48^m\ 13^s$	64° 52′·4
Observed Altitude	64 51·2
Calc.—Obs.	+ 1·2

Meridian.

Deduced from the Altitudes of the Sun . . . . 10° 5′·5

No. 59. Sultánpur, in Kúlu.

Though the chief place of Kúlu, this is a small, unimportant village, situated on a high bank to the right of the Biás.

A fort, with a large house in good condition, formerly the residence of the Rájah of Kúlu, is close to the village; our instruments were put up in a wooded plain which extends along the right side of the Biás, half a mile's distance from this fort. We observed here the dip and declination.

Latitude and longitude are from the G. T. S.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 57′ 50″	77° 5′ 50″	3,830 feet.

Observations: 1856, June 5.

Instruments: Theodolite 3, Troughton; Chron. 2. Observer: Adolphe.

Meridian.

Deduced from low, corresponding Altitudes of the Sun . . . . 226° 6′·6.

No. 60. Kárdong, in Lahól.

Kanéts, a mixed race of Tibetans and Hindus, constitute the chief inhabitants of this place, which is the capital of Lahól, but contains only a small number of houses. It is situated in a narrow part of the Bhága (Chináb) valley. Kárdong is the northernmost missionary station, and at the time we passed through there were three German missionaries here, Messrs. Jäschke, Heyde, and Pagel, by whom we were received in a most friendly manner, and to whom we feel ourselves under deep obligations for the great zeal with which, at a later period, they made inquiries about our late brother.[1]

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
32° 33′ 50″	77° 0′ 35″	10,233 feet.

Latitude and longitude are from the G. T. S.

Observations: 1856, June 14.

Instruments: Theodolite 3, Troughton; Chron. 1. Observer: Adolphe.

Meridian.

Deduced from low, corresponding Altitudes of the Sun . . . . 137° 25′ 8″

No. 61. Srinágger, Capital of Kashmír.

This city is built in a longitudinal form on both sides of the Jhílum.

Our series of observations were taken in the garden surrounding the official building, which had been placed at the disposal of the Indian Government by the late Rájah Guláb Singh. It is situated close to the right bank of the Jhílum, a mile

[1] See pp. 45 and 65.

above the Rájah's own palace, in a very fine garden, called Shēkh Bagh. The geographical co-ordinates are referred to this building.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
34° 4′ 36″	74° 48′ 30″	5,144 feet.

Observations: 1856, October 24, 25, and 26.

Instruments: Theodolite 3, Troughton; Chron. 3; Barom. 6, Adie. Observers: Adolphe and Robert.

Latitude and Time.

First Series.

1856, October 24.	Horizontal Circle.	Vertical Circle.
	Sun, Lower Limb.	
	A.M.	
h m s	° ′ ″	° ′ ″
1) 5 18 4	212 59 20	41 13 40
2) 5 20 38	213 47 20	41 25 10
3) 5 22 51	214 28 40	41 35 10
	Sun, Upper Limb.	
	P.M.	
h m s	° ′ ″	° ′ ″
4) 7 44 59	261 5 40	40 43 55
5) 8 6 37	266 58 0	38 21 5
6) 8 11 29	268 39 20	37 47 30

Barom. { 635·4 millim. / 25·016 inches. Temp. of Air { 19°·4 C. / 66·9 Fahr.

Calculated by Method I.

We use for the calculation the mean of the observations A.M. and P.M.

Mean of A.M.	Time	$5^h\ 20^m\ 31^s$
	Altitude, corrected for Semidiameter, Refraction, and Parallax	41° 39′·7
Mean of P.M.	Time	$8^h\ 1^m\ 2^s$
	Altitude, corrected for Semidiameter, Refraction, and Parallax	38° 40′·3

$\delta = -\ 11° \ 50'{\cdot}3 \qquad \delta' = -\ 11° \ 52'{\cdot}6$

Latitude N. . . . . 34° 3′ 0″

Mean Noon (corrected for Equation of Time) . . . . $6^h\ 40^m\ 20^s$

Second Series.

1856, October 25. Horizontal Circle. Vertical Circle.

Sun, Lower Limb.

A.M.

	h m s	° ′ ″	° ′ ″
1)	5 32 18	217 36 20	41 54 35
2)	5 35 21	218 33 40	42 5 50
3)	5 37 54	219 24 20	42 14 30
4)	5 40 33	220 16 10	42 23 0

Sun, Upper Limb.

P.M.

	h m s	° ′ ″	° ′ ″
5)	7 24 33	254 24 40	41 57 50
6)	7 26 26	255 18 25	41 45 35
7)	7 31 31	256 53 0	41 23 15

Barom. { 636·2 millim. / 25·048 inches. Temp. of Air { 19°·2 C. / 66·6 Fahr.

Calculated by Method II.

We use for the determination of time observations 1, 2, and 4; for the latitude, the mean of the observations A.M.

Mean Noon, deduced from interpolated corresponding Altitudes, and corrected for the variation of the Sun's Declination . . . . $6^h\ 40^m\ 47^s$.

$$\delta = -\ 12°\ 11'\cdot 3$$

Latitude N. . . . . 33° 59′·5

Third Series.

Polaris.

1856, October 26. Vertical Circle.

$1^h\ 0^m\ 13^s$ 34° 39′ 30″

	h m s
Time by Chronometer	13 0 13
Mean Noon, by Chronometer, deduced from the observations, October 24 and 25	6 40 33
Mean Local Time	6 19 40
Mean Greenwich Time	1 19 40
Acceleration of Fixed Stars	+ 12
Approximate Longitude of Srinágger E. Green.	5 0 0
Sidereal Time, at Mean Noon at Greenwich	14 20 14
Local Sidereal Time, at Srinágger	20 40 6
	° ′
Corrected Altitude of Polaris	34 38·3
Corrections from the Tables for Polaris	33·7
Latitude N.	34 4·6

Longitude.

For the definitive determination of the longitude of Srinágger, we took as the basis the results obtained by the G. T. S. for the Lánka Island, in the Great Vúler Lake, and for the mountain Takt-i-Sulaimán.

The longitudes, as given by the G. T. S., are:

	° ′ ″
Lánka Island	74 36 23[1]
Takt-i-Sulaimán	74 49 43.

By combining these places with the building in the Shēkh Bagh (where the observations were taken) we obtain:

Longitude East Green. of Srinágger . . . . 74° 48′·5.

Cunningham gives in his work on "Ladák", p. 425, without mentioning the elements upon which these values are based:

Latitude North.	Longitude East Green.
34° 5′ 28″	74° 58′ 0″.

Another longitude (but, as the result showed, only an approximative one) was calculated from the eclipse of the moon, observed at Pashmín,[2] 1856, October 13 to 14, and referred to Srinágger.

The observations of Tycho gave (see p. 115):

Longitude East Green. . . . . 75° 22′ 40″;

observations of the Mare crisium (see p. 116):

Longitude East Green. . . . . 75° 51′ 30″.

Meridian.

Calculated from the Observations of the second series, October 25 . . . 236° 10′·5.

No. 62. DÁVER, IN KASHMÍR.

This small village is situated in the Gurés valley, on the left side of the Kishengánga, an affluent flowing into the Jhílum, near Mozăferabád.

The Gurés valley and the valley of Kashmír to the south lie parallel to each other. The magnetic intensity only was determined at this place; the co-ordinates are approximatively computed from itinerary references to Srinágger.

Observer: Adolphe.

[1] Corrected for — 3′ 25″, as are all G. T. S. Longitudes. Compare also p. 100.

[2] Pashmín is situated in Kishtvár, in Latitude N.: 33° 57′, Longitude East Green.: 75° 41′.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
34° 34′ 5″	74° 46′ 0″	7,718 feet.

No. 63. MOZĂFERABÁD, IN KASHMÍR.

An important frontier town of Kashmír, towards Hazára, situated on the left side of the Kishengánga, near its confluence with the Jhílum.

I put up my instruments 200 yards to the south of the Mussălmán burial-ground, remarkable for the great number of monuments and graves which it contains.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
34° 22′ 25″	73° 31′ 10″	2,220 feet.

Observations: 1856, November 10.

Instruments: Theodolite 2, Jones; Chron. 5, Grant; Barom. 8, Pistor. Observer: Robert.

Latitude and Time.

	1856, November 10.	Horizontal Circle. Sun, Upper Limb.	Vertical Circle.
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	10 17 21	134 55 35	33 37 47
2)	10 20 37	135 46 40	34 12 12
3)	10 26 8	137 19 50	34 27 17
4)	10 28 52	138 3 20	34 42 47
		P.M.	
	h m s	° ′ ″	° ′ ″
5)	1 32 45	191 29 35	33 44 27
6)	1 36 10	192 23 20	33 24 57
7)	1 39 14	193 12 15	33 5 37
8)	1 42 7	193 54 45	32 47 57

Barom. { 705·8 millim. / 27·788 inches. Temp. of Air { 16°·4 C. / 61·5 Fahr.

First Approximation.

Calculated by method II., from corresponding altitudes deduced from observations 1, 2, and 5.

Apparent Noon . . . . $11^h\ 56^m\ 23^s$

Latitude N. from the greatest Altitude, No. 4 34° 18′·8

Second Approximation.

	Group I.				Group II.			
	1.	2.	3.	4.	5.	6.	7.	8.
Time of Observation by Chron.	$5^h 17^m 21^s$	$5^h 20^m 37^s$	$5^h 26^m 8^s$	$5^h 28^m 52^s$	$8^h 32^m 45^s$	$8^h 36^m 10^s$	$8^h 39^m 14^s$	$8^h 42^m 7^s$
Mean Noon } from 1st	$7^h 12^m 16^s$	$7^h 12^m 16^s$	$7^h 12^m 16^s$	$7^h 12^m 16^s$	$7^h 12^m 16^s$	$7^h 12^m 16^s$	$7^h 12^m 16^s$	$7^h 12^m 16^s$
Mean Local Time } Approx.	$-1^h 54^m 55^s$	$-1^h 51^m 39^s$	$-1^h 46^m 8^s$	$-1^h 43^m 24^s$	$+1^h 20^m 29^s$	$+1^h 23^m 54^s$	$+1^h 26^m 58^s$	$+1^h 29^m 51^s$
Equation of Time	$+15^m 55^s$	$+15^m 55^s$	$+15^m 55^s$	$+15^m 55^s$	$+15^m 54^s$	$+15^m 54^s$	$+15^m 54^s$	$+15^m 54^s$
Hour Angle in Time	$-1^h 39^m 0^s$	$-1^h 35^m 44^s$	$-1^h 30^m 13^s$	$-1^h 27^m 29^s$	$+1^h 36^m 23^s$	$+1^h 39^m 48^s$	$+1^h 42^m 52^s$	$+1^h 45^m 45^s$
Hour Angle in Arc = t	− 24° 45′·0	− 23° 56′·0	− 22° 33′·3	− 21° 52′·3	− 24° 5′·8	− 24° 57′·0	+ 25° 43′·0	− 26° 26′·3
δ (Sun's Declination)	− 17° 13′·3	− 17° 13′·3	− 17° 13′·3	− 17° 13′·3	− 17° 15′·7	− 17° 15′·7	− 17° 15′·7	− 17° 15′·7
sin φ sin δ	− 0·16690	− 0·16690	− 0·16690	− 0·16690	− 0·16727	− 0·16727	− 0·16727	− 0·16727
cos φ cos δ cos t	+ 0·71647	+ 0·72110	+ 0·72860	+ 0·73215	+ 0·72003	+ 0·71515	+ 0·71063	+ 0·70627
Sum = sin h	0·54957	0·55420	0·56170	0·56525	0·55276	0·54788	0·54336	0·53900
h (True Altit. of the Sun's Centre)	33° 20′·3	33° 39′·3	34° 10′·4	34° 25′·2	33° 33′·4	33° 13′·2	32° 54′·8	32° 37′·0
Refraction Parallax } . . . . ± Sun's Semidiameter	+ 17′·6	+ 17′·6	+ 17′·6	+ 17′·6	+ 17′·6	+ 17′·6	+ 17′·6	+ 17′·6
Calculated Observation	33° 37′·9	33° 56′·9	34° 28′·0	34° 42′·8	33° 51′·0	33° 30′·8	33° 12′·4	32° 54′·6
Direct Observation	33° 37′·8	34° 12′·2	34° 27′·3	34° 42′·8	33° 44′·5	33° 25′·0	33° 5′·6	32° 48′·0
Calc.—Obs.	+ 0′·1	− 15·3	+ 0′·7	± 0′·0	+ 6′·5	+ 5′·8	+ 6′·8	+ 6′·6
	Group *A* (excluding No. 2).				Group *B*.			

27*

A comparison of the single observations with the elements found by the first approximation shows, that the observation No. 2, which we use for the formation of corresponding altitudes, contains a considerable error. But as deviations present themselves, still small enough for the limits adopted, the method of equations of condition could be applied.

The mean of Group A, excluding No. 2 $= + 0' \cdot 3$, the mean of Group $B = + 6' \cdot 4$. The great difference in quantity and the signs being the same, show *a priori*, that the determination of time as well as of latitude will have to be considerably altered.

For reducing the errors to a minimum, we obtain as the two equations of condition:

$$1)\quad 0 = + 9 \cdot 40 - 9 \cdot 88\ d\varphi + 9 \cdot 49\ dt$$
$$2)\quad 0 = + 0 \cdot 73 - 9 \cdot 87\ d\varphi - 9 \cdot 54\ dt,$$

the co-efficients being logarithmical.

The solution of these equations gives:

$$\left.\begin{aligned} d\varphi &= + \ 3' \cdot 6 \\ dt &= + \ 7' \cdot 9 \\ dT &= - \ 31^s \cdot 6 \end{aligned}\right\}$$
These differentials are great, because in the first approximation the time was based on an altitude interpolated from observations 1 and 2, and the latter accidentally happened to be erroneous by $15' \cdot 3$,

and for the true elements:

Latitude N. $= \varphi = 34° \ 22' \cdot 4$
Mean Noon $= \quad 12^h \ 11^m \ 44^s$.

For these results the following errors remain:

1)	$- 0' \cdot 2$	6)	$- 0' \cdot 6$
3)	$+ 0 \cdot 4$	7)	$+ 0 \cdot 4$
4)	$- 0 \cdot 3$	8)	$+ 0 \cdot 2$
5)	$+ 0 \cdot 1$		

Cunningham gives in "Ladák", p. 483:

Latitude N. . . . . . . 34° 21′ 46″.

Longitude.

The longitude is referred to itinerary distances from Srinágger. We adopt 73° 31′ 10″ East Green.

Meridian.

Calculated from the Altitudes of the Sun . . . . . 163° 26′·6.

No. 64. MÁRRI, IN THE PROVINCE OF MÁRRI.

This is one of the most recently established sanitariums, having been erected about nine years ago by the exertions of Mr. Edward Thornton, Commissioner of Raulpíndi. It is situated on the top of a ridge, about 32 miles to the north of Raulpíndi. We made our observations on the southern side of the station.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
33° 51′ 0″	73° 22′ 40″	7,260 feet.

Observations: 1856, November 13.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 10, Pistor. Observers: Hermann and Adolphe.

Latitude and Time.

	1856, November 13.	Horizontal Circle.	Vertical Circle.
		Sun, Upper Limb.	
		A. M.	
	h m s	° ′ ″	° ′ ″
1)	6 42 1	43 30 0	38 7 30
2)	6 48 25	45 24 55	38 15 10
3)	6 57 41	48 11 40	38 21 10
		P. M.	
	h m s	° ′ ″	° ′ ″
4)	10 20 29	100 1 10	20 24 10
5)	10 27 14	101 16 55	19 19 45
6)	10 34 51	102 43 15	18 2 30
7)	10 39 10	103 26 20	17 22 10

Barom. { 593·9 millim. / 23·382 inches. Temp. of Air { 11°·7 C. / 53·1 Fahr.

First Approximation.

Calculated by Method I.

For the first approximation we use observations 3 and 7, for which we find the following corrections:

	3.	7.
	′	′
Refraction	− 0·9	− 2·4
Parallax	+ 0·1	+ 0·1
Sun's Semidiameter	− 16·1	− 16·2
Sum of Corr.	− 16·9	− 18·5

3) h corr.	= 38° 4′·3	δ = − 18° 3′·2
7) h' corr.	= 17 3·7	δ' = − 18 5·8

Latitude N. . . . . 33° 51′·4
Mean Noon (corr. for Equation of Time) . . . $7^h\ 19^m\ 34^s$.

Second Approximation.

The detail is given as example p. 123.

Resulting Latitude N. . . . . 33° 51′ 0″
,, Mean Noon . . . . $7^h\ 19^m\ 30^s$

Longitude.

The Longitude is from the G. T. S.

Meridian.

Deduced from Altitudes of the Sun . . . . 49° 44′·6.

b. TÍBET.

GROUP IX.

GNÁRI KHÓRSUM.

STATIONS 65 TO 73.

Laptél.—Giúngul.—Gunshankár.—Cháko La pass.—Gártok.—Díra.—Íbi Gămin glacier.—Púling.—Nélong.

No. 65. △ LAPTÉL, IN GNÁRI KHÓRSUM.

This halting place, at the southern foot of the pass "Balch Dhúra", leading from Johár to Gnári Khórsum, is several marches distant from every inhabited place. Halts are frequently made here, on account of the good pasturage and shrubs surrounding it on all sides.

Nominally Laptél still belongs to British Kămáon; but the Chinese consider it already as their own territory, and treat it as dependent upon their government.

We found a guard of Chinese soldiers here, whose vigilance, however, we managed to elude, though not without considerable difficulty.[1]

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
30° 46′ 20″	79° 52′ 0″	14,304 feet.

Observations: 1855, July 14.

Instruments: Theodolite 2, Jones; Chron. 2; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1855, July 14.	Horizontal Circle.	Vertical Circle.
	Sun, Centre.	
h m s	° ′ ″	° ′ ″
1) 6 17 2	270 36 30	80 35 30
2) 6 21 22	277 14 0	80 54 15
3) 6 30 19	290 31 0	80 59 30
4) 6 37 29	300 24 45	80 41 55
5) 6 41 42	305 50 15	80 21 0

[1] See p. 18.

Barom. { 458·7 millim. / 18·060 inches. Temp. of Air { 21°·2 C. / 70·2 Fahr.

Calculated by Method III., from Observations 2, 3, and 4.

Apparent Noon	7h 27m 23s
Culminating Altitude of Sun's Centre, corrected for Refraction and Parallax	81° 0'·9
Sun's Declination	+ 21 47·2
Elevation of the Equator	59 13·7
Latitude N.	30 46·3
Mean Noon (corrected for Equation of Time)	6h 21m 57s

We have no data for comparing the latitude with previous observations.

The longitude is deduced from bearings to peaks west of Mílum, which we could see from both places, and which we had fortunately succeeded in measuring before being interrupted by the Chinese.

These bearings gave Laptél to be 2′ 50″ to the west of Mílum.[1]

No. 66. △ Giúngul, in Gnári Khórsum.

We selected this place, at the junction of the Giúngul river with the Sátlej, as a place of concealment for a few days, while awaiting the result of some negociations for permission to extend our journey. With these negociations we had charged Bára Máni, the cousin of our chief guide, whom we had for that purpose sent to the Chinese authorities at Dába. Our camp lay in an uninhabited and rarely frequented spot, that presented but few traces of vegetation.

The small village of Giúngul, which we passed nine days later, is half a day's journey higher up the river, on its left bank.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 14′ 0″	79° 44′ 40″	13,420 feet.

Observations: 1855, July 21 and 22.

Instruments: Theodolite 2, Jones; Chron. 2; Hypsom. 8, Geissler. Observer: Adolphe.

[1] The longitude could not be determined by the Mean Noon of the chronometer at Mílum, as the chronometer had stopped between Mílum and △ Laptél. See p. 105.

Latitude and Time.

1855, July 21.	Horizontal Circle.	Vertical Circle.
	Sun's Centre.	
	A.M.	
h m s	° ′ ″	° ′ ″
1) 6 8 43	358 53 0	78 34 45
2) 6 16 36	8 5 5	78 54 52
3) 6 26 32	20 8 0	79 21 52
	P.M.	
h m s	° ′ ″	° ′ ″
4) 6 34 40	30 53 45	79 22 7
5) 6 42 35	40 34 0	78 59 10
6) 6 54 42	52 55 0	77 54 35

Hypsom. { 87°·18 C. = 471·5 millim.; 18·564 inches. Temp. of Air { 16°·4 C.; 61·5 Fahr.

A. Calculated by Method II., from Observation 1, and a corresponding Altitude, interpolated between Observations 5 and 6.

Apparent Noon . . . . 6h 28m 12s.

For the latitude, observation 3 was chosen.

		° ′
Refraction	—	0·1
Parallax	+	0·1
Sun's Declination	+	20 36·5
Latitude N. (A)		31 14·5

B. The latitude was also deduced from Observations 3, 4, and 5, by Method III., with regard to the variation of the sun's declination.

The results are:

		° ′
Altitude of the Sun, when culminating . . .		79 23·3
Refraction	—	0·1
Parallax	+	0·1
Apparent Noon		6h 30m 43s
Latitude N. (B)		31° 13′·5

The latitudes, calculated by two different methods, and from different observations, agree within 1′; a second approximation, therefore, is unneccessary. The final result for the latitude is the mean: 31° 14′·0 N.

Longitude.

	h	m	s
Mean Noon at Laptél, 1855, June 14	6	21	57
Rate = V. = losing $2^s\cdot85$, for 7 days			20
Mean Noon at Laptél, reduced to June 21 . .	6	21	37
Mean Noon at Giúngul, July 21	6	22	6
Meridional Difference in Time	0	0	29
	°	′	″
Laptél, East of Green.	79	52	0
Giúngul, West of Laptél		7	15
Giúngul, East of Green.	79	44	45

No. 67. Gunshankár, in Gnári Khórsum.

This is one of the highest peaks in the range which separates the Indus from the Sátlej. The whole country surrounding the base of this range being of great elevation, the ascent of the peak offered no peculiar difficulties.

The slopes are so gentle, that we could ride up with our Tibetan horses to more than 19,000 feet, the greatest height reached by us on horseback. From here to the summit we went on foot. Wild yaks are very numerous in these regions.

The sky was perfectly clear, and the air of that beautiful transparency so characteristic of fine days in Tíbet, and scarcely to be surpassed anywhere else. From the state of the atmosphere, the surrounding panorama was viewed by us with more than usual advantage; to the south, numerous peaks of the Himálaya range were visible from Nepál to Spíti and Ladák; to the north, across the Indus, we saw the eastern part of the chain of the Karakorúm, forming with its dark and less elevated peaks a striking contrast to the snow-clad Himálaya. The two chains were separated by the broad intervening valley of Tíbet, in which the lakes Mansaráuer and Rákus, and the courses of the Indus and Sátlej, could be distinctly seen and surveyed.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 23′ 30″	80° 18′ 0″	19,980 feet.

Observations: 1855, July 29.

Instruments: Theodolite 2. Troughton; Chron. 2; Hypsom. 8, Geissler. Observer: Adolphe.

Latitude.

1855, July 29.	Horizontal Circle. Sun, Centre.	Vertical Circle.
h m s	° ′ ″	° ′ ″
1) 6 26 10	90 37 30	77 19 50
2) 6 32 35	97 26 30	77 18 30
3) 6 39 7	104 18 45	77 4 50
4) 6 46 6	111 43 45	76 34 35

Hypsom. { 81°·18 C. = 372·0 millim. / 14·646 inches. — Temp. of Air { 12°·1 C. / 53·8 Fahr.

Calculated by Method III., with regard to the variation of the sun's declination.

Apparent Noon		6h 24m 25s
		° ′
Calculated Apparent Altitude of Sun's Culmination		77 20·0
Declination	+	18 43·5
Refraction	—	0·1
Parallax	+	0·1
Latitude N.		31 23·5

The longitude is estimated from itinerary distances. Observations so near the culmination of the sun do not allow of a sufficient accuracy in the determination of time. The great distance we had to traverse before reaching our camp greatly limited us as to time.

No. 68. Cháko-La Pass, in Gnári Khórsum.

This is the principal pass on the commercial road between the higher valleys of Johár and Gártok. It is crossed without any difficulty by pack-horses and laden sheep, and is situated on the high ridge, which separates the valleys of the Indus and the Sátlej. The longitude is deduced from itinerary distances[1].

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 23′ 55″	80° 11′ 0″	17,730 feet.

[1] In this case, and on several occasions during the two following months, when the chronometers 1 and 2 got out of order, the longitude was computed from itinerary distances. The respective parts of Captain Strachey's map agree very well with our results in reference to the relative position of the different places; but the absolute longitudes found by us are, on an average, 10 minutes more to the west.

Observations: 1855, July 30.

Instruments: Theodolite 2, Jones; Chron. 2; Hypsom. 8, Geissler. Observer: Adolphe.

1855, July 30. Vertical Circle.

Sun, Upper Limb.

	h	m	s	°	′	″
1)	6	27	6	77	24	15
2)	6	31	33	77	25	30
3)	6	32	42	77	16	15

Hypsom. { 83°·15 C. = 402·5 millim. / 15·847 inches. Temp. of Air { 6°·7 C. / 44·1 Fahr.

Calculated by Method III.

		h m s
Apparent Noon, deduced from Observations 1 and 3		6 29 25
" " " 2 and 3		6 29 25
		° ′ ″
Observed Altitude, reduced		77 8·2
Reduction to the Meridian	+	7·9
Altitude of the Sun, when culminating		77 16·1
Sun's Declination	+	18 40·0
Elevation of the Equator		58 36·1
Latitude N.		31 23·9

No. 69. Gártok, in Gnári Khórsum.

This place is the seat of the Chinese governor, or Gárpon, of Gnári Khórsum, and one of the most important commercial *entrepôts* of Central Tíbet. It is situated near the confluence of the two principal branches of the Indus.

A large fair is annually held at Gártok, in August, which is attended by the merchants of Central Asia, as well as by the Bhot-Rajpúts and Bhútias, of the Himálaya, and during the trading season there is often an assemblage of several thousand people.

Its great elevation, far above the limit of cereals, renders it uninhabitable in winter; and the population at that time occupy villages a few marches lower down the valley of the Indus.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 40′ 0″	80° 18′ 25″	15,090 feet.

Observations: 1855, July 28.

Instruments: Sextant, Troughton; Chron. 2; Hypsom. 8, Geissler. Observer: Adolphe.

Time and Longitude.

The latitude adopted = 31° 40′·0 was deduced from itinerary distances.

Preliminary Elements.

Sun's Declination = δ = 19° 10′·4

Const. sin φ sin δ	0·1724
log sec φ sec δ	0·0948
Refraction	— 1′

	h m s
Mean Noon at △ Laptél, by Chron. 2, July 14	6 21 57
Rate = V. = losing $2^s·85$, for 14 days	40
Mean Noon at △ Laptél, reduced to July 28	6 21 17

Hypsom. { 85°·49 C. = 441·5 millim. / 17·382 inches. Temp. of Air { 14°·2 C. / 57·6 Fahr.

Calculation of the Single Observations.

Time by Chron. 2	$2^h 44^m 21^s$	$2^h 47^m 44^s$	$2^h 56^m 21^s$	$3^h 3^m 23^s$
Obs. Apparent Altitude	38° 59′·5	39° 45′·0	41° 30′·0	43° 2′·5
Corr. Hour Angle of Sun calc. from each Altitude, in Arc . .	55 21·5	54 28·5	52 25	50 36·5
Corr. Hour Angle of Sun calc. from each Altitude, in Time .	3h 41m·4	3h 37m·9	3h 29m·7	3h 22m·4
Time by Chron. 2	2 44·3	2 47·7	2 56·3	3 3·4
App. calc. Noon	6 25·7	6 25·6	6 26·0	6 25·8
Equation of Time	6·2	6·2	6·2	6·2
Mean Local Noon	6 19·5	6 19·4	6 19·8	6 19·6
Mean Noon at △ Laptél, red. to July 28	6 21·3	6 21·3	6 21·3	6 21·3
Meridional Difference in Time	1·8	1·9	1·5	1·7
,, ,, in Arc	0 27·0	0 28·5	0 22·5	0 25·5
△ Laptél, East of Green.	79 52·0	79 52·0	79 52·0	79 52·0
Gártok, East of Green.	80 19·0	80 20·5	80 14·5	80 17·5

The mean of the 4 different values, giving half the weight to the 3rd, is:

Longitude East Green. . . . . 80° 18′·4.

No. 70. △ Díra, in Gnári Khórsum.

An uninhabited place in winter, it is nevertheless regularly frequented in summer by the Tibetan shepherds, who bring their herds of sheep here, on account of the excellent pasturage.

△ Díra is situated in the broad valley of Mángnang, a few miles above the village of the same name.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 18′ 55″	79° 32′ 40″	13,800 feet.

Observations: 1855, August 7 and 8.

Instruments: Theodolite 2, Jones; Chron. 2; Hypsom. 8, Geissler. Observer: Adolphe.

Latitude and Time.

1855, August 7.	Horizontal Circle. Sun, Centre.	Vertical Circle.
h m s	° ′ ″	° ′ ″
1) 6 20 20	6 7 10	75 11 45
2) 6 36 56	22 28 0	75 11 52
3) 7 6 20	46 24 15	72 53 37

Hypsom. { 86°·83 C. = 465·1 millim. / 18·311 inches. Temp. of Air { 22°·4 C. / 72·3 Fahr.

Calculated by Method I., from Observations 1 and 3.

1) h corr. = 75° 11′·7
3) h' corr. = 72 53·4

$\delta = \delta' = + 16° 37'·9$

Latitude N. . . . . 31° 20′1
Mean Noon (corrected for Equation of Time) $6^h\ 22^m\ 20^s$

Latitude and Time.

1855, August 8.	Horizontal Circle. Sun, Centre.	Vertical Circle.
h m s	° ′ ″	° ′ ″
1) 6 12 18	359 12 30	74 40 45
2) 6 30 11	15 2 15	74 56 50
3) 6 57 26	39 7 0	73 33 45

Hypsom. { 86°·97 C. = 467·7 millim. / 18·414 inches. Temp. of Air { 23°·0 C. / 73·4 Fahr.

Calculated by Method I., from Observations 1 and 3.

1) h corr. = 74° 40′·6
3) h' corr. = 73 33·4

$\delta = \delta' = + 16° 21'·1$

Latitude N. . . . . 31° 17′·8
Mean Noon (corrected for Equation of Time) 6^h 21^m 50^s.

Longitude.

Mean Noon at △ Laptél, 1855, July 14 . . . . 6^h 21^m 57^s.

Data.	Observations, 1855, Aug. 7.	Observations, 1855, Aug. 8.
	h m s	h m s
Mean Noon at △ Laptél	6 21 57	6 21 57
Rate = V. = losing $2^s·85$	1 8	1 11
Mean Noon at △ Laptél, reduced to the epoch of △ Díra	6 20 49	6 20 46
Mean Noon at △ Díra	6 22 20	6 21 50
Meridional Difference in Time . . .	1 31	1 4
	° ′ ″	° ′ ″
△ Laptél, East of Green.	79 52 0	79 52 0
△ Díra, West of △ Laptél	22 45	16 0
△ Díra, East of Green.	79·29 15	79 36 0

△ Díra, East of Green.: 79° 32′ 40″, being the mean of the longitude obtained by the observations of August 7 and 8.

No. 71. Íbi Gámin Glacier, in Gnári Khórsum.

One of the largest glacier groups filling out the northern valleys of the massif of the Íbi Gámin.

We first made observations at the lower end of the glacier, the detail of which is given under *A*.

During our ascent of the glacier, we saw a star at daylight, which induced us to make a second series of observations (*B*). The distance between *A* and *B* was half a day's march, or about five miles. The longitude is deduced from our trigonometrical angles.

Geographical Co-ordinates.

A. At the lower end of the glacier.

Latitude North.	Longitude East Green.	Height.
30° 56′ 10″	79° 19′ 30″	16,910 feet.

Observations: 1855, A. August 13; B. August 16.

Instruments: Theodolite 2, Jones; Chron. 2; Hypsom. 8, Geissler; Barom. 6, Adie. Observer: Adolphe.

A. Lower end of the Íbi Gámin glacier.

Latitude and Time.

1855, August 13.	Horizontal Circle. Sun, Lower Limb.	Vertical Circle.
	A.M.	
h m s	° ′ ″	° ′ ″
1) 6 32 21	64 50 30	73 39 45
2) 6 38 48	70 2 0	73 40 15
	P.M.	
h m s	° ′ ″	° ′ ″
3) 6 44 52	75 6 0	73 24 45
4) 7 7 17	92 16 30	71 32 40

Hypsom. { 83°·98 C. = 416·2 millim.; 16·386 inches. Temp. of Air { 12°·0 C.; 53·6 Fahr.

Calculated by Method I., from Observations 1 and 4.

1) h corr. = 73° 55′·3
4) h' corr. = 71 48·3 $\delta = \delta' = +14° 52'·5$

Latitude N. . . . . 30° 56′·7
Mean Noon (corrected for Equation of Time) 6h 29m 58s

By calculating the latitude with this mean noon we obtain as definitive result:

Latitude N. . . . . 30° 56′·2;

the coincidence of the results is at the same time the control of the observations.

B. Five miles above the lower end of the Íbi Gámin glacier.

During our ascent of the Íbi Gámin glacier, while resting on a small grassy plain on the left flanks of the old lateral moraine of the glacier, we saw, in the dark blue sky, besides the sun and the moon, the planet Venus, which was distinctly visible to the naked eye.

The appearance of a star in full daylight took all our companions (Bhútias from

Johár) greatly by surprise; they, as well as the Tibetans, of whom we frequently made inquiries, assured us they had never before seen a star in the day time, a circumstance probably to be accounted for from the fact of their not having paid particular attention to the phenomena of the sky during the hours of daylight.

Venus is known to have been seen in Europe under similar circumstances, but this is a case of rare occurrence, and when seen, its visibility has been neither so perfect nor of so long duration as in the present instance, when the planet was clearly distinguishable for three consecutive days.

The phase of Venus was the Western Quadrature; its greatest brilliancy did not take place till August 25, 2^h P.M. Mean Greenwich Time.

Throughout the whole of our travels, this was the only instance of Venus, or of any other star, becoming visible in the day time.

Height and Azimuth of Venus were:

1855, August 16.	Horizontal Circle.	Vertical Circle.
h m s	° ′ ″	° ′ ″
7 1 33	205 18 49	44 8 5
7 14 2	208 55 50	45 53 55

We also made observations of the sun, of which the following are the results:

Point *B.* of Íbi Gámin glacier.

Latitude and Time.

	1855, August 16.	Horizontal Circle. Sun, Centre.	Vertical Circle.
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	6 35 21	256 34 15	72 55 7
		P.M.	
	h m s	° ′ ″	° ′ ″
2)	6 39 38	260 1 0	72 37 45
3)	6 43 22	262 58 30	72 27 57
4)	7 20 3	288 9 30	68 59 45

Barom. { 406·2 millim. / 15·993 inches. Temp. of Air { 13°·3 C. / 55·9 Fahr.

Calculated by Method I., from Observations 1 and 4.

1) h corr. = 72° 55′·0
4) h' corr. = 68 59·6

$\delta = \delta' = + 13° 56·1$

Latitude N., of point B . . . . 30° 53′·1
Mean Noon (corrected for Equation of Time) . . . 6^h 40^m 28^s

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No. 72. Púling, in Gnári Khórsum.

A small village, on the commercial road from Gårhvál to Gnári Khórsum, situated on the right side of an affluent of the Såtlej.

The longitude is only an approximate one, deduced from itinerary distances.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 15′ 30″	79° 15′ 40″	14,207 feet.

Observations: 1855, September 16 and 22.

Instruments: Theodolite 2. Jones; Chron. 2; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

A. 1855, September 16.

	1855, September 16.	Horizontal Circle. Sun, Centre.	Vertical Circle.
		A. M.	
	h m s	° ′ ″	° ′ ″
1)	11 43 14	26 11 45	61 27 15
		P. M.	
	h m s	° ′ ″	° ′ ″
2)	1 18 55	71 2 30	55 30 22
3)	1 25 50	73 17 0	54 29 15
4)	1 29 33	74 40 0	54 5 0

Barom. { 461·5 millim. / 18·170 inches. Temp. of Air { 17°·8 C. / 64·0 Fahr.

Calculated by Method I., from Observations 1 = I., and the mean of Observations 2, 3, and 4 = II.

I. h corr. = 61° 26′·7 δ = + 2° 51′·2
II. h' corr. = 54 40·8 δ' = + 2 49·9

Latitude N. . . . . 31° 15′·4
Mean Noon (corrected for Equation of Time) . . . 12^h 0^m 50^s

B. 1855, September 22.

1855, September 22. Vertical Circle.

Sun, Centre.

	h m s	° ′ ″
1)	11 55 2	59 9 0
2)	12 0 49	59 15 45
3)	12 3 9	59 16 7

Barom. { 463·0 millim. / 18·229 inches. Temp. of Air { 18°·1 C. / 64·6 Fahr.

Calculated by Method III.

Apparent Noon, calculated from Observations 1 and 3	12h 2m 40s
" " " 2 and 3	12 2 40
Calcul. Culminat. Altitude, corr. for Refraction and Parallax	59° 15′·8
Sun's Declination	+ 0 31·4
Elevation of the Equator	58 44·4
Latitude N., from September 22	31 15·6
Latitude N., from September 16	31 15·4
Latitude N. (Mean)	31 15·5

No. 73. Nélong Pass, in Gnári Khórsum.

This pass, also known under the name of Sangkiók, is situated at the western extremity of Gărhvál. It is one of those high passes in the range which separates Gnári Khórsum from Gărhvál. The instruments were put up on the top of the pass. The longitude is deduced from itinerary distances.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 7′ 30″	79° 0′ 40″	18,475 feet.

Observations: 1855, September 19.

Instruments: Theodolite 2, Jones; Chron. 2; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1855, September 19. Horizontal Circle. Vertical Circle.

Sun, Lower Limb.

	h m s	° ′ ″	° ′ ″
1)	12 5 4	117 21 15	60 18 5
2)	12 12 24	120 21 37	60 13 45
3)	12 23 33	126 6 52	59 58 7

Barom.	392·2 millim. / 15·441 inches.	Temp. of Air	6·3 C. / 43·3 Fahr.

Calculated by Method III.

	h	m	s
Calculated Apparent Noon, deduced from Observations 1 and 3 . .	12	1	53
" " " " 2 and 3 . .	12	1	54
Calculated Culminating Altitude of the Sun's Centre, corrected for Refraction, Parallax, and Semidiameter	60°	34'·2	
Sun's Declination	+ 1	41·7	
Elevation of the Equator	58	52·5	
Latitude N.	31°	7'·5.	

GROUP X.

LADÁK.

STATIONS 74 TO 83.

Mud.—Tsomoríri.—Tsomognalarí.—Lácha Lung pass.—Leh.—Pádum.—Dah.—Sásser pass.—Kárgil.—Dras.

No. 74. MŪD, IN SPÍTI.

This was the first inhabited place still remarkably elevated, which I (Hermann) reached after two days' march to the north of the Tári pass.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
31° 55' 35"	78° 1' 20"	12,421 feet.

Observations: 1856, June 13.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

1856, June 13.	Horizontal Circle. Sun, Lower Limb.	Vertical Circle.
	A. M.	
5^h 58^m 1^s	2° 27' 0"	79° 8' 30"
	P. M.	
7^h 50^m 22^s	110° 48' 32"	69° 4' 50"

Barom. { 482·8 millim. / 19·008 inches. Temp. of Air { 15°·0 C. / 59·0 Fahr.

Calculated by Method I.

	′ ″	′ ″
Refraction	— 0 7	— 0 16
Parallax	+ 0 4	+ 0 4
Sun's Semidiameter	+ 15 51	+ 15 51
Sum of Corr.	+ 15 48	+ 15 39

h corr. = 79° 31′·6
h' corr. = 67 41·7

$\delta = \delta' + 23° 14'·7$

Latitude N. . . . . 31° 55′·6
Mean Noon (corrected for Equation of Time) . 6h 25m 15s

Longitude.

	h m s
Mean Noon at Símla, by Chron. 3, 1856, May 15	6 28 21
Rate = XIII. = gaining 1s·01	+ 0 0 29
Mean Noon at Símla, reduced to 1856, June 13	6 28 50
Mean Noon at Mūd, 1856, June 13	6 25 15
Meridional Difference in Time	0 3 35
	° ′ ″
Símla, East of Green.	77 7 36
Mūd, East of Símla	0 53 45
Mūd, East of Green.	78 1 21

Meridian.

Deduced from low, corresponding Altitudes of the Sun . . . . 58° 35′·9.

No. 75. Tsomoríri Salt Lake, in Spíti.

The observations of latitude, longitude, and declination were made on the right shore, near the southern end of the lake, in an uninhabited spot occasionally visited for pasturage. Its name is Náma Bíngbo, the long meadow.

The observations of magnetic intensity were made eight miles to the north, at Kórzok, the name of a fortified house, inhabited only in summer by shepherds.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
32° 45′ 25″	78° 16′ 36″	15,130 feet.

Observations: 1856, June 21.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

Sun, Upper Limb.

	1856, June 21.	Horizontal Circle.	Vertical Circle.
	A. M.		
	h m s	° ′ ″	° ′ ″
1)	5 58 20	106 12 40	79 6 25
2)	6 2 50	111 54 40	79 37 25
3)	6 13 3	124 20 0	80 27 47
	P. M.		
	h m s	° ′ ″	° ′ ″
4)	6 55 54	177 53 0	78 53 45
5)	7 0 58	183 23 0	78 3 8

Barom. { 442·0 millim. / 17·402 inches. Temp. of Air { 17°·5 C. / 63·5 Fahr.

Calculated by Method III.

		h m s
Apparent Noon, calculated from Observations	1 and 3 . . .	6 29 9
" " " " "	2 and 3 . . .	6 29 9

	° ′ ″
Calculated Culminating Altitude of the Sun's Upper Limb	80 58 19
Correction of Sun's Semidiameter, Refraction, and Parallax	— 15 49
True Culminating Altitude	80 42 30
Sun's Declination	+ 23 27 34
Elevation of the Equator	57 14 56
Latitude N.	32 45 4

Longitude.

The apparent noon = $6^h\ 29^m\ 9^s$ is only to be considered as an element of calculation, not as a result.

For deducing the longitude, we calculated the time from lower altitudes.

	h m s
Mean Noon at Símla, by Chron. 3, 1856, May 15 . . .	6 28 21
Rate = XIII. = gaining $1^s \cdot 01$, for 37 days	+ 37
Mean Noon at Símla, reduced to 1856, June 21	6 28 58
Mean Noon at lower end of Tsomoríri	6 24 22
Meridional Difference in Time	4 36

	° ′ ″
Símla, East of Green.	77 7 36
Lower end of Tsomoríri, East of Símla	1 9 0
Lower end of Tsomoríri, East of Green.	78 16 36

Meridian.

During the adjustment of the declinometer in the afternoon, the theodolite got out of order, and had to be put up again. The meridian was found by the transit of *Antares* (α Scorpii) . . . . 112° 11′·4.

No. 76. TSOMOGNALARÍ, THE GREAT SALT LAKE, IN THE DISTRICT OF PANGKONG.

This great salt lake is divided into two parts, communicating with each other by a comparatively narrow channel.

The part of the lake east of the junction is fresh water, or nearly so, and shallow; the western part, somewhat deeper, is very brackish.

My instruments (Hermann) were put up near Tákung, a location for shepherds on the left shore. The total length of the lake exceeds 40 miles, and its general direction is east to west as far as Tákung, from whence to the lower end it takes a north-westerly turn.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
33° 39′ 50″	78° 38′ 30″	14,010 feet.

We have no exact data for comparison.

The longitude was estimated from distances referred to Tsomoríri, the high altitudes observed not giving sufficient accuracy for the determination of time.

Observations: 1856, July 2.

Instruments: Theodolite 2, Jones; Chron. 3; Barom. 1, Greiner. Observer: Hermann.

Latitude and Time.

1856, July 2.	Horizontal Circle.	Vertical Circle.
	Sun, Upper Limb.	
	A.M.	
	° ′ ″	° ′ ″
1) 5h 56m 51s	28 28 40	77 43 25
2) 6 6 21	37 35 50	78 42 55
	P.M.	
3) 6h 51m 58s	89 51 20	78 30 30
4) 6 56 3	94 0 5	78 7 0
5) 6 59 52	97 26 50	77 39 55

Barom. { 456·8 millim. / 17·984 inches. Temp. of Air { 18°·1 C. / 64·6 Fahr.

Calculated by Method II., from corresponding Altitudes.

	h m s
Apparent Noon, deduced from 1, 2, and 3, including the variation of the Sun's Declination	6 28 10
Equation of Time	3 30
Mean Noon (corrected for Equation of Time)	6 24 40

For the determination of the latitude, the mean was taken from observations 3, 4, and 5.

At $6^h\ 55^m\ 58^s$ 78° 5′ 48″ Vertical Circle.

	h m s
Time by Chronometer 3	6 55 58
Apparent Noon	6 28 10
Apparent Local Time	0 27 47
	° ′
Altitude of the Sun	78 5·8
Sum of Corr.	— 16·0
True Altitude of the Sun	77 49·8
Latitude N.	33 39·8

Meridian.

Deduced from low, corresponding Altitudes of the Sun . . . . 62° 46′·5

No. 77. LÁCHA LUNG PASS, IN SPÍTI.

This is one of the higher passes, on the road from Lahól to Ládak. It is situated several days' march distant from inhabited places.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
33° 3′ 50″	77° 35′ 35″	16,750 feet.

Observations: 1856, June 23.

Instruments: Theodolite 1, Jones; Chron. 2; Barom. 5, Adie. Observer: Robert.

Latitude and Time.

	1856, June 23.	Horizontal Circle. Sun, Lower Limb. A.M.	Vertical Circle.
	h m s	° ′ ″	° ′ ″
1)	2 42 20	21 46 45	31 55 43
2)	2 57 18	23 18 20	35 1 5
3)	3 6 21	24 18 45	36 56 25
4)	3 13 27	25 12 50	38 22 55
5)	3 21 13	26 12 0	40 1 50
6)	3 28 28	27 2 43	41 35 43
7)	3 34 55	27 54 55	42 53 50
8)	3 41 26	28 2 40	44 14 35

Barom. { 413·6 millim. / 16·284 inches.   Temp. of Air { 12·2 °C. / 54·0 Fahr.

Calculated by Method I., from Observations 1 and 8.

	1.	8.
	′ ″	′ ″
Refraction	− 52	− 32
Parallax	+ 7	+ 7
Sun's Semidiameter	+ 15 46	+ 15 46
Sum of Corr.	+ 15 1	+ 15 21

1) h corr. = 32° 10′·7   δ = + 23° 26′·9

8) h' corr. = 44 29·9   δ′ = + 23 26·9

Latitude N.	33° 3′·8
Mean Noon (corrected for Equation of Time)	$7^h\ 3^m\ 39^s$
Calculated Apparent Altitude at $3^h\ 6^m\ 21^s$.	36° 57′·1
Observed Altitude	36 56·4
Calc.—Obs.	+ 0 0·7

No. 78. Leh, in Ladák.

This important town, the capital of Ladák, is the principal place in Western Tíbet. It is situated on the right side of the Indus, three miles distant from the river. An extensive trade between India and Central Asia is carried on through Western Tíbet, of which Leh is the great *entrepôt*. During our stay we occupied a native house with an extensive walled compound, at the lower end of the town. We also erected an observatory, which we left, during our travels in Turkistán, in charge of our native doctor Hărkíshen and his assistant Nain Singh.[1]

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
34° 8′ 21″	77° 14′ 36″	11,527 feet.

Observations and Instruments, 1856. *A.* Latitude from Polaris, July 10 (Theodolite 4, Pistor), and September 16 (Theodolite 1, Jones). *B.* Latitude from Altitudes of the Sun, September 17 (Theodolite 2, Jones). Chron. 3; Barom. 1, Greiner, and 8, Pistor. Observers: Hermann and Robert.

For the latitude, we give the preference to observations of Polaris. With respect to the chronometric longitude, we may mention here how well chronometer 3 kept its rate during our journeys in Western Tíbet.

We have the following data for comparison: Colonel Waugh's map of the Pănjáb (1854) agrees very well for the latitude, but it makes the longitude more than 20′ farther to the east; Moorcroft had found, by observations with the sextant, latitude N.[2] 34° 9′ 21″; Cunningham gives[3] latitude N. 34° 9′ 7″, longitude E. Gr. 77° 59′ 3″.

A. *Latitude by Polaris.*

First Observation.

1856, July 10.	Altitude of Polaris.
$5^h\ 43^m\ 27^s$	33° 54′ 58″

[1] See p. 26. The details of the corresponding Magnetic Observations are contained in part III. of this volume.

[2] Asiatic Journal, 1825, Vol. X., p. 687.

[3] "Ladák", London, 1854, p. 422. The data, however, on which he bases the latitudes and longitudes contained in his book, are wanting.

		h m s
Time by Chronometer		17 43 27
Mean Noon		6 29 24[1]
Mean Local Time		11 14 3
Approximate Longitude		5 10 0
Mean Time at Green.		6 4 3
Sidereal Time at Mean Noon Green.		7 18 19
Acceleration of Fixed Stars	+	1 0
Approximate Longitude		5 10 0
Sidereal Time at Leh		18 33 22

		° ′
Observed Altitude of Polaris, corrected for Refraction		33 54·1
First Term from the Tables for Polaris	+	11·6
Second Term " " "	+	0·7
Third Term " " "	+	1·1
Latitude N.		34 7·5

Barom. { 499·9 millim. / 19·681 inches. Temp. of Air { 14·9° C. / 58·8 Fahr.

Second Observation.

1856, September 16. Altitude of Polaris.
$4^h 26^m 50^s$ 35° 2′ 14″

		h m s
Time by Chronometer		16 26 50
Mean Noon, from observed Altitudes of the Sun		6 29 27
Mean Local Time		9 57 23
Approximate Longitude		5 10 0
Mean Time at Green.		4 47 23
Acceleration of Fixed Stars	+	48
Approximate Longitude	+	5 10 0
Sidereal Time at Mean Noon Green.		11 42 28
Sidereal Time at Leh		21 40 39

		° ′
Observed Altitude of Polaris, corrected for Refraction		35 2·7
First Term from the Tables for Polaris	—	54·7
Second Term " " "	+	0·5
Third Term " " "	+	0·7
Latitude N.		34 9·2
Mean of Latitudes, deduced from the 2 Observations of Polaris		34° 8′ 21″.

This is the latitude we adopt as the most correct.

[1] Mean Noon, deduced from Altitudes of the Sun, July 11 (see p. 100).

B. *Latitude by Observations of the Sun.*

1856, September 17. Horizontal Circle. Vertical Circle.

Sun, Upper Limb.

	Time	Horizontal Circle	Vertical Circle
	A.M.		
	h m s	° ′ ″	° ′ ″
1)	1 42 37	212 56 0	17 49 42
2)	1 58 11	215 20 50	20 59 54
3)	2 10 43	217 21 27	23 30 49
4)	2 20 48	219 0 37	25 31 9
5)	2 31 21	220 50 43	27 33 54
6)	2 41 46	222 37 30	29 36 44
7)	2 46 33	223 27 50	30 33 59
8)	2 50 51	224 18 20	31 23 54
9)	2 55 36	225 12 20	32 19 9
10)	2 59 7	225 50 10	32 59 4
	P.M.		
	h m s	° ′ ″	° ′ ″
11)	10 41 21	190 33 20	22 31 14
12)	10 46 18	191 18 50	21 30 54
13)	10 50 52	192 2 43	20 35 39
14)	10 54 38	192 38 50	19 50 34
15)	10 58 39	193 20 10	19 0 54
16)	11 6 1	194 28 3	17 36 22
17)	11 9 39	195 0 10	16 45 34

Barom. { 502·0 millim. / 19·764 inches. Temp. of Air { 24°·0 C. / 75·2 Fahr.

First Approximation.

Calculated by Method I., from the means of observations 6 to 10 = I., and of observations 11 to 17 = II.

	Time.	Vertical Circle.
	h m s	° ′ ″
I. = Mean A.M. at	2 50 46	31 22 34
II. = Mean P.M. at	10 55 21	19 41 36

	I.	II.
	′ ″	′ ″
Refraction	− 1 2	− 1 46
Parallax	+ 0 7	+ 0 8
Semidiameter	− 15 58	− 15 58
Sum of Corr. . .	− 16 53	− 17 36

I.	h corr. $= 31^\circ\ 5'\ 41''$	$\delta = +\ 2^\circ\ 13'\ 55''$
II.	h' corr. $= 19\ 24\ 0$	$\delta' = +\ 2\ 6\ 6$

Latitude N. . . . . $34^\circ\ 5'\ 33''$
Mean Noon (corrected for Equation of Time) . . . $6^h\ 29^m\ 31^s$.

Second Approximation.

Comparison of the single observations with the elements obtained by the first approximation.

	A.M.						
	1.	2.	3.	4.	5.	6.	7.
Time by Chronometer . . .	$1^h42^m37^s$	$1^h58^m11^s$	$2^h10^m43^s$	$2^h20^m48^s$	$2^h31^m21^s$	$2^h41^m46^s$	2^h46^m[illegible]
Mean Noon . . . . } from 1st	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	6^h29^m3[illegible]
Mean Local Time } Approx.	$-4^h46^m54^s$	$-4^h31^m20^s$	$-4^h18^m48^s$	$-4^h\ 8^m43^s$	$-3^h58^m10^s$	$-3^h47^m45^s$	-3^h42^m[illegible]
Equation of Time	$+\ 5^m33^s$	$+\ 5^m33^s$	$+\ 5^m33^s$	$+\ 5^m33^s$	$+\ 5^m34^s$	$+\ 5^m34^s$	$+\ 5^m$[illegible]
Hour Angle in Time	$-4^h41^m21^s$	$-4^h25^m47^s$	$-4^h13^m15^s$	$-4^h\ 3^m10^s$	$-3^h52^m36^s$	$-3^h42^m11^s$	-3^h37^m2[illegible]
Hour Angle in Arc = t. . .	70°20'·3	66°26'·8	63°18'·8	60°47'·5	58° 9'·0	55°32'·8	54°21'·[illegible]
δ (Sun's Declination).	+ 2°14'·9	+ 2°14'·7	+ 2°14'·5	+ 2°14'·3	+ 2°14'·1	+ 2°14'·0	— 2°13'·[illegible]
sin φ sin δ	+0·02199	+0·02195	+0·02192	+0·02189	+0·02186	+0·02183	+0·0218[illegible]
cos φ cos δ cos t	+0·27842	+0·33068	+0·37164	+0·40380	+0·43667	+0·46816	+0·4822[illegible]
Sum = sin h . .	0·30041	0·35263	0·39356	0·42569	0·45853	0·48999	0·50411
h (True Altitude of the Sun's Centre)	17°28'·9	20°38'·9	23°10'·6	25°11'·6	27°17'·5	29°20'·4	30°16'·[illegible]
Refraction	+ 1'·9	+ 1'·8	+ 1'·4	+ 1'·3	+ 1'·2	+ 1'·1	+ 1'·[illegible]
Parallax	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1
± Sun's Semidiameter . . .	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	— 15'·9	+ 15'·[illegible]
Calculated Observation . .	17°46'·6	20°56'·5	23°27'·8	25°28'·7	27°34'·5	29°37'·3	30°33'·[illegible]
Direct Observation	17°49'·7	20°59'·9	23°30'·8	25°31'·1	27°33'·9	29°36'·7	30°33'·[illegible]
Calc.—Obs.	— 3'·1	— 3'·4	— 3'·0	— 2'·4	+ 0'·6	+ 0'·6	— 0'·[illegible]

	A.M.			P.M.						
	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Time by Chronometer	$2^h50^m51^s$	$2^h55^m36^s$	$2^h59^m\ 7^s$	$10^h41^m21^s$	$10^h46^m18^s$	$10^h50^m52^s$	$10^h54^m38^s$	$10^h58^m39^s$	$11^h\ 6^m\ 1^s$	$11^h\ 9^m39^s$
Mean Noon from 1st	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$	$6^h29^m31^s$
Mean Local Time Approx.	$-3^h38^m40^s$	$-3^h33^m55^s$	$-3^h30^m24^s$	$+4^h11^m50^s$	$+4^h16^m47^s$	$+4^h21^m21^s$	$+4^h25^m\ 7^s$	$+4^h29^m\ 8^s$	$+4^h36^m30^s$	$+4^h40^m\ 8^s$
Equation of Time	$+\ 5^m34^s$	$+\ 5^m34^s$	$+\ 5^m34^s$	$+\ 5^m41^s$	$+\ 5^m41^s$	$+\ 5^m41^s$	$+\ 5^m42^s$	$+\ 5^m42^s$	$+\ 5^m42^s$	$+\ 5^m42^s$
Hour Angle in Time	$-3^h33^m\ 6^s$	$-3^h28^m21^s$	$-3^h24^m50^s$	$+4^h17^m31^s$	$+4^h22^m28^s$	$+4^h27^m\ 2^s$	$+4^h30^m49^s$	$+4^h34^m50^s$	$+4^h42^m12^s$	$+4^h45^m50^s$
Hour Angle in Arc = t	53°16'·5	52° 5'·3	51°12'·5	64°22'·8	65°37'·0	66°45'·5	67°42'·3	68°42'·5	70°33'·0	71°27·5
δ (Sun's Declination)	+ 2°13'·8	+ 2°13'·8	+ 2°13'·7	+ 2° 6'·4	+ 2° 6'·3	+ 2° 6'·2	+ 2° 6'·1	+ 2° 6'·1	+ 2° 6'·0	+ 2° 5·9
sin φ sin δ	+0·02181	+0·02180	+0·02179	+0·02060	+0·02059	+0·02057	+0·02056	+0·02055	+0·02053	0·02052
cos φ cos δ cos t	+0·49483	+0·50845	+0·51843	+0·35784	+0·34167	+0·32657	+0·31396	+0·30051	+0·27557	0·26316
Sum = sin h	0·51664	0·53025	0·54022	0·37844	0·36226	0·34714	0·33452	0·32106	0·29610	0·28368
h (True Altitude of the Sun's Centre)	31° 6'·4	32° 1'·3	32°41'·9	22°14'·2	21°14'·3	20°18'·7	19°32'·6	18°43'·6	17°13'·4	16°28'·8
Refraction	+ 0'·9	+ 0'·9	+ 0'·8	+ 1'·3	+ 1'·4	+ 1'·4	+ 1'·5	+ 1'·6	+ 1'·7	+ 1'·8
Parallax	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1	— 0'·1
± Sun's Semidiameter	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9	+ 15'·9
Calculated Observation	31°23'·1	32°18'·0	32°58'·5	22°31'·3	21°31'·5	20°35'·9	19°49'·9	19° 1'·0	17°30'·9	16°46'·4
Direct Observation	31°23'·9	32°19'·1	32°59'·1	22°31'·2	21°30'·9	20°35'·7	19°50'·6	19° 0'·9	17°36'·4	16°45'·6
Calc.—Obs.	— 0'·8	— 1'·1	— 0'·6	+ 0'·1	+ 0'·6	+ 0'·2	— 0'·7	+ 0'·1	— 5'·5	+ 0'·8

In the present case, the importance of the object required particular care in the deduction of the final results; therefore, the differential equations for each single observation were formed by the method explained, instead of simply taking the means of "Calc.—Obs." for the groups A.M. and P.M. The observations in general agree very well with each other, with the exception of No. 16, which has consequently been excluded.

We obtain the following sixteen differential equations, which are to be treated by the method of least squares:[1]

1)	0	=	− 0·491	−	9·216 $d\varphi$	+	9·912 dt
2)	0	=	− 0·531	−	9·313 $d\varphi$	+	9·909 dt
3)	0	=	− 0·477	−	9·379 $d\varphi$	+	9·905 dt
4)	0	=	− 0·380	−	9·425 $d\varphi$	+	9·902 dt
5)	0	=	+ 9·778	−	9·473 $d\varphi$	+	9·898 dt
6)	0	=	+ 9·778	−	9·505 $d\varphi$	+	9·893 dt
7)	0	=	− 9·845	−	9·533 $d\varphi$	+	9·891 dt
8)	0	=	− 9·903	−	9·551 $d\varphi$	+	9·890 dt
9)	0	=	− 0·041	−	9·568 $d\varphi$	+	9·888 dt
10)	0	=	− 9·778	−	9·579 $d\varphi$	+	9·881 dt
11)	0	=	+ 9·000	−	9·358 $d\varphi$	−	9·907 dt
12)	0	=	+ 9·778	−	9·332 $d\varphi$	−	9·908 dt
13)	0	=	+ 9·301	−	9·306 $d\varphi$	−	9·909 dt
14)	0	=	− 9·845	−	9·285 $d\varphi$	−	9·910 dt
15)	0	=	+ 9·000	−	9·260 $d\varphi$	−	9·911 dt
17)	0	=	+ 9·903	−	9·186 $d\varphi$	−	9·913 dt

The final equations, which we obtain from these sixteen, are:

$$A.\quad 0 = +\,0{\cdot}498 + 0{\cdot}059\,d\varphi - 0{\cdot}132\,dt$$
$$B.\quad 0 = -\,1{\cdot}081 - 0{\cdot}132\,d\varphi + 1{\cdot}008\,dt$$

In all these equations the co-efficients are logarithmical, and the equations calculated so that the last decimal is exact. The solution of these equations, after reducing the sum of the squares of errors to a minimum, gives as values:

$$d\varphi = -\,1'{\cdot}6$$
$$dt = +\,1'{\cdot}0; \qquad dT = -\,4^{s}{\cdot}0;$$

therefore,

Latitude N. = φ . . . . $34^\circ\ 3'{\cdot}9$
Mean Noon = T . . . . $6^h\ 29^m\ 27^s$.

[1] The values "Calc.—Obs." are not multiplied with $\cos h$, but the co-efficients of $d\varphi$ and dt have been divided by $\cos h$.

The probable error of φ is five times greater than the probable error of T, which does not exceed one minute of arc, and, therefore, gives the time with a correctness most valuable for the chronometrical longitude.

Longitude.

	h	m	s
Mean Noon at Símla, by Chron. 3, 1856, May 15	6	28	21
Rate = XIII. = gaining $1^s{\cdot}01$, for 94 days		1	34
Mean Noon at Símla, reduced to 1856, September 17	6	29	55
Mean Noon at Leh, 1856, September 17	6	29	27
Meridional Difference in Time	0	0	28
	°	′	″
Símla, East of Green.	77	7	36
Leh, East of Símla	0	7	0
Leh, East of Green.	77	14	36

Meridian.

a. 1856, July 18.

By the passage of *Antares*, at about 9^h P.M. Local Time . . . . 135° 36′·2.

b. 1856, September 30.

The theodolite had been removed after the observations of September 17, and was put up again for the determination of the meridian.

We obtained by the passage of *Fomalhaud*, at about 10^h P.M. Local Time . . 225° 15′·6.

No. 79. Pádum, in Tsánskar.

This small village is the chief place of Tsánskar, situated on the left side of the Tsánskar river, in a broad valley, which, though well cultivated, is nearly devoid of trees. A fort built of unburnt bricks stands near the village.

The latitude and longitude is estimated from itinerary distances.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
33° 28′ 0″	76° 54′ 15″	11,590 feet.

Meridian.

Deduced from low, corresponding Altitudes of the Sun, 1856, June 25 . . . 27° 10′·2.

No. 80. Dah, in Ladák.

The road from Leh to Skárdo leads through this village, which is situated on the right side of the Indus. It is one of the numerous small villages which are found along the Indus valley; they are generally separated by tracts of uncultivated ground.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
34° 32′ 35″	76° 25′ 5″	9,690 feet.

Observations: 1856, July 6.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

Sun, Upper Limb.

	1856, July 6.	Horizontal Circle.	Vertical Circle.
	A.M.		
	h m s	° ′ ″	° ′ ″
1)	4 18 22	141 12 40	59 0 40
2)	4 23 11	142 16 9	59 57 50
3)	4 29 1	143 39 40	61 8 12
4)	4 32 36	144 34 30	61 48 15
	P.M.		
	h m s	° ′ ″	° ′ ″
5)	10 33 37	311 14 20	36 32 45
6)	10 43 16	312 29 40	34 33 55

Barom. { 544·1 millim. / 21·432 inches. Temp. of Air { 21°·6 C. / 70·9 Fahr.

Calculated by Method I.

We use for the calculations the means of 1, 2, 3, 4 = I., and of 5 and 6 = II., and give to observation 1 threefold weight, since it was marked as particularly good in the manuscripts of observation.

	h m s	° ′ ″
I. =	4 23 19	59 59 23
II. =	10 43 16	34 33 55

	I.	II.
	′ ″	′ ″
Refraction	— 22	— 58
Parallax	+ 4	+ 7
Sun's Semidiameter. .	— 15 46	— 15 46
Sum of Corr. . .	— 16 4	— 16 37

I. h corr.	= 59° 43'·3	δ	= + 22° 41'·9
II. h' corr.	= 34 17·3	δ'	= + 22 40·3

Latitude N.	34° 32'·6
Mean Noon (corrected for Equation of Time)	$6^h\ 26^m\ 43^s$

Control.

Calcul. Apparent Altitude of the Sun's Upper Limb at $4^h\ 29^m\ 1^s$	61° 7'·6
Observed Altitude	61 8·2
Calc.—Obs.	— 0·6

Longitude.

	h m s
Símla, May 15, Mean Noon by Chron. 1	6 25 21
Rate = X. = losing $1^s\cdot 7$, for 52 days	— 1 28
Mean Noon at Símla, reduced to July 6	6 23 53
Mean Noon at Dah	6 26 43
Meridional Difference	2 50

Símla, East of Green.	77° 7'·6
Dah, West of Símla.	0 42·5
Dah, East of Green.	76 25·1

We have no exact data for comparison.

No. 81. Sásser Pass, in Núbra.

The summer route from Ladák to Yárkand leads over this pass, which is situated in one of the greatest accumulations of glaciers we met with in this part of Tíbet.

It is the most difficult of all passes between Ladák and Turkistán; the track is easily discoverable, as it is strewn over its whole length with the skeletons of beasts of burden that have been exhausted with fatigue, and have dropped by the way.

We placed our instruments on the broad snow-covered top of the pass itself.

The stands were well secured against sinking unequally in the snow. In all similar instances we were able to preserve the proper level by placing the legs upon a solid foundation of stones.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 6' 0"	77° 27' 35"	17,753 feet.

Observations: 1856, August 2.

Instruments: Theodolite 2, Jones; Chron. 3; Hypsom. 5, Geissler. Observer: Hermann and Robert.

Latitude and Time.

1856, August 2. Horizontal Circle. Vertical Circle.

Sun, Upper Limb.

P.M.

	h m s	° ′ ″	° ′ ″
1)	11 17 7	9 5 40	26 1 43
2)	11 20 29	9 31 32	25 18 8
3)	11 23 44	9 57 40	24 30 45
4)	11 26 2	10 16 15	24 0 43
5)	11 29 11	10 41 20	23 21 43
6)	11 31 28	11 0 15	22 53 18

Barom. { 387·6 millim. / 15·260 inches. Temp. of Air { 12°·4 C. / 54·3 Fahr.

B. Polaris.

2^h 57^m 12^s 275° 54′ 50″ 34° 26′ 0″

Hypsom. { 82°·74 C. = 396·0 millim. / 15·591 inches. Temp. of Air { 6°·1 C. / 43·0 Fahr.

Latitude.

The latitude was obtained from the altitude of Polaris, an approximation for time having been previously calculated from the series of observations of the sun.

Resulting Latitude N. . . . . 35° 6′.

Longitude.

For calculating the time, the mean of the observations of the sun was introduced = 11^h 24^m 40^s;

		° ′
h		24 21·0
Refraction	—	1·1
Parallax	+	0·1
Sun's Semidiameter	—	15·8
h corr.		24 4·2
δ	+	17 40·9

	h m s
Hour Angle of the Sun	4 50 22
Time by Chronometer	11 24 40
Apparent Noon	6 34 18
Equation of Time	+ 5 57
Mean Noon	6 28 21
Mean Noon at Símla, May 15	6 28 21
Rate = XIII. = gaining 1ˢ·01, for 79 days	+ 1 20
Mean Noon at Símla, reduced to August 2	6 29 41
Mean Noon at Sásser pass	6 28 21
Meridional Difference in Time	1 20

	° ′
Símla, East of Green.	77 7·6
Sásser, East of Símla	20·0
Sásser, East of Green.	77 27·6

We have no data for comparison.

Meridian.

Deduced from the Altitudes of the Sun . . . . 274° 46′·5.

Nos. 82 and 83. Kárgil and Dras.

Both these villages belong to the Tibetan province of Dras.

Kárgil, the chief place of the province, is situated on a terrace upon the left side of the Kártse (Súru) river; Dras, though a small village, is of political importance, and is protected by a strong native fort.

The two places lie on the road which leads from Ladák to Kashmír. Complete observations of magnetic intensity were made at each station; we, therefore, give their latitudes and longitudes, as we estimated them by itinerary distances from Srinágger.

Kárgil.

Latitude North.	Longitude East Green.	Height.
34° 30′ 0″	76° 4′ 2″	8,845 feet.

Meridian.

From the passage of *Fomalhaut*, 1856, October 10 . . . . . . 210° 15′·0.

Dras.

Latitude North.	Longitude East Green.	Height.
34° 28′ 0″	75° 43′ 5″	9,951 feet.

Cunningham gives in "Ladák", p. 476, latitute N. 34° 23′ 49″; for the longitude the same number is repeated by mistake.

GROUP XI.

BÁLTI AND HASÓRA.

STATIONS 84 TO 92.

Húshe.—Chorkónda glacier.—△ Shincbákbi.—Tso-Ka.—Áskoli.—Chutrón.—Shígar.—Skárdo.—Táshing.

No. 84. Húshe, in Bálti.

This small village is situated in the valley of the Chetánga river, on a terrace above its present level.

The river is a tributary of the Shayók, and flows into it from the right, nearly opposite Kápalu.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 33′ 30″	76° 35′ 20″	10,440 feet.

Observations: 1856, July 14.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

A. Altitudes of the Sun.

Latitude and Time.

	1856, July 14.	Horizontal Circle. Sun, Upper Limb.	Vertical Circle.
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	4 7 54	339 34 15	55 20 30
2)	4 16 38	341 31 0	57 4 20
3)	4 24 9	343 18 20	58 32 35
4)	4 46 59	349 20 0	62 55 55
5)	4 54 38	351 44 55	64 20 10
		P.M.	
	h m s	° ′ ″	° ′ ″
6)	9 54 40	142 37 20	44 48 55
7)	10 1 29	143 41 20	43 25 45
8)	10 6 9	144 23 40	42 28 20
9)	10 10 13	145 0 40	41 38 25
10)	10 14 23	145 38 0	40 47 30

Barom. { 523·0 millim. / 20·591 inches. Temp. of Air { 26°·2 C. / 79·2 Fahr.

Calculated by Method I.

We use observation 4 = I. (since observation 5 is marked "doubtful"[1] in the original manuscripts), and the mean of observations 7, 8, 9, and 10 = II.

	I.	II.
	′ ″	′ ″
Refraction	— 0 19	— 0 42
Parallax	+ 4	+ 6
Sun's Semidiameter	— 15 46	— 15 46
Sum of Corr.	— 16 1	— 16 22

I. h corr. = 62° 39′·9 δ = + 21° 40′·9

II. h' corr. = 41 48·6 δ′ = + 21 38·8

Latitude N. . . . . 35° 36′·2

Mean Noon (corrected for Equation of Time) . . . . . 6^h 29^m 25^s

Control.

	° ′
Calc. Appar. Altitude of the Sun's Upper Limb at 4^h 57^m 38^s . . .	64 20·8
Observed Altitude	64 20·2
Calc.—Obs.	0·6

B. Observations of Polaris.

1856, July 14.

Barom. { 523·2 millim. / 20·599 inches. Temp. of Air { 20°·6 C. / 69·1 Fahr.

	° ′ ″
Altitude of Polaris at 3^h 17^m 40^s	34 32 40
Refraction	— 56
h corr.	34 31 44

Latitude N. . . . . 35° 30′·7

As resulting latitude we adopt the mean of both determinations:

Latitude N. . . . . 35° 33′·5

[1] The control, however, shows that it is correct.

Longitude.

	h m s
Mean Noon at Shígar, by Chron. 1, 1856, August 5	6 32 44
Mean Noon at Húshe, 1856, July 14	6 29 25
Rate = XI. = 0s·0	0 0 0
Meridional Difference in Time	0 3 19

	° ′
Shígar, East of Green.	75 45·5
Húshe, East of Shígar	49·8
Húshe, East of Green.	76 35·3

No. 85. Chorkónda Glacier, above △ Dondóng, in Bálti.

This was Adolphe's encamping place on the left side of the Chorkónda glacier. As high up as △ Dondóng, which is already far from every inhabited place, shrubs are to be seen; but beyond there is scarcely any sign of vegetation.

The longitude is estimated from distances by Shígar.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 33′ 20″	75° 56′ 0″	13,790 feet.

Observations: 1856, July 24.

Instruments: Theodolite 3, Troughton; Chron.: In this case he used his pocket watch, by Dent, for the intervals of Time, the Chronometer not being at hand at the moment of the Observation. Hypsom. 8, Geissler. Observer: Adolphe.

Latitude and Time.

	1856, July 24.	Horizontal Circle. Sun, Upper Limb.	Vertical Circle.
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	10 12 12	210 42 0	55 35 40
2)	10 23 29	213 28 50	57 46 30
3)	10 33 0	215 59 15	59 35 0
4)	10 37 53	217 23 30	60 30 0
		P.M.	
	h m s	° ′ ″	° ′ ″
5)	3 56 9	8 12 0	43 15 45
6)	4 1 21	. . .	42 12 7
7)	4 5 28	. . .	41 20 25
8)	4 8 52	10 12 20	40 39 10

Hypsom. { 86°·46 C = 458·5 millim. / 18·052 inches. } Temp. of Air { 10°·4 C. / 50·7 Fahr. }

Calculated by Method I.

	Time.	Vertical Circle.
	h m s	° ′ ″
I. = Mean A.M. . . . . . at	4 26 39	58 21 48
II. = Mean P.M. . . . . . at	10 2 57	41 51 52

	I.	II.
	′ ″	′ ″
Refraction	— 22	— 40
Parallax	+ 4	+ 6
Semidiameter	— 15 47	— 15 47
Sum of Corr.	— 16 5	— 16 21

I. h corr. = 58° 5′·7 δ = + 19° 51′·8

II. h' corr. = 44 35·5 δ′ = + 19 48·9

Mean Noon (corr. for Equation of Time) . . $12^h\ 27^m\ 4^s$

Latitude N. . . . . 35° 33′·3

Control.

	° ′
Calcul. Apparent Altitude of the Sun's Upper Limb at $10^h\ 33^m\ 0^s$	59 35·1
Observed Altitude	59 35·0
Calc.—Obs.	+ 0·1

The control shows that the single observations are so correct that a more minute calculation is unnecessary.

Meridian.

Deduced from the Altitudes of the Sun . . . . . 283° 19′·8

No. 86. △ Shinchákbi Biánga, in Bálti.

An uninhabited place, with shrubs and fine grass, situated on the left side of the lower part of the Musták glacier. At this spot Adolphe made a halt on his way up the Musták pass.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 56′ 35″	76° 0′ 20″	13,553 feet.

Observations: 1856, August 25.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1856, August 25.	Horizontal Circle.	Vertical Circle.
	Sun, Upper Limb.	
	A.M.	
h m s	° ′ ″	° ′ ″
1) 4 10 50	220 0 0	49 21 55
2) 4 18 28	221 59 50	50 41 55
3) 4 22 36	223 8 30	51 24 50
	P.M.	
h m s	° ′ ″	° ′ ″
4) 9 5 34	344 21 40	47 39 30
5) 9 13 31	346 14 40	46 12 35
6) 9 18 45	347 28 10	45 14 10
7) 9 24 7	348 40 30	44 13 50

Barom. { 466·9 millim. / 18·382 inches. Temp. of Air { 12°·4 C. / 54·3 Fahr.

Calculated by Method I.

For the calculation of the latitude we use the means of 1, 2, and 3 = I., and of 4, 5, 6, and 7 = II., giving to observation 6 double weight, since it was marked in the manuscripts as particularly good.

	Time.	Vertical Circle.
	h m s	° ′ ″
I. = Mean A.M. . . . . . . at	4 17 28	50 29 13
II. = Mean P.M. . . . . . . at	9 16 8	45 42 51

	I.	II.
	′	′
Refraction	− 0·8	− 1·0
Parallax	+ 0·1	+ 0·1
Sun's Semidiameter	− 15·9	− 15·9
Sum of Corr.	− 16·6	− 16·8

I. h corr. = 50° 12′·6   δ = + 10° 44′·2

II. h' corr. = 45 26·0   δ′ = + 10 39·9

Latitude N. . . . . 35° 56′·6

Mean Noon (corrected for Equation of Time) . . . 6h 31m 45s

Controls.

	° ′
Calcul. Apparent Altitude of the Sun's Upper Limb at 4h 22m 36s	51 23·1
Observed Altitude	51 24·8
Calc.—Obs.	− 1·7

	° ′
Calcul. Apparent Altitude of the Sun's Upper Limb at 4^h 18^m 28^s	50 40·1
Observed Altitude	50 41·9
Calc.—Obs.	— 1·8

Longitude.

	h m s
Mean Noon at Shígar, by Chron. 1, 1856, August 5	6 32 44
Mean Noon at △ ShincHákbi Biánga, 1856, August 25	6 31 45
Rate = XI. = 0^s·0	0 0 0
Meridional Difference in Time	0 0 59

	° ′
Shígar, East of Green.	75 45·5
△ Shinchákbi Biánga, East of Shígar	0 14·8
△ Shinchákbi Biánga, East of Green.	76 0·3

No. 87. △ Tso Ka, in Bálti.

This small glacier lake is a periodical one, formed in summer by the melting of the ice on the left side of the large Musták glacier.

Patches of grass are to be found on the flanks of the mountains which skirt the lake, but the locality is beyond the limit of shrubs.

△ Tso Ka is on the way leading from Shígar across the Musták pass to Turkistán.

Adolphe here determined the dip only; we adopt:

	° ′
Latitude N.	35 58
Longitude	76 3

referred to △ Shinchákbi Biánga. Height of △ Tso Ka: 15,724 feet.

No. 88. Áskoli, in Bálti.

The highest village in the Upper Braháldo, or Kóngma Braháldo valley, situated on the right side of the Braháldo river, an affluent of the principal river of Shígar.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 41′ 20″	75° 56′ 0″	9,710 feet.

Observations: 1856, August 14.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1856, August 14.		Horizontal Circle.	Vertical Circle.
		Sun, Upper Limb.	
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	4 12 8	100 1 10	51 39 50
2)	4 16 55	101 4 10	52 26 30
3)	4 23 26	102 47 50	53 38 10
		P.M.	
	h m s	° ′ ″	° ′ ″
4)	9 59 37	244 0 20	40 10 25
5)	10 3 35	244 42 0	39 23 57
6)	10 8 37	245 36 20	38 23 30

Barom. { 534·8 millim. / 21·055 inches.   Temp. of Air { 20°·2 C. / 68·4 Fahr.

Calculated by Method I.

We use for the calculation the means of 1, 2, 3 = I., and of 4, 5 = II., observation 6 being marked "doubtful" in the original manuscript.[1]

	Time.	Vertical Circle.
	h m s	° ′ ″
I. =	4 17 30	52 34 50
II. =	10 1 36	39 47 11

	I.	II.
	′	′
Refraction	− 0·9	− 0·7
Parallax	+ 0·1	+ 0·1
Sun's Semidiameter	− 15·8	− 15·8
Sum of Corr.	− 16·6	− 16·4

I. h corr. = 52° 18′·2 δ = + 14° 21′·0

II. h' corr. = 39 30·8 δ' = + 14 16·6

Latitude N. . . . . 35° 41′·3

Mean Noon (corrected for Equation of Time) . . 6h 32m 2s

Control.

	° ′
Calcul. Apparent Altitude of the Sun's Upper Limb at 10h 8m 37s . . .	38 23·7
Observed Altitude	38 23·5
Calc.—Obs.	+ 0·2

[1] The control, however, shows that it is correct.

Longitude.

	h	m	s
Mean Noon at Shígar, by Chron. 1, 1856, August 5	6	32	44
Mean Noon at Áskoli, 1856, August 14	6	32	2
Rate = XI. = 0s·0	0	0	0
Meridional Difference in Time	0	0	42

	°	′
Shígar, East of Green.	75	45·5
Áskoli, East of Shígar		10·5
Askoli, East of Green.	75	56·0

No. 89. Chutrón, in Bálti.

Several hot springs take their rise near this small village, which is situated on the right side of the Shígar river, in its upper course, where it flows through the district of Básha. The springs, which have a temperature of 44°·0 C. = 111°·2 Fahr., issue from the base of a steep gypsum rock.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 44′ 35″	75° 25′ 40″	8,060 feet.

Observations: 1856, August 8.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

	1856, August 8.	Horizontal Circle. Sun, Upper Limb.	Vertical Circle.
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	3 51 47	81 27 20	48 14 40
2)	3 56 35	82 26 30	49 8 50
3)	4 2 14	83 24 20	50 14 30
4)	4 11 47	85 51 30	52 3 20
		P.M.	
	h m s	° ′ ″	° ′ ″
5)	10 4 29	235 15 20	40 48 0
6)	10 10 2	236 14 0	39 41 15
7)	10 16 26	237 17 50	38 24 40

Barom. { 564·2 millim. / 22·213 inches. Temp. of Air { 23°·2 C. / 73·8 Fahr.

Calculated by Method I.

We take for the calculation observation 4 = I., since it is marked in the manuscript as particularly good, and the mean of 5, 6, 7 = II.

	I.	II.
	′ ″	′ ″
Refraction	— 37	— 57
Parallax	+ 5	+ 7
Sun's Semidiameter	— 15 48	— 15 48
Sum of Corr. . . .	— 16 20	— 16 38

I. h corr. = 51° 47′·0 δ = + 16° 8′·1
II. h' corr. = 39 21·3 δ' = + 16 3·8

Latitude N. . . . . 35° 44′·6
Mean Noon (corrected for Equation of Time) . . $6^h\ 34^m\ 3^s$

Control.

	° ′
Calcul. Apparent Altitude of the Sun's Upper Limb at $4^h\ 2^m\ 14^s$ . . .	50 14·3
Observed Altitude	50 14·5
Calc.—Obs.	— 0·2

Longitude.

	h	m	s
Mean Noon at Shígar, by Chron. 1, 1856, August 5	6	32	44
Mean Noon at Chutrón, 1856, August 8	6	34	3
Rate = XI. = 0^s·0	0	0	0
Meridional Difference in Time	0	1	19

	° ′
Shígar, East of Green.	75 45·5
Chutrón, West of Shígar	0 19·8
Chutrón, East of Green.	75 25·7

No. 90. Shígar, in Bálti.

Though the chief place in the district to the north of Skárdo, this is but an unimportant village, situated on the right side of the Shígar Lungba river.

The longitude was computed most carefully from itinerary distances. Compare p. 107.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 28′ 35″	75° 45′ 30″	7,537 feet.

Observations: 1856, August 5.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

1856, August 5.	Horizontal Circle.	Vertical Circle.
	Sun, Upper Limb.	
	A.M.	
h m s	° ′ ″	° ′ ″
1) 3 1 31	279 27 0	38 56 30
2) 3 6 1	280 11 40	39 50 40
3) 3 12 23	281 15 30	41 8 10
4) 3 19 55	282 33 40	42 39 20
	P.M.	
h m s	° ′ ″	° ′ ″
5) 10 33 26	89 32 40	35 14 15
6) 10 38 49	90 23 40	34 8 10
7) 10 43 57	91 8 20	33 6 10

Barom. { 578·1 millim. / 22·760 inches. Temp of Air { 22°·7 C. / 72·9 Fahr.

Calculated by Method I.

We use for the calculation the means of observations 1, 2, 3, 4 = I., and of 5, 6, 7 = II., giving to observation 5 double weight, on account of its being marked as particularly good in the manuscripts of observations.

	Time.	Vertical Circle.
	h m s	° ′ ″
I. = Mean A.M. . . . . . . at	3 9 58	40 38 40
II. = Mean P.M. . . . . . . at	10 37 24	34 25 42

	I.	II.
	′	′
Refraction	— 1·0	— 1·2
Parallax	+ 0·1	+ 0·1
Semidiameter	— 15·8	— 15·8
Sum of Corr.	— 16·7	— 16·9

I. h corr. = 40° 22′·0 δ = + 16° 58′·8

II. h' corr. = 34 8·8 δ' = + 16 53·7

Latitude N. . . . . 35° 28′·6
Mean Noon (corrected for Equation of Time). . 6^h 32^m 44^s.

Control.

	° ′
Calcul. Apparent Altitude of the Sun's Upper Limb at 3^h 19^m 55^s	42 38·8
Observed Altitude	42 39·3
Calc.—Obs.	— 0·5

No. 91. Skárdo, in Bálti.

Skárdo lies upon the left bank of the Indus, and, though the capital of Bálti, is in a commercial point of view a town of far less importance than Leh, the capital of Ladák, and Gártok, the principal place in Gnári Khórsum.

The Báltis, however, are generally good cultivators, and produce many articles for export, of which dried fruits form the largest item.

Adolphe took his observations at Nagolisbáng, about one mile S.W. of the fort, where a few isolated houses are standing.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 20′ 12″	75° 44′ 0″	7,250 feet.

Observations: 1856, September 2.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

A. Altitudes of the Sun.

Latitude and Time.

	1856, September 2.	Horizontal Circle.	Vertical Circle.
		Sun, Upper Limb.	
		A.M.	
	h m s	° ′ ″	° ′ ″
1)	3 42 13	231 11 30	42 46 0
2)	3 49 23	232 49 50	44 5 20
3)	3 54 22	233 59 40	44 59 55
4)	3 57 47	234 49 40	45 36 15
5)	4 11 7	238 11 25	47 57 30
6)	4 16 10	239 31 0	48 17 0

P.M.

	h m s	° ′ ″	° ′ ″
7)	10 25 19	13 34 25	30 30 40
8)	10 51 37	17 54 0	25 15 0

Barom. { 583·2 millim. / 22·961 inches. Temp of Air { 22°·9 C. / 73·2 Fahr.

Calculated by Method I.

Latitude N. . . . . 35° 18′·3
Mean Noon (corrected for Equation of Time) . . . . $6^h\ 32^m\ 50^s$

The detail of these calculations is given as one of the examples, pp. 86 et seq.

B. Observations of Polaris.

1856, September 2.	Vertical Circle.
h m s	° ′ ″
3 18 5	35 30 40
3 29 11	35 34 36
3 42 19	35 39 30
Mean 3 29 52	Mean 35 34 55

Barom. { 584·2 millim. / 23·0 inches. Temp of Air { 20°·6 C. / 69·1 Fahr.

	° ′ ″
Refraction	— 1 0
Latitude N.	35 20 17
Latitude N., calculated from the highest Altitude alone	35 20 8
Latitude N. (Mean of both calculations of Polaris)	35 20 12

This is the latitude we adopt.

Longitude.

	h m s
Mean Noon at Shígar, by Chron. 1, 1856, August 5	6 32 44
Mean Noon at Skárdo, 1856, September 2	6 32 50
Rate = XI. = $0^s·0$	0 0 0
Meridional Difference in Time	0 0 6

	° ′
Shigar, East of Green.	75 45·5
Skárdo, West of Shígar	1·5
Skárdo, East of Green.	75 44·0

Meridian.

Deduced from the Altitudes of the Sun . . . . . 296° 23′·1.

No. 92. Táshing, in Hasóra.

A small fort stands near this place, which is an unimportant village to the north-east of the Diámer peak, in the valley of Hasóra.

The instruments were put up 200 yards N.N.W. of the fort, in a fine, open meadow.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 15′ 40″	74° 40′ 40″	9,691 feet.

Observations: 1856, September 20.

Instruments: Theodolite 3, Troughton; Chron. 1; Barom. 6, Adie. Observer: Adolphe.

Latitude and Time.

Sun, Upper Limb.

	1856, September 20.	Horizontal Circle.	Vertical Circle.
	A.M.		
	h m s	° ′ ″	° ′ ″
1)	4 12 16	8 24 0	43 25 30
2)	4 19 56	10 28 24	44 37 57
3)	4 24 23	11 42 44	45 18 30
4)	4 27 53	12 44 50	45 50 30
5)	4 36 43	15 19 30	47 6 10
6)	4 42 14	16 57 47	47 51 10
	P.M.		
	h m s	° ′ ″	° ′ ″
7)	9 32 46	120 40 40	35 41 35
8)	9 39 22	122 5 0	34 41 0
9)	9 51 6	124 27 55	32 21 20
10)	9 58 41	125 52 40	31 0 10

Barom. { 537·2 millim. / 21·150 inches. } Temp of Air { 15°·7 C. / 60·3 Fahr. }

Calculated by Method I.

We use for the calculation the means of observations 1 to 6 = I., and of 7 to 10 = II.

		Time.	Vertical Circle.
		h m s	° ′ ″
I. =	Mean A.M.	at 4 27 14	45 41 38
II. =	Mean P.M.	at 9 45 24	33 26 1

I. h corr. = 45° 25′·2 δ = + 1° 2′·5

II. h' corr. = 33 9·2 δ' = + 0 57·3

Latitude N. . . . . 35° 15′·7

Mean Noon (corrected for Equation of Time) 37ᵐ 3ˢ

Longitude.

	h	m	s
Mean Noon at Shígar, by Chron. 1, 1856, August 5	6	32	44
Mean Noon at Táshing, 1856, September 20	6	37	3
Rate = XI. = 0s·0	0	0	0
Meridional Difference in Time	0	4	19

	°	′
Shígar, East of Green.	75	45·5
Táshing, West of Shígar	1	4·8
Táshing, East of Green.	74	40·7

Meridian.

Calculated from the Altitudes of the Sun . . . . . 58° 36′·0

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c. KARAKORÚM AND KUENLÚEN.

GROUP XII.

TURKISTÁN.

STATIONS 93 TO 112.

Karakorúm.—Kiúk-Kiŏl.—Súget.—Route from the Karakorúm pass to Búshia.

For the extent of the range included under the name of "Karakorúm", compare our general map, and the map of routes No. I. of the Atlas.

The Karakorúm runs generally parallel to the Himálaya, beginning east of Lhássa and ending at the longitude of Hasóra. It forms the northern border of Eastern and Western Tíbet, and, what is more important still, this range, and not that of the Kuenlúen, forms the watershed between India and Central Asia.

Different names are given to this chain in the various provinces along its foot; we selected as the general name the one used in Turkistán, and which is also known in Ladák. Its signification, "the black mountains", in contrast to the more snowy chain, "Himálaya", also appeared to us very well to express one of the most characteristic features of its physical geography.

No. 93. Karakorúm Pass,

forming the Frontier between Ladák and Turkistán.

We reached this pass at 2 P.M., and remained till the approach of night compelled us to descend. Heavy gusts of wind, which sprang up soon after 3 P.M., considerably added to the difficulties of the observations, as the rarefaction of the air causes much more pain under the influence of strong winds.[1] The effect on this occasion was such that only two of our people could be induced to remain with us at the top of the pass; the others, who had already gone down, we did not reach till 11 o'clock at night.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 46′ 55″	77° 30′ 21″	18,341 feet.

Observations: 1856, August 9.

Instruments: Theodolite 2, Jones; Chron. 3; Hypsom. 5, Geissler. Observers: Hermann and Robert.

Latitude.

Our very limited stay, and the various observations we had to make for completing the magnetic determinations, rendered it impossible to take altitudes of the sun till late in the afternoon. These altitudes give time and longitude very well, but the latitude with hardly sufficient accuracy. We, therefore, preferred deducing the latitude from itinerary distances and bearings referred to the Sásser pass.

We obtain Latitude N. 35° 46′·9.

Time and Longitude.

1856, August 9.	Horizontal Circle.	Vertical Circle.
h m s	° ′ ″	° ′ ″
10 48 31	193 54 15	30 43 42
10 55 8	195 1 0	29 10 42
11 1 15	195 55 50	27 56 12
11 5 6	196 29 50	27 7 22

Hypsom. { 82°·4 C. = 390·6 millim. / 15·379 inches. Temp. of Air { 10°·8 C. / 51·4 Fahr.

The time is calculated (with the latitude given above) from the mean of the preceding observations.

Mean of Time.	Mean Altitude.
10h 57m 30s	28° 44′·5

[1] See pp. 25 and 26.

		° ′
Refraction	—	1·7
Parallax	+	0·1
Sun's Semidiameter	—	15·8
Corr. Altitude at $10^h\ 57^m\ 30^s$		28 27·1

$\delta = +\ 15^\circ\ 45'\cdot6$

	h m s
Time by Chronometer	10 57 30
Hour Angle of Sun	4 24 1
Apparent Noon	6 33 29
Equation of Time	5 12
Mean Noon	6 28 17

		h m s
Mean Noon at Símla, by Chron. 3, 1856, May 15 . . .		6 28 21
Rate = XIII. = gaining $1^s\cdot01$, for 86 days	+	1 27
Mean Noon at Símla, reduced to 1856, August 9 . . .		6 29 48
Mean Noon at Karakorúm pass		6 28 17
Meridional Difference in Time		0 1 31

	° ′ ″
Símla, East of Green.	77 7 36
Karakorúm pass, East of Símla	0 22 45
Karakorúm pass, East of Green.	77 30 21

Meridian.

From the Altitudes of the Sun . . . . 285° 53′·5

No. 94. Kiúk-Kiŏl, the "Blueish-Green Lake", in Turkistán.

This lake of brackish water is situated on the right side of the Karakásh river, in its upper eastern course.

It is scarcely ever visited by caravans, on account of its great distance from every inhabited place, though it is surrounded by large patches of grass, and is frequented by herds of wild animals. Hot saline springs are very numerous a few miles lower down the Karakásh valley.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
35° 40′ 0″	77° 56′ 0″	15,460 feet.

Observations: 1856, August 13.

Instruments: Theodolite 2, Jones; Chron. 3; Hypsom 5, Geissler. Observer: Hermann.

Latitude and Time.

1856, August 13.	Horizontal Circle.	Vertical Circle.
	A.M.	
	Sun, Lower Limb.	
h m s	° ′ ″	° ′ ″
1) 5 12 58	124 35 15	52 7 20
2) 5 32 22	130 0 30	55 36 30
	P.M.	
	Sun, Upper Limb.	
h m s	° ′ ″	° ′ ″
3) 10 12 44	259 33 40	48 12 20
4) 10 32 9	263 42 15	44 28 10

Hypsom. { 85°·18 C. = 436·1 millim. / 17·170 inches. Temp. of Air { 17°·6 C. / 63·7 Fahr.

When descending the Karakorúm pass on the evening of the 9th August, we were overtaken by the night before reaching our encampment at △ Búllu. One of the horses carrying the theodolite fell down, and the level of the vertical circle was unfortunately broken. We had a spare level with us, which we connected with the vertical circle, but only with approximate accuracy. We thought at first that we had succeeded in properly adjusting the vertical circle; but upon repeating our trials, we found, when taking the vertical angles of different peaks, that the adjustment was not sufficiently correct.

A few days later we succeeded in properly fixing the spare level. It then kept in perfect order, as is proved by our subsequent observations taken at △ Súget.[1]

Kiúk-Kiől seemed to us a station of such importance that we attempted to find a method for calculating the latitude from the azimuthal motion of the sun.

The method we employed was the following:

We have four observed times:

$$t,\ t'\ t'',\ t''',$$

and four altitudes reduced to the sun's centre, containing an unknown error, y:

$$h + y,\ \ h' + y,\ \ h'' + y,\ \ h''' + y;$$

and

$$t' - t \text{ is about equal to } t''' - t'', \quad (1)$$

$$h \text{ is about equal to } h'' + (h' - h). \quad (2)$$

The altitudes are not corresponding ones; but, nevertheless, they can be used in

[1] See pp. 264 et seq.

a similar manner to corresponding altitudes for the determination of the apparent noon, as will be seen from the following formulæ:

I.	$t = 5^h\ 12^m\ 58^s$	$h + y = 52^\circ\ 23'{\cdot}1$
	$t' = 5\ 32\ 22$	$h' + y = 55\ 52{\cdot}1$
	$t' - t = 19\ 24$	$h' - h = 3\ 29{\cdot}0$
II.	$t'' = 10\ 12\ 44$	$h'' + y = 47\ 56{\cdot}5$
	$t''' = 10\ 32\ 9$	$h''' + y = 44\ 12{\cdot}4$
	$t''' - t'' = 19\ 25$	$h''' - h'' = 3\ 44{\cdot}1$

Neither of these two groups alone can be used for forming corresponding altitudes; as, in doing so, the higher terms of the vertical motion of the sun would be omitted.

The approximate equations (1) and (2), however, show that the apparent noon may be deduced with quite sufficient accuracy by representing

h by $h''' - h''$, and
h'' by $h' - h$.

We then obtain the two following equations:

$$3^\circ\ 44'{\cdot}1 : 4^\circ\ 26'{\cdot}6 = 19'\ 25'' : x$$
$$3\ 29{\cdot}0 : 4\ 26{\cdot}6 = 19\ 24 : x.$$

Apparent noon by combination A:

h and h'' reduced by $h''' - h''$ to $h = 7^h\ 31^m\ 18^s$;

" " by combination B:

h'' and h reduced by $h' - h$ to $h'' = 7\ 30\ 28$

Apparent Noon, Mean 7 30 53

Latitude.

We adopt an approximate value, 36° 19′ (obtained by method II.) as first hypothesis, but recollecting the error in the adjustment of the vertical circle, we take as second hypothesis any other value, say 20′ less (for facility of interpolation) = 35° 59′, and we then deduce the latitude representing the azimuthal motion of the sun.

Hypothesis	A	B
	° ′	° ′
Azimuthal motion, calculated	137 30	138 22
" " observed	139 7	139 7
Calc.—Obs.	— 1 37	— 0 45

The true latitude therefore is obtained by the equation:

$$52'' : 45' = 20' : \Delta\varphi$$
$$\Delta\varphi = 19'; \qquad \varphi = 35^\circ\ 40' = \text{Latitude N.}$$

The longitude was deduced from itinerary distances; chronometer 4 might have been reduced by comparison with chron. 3, but, the level of the theodolite being out of order, the longitude so obtained would, nevertheless, have been very badly defined.

No. 95. △ Súget, in Turkistán.

This halting place for caravans trading between Ladák and Khótan is one of the finest to be found on this deserted route. It is about two miles distant from the left side of the Karakásh river, in a broad, lateral valley, which, however, is narrow and steep at its lower end.

Shrubs, called "Súget" by the Turks, and covering isolated spots in the valley, have given the present name to the place. Circular walls of stones are erected at the halting place to shelter travellers from the wind during the night.

The nearest inhabited places to the south are nine marches distant.

Geographical Co-ordinates.

Latitude North.	Longitude East Green.	Height.
36° 10′ 25″	77° 50′ 5″	12,960 feet.

Observations: 1856, September 1.

Instruments: Theodolite 2, Jones; Chron. 3; Hypsom. 5, Geissler. Observers: Hermann and Robert.

Latitude and Time.

	1856, September 1.	Horizontal Circle.	Vertical Circle.
		Sun, Upper Limb.	
	h m s	° ′ ″	° ′ ″
1)	6 28 33	331 39 35	62 16 40
2)	6 32 22	332 42 15	62 18 15
3)	6 36 40	335 57 0	62 14 30
4)	6 40 18	337 50 20	62 9 40
5)	6 58 11	347 2 10	61 30 45

Hypsom. { 89°·0 C. = 505·8 millim. / 19·913 inches. Temp. of Air { 15°·0 C. / 59·0 Fahr.

First Approximation.

Calculated by Method III. The detail of the calculation is given pp. 92 and 93.

We had obtained:

Latitude N. . . . . 36° 10′ 54″
Apparent Noon . . . . $6^h\ 31^m\ 49^s$

Second Calculation.

I. Comparison of the Observations.

	1.	2.	3.	4.	5.
Time by Chronometer	$6^h\ 28^m\ 33^s$	$6^h\ 32^m\ 22^s$	$6^h\ 36^m\ 40^s$	$6^h\ 40^m\ 18^s$	$6^h\ 58^m\ 11^s$
Apparent Noon by the first Approximation	$6^h\ 31^m\ 49^s$	$6^h\ 31^m\ 49^s$	$6^h\ 31^m\ 49^s$	$6^h\ 31^m\ 49^s$	$6^h\ 31^m\ 49^s$
Hour Angle in Time.	$-0^h\ 3^m\ 16^s$	$+0^h\ 0^m\ 33^s$	$+0^h\ 4^m\ 51^s$	$+0^h\ 8^m\ 29^s$	$+0^h\ 26^m\ 22^s$
Hour Angle in Arc $= t$	— 0° 49′·0	+ 0° 8′·3	+ 1° 12′·8	+ 2° 7′·3	+ 6° 35′·5
$\sin \varphi \sin \delta$	+ 0·08433	+ 0·08433	+ 0·08433	+ 0·08433	+ 0·08433
$\cos \varphi \cos \delta \cos t$	+ 0·79884	+ 0·79892	+ 0·79873	+ 0·79836	+ 0·79363
Sum $= \sin h$	0·88317	0·88325	0·88306	0·88269	0·87796
h (True Altitude of the Sun's Centre)	62° 1′·7	62° 2′·3	62° 0′·8	61° 58′·0	61° 23′·7
Sum of Corr.[1]	+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1	+ 16′·1
Calculated Observation	62° 17′·8	62° 18′·4	62° 16′·9	62° 14′·1	61° 39′·8
Direct Observation	62° 16′·7	62° 18′·3	62° 14′·5	62° 9′·7	61° 30′·8
Calc.—Obs.	+ 1′·1	+ 0′·1	+ 2′·4	+ 4′·4	+ 9′·0

II. Determination of the most probable Elements by the Method of Least Squares.

We obtain the five following differential equations developed for each single observation:

$$1)\quad 0 = +\ 9\cdot71 - 9\cdot68\, d\varphi + 8\cdot05\, dt$$
$$2)\quad 0 = +\ 8\cdot67 - 9\cdot68\, d\varphi - 7\cdot28\, dt$$
$$3)\quad 0 = +\ 0\cdot05 - 9\cdot68\, d\varphi - 8\cdot24\, dt$$
$$4)\quad 0 = +\ 0\cdot31 - 9\cdot68\, d\varphi - 8\cdot47\, dt$$
$$5)\quad 0 = +\ 0\cdot63 - 9\cdot68\, d\varphi - 8\cdot96\, dt$$

[1] Refraction + 0′·3; Parallax — 0′·1; Sun's Semidiameter + 15′·9.

These equations, applying the method of least squares, give:

	$d\varphi = -0'\cdot2$		h m s
$dt = +1°\ 9'\cdot5$	dT	=	$-$ 4 38
Apparent Noon		=	6 27 11
φ = Latitude N.		=	36° 10′·4

The great correction of dT, exceeding the usual limits of the differentials, is caused by the first altitude having been observed 2′·9 too low, an error only discovered by the various methods of calculation.

III. Comparison of the Single Observations with the Final Elements.

No. of Observ.	Calc.—Obs.
	′
1	+ 2·9
2	— 0·4
3	— 0·3
4	— 0·2
5	— 4·4

Longitude.

		h m s
Mean Noon at Símla, by Chron. 3, 1856, May 15		6 28 21
Rate = XIII. = gaining 1ˢ·01, for 109 days	+	1 50
Mean Noon at Símla, reduced to 1856, September 1		6 30 11
Mean Noon at △ Súget		6 27 21
Meridional Difference in Time		0 2 50
		° ′
Símla, East of Green.		77 7·6
△ Súget, East of Símla		0 42·5
△ Súget, East of Green.		77 50·1

Meridian.

Deduced from the second Approximation . . . . . 330° 55′·8.

ROUTE FROM THE NORTHERN FOOT OF THE KARAKORÚM PASS TO BÚSHIA.

Besides the direct observations, given above in detail, the circumstance, that we could use as points of reference a great number of peaks with very well defined forms, allowed us to connect our several halting places along the whole line of route with each other, and to refer them to the stations fixed by our direct observations.

The northernmost point which we (Hermann and Robert) reached in Khótan, after crossing the Kuenlúen, was Búshia. Though permanently inhabited by shepherds (who, failing to penetrate our disguise, gave us a very hospitable reception) it does not contain any regularly built houses; caves and tents forming the places of abode for the inhabitants, even during the winter. Búshia is situated just at the uppermost limit of the cultivation of grain, which rises here to a height exceeding the average height of the snowline in the Alps.

All our movements being closely watched by the population, amongst whom we had to encamp, while awaiting the result of negociations for provisions, horses, and yaks, we were frustrated in our repeated endeavours to make some observations with our sextants. Though selecting the quietest hours of the night, between 3 and 4 o'clock in the morning, we soon found that our early rising excited notice, and we were obliged to give up all idea of taking observations of Saturn and the moon, a circumstance which we felt the more vexatious, as, from the beautiful transparency of the air, they presented a particularly brilliant appearance.

The following list contains the geographical co-ordinates of our encampments.[1]

No. 96. △ BÚLLU, at the northern foot of the Karakorúm pass, on the road to Yárkand. Lat. N.: 35° 49′. Long. E. Gr.: 77° 31′. Height: 16,889 feet.

No. 97. △ CHILGÁNE, east of the Yárkand road, a barren place covered with saline efflorescences. Lat. N.: 35° 58′. Long. E. Gr.: 77° 35′. Height: 16,416 feet.

No. 98. △ KISSILKORÚM,[2] a secondary watershed between the Yárkand and the Karakásh rivers. Lat. N.: 35° 57′. Long. E. Gr.: 77° 50′. Height: 17,762 feet.

[1] Though considering them as one general group, we number them separately for greater convenience of quotation.

[2] We frequently made similar determinations of geographical positions along our routes in the Himálaya and in Tibet. The detail of these will be communicated in another part of our publications.

No. 99. △ AKSÁE CHÍN, the basin of a lake now drained, in the upper part of the Karakásh valley. A short distance lower down we came upon a similar basin, filled with solid ice, even in August. Lat. N.: 35° 52′. Long. E. Gr.: 77° 51′. Height: 16,620 feet.

No. 100. △ 1856, August 16, in the Karakásh valley, below the Kiúk-Kiól. Lat. N.: 35° 49′. Long. E. Gr.: 77° 51′. Height: 14,820 feet.

No. 101. △ KÁFIR DÉRA, in the right side of the Karakásh valley. Lat. N.: 35° 50′. Long. E. Gr.: 78° 12′. Height: 14,420 feet.

No. 102. △ BASHMALGÚN, name of a small island in the Karakásh river. Lat. N.: 35° 50′. Long. E. Gr.: 78° 17′. Height: 14,214 feet.

No. 103. △ 1856, August 17, in the Karakásh valley, below Bashmalgún. Lat. N.: 35° 51′. Long. E. Gr.: 78° 22′. Height: 14,000 feet.

No. 104. △ SIKÁNDER MOKÁM, in the Karakásh valley, with an old ruined fort.[1] Lat. N.: 36° 3′. Long. E. Gr.: 78° 29′. Height: 13,864 feet.

No. 105. △ 1856, August 19, in the Karakásh valley. Lat. N.: 36° 8′. Long. E. Gr.: 78° 14′. Height: 13,613 feet.

No. 106. △ SÚMGAL, a halting place with some shrubs and pasturage. Here the road branches off to Élchi. At this spot we stayed for a day, which enabled us to make some magnetic observations, and at the same time to give the necessary rest to our animals, who were by this time in a most wretched condition. Lat. N.: 36° 8′. Long. E. Gr.: 78° 5′. Height: 13,212 feet.

No. 107. △ GULBAGASHÉN, with large Yáshem (Nephrite) quarries, occasionally frequented by numerous caravans. Lat. N.: 36° 9′. Long. E. Gr.: 77° 45′. Height: 12,252 feet.

No. 108. ÉLCHI DAVÁN, is the pass leading from the Karakásh valley to Élchi, very steep on the southern side, and with an extensive glacier descending to the north. For commercial purposes the routes over the pass "Yurungkásh Daván" are preferred. Lat. N.: 36° 13′. Long. E. Gr.: 78° 7′. Height: 17,379 feet.

No. 109. BÚSHIA, in the upper part of the Élchi river. Lat. N.: 36° 26′. Long. E. Gr.: 78° 19′. Height: 9,310 feet.

[1] Visited also the year following by Adolphe; see the description of this place, p. 63.

Approximate Determination of Élchi, Yárkand, and Káshgar.

Our brother's routes, and such information as we could derive from various itineraries, allowed us also approximatively to determine the geographical positions of these places. From official information, just received (July, 1860), we have reason to hope[1] that our late brother's manuscripts, during his journeys in Turkistán, may still be saved. If so, we will subsequently give the full detail of his observations. For the present, we adopt, as the most probable results:

		Lat. N.	Long. E. Gr.
		° ′	° ′
No. 110.	Élchi	36 50	78 20
No. 111.	Yárkand	38 10	74 0
No. 112.	Káshgar	39 15	71 50

Klaproth,[2] Humboldt,[3] and Ritter,[4] and also Waugh (for Yárkand) give for the latitude values very little differing from ours; but their longitudes appear to be nearly 2° too far to the east.[5]

The values adopted by these authorities are:

Place.	Lat. N.	Long. E. Gr.
	° ′	° ′
Élchi	37 0	80 35
Yárkand	38 19	76 18[6]
Káshgar	39 25	73 55

We have, however, the more reason to think our determinations correct, from the greater proximity of our stations of direct observation. Hitherto all the geographical positions in this part of Central Asia have been referred to Peking, which is much too distant to afford sufficient accuracy for longitude.

[1] Compare also the *Lahore Chronicle*, and the *Bombay Times*, May, 1860.

[2] J. Klaproth, Carte de l'Asie Centrale, dressée d'après les cartes levées par ordre de l'Empereur Khienlong, par les Missionaires de Peking, et d'après un grand nombre de notions, extraites et traduites de livres chinois. Paris, 1833, 4 sections.

[3] A. v. Humboldt: Gebirgsketten und Vulkane in Central-Asien, 1844.

[4] Ritter's Erdkunde von Asien. 1837, Bd. 5. p. 347, 389 und 432.

[5] D'Anville's old map had Élchi still 3° more to the east, in about 83° 36′.

[6] In his map of the Punjab and adjoining countries, Calcutta, January, 1854, Waugh adopts Lat. N. 38° 20′, Long. E. Gr. 76° 0′, therein nearly agreeing with Klaproth's map, which gives Lat. N. 38° 19′, Long. E. Gr. 76° 18′

CONCLUDING GENERAL REMARKS AND RESULTS.

The general list of our stations is given in a tabular form, in connection with the magnetic elements, at the end of part III.; and they are laid down in four charts, containing our routes and the magnetic lines.

1. For India, we were particularly happy to see that our own determinations of latitude and longitude agree very well with the exact data furnished by the Great Trigonometrical Survey;[1] also in Western India, where, as far as we know, the operations of the Great Trigonometrical Survey have but recently been commenced, we find that the geographical positions, also the longitudes, as laid down, generally coincide with ours. The station Déra Ismáel Khan and its environs, however, are laid down 9′ too much to the north.

2. For the Himálaya[2] of *Kămáon* and of *Gărhvál*, and for the Tibetan province of *Gnári Khórsum*, our observations show, with a few exceptions (as Nélong and

[1] See p. 126.

[2] In Bhután, and in the Himálaya of Síkkim and of Nepál, we determined the geographical positions of various places and peaks by triangulation; but the detail of these observations, as well as of similar ones in the western part of the Himálaya and of Tíbet, will be given in another part of our publications.

We add a list of the principal original maps:

A. Bhután and Síkkim:

A survey of the road from Buxadewar to Tassisudon, in Bhotan, in Turner's "Account of an Embassy to the Court of the Teshoo Lama, in Tíbet". London, 1800.

Sketch of Bootan, in Vol. VIII. of the Asiatic Society's Journal.

Map of Síkkim, illustrative of Dr. A. Campbell's Trip into that Country, by Major J. A. Crommelin. Darjeeling, 1849.

Map of Síkkim and Eastern Népal, by Dr. J. D. Hooker, London, 1853.

Map of British Síkkim, by Capt. W. S. Sherwill. Calcutta, 1855.

B. Kămáon, Gărhvál, Central Tíbet:

Map of Kămáon and British Gărvhal, by the Stracheys. Calcutta, 1850.

Map of West Nari, to illustrate Capt. H. Strachey's memoir on the physical geography of Western Tíbet. London, 1853.

Indian Atlas. Sheets 47, 65, 66.

C. Pănjáb and adjoining Countries:

Map of the Punjaub and adjoining countries, by Colonel A. S. Waugh. Calcutta, January, 1854.

Map of the Pănjáb, Western Himálaya, and adjoining parts of Tíbet, by J. Walker. London, 1854. It is annexed to "Cunningham's Ládak". A second, revised edition appeared in March, 1859.

Map of the Mountains of Northern India, to illustrate Dr. Thomson's travels in Western Himalaya and Tíbet, in Dr. Thomson's "Western Tíbet". London, 1852.

D. Original maps of Kashmír:

Map of Kashmír, the Panjab, &c., by J. Arrowsmith, in Hügel's "Travels in Kashmír and the Pănjáb". London, 1845.

Púling), a satisfactory coincidence with former latitudes; but the longitudes we found to be more to the west than had hitherto been supposed. The difference, however, does not on the average exceed 10′ in the eastern parts of Gnári Khórsum, and 8′ in the western.

3. The latitudes of *Spíti* and *Ladák*, in Western Tíbet, are generally given too high; but the difference is very small; those of *Bálti* differ much more from our own determinations, being generally laid down considerably too low, with an error exceeding 10′ even at the principal places, as Skárdo and Shígar. In addition to these corrections, a number of places, not yet contained in any map, have been fixed from direct observations by Adolphe along his various routes in 1856.

The differences of longitude are still greater. The northern part of Western Tíbet, throughout its vast extent, must, according to our observations, be placed 22′ to 25′ more to the west; for the south-western margin, the error of the longitude is smaller, on an average 18′ to 12′.

This result at first surprised us; but the G. T. S., recently extended as far as Srinágger, has also found the longitude of the Vúler lake to be 22′·5 more to the west than was till now generally laid down on maps.

The progress of the G. T. S. also enables us to profit by our general and detailed comparison of chronometers at Srinágger, to connect all our chronometric longitudes of Western Tíbet direct with those of the G. T. S. in Kashmír.

4. The positions to the north of Tíbet, in the *Kuenlúen* and in *Turkistán*, have been hitherto laid down according to various data carefully collected and made known by Klaproth. They are chiefly based on Chinese authorities, and on some old observations made by missionaries in the 17th century.

Some few of the latitudes had been determined by altitudes of Polaris; the longitudes were referred to Peking. But the accuracy of these positions had always been considered doubtful by many geographers. We found, that on the maps even the secondary range of the Kuenlúen had hitherto been mistaken for the watershed between

Map of Kashmír, Ládak, and Little Tíbet, from the Surveys of G. T. Vigne. London, 1846.

Carte de la Vallée de Cachmire, par Victor Jacquemont. "Correspondence avec sa famille pendant ces Voyages dans l'Inde." Paris, 1846.

E. Maps of Central Asia compiled:

Klaproth's, Carte de l'Asie centrale. 4 sections. Paris, 1833.

Gebirgsketten und Vulkane in Central Asien, von Alexander v. Humboldt. 1844.

Tíbet and Turkistán, whilst the principal chain, that of the Karakorúm, had either been left out or considered as of secondary importance only,[1] and we, therefore, could not be surprised to find, from our own observations, and, farther to the north, from the combination of various itineraries, that the longitude is on an average 2° too much to the east; the latitude, however, differs very little, being on an average only 9′ too high.

[1] Compare our communications to the Dublin meeting of the British Association, August, 1857, and to the French Academy of Science at Paris, October, 1857.

PART III.

MAGNETIC OBSERVATIONS.

FOR THE MAGNETIC OBSERVATIONS, ENGLISH UNITS ARE USED THROUGHOUT; THE BAROMETER READINGS ARE GIVEN IN MILLIMETRES AND ENGLISH INCHES, THE THERMOMETER READINGS IN CENTIGRADE AND FAHRENHEIT.

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SECTION III.

METHOD OF DETERMINATION OF THE MAGNETIC ELEMENTS.

I. DECLINATION.

A. INSTRUMENTS.

The true meridian being fixed by one of the methods detailed p. 94, the magnetic meridian was determined.

We used:

a. Two Declinometers, with two collimator magnets, marked 1 and 2.

b. Universal Magnetometers, by Barrow and Lamont.

c. The Needle in Theodolite 3, Troughton.

d. In a few instances, Troughton's Prismatic Compasses, marked 4 and 6.

e. Various Cylindrical Needles, for daily variations.

a. DECLINOMETERS.

The declinometers we used were those generally adopted in English magnetic surveys, the construction of which, as well as that of the other magnetic instruments, is minutely described in "Captain Riddle's Magnetical Instructions." London, 1844. Our declinometers consisted of:

1. A wooden box with removable slides, and the ends fitted with glazed apertures. The front aperture is half an inch in diameter, the other one inch; the front aperture has also a glass slide, which can be inverted.

2. A glass tube, one third of a foot in length, having a torsion circle at the upper end; it was screwed to the top of the box.

3. Collimators with achromatic lenses and micrometrical glass scales.

4. Hollow brass cylinder with lens and scale, and a weak magnet attached in a position parallel to the axis of the cylinder.

5. Stirrups carrying a pair of supports, with a pin underneath the centre attached to the plummet.

6. Copper damper in the box, brass plummet, lamp, circular mirror to be attached to the wooden box, reel of silk fibre, spare glass tube, &c.

Considerable delay being often caused by the operation of properly adjusting the stand of the theodolite with the stand of the declinometer, we had a board made with two sets of metallic grooves. This board could be fixed on the top of a tripod stand, and in this way the position which the centre of the axis of the theodolite ought to have, in order to lie in the prolongation of the line passing through the central glazed apertures of the collimator, was easily found. But the board being of considerable size, we found it difficult to carry it about, or even to fix it very firmly on the stand; we therefore preferred putting up the two instruments separately. As we subsequently found, the most convenient form for combining the collimator box with the theodolite was the following:

A metallic brass ring, resting on a tripedal base, was made. The diameter of the ring was about two inches larger than the lower part of the theodolite, *i. e.* large enough to allow of the free movement also of the telescope. It could be placed in the same grooves which received the theodolite. The outer part of the ring itself was moveable, and could afterwards be clamped. The wooden collimator box could be firmly screwed on the outer part, and two weights, placed 120 degrees distant from the box, so as not to interfere with the ocular end of the telescope, preserved the equilibrium. The wooden box (mentioned p. 276 sub 1) with all appendages could be made to fit this new tripedal basis.

Before putting up the instrument, we always took the precaution to reduce the torsion as much as possible, and indeed, upon determining it with the torsion circle attached to the upper end of the glass tube, it was never found to be of any appreciable magnitude. We always attached the brass plummet several hours before the observations were commenced, and took particular care never to make any alteration afterwards in the position of the support which was to receive the collimator. The silk fibre used was previously prepared by a special process, and had its natural glossy surface removed; this considerably reduced the torsion of the fibre, but as in this state it became liable to get rotten by moisture, we were obliged always to keep a large supply on hand.

When determining the magnetic meridian, the cross wire of the telescope of the theodolite was adjusted so as to be bisected by the central line of the division of the collimator; but, at the same time, the angular values of the division were carefully ascertained for observations of variation.

These values were found to be:

	′	″
For collimator 1	2	12·65
For collimator 2	5	7·5

The micrometer was brought into a position as nearly vertical as possible. For eliminating its eccentrical position, as well as the difference between the optical and magnetic axis of the cylinder, the collimator was inverted in the stirrup; in one position the ends of the principal lines were turned downwards, in the other upwards. (A mark, made upon the outer surface of the collimator magnet, served to show whether the position of the micrometer inside had remained the same.) Even in the event of an alteration of position, the *difference* of the readings would have remained unaltered, provided the magnetic and optical axes strictly coincided; this, however, not being the case, the determination of the two positions was made in connection with every observation.

Collimator 1 kept the same difference between the two positions very well till March, 1856. The difference between one position and the other varied only between 55′ and 57′. (In other collimators its absolute value is often much greater, on account of the difficulty of fixing the scale in the collimator.) At a later date, however, this value had changed; in Leh, July, 1856, being 30′·5, and in Kathmándu, March, 1857, 44′·3.[1]

Collimator 2 varied for the two positions between 40′ and 52′, the difference being sometimes greater, sometimes smaller.

The glass in the front aperture of the collimator box must have strictly parallel surfaces, otherwise refraction may easily become large enough sensibly to affect the results. As the apparatus allows of the inversion of the glass, any irregularity in the parallelism of its surfaces can be easily ascertained, for, if the sides are not strictly parallel, the resulting values of the possible errors will then have opposite signs.

The glass in the apparatus belonging to collimator 1 was found to have its sides strictly parallel, but in the apparatus belonging to collimator 2, the readings in the two different positions differed nearly half a degree. The irregularity in the form of the glass being so great, we did not at first suspect it as the cause of the differences which were found to exist by the most careful comparisons of Hermann's and Adolphe's instruments. It was only at Símla, May, 1856, that we discovered the non-parallelism of the two surfaces of the glass to be the real cause of these differences. However, the error in all the preceding observations could be corrected with the utmost exactness, as, on account of the hitherto unaltered position, the error had remained constantly the same. Mr. Kleyser, a watchmaker at Símla, was fortunately able to replace this glass by another with nicely parallel surfaces.

b. UNIVERSAL MAGNETOMETER.

This instrument was a universal magnetometer, constructed by Barrow under the direction of General Sabine, and in its small compass were most ingeniously combined all the different parts, required both for the absolute determination of horizontal and vertical intensity, as well as for declination. Its size, however, precluded a minute division of the scales, and consequently the possibility of making observations so detailed as we could desire. In the earlier part of our travels we used it between Bombay and Madras, but afterwards gave it up; in the journey from Calcutta up to Símla, April, 1856, it got altogether out of order from the effects of an accident. In general, the separate apparatuses for declination, dip, vibration, and deflection, as used in the English surveys, proved to be by far the best adapted for accurate determi-

[1] For the detail, see the magnetic stations, Section V.

nations of absolute values, and to be, nevertheless, from their size and weight, easy of transportation from one place to another.

Two other universal magnetometers, of the well known construction of Professor Lamont, we received through the kindness of that gentleman. These instruments are particularly well adapted for showing the differential values of horizontal and vertical intensity, besides giving the absolute values of these elements. Unfortunately they reached us so late (it was only at Calcutta, just before leaving India) that I (Hermann) could make but a comparative series of observations.

c. MAGNETIC NEEDLE IN THEODOLITE 3, TROUGHTON.

Theodolite 3, Troughton, had a magnetic needle with agate plate resting on a steel pivot. Though, generally speaking, such needles are not worked carefully enough for accurate determinations of declination, yet it is possible to make them very delicate. Indeed, Professor Lamont showed me many such instruments, which had been executed in the workshop connected with his observatory,[1] and brought to great perfection.

In our theodolite, the repetition circle allowed of the position of the magnetic meridian being changed, thus increasing the accuracy of the result, which is then deduced from the mean of a greater number of readings. Nevertheless, we generally used the instrument only for comparison with the collimator.

d. PRISMATIC COMPASSES.

Of these instruments we selected prismatic compass No. 4, by Troughton and Simms, for some determinations of declination along Robert's routes in Sindh, who at that time had no collimator with him. The readings, when directed to various points, the angular distances of which were ascertained with theodolite 1, Troughton, could easily be taken with a correctness of three to five minutes. The fundamental error of the compass, determined at Woolwich before our departure for India, and again determined several times during our journeys, was + 2′ (East). The readings are given already corrected.

Prismatic compass No. 6, by Troughton, though not used for the determination of the declination, has also frequently been compared by Hermann with the collimator. Its fundamental error was — 1′ (West).

[1] Professor Lamont prefers making the top of glass and the pin of copper; but in travelling, pins of this construction are very liable to get their points injured.

e. CYLINDRICAL NEEDLES FOR DAILY VARIATIONS.

For a longer series of observations of the daily variation of the declination we used the cylindrical magnets with mirrors attached, which were also employed in the observations of deflection. The angular values of the scales attached to the apparatus were directly measured, by fixing the box on the centre of a divided horizontal circle, as, for instance, the lower circle of a theodolite.

We mention particularly the observations at Leh and Pesháur as series of such determinations. For several short series, the scales in the collimators were observed directly.

B. METHOD OF CALCULATION.

The angle between the true and magnetic meridian being the direct result of the readings (after the inversion of the collimators) no example is required. As one instance of the comparison of *different methods*, we quote station No. 4, Gohátti. The limits of the accuracy of *absolute* determination are from one to three minutes, on account of the errors contained in the true and magnetic meridian.

When deducing the general results for the construction of the isogonic lines, the question of the reduction of these observations to one common epoch presented itself. But from the tables for Bombay (pp. 302 to 311) it will be easily seen, that the changes are comparatively so small, that no reduction is required, if we adopt as a common epoch one favourable to all our observations, as for instance, January, 1856,—a period not too distant from the majority of our observations. Also the last excellent chart of Captain Evans[1], for 1858, shows for the western parts of the coast of India an annual change in the variation of + 0′·6 only, and, on the other hand, a decrease of it on the eastern coast.[2]

[1] Chart of the Curves of equal magnetic variation, by Frederick J. Evans.—The first map of isogonic lines was made by Halley, after whom these lines were for some time called Halleyan lines. See Sabine's Explanation about terrestrial magnetism in Johnston's Physical Atlas.

[2] In southern Europe the annual change in many places exceeds 6′. Some instances of early previous observation on the coasts of India will be given at the end of this part.

II. HORIZONTAL INTENSITY.

METHOD OF OBSERVATION AND CALCULATION,

INCLUDING THE DESCRIPTION OF THE APPARATUSES USED.

The Horizontal Intensity is determined in absolute values by a series of experiments on vibration, combined with another on deflection.

By the vibration we obtain:

mX = The product of the horizontal intensity into the magnetic moment of the suspended magnet.

By the deflection:

$\frac{m}{X}$ = The ratio of the magnetic moment of the deflecting magnet to the horizontal intensity.

By the combination of the two results the values m and X are obtained separately.[1]

For the calculation of the value of the horizontal component of the earth's magnetic force from observations of vibration and deflection, we employ, in exact accordance with the terms used by General Sabine, and now most generally adopted, the following terms and formulæ:.[2]

T_0 = Observed time of one vibration of the magnet.

$T_{,}$ = Time of vibration, corrected for rate of chronometer and arc of vibration.

T = Time of vibration, corrected for rate of chronometer, arc of vibration, temperature, torsion force of the suspending thread, and induction.

s = Daily rate of the chronometer, + when gaining, — when losing.

α, α' = Semiarcs of vibration, at the beginning and end of the observation, expressed in parts of radius.

$\frac{H}{F}$ = Ratio of the force of torsion of the suspending thread to the magnetic directive force.

q = The correction for the decrease of the magnetic moment of the magnet produced by an increase of temperature of 1° Fahr.

[1] Formerly the time of vibration, where the inclination is 0, was taken as the relative unit. (Humboldt's observations are referred to this.)

[2] These were communicated to us from the Kew Observatory. At the same time we were favoured by receiving some very conveniently arranged blank sheets for entering observations and calculating them, which very much facilitated the working out of our materials.

K = Moment of inertia of the magnet, including its suspending stirrup and other appendages.

π = Ratio of the circumference to the diameter of the circle = 3·1415927 . . .

μ = The increase in the magnetic moment of the magnet, produced by the inducing action of a magnetic force equal to the unity of the English system of absolute measurement.

r_0 = Apparent distance between the centres of the deflecting and suspended magnets in the observations of deflection.

r = Distance corrected for error of graduation and temperature.

u_0 = Observed angle of deflection.

P = A constant depending upon the distribution of magnetism in the deflecting and suspended magnet.

m = Magnetic moment of the deflecting or vibrating magnet.

X = Horizontal component of the earth's magnetic force.

$\frac{m_0}{X_0}$ = Approximate value of $\frac{m}{X}$.

$\frac{m'}{X'}$ = Value of $\frac{m}{X}$ before the application of the correction $\left(1 - \frac{P}{r_0^2}\right)$.

Formulæ for calculating mX:

$$T_{,} = T_0 \left\{1 - \frac{s}{86400} - \frac{\alpha\alpha'}{16}\right\}.$$

$$T^2 = T_{,}^2 \left\{1 + \frac{H}{F} - q\,(t_0 - t) + \mu\frac{X_0}{m_0}\right\}.$$

$$mX = \frac{\pi^2 K}{T^2}.$$

Formulæ for calculating $\frac{m}{X}$:

$$\frac{m_0}{X_0} = \tfrac{1}{2}\, r^3 \sin u_0.$$

$$\frac{m'}{X'} = \frac{m_0}{X_0}\left\{1 + 2\,\frac{\mu}{r_0^3} + q\,(t_0 - t)\right\}.$$

$$\frac{m}{X} = \frac{m'}{X'}\left(1 - \frac{P}{r_0^2}\right).$$

In reference to our observations of Intensity in general, and particularly to the instruments employed, we add the following details:

T_0 (= observed time of one vibration of the magnet). The time was noted at the precise moment when the point of the scale most distant from the centre touched the cross in the telescope. The passing of the central line would be more rapid, and therefore better defined, but it is on this very account more indistinctly seen; therefore the double observations of the two terminal points seemed to us to be preferable. On an average, several hundred vibrations have been observed; their number is given under each station.

s (= the daily rate of chronometer). Generally, we used our Pocket Chronometers; their rate was carefully ascertained by comparison with our standard chronometers (see p. 342).

α, α', were deduced from original readings on a circular scale, divided into minutes, and attached above the telescope.

$\frac{H}{F}$ is obtained from the formula $\frac{H}{F} = \frac{u}{90^0 - u}$, where u = the angle through which the magnet is deflected by a twist of 90° in the suspending thread. As has been already mentioned in the observations of declination, p. 277, our silk threads had but very little torsion.

q (= the correction of the magnet for temperature) was most minutely determined at Kew by the late Mr. Welsh, after our return from India, for magnets $L\,1$ and $D\,2$, both of which belonged to Hermann's magnetic apparatus. This correction is not constant at all temperatures, and the correction is more exactly expressed by a formula of the form:

Correction to $t = q\,(t_0 - t) + q\,(t_0 - t)^2$ &c., t_0 being the observed temperature, and t the standard temperature adopted.

We adopt as standard temperature 80° Fahr. = 26°·7 C., on account of the average difference from the temperature observed not being very great. Captain Elliot has also adopted 80° Fahr. as his standard temperature.

At Kew the correction q was found

$$\text{for } L\,1 = 0\cdot000195\,(t_0 - 80) + 0\cdot00000055\,(t_0 - 80)^2$$
$$\text{for } D\,2 = 0\cdot000222\,(t_0 - 80) + 0\cdot00000000\,(t_0 - 80)^2.$$

The second term is also for $L\,1$ so small that, in calculating the results, we found it could be omitted.

For Adolphe's magnet $B\,7$, which was lost, we adopt (= the mean of the value of q for $L\,1$ and $D\,2$) $q = 0\cdot00021$.

Under these unhappy circumstances we had no choice of doing otherwise; besides, his magnet was of the same size and material as those of Hermann, and made by the same maker (Jones). Under such conditions q seems in general to vary but very slightly.

K (= moment of inertia). Though constant for the same magnet and its appendages, and varying but slightly with the temperature on account of expansion, its value has been very frequently determined for $L1$.

We obtain for the different stations the following values of log $K_{,}$, $K_{,}$ being the value directly obtained by *each observation.*

Station.		Value of log $K_{,}$.	Station.		Value of log $K_{,}$.
No. of Station.	Name.		No. of Station.	Name.	
1	Dibrugárh	0·43858	40	Bellári	0·33293
2	Tézpur	0·43937	43	Gálle	0·44230
3	Udelgúri	0·44182	44	Nărigún	0·44465
4	Gohátti	0·43743	45[a]	Darjíling	0·41201
5	Chérra Púnji	0·41970	45[b]	Darjíling	0·45022
9[a]	Calcutta	0·43552	47	Tónglo	0·46400
9[b]	Calcutta	0·43334	48	Fălút	0·44549
10	Rámpur Bólea	0·43830	49	Kathmándu	0·43854
11	Kissengánj	0·44293	63	Mozăferabád	0·43868
12	Pátna	0·43720	76	Tsomognalarí	0·44591
14	Benáres	0·43415	78[a]	Leh	0·42926
15	Lăkhnáu	0·43471	78[b]	Leh	0·43382
20	Lahór	0·43696	82[a]	Kárgil	0·43603
21	Raulpíndi	0·43821	82[b]	Kárgil	0·43970

Numerical *mean value* = K = 2·7429, of which the logarithm is 0·43821. The station Bellári, No. 40, is excluded from this mean.

For the calculation of these values a large ring[1] was employed, with the exception of Kárgil, when two rings were used; 82[a] gives the value of log $K_{,}$ with the large ring, and 82[b] with a smaller one. The detail of the determinations of log $K_{,}$ is given respectively at each station.

[1] When a cylinder is employed, the value of K is obtained from the formula: $K = W\left(\frac{l^2}{12} + \frac{d^2}{16}\right)\frac{t^2}{t'^2 - t^2}$, where W is the weight of the cylinder in grains, l and d its length and diameter expressed in feet; t' and t being the times of vibration (corrected for torsion, temperature &c.) of the magnet with and without the additional weight.

When rings are employed

$$K = W\left(\frac{r_i^2 + r_e^2}{2}\right)\frac{t^2}{t'^2 - t^2},$$

r_i and r_e being the external and internal radii of the ring.

The dimensions of the inertia rings, large ring and small ring belonging to Hermann's unifilar magnetometer were found, when determined in November, 1858, at the Kew Observatory:[1]

		Large Ring.	Small Ring.	
External diameter	in inches	3·4860	2·6978	at 62° Fahr
Internal diameter	in inches	2·7984	1·9772	at 62° Fahr
Weight in grains		925·64	738·42	

The rings employed with $B\,7$ by Adolphe were lost with his instruments, and the maker, Mr. Jones, was unfortunately unable to supply us with the detail of their dimensions, but happily we had made, at Srinágger, a very detailed series of comparative vibrations of $L\,1$ and $B\,7$, employing both Hermann's and Adolphe's rings. The result was for $B\,7$: $\log K = 0{\cdot}26891$, which we adopt as the mean $\log K$ for all his observations.

Robert's determinations of the magnetic elements, along his route from Raulpíndi to Bombay, were made with an apparatus which did not allow of the same detail as the two others. He used the larger magnet of Barrow's Universal Magnetometer, the dimensions of which were:

External diameter	0·298 inches
Internal diameter	0·166 ,,
Length	3·672 ,,
Weight	329·97 grains.

A comparison of Barrow's magnet with the other magnets, at Raulpíndi, December, 1856, gave for Barrow's magnet:

$$q = 0{\cdot}00022; \qquad \mu = 0{\cdot}00017$$
$$m = 0{\cdot}42600; \qquad \log K = 0{\cdot}45945.$$

These are the values used for calculating Robert's observations.

[1] The dimensions of the inertia rings as given by the maker, in 1854, were:

		Large Ring.	Small Ring.
External diameter	in inches	3·480	2·693
Width	in inches	0·345	0·362
Weight (in grains)		925·72	738·46

For deducing approximatively the total intensity, we were favoured in this region by a very regular variation of the isoclinal lines. In the only two stations for which the magnet Barrow was employed, viz. at Shikárpur and Bhūj, we took the dip from our map, and then calculated the total intensity by the formula generally used.

μ (= the inducing influence of the earth on the magnets employed) was determined at Kew:

$$\text{for } L1 = 0\cdot000170$$
$$\text{for } D2 = 0\cdot000173;$$

we adopt:

$$\text{for } B7 = 0\cdot00017.$$

r (= the distance of the magnets when placed on the deflection bar). It is corrected for graduation and temperature; r_0 being the apparent distance and the temperatures given in Fahrenheit, we get:

$$r = r_0 \{ 1 + 0\cdot00001\,(t_0 - 62) \} + \text{correction for error of scale.}$$

Each deflecting apparatus had a deflection bar, originally of brass, to receive the deflecting magnet at 1 foot and 1·3 foot distance. During a part of the experiments by Hermann, the second position was 1 foot 4 inches = 1·33 foot, as specified in the detail of the elements of each observation.

With the deflection apparatus No. 1 the following bars were used (by Hermann):

1. The original brass bar by Barrow, "H_1". This was stolen by a kúli on the way up to Darjíling. The man had brought its empty cylindrical case, and the theft was only discovered after he had made his escape.

I (Hermann) replaced it by a bar of strong, well seasoned wood, which I received through the kindness of Captain Murray, the Engineer of the station. I divided it with a valuable standard foot scale, by Hofer at Berlin, into 1 foot and 1 foot 4 inches. My wooden bar "H_2" consisted of *two* pieces[1] (the proper position of which was secured by the apparatus itself), which I considered the best plan for preventing any change of form by the packing. The bar was subjected to frequent examinations, and was always found to have remained unaltered. It required no correction for temperature, but a comparison with the Calcutta standard foot, in the Surveyor's General's office, showed an error of

[1] For convenience of carriage, and even for giving additional strength, the brass bar might also be made with a hinge in the middle, so as to fold up.

+ 0′·005 for the unit of 1 foot (a deviation, however, of no importance), and no appreciable error for the unit of 1 foot 4 inches. A new brass scale "H_3" was made in Calcutta, and was in use from March, 1856, till the end of the Survey.

The deflection apparatus No. 2 was always used by Adolphe, with the original brass bar, the distances employed being 1 foot and 1·3 foot.

In the deflection apparatus No. 1, the supports for fixing the bar were placed at not perfectly equal distances from the centre, an error, which, as afterwards found, made the bar to be 0·012 foot too far to the right, viz. too far to the east, when looking north, and to the west, when looking south. The difference was only ascertained, when, after our return, all our apparatuses underwent a strict examination. For the observations themselves, this error in the construction of the instrument is of no consequence, as any such error is eliminated by the method of observation, in which the positive and negative errors of the readings (an equal number of observations being taken an each side) balance each other.

P (= the constant depending on the relative distribution of magnetism) is to be determined from several series of observations of deflection at two or more distances.

Notwithstanding that this correction is very small, we have taken care repeatedly to ascertain the deflections in two different positions. We obtain *P* from the formula:

$$P = \frac{A - A'}{\frac{A}{r^2} - \frac{A'}{r'^2}},$$

where A = the value of $\frac{m'}{X'}$ from deflection at the distance r, and A' = the same value for the distance r'.

For the comparatively few stations where the deflection was made in *one* series only of positions of the deflecting magnet (at the distance of 1 foot), the value of $\frac{m_0}{X_0}$, required for calculating the value $\mu \frac{X_0}{m_0}$ in the formula for the vibration, was considered as not differing in the first three decimals from the value which would have been obtained, if the distance 1·3 foot had also been taken. This supposition is generally in accordance with the results of all the stations, where two positions had been observed.

m (= the magnetic moment) had changed, comparatively speaking, very little. The circumstance that the magnets were always placed in the box with the greatest possible care, and that they had been already made some time before our using them, may be the principal causes of this element remaining so constant.

For the observations in Turkistán we adopt $m = 0{\cdot}4374$, which is the mean of the values obtained at Leh, where it only varied between 0·4393, in July, and 0·4355, in September, 1856.

For some other places where either vibration or deflection alone could be made, the value of m, as detailed in each single case, was taken from the two next observations of the magnet. We calculate m to three, X to four decimals, the logarithmic values being equally correct in both cases.[1]

REMARKS ON THE APPARATUSES.

Both our *vibration* apparatuses[2] were made by Jones, London, and had a circular scale above the telescope for reading off the observations of variation in minutes. Our two deflection apparatuses were also by the same maker.

The two magnets, the suspended and the deflecting one, were always placed at right angles to one another (as first proposed by Lamont), and the angles of deflection were measured on a horizontal circle, which read 20″ with the vernier.

The *deflecting* apparatus No. 1 was used by Hermann, No. 2 by Adolphe and Robert, and both had a circular ivory scale over the telescope, which we used in our observations of variation. A contrivance, by which the telescopes in the vibration and deflection apparatuses are allowed an upward and downward movement, greatly facilitates the adjustment of the suspended magnets. We adopted this improvement from one of Lamont's Universal Magnetometers. We had no bifilar instruments with us.

The resulting horizontal intensity would, strictly speaking, require *simultaneous* observations of deflection and vibration. But the daily variations being very small, and moreover, it being impossible to avoid small errors, arising partly from the imperfection of the instruments themselves, partly from natural causes (such as influence of

[1] The small differences of $\frac{m'}{X'}$ when calculated for the different distances show for the magnets, as well as for the apparatus, a very minute accuracy.

[2] For details see: Riddle, pp. 63, 66.

the soil, &c.), we have applied no correction for reducing the observations of vibration and deflection to the same time.

The horizontal, as well as the vertical and total intensity, was calculated from the results immediately obtained, without taking into consideration the difference of the time of observation. Also in our general map, including a smaller map of the territories examined by Captain Elliot, no corrections for the different periods of time are applied, chiefly on account of the annual variations being very small, and partly because they have not yet been defined with sufficient accuracy.

We give, as example, a set of observations of horizontal intensity made at Calcutta in 1857, and the calculations connected with them. As explained above, p. 284, we introduce for K its mean value, the logarithm of which is 0·43821.

EXAMPLE.

No. 9[b]. CALCUTTA, Lat. N. 22° 33′ 1″.

A. *Observations of Deflection.*

1857, April 12, 5[h] P.M. Local Time.

Magnets employed: Deflecting $L1$; Deflected $H21$; Deflection Bar $H3$. Distances 1 foot; 1·3 foot.
Temp. at 1 foot distance: 32°·0 C. = 89°·6 Fahr.; at 1·3 foot distance: 31·6 C. = 88°·9 Fahr.

Distance.	North End.	Reading of Verniers.	Mean of Verniers.	Means.
1 foot West	East	° ′ ″ 41 51 35 221 51 48	° ′ ″ α 41 51 41·5	° ′ ″ α 41 51 41·5 β 41 58 17·5
	West	29 45 0 209 44 15	γ 29 44 37·5	*a* 41 54 59·5
1 foot East	East	41 57 25 221 59 10	β 41 58 17·5	γ 29 44 37·5 δ 29 38 50·0
	West	29 38 40 209 39 0	δ 29 38 50	*b* 29 41 43·7
1·3 foot West	East	38 36 20 218 36 0	α′ 38 36 10	α′ 38 36 10 β′ 38 34 40
	West	33 0 55 213 1 5	γ′ 33 1 0	*a*′ 38 35 25
1·3 foot East	East	38 34 50 218 34 30	β′ 38 34 40	γ′ 33 1 0 δ′ 33 1 0
	West	33 0 0 213 2 0	δ′ 33 1 0	*b*′ 33 1 0

$a - b =$ 12° 13′ 16″; $u_0 =$ 6° 6′ 38″ at 1 foot distance
$a' - b' =$ 5 34 25; $u'_0 =$ 2 47 12·5 at 1·3 foot distance.

HORIZONTAL INTENSITY.

Long. East Green.: 88° 20′ 34″. Height: 5 feet above the Húgli at mean height.

B. *Observations of Vibration.*

1857, April 12, 3^h 10^m P.M. Local Time.

Magnet vibrated: *L* 1. $q = 0 \cdot 00022$, $\mu = 0 \cdot 00017$. Effect of Torsion: 9′ (at 0° = 273, at 90° = 282). Arcs, beginning: 85 to 461, ending: 200 to 346. Semiarcs: 188 and 73. Temp. of Magnet: 33°·0 C. = 92°·4 Fahr.

No. of Vibrations.	Time by Chron. 3. t = tick, 1t = $0^s \cdot 4$.	Difference.	No. of Vibrations.	Time by Chron. 3. t = tick, 1t = $0^s \cdot 4$.	Difference.
	h m s ″			h m s ″	
0	2 30 40—11t =35·6	28·2	230	2 41 25— 3t =23·8	28·0
10	31 5— 3t = 3·8	28·4	240	41 55— 7t =52·2	28·4
20	31 35— 7t =32·2	28·0	250	42 25—11½t=20·4	28·2
30	32 5—12t = 0·2	28·4	260	42 50— 4t =48·4	28·0
40	32 30— 3½t=28·6	28·2	270	43 20— 9t =16·4	28·0
50	32 60— 8t =56·8	28·0	280	43 50—13½t=44·6	28·2
60	33 30—13t =24·8	28·2	290	44 15— 5t =13·0	28·4
70	33 55— 5t =53·0	28·4	300	44 45— 9t =41·4	28·4
80	34 25— 9t =21·4	28·2	500	Calc. 2 54 5·8	
90	34 55—13½t=49·6	28·2	500	Obs. 2 54 10— 9½t= 6·2	28·2
100	35 20— 5½t=17·8		510	54 40—14t =34·4	28·0
200	Calc. 2 40 0		520	55 5— 6½t= 2·4	28·4
200	Obs. 2 39 60— 2t =59·2	28·4	530	55 35—10½t=30·8	28·2
210	40 30— 6t =27·6	28·2	540	56 5—15t =59·0	28·0
220	40 60—10½t=55·8		550	56 30— 7½t=27·0	

One Single Vibration:

$$\begin{array}{r} {}^{h}\;\;{}^{m}\;\;{}^{s} \\ 2\;\;56\;\;27 \cdot 0 \\ \underline{2\;\;30\;\;35 \cdot 6} \\ 25\;\;51 \cdot 4 \end{array} = \frac{1551^s \cdot 4}{550 \text{ vibr.}} = 2^s \cdot 820$$

CALCULATION.

HORIZONTAL INTENSITY.

A. *Deflection.*

$$\frac{m_0}{X_0} = \tfrac{1}{2}\, r^3 \sin u_0;\quad \frac{m'}{X'} = \frac{m_0}{X_0}\left\{1 + \frac{2\mu}{r_0^3} + (t_0 - t)\, q\right\};\quad \frac{m}{X} = \frac{m'}{X'}\left(1 - \frac{P}{r_0^2}\right)$$

$r_0 = 1$ foot. Temp. $89°\cdot6$ Fahr. $u_0 = 6° 6'\cdot6$	$r'_0 = 1\cdot3$ foot. Temp. $88°\cdot9$ Fahr. $u'_0 = 2°47'\cdot2$
$t_0 = 89°\cdot6$ Fahr.	$t_0 = 88°\cdot9$ Fahr.
$r = 1\cdot00028$ $\frac{62°\cdot0}{27°\cdot6}$ $t = 80°\cdot0$ " ; $t_0 - t = 9°\cdot6$ "	$r' = 1\cdot30028$ $\frac{62°\cdot0}{26°\cdot9}$ $t = 80°\cdot0$ " ; $t_0 - t = 8°\cdot9$ "
$\tfrac{1}{2} r_3$ log $= 9\cdot69933$	$\tfrac{1}{2} r'^3$ log $= 0\cdot04109$
$\sin u_0$ log $= 9\cdot02710$	$\sin u'_0$ log $= 8\cdot68679$
$1 + \frac{2\mu}{r_0^3} = 1\cdot00034$ $\frac{m^0}{X^0}$ log $= 8\cdot72643$	$1 + \frac{2\mu}{r'^3_0} = 1\cdot00015$ $\frac{m^0}{X^0}$ log $= 8\cdot72788$
$+(t_0 - t)\, q = 0\cdot00192$	$+(t_0 - t)\, q = 0\cdot00178$
$1 + \frac{2\mu}{r_0^3} + (t_0 - t)\, q = 1\cdot00226$ . . . log $= 0\cdot00099$	$1 + \frac{2\mu}{r'^3_0} + (t_0 - t)\, q = 1\cdot00193$ . . . log $= 0\cdot00084$
$\log (A) = \frac{m'}{X'}$ log $= 8\cdot72742$	$\log (A') = \frac{m'}{X'}$ log $= 8\cdot72872$

$A = 0\cdot053385$	$\log A = 8\cdot72742$	$\log A' = 8\cdot72872$	$\log (A - A') = 6\cdot2014$
$A' = 0\cdot053544$	$\log r^2 = 0\cdot00024$	$\log r'^2 = 0\cdot22808$	$-\log\left(\frac{A}{r^2} - \frac{A'}{r'^2}\right) = 8\cdot3361$
$A - A' = -0\cdot000159$	$\log \frac{A}{r^2} = 8\cdot72718$	$\log \frac{A'}{r'^2} = 8\cdot50064$	$\log P = 7\cdot8653_n$
$\log (A - A') = 6\cdot2014$	$\frac{A}{r^2} = 0\cdot05335$	$\frac{A'}{r'^2} = 0\cdot03167$	

$$\frac{A}{r^2} - \frac{A'}{r'^2} = 0\cdot02168 \qquad \log\left(\frac{A}{r^2} - \frac{A'}{r'^2}\right) = 8\cdot3361$$

$\log P = 7\cdot8653_n$	$\log P = 7\cdot8653_n$	$1 - \frac{P}{r_0^2} = 1\cdot00733$	$1 - \frac{P}{r'^2_0} = 1\cdot00434$
$\log r_0^2 \quad 0\cdot0000_n$	$\log r'^2_0 = 0\cdot2279$	log $= 0\cdot00317$	$0\cdot00188$
$\log \frac{P}{r_0^2} = 7\cdot8653_n$	$\log \frac{P}{r'^2_0} = 7\cdot6374_n$	$\log \frac{m'}{X'} = 8\cdot72742$	$8\cdot72871$
		$\log \frac{m}{X} = 8\cdot73059$	$8\cdot73059$

B. *Vibration.*

$$T_{,} = T_0 \left\{ 1 - \frac{s}{86400} - \frac{\alpha\alpha'}{16} \right\}; \quad T^2 = T_{,}^2 \left\{ 1 + \frac{H}{F} - q\,(t_0 - t) + \mu\,\frac{X_0}{m_0} \right\}; \quad mX = \frac{\pi^2 K}{T^2}$$

$T_0 = 2^s{\cdot}820$. Chron. Rate $= 0^s{\cdot}17$ los. Tors. 9′. $t_0 = 92{\cdot}4$; $t = 80{\cdot}0$; $t_0 - t = 12^\circ{\cdot}4$ Fahr. Semiarcs: 188; 73.

$1 + \frac{H}{F} = 1{\cdot}00167$	T_0 log $= 0{\cdot}45031$	$\pi^2 K$ log $= 1{\cdot}43251$
$-q(t_0 - t) = -0{\cdot}00272$	$\left(1 - \frac{s}{86400} - \frac{\alpha\alpha'}{16}\right)$ log $= 9{\cdot}99999$	T^2 log $= 0{\cdot}90153$
$\mu : \frac{m_0}{X_0} = 0{\cdot}00319$	$T_{,}$ log $= 0{\cdot}45030$	$mX = \frac{\pi^2 K}{T^2}$ log $= 0{\cdot}53098$
	$\times\ 2$	
	$T_{,}^2$ log $= 0{\cdot}90060$	$\frac{m}{X}$ log $= 8{\cdot}73059$
$1 + \frac{H}{F} - q(t_0 - t) + \mu : \frac{m_0}{X_0} = 1{\cdot}00214$	. . . . log $= 0{\cdot}00093$	X^2 log $= 1{\cdot}80039$
	T^2 log $= 0{\cdot}90153$	X log $= 0{\cdot}90019$
		m log $= 9{\cdot}63079$

$m = 0{\cdot}4274 \qquad X = 7{\cdot}947$

If $\frac{m}{X} = A$, and $mX = B$, then $X = \sqrt{\frac{B}{A}}$, and $m = \sqrt{AB}$.

Total Intensity. . $= \frac{X}{\cos \text{dip}} = \frac{7{\cdot}947}{\cos 28^\circ\ 22'{\cdot}94}$;

Vertical Intensity $= \sqrt{T^2 - X^2} = \sqrt{(9{\cdot}033)^2 - (7{\cdot}947)^2}$;

X log	$= 0{\cdot}90019$
cos dip log	$= 9{\cdot}94438$
Total Intensitiy log	$= 0{\cdot}95581$

Vertical Intensity $= V = 4{\cdot}294$

Total Intensity $= T = 9{\cdot}033$

III. DIP AND VERTICAL INTENSITY.

A. DIP.

a. DIP CIRCLES USED.

Our two dip circles were made by Barrow in the form described in Riddle, p. 84; but we had two additional holes made ($^1/_3$ inch in diameter) in the horizontal brass supports; the position of the holes was such as to allow the lower end of the dip needle to be visible at low angles of inclination. Another slight modification we made by using ground glass, instead of transparent, in the side opposite to the vertical circle and its microscopes. This glass had a semi-transparent ring, of about the diameter of the length of the needles, which allowed of the outlines of the needles being seen with much greater distinctness, since the observations are not interfered with by the objects and the light behind the instrument.

The detailed example given below[1] will suffice without further explanation to show our method of observing.

In the regions where the dip is very small and the vertical intensity very weak, it sometimes becomes very difficult to determine the magnetic meridian by the process of finding the positions at right angles to it, where the needle stands vertically. A tangent screw on the horizontal circle, which was wanting in our instrument, would have considerably facilitated this operation. We afterwards had one put on.

In comparing different needles even with the same dip circle, the results are not absolutely the same, for every needle has an individual correction, partly occasioned by defects in the metal, partly by the irregularities of its axles. The dip circle itself also might not be entirely free from all admixture of magnetic metal. We, however, examined our instruments, and found them to be perfectly free (as far as controlable) from all alloy, by the following experiment: The dip circle, without the magnet, was placed a little to the side of one end of a vibration magnet upon a board, where it could be turned completely round; the presence of magnetism in the instrument, even in the slightest degree, would have immediately been detected by a deflection of the magnet suspended.

The errors of our needles were determined by three comparisons, at Bombay, at Símla, and at Srinágger. Besides the four needles mentioned here, there were two spare needles, which, however, we had no occasion to use.

[1] Observations can also be made in different azimuths. If η = the observed inclination of the needle, ϑ the inclination sought, α the azimuth of the vertical circle,

$$\tan \vartheta = \tan \eta \cos \alpha.$$

Also the inclination observed in any two planes at right angles to each other will allow of the true inclination being deduced without the knowledge of the angle α, according to the formula:

$$\cot^2 \vartheta = \cot^2 \eta + \cot^2 \eta'$$

b. COMPARISON OF THE DIP NEEDLES.

1. BOMBAY, December 1, 1854, 2^h to 6^h P.M. Local Time.

In a tent on alluvial soil, on the esplanade, 2½ miles to the north of the Magnetic Observatory.

NEEDLE No. 1.

	Poles direct. End $B = N$.	Poles reversed. End $A = N$.
Face.	East 18° 28′·4	18° 40′·5
	West 18° 32′·1	18° 48′·5
Reverse.	West 18° 29′·0	18° 47′·5
	East 18° 21′·5	18° 47′·0
	Mean α	Mean β
	18° 27′·75	18° 45′·87

$$\frac{\alpha + \beta}{2} = 18° \; 36'\cdot81$$

NEEDLE No. 2.

	Poles direct. End $A = N$.	Poles reversed. End $B = N$.
Face.	18° 35′·0	18° 21′·0
	18° 39′·0	18° 40′·0
Reverse.	18° 45′·0	18° 35′·0
	19° 0′·0	18° 47′·0
	Mean α	Mean β
	18° 44′·75	18° 35′·75

$$\frac{\alpha + \beta}{2} = 18° \; 40'\cdot25$$

NEEDLE No. 3.

	Poles direct. End $A = N$.	Poles reversed. End $B = N$.
Face.	East 19° 21′·5	17° 35′·5
	West 19° 30′·5	17° 54′·4
Reverse.	West 19° 4′·0	17° 49′·0
	East 19° 34′·4	18° 13′·2
	Mean α	Mean β
	19° 22′·60	17° 53′·03

$$\frac{\alpha + \beta}{2} = 18° \; 37'\cdot82$$

NEEDLE No. 4.

	Poles direct. End $A = N$.	Poles reversed. End $B = N$.
Face.	18° 50′·5	18° 8′·4
	18° 52′·0	18° 39′·3
Reverse.	18° 46′·0	18° 36′·6
	18° 57′·5	18° 42′·5
	Mean α	Mean β
	18° 51′·5	18° 31′·7

$$\frac{\alpha + \beta}{2} = 18° \; 41'\cdot6$$

On the trap rocks near Breach Candy, where we lived with Mr. Ventz, in Sans-souci bángalo, the dip was found to be on an average 15′ to 30′ less, probably on account of the local magnetism of the rocks, their north poles being turned upwards. But on the instrument being raised 8 or 10 feet above the ground no disturbance could be observed. In general, local disturbances must be expected to have the greatest influence where, as in Southern India, the value of the vertical force is very small.[1]

[1] Compare our remarks on the magnetic equator (at the end of this part) and the results obtained in its environs by Mr. J. A. Broun.

2. Símla, 1856, May 15, 3^h to 5^h P.M. Local Time.

In the garden belonging to Aln Cottage, a house in the station.

Our regular observations were made in General Boileau's former magnetic observatory, at some distance from the station; we preferred making the comparison of the needles at not too great a distance from our house.

Needle No. 1.

	Poles direct. End $A = N$.	Poles reversed. End $B = N$.
Face.	East 42° 36′·3	42° 33′·6
	West 42° 38′·0	42° 15′·5
Reverse.	West 42° 35′·0	42° 0′·5
	East 42° 27′·5	42° 22′·4
	Mean α	Mean β
	42° 34′·2	42° 18′·0

$$\frac{\alpha+\beta}{2} = 42° 26'\cdot10$$

Needle No. 2.

	Poles direct. End $B = N$.	Poles reversed. End $A = N$.
Face.	42° 9′·4	42° 41′·1
	42° 51′·3	42° 15′·5
Reverse.	42° 39′·0	42° 13′·5
	42° 34′·0	42° 23′·4
	Mean α	Mean β
	42° 33′·42	42° 23′·34

$$\frac{\alpha+\beta}{2} = 42° 28'\cdot38$$

Needle No. 3.

	Poles direct. End $A = N$.	Poles reversed. End $B = N$.
Face.	East 43° 36′·2	41° 40′·5
	West 43° 14′·5	41° 46′·0
Reverse.	West 43° 12′·5	41° 24′·5
	East 43° 0′·8	41° 47′·4
	Mean α	Mean β
	43° 16′·0	41° 39′·6

$$\frac{\alpha+\beta}{2} = 42° 27'\cdot80$$

Needle No. 4.

	Poles direct. End $B = N$.	Poles reversed. End $A = N$.
Face.	42° 55′·5	42° 30′·5
	42° 32′·4	42° 21′·5
Reverse.	42° 44′·4	42° 12′·5
	44° 14′·1	42° 31′·0
	Mean α	Mean β
	42° 51′·6	42° 23′·84

$$\frac{\alpha+\beta}{2} = 42° 37'\cdot72$$

3. Srinágger, 1856, October 23, 2^h to 3^h 50^m P.M. Local Time.

In the garden "Shĕkh-bagh" under trees; where also our other magnetic observations have been made.

Needle No. 1.

	Poles direct. End $B = N$.	Poles reversed. End $A = N$.
Face.	46° 29'·5	47° 10'·0
	46° 52'·5	47° 0'·5
Reverse.	46° 51'·5	46° 44'·5
	46° 38'·5	46° 43'·4
	Mean α	Mean β
	46° 43'·0	46° 54'·6

$$\frac{\alpha + \beta}{2} = 46° 48'·8$$

Needle No. 2.

	Poles direct. End $B = N$.	Poles reversed. End $A = N$.
Face.	46° 48'·4	46° 28'·4
	46° 55'·0	46° 56'·1
Reverse.	46° 52'·7	47° 1'·9
	46° 43'·3	47° 2'·3
	Mean α	Mean β
	46° 49'·85	46° 52'·18

$$\frac{\alpha + \beta}{2} = 46° 51'·02$$

Needle No. 3.

	Poles direct. End $A = N$.	Poles reversed. End $B = N$.
Face.	47° 41'·4	46° 27'·1
	47° 34'·8	46° 8'·6
Reverse.	47° 29'·1	46° 7'·3
	47° 45'·5	46° 24'·3
	Mean α	Mean β
	47° 37'·7	46° 16'·83

$$\frac{\alpha + \beta}{2} = 46° 57'·27$$

Needle No. 4.

	Poles direct. End $A = N$.	Poles reversed. End $B = N$.
Face.	46° 40'·1	46° 52'·3
	46° 45'·4	46° 45'·3
Reverse.	46° 39'·3	46° 16'·4
	46° 41'·9	47° 11'·4
	Mean α	Mean β
	46° 41'·67	46° 46'·35

$$\frac{\alpha + \beta}{2} = 46° 44'·01$$

MEAN CORRECTION OF THE DIP NEEDLES.

		Bombay.	Símla.	Srinágger.	Mean Correction.
	Dip:	18° 40′·42	42° 30′·00	46° 50′·28	′
Needle	No. 1.	+ 3·61	+ 3·90	+ 1·48	+ 2·99
	No. 2.	+ 0·17	+ 1·62	+ 0·74	+ 0·35
	No. 3.	— 2·60	+ 2·20	— 6·99	— 2·46
	No. 4.	— 1·18	— 7·72	+ 6·27	— 0·88

The values of the last column will be found applied to the final results. The needle No. 2 seemed to be decidedly the best, the correction being small and varying very little. A correction for temperature is not necessary; but it seemed important that the needles should not get weak, by remaining too long without being re-magnetised. We generally magnetised them afresh at every station.

In reference to the comparison of the different stations, no correction for reducing them to a common period was applied, the changes in so short a time being below the limit of accuracy obtained by absolute determinations.[1]

We conclude by giving a detailed example of our mode of observing the dip.

EXAMPLE.

No. 78ᵇ. Dip at Leh, in Ladák, 1856, September 28, 10ʰ A.M. Local Time.

Needle No. 2. Dip Apparatus: Hermann.

A. *Orientation of the Needle.*

		Face of Needle to Face of Instrument.		Face of Needle reversed.	
		Upper Microscope at 90°.	Lower Microscope at 90°.	Upper Microscope at 90°.	Lower Microscope at 90°.
Instrument facing	North.	24° 32′	24° 16′	22° 16′	22° 58′
	South.	24° 14′	24° 50′	23° 11′	24° 3′

General Mean: 23° 47′·5.

The horizontal circle of the dip apparatus being divided into quarter circles of 90° each, the same number, 90° distant from its first position, gives the direction of the magnetic meridian.

[1] Captain Elliot (Philosophical Transactions, 1851, p. 317), found at Singapúr, from 1841 to 1848, a decrease of 2′·3 per annum, at Madras, from 1840 to 1849, an increase of 2′·7 per annum. The Bombay observations give, between 1854 and 1856, an increase of 19′, from 1856 to 1857, a decrease of 5′.

B. *Readings of the Dip.*

	Position of the Instrument.	Poles direct. North End = *A*. Readings of Needle No. 2. Upper End.	Lower End.	Means.	Poles reversed. North End = *B*. Readings of Needle No. 2. Upper End.	Lower End.	Means.
		° ′	° ′	° ′	° ′	° ′	° ′
Face of Needle to Face of Instrument.	East.	46 37	46 58	46 47·5	46 43	47 9	46 56·0
		46 37	46 58	46 47·5	46 42	47 10	46 56·0
		46 38	46 57	46 47·5	46 41	47 8	46 54·5
					46 40	47 7	46 53·5
			Mean = a . .	46 47·5		Mean = b . .	46 55·0
	West.	46 17	47 11	46 44·0	46 58	46 55	46 56·5
		46 17	47 11	46 44·0	46 57	46 53	46 55·0
		46 15	47 14	46 44·5	47 0	46 55	46 57·5
		46 18	47 16	46 47·0			
			Mean = a' . .	46 44·87		Mean = b' . .	46 56·33
Face of Needle reversed.	West.	46 30	47 7	46 48·5	47 7·0	46 28·5	46 47·75
		46 36	47 15	46 55·5	47 6·5	46 28·0	46 47·25
		46 37	47 4	46 50·5	47 5·0	46 25·5	46 45·25
		46 36	47 3	46 49·5			
			Mean = a'' . .	46 51·0		Mean = b'' . .	46 46·75
	East.	46 26	46 44	46 35·0	47 15·0	47 0·5	47 7·75
		46 25	46 45	46 35·0	47 14·5	47 1·0	47 7·75
		46 30	46 50	46 40·0	47 15·0	47 1·5	47 8·25
			Mean = a''' . .	46 36·67		Mean = b''' . .	47 7·92
			a'' . .	46 51·0		b'' . .	46 46·75
			a' . .	46 44·87		b' . .	46 56·33
			a . .	46 47·50		b . .	46 55·00
			Mean of Means = α . .	46 45·02		Mean of Means = β . .	46 56·51
						α . .	46 45·02

$$\frac{\alpha + \beta}{2} = \text{Dip} \; . \; . \; . \; . \; . \quad 46^\circ\ 50'{\cdot}77$$

Correction of Needle 2 . . . + 0 0·35

Dip corrected . . . . . . 46 51·12

B. VERTICAL INTENSITY.

The vertical intensity ($= V$) was deduced, T and $H =$ total and horizontal intensity being previously calculated, by the formula:

$$V = \sqrt{T^2 - H^2}.$$

In the Bombay Observatory the variations of the vertical intensity are obtained by direct observation; they are also periodically determined according to our method of calculation.

IV. TOTAL INTENSITY.

The formula for deducing the total intensity, T, from the dip or inclination and the horizontal intensity, is

$$T = X \sec \vartheta = \frac{X}{\cos \vartheta},$$

where X is the horizontal intensity, ϑ the angle of the dip.

In some few cases, where two of our stations were very close to each other, either the horizontal intensity or the dip, when not obtained by direct observation, could be interpolated for calculating the probable value of the total intensity.

In the proceedings of the Royal Irish Academy for 1857, a very ingenious method for the determination of the total intensity is described by Dr. Lloyd. He uses a dip circle furnished with three needles, one of which is to be employed for the ordinary observations of dip, and the two others for observations of intensity.

The *product* of the earth's magnetic force by the magnetic moment of the needle, mX, is obtained by observing the position of equilibrium of the dipping needle No. 2, loaded with small weights, and the *ratio* of the same quantities, $\frac{m}{X}$, is found by using needle No. 2 to deflect another needle, No. 3, substituted in its place.

If $\eta =$ the inclination of needle No. 2 with its weights, $u =$ the difference between the dip observed by needle No. 1 and the inclination of needle No. 2 with its weights, and $u' =$ the deviation of needle No. 3 from the direction of the magnetic force when deflected by needle No. 2, the total force will be given by the formula:

$$T = A \sqrt{\frac{\cos \eta}{\sin u \ \sin u'}}$$

A = the constant, which can be obtained either from direct observations, or, still better, by observing the absolute horizontal intensity at some one station with a unifilar magnetometer, and by making simultaneously with it a determination of the dip and of η, u, u', after the foregoing method.

If r denotes the value of the radical

$$\sqrt{\frac{\cos \eta}{\sin u \ \sin u'}}$$

at this station, and X the horizontal intensity in absolute measure, we have

$$A = \frac{X}{r \cos \text{dip.}}$$

SECTION IV.

GENERAL RESULTS OF THE CORRESPONDING MAGNETIC OBSERVATIONS AT BOMBAY.

I. Declination. II. Horizontal Intensity. III. Dip. IV. Vertical Intensity. V. Total Intensity.

In the following tables we give the principal mean results of the Bombay magnetic observations, which are published for every year at Bombay by the zealous superintendent, Lieutenant E. F. T. Fergusson, I.N. These tables give a very characteristic aperçu of the magnetic elements and their variations, and we shall have occasion to return to them for comparison, when communicating the detail of our own observations.[1]

Days of disturbances are marked by asterisks (*).

The declination at Bombay is East.

The following are the days of disturbances for 1854-7:

1854. November 1 and 8.

1855. February 8; March 12; April 4; May 27; July 18, 19, and 20; September 27; October 2, 18, and 19; December 30.

1856. No disturbance great enough to be measured occurred this year.

1857. May 7; September 2, 3, and 21; December 16, 17, 18, 27, and 28.

On all these days the disturbances were not very great.[2] It so happened that only one day, on which absolute determinations were taken by us, coincided with

[1] The means of some corresponding observations, communicated to us at Madras for the period of our travels in Southern India, are contained Section V., Group V., Station No. 35.

[2] In higher latitudes the disturbances are not only much greater, but also show periodical laws decidedly marked. See the most interesting researches of General Sabine, "On Periodical Laws discoverable in the Mean Effects of the larger Magnetic Disturbances". Philosophical Transactions. February 27, 1851.

a day, when disturbances were observed at Bombay. This was the 30th December 1855, when observations at Udelgúri, station 3, were made.

I. DECLINATION.

DECLINATION: 1, Mean Yearly Values.

Year.	Mean Easterly Declination.	Year.	Mean Easterly Declination.
	′		′
1847	14·02	1853	18·13
1848	14·39	1854	18·09
1849	14·66	1855	19·34
1850	15·85	1856	18·92
1851	16·78	1857	19·28
1852	16·75		

DECLINATION: 2, Mean Monthly Values.

Month.	Mean Easterly Declination.				Month.	Mean Easterly Declination.			
	1854.	1855.	1856.	1857.		1854.	1855.	1856.	1857.
	′	′	′	′		′	′	′	′
January	18·92	19·12	18·64	19·80	September	16·84	19·03	18·85	18·86
February	19·08	19·32	18·96	20·02	October	18·79	19·34	19·15	18·06
March	18·76	19·38	18·68	20·00	November	18·09	19·53	19·57	18·69
April	18·48	19·38	18·55	19·52	December	18·57	19·51	19·77	18·96
May	18·13	19·57	18·81	19·69	Mean of Winter[1]	18·70	19·37	19·13	19·26
June	17·78	19·35	18·75	19·81					
July	16·78	19·23	18·41	19·06	Mean of Summer[2]	17·47	19·31	18·72	19·30
August	16·82	19·31	18·94	18·86	Mean of the Year	18·09	19·34	18·92	19·28

[1] Winter = { January, February, March, October, November, December.

[2] Summer = { April, May, June, July, August, September.

DECLINATION: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

A. 1854.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	′	′	′	′	′	′	′	′	′	′	′	′
1	18·46	18·85	18·95	. . .	17·95	18·54	. . .	16·70	16·91	18·92	18·64	18·94
2	*19·44	19·05	18·70	19·04	18·25	18·62	18·86	16·47	. . .	18·78	17·84	. . .
3	19·41	18·89	18·32	18·61	18·10	. . .	16·33	16·91	16·63	18·77	18·08	18·19
4	19·04	. . .	. . .	18·42	17·93	18·57	17·01	16·99	16·78	18·75	. . .	18·16
5	19·06	18·97	18·44	18·41	18·34	18·55	16·77	. . .	16·45	19·00	18·04	18·39
6	18·54	18·78	18·62	18·15	. . .	18·53	16·63	16·64	16·90	18·74	17·65	18·29
7	. . .	19·06	18·86	18·36	17·74	18·17	16·50	. . .	16·85	. . .	17·91	18·39
8	18·99	19·00	18·65	. . .	18·43	18·10	. . . .	16·78	16·70	20·12	17·99	18·37
9	19·19	18·68	18·75	18·42	18·84	17·97	16·90	16·50	. . .	19·23	17·98	. . .
10	18·72	19·44	18·83	18·65	18·42	. . .	17·38	16·95	16·55	19·38	17·84	18·38
11	19·13	. . .	. . .	18·65	18·32	17·60	17·23	16·89	*17·35	18·86	. . .	18·35
12	18·77	19·07	18·62	18·48	18·11	18·27	17·13	. . .	17·16	18·49	17·52	18·17
13	18·60	19·11	18·53	. . .	. . .	17·87	16·69	16·78	16·51	18·55	18·05	18·15
14	. . .	19·13	. . .	18·75	17·62	17·59	16·86	16·86	16·77	. . .	18·05	18·33
15	19·04	19·45	19·47	. . .	18·39	17·80	. . .	16·89	16·43	18·21	18·05	18·13
16	18·60	19·32	19·53	18·62	18·55	17·16	16·48	16·42	. . .	18·42	17·92	. . .
17	19·11	19·16	19·11	18·48	17·80	. . .	16·83	16·88	17·01	17·88	17·87	18·28
18	18·81	. . .	. . .	17·71	17·98	17·61	17·07	16·74	16·91	18·23	. . .	18·86
19	19·25	19·07	18·64	18·29	18·10	17·82	16·43	. . .	16·94	18·69	18·04	18·67
20	19·06	18·60	18·74	18·47	. . .	17·69	16·55	16·81	16·56	. . .	17·36	18·92
21	. . .	18·64	18·86	18·72	18·48	17·59	16·56	17·01	17·14	18·65	18·07	19·00
22	18·74	18·50	18·80	. . .	17·98	17·34	. . .	16·92	17·09	18·34	17·99	18·81
23	18·98	18·92	18·65	18·83	. . .	17·60	16·65	16·87	. . .	18·91	18·03	. . .
24	19·83	19·47	18·39	18·64	16·68	. . .	16·86	16·64	16·72	19·08	18·87	. . .
25	18·70	19·42	. . .	18·49	18·41	17·29	16·98	16·77	17·03	19·55	18·72	18·85
26	18·62	. . .	18·76	18·36	18·29	17·46	16·80	16·97	16·77	19·14	. . .	18·57
27	18·29	20·02	19·07	18·32	17·86	17·15	16·85	. . .	17·19	. . .	18·27	18·96
28	. . .	19·31	*19·89	18·33	. . .	17·35	16·91	17·09	16·88	18·66	18·69	18·92
29	18·94	. . .	18·96	. . .	18·14	17·36	. . .	16·82	17·31	18·53	18·52	19·05
30	18·76	. . .	18·32	18·40	18·41	18·75	16·35	16·94	. . .	18·65	18·41	. . .
31	19·20	. . .	18·44	. . .	18·30	. . .	16·54	16·97	. . .	. . .	. . .	19·07

* Abnormal day, or a day on which this element was disturbed.

DECLINATION: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

B. 1855.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	′	′	′	′	′	′	′	′	′	′	′	′
1	19·08	19·35	19·53	19·45	19·69	19·80	19·17	19·62	. . .	19·43	19·51	. . .
2	19·09	19·23	. . .	19·15	19·94	. . .	19·32	19·03	19·00	18·94	19·71	19·58
3	19·19	. . .	. . .	19·14	19·87	19·71	19·12	19·36	19·23	19·78	. . .	19·59
4	19·16	19·16	20·04	*19·52	19·39	19·80	18·64	. . .	19·08	19·29	19·34	19·61
5	19·13	19·14	19·12	. . .	. . .	19·57	18·93	18·74	19·26	19·49	19·92	19·70
6	. . .	18·90	19·31	19·37	19·59	19·49	19·15	19·55	19·08	. . .	19·43	19·58
7	19·14	19·26	18·97	. . .	19·38	19·36	. . .	19·20	18·70	19·27	19·50	19·22
8	18·98	*19·59	19·11	19·41	19·92	19·62	18·85	19·27	. . .	19·13	19·44	. . .
9	18·94	19·59	19·45	19·44	19·70	. . .	19·04	19·39	18·74	19·25	. . .	19·37
10	18·71	. . .	. . .	19·43	19·31	19·09	18·87	18·99	18·77	19·01	. . .	19·33
11	19·29	19·50	19·51	19·56	19·58	19·56	18·93	. . .	19·14	19·35	19·39	19·40
12	19·03	19·43	*19·85	19·19	. . .	18·69	18·89	19·30	*19·04	19·42	19·51	19·65
13	. . .	19·18	19·68	19·47	19·76	19·30	18·89	19·30	18·82	. . .	19·49	19·54
14	19·07	19·20	19·30	. . .	19·54	19·50	. . .	19·16	19·26	19·45	19·35	19·74
15	19·23	19·39	19·34	19·45	19·73	18·98	19·11	18·94	. . .	19·36	19·62	. . .
16	18·98	19·31	19·45	19·33	19·75	. . .	18·96	19·59	19·24	19·40	19·67	19·59
17	18·94	. . .	. . .	19·49	19·43	19·14	19·12	19·60	18·79	19·16	. . .	19·61
18	19·28	19·23	19·37	19·45	19·40	18·90	*19·01	. . .	19·34	*19·89	19·65	19·92
19	19·01	19·38	19·74	19·27	. . .	19·01	*19·14	19·61	19·11	*19·63	19·70	19·80
20	. . .	19·43	19·46	19·43	19·41	19·21	*19·55	19·55	19·19	. . .	19·55	20·04
21	19·07	19·48	19·48	. . .	19·35	19·25	. . .	19·47	18·97	19·34	20·02	19·80
22	18·95	19·34	19·29	19·44	19·21	19·66	19·92	19·11	. . .	19·30	19·27	. . .
23	18·78	19·20	19·09	19·23	. . .	. . .	19·92	19·50	18·99	19·34	19·49	19·68
24	19·34	19·37	. . .	19·48	19·68	19·43	19·54	19·41	19·26	19·49	19·39	. . .
25	19·12	. . .	19·05	19·48	19·43	19·27	19·61	. . .	18·87	19·20	. . .	19·29
26	19·29	19·67	19·34	19·22	19·65	19·17	19·55	. . .	18·65	19·25	19·39	18·97
27	. . .	19·27	19·09	19·40	*19·74	19·19	19·51	19·02	*19·06	. . .	19·41	19·21
28	19·35	19·47	19·46	. . .	. . .	19·24	. . .	19·29	19·00	19·25	19·25	19·14
29	19·41	. . .	19·17	19·61	20·04	19·40	19·82	19·19	. . .	19·32	19·85	. . .
30	19·26	. . .	19·36	19·25	19·70	. . .	19·36	19·12	19·36	19·28	19·45	*18·98
31	19·53	. . .	. . .	. . .	19·91	. . .	19·20	19·74	. . .	19·36	. . .	18·95

DECLINATION:- 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

C. 1856.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	′	′	′	′	′	′	′	′	′	′	′	′
1	18·32	19·14	. . .	18·44	18·68	. . .	18·91	18·52	18·76	19·02	. . .	19·68
2	17·73	. . .	18·72	18·64	18·64	18·77	18·91	. . .	18·44	18·85	19·00	19·56
3	17·18	18·96	18·74	18·64	. . .	18·59	18·10	19·01	18·92	18·53	19·49	19·87
4	16·62	18·71	18·64	18·68	18·71	18·65	18·62	19·14	18·69	. . .	19·15	19·89
5	. . .	18·93	18·44	. . .	18·40	18·60	. . .	19·14	18·61	19·33	19·14	19·86
6	17·73	18·69	18·82	18·74	18·64	18·82	18·04	18·91	. . .	19·02	19·44	. . .
7	17·50	18·82	18·87	18·15	18·73	. . .	18·55	19·10	18·82	19·10	19·54	19·80
8	18·20	18·75	. . .	18·31	18·80	18·95	18·71	19·10	18·80	18·76	. . .	19·71
9	18·55	. . .	18·79	18·27	18·46	18·36	18·87	. . .	19·13	18·98	19·48	19·99
10	18·90	18·69	18·49	18·20	. . .	18·36	18·59	18·67	19·15	18·90	19·51	19·60
11	18·89	19·13	18·61	18·06	18·70	18·78	18·54	19·06	19·10	. . .	19·87	19·82
12	. . .	19·01	18·21	. . .	18·86	18·81	. . .	18·79	18·69	*19·34	19·64	19·68
13	19·37	18·91	18·53	18·48	18·32	18·73	18·54	18·87	. . .	19·22	19·64	. . .
14	19·01	18·91	18·55	18·36	19·04	. . .	18·46	. . .	18·82	19·24	19·67	19·60
15	19·37	18·92	. . .	18·50	19·02	18·50	18·66	18·92	18·87	19·27	. . .	19·87
16	19·22	. . .	18·52	18·73	18·92	18·74	18·43	. . .	19·11	19·18	19·79	19·65
17	19·31	19·13	18·86	18·72	. . .	18·84	18·35	18·79	19·33	19·12	19·70	19·69
18	19·15	19·46	18·57	19·06	18·77	18·62	18·05	18·94	19·01	. . .	19·70	19·94
19	. . .	18·76	18·94	. . .	19·06	18·74	. . .	18·98	18·81	18·77	19·62	19·72
20	18·65	19·14	. . .	19·01	18·98	18·76	17·75	18·96	. . .	19·33	19·92	. . .
21	19·10	19·21	. . .	18·62	18·92	. . .	17·61	18·64	18·69	19·06	19·84	19·90
22	18·65	19·06	. . .	18·68	18·78	18·67	17·78	18·82	18·90	19·63	. . .	19·86
23	18·96	19·03	18·86	18·53	. . .	18·99	18·14	. . .	18·81	19·38	19·44	19·53
24	18·54	. . .	18·95	18·65	. . .	19·18	17·85	*18·99	18·85	19·45	19·57	19·87
25	19·07	18·74	18·67	18·40	19·03	19·24	18·05	19·16	18·67	. . .	19·37	19·75
26	. . .	18·86	18·55	. . .	19·14	18·70	. . .	19·15	18·91	. . .	19·37	. . .
27	19·12	19·01	18·93	18·82	19·03	18·98	18·68	19·08	. . .	19·32	19·81	. . .
28	18·69	19·08	18·62	18·59	18·62	. . .	18·78	18·82	18·72	19·12	19·57	20·03
29	19·36	18·90	. . .	18·49	19·00	18·79	18·64	18·97	18·68	19·43	19·92	*19·98
30	18·83	. . .	18·74	18·62	18·94	18·56	18·58	19·14	18·79	19·28	. . .	19·71
31	19·14	. . .	18·62	. . .	19·00	. . .	18·85	. . .	. . .	19·33	. . .	19·65

DECLINATION: 3, Mean Daily Values.

for each Day of Göttingen Mean Time.

D. 1857.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	′	′	′	′	′	′	′	′	′	′	′	′
1	19·49	20·12	. . .	19·92	19·36	19·96	18·90	. . .	19·31	17·98	18·18	18·38
2	19·56	19·80	20·01	20·12	. . .	20·19	18·58	18·55	18·64	17·90	18·07	18·48
3	. . .	20·25	20·00	19·82	19·28	19·80	18·66	18·82	*19·34	. . .	18·40	18·12
4	19·41	19·79	20·03	. . .	19·12	20·22	. . .	. . .	*19·38	17·71	18·66	18·48
5	19·73	19·96	19·79	19·69	19·02	19·89	18·92	19·02	. . .	18·14	18·65	. . .
6	19·81	19·60	19·65	19·77	19·14	. . .	19·05	18·61	19·04	17·81	18·43	18·79
7	19·87	. . .	. . .	19·64	*18·50	19·84	18·89	18·77	19·46	17·84	. . .	18·53
8	19·77	20·22	19·92	19·76	19·83	19·64	18·80	. . .	19·15	17·53	18·43	18·53
9	19·71	20·13	19·74	. . .	. . .	19·60	19·26	18·91	19·03	17·67	18·58	18·93
10	. . .	20·13	. . .	19·34	20·26	19·76	19·07	19·00	19·38	. . .	18·71	18·88
11	19·59	20·02	20·06	. . .	20·33	19·83	. . .	18·46	19·30	17·92	18·70	18·02
12	19·71	20·11	19·87	19·79	19·93	19·89	19·01	19·00	. . .	17·89	18·82	. . .
13	19·60	19·70	20·23	19·54	19·61	. . .	19·55	18·84	19·05	17·76	18·76	18·72
14	19·63	. . .	. . .	19·57	19·74	19·92	19·19	. . .	19·37	17·70	. . .	18·59
15	19·69	20·10	20·03	19·31	19·77	19·60	19·24	. . .	19·18	17·74	18·70	18·84
16	19·95	20·28	19·86	18·83	. . .	20·08	19·11	18·62	19·46	. . .	18·77	*18·60
17	. . .	19·98	20·18	19·31	19·45	19·84	19·30	18·78	19·38	. . .	18·98	*20·60
18	19·80	20·01	20·39	. . .	19·62	19·98	. . .	18·66	19·51	18·52	19·62	*19·90
19	20·01	20·22	19·97	19·65	19·93	19·92	19·43	18·76	. . .	18·23	18·72	. . .
20	19·81	19·99	20·07	19·45	19·72	. . .	18·97	18·83	18·78	18·29	18·66	19·22
21	19·86	. . .	. . .	19·41	19·96	19·87	18·69	19·02	19·72	18·07	. . .	19·44
22	19·60	19·83	19·85	19·17	20·07	19·81	19·50	. . .	19·20	17·96	18·60	19·30
23	20·03	19·88	19·68	19·27	. . .	19·44	19·13	19·02	18·33	18·36	19·07	19·46
24	. . .	19·98	20·63	19·84	19·73	19·91	19·68	19·96	17·78	. . .	18·98	. . .
25	20·31	19·85	20·02	. . .	19·87	19·48	. . .	19·16	17·68	18·44	18·92	18·03
26	20·09	20·02	20·13	19·32	19·89	19·70	19·07	18·82	. . .	18·34	18·54	. . .
27	19·95	20·01	19·86	19·53	19·86	. . .	18·98	19·02	18·08	18·15	18·95	*19·30
28	19·93	20·30	. . .	19·15	19·71	19·72	19·10	18·76	18·01	18·01	18·56	*19·48
29	19·84	. . .	20·25	19·22	19·49	19·99	19·24	18·89	17·89	18·70	. . .	19·24
30	20·01	. . .	20·07	19·45	19·63	19·13	18·52	. . .	18·17	18·73	18·61	20·08
31	. . .	. . .	19·80	. . .	. . .	. . .	18·71	19·35	. . .	. . .	. . .	20·09

DECLINATION: 4, Mean Hourly Values for each Month.

A. 1854.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	′	′	′	′	′	′	′	′	′	′	′	′	h m
Noon	19·59	18·93	18·86	18·44	17·93	17·23	16·31	16·98	17·60	19·35	18·20	19·07	4 12 P.M.
1	19·27	19·22	18·71	18·32	18·08	17·57	16·48	17·04	17·30	18·75	18·18	18·98	5 12 ″
2	19·23	18·97	18·62	18·18	18·01	17·48	16·50	16·67	16·80	18·56	18·21	18·87	6 12 ″
3	19·32	19·28	18·50	18·12	17·82	17·16	16·15	16·45	16·72	18·64	18·25	18·84	7 12 ″
4	19·37	19·30	18·57	18·23	17·87	17·20	16·19	16·38	16·69	18·82	18·27	18·91	8 12 ″
5	19·30	19·30	18·80	18·48	18·04	17·41	16·37	16·53	16·72	18·93	18·24	18·82	9 12 ″
6	19·35	19·38	18·73	18·64	18·18	17·74	16·69	16·68	16·95	18·95	18·33	18·85	10 12 ″
7	19·27	19·37	18·79	18·77	18·43	17·96	16·85	16·89	17·10	19·14	18·42	18·83	11 12 ″
8	19·33	19·63	18·99	18·86	18·62	18·15	16·90	17·10	17·16	19·18	18·46	18·83	Midnight
9	19·11	19·59	19·04	18·97	18·64	18·20	17·21	17·27	17·26	19·13	18·42	18·71	1 12 A.M.
10	19·04	19·34	19·05	18·95	18·79	18·32	17·29	17·41	17·38	19·01	18·29	18·59	2 12 ″
11	18·80	19·09	18·90	18·68	18·73	18·28	17·30	17·37	17·36	18·90	17·86	18·30	3 12 ″
12	18·65	18·81	18·83	18·59	18·60	18·37	17·32	17·39	17·25	18·93	17·73	18·18	4 12 ″
13	18·36	18·67	18·56	18·62	18·85	18·46	17·50	17·72	17·46	18·83	17·54	18·06	5 12 ″
14	18·21	18·48	18·50	19·35	18·66	19·53	18·55	18·66	18·21	18·94	17·20	17·86	6 12 ″
15	18·26	18·19	19·14	20·16	20·59	20·09	19·04	19·20	19·02	19·39	17·21	17·73	7 12 ″
16	18·99	18·83	19·75	20·31	20·27	19·98	18·79	18·73	18·58	19·59	17·81	18·27	8 12 ″
17	19·16	19·32	19·86	19·92	19·10	19·12	17·94	17·30	17·20	18·98	18·21	18·57	9 12 ″
18	18·95	19·54	19·80	18·64	17·54	17·87	16·70	15·88	15·66	18·29	18·10	18·55	10 12 ″
19	18·01	19·24	18·71	17·43	16·50	16·45	15·53	14·95	14·45	17·54	17·82	18·23	11 12 ″
20	17·87	18·80	18·00	16·52	15·88	15·74	15·03	14·45	14·00	17·39	18·08	18·14	Noon
21	18·39	18·71	17·75	16·66	15·93	15·75	14·86	14·66	14·56	17·88	18·46	18·59	1 12 P.M.
22	18·90	18·91	18·00	17·07	16·66	16·17	15·31	15·51	15·80	18·61	18·53	18·91	2 12 ″
23	19·15	19·02	17·80	17·90	17·37	16·66	15·80	16·24	16·97	19·14	18·39	19·04	3 12 ″

DECLINATION: 4, Mean Hourly Values for each Month.

B. 1855.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	′	′	′	′	′	′	′	′	′	′	′	′	h m
Noon	19·30	19·32	19·63	19·27	19·30	18·96	18·63	19·11	19·77	19·65	20·02	19·89	4 12 P.M.
1	19·49	19·37	19·42	19·52	19·58	19·17	18·93	19·33	19·57	19·33	19·74	19·67	5 12 ,,
2	19·48	19·39	19·22	19·35	19·45	19·01	19·10	19·18	18·97	19·29	19·79	19·69	6 12 ,,
3	19·56	19·39	19·22	19·04	19·13	18·83	18·91	19·12	18·92	19·26	19·84	19·73	7 12 ,,
4	19·49	19·40	19·31	19·17	19·23	18·79	18·68	19·16	18·98	19·30	19·84	19·68	8 12 ,,
5	19·49	19·44	19·33	19·30	19·30	18·90	18·79	19·25	19·14	19·47	19·86	19·54	9 12 ,,
6	19·39	19·36	19·41	19·41	19·47	19·16	19·04	19·34	19·11	19·53	19·88	19·54	10 12 ,,
7	19·39	19·37	19·49	19·64	19·24	19·26	19·18	19·54	19·16	19·70	19·89	19·58	11 12 ,,
8	19·30	19·41	19·52	19·62	19·86	19·55	19·45	19·70	19·27	19·68	19·98	19·55	Midnight
9	19·22	19·28	19·59	19·73	20·02	19·73	19·60	19·77	19·32	19·71	19·90	19·50	1 12 A.M.
10	19·03	19·21	19·54	19·89	20·03	19·87	19·71	19·87	19·35	19·59	19·83	19·42	2 12 ,,
11	18·88	19·04	19·42	19·72	20·01	19·84	19·68	19·45	19·42	19·55	19·53	19·23	3 12 ,,
12	18·73	18·95	19·34	19·45	19·99	19·91	19·75	19·46	19·49	19·46	19·23	19·07	4 12 ,,
13	18·44	18·78	19·20	19·54	20·30	20·03	19·96	20·03	19·67	19·30	19·10	19·03	5 12 ,,
14	18·24	18·67	19·36	20·17	21·18	20·86	20·72	20·79	20·45	19·39	19·06	19·21	6 12 ,,
15	18·04	18·73	19·98	21·25	21·92	21·48	21·13	21·45	21·53	20·02	19·11	19·33	7 12 ,,
16	18·54	19·51	20·36	21·37	21·82	21·33	20·97	21·26	21·04	20·31	19·60	19·90	8 12 ,,
17	19·59	20·39	20·46	20·65	20·67	20·63	20·48	20·12	19·58	19·85	19·64	19·89	9 12 ,,
18	19·92	20·36	19·72	19·58	19·10	19·52	19·44	18·74	17·99	19·16	19·04	19·14	10 12 ,,
19	19·52	19·77	18·94	18·28	18·09	18·39	18·23	17·81	16·64	18·20	18·44	18·46	11 12 ,,
20	18·96	19·30	18·28	17·43	17·47	17·51	17·59	17·18	16·06	17·73	18·65	18·93	Noon
21	19·06	19·05	18·23	17·22	17·66	17·48	17·44	17·30	16·77	18·17	19·26	19·75	1 12 P.M.
22	19·02	19·11	18·78	17·85	18·13	17·78	17·67	17·85	17·75	18·93	19·70	20·29	2 12 ,,
23	19·05	19·14	19·42	18·56	18·74	18·40	18·28	18·46	18·94	19·41	19·92	20·31	3 12 ,,

DECLINATION: 4, Mean Hourly Values for each Month.

C. 1856.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	'	'	'	'	'	'	'	'	'	'	'	'	h m
Noon	19·07	19·07	18·80	18·42	18·75	18·21	18·16	19·18	19·32	19·53	19·62	20·20	4 12 P.M.
1	18·80	18·99	18·56	18·51	18·73	18·37	18·31	19·28	19·26	19·20	19·47	20·04	5 12 „
2	18·69	19·06	18·45	18·36	18·50	18·34	18·20	18·87	18·84	19·06	19·58	20·03	6 12 „
3	18·72	19·14	18·45	18·15	18·31	18·09	17·91	18·64	18·83	19·18	19·66	19·99	7 12 „
4	18·71	19·07	18·44	18·15	18·37	18·17	17·97	18·57	18·90	19·31	19·67	19·99	8 12 „
5	18·79	19·07	18·53	18·35	18·50	18·35	18·11	18·72	18·96	19·34	19·69	20·13	9 12 „
6	18·80	19·02	18·66	18·46	18·68	18·53	18·27	18·86	19·15	19·38	19·74	20·08	10 12 „
7	18·84	19·09	18·71	18·58	18·93	18·81	18·44	19·05	19·16	19·48	19·75	20·01	11 12 „
8	18·85	19·06	18·75	18·78	19·09	19·05	18·71	19·19	19·26	19·44	19·86	19·89	Midnight
9	18·70	18·94	18·76	18·88	19·20	19·23	18·86	19·30	19·28	19·44	19·94	19·80	1 12 A.M.
10	18·63	18·89	18·71	18·91	19·24	19·32	18·99	19·38	19·23	19·36	19·73	19·73	2 12 „
11	18·45	18·86	18·63	18·79	19·33	19·35	19·07	19·46	19·18	19·28	19·55	19·52	3 12 „
12	18·26	18·71	18·56	18·75	19·30	19·28	19·13	19·57	19·27	19·12	19·36	19·33	4 12 „
13	18·06	18·71	18·54	18·69	19·41	19·55	19·36	19·83	19·41	19·06	19·12	19·11	5 12 „
14	18·03	18·59	18·63	19·25	20·13	20·38	20·13	20·91	20·16	19·18	18·86	18·99	6 12 „
15	18·19	18·62	19·13	20·09	20·51	20·87	20·41	21·45	20·96	19·73	18·88	18·77	7 12 „
16	19·30	19·24	19·75	20·48	20·44	20·74	20·03	20·80	20·71	19·88	19·27	19·45	8 12 „
17	20·06	19·61	19·88	20·29	19·61	19·81	19·17	19·38	19·45	19·37	19·46	19·87	9 12 „
18	19·13	19·49	19·39	19·05	18·47	18·73	18·03	17·81	17·94	18·63	19·37	19·59	10 12 „
19	17·91	18·88	18·36	17·68	17·58	17·63	17·00	16·90	16·66	18·05	19·21	19·33	11 12 „
20	17·57	18·44	17·79	16·73	17·06	17·01	16·42	16·46	15·95	17·85	19·69	19·70	Noon
21	18·09	18·52	17·87	16·75	17·26	17·00	16·56	16·80	16·39	18·26	20·15	20·26	1 12 P.M.
22	18·59	18·86	18·26	17·18	17·80	17·39	16·99	17·70	17·42	18·97	20·15	20·32	2 12 „
23	19·00	19·09	18·77	17·90	18·30	17·86	17·56	18·51	18·68	19·46	19·90	20·26	3 12 „

DECLINATION: 4, Mean Hourly Values for each Month.

D. 1857.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	′	′	′	′	′	′	′	′	′	′	′	′	h m
Noon	19·99	19·79	20·34	19·56	19·47	19·60	18·67	18·93	19·34	18·41	18·83	18·97	4 12 P.M.
1	20·08	20·01	19·97	19·53	19·49	19·64	18·84	19·13	19·00	18·09	18·61	18·89	5 12 ,,
2	20·01	20·09	19·80	19·33	19·29	19·42	18·79	18·84	18·65	17·86	18·74	18·94	6 12 ,,
3	20·03	20·13	19·72	19·14	19·19	19·20	18·55	18·53	18·65	17·92	18·80	19·10	7 12 ,,
4	20·08	20·06	10·75	19·11	19·31	19·26	18·47	18·50	18·71	18·00	18·91	19·18	8 12 ,,
5	20·01	20·12	19·92	19·28	19·51	19·47	18·66	18·59	18·77	18·07	18·97	19·04	9 12 ,,
6	20·03	20·13	19·98	19·46	19·76	19·68	18·88	18·71	18·96	18·17	19·14	19·09	10 12 ,,
7	20·04	20·12	20·06	19·69	19·98	19·84	19·16	18·87	19·13	18·37	19·16	19·19	11 12 ,,
8	19·96	20·14	20·03	19·82	20·09	20·07	19·37	18·95	19·15	18·43	19·10	19·07	Midnight
9	19·87	20·06	20·00	19·94	20·40	20·15	19·49	19·12	19·15	18·38	19·05	18·91	1 12 A.M.
10	19·79	19·86	19·85	19·99	20·37	20·26	19·54	19·24	19·21	18·17	18·85	18·81	2 12 ,,
11	19·63	19·75	19·79	19·84	20·38	20·22	19·59	19·28	19·26	18·13	18·58	18·67	3 12 ,,
12	19·46	19·63	19·75	19·77	20·27	20·29	19·55	19·34	19·17	17·93	18·37	18·49	4 12 ,,
13	19·11	19·43	19·77	19·79	20·37	20·52	19·82	19·56	19·53	17·90	18·18	18·35	5 12 ,,
14	19·00	19·31	19·87	20·26	21·19	21·47	20·70	20·58	20·55	18·13	17·98	18·24	6 12 ,,
15	19·09	19·23	20·56	21·10	22·00	21·86	21·24	21·32	21·70	18·91	18·13	18·24	7 12 ,,
16	19·78	20·05	20·98	21·10	21·91	21·67	20·87	21·08	21·37	19·33	18·57	19·04	8 12 ,,
17	20·52	20·82	20·90	20·55	20·78	20·76	20·02	19·76	19·76	18·98	18·66	19·71	9 12 ,,
18	20·50	21·11	20·48	19·44	19·25	19·66	18·79	18·27	17·88	18·17	18·49	19·45	10 12 ,,
19	19·82	20·79	19·81	18·45	17·93	18·61	17·73	17·18	16·41	17·20	18·07	19·00	11 12 ,,
20	19·57	20·25	19·37	17·74	17·32	18·03	17·31	16·68	15·72	16·66	18·52	18·91	Noon
21	19·57	20·01	19·38	17·88	17·43	18·11	17·37	16·66	16·24	16·81	19·06	19·34	1 12 P.M.
22	19·61	19·82	19·79	18·46	18·17	18·53	17·69	17·23	17·50	17·30	19·08	19·31	2 12 ,,
23	19·65	19·75	20·25	19·15	18·93	19·07	18·27	18·17	18·76	18·01	18·90	19·03	3 12 ,,

II. HORIZONTAL INTENSITY.

HORIZONTAL INTENSITY: 1, Mean Yearly Values.

(English Units are used throughout.)

Year.	Absolute Horizontal Intensity.	Year.	Absolute Horizontal Intensity.
1847	7·943	1853	7·998
1848	8·940	1854	8·000
1849	7·951	1855	7·998
1850	7·967	1856	8·017
1851	7·968	1857	8·025
1852	7·997		

HORIZONTAL INTENSITY: 2, Mean Monthly Values.

Month.	English Units.				Month.	English Units.			
	1854.	1855.	1856.	1857.		1854.	1855.	1856.	1857.
January	7·985	7·987	8·022	8·200	September	8·007	8·003	8·011	8·021
February	7·988	7·988	8·021	8·025	October	8·011	8·005	8·010	8·025
March	7·992	7·991	8·019	8·028	November	8·015	8·009	8·018	8·024
April	7·991	7·993	8·017	8·028	December	8·017	8·013	8·017	8·028
May	7·996	7·995	8·015	8·028	Mean of Winter[1]	8·001	7·999	8·018	8·025
June	8·000	7·998	8·013	8·029	Mean of Summer[2]	7·999	7·998	8·016	8·026
July	8·000	7·998	8·024	8·025	Mean of the Year	8·000	7·998	8·017	8·025
August	8·004	8·000	8·017	8·023					

[1] Winter = { January, February, March, October, November, December.

[2] Summer = { April, May, June, July, August, September.

HORIZONTAL INTENSITY: 3, MEAN DAILY VALUES,

for each Day of Göttingen Mean Time.

A. 1854.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	7·987	7·987	7·990	. . .	7·994	8·000	. . .	8·003	8·004	8·010	8·008	8·010
2	*7·972	7·989	7·993	7·994	7·994	8·001	8·002	8·007	. . .	8·009	8·010	. . .
3	7·977	7·991	7·990	7·992	7·997	. . .	8·001	8·000	8·005	8·009	8·011	8·014
4	7·981	. . .	. . .	7·993	7·995	8·000	8·001	7·999	8·007	8·010	. . .	8·013
5	7·983	7·988	7·992	7·992	7·992	8·000	8·001	. . .	8·008	8·012	8·013	8·013
6	7·983	7·989	7·990	7·993	. . .	8·003	8·003	8·001	8·007	8·012	8·011	8·014
7	. . .	7·990	7·990	7·992	8·001	8·000	8·002	. . .	8·007	. . .	8·012	8·015
8	7·981	7·991	7·992	. . .	7·997	8·002	. . .	8·002	8·008	7·995	8·008	8·015
9	7·983	7·991	7·993	7·995	7·989	8·003	7·999	8·003	. . .	8·004	8·011	. . .
10	7·986	7·981	7·993	7·984	7·995	. . .	7·993	8·003	8·008	8·008	8·015	8·017
11	7·984	. . .	. . .	*7·980	7·995	8·002	7·995	8·001	*7·996	8·009	. . .	8·018
12	7·984	7·986	7·993	7·989	7·995	7·994	7·997	. . .	8·003	8·004	8 ·17	8·019
13	7·984	7·986	7·994	. . .	. . .	7·997	7·999	8·004	8·005	8·006	8·016	8·017
14	. . .	7·985	. . .	7·984	8·000	8·000	7·997	8·004	8·003	. . .	8·017	8·016
15	7·986	7·982	7·989	. . .	7·992	7·999	. . .	8·005	9·005	8·010	8·016	8·021
16	7·986	7·987	7·985	7·992	7·991	7·999	8·001	8·006	. . .	8·011	8·016	. . .
17	7·984	7·988	7·988	7·994	7·993	. . .	8·001	8·004	8·004	8·014	8·017	8·018
18	7·985	. . .	. . .	7·986	7·997	8·000	8·001	8·005	8·005	8·011	. . .	8·016
19	7·983	7·989	7·993	7·989	7·995	7·999	8·002	. . .	8·008	8·012	8·017	8·017
20	7·984	7·991	7·991	7·990	. . .	7·997	8·004	8·000	8·010	. . .	8·018	8·017
21	. . .	7·991	7·994	7·991	7·996	8·000	8·003	8·001	8·006	8·013	8·015	8·018
22	7·998	7·993	7·994	. . .	7·996	8·002	. . .	8·003	8·007	8·016	8·015	8·019
23	7·994	7·992	7·994	7·988	. . .	7·999	8·000	8·003	. . .	8·011	8·016	. . .
24	7·996	7·995	7·996	7·983	8·002	. . .	7·996	8·005	8·008	8·012	8·016	8·021
25	7·990	7·993	. . .	7·991	7·996	8·000	7·998	8·004	8·006	8·013	8·015	8·021
26	7·989	. . .	7·990	7·994	7·997	8·002	8·000	8·005	8·008	8·012	. . .	8·022
27	7·990	7·987	*7·987	7·992	7·997	8·001	7·998	. . .	8·005	. . .	8·018	8·017
28	. . .	7·988	7·978	7·993	. . .	8·003	8·002	8·007	8·006	8·015	8·013	8·015
29	7·984	. . .	7·986	. . .	7·998	8·001	. . .	8·008	8·008	8·014	8·015	. . .
30	7·984	. . .	7·991	7·992	8·000	8·002	8·001	8·008	. . .	8·015	8·015	8·018
31	7·986	. . .	7·989	. . .	8·001	. . .	8·001	8·006	. . .	. . .	. . .	. . .

* Abnormal day, or a day on which this element was disturbed.

HORIZONTAL INTENSITY: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

B. 1855.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	7·985	7·988	7·990	7·993	7·993	7·997	7·996	7·997	. . .	8·003	8·008	. . .
2	7·984	7·988	. . .	7·997	7·993	. . .	7·998	7·999	8·003	8·005	8·008	8·013
3	7·985	. . .	. . .	7·995	7·994	7·997	7·995	7·999	8·002	*7·995	. . .	8·011
4	7·985	7·989	7·991	*7·985	7·994	7·995	7·996	. . .	8·003	7·997	8·010	8·013
5	7·986	7·990	7·994	. . .	. . .	7·997	7·996	7·997	8·002	7·998	8·008	8·012
6	. . .	7·990	7·992	7·989	8·000	7·997	7·997	7·999	8·003	. . .	8·006	8·013
7	7·985	7·991	7·992	. . .	7·595	7·996	. . .	7·999	8·003	8·005	8·007	8·013
8	7·986	*7·983	7·994	7·993	7·990	7·995	7·997	7·999	. . .	8·006	8·007	. . .
9	7·988	7·984	7·987	7·990	7·992	. . .	7·999	8·000	8·003	8·007	. . .	8·014
10	7·985	. . .	. . .	7·991	7·997	7·998	7·998	8·001	8·005	8·006	. . .	8·013
11	7·986	7·988	7·993	7·994	7·994	7·997	7·997	. . .	7·999	8·005	8·008	8·014
12	7·986	7·986	*7·983	7·989	. . .	7·996	7·990	8·003	8·001	8·005	8·007	8·009
13	. . .	7·988	7·986	7·993	7·995	7·997	8·000	8·001	8·002	. . .	8·008	8·012
14	7·987	7·986	7·989	. . .	7·996	7·998	. . .	8·002	8·003	8·006	8·011	8·012
15	7·987	7·986	7·990	7·991	7·994	7·999	8·002	7·998	. . .	8·006	8·011	. . .
16	7·988	7·989	7·990	7·993	7·996	. . .	8·001	7·998	8·002	8·005	8·007	8·013
17	7·988	. . .	. . .	7·992	7·996	7·999	*8·001	7·999	8·001	8·007	. . .	8·011
18	7·989	7·988	7·991	7·990	7·995	8·000	*8·004	. . .	8·002	*7·997	8·007	8·010
19	7·991	7·988	7·991	7·992	. . .	8·000	*7·994	8·000	8·004	*7·999	8·009	8·012
20	. . .	7·989	7·991	7·993	7·996	8·001	*7·993	7·999	8·004	. . .	8·008	8·012
21	7·989	7·988	7·992	. . .	7·997	7·999	. . .	7·999	8·003	8·004	8·006	8·015
22	7·988	7·988	7·992	7·996	7·997	7·996	7·995	8·001	. . .	8·005	8·009	. . .
23	7·989	7·989	7·993	7·994	. . .	. . .	7·996	8·002	8·005	8·004	8·008	8·017
24	7·987	7·989	. . .	7·995	8·001	7·997	7·997	8·000	8·005	8·004	8·010	. . .
25	7·987	. . .	7·993	7·997	7·999	7·997	7·996	. . .	8·004	8·007	. . .	8·015
26	7·986	7·991	7·992	7·997	7·997	7·998	7·997	. . .	8·006	8·008	8·011	8·017
27	. . .	7·990	7·994	7·997	*7·990	7·998	7·998	8·004	*8·003	. . .	8·012	8·015
28	7·989	7·989	7·993	. . .	. . .	7·996	. . .	8·002	8·004	8·006	8·013	8·016
29	7·987	. . .	7·995	7·996	7·995	7·997	7·995	8·003	. . .	8·005	8·008	. . .
30	7·988	. . .	7·994	7·992	7·996	. . .	7·997	8·003	8·005	8·008	8·010	*8·008
31	7·985	. . .	. . .	. . .	7·996	. . .	7·997	7·999	. . .	8·009	. . .	8·018

HORIZONTAL INTENSITY: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

C. 1856.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	8·025	8·022	. . .	8·021	8·013	. . .	8·017	8·021	8·011	8·008	. . .	8·017
2	8·025	. . .	8·022	8·020	8·013	8·010	8·015	. . .	8·013	8·008	8·015	8·019
3	8·029	8·027	8·019	8·018	. . .	8·010	8·020	8·021	8·013	8·013	8·012	8·017
4	8·028	8·029	8·021	8·019	8·017	8·007	8·019	8·017	8·013	. . .	8·015	8·008
5	. . .	8·032	8·020	. . .	8·016	8·007	. . .	8·018	8·016	8·004	8·010	8·015
6	8·026	8·027	8·017	8·018	8·018	8·009	8·021	8·018	. . .	8·007	8·013	. . .
7	8·034	8·022	8·021	8·020	8·019	. . .	8·020	8·018	8·016	8·008	8·013	8·017
8	8·026	8·025	. . .	8·019	8·018	8·007	8·018	8·020	8·012	8·012	. . .	8·013
9	8·031	. . .	8·017	8·019	8·018	8·006	8·020	. . .	8·009	8·008	8·017	8·020
10	8·030	8·024	8·019	8·019	. . .	8·007	8·021	8·021	8·013	8·012	8·017	8·012
11	8·022	8·021	8·019	8·018	8·016	8·006	8·022	8·015	8·015	. . .	8·016	8·014
12	. . .	8·019	8·020	. . .	8·015	8·008	. . .	8·018	8·015	*8·001	8·018	8·020
13	8·013	8·019	8·022	8·018	8·019	8·011	8·023	8·020	. . .	8·008	8·019	. . .
14	8·012	8·017	8·021	8·018	8·011	. . .	8·022	. . .	8·015	8·009	8·021	8·018
15	8·011	8·020	. . .	8·019	8·010	8·014	8·023	8·019	8·015	8·010	. . .	8·017
16	8·015	. . .	8·017	8·016	8·010	8·016	8·025	. . .	8·009	8·012	8·018	8·019
17	8·015	8·022	8·020	8·018	. . .	8·011	8·022	8·018	8·008	8·012	8·019	8·014
18	8·012	8·022	8·015	8·016	8·016	8·013	8·015	8·021	8·008	. . .	8·020	8·015
19	. . .	8·026	8·014	. . .	8·015	8·017	. . .	8·018	8·008	8·014	8·016	8·018
20	8·015	8·021	. . .	8·019	8·016	8·016	8·027	8·019	. . .	8·007	8·016	. . .
21	8·013	8·020	. . .	8·019	8·016	. . .	8·025	8·017	8·010	8·010	8·014	8·019
22	8·013	8·023	. . .	8·011	8·015	8·020	8·022	8·010	8·011	8·005	. . .	8·018
23	8·015	8·020	8·018	8·010	. . .	8·021	8·019	. . .	8·008	8·002	8·019	8·019
24	8·027	. . .	8·019	8·014	. . .	8·019	8·021	*8·006	8·010	8·006	8·017	8·015
25	8·031	8·018	8·021	8·015	8·021	8·019	8·021	8·011	8·012	. . .	8·021	8·015
26	. . .	8·009	8·021	. . .	8·018	8·020	. . .	8·015	8·005	. . .	8·020	. . .
27	8·030	8·005	8·010	8·016	8·014	8·018	8·021	8·017	. . .	8·013	8·018	. . .
28	8·028	8·010	8·020	8·015	8·013	. . .	8·021	8·016	8·009	8·013	8·017	8·014
29	8·027	8·012	. . .	8·016	8·012	8·019	8·021	8·015	8·008	8·012	8·013	*8·005
30	8·028	. . .	8·016	8·012	8·013	8·017	8·022	. . .	8·007	8·016	. . .	8·013
31	8·022	. . .	8·020	. . .	8·011	. . .	8·020	8·015	. . .	8·016	. . .	8·014

HORIZONTAL INTENSITY: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

D. 1857.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	8·021	8·022	. . .	8·029	8·032	8·030	8·028	. . .	8·023	8·019	8·025	8·031
2	8·021	8·026	8·031	8·029	. . .	8·029	8·028	8·025	8·025	8·022	8·030	8·026
3	. . .	8·025	8·031	8·031	8·033	8·030	8·028	8·019	*8·008	. . .	8·026	8·029
4	8·017	8·023	8·028	. . .	8·032	8·028	. . .	. . .	*8·010	8·027	8·021	8·033
5	8·016	8·023	8·025	8·029	8·033	8·029	8·029	8·025	. . .	8·025	8·024	. . .
6	8·019	8·025	8·027	8·027	8·030	. . .	8·030	8·026	8·020	8·030	8·028	8·030
7	8·018	. . .	. . .	8·028	*8·009	8·032	8·031	8·021	8·016	8·024	. . .	8·031
8	8·018	8·019	8·025	8·030	8·012	8·032	8·020	. . .	8·019	8·028	8·028	8·033
9	8·023	8·021	8·026	. . .	. . .	8·035	8·023	8·022	8·019	8·028	8·015	8·033
10	. . .	8·020	. . .	8·028	8·019	8·036	8·025	8·022	8·015	. . .	8·020	8·028
11	8·022	8·024	8·023	. . .	8·016	8·036	. . .	8·024	8·019	8·028	8·018	8·030
12	8·022	8·025	8·028	8·015	8·021	8·035	8·022	8·021	. . .	8·029	8·019	. . .
13	8·019	8·025	8·023	8·021	8·022	. . .	8·025	8·022	8·023	8·030	8·024	8·035
14	8·021	. . .	. . .	8·025	8·024	8·036	8·025	. . .	8·019	8·032	. . .	8·033
15	8·024	8·025	8·026	8·027	8·026	8·031	8·026	. . .	8·018	8·024	8·029	8·033
16	8·016	8·022	8·029	8·029	. . .	8·029	8·026	8·021	8·019	. . .	8·026	*8·023
17	. . .	8·026	8·025	8·027	8·030	8·027	8·023	8·020	8·020	. . .	8·014	*7·975
18	8·017	8·026	8·024	. . .	8·031	8·025	. . .	8·023	8·019	8·020	8·013	*8·009
19	8·018	8·026	8·026	8·029	8·030	8·029	8·027	8·021	. . .	8·021	8·025	. . .
20	8·021	8·027	8·027	8·031	8·030	. . .	8·028	8·021	8·025	8·022	8·029	8·016
21	8·021	. . .	. . .	8·031	8·028	8·030	8·028	8·022	*8·009	8·023	. . .	8·019
22	8·021	8·029	8·027	8·031	8·029	8·020	8·030	. . .	8·016	8·026	8·030	8·021
23	8·019	8·028	8·029	8·031	. . .	8·026	8·024	8·019	8·018	8·023	8·023	8·016
24	. . .	8·030	8·029	8·031	8·031	8·026	8·024	8·024	8·022	. . .	8·022	. . .
25	8·019	8·031	8·030	. . .	8·030	8·029	. . .	8·026	8·023	8·025	8·024	8·023
26	8·017	8·028	8·029	8·032	8·032	8·031	8·020	8·027	. . .	8·026	8·027	. . .
27	8·018	8·024	8·031	8·028	8·030	. . .	8·020	8·027	8·025	8·029	8·024	*8·017
28	8·020	8·026	. . .	8·029	8·030	8·019	8·021	8·023	8·028	8·031	8·025	*8·009
29	8·021	. . .	8·028	8·028	8·033	8·025	8·019	8·024	8·028	8·022	. . .	8·014
30	8·022	. . .	8·028	8·031	8·027	8·022	8·023	. . .	8·019	8·022	8·032	8·032
31	. . .	. . .	8·033	. . .	. . .	. . .	8·021	8·025	. . .	. . .	. . .	8·032

HORIZONTAL INTENSITY: 4, MEAN HOURLY VALUES FOR EACH MONTH.

A. 1854.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
													h m
Noon	7·984	7·988	7·990	7·991	7·996	7·999	7·999	8·003	8·006	8·010	8·011	8·017	4 12 P.M.
1	7·981	7·987	7·989	7·990	7·995	7·998	7·998	8·002	8·005	8·009	8·012	8·015	5 12 „
2	7·981	7·986	7·988	7·989	7·992	7·998	7·997	8·002	8·005	8·008	8·011	8·013	6 12 „
3	7·981	7·984	7·988	7·987	7·992	7·997	7·997	8·001	8·004	8·007	8·010	8·013	7 12 „
4	7·980	7·984	7·988	7·988	7·992	7·997	7·997	8·001	8·004	8·006	8·010	8·012	8 12 „
5	7·981	7·984	7·989	7·988	7·993	7·998	7·997	8·001	8·004	8·006	8·010	8·012	9 12 „
6	7·982	7·984	7·989	7·989	7·993	7·998	7·999	8·002	8·005	8·007	8·011	8·013	10 12 „
7	7·982	7·986	7·990	7·989	7·993	7·998	7·998	8·002	8·005	8·007	8·011	8·013	11 12 „
8	7·982	7·985	7·990	7·989	7·994	7·999	7·998	8·002	8·005	8·008	8·012	8·014	Midnight
9	7·983	7·986	7·989	7·990	7·994	7·999	7·998	8·002	8·006	8·008	8·012	8·014	1 12 A.M.
10	7·983	7·987	7·989	7·990	7·994	7·999	7·999	8·002	8·006	8·009	8·013	8·015	2 12 „
11	7·984	7·987	7·990	7·991	7·994	7·999	7·999	8·003	8·006	8·010	8·013	8·015	3 12 „
12	7·984	7·987	7·989	7·991	7·995	8·000	7·999	8·003	8·007	8·010	8·014	8·015	4 12 „
13	7·985	7·988	7·991	7·991	7·995	8·000	7·999	8·003	8·007	8·010	8·014	8·016	5 12 „
14	7·985	7·988	7·991	7·990	7·995	8·001	7·999	8·003	8·005	8·010	8·014	8·016	6 12 „
15	7·987	7·988	7·991	7·990	7·996	8·003	8·000	8·003	8·005	8·010	8·016	8·017	7 12 „
16	7·986	7·990	7·994	7·992	7·998	8·005	8·001	8·004	8·006	8·013	8·018	8·018	8 12 „
17	7·989	7·993	7·997	7·995	8·001	8·006	8·004	8·007	8·006	8·016	8·021	8·020	9 12 „
18	7·992	7·996	7·999	7·998	8·004	8·007	8·007	8·009	8·012	8·018	8·022	8·021	10 12 „
19	7·992	7·997	8·000	7·998	8·004	8·007	8·008	8·010	8·012	8·018	8·023	8·022	11 12 „
20	7·992	7·996	7·999	7·996	8·003	8·007	8·007	8·010	9·012	8·018	8·021	8·021	Noon
21	7·990	7·995	7·996	7·995	8·002	8·006	8·005	8·009	8·010	8·016	8·019	8·020	1 12 P.M.
22	7·989	7·992	7·993	7·994	8·000	8·003	8·003	8·007	8·009	8·014	8·017	8·019	2 12 „
23	7·987	7·989	7·991	7·991	7·988	8·001	8·001	8·005	8·007	8·012	8·015	8·018	3 12 „

HORIZONTAL INTENSITY: 4, Mean Hourly Values for each Month.

B. 1855.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
													h m
Noon	7·987	7·988	7·990	7·992	7·994	7·995	7·997	8·000	8·003	8·003	8·009	8·014	4 12 P.M.
1	7·986	7·986	7·989	7·991	7·992	7·994	7·995	7·999	8·002	8·003	8·007	8·012	5 12 "
2	7·984	7·985	7·987	7·990	7·992	7·994	7·995	7·998	8·001	8·002	8·005	8·011	6 12 "
3	7·983	7·984	7·987	7·990	7·991	7·993	7·994	7·997	8·000	8·001	8·005	8·010	7 12 "
4	7·983	7·984	7·987	7·990	7·991	7·993	7·994	7·996	7·999	8·001	8·005	8·010	8 12 "
5	7·983	7·985	7·987	7·990	7·991	7·994	7·994	7·997	8·000	8·001	8·005	8·010	9 12 "
6	7·983	7·985	7·988	7·992	7·992	7·994	7·995	7·997	8·000	9·002	8·005	8·010	10 12 "
7	7·984	7·986	7·989	7·992	7·993	7·994	7·995	7·997	8·001	8·002	8·000	8·010	11 12 "
8	7·985	7·986	7·989	7·992	7·994	7·994	7·996	7·998	8·001	8·003	8·006	8·011	Midnight
9	7·985	7·988	7·989	7·992	7·994	7·995	7·995	7·999	8·001	8·003	8·006	8·011	1 12 A.M.
10	7·985	7·987	7·990	7·990	7·993	7·995	7·996	7·998	8·002	8·003	8·006	8·011	2 12 "
11	7·986	7·987	7·990	7·992	7·994	7·995	7·996	7·998	8·002	8·004	8·007	8·012	3 12 "
12	7·986	7·988	7·990	7·993	7·994	7·995	7·996	7·998	8·002	8·004	8·007	8·012	4 12 "
13	7·987	7·988	7·990	7·992	7·994	7·995	7·996	7·999	8·003	8·004	8·007	8·012	5 12 "
14	7·987	7·988	7·990	7·991	7·994	7·995	7·996	7·999	8·002	8·004	8·007	8·013	6 12 "
15	7·986	7·988	7·990	7·992	7·995	7·996	7·998	7·998	8·001	8·003	8·009	8·013	7 12 "
16	7·988	7·989	7·993	7·994	7·998	7·998	7·999	8·001	8·003	8·006	8·011	8·015	8 12 "
17	7·990	7·992	7·997	7·997	8·001	8·000	8·002	8·003	8·006	8·009	8·013	8·017	9 12 "
18	7·992	7·994	8·000	8·000	8·003	8·001	8·003	8·005	8·008	8·011	8·014	8·018	10 12 "
19	7·992	7·994	8·001	8·000	8·003	8·001	8·005	8·006	8·009	8·013	8·016	8·019	11 12 "
20	7·993	7·994	7·999	8·000	8·002	8·000	8·005	8·006	8·008	8·012	8·015	8·018	Noon
21	7·991	7·993	7·997	7·998	8·001	7·999	8·003	8·005	8·007	8·010	8·014	8·018	1 12 P.M.
22	7·990	7·991	7·995	7·996	7·998	7·998	8·001	8·004	8·006	8·008	8·012	8·017	2 12 "
23	7·988	7·990	7·993	7·994	7·996	7·996	7·999	8·002	8·004	8·006	8·010	8·014	3 12 "

HORIZONTAL INTENSITY: 4, Mean Hourly Values for each Month.

C. 1856.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
													h m
Noon	8·024	8·024	8·020	8·017	8·015	8·014	8·024	8·019	8·012	8·009	8·019	8·020	4 12 P.M.
1	8·022	8·022	8·018	8·015	8·013	8·012	8·022	8·016	8·010	8·007	8·016	8·017	5 12 „
2	8·020	8·018	8·016	8·013	8·011	8·010	8·021	8·015	8·008	8·006	8·014	8·012	6 12 „
3	8·018	8·016	8·014	8·012	8·009	8·009	8·019	8·013	8·006	8·004	8·012	8·011	7 12 „
4	8·018	8·016	8·013	8·012	8·009	8·008	8·019	8·013	8·006	8·003	8·011	8·010	8 12 „
5	8·017	8·016	8·013	8·011	8·010	8·009	8·019	8·012	8·006	8·003	8·011	8·010	9 12 „
6	8·017	8·016	8·014	8·011	8·010	8·009	8·019	8·012	8·006	8·003	8·012	8·010	10 12 „
7	8·017	8·016	8·014	8·011	8·010	8·009	8·020	8·013	8·008	8·004	8·012	8·011	11 12 „
8	8·017	8·016	8·014	8·012	8·011	8·009	8·020	8·013	8·008	8·005	8·012	8·012	Midnight
9	8·017	8·016	8·014	8·012	8·011	8·009	8·021	8·013	8·007	8·006	8·013	8·013	1 12 A.M.
10	8·017	8·017	8·014	8·012	8·012	8·009	8·021	8·014	8·008	8·006	8·013	8·013	2 12 „
11	8·017	8·016	8·014	8·013	8·011	8·009	8·021	8·014	8·008	8·006	8·013	8·013	3 12 „
12	8·017	8·017	8·015	8·013	8·012	8·009	8·021	8·014	8·009	8·007	8·013	8·014	4 12 „
13	8·018	8·017	8·015	8·013	8·012	8·010	8·021	8·014	8·009	8·006	8·014	8·014	5 12 „
14	8·018	8·018	8·016	8·013	8·012	8·011	8·022	8·014	8·009	8·006	8·015	8·015	6 12 „
15	8·018	8·018	8·016	8·014	8·013	8·013	8·023	8·014	8·008	8·007	8·016	8·015	7 12 „
16	8·022	8·022	8·020	8·019	8·017	8·016	8·027	8·018	8·011	8·012	8·021	8·019	8 12 „
17	8·026	8·027	8·026	8·024	8·021	8·018	8·030	8·022	8·016	8·018	8·026	8·023	9 12 „
18	8·036	8·030	8·030	8·028	8·024	8·020	8·033	8·026	8·020	8·021	8·029	8·027	10 12 „
19	8·033	8·033	8·031	8·029	8·025	8·022	8·034	8·027	8·022	8·022	8·030	8·028	11 12 „
20	8·032	8·033	8·030	8·028	8·024	8·023	8·033	8·027	8·021	8·021	8·029	8·028	Noon
21	8·030	8·031	8·028	8·025	8·022	8·022	8·032	8·026	8·019	8·017	8·027	8·026	1 12 P.M.
22	8·029	8·028	8·025	8·023	8·020	8·019	8·030	8·024	8·017	8·015	8·024	8·024	2 12 „
23	8·027	8·027	8·022	8·020	8·017	8·016	8·027	8·021	8·014	8·012	8·022	8·024	3 12 „

HORIZONTAL INTENSITY: 4, Mean Hourly Values for each Month.

D. 1857.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
Noon	8·022	8·028	8·030	8·030	8·030	8·028	8·026	8·024	8·022	8·027	8·025	8·030	h m 4 12 P.M.
1	8·020	8·025	8·027	8·026	8·027	8·026	8·024	8·022	8·020	8·024	8·022	8·027	5 12 ,,
2	8·017	8·021	8·025	8·024	8·025	8·025	8·023	8·020	8·019	8·023	8·020	8·025	6 12 ,,
3	8·016	8·019	8·023	8·023	8·023	8·024	8·020	8·018	8·017	8·020	8·018	8·023	7 12 ,,
4	8·015	8·019	8·023	8·023	8·022	8·023	8·019	8·017	8·017	8·019	8·018	8·022	8 12 ,,
5	8·014	8·019	8·022	8·023	8·022	8·022	8·020	8·017	8·016	8·018	8·017	8·020	9 12 ,,
6	8·014	8·019	8·022	8·023	8·023	8·023	8·020	8·018	8·016	8·019	8·016	8·020	10 12 ,,
7	8·014	8·020	8·021	8·023	8·023	8·024	8·021	8·018	8·016	8·020	8·017	8·020	11 12 ,,
8	8·015	8·020	8·022	8·024	8·022	8·025	8·021	8·019	8·017	8·020	8·019	8·022	Midnight
9	8·015	8·020	8·022	8·023	8·023	8·025	8·020	8·019	8·018	8·020	8·019	8·022	1 12 A.M.
10	8·015	8·021	8·023	8·023	8·023	8·025	8·020	8·019	8·018	8·022	8·019	8·023	2 12 ,,
11	8·015	8·020	8·022	8·023	8·024	8·025	8·020	8·019	8·018	8·021	8·020	8·023	3 12 ,,
12	8·015	8·021	8·022	8·023	8·024	8·025	8·020	8·019	8·018	8·022	8·020	8·023	4 12 ,,
13	8·016	8·021	8·022	8·023	8·024	8·025	8·021	8·020	8·018	8·021	8·021	8·023	5 12 ,,
14	8·017	8·023	8·024	8·023	8·024	8·026	8·022	8·020	8·018	8·022	8·021	8·024	6 12 ,,
15	8·017	8·030	8·024	8·025	8·025	8·028	8·024	8·021	8·017	8·022	8·022	8·024	7 12 ,,
16	8·019	8·034	8·028	8·030	8·029	8·031	8·027	8·023	8·020	8·027	8·027	8·029	8 12 ,,
17	8·024	8·030	8·034	8·036	8·034	8·035	8·030	8·028	8·025	8·033	8·031	8·033	9 12 ,,
18	8·028	8·034	8·039	8·040	8·037	8·039	8·034	8·032	8·030	8·036	8·035	8·038	10 12 ,,
19	8·031	8·037	8·041	8·041	8·038	8·040	8·036	8·033	8·031	8·039	8·037	8·040	11 12 ,,
20	8·030	8·038	8·041	8·040	8·039	8·040	8·035	8·034	8·032	8·038	8·036	8·041	Noon
21	8·029	8·037	8·039	8·038	8·038	8·039	8·037	8·033	8·029	8·036	8·033	8·039	1 12 P.M.
22	8·027	8·035	8·036	8·035	8·036	8·035	8·031	8·030	8·027	8·032	8·031	8·037	2 12 ,,
23	8·025	8·022	8·033	8·033	8·033	8·032	8·029	8·028	8·024	8·030	8·028	8·034	3 12 ,,

III. CALCULATED DIP.

DIP: 1, Mean Yearly Values.

Year.	Dip.	Year.	Dip.
	° ′		° ′
1847	18 17·9	1853	19 18·2
1848	18 08·6	1854	18 52·8
1849	18 47·9	1855	19 01·4
1850	19 18·2	1856	19 11·8
1851	19 01·5	1857	19 06·6
1852	18 51·1		

DIP: 2, Mean Monthly Values.

Month.	Mean Dip.				Month.	Mean Dip.			
	1854.	1855.	1856.	1857.		1854.	1855.	1856.	1857.
	° ′	° ′	° ′	° ′		° ′	° ′	° ′	° ′
January	18 50·6	18 41·6	19 11·3	18 57·3	September	18 51·6	19 14·4	19 01·5	19 10·0
February	19 05·1	18·49·3	19 22·7	18 58·1	October	18 44·9	19 08·2	19 03·9	19 08·5
March	19 03·7	18·55·4	19 17·4	19 02·0	November	18 39·9	19 12·3	19 13·7	19 12·3
April	18 54·7	18 59·8	19 17·6	19 05·7	December	18 31·6	19 11·8	19 02·0	19 12·1
May	18 56·0	18 59·0	19 21·6	19 04·0	Mean of Winter[1]	18 49·3	18 59·8	19 11·8	19 05·0
June	19 00·1	18 52·0	19 14·8	19 09·2	Mean of Summer[2]	18 56·4	19 03·1	19 11·7	19 08·2
July	18 58·7	18 57·0	19 08·6	19 13·6	Mean of the Year	18 52·8	19 01·4	19 11·8	19 06·6
August	18 57·2	19 16·7	19 06·2	19 06·7					

[1] Winter = { January, February, March, October, November, December.

[2] Summer = { April, May, June, July, August September.

DIP: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

A. 1854.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	18 26·4	19 00·5	19 03·3	. . .	18 55·8	19 03·2	. . .	18 55·9	19 01·3	18 52·8	18 51·5	18 38·1
2	* 49·9	02·7	03·4	18 56·9	58·0	02·3	19 04·2	53·1	. . .	52·4	50·2	. . .
3	51·3	02·1	02·5	57·2	58·4	. . .	01·7	54·5	04·9	51·1	46·1	33·0
4	51·1	. . .	. . .	55·2	58·2	01·8	02·0	56·1	18 59·4	47·0	. . .	29·8
5	48·1	03·8	01·0	54·8	57·8	07·2	01·0	. . .	50·0	47·0	38·9	29·7
6	46·1	04·1	01·7	55·8	. . .	10·4	18 57·1	56·3	50·7	48·0	39·3	29·0
7	. . .	03·7	01·9	57·0	59·7	06·8	51·5	. . .	55·2	. . .	39·2	31·5
8	47·9	03·9	01·9	. . .	19 00·5	03·9	. . .	51·5	58·5	47·4	39·5	33·9
9	47·4	04·9	01·1	54·8	02·6	03·2	50·9	53·3	. . .	38·9	38·1	. . .
10	44·9	07·3	00·7	54·9	04·4	. . .	59·4	51·4	46·3	34·8	35·9	35·4
11	46·4	. . .	. . .	* 56·0	00·7	18 49·1	55·1	53·2	* 46·4	34·2	. . .	33·1
12	48·8	06·4	07·4	52·2	18 56·1	50·1	55·7	. . .	43·5	33·8	37·5	31·4
13	49·1	05·9	09·2	. . .	. . .	57·0	57·2	57·0	41·9	33·0	38·2	31·3
14	. . .	09·5	. . .	51·0	51·0	59·2	19 02·6	58·8	43·2	. . .	38·0	33·2
15	52·4	10·6	10·1	. . .	51·8	49·7	. . .	57·8	35·7	31·7	37·8	33·1
16	52·4	10·9	10·0	52·3	52·0	47·5	02·6	56·1	. . .	32·1	37·4	. . .
17	52·1	09·7	09·4	53·5	51·6	. . .	00·9	54·0	43·9	31·9	36·6	33·1
18	51·1	. . .	. . .	53·9	50·6	51·3	00·4	54·0	46·4	44·8	. . .	33·3
19	51·2	05·9	07·7	54·9	50·0	54·5	03·6	. . .	49·2	45·6	36·1	33·6
20	51·0	04·3	08·6	55·8	. . .	57·1	00·6	59·4	52·7	. . .	35·4	34·7
21	. . .	05·1	07·7	55·0	50·1	19 01·7	18 59·9	56·5	55·1	. . .	35·7	34·6
22	51·5	05·6	03·9	. . .	50·1	00·8	. . .	58·3	58·9	42·9	35·5	33·9
23	53·2	05·0	01·7	54·2	. . .	00·3	59·0	59·4	. . .	56·1	36·2	. . .
24	54·8	04·8	01·5	56·4	50·9	. . .	19 02·6	58·3	58·0	56·7	42·2	. . .
25	53·6	03·7	. . .	54·7	52·8	01·9	18 57·2	57·9	19 00·4	55·5	40·8	29·5
26	53·4	. . .	18 57·9	52·9	53·5	02·4	52·9	58·9	18 53·9	53·7	. . .	27·2
27	52·4	01·3	57·4	54·9	55·9	03·9	57·1	. . .	51·0	49·0	47·8	26·9
28	. . .	00·6	* 59·7	56·3	. . .	07·7	54·2	59·4	49·7	. . .	47·7	27·5
29	53·2	. . .	58·5	. . .	19 00·6	09·2	. . .	19 03·7	48·7	48·3	39·7	26·5
30	54·9	. . .	58·8	53·4	02·3	02·7	56·7	05·8	. . .	48·0	37·3	. . .
31	57·4	. . .	59·4	. . .	02·3	. . .	59·3	01·9	. . .	49·6	. . .	27·3

* Abnormal day, or a day on which this element was disturbed.

DIP: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

B. 1855.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	18 28·9	18 48·8	18 56·7	18 54·5	19 00·4	19 05·8	18 46·0	19 06·2	...	19 05·9	19 11·6	...
2	30·4	48·6	...	54·3	00·5	...	46·6	06·3	19 23·8	03·5	13·7	19 16·1
3	33·9	...	...	55·4	01·0	18 52·3	47·6	07·8	23·5	* 04·4	...	16·0
4	36·1	49·5	54·8	*58·6	00·0	52·3	48·9	...	21·3	04·6	14·6	15·0
5	37·3	48·6	51·8	...	...	53·3	43·8	07·2	18·3	06·3	14·8	14·7
6	...	45·8	51·9	58·6	18 55·6	53·3	43·0	06·6	17·3	...	14·3	13·1
7	37·7	43·7	52·9	...	54·3	52·5	...	06·4	16·8	08·3	11·8	12·4
8	38·3	* 44·7	53·6	59·6	54·6	52·2	45·9	06·3	...	08·4	08·8	...
9	36·5	46·0	59·0	58·5	53·7	...	45·4	06·2	15·6	08·4	...	07·7
10	37·6	...	...	57·8	52·8	50·3	47·1	06·5	18·0	09·6	...	06·0
11	41·3	46·7	56·7	56·4	55·1	52·4	51·4	...	17·2	11·1	07·7	07·0
12	41·2	47·1	* 56·1	59·6	...	57·3	55·5	06·2	11·6	12·8	08·6	07·9
13	...	46·5	55·4	19 02·3	58·0	19 00·2	58·5	10·8	10·0	...	09·8	07·9
14	46·4	47·4	54·9	...	19 00·4	18 57·3	...	15·6	11·4	09·4	10·2	07·5
15	46·9	46·7	57·6	03·2	01·5	54·1	58·5	20·2	...	09·0	11·0	...
16	49·5	46·5	58·6	02·9	01·8	...	59·0	21·5	12·7	09·3	12·7	11·7
17	52·1	...	...	01·2	01·5	46·2	19 01·3	22·2	13·4	09·5	...	11·3
18	50·7	48·3	54·9	18 59·6	18 58·7	48·7	* 01·9	...	14·2	09·7	12·8	11·0
19	46·4	50·0	54·6	57·4	...	53·4	* 02·5	26·6	11·8	06·7	13·2	10·8
20	...	49·7	57·1	58·7	58·0	55·5	* 04·4	26·5	12·8	...	12·9	11·2
21	40·6	50·7	58·0	...	57·9	51·9	...	24·5	14·7	04·3	12·3	11·4
22	39·2	52·5	57·2	19 01·3	56·8	51·8	08·0	25·8	...	06·6	12·2	...
23	37·6	53·5	55·2	02·6	...	...	08·2	23·5	11·7	08·0	13·0	12·4
24	39·0	54·5	...	03·7	57·2	43·3	08·3	24·6	11·2	09·9	13·1	...
25	40·7	...	54·5	02·9	58·4	44·5	08·1	...	12·9	07·2	...	14·2
26	41·5	54·0	54·6	01·8	59·7	47·8	07·2	...	11·5	06·4	12·2	14·0
27	...	54·0	53·5	03·1	*19 02·8	48·8	06·7	22·9	11·2	...	12·8	15·2
28	46·9	54·6	54·1	...	...	47·3	...	23·8	10·6	08·4	13·4	16·2
29	48·8	...	55·3	00·7	04·6	48·1	07·6	23·0	...	09·4	15·4	...
30	48·5	...	55·7	01·1	05·6	...	06·7	26·0	07·3	09·7	15·3	* 15·9
31	48·1	...	...	...	05·8	...	06·4	31·8	...	10·5	...	14·3

DIP: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

C. 1856.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	19 08·2	19 20·5	. . .	19 19·3	19 18·5	. . .	19 21·6	19 08·1	19 04·5	18 58·3	. . .	19 09·9
2	09·0	. . .	19 21·7	19·3	18·0	19 25·5	20·9	. . .	03·5	57·7	19 15·6	08·2
3	08·2	21·3	21·5	18·7	. . .	24·3	13·7	07·9	04·0	56·1	16·0	08·4
4	09·4	21·4	20·1	19·1	18·4	20·4	09·8	07·2	02·9	. . .	13·9	08·6
5	. . .	22·3	19·8	. . .	18·7	22·2	. . .	07·0	02·0	56·3	14·3	06·8
6	10·3	20·5	18·4	18·2	19·9	19·5	04·0	06·8	. . .	55·3	13·0	. . .
7	07·7	21·4	17·8	18·8	19·3	. . .	00·7	06·5	01·5	54·9	11·8	06·5
8	07·9	20·6	. . .	17·9	19·9	16·8	00·0	06·0	02·0	54·7	. . .	08·1
9	08·3	. . .	15·5	16·6	20·3	19·8	03·0	. . .	22·2	55·1	12·1	07·5
10	08·8	21·2	14·8	16·6	. . .	13·6	03·3	05·2	12·2	54·1	13·3	06·2
11	08·7	21·2	14·1	16·0	22·5	08·1	05·8	05·7	08·8	. . .	14·7	04·2
12	. . .	20·6	14·2	. . .	21·6	04·0	. . .	05·3	09·9	* 55·3	14·8	03·9
13	11·4	21·7	11·5	17·3	21·2	04·7	05·6	04·8	. . .	54·7	15·8	. . .
14	11·9	22·8	11·0	17·3	22·7	. . .	09·8	. . .	00·1	54·7	15·5	01·9
15	12·6	22·9	. . .	17·1	23·1	08·4	07·6	05·0	00·3	54·0	. . .	02·3
16	11·6	. . .	11·2	18·6	23·4	09·8	05·0	. . .	00·8	53·8	15·2	02·7
17	12·6	22·1	11·0	19·9	. . .	10·2	05·9	07·2	00·1	55·6	14·8	01·9
18	14·3	21·5	13·7	21·0	24·4	08·4	07·8	06·6	18 59·6	. . .	14·2	01·3
19	. . .	19·6	17·6	. . .	24·3	07·4	. . .	07·0	59·7	19 02·6	14·6	00·9
20	11·0	20·8	. . .	22·8	22·3	08·3	07·6	06·7	. . .	08·0	14·5	. . .
21	14·0	21·5	. . .	23·8	23·2	. . .	07·2	06·4	19 04·4	12·2	14·9	18 59·8
22	12·9	21·8	. . .	23·9	19·9	11·7	08·1	07·1	04·0	12·5	. . .	57·7
23	13·5	23·7	18·8	23·0	. . .	12·4	09·3	. . .	02·3	14·4	13·3	57·2
24	11·3	. . .	18·9	20·0	. . .	17·0	10·2	* 07·1	00·8	14·8	13·4	57·8
25	11·4	25·7	20·2	19·0	18·6	19·2	10·2	05·8	18 59·8	. . .	11·7	57·8
26	. . .	24·9	19·6	. . .	20·5	21·3	. . .	04·6	19 00·8	. . .	10·5	. . .
27	12·0	25·5	20·4	18·6	25·2	20·3	09·6	04·2	. . .	14·8	11·0	. . .
28	12·9	25·0	17·7	19·0	23·0	. . .	09·1	04·6	00·4	15·1	11·0	56·3
29	14·4	23·9	. . .	18·8	22·1	14·8	08·9	04·6	18 59·5	15·6	11·7	* 55·8
30	14·5	. . .	20·7	19·2	21·8	16·2	08·4	04·4	59·0	16·3	. . .	53·4
31	18·8	. . .	21·0	. . .	23·3	. . .	08·1	. . .	. . .	15·8	. . .	52·4

DIP: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

D. 1857.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	19 03·7	18 57·9	. . .	19 01·1	19 03·5	19 06·3	19 06·9	. . .	19 10·7	19 13·3	19 11·1	19 16·6
2	01·7	56·7	19 00·1	02·0	. . .	09·2	06·5	19 12·8	10·7	12·9	10·0	16·9
3	. . .	56·0	00·2	03·4	01·9	08·3	06·8	11·1	* 13·5	. . .	12·4	16·2
4	00·6	57·7	01·8	. . .	02·0	07·2	. . .	. . .	12·3	12·2	15·2	14·7
5	00·8	59·0	01·6	05·4	01·5	06·8	07·9	10·9	. . .	12·1	12·5	. . .
6	01·2	58·2	01·7	05·8	02·0	. . .	08·6	11·1	09·8	11·2	11·1	15·1
7	18 59·7	. . .	. . .	05·5	* 01·8	07·7	08·9	10·0	10·9	11·3	. . .	15·5
8	58·6	58·9	03·1	05·6	* 03·7	08·1	10·4	. . .	11·7	10·6	09·5	15·0
9	56·5	59·3	03·2	. . .	. . .	08·7	08·8	09·7	11·9	09·8	11·8	14·7
10	. . .	56·6	. . .	06·5	02·5	09·1	08·6	09·4	13·5	. . .	11·3	14·8
11	54·6	56·5	03·5	. . .	03·2	10·7	. . .	08·3	11·7	09·8	11·4	15·0
12	54·3	56·5	02·8	08·5	02·4	09·9	10·3	05·8	. . .	09·2	12·0	. . .
13	55·5	57·5	04·4	07·3	03·0	. . .	12·3	04·4	10·9	08·9	11·1	12·2
14	56·3	. . .	. . .	05·9	04·0	09·8	14·3	. . .	11·0	08·8	. . .	12·0
15	54·5	58·5	03·3	05·5	04·9	10·4	14·9	. . .	09·5	09·8	09·5	11·9
16	55·0	58·4	02·7	04·7	. . .	10·5	15·7	07·3	09·6	. . .	10·0	* 13·4
17	. . .	57·9	00·9	04·4	03·7	11·0	15·5	07·2	09·8	. . .	13·0	* 20·5
18	55·6	57·7	00·4	. . .	03·9	11·7	. . .	06·4	09·5	08·7	13·8	* 17·2
19	55·5	57·2	00·9	07·0	04·1	08·5	14·7	05·9	. . .	08·2	12·4	. . .
20	54·3	57·7	01·6	08·9	05·3	. . .	15·5	05·9	06·8	07·8	11·7	14·1
21	53·6	. . .	. . .	07·9	05·4	05·5	17·1	05·8	* 06·9	07·1	. . .	12·7
22	53·5	58·1	00·3	06·6	05·0	08·6	17·0	. . .	01·3	06·2	10·3	09·6
23	55·4	58·6	01·2	06·9	. . .	09·6	18·0	02·0	18 59·3	06·2	11·4	09·6
24	. . .	58·6	01·4	06·4	05·1	09·1	17·4	01·7	19 01·0	. . .	12·4	. . .
25	56·9	57·9	01·6	. . .	06·6	06·8	. . .	01·2	06·0	05·7	11·9	08·1
26	57·8	58·6	03·0	05·7	05·8	06·8	17·0	02·4	. . .	05·2	16·6	. . .
27	59·3	59·6	03·7	06·3	06·8	. . .	20·7	03·6	17·8	04·3	17·9	* 08·0
28	58·8	19 00·7	. . .	05·8	05·5	06·6	21·4	05·0	16·5	03·7	17·7	* 08·6
29	58·3	. . .	03·0	05·0	03·6	06·7	19·7	05·7	14·6	04·7	. . .	06·6
30	58·4	. . .	02·5	04·2	04·7	06·0	16·8	. . .	14·2	04·7	16·1	02·1
31	. . .	. . .	01·0	. . .	. . .	. . .	16·3	08·1	. . .	. . .	. . .	01·4

DIP: 3, Mean Hourly Values for each Month.

A. 1854.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	h m
Noon	18 47·5	19 01·6	19 00·3	18 50·9	18 53·0	18 57·6	18 57·1	18 54·7	18 50·3	18 44·0	18 38·9	18 27·9	4 12 P.M.
1	47·3	01·4	18 59·9	50·4	51·9	57·5	57·3	54·4	49·6	43·5	39·2	28·2	5 12 „
2	48·1	02·0	19 00·5	51·0	51·9	57·4	57·3	54·3	49·5	43·8	39·6	28·9	6 12 „
3	48·9	03·2	01·3	52·2	53·4	58·1	57·6	55·3	50·1	44·1	39·9	29·5	7 12 „
4	49·5	03·9	02·2	53·1	53·9	58·8	58·3	56·0	50·7	44·5	40·0	30·2	8 12 „
5	49·9	04·3	02·8	54·2	54·2	59·6	58·9	56·6	51·0	44·7	40·1	30·8	9 12 „
6	50·3	04·9	03·4	54·9	55·7	19 00·2	59·1	57·0	51·6	45·0	40·2	31·3	10 12 „
7	50·6	05·2	03·9	55·5	56·0	00·8	59·6	57·4	52·1	45·2	40·3	31·8	11 12 „
8	51·1	05·8	04·5	56·0	57·3	01·2	59·9	57·9	52·4	45·2	40·4	32·2	Midnight
9	51·5	06·2	04·9	56·4	58·2	01·4	19 00·1	58·2	52·6	45·3	40·5	32·2	1 12 A.M.
10	51·9	06·5	05·3	56·8	58·8	01·7	00·3	58·6	52·8	45·4	40·4	32·8	2 12 „
11	52·2	06·8	05·7	57·1	59·3	02·1	00·5	59·1	52·9	45·6	40·5	33·0	3 12 „
12	52·6	07·2	06·2	57·5	58·6	02·5	00·6	59·4	53·2	45·8	40·5	33·3	4 12 „
13	53·1	07·4	06·4	57·8	19 00·5	03·1	01·0	19 00·2	53·5	45·9	40·8	33·7	5 12 „
14	53·4	07·3	06·9	58·9	01·5	03·8	02·4	01·0	54·4	46·2	40·8	34·0	6 12 „
15	53·7	08·0	07·6	59·6	01·4	04·0	01·4	01·2	54·8	46·4	40·8	34·3	7 12 „
16	54·4	08·5	07·7	58·6	18 59·9	02·9	00·5	00·3	53·6	45·8	40·3	35·1	8 12 „
17	53·7	08·1	06·5	56·9	57·3	01·4	18 59·3	18 58·2	51·9	45·1	40·2	34·8	9 12 „
18	51·7	07·0	04·7	54·6	54·1	18 59·6	57·9	57·0	50·7	44·5	39·6	33·5	10 12 „
19	49·9	05·2	02·8	52·8	54·0	58·2	56·6	56·4	49·9	43·9	39·2	31·9	11 12 „
20	49·1	03·7	01·6	52·0	53·1	57·6	56·0	55·1	49·9	43·9	38·9	30·9	Noon
21	48·7	02·9	01·3	52·0	53·1	57·7	56·0	55·2	50·5	44·0	38·9	30·1	1 12 P.M.
22	48·2	02·4	01·3	51·7	53·0	57·5	56·2	55·0	50·6	44·8	38·8	29·3	2 12 „
23	46·5	01·9	00·7	51·5	51·5	57·8	56·4	54·8	49·0	44·7	38·6	28·6	3 12 „

DIP: 4, MEAN HOURLY VALUES FOR EACH MONTH.

B. 1855.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	h m
Noon	18 37·6	18 46·0	18 52·5	18 56·9	18 55·3	18 49·5	18 56·8	19 15·0	19 12·9	19 05·0	19 09·0	19 08·4	4 12 P.M.
1	37·6	46·0	51·9	56·5	55·3	49·5	56·4	15·0	12·0	05·0	08·9	08·6	5 12 „
2	38·5	47·3	52·3	57·2	55·7	49·8	56·5	15·2	11·8	05·7	09·9	09·5	6 12 „
3	39·5	47·6	53·5	58·0	56·8	50·4	56·5	15·7	12·8	06·5	10·7	10·0	7 12 „
4	40·0	48·3	54·2	58·8	57·8	51·1	56·7	15·9	13·9	07·1	11·2	10·7	8 12 „
5	40·7	48·6	54·7	59·4	58·6	52·0	56·7	16·4	14·1	07·8	11·7	11·2	9 12 „
6	41·2	49·0	55·4	19 00·0	59·3	52·6	56·9	16·8	14·7	08·2	12·1	11·8	10 12 „
7	41·9	49·4	55·8	00·7	59·9	53·0	57·1	16·9	15·1	08·7	12·6	12·2	11 12 „
8	42·0	50·2	56·3	01·1	19 00·3	53·6	57·0	17·1	15·2	09·1	13·1	12·6	Midnight
9	42·4	50·4	56·5	01·4	00·9	53·7	57·3	17·4	15·7	09·7	13·3	12·9	1 12 A.M.
10	42·9	50·8	56·9	01·8	01·5	53·8	57·2	17·6	16·0	09·9	13·5	13·2	2 12 „
11	43·2	50·8	57·3	02·1	01·9	54·0	57·3	17·8	15·6	10·2	13·7	13·5	3 12 „
12	43·5	51·1	57·7	02·5	02·2	54·3	57·4	17·9	16·6	11·6	14·2	13·9	4 12 „
13	43·9	51·4	58·0	03·0	02·9	54·7	57·3	18·2	17·0	10·7	14·6	14·0	5 12 „
14	44·2	51·8	58·7	04·0	03·9	55·6	57·5	18·8	17·7	11·1	14·9	14·2	6 12 „
15	44·6	52·1	59·2	04·3	03·8	55·4	57·5	18·9	18·2	11·7	15·4	14·8	7 12 „
16	46·3	53·1	58·8	02·8	02·0	54·5	57·4	18·2	16·6	10·8	15·5	15·0	8 12 „
17	45·7	52·4	57·2	01·1	18 59·9	52·5	57·2	17·0	14·4	09·6	14·3	13·7	9 12 „
18	44·2	50·9	55·2	18 58·9	57·6	51·0	57·2	16·1	12·9	07·6	12·5	11·9	10 12 „
19	42·3	49·0	53·6	57·2	56·6	49·9	56·7	15·7	12·4	06·3	11·6	10·8	11 12 „
20	40·6	47·9	53·0	56·7	55·9	49·5	56·6	15·7	12·4	06·1	11·2	10·7	Noon
21	39·5	47·2	52·9	57·0	55·8	49·5	56·7	15·8	12·7	06·5	10·9	10·6	1 12 P.M.
22	38·4	46·7	53·1	57·1	55·9	49·8	56·8	15·8	13·3	06·6	10·3	09·7	2 12 „
23	37·8	46·2	52·7	57·5	55·8	49·8	56·8	15·9	13·2	06·1	09·8	09·3	3 12 „

DIP: 4, Mean Hourly Values for each Month.

C. 1856.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	h m
Noon	19 07·7	19 18·9	19 13·8	19 16·2	19 18·2	19 12·4	19 08·1	19 06·1	19 01·2	19 03·2	19 12·1	19 00·7	4 12 P.M.
1	07·9	18·7	13·7	16·2	18·2	12·4	08·2	06·4	01·3	03·1	12·4	01·0	5 12 "
2	08·5	20·0	14·4	16·7	19·0	12·6	07·8	06·4	01·7	03·2	13·0	01·8	6 12 "
3	09·6	21·0	15·5	17·7	20·1	13·2	08·4	06·6	02·1	03·4	13·4	02·2	7 12 "
4	10·3	21·8	16·6	18·5	21·1	14·1	08·7	06·6	02·1	03·6	13·7	02·5	8 12 "
5	10·8	22·2	17·2	19·7	21·8	14·7	08·8	06·7	02·1	03·9	13·7	02·5	9 12 "
6	11·4	23·2	17·7	20·4	22·6	15·2	09·1	06·8	02·1	04·2	14·0	02·6	10 12 "
7	12·2	23·3	18·3	21·2	23·2	16·0	09·1	06·7	01·9	04·1	14·0	02·7	11 12 "
8	12·4	23·6	18·8	21·6	23·6	16·4	09·3	06·7	01·9	04·2	14·2	02·7	Midnight
9	12·8	24·0	19·4	22·0	24·0	16·4	09·3	06·5	02·2	04·3	14·5	02·7	1 12 A.M.
10	13·2	24·3	19·6	22·3	24·1	16·7	09·5	06·5	01·8	04·5	14·6	02·8	2 12 "
11	13·6	24·8	19·9	22·4	24·6	17·2	09·5	06·5	01·8	04·7	14·7	02·9	3 12 "
12	14·0	25·2	20·1	22·7	24·6	17·4	09·6	06·7	01·7	04·7	14·8	02·9	4 12 "
13	14·4	25·5	20·4	23·0	25·0	17·8	09·8	06·7	01·9	04·8	14·9	03·0	5 12 "
14	14·6	25·7	20·7	23·8	25·5	18·3	10·0	06·8	02·1	05·1	14·8	02·9	6 12 "
15	15·3	26·0	21·3	24·0	25·2	18·3	09·8	06·8	02·3	05·1	15·1	03·1	7 12 "
16	15·6	26·5	20·9	22·8	23·5	17·0	09·2	06·3	01·8	04·3	14·6	03·0	8 12 "
17	14·0	25·3	19·2	20·3	21·5	15·1	08·5	05·7	01·0	03·4	13·9	02·3	9 12 "
18	11·0	23·4	16·8	17·7	19·8	13·6	07·7	05·2	00·3	02·7	12·9	01·1	10 12 "
19	09·5	21·7	15·2	16·4	18·8	12·3	07·3	05·1	00·1	02·5	12·7	00·4	11 12 "
20	08·8	20·5	14·5	15·9	18·2	12·0	07·9	05·1	00·1	03·0	13·0	00·6	Noon
21	08·8	20·2	14·7	16·3	18·5	12·0	07·1	05·1	00·4	03·5	13·0	00·7	1 12 P.M.
22	08·5	19·8	14·5	16·3	18·6	12·6	07·2	05·3	00·6	04·0	12·7	00·5	2 12 "
23	08·3	19·3	14·2	16·0	18·4	12·3	07·5	05·9	01·1	04·1	12·5	00·7	3 12 "

DIP: 4, Mean Hourly Values for each Month.

D. 1857.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	h m
Noon	18 56·2	18 56·6	19 00·8	19 05·0	19 03·4	19 08·9	19 12·9	19 05·8	19 09·6	19 08·5	19 10·9	19 11·2	4 12 P.M.
1	56·3	56·7	00·7	04·9	03·4	08·9	12·7	05·8	09·4	08·6	11·2	11·7	5 12 ,,
2	56·9	57·4	01·2	05·3	03·2	08·7	12·7	05·8	09·6	08·6	11·7	12·2	6 12 ,,
3	57·3	57·8	01·6	05·5	04·0	09·0	12·9	06·2	10·0	09·0	12·4	12·5	7 12 ,,
4	57·6	58·3	01·7	05·8	04·0	09·3	13·3	06·6	10·3	09·0	12·6	12·6	8 12 ,,
5	58·0	58·4	02·3	06·2	04·2	09·6	13·4	07·0	10·3	09·3	12·9	12·9	9 12 ,,
6	58·0	58·5	02·4	06·4	04·4	09·8	13·7	07·3	10·4	09·1	13·4	13·0	10 12 ,,
7	58·0	58·8	02·9	06·5	04·3	09·8	13·8	07·6	10·4	09·1	13·4	13·2	11 12 ,,
8	58·1	59·0	02·9	06·4	04·9	09·9	14·0	07·7	10·4	09·0	13·2	12·9	Midnight
9	58·3	58·9	03·0	06·8	05·2	10·0	14·4	07·8	10·4	09·1	13·2	13·0	1 12 A.M.
10	58·4	59·0	03·3	07·1	05·4	10·2	14·5	08·0	10·5	08·9	13·3	12·9	2 12 ,,
11	58·6	59·1	03·5	07·1	05·3	10·3	14·8	08·2	10·5	09·0	13·3	13·0	3 12 ,,
12	58·7	59·3	03·7	07·3	05·4	10·7	15·0	08·4	10·6	09·0	13·5	13·1	4 12 ,,
13	58·6	59·5	03·7	07·5	05·7	10·9	15·4	08·7	10·7	09·1	13·6	13·2	5 12 ,,
14	58·8	59·5	03·8	07·6	06·5	11·3	15·3	09·2	10·9	09·0	13·6	13·2	6 12 ,,
15	59·1	19 00·0	03·9	08·1	06·2	10·5	15·4	09·1	11·3	09·0	13·7	13·6	7 12 ,,
16	59·2	00·2	03·1	06·2	03·2	09·6	14·5	08·0	10·6	08·3	13·1	13·4	8 12 ,,
17	58·5	18 59·3	02·0	04·4	03·0	08·5	13·4	06·3	09·6	07·9	12·0	12·3	9 12 ,,
18	56·7	57·9	00·5	03·6	02·0	07·4	12·2	05·2	08·9	07·3	10·9	11·4	10 12 ,,
19	55·1	56·5	18 59·8	02·8	01·4	06·7	11·8	04·4	08·6	07·0	10·2	10·0	11 12 ,,
20	54·7	55·7	59·8	03·1	01·7	06·8	11·8	04·2	08·8	07·2	10·5	10·4	Noon
21	54·7	55·6	19 00·2	03·8	02·4	07·1	12·0	04·3	09·0	07·6	11·0	11·5	1 12 P.M.
22	54·8	55·5	00·6	04·1	03·0	08·0	12·5	04·7	09·3	08·0	10·9	11·5	2 12 ,,
23	55·2	55·7	01·3	04·7	03·4	08·2	12·7	05·1	09·7	08·4	11·1	10·4	3 12 ,,

IV. VERTICAL INTENSITY.

VERTICAL INTENSITY: 1, Mean Yearly Values.

Year.	Absolute Vertical Intensity.	Year.	Absolute Vertical Intensity.
1847	2·627	1853	2·785
1848	2·603	1854	2·743
1849	2·707	1855	2·758
1850	2·790	1856	2·791
1851	2·751	1857	2·778
1852	2·731		

VERTICAL INTENSITY: 2, Mean Monthly Values.

Month.	English Units.				Month.	English Units.			
	1854.	1855.	1856.	1857.		1854.	1855.	1856.	1857.
January	2·740	2·701	2·792	2·751	September	2·736	2·793	2·764	2·786
February	2·776	2·722	2·821	2·753	October	2·719	2·778	2·768	2·781
March	2·771	2·740	2·806	2·767	November	2·719	2·790	2·798	2·791
April	2·747	2·751	2·811	2·775	December	2·686	2·790	2·767	2·793
May	2·751	2·750	2·817	2·774	Mean of Winter[1]	2·735	2·753	2·792	2·772
June	2·761	2·734	2·797	2·787	Mean of Summer[2]	2·751	2·762	2·791	2·783
July	2·757	2·746	2·782	2·798	Mean of the Year	2·743	2·758	2·791	2·778
August	2·753	2·796	2·776	2·782					

[1] Winter = { January, February, March, October, November, December.

[2] Summer = { April, May, June, July, August, September.

VERTICAL INTENSITY: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

A. 1854.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	2·732	2·765	2·771	. . .	2·750	2·770	. . .	2·750	2·761	2·741	2·735	2·701
2	*2·734	2·771	2·772	2·755	2·756	2·768	2·772	2·743	. . .	2·739	2·733	. . .
3	2·739	2·770	2·769	2·755	2·758	. . .	2·768	2·745	2·772	2·736	2·722	2·689
4	2·740	. . .	. . .	2·751	2·756	2·766	2·766	2·749	2·758	2·726	. . .	2·681
5	2·733	2·773	2·765	2·748	2·756	2·780	2·763	. . .	2·734	2·725	2·704	2·680
6	2·729	2·774	2·766	2·751	. . .	2·789	2·764	2·750	2·735	2·728	2·705	2·679
7	. . .	2·773	2·767	2·754	2·763	2·779	2·739	. . .	2·747	. . .	2·705	2·686
8	2·732	2·774	2·765	. . .	2·763	2·772	. . .	2·753	2·756	2·721	2·704	2·692
9	2·731	2·777	2·764	2·749	2·764	2·771	2·737	2·742	. . .	2·702	2·702	. . .
10	2·725	2·780	2·765	2·746	2·772	. . .	2·756	2·738	2·725	2·693	2·697	2·696
11	2·729	. . .	. . .	*2·767	2·763	2·734	2·746	2·742	*2·721	2·692	. . .	2·691
12	2·735	2·779	2·783	2·741	2·752	2·734	2·748	. . .	2·716	2·689	2·702	2·687
13	2·736	2·777	2·788	. . .	. . .	2·753	2·753	2·752	2·712	2·688	2·704	2·686
14	. . .	2·786	. . .	2·736	2·740	2·760	2·766	2·757	2·715	. . .	2·702	2·691
15	2·744	2·789	2·787	. . .	2·739	2·734	. . .	2·754	2·795	2·685	2·702	2·691
16	2·744	2·790	2·786	2·741	2·739	2·728	2·766	2·750	. . .	2·686	2·701	. . .
17	2·742	2·787	2·785	2·745	2·738	. . .	2·762	2·744	2·717	2·687	2·699	2·690
18	2·741	. . .	. . .	2·746	2·737	2·738	2·760	2·744	2·723	2·719	. . .	2·690
19	2·740	2·778	2·783	2·748	2·735	2·746	2·770	. . .	2·731	2·721	2·697	2·691
20	2·739	2·774	2·784	2·747	. . .	2·753	2·762	2·751	2·741	. . .	2·697	2·694
21	. . .	2·776	2·782	2·748	2·735	2·765	2·760	2·750	2·746	. . .	2·697	2·693
22	2·742	2·778	2·773	. . .	2·726	2·763	. . .	2·755	2·756	2·715	2·696	2·692
23	2·755	2·776	2·767	2·745	. . .	2·761	2·757	2·788	. . .	2·750	2·698	. . .
24	2·750	2·773	2·767	2·749	2·739	. . .	2·765	2·756	2·754	2·749	2·713	. . .
25	2·748	2·770	. . .	2·747	2·742	2·766	2·752	2·754	2·759	2·746	2·710	2·682
26	2·747	. . .	2·756	2·744	2·745	2·767	2·740	2·756	2·753	2·742	. . .	2·676
27	2·744	2·765	2·754	2·748	2·751	2·771	2·751	. . .	2·734	2·730	2·729	2·676
28	. . .	2·764	*2·757	2·752	. . .	2·772	2·745	2·758	2·731	. . .	2·727	2·675
29	2·746	. . .	2·757	. . .	2·743	2·785	. . .	2·770	2·729	2·729	2·707	2·672
30	2·749	. . .	2·759	2·745	2·750	2·768	2·751	2·775	. . .	2·729	2·700	. . .
31	2·756	. . .	2·761	. . .	2·751	. . .	2·757	2·764	. . .	2·733	. . .	2·675

* Abnormal day, or a day on which this element was disturbed.

VERTICAL INTENSITY: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

B. 1855.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	2·669	2·721	2·742	2·739	2·752	2·769	2·718	2·770	. . .	2·722	2·786	. . .
2	2·673	2·721	. . .	2·738	2·753	. . .	2·720	2·770	2·814	2·767	2·791	2·802
3	2·682	. . .	. . .	2·741	2·754	2·735	2·721	2·774	2·813	*2·765	. . .	2·802
4	2·680	2·723	2·738	*2·745	2·751	2·733	2·725	. . .	2·807	2·767	2·795	2·799
5	2·690	2·711	2·731	. . .	. . .	2·737	2·712	2·772	2·802	2·771	2·795	2·797
6	. . .	2·714	2·731	2·746	2·740	2·737	2·713	2·771	2·800	. . .	2·793	2·794
7	2·692	2·709	2·734	. . .	2·738	2·735	. . .	2·770	2·798	2·779	2·788	2·792
8	2·693	*2·709	2·737	2·750	2·737	2·734	2·717	2·770	. . .	2·779	2·780	. . .
9	2·688	2·712	2·749	2·746	2·735	. . .	2·717	2·770	2·796	2·780	. . .	2·780
10	2·691	. . .	. . .	2·744	2·735	2·729	2·721	2·771	2·802	2·782	. . .	2·778
11	2·700	2·715	2·745	2·741	2·739	2·734	2·732	. . .	2·799	2·786	2·777	2·778
12	2·700	2·716	*2·740	2·748	. . .	2·747	2·743	2·769	2·785	2·780	2·778	2·779
13	. . .	2·715	2·739	2·757	2·748	2·754	2·751	2·782	2·782	. . .	2·783	2·779
14	2·713	2·716	2·738	. . .	2·758	2·747	. . .	2·794	2·785	2·781	2·785	2·778
15	2·713	2·714	2·745	2·758	2·756	2·739	2·751	2·802	. . .	2·780	2·787	. . .
16	2·720	2·714	2·748	2·758	2·757	. . .	2·752	2·808	2·789	2·780	2·790	2·789
17	2·727	. . .	. . .	2·753	2·757	2·719	2·758	2·810	2·790	2·782	. . .	2·788
18	2·724	2·720	2·739	2·749	2·749	2·726	*2·761	. . .	2·792	*2·779	2·790	2·786
19	2·713	2·724	2·738	2·744	. . .	2·738	*2·759	2·822	2·787	*2·772	2·792	2·786
20	. . .	2·723	2·744	2·748	2·748	2·744	*2·764	2·821	2·790	. . .	2·791	2·787
21	2·698	2·726	2·746	. . .	2·749	2·734	. . .	2·816	2·795	2·767	2·789	2·789
22	2·694	2·730	2·745	2·756	2·746	2·733	2·774	2·819	. . .	2·773	2·790	. . .
23	2·690	2·734	2·740	2·759	. . .	. . .	2·775	2·814	2·787	2·776	2·792	2·791
24	2·693	2·736	. . .	2·762	2·749	2·711	2·775	2·816	2·787	2·780	2·793	. . .
25	2·698	. . .	2·738	2·760	2·751	2·714	2·774	. . .	2·791	2·774	. . .	2·795
26	2·700	2·736	2·738	2·758	2·753	2·723	2·772	. . .	2·788	2·773	2·791	2·795
27	. . .	2·736	2·736	2·761	*2·759	2·725	2·771	2·813	*2·786	. . .	2·793	2·798
28	2·715	2·739	2·737	. . .	. . .	2·721	. . .	2·814	2·784	2·777	2·795	2·800
29	2·720	. . .	2·741	2·755	2·765	2·724	2·771	2·812	. . .	2·779	2·798	. . .
30	2·720	. . .	2·742	2·754	2·768	. . .	2·771	2·820	2·776	2·781	2·799	*2·796
31	2·718	. . .	. . .	. . .	2·769	. . .	2·770	2·833	. . .	2·783	. . .	2·795

VERTICAL INTENSITY: 3, MEAN DAILY VALUES,

for each Day of Göttingen Mean Time.

C. 1856.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	2·785	2·816	. . .	2·810	2·809	. . .	2·816	2·782	2·769	2·754	. . .	2·785
2	2·787	. . .	2·820	2·811	2·809	2·826	2·813	. . .	2·767	2·753	2·804	2·784
3	2·786	2·819	2·818	2·809	. . .	2·823	2·796	2·782	2·767	2·750	2·804	2·784
4	2·788	2·823	2·815	2·810	2·810	2·812	2·785	2·778	2·766	. . .	2·800	2·781
5	2·791	2·824	2·814	. . .	2·810	2·806	. . .	2·778	2·765	2·747	2·797	2·779
6	. . .	2·818	2·809	2·808	2·814	2·800	2·771	2·778	. . .	2·745	2·796	. . .
7	2·787	2·818	2·819	2·809	2·813	. . .	2·762	2·776	2·764	2·745	2·791	2·779
8	2·784	2·818	. . .	2·807	2·814	2·802	2·759	2·776	2·764	2·745	. . .	2·781
9	2·788	. . .	2·801	2·803	2·815	2·809	2·768	. . .	2·763	2·745	2·794	2·782
10	2·788	2·819	2·800	2·804	. . .	2·793	2·769	2·774	2·762	2·744	2·798	2·780
11	2·785	2·818	2·798	2·802	2·820	2·778	2·775	2·774	2·762	. . .	2·800	2·776
12	. . .	2·816	2·799	. . .	2·818	2·768	. . .	2·774	2·763	*2·743	2·801	2·773
13	2·789	3·819	2·792	2·805	2·818	2·771	2·774	2·772	. . .	2·744	2·804	. . .
14	2·790	2·821	2·791	2·806	2·819	. . .	2·784	. . .	2·761	2·744	2·802	2·767
15	2·791	2·822	. . .	2·803	2·820	2·781	2·779	2·773	2·762	2·743	. . .	2·768
16	2·792	. . .	2·790	2·808	2·820	2·786	2·773	. . .	2·761	2·744	2·801	2·770
17	2·790	2·820	2·790	2·812	. . .	2·785	2·775	2·778	2·759	2·748	2·801	2·766
18	2·796	2·819	2·795	2·814	2·825	2·781	2·780	2·778	2·757	. . .	2·800	2·765
19	. . .	2·815	2·805	. . .	2·824	2·780	. . .	2·777	2·757	2·767	2·799	2·765
20	2·789	2·816	. . .	2·820	2·820	2·783	2·781	2·777	. . .	2·779	2·800	. . .
21	2·796	2·818	. . .	2·823	2·822	. . .	2·787	2·776	2·770	2·786	2·799	2·762
22	2·793	2·820	. . .	2·821	2·813	2·792	2·781	2·775	2·769	2·791	. . .	2·757
23	2·795	2·829	2·809	2·818	. . .	2·794	2·783	. . .	2·764	2·794	2·797	2·756
24	2·793	. . .	2·810	2·812	. . .	2·805	2·786	*2·774	2·761	2·797	2·796	2·756
25	2·795	2·829	2·814	2·810	2·812	2·810	2·786	2·772	2·759	. . .	2·792	2·756
26	. . .	2·827	2·812	. . .	2·816	2·816	. . .	2·770	2·759	. . .	2·789	. . .
27	2·796	2·827	2·810	2·810	2·827	2·810	2·785	2·770	. . .	2·801	2·790	. . .
28	2·796	2·827	2·807	2·810	2·820	. . .	2·784	2·771	2·760	2·801	2·790	2·752
29	2·801	2·826	. . .	2·810	2·818	2·794	2·784	2·770	2·757	2·803	2·791	*2·748
30	2·802	. . .	2·812	2·810	2·817	2·802	2·783	2·770	2·755	2·805	. . .	2·744
31	2·811	. . .	2·815	. . .	2·821	. . .	2·782	. . .	. . .	. . .	. . .	2·742

VERTICAL INTENSITY: 3, Mean Daily Values,

for each Day of Göttingen Mean Time.

D. 1857.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1	2·770	2·750	. . .	2·765	2·774	2·781	2·781	. . .	2·789	2·793	2·786	2·807
2	2·765	2·748	2·762	2·767	. . .	2·788	2·780	2·798	2·790	2·792	2·785	2·806
3	. . .	2·746	2·762	2·771	2·770	2·786	2·781	2·793	*2·791	. . .	2·785	2·805
4	2·761	2·750	2·765	. . .	2·770	2·783	. . .	. . .	*2·789	2·793	2·791	2·803
5	2·761	2·753	2·766	2·776	2·769	2·783	2·785	2·795	. . .	2·791	2·786	. . .
6	2·762	2·752	2·765	2·776	2·770	. . .	2·786	2·796	2·786	2·791	2·784	2·802
7	2·758	. . .	. . .	2·776	*2·770	2·786	2·788	2·792	2·787	2·789	. . .	2·804
8	2·755	2·755	2·769	2·777	*2·768	2·787	2·788	. . .	2·790	2·788	2·783	2·803
9	2·751	2·754	2·769	. . .	. . .	2·790	2·785	2·790	2·790	2·787	2·784	2·802
10	. . .	2·747	. . .	2·780	2·768	2·790	2·785	2·790	2·793	. . .	2·785	2·802
11	2·745	2·748	2·769	. . .	2·769	2·795	. . .	2·787	2·789	2·787	2·787	2·802
12	2·744	2·749	2·769	2·780	2·768	2·793	2·789	2·780	. . .	2·785	2·789	. . .
13	2·746	2·751	2·772	2·779	2·770	. . .	2·795	2·777	2·789	2·785	2·789	2·796
14	2·748	. . .	. . .	2·777	2·774	2·792	2·800	. . .	2·788	2·785	. . .	2·795
15	2·745	2·754	2·770	2·777	2·777	2·793	2·802	. . .	2·783	2·785	2·788	2·795
16	2·743	2·753	2·770	2·775	. . .	2·793	2·803	2·784	2·784	. . .	2·789	*2·795
17	. . .	2·753	2·763	2·774	2·776	2·793	2·802	2·785	2·785	. . .	2·793	*2·798
18	2·745	2·753	2·762	. . .	2·776	2·794	. . .	2·781	2·784	2·780	2·794	*2·799
19	2·744	2·752	2·764	2·781	2·776	2·787	2·802	2·780	. . .	2·779	2·795	. . .
20	2·742	2·753	2·766	2·787	2·779	. . .	2·804	2·779	2·779	2·778	2·794	2·795
21	2·741	. . .	. . .	2·784	2·778	2·779	2·808	2·778	*2·774	2·776	. . .	2·792
22	2·741	2·755	2·762	2·781	2·777	2·784	2·811	. . .	2·762	2·774	2·791	2·785
23	2·744	2·756	2·766	2·782	. . .	2·788	2·807	2·767	2·757	2·773	2·792	2·783
24	. . .	2·757	2·766	2·780	2·779	2·787	2·808	2·767	2·761	. . .	2·792	. . .
25	2·747	2·756	2·766	. . .	2·782	2·782	. . .	2·767	2·776	2·772	2·793	2·782
26	2·749	2·757	2·770	2·779	2·781	2·781	2·806	2·770	. . .	2·771	2·805	. . .
27	2·753	2·758	2·772	2·779	2·782	. . .	2·816	2·773	2·807	2·769	2·808	*2·780
28	2·752	2·762	. . .	2·778	2·779	2·780	2·818	2·775	2·804	2·769	2·808	*2·780
29	2·751	. . .	2·769	2·776	2·775	2·780	2·813	2·777	2·800	2·768	. . .	2·779
30	2·752	. . .	2·768	2·775	2·776	2·779	2·807	. . .	2·795	2·767	2·806	2·770
31	. . .	. . .	2·766	. . .	. . .	. . .	2·805	2·783	. . .	. . .	. . .	2·769

VERTICAL INTENSITY: 4, MEAN HOURLY VALUES FOR EACH MONTH.

A. 1854.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
													h m
Noon	2·731	2·767	2·762	2·738	2·741	2·754	2·752	2·736	2·733	2·716	2·716	2·677	4 12 P.M.
1	2·730	2·766	2·761	2·736	2·740	2·754	2·752	2·735	2·731	2·715	2·717	2·677	5 12 ,,
2	2·733	2·767	2·762	2·737	2·739	2·753	2·753	2·735	2·730	2·715	2·717	2·677	6 12 ,,
3	2·734	2·770	2·764	2·740	2·742	2·755	2·753	2·737	2·731	2·715	2·717	2·680	7 12 ,,
4	2·735	2·772	2·766	2·742	2·745	2·757	2·754	2·739	2·733	2·716	2·718	2·682	8 12 ,,
5	2·736	2·773	2·768	2·745	2·747	2·759	2·756	2·740	2·734	2·717	2·719	2·683	9 12 ,,
6	2·738	2·774	2·770	2·747	2·750	2·761	2·757	2·742	2·736	2·718	2·719	2·685	10 12 ,,
7	2·738	2·776	2·771	2·749	2·752	2·762	2·758	2·743	2·737	2·718	2·719	2·686	11 12 ,,
8	2·740	2·777	2·773	2·750	2·754	2·763	2·759	2·744	2·738	2·719	2·720	2·687	Midnight
9	2·741	2·778	2·774	2·751	2·756	2·764	2·759	2·745	2·738	2·719	2·721	2·688	1 12 A.M.
10	2·742	2·780	2·775	2·752	2·758	2·765	2·760	2·746	2·739	2·719	2·720	2·689	2 12 ,,
11	2·743	2·780	2·776	2·754	2·759	2·768	2·761	2·747	2·740	2·720	2·721	2·690	3 12 ,,
12	2·744	2·781	2·777	2·755	2·760	2·769	2·761	2·748	2·740	2·721	2·721	2·690	4 12 ,,
13	2·746	2·782	2·775	2·756	2·762	2·770	2·762	2·750	2·741	2·721	2·721	2·692	5 12 ,,
14	2·747	2·783	2·779	2·758	2·765	2·773	2·764	2·752	2·744	2·722	2·721	2·693	6 12 ,,
15	2·747	2·784	2·781	2·760	2·765	2·773	2·763	2·753	2·743	2·723	2·722	2·694	7 12 ,,
16	2·751	2·786	2·783	2·758	2·762	2·771	6·762	2·751	2·737	2·722	2·723	2·696	8 12 ,,
17	2·749	2·786	2·781	2·754	2·754	2·768	2·759	2·746	2·738	2·721	2·722	2·696	9 12 ,,
18	2·745	2·784	2·770	2·749	2·752	2·764	2·757	2·744	2·736	2·720	2·721	2·693	10 12 ,,
19	2·740	2·779	2·772	2·748	2·749	2·761	2·754	2·742	2·734	2·719	2·720	2·689	11 12 ,,
20	2·738	2·776	2·769	2·742	2·747	2·759	2·752	2·739	2·734	2·718	2·719	2·687	Noon
21	2·737	2·773	2·767	2·742	2·747	2·759	2·751	2·739	2·735	2·718	2·718	2·684	1 12 P.M.
22	2·735	2·771	2·765	2·740	2·745	2·750	2·751	2·738	2·734	2·721	2·717	2·681	2 12 ,,
23	2·733	2·768	2·764	2·739	2·743	2·758	2·751	2·737	2·734	2·719	2·716	2·679	3 12 ,,

VERTICAL INTENSITY: 4, Mean Hourly Values for each Month.

B. 1855.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
Noon	2·691	2·714	2·732	2·743	2·740	2·722	2·744	2·793	2·788	2·769	2·781	2·781	h m 4 12 P.M.
1	2·690	2·713	2·732	2·741	2·740	2·726	2·744	2·792	2·786	2·769	2·780	2·781	5 12 „
2	2·692	2·714	2·731	2·743	2·740	2·727	2·744	2·792	2·785	2·770	2·782	2·783	6 12 „
3	2·694	2·716	2·734	2·745	2·743	2·729	2·744	2·793	2·788	2·772	2·784	2·784	7 12 „
4	2·696	2·718	2·736	2·747	2·746	2·730	2·744	2·794	2·789	2·774	2·785	2·786	8 12 „
5	2·698	2·720	2·737	2·749	2·748	2·729	2·744	2·794	2·791	2·776	2·786	2·787	9 12 „
6	2·699	2·720	2·739	2·750	2·750	2·734	2·745	2·795	2·793	2·777	2·788	2·789	10 12 „
7	2·700	2·721	2·741	2·752	2·752	2·736	2·745	2·796	2·794	2·777	2·789	2·790	11 12 „
8	2·701	2·723	2·742	2·753	2·753	2·737	2·745	2·797	2·795	2·779	2·790	2·791	Midnight
9	2·703	2·724	2·742	2·754	2·755	2·738	2·746	2·797	2·796	2·781	2·791	2·792	1 12 A.M.
10	2·704	2·725	2·743	2·755	2·756	2·738	2·746	2·798	2·796	2·782	2·792	2·793	2 12 „
11	2·704	2·726	2·744	2·756	2·757	2·738	2·746	2·798	2·797	2·782	2·793	2·794	3 12 „
12	2·706	2·727	2·745	2·757	2·758	2·739	2·747	2·799	2·798	2·783	2·794	2·795	4 12 „
13	2·707	2·728	2·746	2·758	2·760	2·740	2·746	2·800	2·799	2·784	2·795	2·795	5 12 „
14	2·708	2·729	2·748	2·761	2·762	2·742	2·747	2·801	2·801	2·785	2·796	2·796	6 12 „
15	2·708	2·730	2·749	2·762	2·763	2·742	2·747	2·802	2·802	2·786	2·797	2·798	7 12 „
16	2·712	2·732	2·749	2·758	2·759	2·741	2·748	2·800	2·799	2·785	2·797	2·799	8 12 „
17	2·713	2·731	2·745	2·753	2·753	2·736	2·748	2·798	2·794	2·783	2·796	2·796	9 12 „
18	2·709	2·728	2·742	2·751	2·749	2·729	2·748	2·796	2·791	2·778	2·792	2·791	10 12 „
19	2·704	2·723	2·739	2·746	2·747	2·730	2·747	2·796	2·789	2·775	2·790	2·789	11 12 „
20	2·700	2·721	2·737	2·745	2·745	2·728	2·747	2·795	2·789	2·775	2·789	2·789	Noon
21	2·697	2·718	2·735	2·745	2·744	2·728	2·747	2·795	2·790	2·775	2·787	2·787	1 12 P.M.
22	2·694	2·717	2·735	2·745	2·743	2·728	2·747	2·795	2·791	2·773	2·785	2·786	2 12 „
23	2·692	2·715	2·734	2·745	2·742	2·728	2·746	2·795	2·790	2·773	2·783	2·784	3 12 „

VERTICAL INTENSITY: 4, Mean Hourly Values for each Month.

C. 1856.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
													h m
Noon	2·783	2·812	2·798	2·802	2·800	2·791	2·780	2·776	2·763	2·765	2·794	2·765	4 12 P.M.
1	2·782	2·811	2·797	2·801	2·808	2·791	2·780	2·776	2·763	2·765	2·794	2·764	5 12 „
2	2·784	2·813	2·798	2·802	2·808	2·791	2·780	2·775	2·763	2·764	2·795	2·765	6 12 „
3	2·786	2·815	2·780	2·804	2·812	2·792	2·780	2·775	2·763	2·764	2·795	2·765	7 12 „
4	2·788	2·817	2·802	2·806	2·814	2·794	2·780	2·775	2·763	2·764	2·795	2·766	8 12 „
5	2·780	2·818	2·804	2·809	2·816	2·795	2·781	2·775	2·763	2·766	2·796	2·766	9 12 „
6	2·791	2·820	2·805	2·811	2·818	2·797	2·781	2·775	2·763	2·766	2·796	2·766	10 12 „
7	2·792	2·821	2·807	2·813	2·820	2·799	2·782	2·775	2·764	2·767	2·797	2·767	11 12 „
8	2·793	2·822	2·808	2·814	2·821	2·800	2·782	2·775	2·764	2·767	2·797	2·767	Midnight
9	2·794	2·823	2·809	2·815	2·822	2·800	2·783	2·775	2·764	2·767	2·798	2·767	1 12 A.M.
10	2·795	2·824	2·810	2·816	2·822	2·801	2·783	2·775	2·763	2·768	2·798	2·767	2 12 „
11	2·796	2·825	2·811	2·817	2·824	2·802	2·783	2·775	2·763	2·768	2·799	2·768	3 12 „
12	2·797	2·826	2·812	2·818	2·824	2·803	2·784	2·775	2·763	2·769	2·799	2·768	4 12 „
13	2·798	2·827	2·813	2·818	2·824	2·804	2·784	2·776	2·764	2·769	2·799	2·769	5 12 „
14	2·799	2·828	2·814	2·820	2·826	2·806	2·785	2·776	2·764	2·769	2·800	2·769	6 12 „
15	2·801	2·830	2·815	2·821	2·826	2·806	2·785	2·776	2·764	2·770	2·801	2·769	7 12 „
16	2·803	2·831	2·816	2·820	2·823	2·800	2·784	2·776	2·765	2·770	2·801	2·771	8 12 „
17	2·800	2·830	2·813	2·815	2·815	2·800	2·783	2·776	2·764	2·769	2·800	2·770	9 12 „
18	2·794	2·826	2·808	2·810	2·816	2·797	2·782	2·776	2·764	2·768	2·799	2·768	10 12 „
19	2·790	2·823	2·805	2·806	2·813	2·794	2·782	2·776	2·763	2·768	2·799	2·767	11 12 „
20	2·788	2·819	2·803	2·805	2·812	2·794	2·781	2·776	2·763	2·769	2·800	2·767	Noon
21	2·788	2·818	2·802	2·805	2·812	2·793	2·781	2·776	2·763	2·770	2·798	2·767	1 12 P.M.
22	2·787	2·816	2·801	2·804	2·811	2·793	2·780	2·776	2·763	2·770	2·797	2·766	2 12 „
23	2·786	2·814	2·799	2·803	2·806	2·792	2·780	2·776	2·763	2·769	2·796	2·765	3 12 „

VERTICAL INTENSITY: 4, Mean Hourly Values for each Month.

D. 1857.

Göttingen Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Bombay Civil Time.
													h m
Noon	2·748	2·750	2·764	2·774	2·773	2·786	2·797	2·780	2·785	2·782	2·787	2·791	4 12 P.M.
1	2·748	2·750	2·763	2·772	2·772	2·785	2·796	2·779	2·784	2·781	2·787	2·792	5 12 „
2	2·748	2·750	2·764	2·772	2·771	2·784	2·795	2·778	2·784	2·780	2·788	2·792	6 12 „
3	2·749	2·750	2·764	2·772	2·770	2·785	2·795	2·779	2·784	2·780	2·789	2·792	7 12 „
4	2·750	2·751	2·764	2·773	2·772	2·785	2·796	2·780	2·785	2·780	2·790	2·792	8 12 „
5	2·750	2·752	2·766	2·774	2·773	2·785	2·796	2·781	2·785	2·780	2·790	2·792	9 12 „
6	2·751	2·752	2·766	2·774	2·773	2·786	2·797	2·782	2·785	2·781	2·791	2·793	10 12 „
7	2·751	2·753	2·767	2·775	2·774	2·787	2·797	2·783	2·785	2·781	2·791	2·793	11 12 „
8	2·751	2·753	2·767	2·775	2·775	2·787	2·798	2·783	2·785	2·781	2·791	2·793	Midnight
9	2·752	2·753	2·768	2·776	2·775	2·788	2·799	2·784	2·786	2·781	2·791	2·793	1 12 A.M
10	2·752	2·753	2·769	2·776	2·776	2·788	2·799	2·784	2·786	2·781	2·792	2·793	2 12 „
11	2·752	2·754	2·769	2·776	2·776	2·788	2·800	2·784	2·786	2·781	2·792	2·794	3 12 „
12	2·752	2·754	2·769	2·777	2·776	2·789	2·800	2·785	2·787	2·781	2·792	2·794	4 12 „
13	2·753	2·755	2·769	2·777	2·777	2·790	2·802	2·786	2·787	2·781	2·793	2·794	5 12 „
14	2·753	2·755	2·770	2·779	2·779	2·791	2·803	2·787	2·787	2·781	2·793	2·794	6 12 „
15	2·754	2·756	2·771	2·779	2·779	2·791	2·803	2·787	2·788	2·781	2·794	2·795	7 12 „
16	2·755	2·758	2·770	2·777	2·776	2·789	2·801	2·785	2·787	2·781	2·794	2·796	8 12 „
17	2·755	2·757	2·769	2·774	2·773	2·787	2·800	2·782	2·786	2·781	2·792	2·795	9 12 „
18	2·752	2·756	2·767	2·772	2·772	2·785	2·798	2·781	2·786	2·782	2·791	2·794	10 12 „
19	2·748	2·753	2·765	2·772	2·771	2·784	2·797	2·779	2·785	2·782	2·790	2·792	11 12 „
20	2·747	2·751	2·765	2·772	2·772	2·784	2·797	2·779	2·786	2·782	2·790	2·792	Noon
21	2·747	2·750	2·766	2·773	2·773	2·785	2·798	2·779	2·786	2·782	2·790	2·791	1 12 P.M.
22	2·747	2·749	2·766	2·774	2·774	2·785	2·798	2·780	2·786	2·782	2·789	2·791	2 12 „
23	2·747	2·749	2·765	2·774	2·774	2·785	2·797	2·779	2·786	2·782	2·789	2·790	3 12 „

V. TOTAL INTENSITY.

TOTAL INTENSITY: 1, Mean Yearly Values.

Year.	Total Intensity.	Year.	Total Intensity.
1847	8·368	1853	8·470
1848	8·355	1854	8·455
1849	8·400	1855	8·461
1850	. . .	1856	8·489
1851	8·429	1857	8·493
1852	8·450		

TOTAL INTENSITY: 2, Mean Monthly Values.

Month.	1854.	1855.	1856.	1857.	Month.	1854.	1855.	1856.	1857.
January	8·437	8·432	8·494	8·489	September	8·461	8·476	8·474	8·494
February	8·459	8·439	8·503	8·489	October	8·460	8·473	8·475	8·494
March	8·455	8·448	8·496	8·489	November	8·459	8·482	8·492	8·501
April	8·447	8·453	8·494	8·490	December	8·454	8·485	8·481	8·510
May	8·453	8·455	8·495	8·483	Mean of Winter[1]	8·453	8·460	8·490	8·495
June	8·462	8·453	8·487	8·493	Mean of Summer[2]	8·458	8·461	8·488	8·491
July	8·461	8·456	8·494	8·496	Mean of the Year	8·455	8·461	8·489	8·493
August	8·463	8·475	8·484	8·492					

[1] Winter = { January, February, March, October, November, December.

[2] Summer = { April, May, June, July, August, September.

TOTAL INTENSITY: 3, MEAN HOURLY VALUES FOR EACH YEAR.

Göttingen Mean Time.	Bombay[1] Civil Time.	Yearly Total Intensity.			
		1854.	1855.	1856.	1857.
	h m				
Noon	4 12 P.M.	8·452	8·458	8·489	8·494
1	5 12 „	8·451	8·456	8·487	8·491
2	6 12 „	8·451	8·455	8·484	8·489
3	7 12 „	8·450	8·455	8·484	8·488
4	8 12 „	8·451	8·456	8·483	8·488
5	9 12 „	8·451	8·456	8·484	8·487
6	10 12 „	8·452	8·457	8·484	8·488
7	11 12 „	8·453	8·458	8·484	8·488
8	Midnight	8·454	8·459	8·485	8·489
9	1 12 A.M.	8·454	8·459	8·486	8·490
10	2 12 „	8·455	8·459	8·486	8·490
11	3 12 „	8·456	8·460	8·486	8·490
12	4 12 „	8·456	8·461	8·487	8·490
13	5 12 „	8·457	8·461	8·487	8·490
14	6 12 „	8·457	8·462	8·489	8·491
15	7 12 „	8·458	8·463	8·489	8·492
16	8 12 „	8·459	8·464	8·493	8·495
17	9 12 „	8·461	8·466	8·498	8·499
18	10 12 „	8·462	8·466	8·501	8·502
19	11 12 „	8·462	8·467	8·502	8·504
20	Noon	8·461	8·465	8·500	8·504
21	1 12 P.M.	8·460	8·464	8·497	8·502
22	2 12 „	8·457	8·462	8·495	8·500
23	3 12 „	8·453	8·459	8·493	8·497

[1] In this, as in all the preceding tables "Midnight" and "Noon" is written for $0^h\ 12^m$ A.M., and $0^h\ 12^m$ P.M., in order more clearly to mark the divisions of day and night.

SECTION V.

MAGNETIC STATIONS.

A. INDIA.

GROUP I.

ASSÁM AND KHÁSSIA HILLS.

Dibrugárh.—Tēzpur.—Udelgúri.—Gohátti.—Chérra Púnji.

No. 1. Dibrugárh, in Upper Assám.

Latitude North.	Longitude East Green.	Height.
27° 32′ 0″	94° 57′ 35″	395 feet.

Under trees at a short distance from the left bank of the Brahmapútra, near the building called "namgárh". See p. 128.

Observer: Hermann.

DECLINATION.

1856, February 5, 5h 10m P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron 3.

	°	′
Magnetic meridian	261	33·5
True meridian (see p. 130)	260	47·1
Declination East	0	46·4

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*[1]

1856, February 6, 2^h P.M. local time.

Magnet vibrated { $L1$ / $L1$ with ring. Temp. { 20°·1 C., 68°·2 Fahr. / 20°·4 C., 68°·7 Fahr.

Chron. H, losing $0^s \cdot 2$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	400	220	Time of 1 vibration	2·814	7·518
Semiarc { beginning	129·5	132	q =	0·00020	0·00020
Semiarc { ending	49·5	110	μ =	0·00017	0·00017
Torsion (90°)	0′	0′	Time of 1 vibration corr. . .	2·821	7·587

$\log K_{,} = 0 \cdot 43858$ $\log K = 0 \cdot 43821$

$\log mX = 0 \cdot 53157$

B. *Deflection.*

1856, February 6, 1^h 30^m P.M. local time.

Magnets: Deflecting $L1$, deflected $H21$.

Deflection bar: $H2$. Distances: 1 foot. Temp.: 19°·1 C., 66°·4 Fahr.

1 foot.		1 foot.
u_0 = 6° 46′ 55″	Temp. of magnet	19°·1 C., 66°·4 Fahr.
μ = 0·00017	q =	0·00020

$$\log \frac{m}{X} = 8 \cdot 75489$$

$m = 0 \cdot 4398$ X = Horizontal Intensity = 7·733

2. Dip.

1856, February 5, 11^h A.M. local time.

Dip needle: No. 2. Temp: 16°·5 C., 61°·7 Fahr.

End A.

Face to instrument	38° 19′·1	Mean α = 38° 24′·4
Face reversed ...	38 29·7	

[1] In order to expose our standard chronometers as little as possible, we used for the vibration chronometers "H" and "A" by Dent, and 5 by Grant, their rate being referred, by comparison, to the standard chronometer. Compare p. 283.

End *B*.

Face to instrument	38° 39′·0	Mean β =	38° 35′·6
Face reversed . . .	38 32·2		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 38 30·0

Dip corrected for error of needle . . . . 38 30·35

3. VERTICAL INTENSITY . . . . 6·150

4. TOTAL INTENSITY . . . . 9·882

NO. 2. TÉZPUR, IN ASSÁM.

Latitude North.	Longitude East Green.	Height.
36° 34′ 35″	92° 46′ 45″	239 feet.

On alluvial soil, right bank of the Brahmapútra in the vicinity of the circuit bángalo. See p. 130.

Observer: Hermann.

DECLINATION.

1856, January 25, 8ʰ A.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

Magnetic meridian	278° 33′·8
True meridian (see p. 131)	278 11·3
Declination East	0 22·5

INTENSITY.

1. HORIZONTAL INTENSITY.

A. *Vibration*.

1856, January 28, 2ʰ 20ᵐ P.M. local time.

Magnet vibrated	*L* 1	Temp.	17°·3 C., 63°·1 Fahr.
	L 1 with ring.		17·6 C., 63·7 Fahr.

Chron. *H*, losing 0ˢ·2.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	600	160	Time of 1 vibration	2·804	7·535
Semiarc, beginning	170·5	155	q =	0·00020	0·00020
Semiarc, ending	140·5	120	μ =	0·00017	0·00017
Torsion (90°)	1′	1′	Time of 1 vibration corr.	2·813	7·559

$\log K_{,} = 0 \cdot 43937$ $\log K = 0 \cdot 43821$

$\log mX = 0 \cdot 53407.$

B. *Deflection.*

1856, January 28, $2^h\ 40^m$ P.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 2. Distances: 1 foot. Temp.: 17°·1 C., 62°·8 Fahr.

1 foot.	1 foot.
$u_0 = 6° \ 46' \ 50$	Temp. of magnet: 17°·8 C., 64°·0 Fahr.
$\mu = 0 \cdot 00017$	$q = 0 \cdot 00020$

$$\log \frac{m}{X} = 8 \cdot 75458$$

$m = 0 \cdot 4399$ X = Horizontal Intensity = 7·758

2. Dip.

1856, January 24, $4^h\ 20^m$ P.M. local time.

Dip needle: No. 2. Temp.: 16°·0 C., 60°·8 Fahr.

End *A*.

	° ′	
Face to instrument	37 0·5	Mean α = 37° 6′·25
Face reversed	37 12·0	

End *B*.

	° ′	
Face to instrument	37 18·3	Mean β = 37 22·9
Face reversed	37 27·5	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 37 14·58

Dip corrected for error of needle . . . . 37 14·93

3. Vertical Intensity . . . . 5·898

4. Total Intensity . . . . 9·746

No. 3. Udelgúri, in Assám.

Latitude North.	Longitude East Green.	Height.
26° 45′ 40″	91° 56′ 30″	352 feet.

In a house constructed of cane and bamboo, on alluvial soil. See p. 131.

Observer: Hermann.

DECLINATION.

1856, January 2, 4^h P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	358 13·2
True meridian (see p. 134)	355 36·9
Declination East	2 36·3

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, December 31, 3^h 5^m P.M. local time.

Magnet vibrated { *L* 1 ; *L* 1 with ring. Temp. { 19·7 C., 67·4 Fahr. ; 19·9 C., 67·8 Fahr.

Chron. *H*, losing 0^s·5.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	400	200	Time of 1 vibration . . .	2·809	7·532
Semiarc { beginning	179	155	q =	0·00020	0·00020
Semiarc { ending	7	120	μ =	0·00017	0·00017
Torsion (90°)	1′	1′	Time of 1 vibration corr.	2·818	7·553

log $K_{,}$ = 0·44182 log K = 0·43821

log mX = 0·53271

B. *Deflection.*

1856, January 4, 3^h 45^m P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 2. Distances: 1 foot, 1·33 foot. Temp.: 20°·0 C., 68°·0 Fahr.

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
u_0 =	6° 45′ 34″	2° 51′ 15″	Temp. of magnet:	20°·0 C.	19°·4 C.
μ =	0·00017	0·00017		68°·0 Fahr.	66°·9 Fahr.
			q =	0·00020	0 00020

$$\log \frac{m}{X} = 8·75521$$

m = 0·4405 X = Horizontal Intensity = 7·740

2. Dip.

1855, December 30, $2^h\ 30^m$ P.M. local time.

Dip needle: No. 2. Temp.: 21°·8 C., 71°·2 Fahr.

End *A*.

	° ′	
Face to instrument	36 21·8	Mean α = 36° 22′·2
Face reversed	36 22·6	

End *B*.

	° ′	
Face to instrument	36 28·0	Mean β = 36 32·4
Face reversed	36 36·8	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 36 27·30

Dip corrected for error of needle . . . . 36 27·65

This day is marked in the Bombay magnetic observations as an abnormal day, but with only a very light disturbance, scarcely amounting to 1′.

3. Vertical Intensity . . . . 5·653

4. Total Intensity . . . . 9·624

No. 4. Goháttí, in Assám.

Latitude North.	Longitude East Green.	Height.
26° 5′ 50″	91° 43′ 45″	134 feet.

On detritus resting on granitic subsoil, not far from Major Vetch's House. See p. 135.

Observer: Hermann.

DECLINATION.

a. 1855, December 14, $3^h\ 10^m$ P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	2 3·2
True meridian (see p. 139)	0 3·8
Declination East	1 59·4

b. By Prismatic Compass No. 6.

Meridian as obtained December 14, was marked by turning the telescope to a well defined object, the temple on Kamáikia Hill, and reading off the angular distance.—Prismatic Compass No. 6, by Troughton, gave:

Difference of the angular distance	. . . .	1° 54′·0
Correction of compass	. . . .	+ 2·0
Declination East, by compass 6 corrected	. . . . . .	1 56·0

c. 1856, November 19, 11^h 20^m P.M. local time. Troughton's needle.

In determining the longitude by lunar distances the needle in Troughton's theodolite was turned, so as to read 360°, when pointing to the magnetic north.

Meridian obtained by the Observations of Jupiter + 180	357° 55′·2
Declination East	2 4·8
Mean of the three series *a*, *b*, *c*:	
Declination East	2 0·1

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, December 12, 12^h 15^m P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring. Temp. { 19°·7 C., 67°·4 Fahr. / 19·9 C., 67·8 Fahr.

Chron. *H*, losing 0^s·4.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	500	500	Time of 1 vibration . . .	2·801	7·542
Semiarc { beginning	148·5	170	q =	0·00020	0·00020
Semiarc { ending	51·5	120	μ =	0·00017	0·00017
Torsion (90°)	0′	0′	Time of 1 vibration corr.	2·808	7·561

$\log K_{,} = 0\cdot43743$ $\log K = 0\cdot43821$

$\log mX = 0\cdot53557$

B. *Deflection.*

1855, December 11, 3^h 15^m P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 2. Distances: 1 foot, 1·33 foot. Temp.: 20°·0 C., 68°·0 Fahr.

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
u_0 =	6° 46′ 39″	2° 51′ 9″	Temp. of magnet . .	21·0 C.	20°·6 C.
μ =	0·00017	0·00017		69·8 Fahr.	69·1 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot75320$$

$m = 0\cdot4410$ X = Horizontal Intensity = 7·784

2. Dip.

1855, December 10, $4^h\ 30^m$ P.M. local time.
Dip needle: No. 2. Temp. 19°·8 C., 67°·6 Fahr.

End *A*.

	° ′	
Face to instrument	35 13·3	Mean α = 35° 10′·4
Face reversed . . .	35 7·5	

End *B*.

	° ′	
Face to instrument	35 27·4	Mean β = 35 27·2
Face reversed . . .	35 27·0	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 35 18·80

Dip corrected for error of needle . . . . 35 19·15

3. Vertical Intensity . . . . 5·513

4. Total Intensity . . . . 9·449

No. 5. Chérra Púnji, in the Khássia Hills.

Latitude North.	Longitude East Green.	Height.
25° 14′ 15″	91° 40′ 30″	4,164 feet.

On sandstone rocks, in an open place of the station. See p. 139.

Observer: Hermann.

DECLINATION.

a. 1855, November 14, $2^h\ 14^m$ P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	360 14·4
True meridian (see p. 144)	357 55·6
Declination East	2 18·8

b. For determining the declination with *Troughton's needle* and with *compass* No. 6, the angular distance between the meridian and a Khássia-Temple to the east of it was taken, and found to be 20° 58′·8. The means of the declination, thus obtained by repeated readings of the needle and bearings by the compass, were found:

Declination East . . . . 2° 22′·0

Mean of the two series: Declination East . . . 2 20·4

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, October 26, $2^h\ 5^m$ P.M. local time.

Magnet vibrated { L 1 / L 1 with ring. Temp. { 18°·8 C., 65°·8 Fahr. / 18°·6 C., 65°·5 Fahr.

Chron. H, losing $0^s \cdot 3$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	500	250	Time of 1 vibration	2 782	7·625
Semiarc, beginning	120	211	q =	0·00020	0·00020
Semiarc, ending	36·5	146·5	μ =	0·00017	0·00017
Torsion (90°)	0′	0′	Time of 1 vibration corr.	2·791	7·647

$\log K_{,} = 0 \cdot 41970$ $\log K = 0 \cdot 43821$

$\log mX = 0 \cdot 54105$

B. *Deflection.*

1855, October 28, $3^h\ 30^m$ P.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 2. Distances: 1 foot, 1·33 foot. Temp.: 21°·0 C., 69°·8 Fahr.

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
u_0 =	6° 42′ 17″	2° 49′ 27″	Temp. of magnet	20°·2 C.	20°·0 C.
μ =	0·00017	0·00017		68·4 Fahr.	68·0 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8 \cdot 74925$$

$m = 0 \cdot 4417$ X = Horizontal Intensity = 7·869

2. Dip.

1855, October 23, $9^h\ 10^m$ P.M. local time.

Dip needle: No. 1. Temp. 23°·2 C., 73°·8 Fahr.

End A.

	° ′
Face to instrument	33 41·9
Face reversed	34 1·6

Mean α = 33° 51′·75

End B.

	° ′
Face to instrument	33 13·0
Face reversed	33 20·6

Mean β = 33 16·8

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 33 34·28

Dip corrected for error of needle . . . . 33 37·27

3. Vertical Intensity . . . . 5·231

4. Total Intensity . . . . 9·449

GROUP II.

DELTA OF THE GANGES AND BRAHMAPÚTRA.

Surajgánj.—Dháka.—Kúlna.—Calcutta.

No. 6. Surajgánj, in Eastern Bengál.

Latitude North.	Longitude East Green.	Height.
24° 22′ 50″	89° 43′ 20″	L. a. L. S.[1] (20 feet.)

Observer: Hermann (see p. 144).

Dip.

1856, February 17, 3^h 50^m P.M. local time.

Dip needle: No. 2. Temp.: 27°·2 C., 81°·0 Fahr.

End *A*.

	° ′		
Face to instrument	31 54·1	Mean α =	31° 57′·3
Face reversed . . .	32 0·5		

End *B*.

	° ′		
Face to instrument	32 10·3	Mean β =	32 9·0
Face reversed . . .	32 7·7		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 32 3·15

Dip corrected for error of needle . . . . 32 3·50

No. 7. Dháka, in Eastern Bengál.

Latitude North.	Longitude East Green.	Height.
23° 42′ 44″	90° 20′ 15″	L. a. L. S.

On âlluvial clay soil, at a short distance from the landing Ghāt. See p. 144.

Observer: Hermann.

[1] L. a. L. S. = Little above the level of the sea.

DECLINATION.

1855, February 21, $1^h\ 10^m$ P.M. local time. Theodolite 3, and Needle Troughton; Chron. 3.

	° ′
Magnetic meridian	163 46·4
True meridian (see p. 145)	161 25·2
Declination East	2 21·2

INTENSITY.

Dip.

1856, February 21, 11^h A.M. local time.

Dip needle: No. 2. Temp.: 25°·2 C., 77°·4 Fahr.

End *A*.

	° ′	
Face to instrument	30 52·0	Mean α = 30° 55′·5
Face reversed . . .	30 59·0	

End *B*.

	° ′	
Face to instrument	31 5·0	Mean β = 31 6·25
Face reversed . . .	31 7·5	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 31 0·88

Dip corrected for error of needle . . . . 31 1·23

No. 8. Kúlna, in Eastern Bengál.

Latitude North.	Longitude East Green.	Height.
22° 45′ 55″	89° 36′ 55″	L. a. L. S.

Alluvial soil of the Ganges Delta. See p. 145.

Observer: Hermann.

DECLINATION.

1856, February 24, $12^h\ 30^m$ P.M. local time. Theodolite 3, and Needle Troughton; Chron. 3.

	° ′
Magnetic meridian	25 23·0
True meridian (see p. 146)	22 52·6
Declination East	2 30·4

INTENSITY.

Dip.

1856, February 24, $12^h\ 30^m$ P.M. local time.

Dip needle: No. 2. Temp.: 26°·8 C., 80°·2 Fahr.

End *A*.

Face to instrument	29° 0'·4	Mean α = 29° 13'·1
Face reversed . . .	29 25·8	

End *B*.

Face to instrument	29° 17'·2	Mean β = 29 23·9
Face reversed . . .	29 30·6	

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 29 18·50

Dip corrected for error of needle . . . . 29 18·85

No. 9. Calcutta, in Bengál.

Latitude North.	Longitude East Green.	Height.
22° 33′ 1″	88° 20′ 34″	L. a. L. S.

On alluvial soil, in the botanical garden, right bank of the Húgli. See p. 147.

Observer: Hermann.

FIRST SERIES.

DECLINATION.

1856, March 24, 1^h 30^m P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

Magnetic meridian	349° 16'·0
True meridian (see p. 148)	346 47·6
Declination East	2 28·4

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, March 22, 2^h 55^m P.M. without ring, 4^h 7^m P.M. with ring, local time.

Magnet vibrated { *L*1 / *L*1 with ring. Temp. { 31°·9 C., 89°·4 Fahr. / 31·1 C., 88·0 Fahr.

Chron. *H*, losing 0^s·5.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	600	80	Time of 1 vibration	2·762	7·489
Semiarc beginning	150	170	q =	0·00020	0·00020
Semiarc ending	30	120	μ =	0·00017	0·00017
Torsion (90°)	1′	1′	Time of 1 vibration corr.	2·763	7·454

$\log K_{,} = 0.43552$ $\log K = 0.43821$

$\log mX = 0.54961$

B. *Deflection.*

1856, March 23, $6^h\ 30^m$ P.M. local time.

Magnets: Deflecting $L1$, deflected $H21$.

Deflection bar: $H2$. Distances: 1 foot, 1·33 foot. Temp.: 30°·0 C., 86°·0 Fahr.

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
$u_0 =$	6° 24′ 48″	2° 41′ 58″	Temp. of magnet	29°·7 C.	29°·3 C.
$\mu =$	0·00017	0·00017		85·5 Fahr.	84·7 Fahr.
			$q =$	0·00020	0·00020

$$\log \frac{m}{X} = 8.73175$$

$m = 4372$ X = Horizontal Intensity = 8·108

2. Dip.

1856, March 23, $8^h\ 40^m$ P.M. local time.

Dip needle: No. 2. Temp.: 25°·7 C., 78°·3 Fahr.

End A.

	° ′	
Face to instrument	27 53·75	Mean α = 27° 56′·38
Face reversed . . .	27 59·0	

End B.

	° ′	
Face to instrument	28 14·25	Mean β = 28 16·38
Face reversed . . .	28 18·50	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 28 6·38

Dip corrected for error of needle . . . . 28 6·73

3. Vertical Intensity . . . . 4·335

4. Total Intensity . . . . 9·193

SECOND SERIES.

DECLINATION.

1857, April 13, $11^h\ 5^m$ A.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	209 34·0
True meridian (see p. 148)	207 12·1
Declination East	2 21·1
General mean of 1856 and 1857	2 25·1

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1857, April 12, 3^h 10^m P.M. without ring } local time.
" " 13, 4^h 0^m " with ring }

Magnet vibrated { *L*1 / *L*1 with ring. Temp. { 33°·6 C., 92°·4 Fahr. / 33·9 C., 93·1 Fahr.

Chron. *H*, losing $0^s·17$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	550	210	Time of 1 vibration	2·820	7·624
Semiarc { beginning	188	180	q =	0·00020	0·00020
Semiarc { ending	73	70	μ =	0·00017	0·00017
Torsion (90°)	9′	9′	Time of 1 vibration corr. . .	2·823	7·630

$\log K_{,} = 0·43334$ $\qquad \log K = 0·43821$

$\log mX = 0·53098$

B. *Deflection.*

1857, April 12, 5^h 0^m P.M. local time.

Magnets: Deflecting *L*1, deflected *H*21.

Deflection bar: *H*3. Distances: 1 foot, 1·3 foot. Temp.: 32°·0 C., 89°·6 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	6° 6′ 38″	2° 47′ 13″	Temp. of magnet	32°·0 C.	31°·6 C.
μ =	0·00017	0·00017		89·6 Fahr.	88·9 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·73059$$

$\log m = 0·4274$ $\qquad X$ = Horizontal Intensity = 7·947

2. Dip.

1857, April 12, 1^h 30^m P.M. local time.

Dip needle: No. 2. Temp.: 32°·3 C., 90°·1 Fahr.

End *A*.

Face to instrument	28° 30′·98	Mean α = 27° 25′·38
Face reversed . . .	28 21·0	

End *B*.

Face to instrument	28° 22′·63	Mean β =	28° 19′·19
Face reversed . . .	28 15·75		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 28 22·59

Dip corrected for error of needle . . . . 28 22·94

3. Vertical Intensity . . . . 4·247

4. Total Intensity . . . . 9·011

GROUP III.

VALLEY OF THE GANGES AND ITS TRIBUTARIES.

Rámpur Bólea.—Kissengánj (Bariadángi).—Pátna.—Sigáuli.—Benáres.—Lăkhnáu.—Aligárh.—Agra.—Mírăth.

No. 10. Rámpur Bólea, in Eastern Bengál.

Latitude North.	Longitude East Green.	Height.
24° 21′ 46″	88° 34′ 20″	54 feet.

On the left shore of the Ganges, a few feet above the level of the water. See p. 148.

Observer: Hermann.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, August 28, 5^h 30^m P.M. local time.[1]

Magnet vibrated: *L* 1. Temp.: 28°·3 C., 83°·0 Fahr.

Chron. *H*, losing 1^s·0.

	Without ring.		Without ring.
No. of vibrations	260	Time of 1 vibration	2·773
Semiarc { beginning	130	q =	0·00020
Semiarc { ending	81	μ =	0·00017
Torsion (90°)	6′	Time of 1 vibration corr. . .	2·778

log *K* = 0·43821 log *mX* = 0·54519

[1] Two days later, August 30, whilst detained by Lieutenant Adam's illness, a second series of vibrations was made, without and with ring, for determining K_r, which was found = 0·43830.

B. *Deflection.*

1855, August 28, 4^h 10^m P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 2. Distances: 1 foot. Temp.: 30°·2 C., 86°·4 Fahr.

1 foot.	1 foot.
u_0 = 6° 16′ 0″	Temp. of magnet 30°·2 C., 86°·4 Fahr.
μ = 0·00017	q = 0·00020

$$\log \frac{m}{X} = 8\cdot 89269$$

m = 0·5235 X = Horizontal Intensity = 6·703

2. Dip.

1855, August 28, 4^h 50^m P.M. local time.

Dip needle: No. 1. Temp.: 28°·9 C., 84°·0 Fahr.

End *A*.

	° ′	
Face to instrument	32 31 7	Mean α = 32° 33′·75
Face reversed . . .	32 35 8	

End *B*.

	° ′	
Face to instrument	31 17·4	Mean β = 31 21·8
Face reversed . . .	31 26·2	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 31 57·78

Dip corrected for error of needle . . . . 32 0·77

3. Vertical Intensity . . . . 6·203

4. Total Intensity . . . . 9·132

No. 11. Kissengánj, or Bariadángi, in Western Bengál.

Latitude North.	Longitude East Green.	Height.
26° 6′ 0″	87° 56′ 8″	140 feet.

On alluvial soil deposited by the Mahanádi river. See p. 149.

Observer: Hermann.

DECLINATION.

1855, August 18, 8^h 30^m P.M. local time. Theodolite 1 and Needle, Troughton; Chron. 3.

	° ′
Magnetic meridian	260 30·6
True meridian (see p. 149)	258 10·4
Declination East	2 20·2

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, August 18, 9^h 35^m A.M. without ring, 1^h 40^m P.M. with ring; local time.

Magnet vibrated { *L*1 / *L*1 with ring. Temp. { 26°·8 C., 80°·2 Fahr. / 27·6 C., 81·7 Fahr.

Chron. *H*, losing $0^s·6$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	500	190	Time of 1 vibration	2·779	7·443
Semiarc { beginning	140	160	q =	0·00020	0·00020
Semiarc { ending	70	101	μ =	0·00017	0·00017
Torsion (90°)	6′	6′	Time of 1 vibration corr. . .	2·785	7·457

$\log K_{,} = 0·44293$ $\log K = 0·43821$

$\log mX = 0·54289$

B. *Deflection.*

1855, August 18, 12^h 10^m P.M. local time.

Magnets: Deflecting *L*1, deflected *H*21.

Deflection bar: *H*2. Distances: 1 foot. Temp.: 27°·2 C., 81°·0 Fahr.

1 foot.	1 foot.
u_0 = 6° 15′ 50	Temp. of magnet 27°·2 C., 81°·0 Fahr.
μ = 0·00017	q = 0·00020

$$\log \frac{m}{X} = 8·89200$$

$m = 0·5217$ X = Horizontal Intensity = 6·690

2. Dip.

1855, August 17, $5^h\ 25^m$ P.M. local time.

Dip needle: No. 2. Temp.: 26°·5 C., 79°·7 Fahr.

End *A*.

	° ′	
Face to instrument	35 16·4	Mean α = 35° 17′·2
Face reversed . . .	35 18·0	

End *B*.

	° ′	
Face to instrument	35 9·0	Mean β = 35 6·0
Face reversed . . .	35 3·0	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 35 11·60

Dip corrected for error of needle . . . . 35 11·95

3. Vertical Intensity . . . . 4·719

4. Total Intensity . . . . 8·187

No. 12. Pátna, in Western Bengál.

Latitude North.	Longitude East Green.	Height.
25° 37′ 12″	85° 7′ 32″	170 feet.

On rich alluvial soil, in a garden. See p. 149.

Observer: Hermann.

FIRST SERIES.

DECLINATION.

1857, February 6, $11^h\ 10^m$ A.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	223 45·0
True meridian (see p. 150)	221 51·1
Declination East	1 53·9

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1857, February 7, $12^h\ 20^m$ P.M. without ring, $1^h\ 10^m$ P.M. with ring; local time.

Magnet vibrated { L 1 / L 1 with ring. Temp. { 23°·9 C., 75°·0 Fahr. / 24·6 C., 76·2 Fahr.

Chron. H, losing $0^s\cdot 2$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	270	200	Time of 1 vibration	2·844	7·660
Semiarc beginning	163	198	q =	0·00020	0·00020
Semiarc ending	77	136	μ =	0·00017	0·00017
Torsion (90°)	0′	0′	Time of 1 vibration corr.	2·850	7·674

$\log K_{,} = 0\cdot 43720$ $\log K = 0\cdot 43821$

$\log mX = 0\cdot 52285$

B. *Deflection.*

1857, February 7, 5^h 25^m P.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 3. Distances: 1 foot, 1·3 foot. Temp.: 25°·0 C., 77°·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	6° 25′ 37″	2° 56′ 21″	Temp. of magnet	24°·3 C.	24°·1 C.
μ =	0·00017	0·00017		75·8 Fahr.	75·4 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot 75436$$

$m = 0\cdot 4351$ X = Horizontal Intensity = 7·660

2. Dip.

1857, February 7, 3^h 30^m P.M. local time.

Dip needle: No. 2. Temp.: 26°·3 C., 79°·4 Fahr.

End A.

	° ′	
Face to instrument	33 31·25	Mean α = 33° 29′·44
Face reversed . . .	33 27·63	

End B.

	° ′	
Face to instrument	33 32·25	Mean β = 33 30·78
Face reversed . . .	33 29·31	

Mean of the dip $= \dfrac{\alpha + \beta}{2} =$ 33 30·11

Dip corrected for error of needle . . . . 33 30·46

3. Vertical Intensity . . . . 5·075

4. Total Intensity . . . . 9·187

SECOND SERIES.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1857, March 20, 2^h P.M. local time.

Magnet vibrated: L 1. Temp.: 28°·3 C., 83°·0 Fahr.

Chron. H, losing 0^s·6.

No. of vibrations	120	Time of 1 vibration	2·835
Semiarc { beginning	160	q =	0·00020
Semiarc { ending	140	μ =	0·00017
Torsion (90°)	0′	Time of 1 vibration corr.	2·837

log K = 0·43821 log mX = 0·52667

B. *Deflection.*

1857, March 20, 1^h 30^m P.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 3. Distances: 1 foot, 1·3 foot. Temp.: 27°·2 C., 81°·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	6° 28′ 34″	2° 57′ 2″	Temp. of magnet	26°·7 C.	27°·2 C.
μ =	0·00017	0·00017		80·0 Fahr.	81·0 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8 \cdot 75402$$

m = 0·4369 X = Horizontal Intensity = 7·697
Mean of the two series . . . = 7·678

2. Dip.

1857, March 23, 5^h 10^m P.M. local time.

Dip needle: No. 2. Temp.: 27°·3 C., 81°·2 Fahr.

End A.

	° ′	
Face to instrument	33 35·7	Mean α = 33° 38′·1
Face reversed . . .	33 40·5	

End *B*.

Face to instrument	33° 31'·3	Mean β =	33° 32'·1
Face reversed . . .	33 32·9		

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 33 35·10

Dip corrected for error of needle . . . . 33 35·45

General Mean . . . . 33 32·85

3. Vertical Intensity . . . . 5·095

4. Total Intensity . . . . 9·230

For approximatively determining the daily variation of the horizontal intensity, the deflection apparatus was observed March 21. Magnet $L_{\prime}$ was used as the deflecting one, at 1 foot distance.

One tenth of a minute was the unity read off from the scales, to which corresponded an absolute value in English units = 0·00090, as deduced from the preceding observations of deflection.

Increasing numbers denote an increase of the intensity. The time is local time for Pátna and for Bombay. The scale readings were: Pátna, 1857, March 21.

	6h 40m A.M.	10h A.M.	3h 30m P.M.	5h 10m P.M.
	302·8	310·2	309·0	308·9
Differences in scale readings	7·4		1·2	0·1
Differences in English units	+ 0·0068		− 0·0011	− 0·0001

Observations at Bombay, 1857, March 21, in English Units:

	6h 12m A.M.	10h 12m A.M.	3h 12m P.M.	5h 12m P.M.
	8·0181	8·0345	8·0290	No observation.
Differences	+ 0·0164		− 0·0055	

No. 13. Sigáuli, in Western Bengál.

Latitude North.	Longitude East Green.	Height.
26° 46′ 41″	84° 44′ 26″	260 feet.

Near Major Holmes' house; in a fine garden. See p. 151.

Observer: Hermann.

Dip.

1857, February 16. 2h 55m P.M. local time.

Dip needle: No. 2. Temp.: 27°·6 C., 81°·7 Fahr.

End *A*.

Face to instrument	35° 46'·4	Mean α = 35° 44'·6
Face reversed . . .	35 42·8	

End *B*.

Face to instrument	35° 33'·7	Mean β = 35 34·9
Face reversed . . .	35 36·1	

Mean of the dip $\frac{\alpha + \beta}{2}$ = 35 39·75

Dip corrected for error of needle . . . . 35 40·10

No. 14. Benáres, in Hindostán (N. W. Prov.)

Latitude North.	Longitude East Green.	Height.
25° 18′ 26″	82° 59′ 47″	325 feet.

In a garden not far from the English church, on alluvial soil. See p. 151.

Observer: Hermann.

DECLINATION.

1856, April 4, 4^h 30^m P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

Magnetic meridian	102° 52'·2
True meridian (see p. 152)	101 1·9
Declination East	1 50·3

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, April 3, 5^h 50^m P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring. Temp. { 37°·1 C., 98°·7 Fahr. / 36·8 C., 98·2 Fahr.

Chron. *H*, losing 0^s·8.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	300	160	Time of 1 vibration . .	2·801	7·565
Semiarc { beginning	180	220	q =	0·00020	0·00020
Semiarc { ending	80	140	μ =	0·00017	0·00017
Torsion (90°)	1′	1′	Time of 1 vibration corr.	2·799	7·561

log $K_{,}$ = 0·43415 log K = 43821

log mX = 0·53843

B. *Deflection.*

1856, April 3, $4^h\ 20^m$ P.M. local time.

Magnets: Deflecting $L\,1$, deflected $H21$.

Deflection bar: $H\,3$. Distances: 1 foot. Temp.: 38°·6 C., 101°·5 Fahr.

$u_0 = 6°\ 46'\ 40''$	Temp. of magnet 38°·0 C., 100°·4 Fahr.
$\mu = 0{\cdot}00017$	$q = 0{\cdot}00020$

$$\log \frac{m}{X} = 8{\cdot}75179$$

$m = 0{\cdot}4417$ X = Horizontal Intensity = 7·822

2. Dip.

1856, April 3, $12^h\ 20^m$ P.M. local time.

Dip needle employed: No. 2. Temp.: 37°·9 C., 100°·2 Fahr.

End *A*.

	° ′	
Face to instrument	32 41·2	Mean α = 32° 35′·0
Face reversed . . .	32 28·8	

End *B*.

	° ′	
Face to instrument	32 53·6	Mean β = 32 46·8
Face reversed . . .	32 40·0	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 32 40·90

Dip corrected for error of needle = 32 41·25

3. Vertical Intensity . . . . 5·020

4. Total Intensity . . . . 9·294

No. 15. Lăkhnáu, in Audh.

Latitude North.	Longitude East Green.	Height.
26° 51′ 10″	80° 55′ 32″	520 feet.

In a garden, on alluvial soil, not far from the Resident's (then General Outram's) house. See p. 152.

Observer: Hermann.

DECLINATION.

1856, April 9, $8^h\ 30^m$ A.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	324 6·8
True meridian (see p. 153)	321 29·4
Declination East	2 37·4

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, April 9, $7^h\ 10^m$ A.M. local time.

Magnet vibrated { L 1 / L 1 with ring. Temp. { 30°·9 C., 87°·6 Fahr. / 31°·9 C., 89°·5 Fahr.

Chron. H, losing $1^s\cdot3$.

	Without ring.	With ring.
No. of vibrations	400	160
Semiarc { beginning	130	230
Semiarc { ending	43	66
Torsion (90°)	1′	1′

	Without ring.	With ring.
Time of 1 vibration . . .	2·819	7·615
q =	0·00020	0·00020
μ =	0·00017	0·00017
Time of 1 vibration corr.	2·822	7·607

$\log K_{,} = 0\cdot43471$ $\log K = 43821$

$\log mX = 0\cdot53151$

B. *Deflection.*

1856, April 9, 9^h A.M. local time.

Magnets: Deflecting L 1, deflected H 21

Deflection bar: H 3. Distances: 1 foot. Temp.: 31°·5 C., 88°·7 Fahr.

1 foot.	1 foot.
$u_0 = 6°\ 7'\ 0''$	Temp. of magnet 33°·0 C., 91°·4 Fahr.
$\mu = 0\cdot00017$	$q = 0\cdot00020$

$$\log \frac{m}{X} = 8\cdot70644$$

$m = 0\cdot4159$ X = Horizontal Intensity = 8·176

2. Dip.

1856, April 9, $3^h\ 35^m$ P.M. local time.

Dip needle: No. 2. Temp.: 34°·3 C., 93°·7 Fahr.

End A.

	° ′	
Face to instrument	35 26·1	Mean α = 35° 22′·15
Face reversed . . .	35 18·2	

End B.

	° ′	
Face to instrument	35 5·0	Mean β = 35 14·25
Face reversed . . .	35 23·5	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 35 18·20

Dip corrected for error of needle . . . . 35 18·55

3. VERTICAL INTENSITY . . . . 5·789

4. TOTAL INTENSITY . . . . 10·019

No. 16. ALIGÁRH, IN HINDOSTÁN (N.W. PROV.).

Latitude North.	Longitude East Green.	Height.
27° 53′ 50″	78° 3′ 55″	760 feet.

On alluvial soil, in a garden. See p. 153.

Observer: Hermann.

DECLINATION.

1856, January 18, 6^h P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	254 31·1
True meridian, fixed by a mark of Mr. Gubbins' (see p. 153)	252 53·8
Declination East	1 37·3

DIP.

1857, January 18, $11^h\ 35^m$ A.M. local time.

Dip needle: No. 2. Temp.: 21°·6 C., 70°·9 Fahr.

End *A*.

	° ′	
Face to instrument .	37 2·3	Mean α = 37° 3′·8
Face reversed	37 5·3	

End *B*.

	° ′	
Face to instrument .	37 0·8	Mean β = 36 53·3
Face reversed	36 45·8	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 36 58·55

Dip corrected for error of needle . . . . 36 58·90

No. 17. ÁGRA, IN HINDOSTÁN (N.W. PROV.).

Latitude North.	Longitude East Green.	Height.
27° 10′ 26″	78° 1′ 39″	657 feet.

On a thick stratum of alluvial soil. The instruments were put up not far from the Chief Engineer's (General Boileau's) office. See p. 154.

Observer: Hermann.

DECLINATION.

1856, April 15, 2h 10m P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	101 22·9
True meridian (see p. 153)	100 2·9
Declination East	1 20·0

No. 18. Míråth, in Hindostán (N.W. Prov.).

Latitude North.	Longitude East Green.	Height.
29° 0′ 41″	77° 41′ 48″	865 feet.

On alluvial soil, near the central part of the station. See p. 154.

Observer: Hermann.

DECLINATION.

1856, April 18, 4h 30m P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	251 58·5
True meridian, from Mr. Gubbins' meridian marks (see p. 154)	250 10·1
Declination East	1 48·4

GROUP IV.

PĂNJÁB, SINDH, AND KĂCH.

Ambála.—Lahór.—Raulpíndi.—Pesháur.—Sháhpur.—Déra Ismáel Khan.—Multán.—Shikárpur.—Sévan.—Kărráchi.—Bhŭj.—Rajkót.

No. 19. Ambála, in Sărhínd (Pănjáb).

Latitude North.	Longitude East Green.	Height.
30° 21′ 25″	76° 48′ 49″	1,026 feet.

On alluvial soil, with much kánker, but no boulders. See p. 154.

Observer: Hermann.

DECLINATION.

857, January 15, $11^h\ 38^m$ A.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	8 30·5
True meridian (see p. 155)	6 4·3
Declination East	2 26·2

DIP.

1857, January 16, $9^h\ 45^m$ A.M. local time.

Dip needle: No. 2. Temp.: 18°·6 C., 65°·5 Fahr.

End *A*.

	° ′	
Face to instrument	40 52·0	Mean α = 40° 54′·8
Face reversed . . .	40 57·6	

End *B*.

	° ′	
Face to instrument	40 38·0	Mean β = 40 41·3
Face reversed . . .	40 44·6	

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 40 48·05

Dip corrected for error of needle . . . . 40 48·40

No. 20. LAHÓR, IN THE PĀNJÁB.

Latitude North.	Longitude East Green.	Height.
31° 34′ 5″	74° 14′ 37″	790 feet.

Near the Company's garden, clayey soil, but cultivated. See p. 156.

Observer: Hermann.

DECLINATION.

1857, January 7, $4^h\ 30^m$ P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	2 8·3
True meridian (see p. 156)	0 6·0
Declination East	2 2·3

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1857, January 6, $4^h\ 50^m$ P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring   Temp. { 20°·1 C., 68°·2 Fahr. / 19·8 C., 67·7 Fahr.

Chron. *H*, losing 1^s·0.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	559	290	Time of 1 vibration	2·949	7·943
Semiarc { beginning	80	60	q =	0·00020	0·00020
Semiarc { ending	10	30	μ =	0·00017	0·00017
Torsion (90°)	7′	7′	Time of 1 vibration corr.	2·959	7·970

log $K_{,}$ = 0·43696   log K = 0·43821

log mX = 0·49021.

B. *Deflection.*

1857, January 7, $10^h\ 45^m$ A.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 3. Distances: 1 foot, 1·3 foot. Temp. { 12°·8 C., 55°·0 Fahr. / 13·3 C., 55·9 Fahr.

	1 foot.	1·3 foot.		1·3 foot.	1·3 foot.
u_0 =	6° 57′ 39″	3° 9′ 23″	Temp. of magnet . . .	13°·3 C.	13°·9 C.
μ =	0·00017	0·00017		56·0 Fahr.	57·0 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot77863$$

m = 0·4309 X = Horizontal Intensity = 7·175

2. Dip.

1857, January 6, $3^h\ 25^m$ P.M. local time.

Dip needle: No. 2. Temp.: 20°·6 C., 69°·1 Fahr.

End *A*.

Face to instrument	43° 19′·65	Mean α = 43° 20′·45
Face reversed . . .	43 21·25	

End *B*.

	° ′	
Face to instrument	43 14·15	Mean β = 43° 13′·73
Face reversed . . .	43 13·30	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 43 17·09

Dip corrected for error of needle . . . . 43 17·44

3. Vertical Intensity . . . . 6·758

4. Total Intensity . . . . 9·856

No. 21. Raulpíndi, in the Pănjáb.

Latitude North.	Longitude East Green.	Height.
33° 36′ 30″	72° 59′ 49″	1,674 feet.

On hard soil, with numerous strata of conglomerates. See p. 156.

Observers: Adolphe and Robert.

DECLINATION.

1856, December 2, 3^h 10^m P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	214 42·5
True meridian (see p. 161)	211 37·0
Declination East	3 5·5

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, December 3, 2^h 5^m P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring   Temp: { 19°·1 C., 66°·4 Fahr. / 19·6 C., 67·2 Fahr.

Chron. *H*, losing 0^s·8.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	600	420	Time of 1 vibration	2^s·999	8^s·068
Semiarc beginning	117·5	152·5	q =	0·00020	0·00020
Semiarc ending	35	130·5	μ =	0·00017	0·00017
Torsion (90°)	0′	0′	Time of 1 vibration corr. . .	3^s·007	8^s·090

log $K_{,}$ = 0·43821   log K = 0·43821

log mX = 0·47615

B. *Deflection.*

1856, December 5, $4^h\ 15^m$ P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 3. Distances: 1 foot, 1·3 foot. Temp. { 16°·0 C., 60°·8 Fahr. / 15·8 C., 60·4 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	7° 18′ 49″	3° 18′ 52″	Temp. of magnet	16°·0 C.	15°·8 C.
μ =	0·00017	0·00017		60·8 Fahr.	60·4 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8 \cdot 79984$$

$m = 0 \cdot 4345$ X = Horizontal Intensity = 6·889

2. Dip.

1856, December 6, $1^h\ 30^m$ P.M. local time.

Dip needle: No. 2. Temp.: 15°·6 C., 60°·1 Fahr.

End *A*.

	° ′	
Face to instrument	46 9·67	Mean α = 46° 2′·44
Face reversed . . .	45 55·20	

End *B*.

	° ′	
Face to instrument	45 49·69	Mean β = 45 48·27
Face reversed . . .	45 46·85	

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 45 55·36

Dip corrected for error of needle . . . . 45 55·71

3. Vertical Intensity . . . . 7·115

4. Total Intensity . . . . 9·904

No. 22. Pesháur, in the Pánjáb.

Latitude North.	Longitude East Green.	Height.
34° 3′ 10″	71° 33′ 19″	1,250 feet.

On alluvial soil, deposited by the Himálayan rivers. See p. 162.

Observer: Adolphe.

DECLINATION.

1856, December 22, 5^h 30^m P.M. local time. Collimator 2; Theodolite 3, Troughton; Chron. 1.

Magnetic meridian	293° 24′·7
True meridian (see p. 164)	290 56·8
Declination East	2 27·9

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, December 23, 4^h 30^m P.M. local time.

Magnet vibrated: *B* 7 [1] Temp. { 15°·0 C., 59°·0 Fahr. / 13·4 C., 56·1 Fahr.

Chron. *A*, losing $4^s·8$.

	Without ring.		Without ring.
No. of vibrations	150	Time of 1 vibration	$3^s·321$
Semiarc beginning	181·5	q =	0·00021
Semiarc ending	169·5	μ =	0·00017
Torsion (90°)	6′	Time of 1 vibration corr.	$3^s·303$

$\log K = 0·26891$ $\log mX = 0·22063$

B. *Deflection.*

1556, December 23, 10^h 30^m A.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 14°·4 C., 58°·0 Fahr. / 16·1 C., 61·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 23′ 55″	1° 33′ 6″	Temp. of magnet	14°·6 C.	16°·7 C.
μ =	0·00017	0·00017		58·2 Fahr.	62·0 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·47465$$

$m = 0·2226$ X = Horizontal Intensity = 7·464

[1] Like ourselves, Adolphe frequently made observations for determining the value of *K*. We, however, cannot make use of these observations, as his inertia rings have been lost together with his other instruments. Compare p. 285, where the data which we adopt for his *K* are detailed.

2. Dip.

1856, December 22, 5^h P.M. local time.

Dip needle: No. 3. Temp.: 16°·6 C., 61°·9 Fahr.

End *A*.

	°	′		°	′
Face to instrument	47	7·0	Mean α =	47	7·75
Face reversed . . .	47	8·5			

End *B*.

	°	′		°	′
Face to instrument	45	46·5	Mean β =	45	45·5
Face reversed . . .	45	44·5			

Mean of the dip $= \dfrac{\alpha + \beta}{2} =$ 46 26·63

Dip corrected for error of needle . . . . 46 25·75

3. Vertical Intensity . . . . 7·845

4. Total Intensity . . . . 10·830

VARIATIONS.

A. *Declination.*

The declination was observed from December 24, 1856, to January 19, 1857 (needle *B* 5 being suspended in the vibrating apparatus, which could also be used for declination). The units of scale readings are $\frac{1}{10}$ of minutes of arc.

Increasing numbers correspond to an easterly motion of the declination.

Scale Readings of the Declinometer.

PESHÁUR, 1856-7, December and January.

Unit = $^1/_{10}$ Minute.

	$7^h\,15^m$	9^h	12^h	2^h	5^h	8^h
1856, December 24	285	285	284	284	286	286
„ 25	288	288	286	288	290	290
„ 26	288	288	286	...	290	290
„ 27	290	290	288	288	290	289
„ 28	292	292	289	290	290	291
„ 29	290	290	...	288	290	288
„ 30	290	292	290	292	292	291
„ 31	290	292	290	292	292	291
1857, January 1	290	292	290	292	292	293
„ 2	292	293	290	290	292	292
„ 3	294	293	289	292	292	292
„ 4	292	294	291	292	292	290
„ 5	294	294	292	292	292	292
„ 6	292	294	292	292	292	292
„ 7	294	296	293	294	294	295
„ 8	293	296	294	293	294	294
„ 9	294	295	294	294	294	295
„ 10	294	296	295	294	294	294
„ 11	294	295	295	294	295	296
„ 12	295	295	294	294	294	295
„ 13	294	295	294	295	295	296
„ 14	294	296	294	294	295	294
„ 15	293	295	294	294	295	296
„ 16	294	295	295	296	296	297
„ 17	295	296	297	296	299	298
„ 18	295	296	295	297	297	298
„ 19	294	297	296	296	297	297
Means	292·2	293·4	292·2	292·4	292·9	293·0

The curve being completed and the mean of the 24 hours taken, the daily variation of the declination for each hour was found to be as follows:

DECLINATION at PESHÁUR; Daily Variation: 1856, December 24, to 1857, January 19 (compare Plate 2).

A. M.		P. M.	
Midnight	0·01	Noon	— 0·05
1	0·00	1	— 0·04
2	— 0·01	2	— 0·03
3	— 0·02	3	— 0·02
4	— 0·03	4	— 0·00
5	— 0·04	5	0·02
6	— 0·05	6	0·02
7	— 0·05	7	0·03
8	0·03	8	0·04
9	0·07	9	0·03
10	0·08	10	0·02
11	0·02	11	0·02

Though in Bombay the winter months, December and January, also show a considerably smaller difference of the extremes than the summer months, Pesháur has it still much more reduced. The morning maximum nearly coincides in time with Bombay, but the afternoon elevation of the curve takes place later, and is very small.

B. *Horizontal Intensity.*

The deflection by *B* 7 was reduced to absolute values by multiplying the scale readings, $^1/_{10}$ of the minute, with 0·00350. This factor was deduced from the direct observations of deflection by substituting a greater value than the angle observed, and considering the parts of difference of the results to be within the range of the observations here to be reduced, as proportional to the differences between the angles of deflection themselves.

The following tables show the scale readings and their comparison with Bombay. Increasing numbers correspond to an increase of the Horizontal Intensity.

DEFLECTION at PESHÁUR, 1857, January, local time.

	7^h	9^h	Noon	2^h	5^h
January 21	299	300	300	300	302
„ 22	303	304	304	303	304
„ 23	305	307	306	306	308
„ 24	309	312	311	311	314
„ 25	314	316	316	315	317
„ 26	320	322	321	322	322
„ 27	322	323	322	321	322
„ 28	322	322	322	321	. . .
Mean	311·7	312·0	312·7	312·4	312·7

Differences (variations of Horizontal Intensity) { in scale readings + 0·5 + 0·7 — 0·3 + 0·3
{ in absolute values + 0·0175 + 0·0245 — 0·0105 + 0·0105

HORIZONTAL INTENSITY at BOMBAY, 1857, January, local time.

	$7^h\ 12^m$	$9^h\ 12^m$	Noon 12^m	$2^h\ 12^m$	$5^h\ 12^m$
January 21	8·0151	8·0210	8·0271	8·0255	8·0173
„ 22	8·0162	8·0210	8·0280	8·0267	8·0214
„ 23	8·0128	8·0216	8·0276	8·0234	8·0185
„ 24	8·0107	8·0181	8·0226	8·0214	. . .
„ 25	. . .	. . .	. . .	. . .	8·0155
„ 26	8·0151	8·0183	8·0263	8·0194	8·0118
„ 27	8·0099	8·0189	8·0238	8·0189	8·0126
„ 28	8·0093	8·0181	8·0286	8·0234	8·0157
Mean	8·0127	8·0196	8·0263	8·0227	8·0161

Differences (variations in absolute values) + 0·0069 + 0·0067 — 0·0036 — 0·0066

No. 23. SHÁHPUR, IN THE PĂNJÁB.

Latitude North.	Longitude East Green.	Height.
32° 14′ 0″	72° 32′ 30″	680 feet.

Alluvial soil of the Jĕch Duáb. See p. 164.

Observer: Robert.

DECLINATION.

1856, December 28, $9^h\ 20^m$ A.M. local time. Prism. Comp. 7; Theodolite 1, Jones; Chron. 4.

	°	′
Magnetic meridian	103	37·7
True meridian (see p. 169)	102	18·0
Declination East	1	19·7

No. 24. Déra Ismáel Khan, in the Pănjáb.

Latitude North.	Longitude East Green.	Height.
31° 39′ 35″	70° 56′ 30″	478 feet.

Clayey soil, on the right side of the Indus. See p. 169.

Observer: Adolphe.

DECLINATION.

1857, February 25, 9^h 15^m P.M. local time. Collimator 2; Theodolite 1, Troughton; Chron. 1.

	° ′
Magnetic meridian	50 22·2
True meridian (see p. 171)	49 24·0
Declination East	0 58·2

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1857, February 25, 4^h 35^m P.M. local time.

Magnet vibrated: *B* 7. Temp.: 24°·2 C., 75°·6 Fahr.

Chron. *A*, losing $4^s·8$.

	Without ring.		Without ring.
No. of vibrations	300	Time of 1 vibration	$3^s·274$
Semiarc beginning	183·5	q =	0·00021
Semiarc ending	103·5	μ =	0·00017
Torsion (90°)	1′	Time of 1 vibration corr.	$2^s·286$

$\log K = 0·26891$ $\log mX = 0·22993$

B. *Deflection.*

1857, February 25, 3^h 40^m P.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 24°·8 C., 76°·6 Fahr. / 24·5 C., 76·1 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 17′ 13″	1° 30′ 13″	Temp. of magnet	25°·0 C.	25°·0 C.
μ =	0·00017	0·00017		77·0 Fahr.	77·0 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·46282$$

$m = 0·2223$ X = Horizontal Intensity = 7·648

2. Dip.

1857, February 24, $4^h\ 30^m$ P.M. local time.

Dip needle: No. 4. Temp.: 23°·9 C., 75°·0 Fahr.

End *A*.

	° ′	
Face to instrument	44 3·4	Mean α = 44° 5′·8
Face reversed . . .	44 8·2	

End *B*.

	° ′	
Face to instrument	44 45·4	Mean β = 44 42·9
Face reversed . . .	44 40·4	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 44 24·35

Dip corrected for error of needle . . . . 44 23·47

3. Vertical Intensity . . . . 7·489

4. Total Intensity . . . . 10·703

No. 25. Multán, in the Pănjáb.

Latitude North.	Longitude East Green.	Height.
30° 10′ 10″	71° 34′ 34″	480 feet.

Under a grove of palm trees, on alluvial soil. See p. 171.

Observer: Robert.

DECLINATION.

1857, January 8, $10^h\ 0^m$ A.M. local time. Prism. Comp. 7; Theodolite 1, Jones; Chron. 4.

	° ′
Magnetic meridian	119 49·5
True meridian (see p. 174)	118 55·3
Declination East	0 54·2

No. 26. Shikárpur, in Sindh.

Latitude North.	Longitude East Green.	Height.
27° 55′ 10″	68° 51′ 50″	60 feet.

Twenty one miles west of the Indus, on a dry and hard soil. See p. 174.

Observer: Robert.

INTENSITY.

1. Horizontal Intensity.

1857, February 5, 4^h P.M. local time.

Magnet vibrated: Barrow. Temp.: 19°·8 C., 67°·6 Fahr.

Chron. 4, gaining $15^s·0$.

No. of vibrations	140	Time of 1 vibration	$2^s·888$
Semiarc, beginning	210	q	= 0·00022
Semiarc, ending	180	μ	= 0·00017
		log K	= 0·45945
		m	= 0·4260

$X = 8·000$

2. Dip.

Deduced from our map of isoclinal lines . . . . 36° 2′.

3. Vertical Intensity . . . . 5·820

4. Total Intensity . . . . 9·893

No. 27. Sévan, in Sindh.

Latitude North.	Longitude East Green.	Height.
26° 25′ 0″	67° 56′ 40″	140 feet.

On alluvial soil. See p. 176.

Observer: Robert.

DECLINATION.

1857, February 13, 12^h 10^m P.M. local time. Prism. Comp. 7; Theodolite 1, Jones; Chron. 4.

	° ′
Magnetic meridian	239 30·9
True meridian (see p. 176)	238 55·9
Declination East	0 35·0

No. 28. Kárráchi, in Sindh.

Latitude North.	Longitude East Green.	Height.
24° 45′ 30″	67° 0′ 51″	L. a. L. S.

On marine deposits, three miles from the harbour. See p. 177.

Observer: Robert.

DECLINATION.

1857, February 24, 3^h 20^m P.M. local time. Prism. Comp. 7; Theodolite 1, Jones; Chron. 4.

	° ′
Magnetic meridian	301 38·0
True meridian (see p. 178)	301 32·0
Declination East	0 6·0

No. 29. Bhūj, in Kăch.

Latitude North.	Longitude East Green.	Height.
23° 17′	69° 40′	283 feet.

On alluvial soil, very frequently disturbed by earthquakes. See p. 178.

Observer: Robert.

DECLINATION.

1857, March 16, 2^h 30^m P.M. local time. Prism. Comp. 7; Theodolite 1, Troughton; Chron. 4.

	° ′
Magnetic meridian	172 30·7
True meridian (see p. 179)	172 18·7
Declination East	0 12·0

INTENSITY.

1. Horizontal Intensity.

1857, March 16, 4^h 20^m P.M. local time.

Magnet vibrated: Barrow. Temp.: 33·2 C., 91·8 Fahr.

Chron. 4, gaining 15^s·0.

No. of vibrations	100	Time of 1 vibration . . . . 2^s·878
Semiarc beginning	180	q = 0·00022
Semiarc ending	170	μ = 0·00017
		$\log K$ = 0·45945
		m = 0·4260

$X = 8{\cdot}012$

2. Dip.

Deduced from our map of isoclinal lines . . . . 28° 25′·0.

3. Vertical Intensity . . . . 4·335

4. Total Intensity . . . . 9·109

No. 30. Rajkót, in Kattivár.

Latitude North.	Longitude East Green.	Height.
22° 13′ 0″	71° 7′ 0″	325 feet.

Hard, clayey soil. See p. 179.

Observer: Robert.

DECLINATION.

1857, March 22, 1^h 30^m P.M. local time. Prism. Comp. 7; Theodolite 1, Jones; Chron. 4.

	° ′
Magnetic meridian	16 27·0
True meridian (see p. 180)	16 13·7
Declination East	0 13·3

GROUP V.

CENTRAL AND SOUTHERN INDIA.

Ságer.—Jáblpur.—Nágri.—Rajamándri.—Madras.—Bombay.—Púna.—Mahabaléshvar.—Kăládghi.—Bellári.—Utakamánd.—Utatúr.—Gálle.

No. 31. Ságer, in Málva.

Latitude North.	Longitude East Green.	Height.
23° 50′ 9″	78° 43′ 26″	1,880 feet.

Observer: Adolphe. See p. 181.

Dip.

1855, December 18, 4^h 5^m P.M. local time.

Dip needle: No. 3. Temp.: 25°·6 C., 78°·1 Fahr.

End *A*.

	° ′	
Face to instrument	30 41·3	Mean α = 30° 41′·9
Face reversed . . .	30 42·5	

End *B*.

	° ′	
Face to instrument	29 24·7	Mean β = 29 20·7
Face reversed . . .	29 16·7	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 30 1·30

Dip corrected for error of needle . . . . 29 58·84

No. 32. JÁBLPUR, IN MÁLVA.

Latitude North.	Longitude East Green.	Height.
23° 9′ 39″	79° 56′ 18″	1,480 feet.

On a thick stratum of reddish clay. See p. 181.

Observer: Adolphe.

DECLINATION.

1855, December 23, 9ʰ A.M. local time. Collimator 2; Theodolite 2, Jones; Chron. 1.

	°	′
Magnetic meridian	351	0·5
True meridian (see p. 181)	349	50·0
Declination East	1	10·5

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, December 23, 3ʰ 10ᵐ P.M. local time.

Magnet vibrated: *B* 7. Temp.: 26°·7 C., 80°·0 Fahr.

Chron. *A*, losing 4ˢ·0.

No. of vibrations	200	Time of 1 vibration	2ˢ·909
Semiarc, beginning	209·5	q =	0·00021
Semiarc, ending	93·5	μ =	0·00017
Torsion (90°)	4′	Time of 1 vibration corr. . . .	2ˢ·919

$K = 0·26891$ $\log mX = 0·31665$

B. *Deflection.*

1855, December 23, 1ʰ 10ᵐ P.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp.: 26°·7 C., 80°·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 10′ 38″	1° 27′ 53″	Temp. of magnet	26°·1 C.	27°·8 C.
μ =	0·00017	0·00017		79·0 Fahr.	82·0 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8·45720$$

$m = 0·2483$ X = Horizontal Intensity = 8·666

2. Dip.

1855, December 23, $4^h\ 40^m$ P.M. local time.

Dip needle: No. 3. Temp.: 22°·8 C., 73°·1 Fahr.

End *A*.

	° ′	
Face to instrument	29 17·2	Mean α = 29° 18′·2
Face reversed . . .	29 19·2	

End *B*.

	° ′	
Face to instrument	27 46·0	Mean β = 27 49·0
Face reversed . . .	27 52·0	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 28 33·60

Dip corrected for error of needle . . . . 28 31·14

3. Vertical Intensity . . . . 4·711

4. Total Intensity . . . . 9·863

No. 33. Nágri, in Oríssa.

Latitude North.	Longitude East Green.	Height.
20° 25′ 25″	78° 52′ 50″	850 feet.

Observer: Adolphe. See p. 181.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, January 11, $2^h\ 30^m$ P.M. local time.

Magnet vibrated: *B* 7. Temp.: 31°·1 C., 88°·0 Fahr.

Chron. *A*, losing 4^s·4.

No. of vibrations	420	Time of 1 vibration	2^s·954
Semiarc { beginning	300	q =	0·00021
Semiarc { ending	166	μ =	0·00017
Torsion (90°)	0′	Time of 1 vibration corr. . . .	2^s·960

log K = 0·26891 log mX = 0·32069

B. *Deflection.*

1856, January 11, $11^h\ 45^m$ A.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp.: 29°·4 C., 85°·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
$u_0 =$	3° 8′ 19″	1° 26′ 30″	Temp. of magnet	29°·4 C.	30°·0 C.
$\mu =$	0·00017	0·00017		85·0 Fahr.	86·0 Fahr.
			$q =$	0·00021	0·00021

$$\log \frac{m}{X} = 8 \cdot 44832$$

$m = 0 \cdot 2424$ $\qquad X =$ Horizontal Intensity $= 8 \cdot 633$

2. Dip.

1856, January 11, $4^h\ 25^m$ P.M. local time.

Dip needle: No. 3. Temp.: 27°·7 C., 81°·8 Fahr.

End *A*.

	° ′	
Face to instrument	23 31·0	Mean α = 23° 28′·5
Face reversed . . .	23 26·0	

End *B*.

	° ′	
Face to instrument	22 24·0	Mean β = 22 16·4
Face reversed . . .	22 8·8	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 22 52·45

Dip corrected for error of needle . . . . 22 49·99

3. Vertical Intensity . . . . 3·634

4. Total Intensity . . . . 9·367

No. 34. Rajamándri, in Oríssa.

Latitude North.	Longitude East Green.	Height.
17° 10′ 30″	81° 46′ 35″	L. a. L. S. (35 feet.)

On alluvial soil; 100 yards north of the cantonment. See p. 181.

Observer: Adolphe.

DECLINATION.

1856, February 6, 5^h 30^m P.M. local time. Collimator 2; Theodolite 2, Jones; Chron. 2.

	° ′
Magnetic meridian	229 34·5
True meridian (see p. 182)	227 59·7
Declination East	1 24·8

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, February 5, 2^h 30^m P.M. local time.

Magnet vibrated: *B* 7. Temp.: 30°·3 C., 86°·5 Fahr.

Chron. *A*, losing $4^s·4$.

No. of vibrations	420	Time of 1 vibration	$2^s·968$
Semiarc beginning	300	q =	0·00021
Semiarc ending	285	μ =	0·00017
Torsion (90°)	10′	Time of 1 vibration corr.	$2^s·978$

$\log K = 0·26891$ $\log mX = 0·29984$

B. *Deflection.*

1856, February 5, 7^h 45^m A.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp.: 28°·9 C., 84°·0 Fahr.

	1 foot.	1·3 foot.
u_0 =	3° 2′ 57″	1° 23′ 10″
μ =	0·00017	0·00017

	1 foot.	1·3 foot.
Temp. of magnet	28°·8 C.	28°·8 C.
	84·0 Fahr.	84·0 Fahr.
q =	0·00021	0·00021

$$\log \frac{m}{X} = 8·42468$$

$m = 0·2346$ X = Horizontal Intensity = 8·824

2. Dip.

1856, February 6, Series I., $8^h\ 30^m$ A.M., Series II., 9^h A.M. local time.

Dip needles { Series I., No. 3. / „ II., No. 4. Temp. { Series I., 29°·4 C., 85°·0 Fahr. / „ II., 29·7 C., 85·5 Fahr.

End *A*.

	No. 3.	No. 4.		No. 3.	No. 4.
	° ′	° ′		° ′	° ′
Face to instrument	17 11·6	16 5·0	Mean α =	17 10·8	16 20·7
Face reversed . . .	17 10·0	16 36·4			

End *B*.

	° ′	° ′			
Face to instrument	15 40·3	16 36·0	Mean β =	15 42·3	16 27·0
Face reversed . . .	15 44·3	16 18·0			

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 16 26·55 16 23·85

Dip corrected for error of needle . . . . 16 24·09 16 22·97

Dip, general mean . . . . . . 16° 23′·53

3. Vertical Intensity . . . . 2·595

4. Total Intensity . . . . 9·197

No. 35. Madras.

Latitude North.	Longitude East Green.	Height.
13° 4′ 11″	80° 13′ 56″	L. a. L. S.

Close to the sea beach. See p. 183.

Through the kindness of Major Jacob and Major Worcester, then in charge of the Magnetic Observatory, a detailed series of corresponding observations was communicated to us during our stay in India.

The following are the monthly values of the *Declination* from November, 1854, to October, 1856.

1854. November 1° 0′ 46″; December 1° 0′ 38″.

1855. { January 1° 0′ 18″; February 0° 59′ 21″; March 0° 59′ 33″; April 1° 0′ 14″; May 0° 59′ 49″; June 0° 58′ 41″; July 0° 58′ 33″; August 0° 59′ 21″; September 1° 0′ 22″; October 1° 1′ 10″; November 1° 0′ 34″; December 1° 0′ 38″.

1856. { January 1° 0′ 50″; February 1° 0′ 18″; March 1° 0′ 46″; April 1° 2′ 2″; May 1° 2′ 2″; June 1° 1′ 6″; July 1° 1′ 46″; August 1° 2′ 15″; September 1° 1′ 22″; October 1° 1′ 42″.

The means for the time corresponding to our travels in Southern India, viz. February and March, 1855, were found by direct comparisons of our magnets with those of the Government Observatory. The mean results which we obtained, together with Major Worcester, are the following:

Declination East	0° 59′ 30″ [1]
Horizontal Intensity	8·023
Dip	7° 52′·34
Vertical Intensity	1·114
Total Intensity	8·100

For July and August, 1849, Captain Elliot gives:[2]

Declination	0° 56′ 8″
Horizontal Intensity	8·078
Dip	7° 34′·2
Total Intensity	8·149

No. 36. Bombay.

Latitude North.	Longitude East Green.	Height.
18° 53′ 30″	72° 49′·5″	L. a. L. S.

The details of the observations made at the Magnetic Observatory, are contained pp. 302 to 340.

Immediately upon our arrival in India, we availed ourselves of the advantages here offered, to compare our instruments with each other and with those of the Observatory.

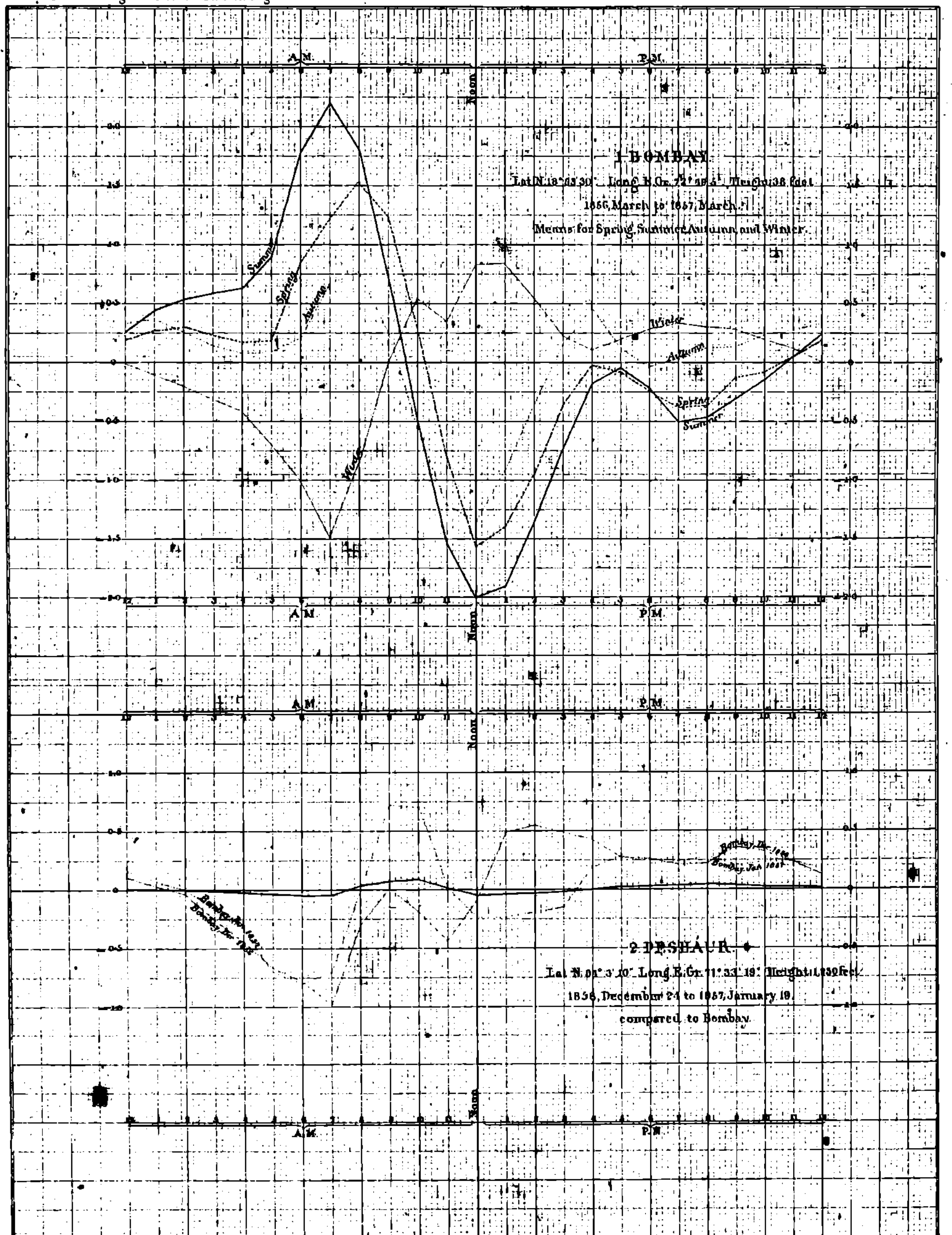
We add here a table of the daily variation of the declination for the four seasons[3], from March, 1856, to March, 1857, to which we shall have occasion to refer for comparison with variations observed by ourselves. The table is calculated from the monthly values contained in the volumes of the Magnetic Observatory at Bombay, 1856, p. 10, and 1857, p. 12.

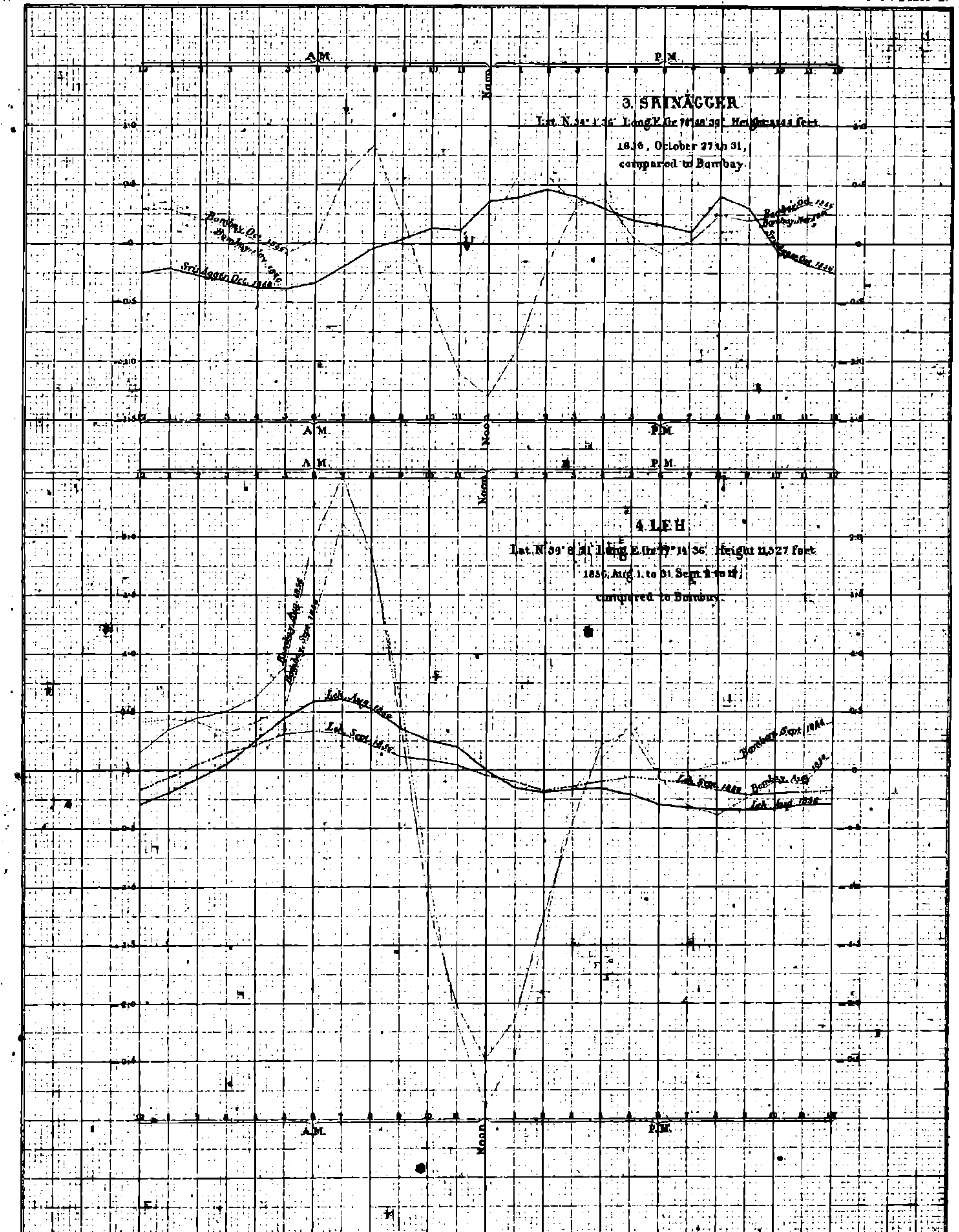
[1] On the excellent chart of the magnetic variation, by Frederick F. Evans, the declination at Madras is decidedly less; but no values, obtained by direct observations, lower than those given above, are known to us.

[2] Philosophical Transactions, 1851, p. CLV. The dip is reduced to January 1, 1848.

[3] Compare plate 2, figure 1.

DIURNAL OSCILLATIONS OF THE MAGNETIC DECLINATION.





Leipzig: F. A. Brockhaus

Engraved by L. Kraatz, Berlin.

Scale: 1' of Arc = 20 Millimetres. The curve rising denotes a movement of the North Pole of the Magnet Eastward.

DAILY VARIATION OF THE DECLINATION FOR THE FOUR SEASONS AT BOMBAY.

In Minutes of Arc. 4^h 12 P.M. Bombay Civil Time = Noon Göttingen Time.

Bombay Civil Time.	Spring, 1856, March, April, and May.	Summer, 1856, June, July, and August.	Autumn, 1856, Sept., Oct., and Nov.	Winter, 1856-7, Dec., Jan., and Feb.
	′	′	′	′
Midnight + 12^m	0·191	0·247	0·333	— 0·008
h m				
1 12 A.M.	0·264	0·428	0·368	— 0·115
2 12 ,,	0·301	0·528	0·256	— 0·200
3 12 ,,	0·235	0·591	0·145	— 0·314
4 12 ,,	0·187	0·625	0·078	— 0·412
5 12 ,,	0·198	0·880	0·009	— 0·688
6 12 ,,	0·853	1·773	0·213	— 1·078
7 12 ,,	1·227	2·209	0·668	— 1·488
8 12 ,,	1·540	1·822	0·766	— 0·884
9 12 ,,	1·244	0·750	0·240	0·008
10 12 ,,	0·287	— 0·512	— 0·555	0·541
11 12 ,,	— 0·809	— 1·523	— 1·217	0·359
Noon + 12^m	— 1·554	— 2·074	— 1·358	0·833
1 12 P.M.	— 1·387	— 1·914	— 0·921	0·845
2 12 ,,	— 0·936	— 1·343	— 0·338	0·559
3 12 ,,	— 0·360	— 0·725	0·161	0·226
4 12 ,,	— 0·028	— 0·182	0·466	0·114
5 12 ,,	— 0·075	— 0·046	0·121	0·199
6 12 ,,	— 0·247	— 0·231	— 0·028	0·284
7 12 ,,	— 0·376	— 0·490	0·036	0·336
8 12 ,,	— 0·368	— 0·464	0·133	0·305
9 12 ,,	— 0·224	— 0·309	0·142	0·288
10 12 ,,	— 0·083	— 0·150	0·237	0·196
11 12 ,,	0·060	0·065	0·276	0·115

We adopt for our maps the following values for the magnetic elements for Bombay. They are reduced to January 1, 1856, by taking the mean of the annual values of 1855 and 1856.

Declination East	0° 19′·13	Vertical Intensity	2·775
Horizontal Intensity . . .	8·008	Total Intensity	8·475
Dip	19° 6′·6		

No. 37. Púna, in the Dékhan.

Latitude North.	Longitude East Green.	Height.
18° 30′ 23″	73° 52′ 8″	1,819 feet.

Near the dāk bángalo, in an open cultivated plain. See p. 183.

Observer: Hermann.

Dip.

1855, January 5, $12^h\ 40^m$ P.M. local time.

Dip Needle: No. 2. Temp.: 19°·4 C., 66°·9 Fahr.

End *A*.

	° ′	
Face to instrument	18 55·0	Mean α = 18° 58′·4
Face reversed . . .	19 1·8	

End *B*.

	° ′	
Face to instrument	19 14·8	Mean β = 19 5·4
Face reversed . . .	18 56·0	

Mean of the dip $\frac{\alpha + \beta}{2}$ = 19 1·90

Dip corrected for error of needle . . . . 19 2·25

No. 38. Mahabaléshvar, in the Dékhan.

Latitude North.	Longitude East Green.	Height.
17° 55′ 25″	73° 38′ 42″	4,396 feet.

Near the bángalo "Cliffton." See p. 184.

Observer: Adolphe.

Dip.

1854, December 14, $2^h\ 15^m$ P.M. local time.

Dip needle: No. 4. Temp.: 18°·6 C., 65°·5 Fahr.

End *A*.

	° ′	
Face to instrument .	16 30·0	Mean α = 16° 36′·0
Face reversed	16 42·0	

End *B*.

	° ′	
Face to instrument .	16 17·0	Mean β = 16 16·75
Face reversed	16 16·5	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 16 26·38

Dip corrected for error of needle . . . . 16 25·50

No. 39. KĂLÁDGHI, IN THE DÉKHAN.

Latitude North.	Longitude East Green.	Height.
16° 12′ 55″	75° 29′ 55″	1,720 feet.

Near the limit of the trap, but already on sandstone. See p. 184.

Observer: Adolphe.

DECLINATION.

1855, January 19, 3^h 50^m P.M. local time. Barrow's Universal Magnetometer; Chron. 3.

	° ′
Magnetic meridian	220 40·7
True meridian (see p. 184)	220 10·7
Declination East[1]	0 30·0

DIP.

1855, January 19, 4^h 5^m P.M. local time.

Dip needle: No. 2. Temp.: 22°·6 C., 72°·7 Fahr.

End *A*.

	° ′	
Face to instrument	14 24·3	Mean α = 14° 23′·4
Face reversed . . .	14 22·5	

End *B*.

	° ′	
Face to instrument	14 23·5	Mean β = 14° 30′·4
Face reversed . . .	14 37·3	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 14 26·90

Dip corrected for error of needle . . . . 14 27·25

No. 40. BELLÁRI, IN MAISSÚR.

Latitude North.	Longitude East Green.	Height.
15° 8′ 57″	76° 53′ 45″	1,580 feet.

On decomposed granite. See p. 184.

Observer: Hermann.

DECLINATION.

1855, January 29, 2^h P.M. local time. Barrow's Universal Magnetometer; Chron. 3.

	° ′
Magnetic meridian	26 40·0
True meridian (see p. 184)	26 19·0
Declination East	0 21·0

[1] Before working out in detail our observations, we were under the impression that the declination was a little westerly between Bombay and Sattára; but, when we had reached no farther than Káládghi, we found it, on the contrary, to be easterly. The previous error was the consequence of our having at first supposed the error in Barrow's instrument to be greater than it really was.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, January 29, 8^h A.M. local time.

Magnets vibrated { *L* 1, *L* 1 with small ring. Temp.: 26°·7 C., 80°·0 Fahr.

Chron. *H*, losing $0^s·3$.

	Without ring.	With small ring.		Without ring.	With small ring.
No. of vibrations	400	180	Time of 1 vibration	$2^s·467$	$5^s·262$
Semiarc { beginning	178·5	228	q =	0·00020	0·00020
Semiarc { ending	41	163·5	μ =	0·00017	0·00017
Torsion (90°)	4′	4′	Time of 1 vibration corr.	$2^s·470$	$5^s·268$

log $K_{,}$ = 0·33293 log K = 0·43821

log mX = 0·64719

B. *Deflection.*

1855, January 30, 8^h 30^m A.M. local time.

Magnets: Deflecting *L* 1, deflected *B* 5.

Deflection bar: *H* 1. Distances: 1 foot, 1·3 foot. Temp.: 30°·0 C., 86°·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	6° 54′ 55″	3° 7′ 23″	Temp. of magnet	30°·0 C.	30°·0 C.
μ =	0·00017	0·00017		86·0 Fahr.	86·0 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·77407$$

m = 0·5136 X = Horizontal Intensity = 8·641

2. Dip.

1855, January 30, 6^h 30^m P.M. local time.

Dip needle: No. 2. Temp.: 29°·0 C., 84°·2 Fahr.

End *A*.

	° ′	
Face to instrument	12 18·8	Mean α = 12° 12′·15
Face reversed . . .	12 5·5	

End *B*.

	° ′	
Face to instrument	11 35·5	Mean β = 11 46·5
Face reversed . . .	11 57·5	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 11 59·33

Dip corrected for error of needle . . . . 11 59·68

3. Vertical Intensity . . . . 1·838

4. Total Intensity . . . . 8·834

No. 41. Utakamánd, in the Nílgiris.

Latitude North.	Longitude East Green.	Height.
11° 23′ 40″	76° 43′ 10″	7,278 feet.

On a level slope of decomposed granite. See p. 185.

Observer: Adolphe.

DECLINATION.

1856, March 14, 9^h 45^m P.M. local time. Collimator 2; Theodolite 2, Jones; Chron. 1.

	° ′
Magnetic meridian	113 54·0
True meridian (see p. 185)	112 57·0
Declination East	0 57·0 [1]

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, March 13, 3^h 45^m P.M. local time.

Magnet vibrated: *B* 7. Temp.: 21°·4 C., 70°·5 Fahr.

Chron. *A*, losing 4^s·4.

	Without ring.		Without ring.
No. of vibrations	240	Time of 1 vibration	2^s·963
Semiarc { beginning	143	q =	0·00021
Semiarc { ending	91	μ =	0·00017
Torsion (90°)	9′	Time of 1 vibration corr. . .	2^s·978
log K = 0·26891		log mX = 0·31537	

[1] Major Jacob had found in 1851 the Declination = 0° 54′ 6″ East (a result which he kindly communicated to our late brother).

B. *Deflection.*

1856, March 13, $2^h\ 5^m$ P.M. local time.

Magnets: Deflecting $B7$, deflected $B2$.

Deflection bar: A. Distances: 1 foot, 1·3 foot. Temp.: 24°·2 C., 75°·5 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 1′ 6″	1° 22′ 45″	Temp. of magnet	24°·2 C.	24°·2 C.
μ =	0·00017	0·00017		75·5 Fahr.	75·5 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot42297$$

$m = 0\cdot2340$ X = Horizontal Intensity = 8·835

2. Dip.

1856, March 14, Series I., $2^h\ 25^m$ P.M.; Series II., 3^h 50 P.M. local time.

Dip needles { Series I., No. 3. / „ II., No. 4. Temp. { Series I., 26°·7 C., 80°·0 Fahr. / „ II., 26·1 C., 79·0 Fahr.

End A.

	No. 3.	No. 4.		No. 3.	No. 4.
Face to instrument	5° 21′·9	4° 12′·1	Mean α =	5° 17′·1	4° 14′·2
Face reversed . . .	5 12·3	4 16·3			

End B.

	No. 3.	No. 4.		No. 3.	No. 4.
Face to instrument	3° 44′·2	4° 30′·8	Mean β =	3 47·2	4 37·4
Face reversed . . .	3 50·2	4 44·0			
			Mean of the dip = $\frac{\alpha+\beta}{2}$ =	4 32·15	4 25·80
			Dip corrected for error of needle	4 29·69	4 24·92

Dip, general mean . . . . . . 4° 27′·32

3. Vertical Intensity . . . . 0·686

4. Total Intensity . . . . 8·862

No. 42. Utatúr, in the Karnátik.

Latitude North.	Longitude East Green.	Height.
11° 4′ 40″	78° 51′ 40″	280 feet.

In an open, cultivated place. See p. 185.

Observer: Adolphe.

Dip.

A. 1856, March 5, 2^h 30^m P.M. local time.

Dip needle: No. 3. Temp.: 22°·5 C., 72°·5 Fahr.

End *A*.

	° ′	
Face to instrument	3 40·0	Mean α = 3° 32′·65
Face reversed . . .	3 25·3	

End *B*.

	° ′	
Face to instrument	2 12·9	Mean β = 2 7·6
Face reversed . .	2 2·3	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 2 50·13

Dip corrected for error of needle . . . . 2 52·79

B. 1856, March 5, 4^h 0^m P.M. local time.

Dip needle: No. 4. Temp.: 24°·1 C., 75°·4 Fahr.

End *A*.

	° ′	
Face to instrument	2 42·0	Mean α = 2° 41′·5
Face reversed . . .	2 41·0	

End *B*.

	° ′	
Face to instrument	2 46·0	Mean β = 2 55·0
Face reversed . . .	3 4·0	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 2 48·25

Dip corrected for error of needle . . . . 2 47·37

General mean of *A* and *B* . . . . 2 50·08

No. 43. Gálle, in Ceylón.

Latitude North.	Longitude East Green.	Height.
6° 2′ 30″	80° 10′ 45″	L. a. L. S.

On sea sand. See p. 186.

Observer: Hermann.

DECLINATION.

1857, May 2, $1^h\ 20^m$ P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	34 6·5
True meridian (see p. 186)	33 25·5
Declination East	0 41·0

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1857, May 2, $6^h\ 35^m$ A.M. local time.

Magnet vibrated { L 1 / L 1 with ring. Temp.: 26°·4 C., 79°·5 Fahr.

Chron. H, losing $0^s·5$.

	Without ring.	With ring.
No. of vibrations	250	136
Semiarc beginning	129	152·5
Semiarc ending	21	123·5
Torsion (90°)	9′	9′

	Without ring.	With ring.
Time of 1 vibration	$2^s·815$	$7^s·560$
q =	0·00020	0·00020
μ =	0·00017	0·00017
Time of 1 vibration corr.	$2^s·821$	$7^s·577$

$\log K_{,} = 0·44230$ $\log K = 0·43821$

$\log mX = 0·53169$

B. *Deflection.*

1857, May 3, $12^h\ 30^m$ P.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 3. Distances: 1 foot, 1·3 foot. Temp. { 29°·2 C., 84°·6 Fahr. / 30·1 C., 86·2 Fahr.

	1 foot.	1·3 foot.
u_0 =	6° 2′ 18″	2° 45′ 19″
μ =	0·00017	0·00017

	1 foot.	1·3 foot.
Temp. of magnet	30°·0 C.	30°·0 C.
	86·0 Fahr.	86·0 Fahr.
q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·72518$$

$m = 0·4250$ X = Horizontal Intensity = 8·003

2. Dip.

1857, May 2, $3^h\ 5^m$ P.M. local time.

Dip needle: No. 2. Temp.: 31°·0 C., 87°·8 Fahr.

This station is south of the magnetic equator.

End *A*.

Face to instrument	7° 37′·0	Mean α = 7° 34′·0
Face reversed . . .	7 31·0	

End *B*.

Face to instrument	7° 39′·0	Mean β = 7 48·5
Face reversed . . .	7 58·0	

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 7 41·25

Dip corrected for error of needle . . . . 7 40·90

3. Vertical Intensity . . . . 1·077

4. Total Intensity . . . . 8·076

B. HIGH ASIA.

a. HIMÁLAYA.

GROUP VI.

BHUTÁN TO NEPÁL.

Nárigún.—Darjíling.—Răngít bridge.—Tónglo.—Fălút.—Kathmándu.

No. 44. NĂRIGÚN, IN BHUTÁN.

Latitude North.	Longitude East Green.	Height.
26° 53′ 50″	92° 6′ 0″	3,615 feet.

On large gravel of fine granite, circumstances preventing us from selecting a spot of ungranitic soil, or clay. See p. 187.

Observer: Hermann.

DECLINATION.

1856, January 12, 10^h 15^m P.M. local time. Collimator 1; Theodolite 2; Chron. 3.

	° ′
Magnetic meridian	142 53·0
True meridian (see p. 187)	138 10·0
Declination East	4 43·0 [1]

[1] Compare the general results (Section VI.) in reference to the cause of this great declination; it is probable that the cause is the same for the smaller declination in Assám.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, January 10, $4^h\ 45^m$ P.M. local time.

Magnet vibrated { $L1$ / $L1$ with ring. Temp. { $11°·0$ C., $51°·8$ Fahr. / $9·6$ C., $49·2$ Fahr.

Chron. H, losing $0^s·5$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	220	100	Time of 1 vibration	$2^s·817$	$7^s·530$
Semiarc { beginning	185	233	q =	0·00020	0·00020
Semiarc { ending	2	213	μ =	0·00017	0·00017
Torsion (90°)	0′	0′	Time of 1 vibration corr.	$2^s·829$	$7^s·565$

$\log K_{,} = 0·44465$ $\log K = 0·43821$

$\log mX = 0·52911$

B. *Deflection.*

1856, January 10, 5^h P.M. local time.

Magnets: Deflecting $L1$, deflected $H21$.

Deflection bar: $H2$. Distances: 1 foot, 1·33 foot. Temp.: 11°·0 C., 51°·8 Fahr.

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
u_0 =	6° 4′ 48″	3° 13′ 25″	Temp. of magnet	10°·7 C.	10°·7 C.
μ =	0·00017	0·00017		51·3 Fahr.	51·3 Fahr.
			q =	0·00020	. . .

$$\log \frac{m}{X} = 8·80654$$

$m = 0·4654$ X = Horizontal Intensity = 7·266

2. Dip.

1856, January 9, $4^h\ 25^m$ P.M. local time.

Dip needle: No. 2. Temp.: 12°·3 C., 54°·2 Fahr.

End A.

	°	′
Face to instrument	37	0·25
Face reversed	37	1·5

Mean α = 37° 0′·88

End *B*.

Face to instrument	37° 16'·0	Mean β =	37° 14'·63
Face reversed . . .	37 13·25		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 37 7·76

Dip corrected for error of needle . . . . 37 8·11

3. Vertical Intensity . . . . 5·502

4. Total Intensity . . . . 9·114

No. 45. Darjíling, in Síkkim.

Latitude North.	Longitude East Green.	Height.
27° 3′ 0″	88° 15′ 15″	7,168 feet.

On thick vegetable earth, resting on a subsoil of gneiss. See p. 188.

Observer: Hermann.

DECLINATION.

1855, July 23, $10^h\ 0^m$ P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	314 26·10
True meridian (see p. 189)	311 38·10
Declination East	2 48·0

FIRST SERIES.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, April 20, $11^h\ 45^m$ A.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring. Temp. { 12°·2 C., 53°·9 Fahr. / 11·1 C., 52·0 Fahr.

Chron. *H*, losing $0^s·7$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	800	300	Time of 1 vibration	$2^s·713$	$7^s·492$
Semiarc beginning	72	73	q =	0·00020	0·00020
Semiarc ending	3·5	24	μ =	0·00017	0·00017
Torsion (90°)	3′	3′	Time of 1 vibration corr. . .	$2^s·726$	$7^s·527$

$\log K_, = 0·41201$ $\log K = 0·43821$

$\log mX = 0·56155$

B. *Deflection.*

1855, April 20, 11h 0m A.M. local time.

Magnets: Deflecting $L1$, deflected $H21$.

Deflection bar: $H2$. Distances: 1 foot, 1·33 foot. Temp. { 10°·1 C., 50°·2 Fahr. / 10·3 C., 50·5 Fahr. }

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
u_0 =	6° 39′ 50″	3° 16′ 43″	Temp. of magnet	10°·3 C.	10°·5 C.
μ =	0·00017	0·00017		50·5 Fahr.	50·9 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot91611$$

$m = 0\cdot5481$ X = Horizontal Intensity = 6·648

2. Dip.

1855, April 19, 9h 35m A.M. local time.

Dip needle: No. 1. Temp.: 10°·1 C., 50°·2 Fahr.

End *A*.

	° ′	
Face to instrument	36 45·75	Mean α = 36° 40′·88
Face reversed . . .	36 36·0	

End *B*.

	° ′	
Face to instrument	36 17·5	Mean β = 36 16·62
Face reversed . . .	36 15·75	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 36 28·75

Dip corrected for error of needle . . . . 36 31·74

3. Vertical Intensity . . . . 4·924

4. Total Intensity . . . . 8·274

SECOND SERIES.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, August 1, 9^h 20^m A.M. local time.

Magnet vibrated { L 1 / L 1 with ring. Temp. { 18°·3 C., 65°·0 Fahr. / 19°·4 C., 67°·0 Fahr.

Chron. H, losing $0^s·7$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	400	300	Time of 1 vibration . . .	$2^s·819$	$7^s·496$
Semiarc { beginning	170	100	q =	0·00020	0·00020
Semiarc { ending	25	61·5	μ =	0·00017	0·00017
Torsion (90°)	16′	16′	Time of 1 vibration corr.	$2^s·831$	$7^s·527$

$\log K_{,} = 0·45022$ $\log K = 0·43821$

$\log mX = 0·52843$

B. *Deflection.*

1855, July 31, 8^h 15^m A.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 2. Distance: 1·33 foot. Temp.: 16°·7 C., 62°·0 Fahr.

1 foot.	1 foot.
$u_0 = 3° \; 13' \; 20''$	Temp. of magnet . . . 17°·2 C., 63°·0 Fahr.
$\mu = 0·00017$	$q = 0·00020$

$$\log \frac{m}{X} = 8·90960$$

$m = 0·5236$ X = Horizontal Intensity = 6·448

2. Dip.

1855, July 30, 4^h P.M. local time.

Dip needle: No. 1. Temp.: 21°·3 C., 70°·4 Fahr.

End A.

	°	′	″
Face to instrument	36	45	25
Face reversed . . .	36	39	5

Mean α = 36° 42′·38

End *B*.

Face to instrument	36° 23′·81	Mean β =	36° 20′·03
Face reversed . . .	36 16·25		

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 36 31·21

Dip corrected for error of needle . . . . 36 34·20

3. Vertical Intensity . . . . 4·783

4. Total Intensity . . . . 8·029

VARIATIONS AT DARJÍLING.

The apparatus of deflection was observed July 31 and August 1, from 4^h A.M. to 10^h P.M. every two hours. The units of the readings are tenths of minutes, and the zero of the scale arbitrary. The value of 1 minute of deflection, reduced to absolute values in English units, gave, for magnet *L* 1 at the distance employed, 1 unit of the scale (or $^1/_{10}$ of a minute in deflection) = 0·000164 English units. The increasing scale numbers denote a decrease of the resulting intensity.

The scale readings are contained in the following table, where the hours interpolated for completing the daily variation are enclosed in parentheses. For those interpolations 4^h P.M. was considered the minimum (as in Bombay), since the direct observation showed that it very nearly coincided with this period. The hour of the maximum also appeared to differ very little from that of Bombay.

Horizontal Intensity, Scale Readings.

1855. Mean of July 31 and August 1.

A.M. Hours.		P.M. Hours.	
12	(264)	12	303
2	(264)	2	293
4	263	4	275
6	264	6	271
8	273	8	268
10	283	10	267

If we reduce the differences of scale readings from the mean (274) to differences in English units, by multiplying them with 0·000164, we obtain the following daily variation:

Darjíling: Variation of Horizontal Intensity, in English Units.

1855. Mean of July 31 and August 1.

A.M. Hours.		P.M. Hours.	
12	— 0·0016	12	+ 0·0047
2	— 0·0016	2	+ 0·0031
4	— 0·0018	4	+ 0·0002
6	— 0·0016	6	— 0·0005
8	— 0·0002	8	— 0·0010
10	+ 0·0014	10	— 0·0012

We add for comparison the observations of Bombay.

Bombay: Variation of Horizontal Intensity, English Units.

1855, July 31.

Hours.		Horizontal Force. Absolute values.	Variation = Diff. from the Mean of the Day.
Midnight	+ 12^m	8·0266	— 0031
1	,,	8·0280	— 0017
2	,,	8·0279	— 0018
3	,,	8·0284	— 0013
4	,,	8·0283	— 0014
5	,,	8·0296	— 0001
6	,,	8·0290	— 0007
7	,,	8·0334	+ 0037
8	,,	8·0322	+ 0025
9	,,	8·0374	+ 0077
10	,,	8·0372	+ 0075
11	,,	8·0362	+ 0065
Noon	,,	8·0340	+ 0043
1	,,	8·0341	+ 0044
2	,,	8·0327	+ 0030
3	,,	8·0306	+ 0009
4	,,	8·0314	+ 0017
5	,,	8·0286	— 0011
6	,,	8·0260	— 0037
7	,,	8·0256	— 0041
8	,,	8·0241	— 0056
9	,,	8·0244	— 0053
10	,,	8·0229	— 0068
11	,,	8·0237	— 0060

No. 46. RĂNGÍT BRIDGE, IN SÍKKIM.

Latitude North.	Longitude East Green.	Height.
27° 4′ 50″	88° 10′ 15″	3,130 feet.

Observer: Hermann. See p. 189.

INTENSITY.

1. HORIZONTAL INTENSITY.

A. *Vibration.*

1855, June 15, 12^h 30^m P.M. local time.

Magnet vibrated: *L* 1. Temp.: 30°·8 C., 87°·5 Fahr.

Chron. *H*, losing 0^s·5.

No. of vibrations	580	Time of 1 vibration	2^s·776
Semiarc beginning	165	q =	0·00020
Semiarc ending	175	μ =	0·00017
Torsion (90°)	6′	Time of 1 vibration corr.	2^s·779

$\log K = 0{\cdot}43821$ $\log mX = 0{\cdot}54470$

B. *Deflection.*

1855, June 15, 12^h 10^m P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 2. Distances: 1 foot. Temp.: 30°·6 C., 87°·1 Fahr.

1 foot.	1 foot.
u_0 = 6° 23′ 36″	Temp. of magnet . . 30°·8 C., 87°·4 Fahr.
μ = 0·00017	q = 0·00020

$$\log \frac{m}{X} = 8{\cdot}90145$$

$m = 0{\cdot}5285$ X = Horizontal Intensity = 6·632

No. 47. TÓNGLO, IN SÍKKIM.

Latitude North.	Longitude East Green.	Height.
27° 1′ 50″	88° 3′ 55″	10,080 feet.

On a fine level stratum resting on rocks of gneiss. (See p. 190.)

Observer: Hermann.

DECLINATION.

1855, May 12, $9^h\ 0^m$ A.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′ ″
Magnetic meridian	113 41 40
True meridian (see p. 190)	111 11 10
Declination East	2 30 30 = 2° 30′·5

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, May 12, $2^h\ 30^m$ P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring. Temp. { 13°·2 C., 55°·8 Fahr. / 13·4 C., 56·1 Fahr.

Chron. *H*, losing $0^s\cdot5$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	500	300	Time of 1 vibration . .	$2^s\cdot867$	$7^s\cdot519$
Semiarc { beginning	148	45	q =	0·00020	0·00020
Semiarc { ending	45·5	20	μ =	0·00017	0·00017
Torsion (90°)	2′	2′	Time of 1 vibration corr.	$2^s\cdot879$	$7^s\cdot550$

$\log K_{,} = 0\cdot46400$ $\log K = 0\cdot43821$

$\log mX = 0\cdot51407$

B. *Deflection.*

1855, May 12, $3^h\ 30^m$ P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 2. Distances: 1 foot, 1·33 foot. Temp. { 13°·0 C., 55°·4 Fahr. / 12·2 C., 54·0 Fahr.

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
u_0 =	7° 8′ 5″	3° 12′ 3″	Temp. of magnet. .	13°·2 C.	13°·4 C.
μ =	0·00017	0·00017		55·7 Fahr.	56·1 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot83997$$

$m = 0\cdot4754$ X = Horizontal Intensity = 6·872

2. Dip.

1855, May 12, 11h 0m A.M. local time.

Dip needle: No. 1. Temp.: 10°·6 C., 51°·1 Fahr.

End *A*.

	° ′	
Face to instrument	36 9·0	Mean α = 36° 28′·28
Face reversed . . .	36 47·56	

End *B*.

	° ′	
Face to instrument	36 16·0	Mean β = 36 15·82
Face reversed . . .	36 15·63	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 36 22·05

Dip corrected for error of needle. . . 36 25·04

3. Vertical Intensity . . . . 5·068

4. Total Intensity . . . . 8·539

No. 48. Fălŭt, in Síkkim.

Latitude North.	Longitude East Green.	Height.
27° 6′ 20″	87° 59′ 0″	12,042 feet.

On rocks of gneiss. See p. 190.

Observer: Hermann.

DECLINATION.

1855, May 22, 10h 15m P.M. local time. Collimator 1; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	216 38·8
True meridian (see p. 191)	214 14·0
Declination East	2 24·8

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, June 10, 2h 0m P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring. Temp.: 12°·0 C., 53°·6 Fahr.

Chron. *H*, losing 0s·3.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	400	150	Time of 1 vibration. . .	$2^s \cdot 790$	$7^s \cdot 484$
Semiarc beginning	181	15·5	q =	0·00020	0·00020
Semiarc ending	53	2·5	μ =	0·00017	0·00017
Torsion (90°)	2′	2′	Time of 1 vibration corr.	$2^s \cdot 802$	$7^s \cdot 517$

$\log K_{,} = 0 \cdot 44549$ $\log K = 0 \cdot 43821$

$\log mX = 0 \cdot 53757$

B. *Deflection.*

1855, June 10, 5^h 0^m P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 2. Distances: 1 foot, 1·33 foot. Temp.: 8°·3 C., 47°·0 Fahr.

	1 foot.	1·33 foot.		1 foot.	1·33 foot.
u_0 =	7° 3′ 35″	3° 20′ 8″	Temp. of magnet . .	9°·0 C.	8°·4 C.
μ =	0·00017	0·00017		48·2 Fahr.	47·1 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8 \cdot 89202$$

$m = 0 \cdot 5185$ X = Horizontal Intensity = 6·648

2. Dip.

1855, June 9, 4^h 55^m P.M., needle 1, 5^h 20^m P.M., needle 2, local time.

Dip needles: Nos. 1 and 2. Temp.: 7°·9 C., 46°·2 Fahr.

End *A*.

		° ′		° ′
Needle 1.	Face to instrument	37 3·0	Mean α =	36 59·0
	Face reversed . . .	36 55·0		
Needle 2.	Face to instrument	36 54·0	Mean α =	37 0·4
	Face reversed . . .	37 6·8		

End *B*.

		° ′		
Needle 1.	Face to instrument	36 45·25	Mean β =	36 46·0
	Face reversed . . .	36 46·75		
Needle 2.	Face to instrument	36 55·38	Mean β =	36 47·75
	Face reversed . . .	36 40·12		

Needle 1. Mean of the dip $\frac{\alpha + \beta}{2}$ = 36 52·50

Needle 2. Mean of the dip $\frac{\alpha + \beta}{2}$ = 36 54·08

Dip corrected for error of needle 1 . . . . 36 55·49

" " " " 2 . . . . 36 54·43

General Mean . . . . 36 54·96

3. VERTICAL INTENSITY . . . . 4·995

4. TOTAL INTENSITY . . . . 8·316

No. 49. KATHMÁNDU, IN NEPÁL.

Latitude North.	Longitude East Green.[1]	Height.
27° 42′ 5″	85° 12′ 9″	4,350 feet.

On lacustrine deposits of large extent. See p. 192.

Observer: Hermann.

DECLINATION.

1857, March 4, 2^h 30^m P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	75 22·5
True meridian (see p. 197)	72 46·7
Declination East	2 35·8

INTENSITY.

1. HORIZONTAL INTENSITY.

A. *Vibration.*

1857, February 27, 3^h 0^m P.M. local time.

Magnet vibrated { L 1 / L 1 with ring. Temp. { 21°·9 C., 71°·4 Fahr. / 21·6 C., 70·8 Fahr.

Chron. H, losing $0^s·2$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	300	100	Time of 1 vibration . .	$2^s·879$	$7^s·742$
Semiarc { beginning . . .	145	154·5	q =	0·00020	0·00020
Semiarc { ending	27·5	145·5	μ =	0·00017	0·00017
Torsion (90°)	0′	0′	Time of 1 vibration corr.	$2^s·885$	$7^s·758$

log $K_{,}$ = 0·43854   log K = 0·43821

log mX = 0·51219

[1] With reference to the longitude adopted, see the remark at p. 197.

B. *Deflection.*

1857, February 27, $4^h\ 0^m$ P.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 3. Distance: 1 foot. Temp.: 20°·2 C., 68°·4 Fahr.

1 foot.	1 foot.
$u_0 = 7°\ 42'\ 0''$	Temp. of magnet . . 19°·9 C., 67°·8 Fahr.
$\mu = 0{\cdot}00017$	$q = 0{\cdot}00020$

$$\log \frac{m}{X} = 8{\cdot}83168$$

$m = 0{\cdot}4698$ X = Horizontal Intensity = 6·922.

2. Dip.

1857, February 23, $1^h\ 15^m$ P.M. local time.

Dip needle: No. 2. Temp.: 18°·4 C., 65°·1 Fahr.

End *A*.

	° ′		° ′
Face to instrument	37 39·44	Mean α =	37 39·93
Face reversed . . .	37 40·43		

End *B*.

	° ′		° ′
Face to instrument	37 23·38	Mean β =	37 27·85
Face reversed . . .	37 32 31		
		Mean of the dip $\frac{\alpha + \beta}{2}$ =	37 33·89
Dip corrected for error of needle			37 34·24

3. Vertical Intensity . . . . 5·326

4. Total Intensity . . . . 8·734

GROUP VII.

KĂMÁON AND GĂṘHVAL.

Nainitál.—Mílum.—Mána.—Ussílla.—Mässúri.

No. 50. Nainitál, in Kămáon.

Latitude North.	Longitude East Green.	Height of the lake
29° 23′ 34″	79° 30′ 55″	6,409 feet.

On detritus along the southern end of the lake. See p. 197.

Observer: Adolphe.

DECLINATION.

1855, April 28, $6^h\ 0^m$ P.M. local time. Collimator 2; Theodolite 2, Jones; Chron. 1.

	° ′
Magnetic meridian	140 29·4
True meridian (see p. 198)	138 1·2
Declination East	2 28·2

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, May 3, $9^h\ 40^m$ A.M. local time.

Magnet vibrated: *B* 7. Temp.: 23°·0 C., 73°·4 Fahr.

Chron. *A*, losing $4^s·4$.

No. of vibration	604	Time of 1 vibration	$3^s·029$
Semiarc { beginning	203	q =	0·00021
Semiarc { ending	90	μ =	0·00017
Torsion (90°)	12′	Time of 1 vibration corr.	$3^s·078$

log K = 0·26891 log $m\,X$ = 0·28667

B. *Deflection.*

1855, May 1, $4^h\ 0^m$ P.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 24°·0 C., 75°·2 Fahr. / 22·1 C., 71·8 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
$u_0 =$	3° 27′ 11″	1° 37′ 24″	Temp. of magnet . .	23°·9 C.	21°·9 C.
$\mu =$	0·00017	0·00017		75·0 Fahr.	71·4 Fahr.
			$q =$	0·00021	0·00021

$$\log \frac{m}{X} = 8 \cdot 51293$$

$m = 0 \cdot 2511$ $X =$ Horizontal Intensity $= 7 \cdot 707$

2. Dip.

1855, May 2, 12^h Noon local time.

Dip needle: No. 4. Temp.: 26°·2 C., 79°·2 Fahr.

End *A*.

	° ′		
Face to instrument	38 35·0	Mean α =	38° 32′·1
Face reversed . . .	38 29·2		

End *B*.

	° ′		
Face to instrument	38 44·20	Mean β =	38 37·08
Face reversed . . .	38 29·95		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 38 34·59

Dip corrected for error of needle . . . . 38 33·71

3. Vertical Intensity . . . . 6·144

4. Total Intensity . . . . 9·856

No. 51. Mílum, in Johár.

Latitude North.	Longitude East Green.	Height.
30° 34′ 35″	79° 54′ 49″	11,640 feet.

On detritus resting on rocks. See p. 198.

Observer: Adolphe.

DECLINATION.

1855, July 24, 3^h 10^m P.M. local time. Collimator 2; Theodolite 2, Jones; Chron. 1.

	° ′
Magnetic meridian	349 53·2
True meridian (see p. 200)	347 12·9
Declination East	2 40·3

INTENSITY.

1. Horizontal Insensity.

A. *Vibration.*

1855, July 2, 9^h 20^m A.M. local time.

Magnet vibrated: *B* 7. Temp.: 19°·0 C., 66°·2 Fahr.

Chron. *A*, losing $4^s·6$.

No. of vibrations	260	Time of 1 vibration	$3^s·058$
Semiarc beginning	263	q =	0·00021
Semiarc ending	171	μ =	0·00017
Torsion (90°)	9′	Time of 1 vibration corr.	$3^s·073$

log K = 0·26891 log mX = 0·28798

B. *Deflection.*

1855, June 25, 9^h 0^m A.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 17°·6 C., 63°·7 Fahr. / 18°·2 C., 64°·8 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 27′ 28″	1° 34′ 43″	Temp. of magnet . .	17°·6 C.	18°·2 C.
μ =	0·00017	0·00017		63·7 Fahr.	64·8 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8·48484$$

m = 0·2434 X = Horizontal Intensity = 7·972

2. Dip.

1855, June 26, 6^h 15^m P.M. local time.

Dip needle: No. 3. Temp.: 16°·4 C., 61°·5 Fahr.

End *A*.

	° ′
Face to instrument	42 0·65
Face reversed . . .	41 38·0

Mean α = 41° 49′·33

End *B*.

Face to instrument	39° 20′·4	Mean β =	39° 19′·4
Face reversed . . .	39 18·4		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 40 34·37

Dip corrected for error of needle . . . . 40 31·91

3. Vertical Intensity . . . . 6·815

4. Total Intensity . . . . 10·489

No. 52. Mána, in Gărhvál.

Latitude North.	Longitude East Green.	Height.
30° 47′ 0″	79° 20′ 50″	10,670 feet.

On detritus of the "Vishnugánga" river. See p. 200.

Observer: Adolphe.

DECLINATION.

1855, September 1, 2^h 45^m P.M. local time. Collimator 2; Theodolite 2, Jones; Chron. 1.

Magnetic meridian	51° 4′·4
True meridian (see p. 201)	48 19·5
Declination East	2 44·9

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, September 1, 4^h 15^m P.M. local time.

Magnet vibrated: *B* 7. Temp.: 17°·6 C., 63°·6 Fahr.

Chron. *A*, losing 5^s·0.

No. of vibrations	320	Time of 1 vibration	3^s·065
Semiarc { beginning	235	q =	0·00021
Semiarc { ending	138	μ =	0·00017
Torsion (90°)	7′	Time of 1 vibration corr.	3^s·081

log K = 0·26891 log mX = 0·28583

B. *Deflection.*

1855, September 1, 8^h 30^m A.M. local time.

Magnet: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 13°·0 C., 55°·4 Fahr. / 13·3 C., 56·0 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 22′ 50″	1° 34′ 20″	Temp. of magnet . .	13°·3 C.	14°·0 C.
μ =	0·00017	0·00017		55·9 Fahr.	57·2 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8\cdot49117$$

$m = 0\cdot2446$ $\quad X$ = Horizontal Intensity = 7·894

2. Dip.

1855, September 1, 5^h 45^m P.M. local time.

Dip needle: No. 3. Temp.: 16°·4 C., 61°·4 Fahr.

End *A*.

	° ′	
Face to instrument	42 27·8	Mean α = 42° 17′·9
Face reversed . . .	42 8·0	

End *B*.

	° ′	
Face to instrument	40 41·5	Mean β = 40 37·5
Face reversed . . .	40 33·5	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 41 27·7

Dip corrected for error of needle . . . . 41 25·24

3. Vertical Intensity . . . . 6·965

4. Total Intensity . . . . 10·528

No. 54. Ussílla, in Gărhvál.[1]

Latitude North.	Longitude East Green.	Height.
31° 7′ 40″	78° 18′ 10″	8,940 feet.

200 yards south from the village; near a cultivated field. See p. 202.

Observer: Adolphe.

[1] For facilitating reference from the magnetic observations to the astronomical determinations of latitudes and longitudes, we here omit those stations where astronomical observations alone have been made, in order that the numbers may be uniform with those in Part II. of this volume. Compare p. 127.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1855, October 8, $10^h\ 30^m$ A.M. local time.

Magnet vibrated: *B* 7. Temp.: 13°·2 C., 55°·8 Fahr.

Chron. *A*, losing $5^s\cdot 2$.

No. of vibrations	220	Time of 1 vibration	$3^s\cdot 084$
Semiarc, beginning	120	q =	0·00021
Semiarc, ending	72	μ =	0·00017
Torsion (90°)	0′	Time of 1 vibration corr.	$3^s\cdot 100$

log K = 0·26891 log mX = 0·28049

B. *Deflection.*

1855, October 8, $9^h\ 7^m$ A.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 10°·5 C., 50°·9 Fahr. / 11·0 C., 51·8 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 27′ 35″	1° 33′ 3″	Temp. of magnet	11°·5 C.	12°·0 C.
μ =	0·00017	0·00017		52·7 Fahr.	53·6 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8\cdot 46170$$

m = 0·2350 X = Horizontal Intensity = 8·116

2. Dip.

1855, October 8, $11^h\ 30^m$ A.M. local time.

Dip needle: No. 3. Temp.: 27°·2 C., 81°·0 Fahr.

End *A*.

	°	′		°	′
Face to instrument	43	0·80	Mean α =	43	4·59
Face reversed	43	8·38			

End *B*.

	°	′		°	′
Face to instrument	41	24·0	Mean β =	41	26·8
Face reversed	41	29·6			

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 42 15·70

Dip corrected for error of needle . . . . 42 13·24

3. VERTICAL INTENSITY . . . . 7·366

4. TOTAL INTENSITY . . . . 10·960

No. 55. MĂSSÚRI, IN GĂRHVÁL.

Latitude North.	Longitude East Green.	Height.
30° 28′ 30″	77° 59′ 58″	7,549 feet.

On a small open place on the southern flanks of the hills. The co-ordinates are referred to Banóg Hill. See p. 203.

Observer: Adolphe.

INTENSITY.

1. HORIZONTAL INTENSITY.

A. *Vibration.*

1855, November 7, 8^h 0^m A.M. local time.

Magnet vibrated: *B* 7. Temp.: 11°·0 C., 51°·8 Fahr.

Chron. *A*, losing $5^s·2$.

No. of vibrations		280	Time of 1 vibration	$3^s·073$
Semiarc	beginning	176·5	q =	0·00021
	ending	106·5	μ =	0·00017
Torsion (90°)		1′	Time of 1 vibration corr.	$3^s·091$

log K = 0·26891 log mX = 0·28306

B. *Deflection.*

1855, November 6, 4^h 15^m P.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp.: 14°·0 C., 57°·2 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 26′ 54″	1° 32′ 58″	Temp. of magnet	14°·0 C.	14°·0 C.
μ =	0·00017	0·00017		57·2 Fahr.	57·2 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8·46338$$

m = 0·2362 X = Horizontal Intensity = 8·125

2. Dip.

1855, November 6, 8^h 45^m A.M. local time.

Dip needle: No. 3. Temp. 11°·8 C., 53°·2 Fahr.

End *A*.

	° ′	
Face to instrument	42 3·9	Mean α = 42° 4′·35
Face reversed . . .	42 4·8	

End *B*.

	° ′	
Face to instrument	40 40·8	Mean β = 40 30·8
Face reversed . . .	40 20·8	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 41 17·58

Dip corrected for error of needle . . . . 41 15·12

3. Vertical Intensity . . . . 7·127

4. Total Intensity . . . . 10·807

GROUP VIII.

SÍMLA TO HAZÁRA.

Vángtu bridge.—Rámpur.—Símla.—Sultánpur.—Kárdong.—Srinágger.—Dáver.—Mozăferabád.—Márr

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No. 56. Vángtu, in the Province of Símla.

Latitude North.	Longitude East Green.	Height.
31° 37′ 0″	77° 54′ 0″	4,200 feet.

On detritus accumulated by the Sátlej, 50 feet above the level of the river. See p. 203.

Observer: Hermann.

Dip.

1856, June 4, 7^h 45^m P.M. local time.

Dip needle: No. 2. Temp. 17°·6 C., 63°·7 Fahr.

End *A*.

	° ′	
Face to instrument	43 19·5	Mean α = 43° 19′·0
Face reversed . . .	43 18·5	

End *B*.

Face to instrument	43° 29′·0	Mean β = 43° 26′·1	
Face reversed . . .	43 23·2		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 43 22·55

Dip corrected for error of needle . . . . 43 22·80

No. 57. Rámpur, in the Province of Símla.

Latitude North.	Longitude East Green.	Height.
31° 31′ 0″	77° 37′ 0″	3,215 feet.

Near the village; on alluvial soil deposited by the Sátlej. See p. 203.

Observer: Hermann.

Dip.

1856, June 2, 6^h 35^m P.M. local time.

Dip needle: No. 2. Temp.: 16°·7 C., 62°·1 Fahr.

End *A*.

Face to instrument	42° 37′·8	Mean α = 42° 46′·15
Face reversed . . .	42 54·5	

End *B*.

Face to instrument	42° 38′·0	Mean β = 42 46·0
Face reversed . . .	42 54·0	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 42 46·08

Dip corrected for error of needle . . . . 42 46·43

No. 58. Símla, in the Province of Símla.

Latitude North.	Longitude East Green.	Height.
31° 6′ 6″	77° 7′ 36″	7,091 feet.

On a mountain ridge thinly covered with decomposed rocks. See p. 204.

Observer: Adolphe.

DECLINATION.

1856, May 15, 2^h 30^m P.M. local time. Collimator 2; Theodolite 3, Troughton; Chron. 3.

	°	′
Magnetic meridian	13	1·0
True meridian (see p. 205)	10	5·5
Declination East	2	55·5

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, May 17, 11^h 30^m A.M. local time.

Magnet vibrated: *L* 1. Temp.: 20°·4 C., 68°·7 Fahr.

Chron. *A*, losing 3^s·0.

No. of vibrations	400	Time of 1 vibration	2^s·890
Semiarc { beginning	150·5	q =	0·00020
Semiarc { ending	92·5	μ =	0·00017
Torsion (90°)	3′	Time of 1 vibration corr. . .	2^s·898

log K = 0·43821 log mX = 0·50836

B. *Deflection.*

1856, May 17, 3^h 27^m P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 3. Distances: 1 foot, 1·3 foot. Temp.: 22°·2 C., 72°·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	7° 5′ 17″	3° 14′ 53″	Temp. of magnet	22°·1 C.	21°·7 C.
μ =	0·00017	0·00017		71·8 Fahr.	71·1 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8{\cdot}79877$$

m = 0·4504 X = Horizontal Intensity = 7·158.

2. Dip.

1856, May 15, $3^h\ 0^m$ to $5^h\ 0^m$ P.M. local time.

Dip Needles.	Dip.
	° ′
No. 1	42 26·10
„ 2	42 28·38
„ 3	42 27·80
„ 4	42 37·72
Resulting Dip (mean of the four determinations)	42 30·0

The detail of the observations see in connection with the comparison of the needles, p. 296.

3. Vertical Intensity . . . . 6·559

4. Total Intensity . . . . 9·709

No. 59. Sultánpur, in Kúlu.

Latitude North.	Longitude East Green.	Height.
31° 57′ 50″	77° 5′ 50″	3,830 feet.

On a high bank of diluvium, on the Biás river. See p. 205.

Observer: Adolphe.

DECLINATION.

1856, June 5, $11^h\ 40^m$ A.M. local time. Theodolite 3, and Needle, Troughton; Chron. 1.

	° ′
Magnetic meridian	229 8·6
True meridian (see p. 206)	226 6·0
Declination East	3 2·6

Dip.

1856, June 5, $8^h\ 30^m$ A.M. local time.

Dip needle: No. 3. Temp.: 20°·0 C., 68°·0 Fahr.

End *A*.

	° ′	
Face to instrument	44 34·0	Mean α = 44° 35′·5
Face reversed . . .	44 37·0	

End *B*.

	° ′		° ′
Face to instrument	43 17·3	Mean β =	43 13·8
Face reversed . . .	43 10·3		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 43 54·65

Dip corrected for error of needle . . . . 43 52·19

No. 60. Kárdong, in Lahól.

Latitude North.	Longitude East Green.	Height.
32° 33′ 50″	77° 0′ 35″	10,233 feet.

On detritus deposited by the river "Chináb". See p. 206.

Observer: Adolphe.

DECLINATION.

1856, June 14, 8ʰ 0ᵐ A.M. local time. Collimator 2; Theodolite 3, Troughton; Chron. 1.

	° ′
Magnetic meridian	140 49·1
True meridian (see p. 206)	137 25·8
Declination East	3 23·3

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, June 14, 12^h 30^m P.M. local time.

Magnet vibrated: *B* 7. Temp.: 19°·2 C., 66°·5 Fahr.

Chron. *A*, losing $4^s \cdot 5$.

No. of vibrations	300	Time of 1 vibration	$3^s \cdot 226$
Semiarc { beginning	208	$q =$	0·00021
Semiarc { ending	53	$\mu =$	0·00017
Torsion (90°)	3′	Time of 1 vibration corr. . .	$3^s \cdot 241$

log K = 0·26891 log mX = 0·24179

B. *Deflection.*

1856, June 14, 4^h 0^m P.M. local time.

Magnets: Deflecting B 7, deflected B 2.

Deflection bar: A. Distances: 1 foot, 1·3 foot. Temp. { 14°·4 C., 58°·0 Fahr. / 13·8 C., 56·8 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
$u_0 =$	3° 19′ 41″	1° 30′ 22″	Temp. of magnet . .	11°·4 C.	13°·0 C.
$\mu =$	0·00017	0·00017		52·5 Fahr.	55·4 Fahr.
			$q =$	0·00021	0·00021

$$\log \frac{m}{X} = 8 \cdot 45520$$

$m = 0 \cdot 2231$ X = Horizontal Intensity = 7·821

2. Dip.

1856, June 12, 4^h 40^m P.M. local time.

Dip needle: No. 3. Temp.: 16°·0 C., 60°·8 Fahr.

End A.

	° ′	
Face to instrument	45 0·4	Mean α = 45° 16′·4
Face reversed . . .	45 32·4	

End B.

	° ′	
Face to instrument	43 48·8	Mean β = 43 45·4
Face reversed	43 42·0	

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 44 30·90

Dip corrected for error of needle . . . . 44 28·44

3. Vertical Intensity . . . . 7·679

4. Total Intensity . . . . 10·960

No. 61. Srinágger, Capital of Kashmír.

Latitude North.	Longitude East Green.	Height.
34° 4′ 36″	74° 48′ 30″	5,144 feet.

On very fertile lacustrine deposits, in a garden. See p. 206.

Observers: Adolphe and Robert.

DECLINATION.

1856, October 25, 4^h 50^m P.M. local time. Collimator 2; Theodolite 3, Troughton; Chron. 3.

	° ′
Magnetic meridian	239 10·4
True meridian (see p. 209)	236 10·5
Declination East	2 59·9

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, October 21, 3^h 20^m P.M. local time.

Magnet vibrated: *B* 7. Temp.: 19°·4 C., 67°·0 Fahr.

Chron. 3, gaining 1^s·01.

No. of vibrations	100	Time of 1 vibration	3^s·320
Semiarc beginning	167	q =	0·00021
Semiarc ending	56	μ =	0·00017
Torsion (90°)	8′	Time of 1 vibration corr.	3^s·336

$\log K = 0·26891$ $\log mX = 0·21676$

B. *Deflection.*

1856, October 22, 3^h 30^m P.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1·3 foot, 1·5 foot. Temp. { 19°·1 C., 66°·3 Fahr. / 18·4 C., 65·2 Fahr. }

	1·3 foot.	1·5 foot.		1·3 foot.	1·5 foot.
u_0 =	1° 42′ 42″	0° 58′ 49″	Temp. of magnet . .	19°·2 C.	18°·3 C.
μ =	0·00017	0·00017		66·5 Fahr.	65·0 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8·55001$$

$m = 0·2418$ X = Horizontal Intensity = 6·814

2. Dip.

1856, October 23, $2^h\ 0^m$ to $3^h\ 50^m$ P.M. local time.

Dip Needles.	Dip.
	° ′
No. 1	46 48·80
2	46 51·02
3	46 57·27
4	46 44·01
Resulting Dip (mean of the four determinations)	46 58·28

The detail of the observations see in connection with the comparison of the needles, p. 297.

3. Vertical Intensity . . . . 7·300

4. Total Intensity . . . . 9·986

SRINÁGGER DAILY VARIATIONS.

A. *Declination.*

From October 27 to October 31 observations on the daily variation of the declination were made, the units of the scale readings being tenths of a minute. The time of the observation includes maximum and minimum, and consequently the curves could easily be completed for the few remaining hours of the night.

Increasing numbers correspond to an easterly motion of the declination.

Scale Readings of the Declinometer.

Srinágger, 1856, October.

Unit = $\frac{1}{10}$ Minute.

1856,	4^h A.M.	6^h	9^h	Noon	2^h P.M.	4^h	6^h	7^h	9^h	9^h	10^h P.M.
Oct. 27	285	285	292	300	303	301	299	298	298	297	296
„ 28	285	286	293	298	300	299	294	292	293	293	292
„ 29	292	293	293	296	299	293	292	291	291	290	289
„ 30	293	293	292	296	297	299	299	297	296	297	297
„ 31	270	270	276	272	268	267	268	267	268	267	267
Mean . . .	285·0	285·4	289·2	292·4	293·4	291·8	290·4	289·0	289·2	288·8	288·2

If, after completing the curves, we take the mean of the 24 hours, we obtain as differences the following values for the daily variation corresponding to each hour:

DECLINATION at SRINÁGGER; Daily Variation: 1856, October 27 to 31, local time.

A.M.		P.M.	
Midnight	— 0·25	Noon	+ 0·36
1	— 0·21	1	+ 0·39
2	— 0·28	2	+ 0·46
3	— 0·33	3	+ 0·39
4	— 0·38	4	+ 0·30
5	— 0·38	5	+ 0·19
6	— 0·34	6	+ 0·16
7	— 0·19	7	+ 0·01
8	— 0·03	8	+ 0·04
9	+ 0·03	9	— 0·00
10	+ 0·13	10	— 0·08
11	+ 0·11	11	— 0·17

In Fig. 3, Plate 2 (p. 386), the curves of these differences, with the corresponding observations at Bombay, are drawn. The hours and the general form coincide very well for November, but the amplitude is considerably smaller at Srinágger.

B. *Horizontal Intensity.*

The deflection by L 1 was observed from October 27 to 31, from 6^h A.M. to 6^h P.M. The scale readings are tenths of the minute, and their differences, multiplied by 0·00322, give the absolute values of variations of horizontal intensity in English units. Increasing numbers correspond to an increase of intensity.

DEFLECTION at SRINÁGGER, 1856, October, local time.

	6^h A.M.	9^h	Noon	2^h P.M.	4^h	6^h
October 27	280	280	271	280	280	281
" 28	280	280	280	280	267	268
" 29	275	277	270	268	268	268
" 30	275	278	278	268	268	268
" 31	300	300	298	298	300	300
Mean	282·0	283·0	279·4	278·8	276·6	277·0

Differences (variations of Horizontal Intensity)	6h–9h	9h–Noon	Noon–2h	2h–4h	4h–6h
in scale readings	+ 1·0	— 3·6	— 0·6	— 2·2	+ 0·4
in absolute values	+ 0·00322	— 0·01159	— 0·00193	— 0·00708	+ 0·00129

VARIATION OF HORIZONTAL INTENSITY at BOMBAY, 1856, October, local time.

	$6^h\ 12^m$ A. M.	$9^h\ 12^m$	$12^h\ 12^m$ P. M.	$2^h\ 12^m$	$4^h\ 12^m$	$6^h\ 12^m$
October 27	. . .	. . .	. . .	. . .	8·0438	8·0432
" 28	8·0481	8·0540	8·0557	8·0497	8·0457	8·0421
" 29	8·0454	8·0546	8·0559	8·0524	8·0473	8·0426
" 30	8·0388	8·0534	8·0585	8·0516	8·0461	8·0409
" 31	8·0453	8·0538	8·0579	8·0518	8·0483	8·0459
Mean	8·0444	8·05395	8·0570	8·051375	8·04624	8·04294
Differences (variations of Horizontal Intensity in absolute values)	+ 0·00955	+ 0·00305	— 0·005625	— 0·005135	— 0·00330	

No. 62. DÁVER, IN KASHMÍR.

Latitude North.	Longitude East Green.	Height.
34° 34′ 5″	74° 46′ 0″	7,718 feet.

Near the fort; on alluvial soil. See p. 209.

Observer: Adolphe.

DIP.

1856, October 4, $7^h\ 45^m$ A.M. local time.

Dip needle: No. 4. Temp.: 10°·6 C., 51°·1 Fahr.

End *A*.

	° ′		
Face to instrument	47 39·5	Mean α =	47° 37′·55
Face reversed . . .	47 35·6		

End *B*.

	° ′		
Face to instrument	47 48·6	Mean β =	47 47·5
Face reversed . . .	47 46·4		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 47 42·53

Dip corrected for error of needle . . . . 47 41·65

No. 63. MOZĂFERABÁD, IN KASHMÍR.

Latitude North.	Longitude East Green.	Height.
34° 22′ 25″	73° 31′ 10″	2,220 feet.

On a level place, covered with grass. See p. 210.

Observer: Robert.

DECLINATION.

1856, November 10, $5^h\ 30^m$ P.M. local time. Collimator 1[1]; Theodolite 2, Jones; Chron. 5.

	° ′
Magnetic meridian	166 50·5
True meridian (see p. 212)	163 26·6
Declination East	3 23·9

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, November 10, $1^h\ 30^m$ P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring. Temp. { 19°·8 C., 67°·6 Fahr. / 20·0 C., 68·0 Fahr.

Chron. 5, Grant, gaining $14^s·0$.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	550	300	Time of 1 vibration	$3^s·017$	$8^s·114$
Semiarc { beginning	218·5	165	q =	0·00020	0·00020
Semiarc { ending	79·5	139·5	μ =	0·00017	0·00017
Torsion (90°)	2′	2′	Time of 1 vibration corr. .	$3^s·025$	$8^s·134$

$\log K_{,} = 0·43868$ $\qquad \log K = 0·43821$

$\log mX = 0·47097$

B. *Deflection.*

1856, November 10, $4^h\ 0^m$ P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 3. Distances: 1 foot, 1·3 foot. Temp. { 19°·6 C., 67°·3 Fahr. / 19·2 C., 66·6 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	7° 10′ 9″	3° 20′ 54″	Temp. of magnet . .	19°·6 C.	19°·2 C.
μ =	0·00017	0·00017		67·3 Fahr.	66·6 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·82402$$

$m = 0·4441$ $\qquad X$ = Horizontal Intensity = 6·660

[1] On the way from Kashmír to Raulpíndi Adolphe and Hermann travelled together, and Robert had Hermann's magnetic instruments with him.

2. Dip.

1856, November 11, $8^h 5^m$ A.M. local time.

Dip needle: No. 2. Temp.: 8°·9 C., 48°·0 Fahr.

End *A*.

	° ′	
Face to instrument	47 14·6	Mean α = 47° 14′·05
Face reversed . . .	47 13·5	

End *B*.

	° ′	
Face to instrument	47 57·0	Mean β = 47 25·25
Face reversed . . .	46 53·5	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 47 19·65

Dip corrected for error of needle . . . . 47 20·00

3. Vertical Intensity . . . . 7·226

4. Total Intensity . . . . 9·827

No. 64. Márri, in the Province of Márri.

Latitude North.	Longitude East Green.	Height.
33° 51′ 0″	73° 22′ 40″	7,260 feet.

In one of the gardens of the station. See p. 213.

Observers: Hermann and Adolphe.

DECLINATION.

1856, November 13, $6^h 20^m$ P.M. local time. Collimator 2; Theodolite 3, Troughton; Chron 1.

	° ′
Magnetic meridian	53 5·7
True meridian (see p. 214)	49 44·6
Declination East	3 21·1

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, November 15, 5^h 37^m P.M. local time.

Magnet vibrated: *B* 7. Temp.: 10°·1 C., 50°·2 Fahr.

Chron. *A*, losing $3^s·0$.

No. of vibrations	380	Time of 1 vibration	$3^s·289$
Semiarc beginning	131·5	q =	0·00021
Semiarc ending	80	μ =	0·00017
Torsion (90°)	3′	Time of 1 vibration corr.	$3^s·310$
$\log K$ =	0·26891	$\log mX$ =	0·22355

B. *Deflection.*

1856, November 13, 3^h 17^m P.M. local time.

Magnets: deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp.: 11°·1 C., 52°·0 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 22′ 9″	1° 41′ 3″	Temp. of magnet	11°·1 C.	11°·1 C.
μ =	0·00017	0·00017		52·0 Fahr.	52·0 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8·57325$$

m = 0·2503 X = Horizontal Intensity = 6·686

2. Dip.

A. 1856, November 13, 4^h 30^m P.M. local time.

Dip needle: No. 3. Temp.: 27°·7 C., 81°·8 Fahr.

End *A*.

	° ′		° ′
Face to instrument	46 46·2	Mean α =	46 49·3
Face reversed	46 52·4		

End *B*.

	° ′		° ′
Face to instrument	45 30·3	Mean β =	45 30·5
Face reversed	45 30·7		

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 46 9·90

Dip corrected for error of needle . . . . 46 7·44

B. 1856, November 15, $12^h\ 30^m$ P.M. local time.

Dip needle: No. 3. Temp.: 22°·8 C., 73°·1 Fahr.

End *A*.

	° ′	
Face to instrument	46 47·0	Mean α = 46° 42′·9
Face reversed . . .	46 38·8	

End *B*.

	° ′	
Face to instrument	45 11·5	Mean β = 45 18·5
Face reversed . . .	45 25·5	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 46 0·70

Dip corrected for error of needle . . . . 45 58·24

General Mean . . . . 46 2·84

3. Vertical Intensity . . . . 6·935

4. Total Intensity . . . . 9·633

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b. TÍBET.

GROUP IX.

GNÁRI KHÓRSUM.

In calculating our observations taken in this province, we found that the readings were generally insufficient or inaccurate. This arises chiefly from the difficulties under which we had to make them. When travelling in disguise, as we did in this case, we were obliged to pack up hurriedly, or to conceal our instruments, whenever we saw people not belonging to us approaching our camp. Subsequently, however, we learnt by experience to take precautions against disturbance, by stationing outposts in advance of us.

GROUP X.

LADÁK.

Mūd.—Tsomoríri.—Tsomognalarí.—Leh.—Pádum.—Sásser pass.—Kárgil.—Dras.

No. 74. Mūd, in Spíti.

Latitude North.	Longitude East Green.	Height.
31° 55′ 35″	78° 1′ 20″	12,421 feet.

On a high bank of detritus of sedimentary rocks. See p. 228.

Observer: Hermann.

DECLINATION.

1856, June 13, 2^h 30^m P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	62 19·4
True meridian (see p. 229)	58 35·9
Declination East	3 43·5

Dip.

1856, June 13, 6^h 0^m P.M. local time.

Dip needle: No. 2. Temp.: 10°·6 C., 51°·1 Fahr.

End *A*.

	° ′	
Face to instrument	44 22·0	Mean α = 44° 16′·9
Face reversed . . .	44 11·8	

End *B*.

	° ′	
Face to instrument	44 18·3	Mean β = 44 18·05
Face reversed . . .	44 17·8	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 44 17·48

Dip corrected for error of needle . . . . 44 17·83

No. 75. Tsomoríri Salt Lake, in Spíti.

Latitude North.	Longitude East Green.	Height.
32° 45′ 25″	78° 16′ 36″	15,130 feet.

On the right shore of the lake, in a place formerly under water, and at present covered with saline deposits. See p. 229.

Observer: Hermann.

DECLINATION.

1856, June 21, $4^h\ 50^m$ P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	115 21·3
True meridian (see p. 231)	112 11·4
Declination East	3 9·9

DIP.

1856, June 22, $4^h\ 30^m$ P.M. local time.

Dip needle: No. 2. Temp.: 8°·4 C., 47°·1 Fahr.

End *A*.

	° ′	
Face to instrument	45 37·2	Mean α = 45° 22′·0
Face reversed	45 6·8	

End *B*.

	° ′	
Face to instrument	45 16·8	Mean β = 45 17·9
Face reversed	45 19·0	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 45 19·95

Dip corrected for error of needle .... 45 20·30

No. 76. TSOMOGNALARÍ, THE GREAT SALT LAKE, IN THE DISTRICT OF PANGKÓNG.

Latitude North.	Longitude East Green.	Height.
33° 39′ 50″	78° 38′ 30″	14,010 feet.

On a terrace of gravel, on the left shore of the lake. See p. 231.

Observer: Hermann.

DECLINATION.

1856, July 2, $9^h\ 10^m$ A.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

	° ′
Magnetic meridian	66 8·3
True meridian (see p. 232)	62 46·5
Declination East	3 21·8

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, July 2, 2^h 30^m P.M. local time.

Magnet vibrated { *L* 1 / *L* 1 with ring. Temp. { 15°·8 C., 60°·4 Fahr. / 16·1 C., 61·0 Fahr.

Chron. 3, gaining 1^s·01.

	Without ring.	With ring.
No. of vibrations	200	31
Semiarc { beginning	140	80
Semiarc { ending	70	70
Torsion (90°)	0′	0′

	Without ring.	With ring.
Time of 1 vibration	2^s 977	7^s·948
q =	0·00020	0·00020
μ =	0·00017	0·00017
Time of 1 vibration corr.	3^s·008	7^s·975

$\log K_{,} = 0\cdot44591$ $\log K = 0\cdot43821$

$\log mX = 0\cdot47591$

B. *Deflection.*

1856, July 2, 9^h 30^m A.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 3. Distances: 1 foot, 1·3 foot. Temp. { 14°·4 C., 57°·9 Fahr. / 15·0 C., 59·0 Fahr.

	1 foot.	1·3 foot.
u_0 =	7° 27′ 48″	3° 21′ 59″
μ =	0·00017	0·00017

	1 foot.	1·3 foot.
Temp. of magnet	13°·9 C.	14°·8 C.
	57·0 Fahr.	58·6 Fahr.
q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot80370$$

$m = 0\cdot4363$ X = Horizontal Intensity = 6·856

2. Dip.

1856, July 3, 12^h Noon local time.

Dip needle: No. 2. Temp.: 14°·1 C., 57°·4 Fahr.

End *A*.

	° ′
Face to instrument	46 30·8
Face reversed	46 37·7

Mean α = 46° 34′·25

End *B*.

Face to instrument	46° 33′·0	Mean β =	46° 33′·15
Face reversed . . .	46 33·3		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 46 33·70

Dip corrected for error of needle . . . . 46 34·05

3. VERTICAL INTENSITY . . . . 7·242

4. TOTAL INTENSITY . . . . 9·972

No. 78. LEH, IN LADÁK.

Latitude North.	Longitude East Green.	Height.
34° 8′ 21″	77° 14′ 36″	11,527 feet.

In a large open place at the lower end of the town.[1] See p. 234.

Observer: Hermann and Robert.

FIRST SERIES.

DECLINATION.

1856, July 18, 3h 35m P.M. local time. Collimator 1; Theodolite 2, Jones; Chron. 3.

Magnetic meridian	139° 0′·3
True meridian, (see p. 241)	135 36·2
Declination East	3 24·1

INTENSITY.

1. HORIZONTAL INTENSITY.

A. *Vibration*.

1856, July 16, 11h 56m A.M. local time.

Magnet vibrated	*L* 1	Temp.	29°·3 C., 84°·8 Fahr.
	L 1 with ring.		30·0 C., 86·0 Fahr.

Chron. *H*, losing 0s·3.

[1] Compare plate 9 of the Atlas of Panoramas, Views, &c., giving a general view of the town, and showing also the position of the tent with the magnetic instruments.

	Without ring.	With ring.		Without ring.	With ring.
No. of vibrations	400	100	Time of 1 vibration	$2^s\cdot973$	$8^s\cdot071$
Semiarc { beginning	132	19·5	q =	0·00020	0·00020
Semiarc { ending	37·5	165	μ =	0·00017	0·00017
Torsion (90°)	6′	6′	Time of 1 vibration corr.	$2^s\cdot977$	$8^s\cdot080$

$\log K_{,} = 0\cdot42926 \qquad \log K = 0\cdot43821$

$\log mX = 0\cdot48495$

B. *Deflection.*

1856, July 17, $10^h\ 10^m$ A.M. local time.

Magnets: Deflecting L 1, deflected H 21.

Deflection bar: H 3. Distances: 1 foot, 1·3 foot. Temp. { 25°·8 C., 78°·4 Fahr. / 26·2 C., 79·2 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	7° 9′ 29″	3° 16′ 9″	Temp. of magnet	25°·0 C.	26°·6 C.
μ =	0·00017	0·00017		77·0 Fahr.	79·9 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot80055$$

$m = 0\cdot4393 \qquad X$ = Horizontal Intensity = 6·953

2. Dip.

1856, July 16, $4^h\ 30^m$ P.M. local time.

Dip needle: No. 2. Temp.: 27°·8 C.; 82°·5 Fahr.

End *A*.

	° ′	
Face to instrument	47 0·0	Mean α = 46° 55′·86
Face reversed	46 51·72	

End *B*.

	° ′	
Face to instrument	46 48·77	Mean β = 46 48·72
Face reversed	46 48·68	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 46 52·29

Dip corrected for error of needle . . . . 46 52·64

3. Vertical Intensity . . . . 7·426

4. Total Intensity . . . . 10·172

SECOND SERIES.[1]

DECLINATION.

1856, September 30, $5^h 50^m$ P.M. local time. Collimator 1; Theodolite 1, Jones; Chron. 3.

	° ′
Magnetic meridian	228 36·7
True meridian (see p. 241)	225 15·6
Declination East	3 21·1

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, September 29, $4^h 0^m$ P.M. local time.

Magnet vibrated: $L1$. Temp.: 10°·8 C., 51°·5 Fahr.

Chron. H, losing $0^s·5$.

No. of vibrations	100	Time of 1 vibration	$2^s·992$
Semiarc { beginning	138·5	q =	0·00020
Semiarc { ending	109·5	μ =	0·00017
Torsion (90°)	9′	Time of 1 vibration corr.	$3^s·007$

$\log K = 0·43821$ $\log mX = 0·47625$

B. *Deflection.*

1856, September 28, $5^h 0^m$ P.M. local time.

Magnets: Deflecting $L1$, deflected $H21$.

Deflection bar: $H3$. Distances: 1 foot, 1·3 foot. Temp. { 13°·0 C., 55°·4 Fahr. / 12·0 C., 53·6 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	7° 9′ 17″	3° 16′ 17″	Temp. of magnet . .	13°·0 C.	12°·0 C.
μ =	0·00017	0·00017		55·4 Fahr.	53·6 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·80184$$

$m = 0·4355$ X = Horizontal Intensity = 6·873

[1] A combination of observations, not quite so complete, July 17 and 18, gave:

log K, ...	0·43382	
Dip	46° 52′·64	Compare Münchner gelehrte Anzeigen, 1859, No. 37.
Horizontal Intensity	6·922	
Total Intensity . . .	10·126	

Though the difference is but very small, we thought it preferable not to take the mean of all three.

2. Dip.

1856, September 28, $10^h\ 0^m$ A.M. local time.

Dip needle: No. 2. Temp.: 14°·2 C., 57°·6 Fahr.

End *A*.

Face to instrument	46° 46'·19	Mean α = 46° 45'·02
Face reversed . . .	46 43·84	

End *B*.

Face to instrument	46° 55'·67	Mean β = 46 56·51
Face reversed . . .	46 57·34	

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 46 50·77

Dip corrected for error of needle . . . . 46 51·12

Mean of the two series . . . . 46 51·88

3. Vertical Intensity . . . . 7·336

4. Total Intensity . . . . 10·053

DAILY VARIATIONS.

1. Declination.

The daily variations of the declination were regularly observed at Leh, during our absence in Turkistán in the months of August and September.

We put up the magnet *D* 2 in a box similar to the vibration apparatus; a scale, which was reflected in the mirror attached to the magnet, showed its angular motion.

The scale rested on a portion of a circle, the radius of which was its distance from the centre of the magnet; the units read on the scale were $^1/_{40}$ minute, and its neutral point (the original position of the 0 point) was arbitrary.

The regular observations were made during our absence from 6^h A.M. to 8^h P.M., and the hours were changed periodically, the better to define the daily motion. Observations taken by ourselves, before our departure and after our return from Turkistán, showed the time of greatest maximum to be $6^h\ 30^m$ A.M., and the time of greatest minimum $8^h\ 30^m$ P.M., which were data very valuable for the construction of the complete daily curve.

On the 6th of August,[1] Hărkíshen observed a decided vertical oscillation of the magnets, which lasted for nearly 14 hours. Though not at all aware of the possibility of such an oscillation occurring, yet he noted it down as a very remarkable phenomenon. At Bombay, the day is not marked as a day of disturbances. Only three similar instances of "constant vertical motion" have till now been recorded in Van Diemen's Island.[2]

The following tables contain the daily observations for August and September. The increasing numbers indicate a more easterly motion of the north end of the needle.

[1] General Sabine's observations have shown, that the month of September, in both hemispheres, in particularly rich in disturbances.

[2] Compare Humboldt's Cosmos. Vol. IV., p. 128.

DAILY OBSERVATIONS OF THE DECLINATION AT LEH.

Unit = $^1/_{40}$ Minute in Arc.

A. August, 1856.

1856, August.	A.M. 6h	7h	A.M. 9h	10h	Noon. 12h	P.M. 1h	P.M. 2h	3h	P.M. 4h	5h	P.M. 6h	7h	P.M. 8h
1		+ 32		+ 16		0		0		+ 8		0	
2		+ 32		+ 8		0		0		0		+ 4	
3		+ 44		+ 24		+ 8		— 4		+ 4		0	
4		0		0		— 8		+ 12		+ 16		— 32	
5		+ 80		+ 64		+ 56		+ 40		+ 16		+ 4	
6		+ 72		+ 64		+ 56		+ 52		+ 40		+ 24	
7		+ 80		+ 40		+ 40		+ 40		+ 40		+ 32	
8	+ 56		+ 56		+ 40		+ 40		+ 40		+ 40		+ 32
9	+ 48		+ 56		+ 32		+ 24		+ 32		+ 32		+ 36
10	+ 48		+ 40		0		+ 16		+ 16		+ 12		+ 12
11	+ 40		+ 20		0		+ 8		+ 6		+ 12		0
12	+ 40		+ 40		+ 16		+ 12		+ 40		+ 40		+ 40
13	+ 80		+ 60		+ 40		+ 24		+ 40		+ 20		+ 16
14	+ 40		+ 20		+ 24		+ 24		+ 8		0		+ 12
15		+ 40		+ 16		0		0		0		+ 8	
16		+ 16		+ 56		0		0		+ 16		+ 20	
17		+ 48		0		0		— 8		— 8		— 20	
18		+ 32		+ 16		0		0		0		— 8	
19		+ 40		+ 40		+ 32		+ 24		— 16		+ 20	
20		+ 40		+ 40		+ 20		+ 20		+ 8		0	
21		+ 40		+ 40		+ 32		+ 20		0		0	
22		+ 72		+ 40		+ 28		+ 32		0		0	
23	+ 80		+ 76		+ 72		+ 60		+ 48		+ 40		+ 40
24	+ 88		+ 80		+ 72		+ 60		+ 72		+ 56		+ 72
25	+ 60		+ 72		+ 32		+ 40		+ 40		+ 16		+ 40
26	+ 60		+ 40		+ 0		0		0		+ 8		+ 40
27	+ 80		+ 84		+ 72		+ 48		+ 40		+ 40		+ 40
28	+ 80		+ 64		+ 48		+ 32		+ 32		+ 32		+ 20
29	+ 40		+ 20		0		0		+ 20		+ 20		
30		+ 32	+ 4			0		0		+ 4		0	
31		+ 32	0			0		0		0		0	

B. September, 1856.

1856, September.	A.M. 6h	7h	A.M. 9h	10h	Noon. 12h	P.M. 1h	P.M. 2h	3h	P.M. 4h	5h	P.M. 6h	7h	P.M. 8h
1		+ 44		+ 44		+ 52		+ 44		+ 44		+ 52	
2		+ 80		+ 48		+ 20		+ 20		+ 28		+ 16	
3		+ 4		0		— 8		— 8		0		0	
4		+ 40		+ 40		+ 12		+ 32		+ 40		+ 40	
5		+ 72		+ 56		+ 40		+ 32		+ 32		+ 16	
6	+ 44		+ 40		+ 32		+ 20		+ 20		+ 40		+ 40
7	+ 80		+ 80		+ 72		+ 40		+ 40		+ 32		+ 24
8	+ 32		+ 4		+ 8		+ 4		+ 20		+ 20		+ 16
9	+ 16		+ 8		+ 4		+ 4		+ 4		0		0
10	+ 4		+ 4		— 8		— 8		— 8		— 12		— 8
11	0		— 24		— 8		— 8		— 8		— 16		— 16
12	0		0		— 8		0		— 8		0		0

For taking the means, the different hours of observation were combined as follows:

$\frac{1}{2}(6+7) = 6^h\,30^m$; $\frac{1}{2}(9+10) = 9^h\,30^m$; $\frac{1}{2}(10+12) = 11^h$; $\frac{1}{2}(12+1) = 12^h.30^m$;

$\frac{\frac{1}{2}(12+2)+1}{2} = 1^h$; $\frac{\frac{1}{2}(1+3)+2}{2} = 2^h$; $\frac{\frac{1}{2}(2+4)+3}{2} = 3^h$; $\frac{\frac{1}{2}(3+5)+4}{2} = 4^h$;

$\frac{\frac{1}{2}(4+6)+5}{2} = 5^h$; $\frac{\frac{1}{2}(5+7)+6}{2} = 6^h$; $\frac{\frac{1}{2}(6+8)+7}{2} = 7^h$.

The means so obtained are given in the following tables; but we have divided the results by 40 in order to show the differences in decimals of real minutes.

h m	1856, August 1 to 31.	September 1 to 12.
6 30	+ 1·288	+ 0·870
9 30	0·992	0·625
11 0	0·871	0·582
12 30	0·594	0·454
1 0	0·568	0·418
2 0	0·526	0·385
3 0	0·537	0·399
4 0	0·534	0·437
5 0	0·471	0·470
6 0	0·402	0·450
7 0	0·381	0·418

The absolute values were found:

		° ′
Declination East	July 31	3 24·1
	September 30 . . .	3 21·1

These two values, as well as the comparison of the variation in August and September, show that the declination during this period became a little more westerly; but the quantity is so small, that its numerical value remains unimportant.

The daily change of the magnetic declination is represented in curves (fig. 4, plate 2, p. 386), in which the data above communicated are introduced; the co-ordinates are the hours and 1/10 of the minutes of arc, the latter co-ordinates being at the same time referred to the true mean of the variation.

h	1856, August 1 to 31.	September 1 to 12.
12 Midnight	— 0·29	— 0·17
1 A.M.	— 0·19	— 0·06
2	— 0·06	+ 0·05
3	+ 0·06	+ 0·13
4	+ 0·24	+ 0·22
5	+ 0·46	+ 0·31
6	+ 0·59	+ 0·33
7	+ 0·61	+ 0·31
8	+ 0·53	+ 0·22
9	+ 0·37	+ 0·12
10	+ 0·26	+ 0·08
11	+ 0·20	+ 0·04
12 Noon	— 0·01	— 0·04
1 P.M.	— 0·15	— 0·11
2	— 0·18	— 0·17
3	— 0·16	— 0·14
4	— 0·16	— 0·10
5	— 0·21	— 0·06
6	— 0·29	— 0·08
7	— 0·32	— 0·12
8	— 0·34	— 0·17
9	— 0·34	— 0·21
10	— 0·33	— 0·20
11	— 0·30	— 0·19

Analogous to the variations of the declination in India, the curves show two maxima, one in the morning and one in the afternoon, but the maximum in the morning is by far the greater one.

Also the difference between maximum and minimum is considerably smaller than might be expected for these latitudes, unless, perhaps, we take into consideration the great absolute height of Leh.

2. Horizontal Intensity.

The variations of the horizontal intensity were determined by observing the changes in the deflection. The deflecting apparatus used was that of Hermann, the magnet suspended being *H* 21, the magnet deflecting, *L* 1.

The scale was an arbitrary one, and could be read off in tenths of a minute. Increasing numbers show a decrease of deflection and an increase of horizontal intensity.

The value of 1 minute of deflection, reduced to absolute values in English units, gave for magnet *L* 1, at the distance employed, 1 unit of the scale (or $^1/_{10}$ of a minute in deflection) $= 0 \cdot 00170$ English units.

The two following tables contain the detail of the regular daily observations.

Some isolated observations (10 days) were, besides, made in July and in September (before and after our journey to Turkistán) in order to fix the time and value of the morning minimum, which was found to take place between 4^h and 5^h A.M., and to amount (with different signs) to about $^1/_4$ of the rise between $6^1/_2$ and $9^1/_2$.

DAILY OBSERVATIONS OF THE HORIZONTAL INTENSITY AT LEH.

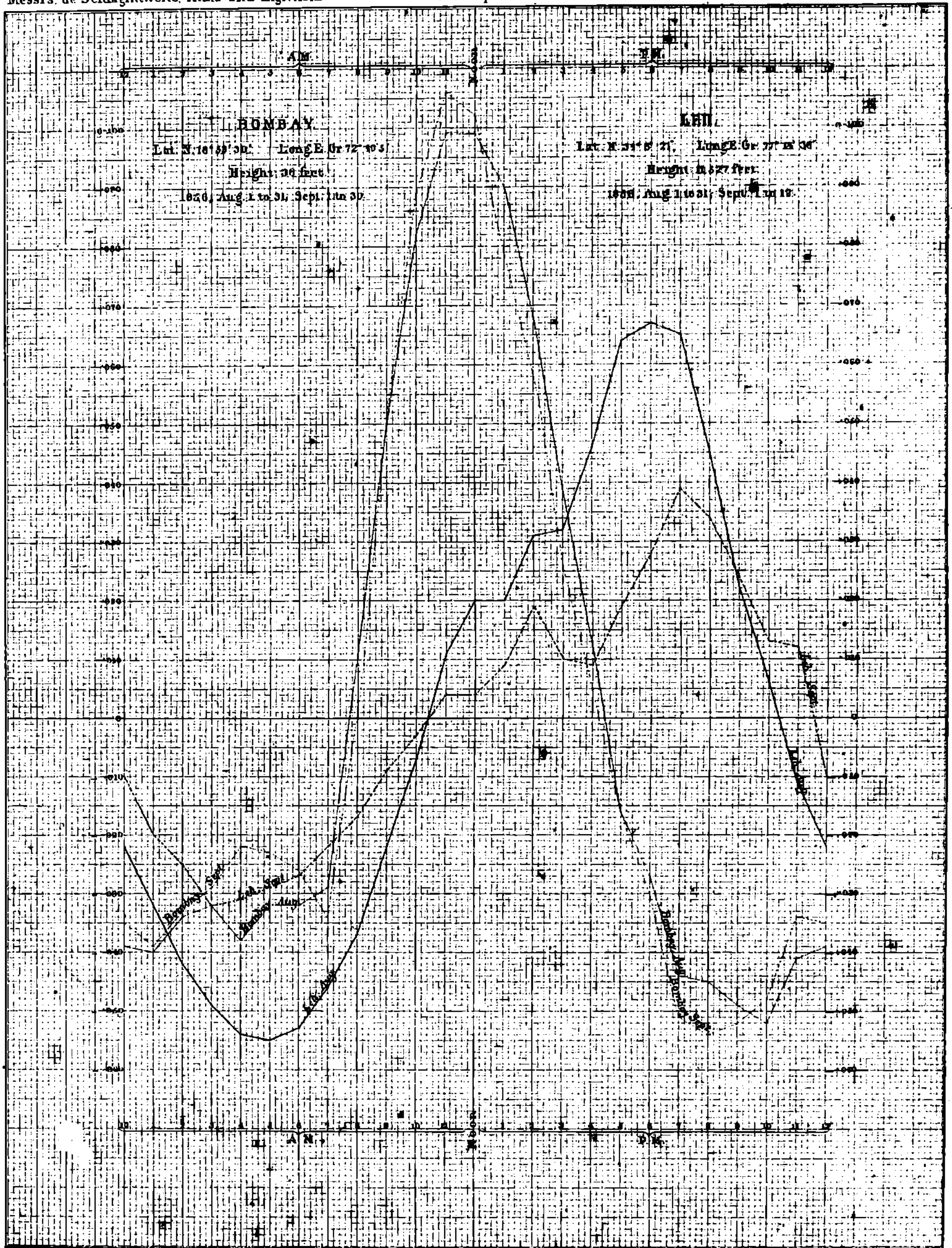
Expressed in scale values. Increasing numbers show an increase of the Intensity.

A. August, 1856.

1856, August.	A.M. 6h	7h	A.M. 9h	10h	Noon. 12h	P.M. 1h	P.M. 2h	3h	P.M. 4h	5h	P.M. 6h	7h	P.M. 8h
1		310		311		307		317		310		306	61
2		316		313		311		311		307		304	62
3		318		315		309		307		306		304	
4		307		303		308		310		307		304	
5		312		316		314		309		304		308	
6		313		309		306		306		308		323	
7		305		310		306		305		304		302	
8	316		314		304		304		303		301		300
9	304		316		308		306		300		300		298
10	305		308		305		304		302		300		300
11	308		308		302		303		303		303		300
12	308		310		306		304		306		306		310
13	318		318		310		309		306		304		301
14	304		306		314		318		317		316		314
15		326		318		314		313		310		316	
16		320		318		314		314		314		315	
17		324		318		313		316		314		313	
18		327		318		315		316		317		316	
19		330		322		318		318		306		318	
20		328		321		318		318		315		316	
21		325		320		318		318		326		320	
22		325		324		318		318		315		311	
23	326		323		320		320		320		318		319
24	330		325		320		320		320		318		320
25	331		320		318		320		320		314		320
26	315		310		310		315		315		312		313
27	327		327		321		320		318		317		318
28	324		320		318		316		316		313		307
29	302		313		310		307		310		310		306
30		314		311		308		306		305		319	
31		312		310		310		300		308		303	

DIURNAL OSCILLATIONS OF HORIZONTAL INTENSITY
in English Units.

LEH AND BOMBAY COMPARED
1856, August and September.



B. September, 1856.

1856, September.	A.M.		A.M.		Noon.	P.M.	P.M.		P.M.		P.M.		P.M.
	6h	7h	9h	10h	12h	1h	2h	3h	4h	5h	6h	7h	8h
1		313		314		318		318		323		321	
2		323		320		320		320		314		310	
3		304		301		300		300		299		296	
4		316		316		315		316		315		317	
5		325		320		315		315		316		316	
6	318		320		316		314		314		312		312
7	322		322		320		316		318		317		310
8	310		310		310		312		310		312		313
9	311		312		311		313		315		313		313
10	313		314		310		308		310		310		312
11	310		311		312		308		310		310		312
12	311		306		306		308		310		310		312

The daily variations of the horizontal intensity, expressed in parts of the English unit, are given in the following tables, where, for Leh, the maximum and minimum being introduced, the hours of no observation were deduced by graphic interpolation. We add the corresponding values at Bombay[1] for comparison.

[1] Bombay Observatory, vol. 1856, p. 24.

Leh.			Bombay.		
1856.	August 1 to 31.	September 1 to 12.	1856.	August 1 to 31.	September 1 to 30.
Midnight	— 0·0022	— 0·0010	Midnight + 12^m	— 0·0039	— 0·0035
1 A.M.	— 0·0032	— 0·0020	1 A.M. ,,	— 0·0040	— 0·0039
2 ,,	— 0·0042	— 0·0025	2 ,,	— 0·0034	— 0·0033
3 ,,	— 0·0049	— 0·0032	3 ,,	— 0·0032	— 0·0029
4 ,,	— 0·0054	— 0·0031	4 ,,	— 0·0038	— 0·0022
5 ,,	— 0·0055	— 0·0029	5 ,,	— 0·0032	— 0·0023
6 ,,	— 0·0053	— 0·0027	6 ,,	— 0·0032	— 0·0026
7 ,,	— 0·0046	— 0·0022	7 ,,	— 0·0029	— 0·0034
8 ,,	— 0·0037	— 0·0017	8 ,,	+ 0·0011	+ 0·0001
9 ,,	— 0·0022	— 0·0009	9 ,,	+ 0·0049	+ 0·0051
10 ,,	— 0·0007	— 0·0003	10 ,,	+ 0·0082	+ 0·0089
11 ,,	+ 0·0011	+ 0·0004	11 ,,	+ 0·0099	+ 0·0106
Noon	+ 0·0020	+ 0·0004	Noon ,,	+ 0·0099	+ 0·0102
1 P.M.	+ 0·0020	+ 0·0009	1 P.M. ,,	+ 0·0090	+ 0·0079
2 ,,	+ 0·0031	+ 0·0019	2 ,,	+ 0·0068	+ 0·0059
3 ,,	+ 0·0032	+ 0·0010	3 ,,	+ 0·0039	+ 0·0026
4 ,,	+ 0·0046	+ 0·0009	4 ,,	+ 0·0012	+ 0·0005
5 ,,	+ 0·0064	+ 0·0019	5 ,,	— 0·0016	— 0·0016
6 ,,	+ 0·0067	+ 0·0028	6 ,,	— 0·0027	— 0·0030
7 ,,	+ 0·0065	+ 0·0039	7 ,,	— 0·0044	— 0·0051
8 ,,	+ 0·0045	+ 0·0034	8 ,,	— 0·0045	— 0·0054
9 ,,	+ 0·0022	+ 0·0025	9 ,,	— 0·0049	— 0·0052
10 ,,	+ 0·0006	+ 0·0013	10 ,,	— 0·0052	— 0·0048
11 ,,	— 0·0011	+ 0·0012	11 ,,	— 0·0041	— 0·0034

The values of the preceding table are represented in curves, plate 3. Both the series at Leh show a great uniformity in their general character, September being here, as in reference to the declination, the month of the smaller variation.

The hours of the maxima and minima are nearly 6 hours later than in Bombay, but notwithstanding this difference in time, the form of the curve, even including the oscillations preceding the maximum, remains very nearly the same.

No. 79. PÁDUM, IN TSÁNSKAR.

Latitude North.	Longitude East Green.	Height.
33° 28′ 0″	76° 54′ 15″	11,590 feet.

On rocks much decomposed. See p. 241.

Observer: Adolphe.

DECLINATION.

1856, June 25, 10ʰ 15ᵐ A.M. local time. Collimator 2; Theodolite 3, Troughton; Chron. 1.

	° ′
Magnetic meridian	30 51·0
True meridian (see p. 241)	27 10·2
Declination East	3 40·8

DIP.

1856, June 25, 7ʰ 0ᵐ A.M. local time.

Dip needle: No. 3. Temp.: 9°·6 C., 49°·3 Fahr.

End *A*.

	° ′	
Face to instrument	46 27·3	Mean α = 46° 27′·45
Face reversed . . .	46 27·6	

End *B*.

	° ′	
Face to instrument	45 26·3	Mean β = 45 21·4
Face reversed . . .	45 16·5	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 45 54·43

Dip corrected for error of needle . . . . 45 51·97

No. 81. SÁSSER PASS, IN NÚBRA.

Latitude North.	Longitude East Green.	Height.
35° 6′ 0″	77° 27′ 35″	17,753 feet.

On the névé of the glacier, near the top of the pass. The legs of the stands rested on broad stones, to prevent them from sinking into the ice. See p. 243.

Observers: Hermann and Robert.

DECLINATION.

1856, August 2, 2^h 30^m P.M. local time. Theodolite 2, Jones, and its magnetic needle;[1] Chron. 3.

	° ′
Magnetic meridian	278 18·4
True meridian (see p. 245)	274 46·5
Declination East	3 31·9

DIP.

1856, August 2, 5^h 30^m P.M. local time.

Dip needle: No. 2. Temp.: 5°·2 C., 41°·4 Fahr.

End *A*.

	° ′	
Face to instrument	48 13·5	Mean α = 48° 13′·25
Face reversed . . .	48 13·0	

End *B*.

	° ′	
Face to instrument	48 10·0	Mean β = 48 21·4
Face reversed . . .	48 32·8	

$$\text{Mean of the dip} = \frac{\alpha + \beta}{2} = 48\ 17{\cdot}33$$

Dip corrected for error of needle . . . . 48 17·68

No. 82. KÁRGIL, IN THE TIBETAN DISTRICT OF DRAS.

Latitude North.	Longitude East Green.	Height.
34° 30′ 0″	76° 4′ 2″	8,845 feet.

On an alluvial terrace on the left bank of the Kártse river. See p. 245.

Observer: Robert.

DECLINATION.

1856, October 10, 10^h 15^m A.M. local time. Collimator 1; Theodolite 1, Jones; Chron. 4.

	° ′
Magnetic meridian	213 25·1
True meridian (see p. 245)	210 15·0
Declination East	3 10·1

[1] Compare p. 74.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, October 10, 1^h 25^m P.M. local time.

Magnet vibrated	*L* 1.	Temp.	13°·9 C., 57°·0 Fahr.
	L 1 with large ring.		13·8 C., 56·8 Fahr.
	L 1 with small ring.		13·8 C., 56·8 Fahr.

Chron. 5, Grant, gaining $12^s·5$.

	Without ring.	With large ring.	With small ring.		Without ring.	With large ring.	With small ring.
No. of vibrations	600	140	200	Time of 1 vibration . .	$3^s·010$	$8^s·114$	$5^s·849$
Semiarc beginning . .	178	152·5	265·5	q =	0·00020	0·00020	0·00020
Semiarc ending . . .	110	128·5	155	μ =	0·00017	0·00017	0·00017
Torsion (90°)	0′	0′	0′	Time of 1 vibrat. corr.	$3^s·021$	$8^s·143$	$5^s·869$

log $K_{,}$ = 0·43603 (large ring) log K = 0·43821

log $K_{,}$ = 0·43970 (small ring) log mX = 0·47235

B. *Deflection.*

1856, October 9, 4^h 0^m P.M. local time.

Magnets: Deflecting *L* 1, deflected *H* 21.

Deflection bar: *H* 3. Distances: 1 foot, 1·3 foot. Temp. { 13°·5 C., 56°·3 Fahr. / 12·1 C., 53·8 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	7° 24′ 42″	3° 21′ 19″	Temp. of magnet	12°·2 C.	11°·8 C.
μ =	0·00017	0·00017		53·9 Fahr.	53·2 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8·80354$$

m = 0·4345 X = Horizontal Intensity = 6·830

2. Dip.

1856, October 10, $12^h\ 45^m$ P.M. local time.

Dip needle: No. 2. Temp.: 15°·2 C., 59°·4 Fahr.

End *A*.

Face to instrument	47° 9′·1	Mean α =	47° 31′·25
Face reversed . . .	47 53·4		

End *B*.

Face to instrument	48° 23′·8	Mean β =	48° 22′·35
Face reversed . . .	48 20·9		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 47 56·80

Dip corrected for error of needle . . . . 47 57·15

3. Vertical Intensity . . . . 7·574

4. Total Intensity . . . . 10·197

No. 83. Dras, in the Tibetan District of Dras.

Latitude North.	Longitude East Green.	Height.
34° 28′ 0″	75° 43′ 5″	9,951 feet.

Near the fort, on the alluvial plain. See p. 245.

Observer: Robert.

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, October 12, $3^h\ 50^m$ P.M. local time.

Magnet vibrated: *L* 1. Temp.: 12°·0 C., 53°·6 Fahr.

Chron. 5, Grant, gaining $12^s·5$.

No. of vibrations	600	Time of 1 vibration	$2^s·994$
Semiarc { beginning	230	q =	0·00020
Semiarc { ending	73·5	μ =	0·00017
Torsion (90°)	1′	Time of 1 vibration corr.	$3^s·004$

log K = 0·43821 log mX = 0·47702

B. *Deflection.*

1556, October 13, $7^h\, 0^m$ A.M. local time.

Magnets: Deflecting $L\,1$, deflected $H\,21$.

Deflection bar: $H\,3$. Distances: 1 foot, 1·3 foot. Temp. { 4°·1 C., 39°·4 Fahr. / 2·2 C., 36·0 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	7° 15′ 7″	3° 17′ 45″	Temp. of magnet . .	4°·0 C.	2°·0 C.
μ =	0·00017	0·00017		39·2 Fahr.	35·6 Fahr.
			q =	0·00020	0·00020

$$\log \frac{m}{X} = 8\cdot79656$$

$m = 0\cdot4333$ X = Horizontal Intensity = 6·922

2. Dip.

1856, October 13, $9^h\, 0^m$ A.M. local time.

Dip needle: No. 2. Temp.: 9°·6 C., 49°·3 Fahr.

End *A*.

	° ′	
Face to instrument	46 54·7	Mean α = 46° 52′·4
Face reversed . . .	46 50·1	

End *B*.

	° ′	
Face to instrument	46 48·7	Mean β = 46 49·8
Face reversed . . .	46 50·9	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 46 51·10

Dip corrected for error of needle . . . . 46 51·45

3. Vertical Intensity . . . . 7·386

4. Total Intensity . . . . 10·122

GROUP XI.

BÁLTI AND HASÓRA.

Chorkónda. — Tso Ka. — Skárdo. — Táshing.

No. 85. Chorkónda Glacier, above △ Dongdóng, in Bálti.

Latitude North.	Longitude East Green.	Height.
35° 33′ 20″	75° 56′ 0″	13,790 feet.

On a slope of detritus, on the left side of the glacier, close to the ice. See p. 248.

Observer: Adolphe.

DECLINATION.

1856, July 24, 4^h 40^m P.M. local time. Collimator 1; Theodolite 3, Troughton. Pocket-watch by Dent

	° ′
Magnetic meridian	286 13·2
True meridian (see p. 249)	283 19·8
Declination East	2 53·4

DIP.

1856, July 26, 10^h 30^m A.M. local time.

Dip needle: No. 4. Temp.: 7°·6 C., 45°·7 Fahr.

End *A*.

	° ′		° ′
Face to instrument	48 51·3	Mean α =	48 42·65
Face reversed . . .	48 34·0		

End *B*.

	° ′		° ′
Face to instrument	48 40·5	Mean β =	48 45·60
Face reversed . . .	48 50·7		

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 48 44·13

Dip corrected for error of needle . . . . 48 43·25

No. 87. △ Tso Ka, in Bálti.

Latitude North.	Longitude East Green.	Height.
35° 58′ 0″	76° 3′ 0″	15,724 feet.

Observer: Adolphe. (See p. 251.)

Dip.

1856, August 21, $4^h\ 0^m$ P.M. local time.

Dip needle: No. 3. Temp.: 6°·2 C., 43°·2 Fahr.

End *A*.

	° ′	
Face to instrument	50 6·5	Mean α = 50° 0′·25
Face reversed . . .	49 54·0	

End *B*.

	° ′	
Face to instrument	49 0·5	Mean β = 48 42·5
Face reversed . . .	48 24·5	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 49 21·38

Dip corrected for error of needle . . . . 49 18·92

No. 91. Skárdo, in Bálti.

Latitude North.	Longitude East Green.	Height.
35° 20′ 12″	75° 44′ 40″	7,250 feet.

On detritus, on the left bank of the Indus. See p. 256.

Observer: Adolphe.

DECLINATION.

1856, September 2, $8^h\ 15^m$ A.M. local time. Collimator 2; Theodolite 3, Troughton; Chron. 1.

	° ′
Magnetic meridian	300 28·2
True meridian (see p. 257)	296 23·1
Declination East	4 5·1

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, September 3, $11^h\ 10^m$ P.M. local time.

Magnet vibrated: *B* 7. Temp.: 25°·6 C., 78°·0 Fahr.

Chron. *A*, losing $2^s·5$.

No. of vibrations	750	Time of 1 vibration	$3^s·355$
Semiarc { beginning	260	q =	0·00021
Semiarc { ending	38	μ =	0·00017
Torsion (90°)	4′	Time of 1 vibration corr. . .	$3^s·366$

log K = 0·26891   log mX = 0·20891

B. *Deflection.*

1856, September 2, $5^h\ 30^m$ P.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 24°·3 C., 75°·7 Fahr. / 23·7 C., 74·7 Fahr.

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 27′ 14″	1° 34′ 55″	Temp. of magnet . .	24°·0 C.	23°·4 C.
μ =	0·00017	0·00017		75·2 Fahr.	74·1 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8·48536$$

m = 0·2224 X = Horizontal Intensity = 7·274

2. Dip.

1856, September 2, $10^h\ 45^m$ A.M. local time.

Dip needle: No. 4. Temp.: 16°·6 C., 61°·9 Fahr.

End *A*.

Face to instrument	47° 51′·1	Mean α = 48° 3′·55
Face reversed . . .	48 16·0	

End *B*.

Face to instrument	48° 44′·6	Mean β = 48 39·25
Face reversed . . .	48 33·9	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 48 21·40

Dip corrected for error of needle . . . . 48 20·52

3. Vertical Intensity . . . . 8·174

4. Total Intensity . . . . 10·943

No. 92. TÁSHING, IN HASÓRA.

Latitude North.	Longitude East Green.	Height.
35° 15′ 40″	74° 40′ 40″	9,691 feet.

On metamophic rocks. See p. 258.

Observer: Adolphe.

DECLINATION.

1856, September 20, $5^h\ 20^m$ P.M. local time. Collimator 2; Theodolite 3, Troughton; Chron. 1.

	°	′
Magnetic meridian	62	53·7
True meridian (see p. 258)	58	36·0
Declination East	4	17·7

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, September 21, $2^h\ 40^m$ P.M. local time.

Magnet vibrated: *B* 7. Temp.: 17°·0 C., 62°·6 Fahr.

Chron. *A*, losing $2^s·5$.

No. of vibrations	200	Time of 1 vibration	$3^s·328$
Semiarc beginning	256·5	q =	0·00021
Semiarc ending	36	μ =	0·00017
Torsion (90°)	6′	Time of 1 vibration corr. . .	$3^s·346$
log K = 0·26891		log mX = 0·21427	

B. *Deflection.*

1856, September 21, $4^h\ 45^m$ P.M. local time.

Magnets: Deflecting *B* 7, deflected *B* 2.

Deflection bar: *A*. Distances: 1 foot, 1·3 foot. Temp. { 15°·8 C., 60°·4 Fahr. / 14·9 C., 58·8 Fahr. }

	1 foot.	1·3 foot.		1 foot.	1·3 foot.
u_0 =	3° 28′ 57″	1° 37′ 21″	Temp. of magnet . .	15°·5 C.	14°·6 C.
μ =	0·00017	0·00017		59·9 Fahr.	58·3 Fahr.
			q =	0·00021	0·00021

$$\log \frac{m}{X} = 8\cdot50706$$

$m = 0\cdot2294$ X = Horizontal Intensity 7·138

2. Dip.

1856, September 23, $9^h\ 0^m$ A.M. local time.

Dip needle: No. 4. Temp.: 16°·5 C., 61°·7 Fahr.

End *A*.

	° ′	
Face to instrument	48 20·7	Mean α = 48° 20′·4
Face reversed . . .	48 20·1	

End *B*.

	° ′	
Face to instrument	48 28·9	Mean β = 48 29·0
Face reversed . . .	48 29·1	

Mean of the dip $= \frac{\alpha + \beta}{2} =$ 48 24·70

Dip corrected for error of needle . . . . 48 23·82

3. Vertical Intensity . . . . 8·039

4. Total Intensity . . . . 10·751

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c. KARAKORÚM AND KUENLÚEN.

GROUP XII.

TURKISTÁN.

Karakorúm pass.—Súget.—Súmgal.

No. 93. Karakorúm Pass, between Ladák and Turkistán.

Latitude North.	Longitude East Green.	Height.
35° 46′ 55″	77° 30′ 21″	18,341 feet.

Crystalline rocks. See p. 260.

Observers: Hermann and Robert.

DECLINATION.

1856, August 9, $2^h\ 50^m$ P.M. local time. Theodolite 2, Jones, and its needle; Chron. 3.

	° ′
Magnetic meridian	289 27·1
True meridian (see p. 260)	285 53·5
Declination East	3 33·6

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, August 9, $3^h\ 55^m$ P.M. local time.

Magnet vibrated: *B* 5, reduced to *L* 1.[1] Temp.: 14°·2 C., 57°·5 Fahr.

Chron. *H*, losing $0^s \cdot 5$.

No. of vibrations	150	Time of 1 vibration	$2^s \cdot 934$
Semiarc beginning	250	q =	0·00020
Semiarc ending	210	μ =	0·00017
Torsion (90°)	0′	Time of 1 vibration corr.	$2^s \cdot 944$

log mX = 0·49452

m = 0·4374 X = Horizontal Intensity = 7·140

2. Dip.

1856, August 9, $3^h\ 55^m$ P.M. local time.

Dip needle: No. 2. Temp.: 14°·2 C., 57°·5 Fahr.

End *A*.

	° ′	
Face to instrument	49 6·8	Mean α = 49° 9′·4
Face reversed	49 12·0	

End *B*.

	° ′	
Face to instrument	49 24·4	Mean β = 49 17·4
Face reversed	49 10·4	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 49 13·40

Dip corrected for error of needle . . . . 49 13·75

[1] During our absence from Leh, *L* 1 being used as deflector for observing the daily variations, we vibrated *B* 5, reducing by direct comparisons, several times repeated, the time of its vibration to the time of *L* 1. The *m* corresponding to *L* 1 had been determined, and was found very well to agree, in July and in September, at Leh.

3. VERTICAL INTENSITY . . . . 8·280

4. TOTAL INTENSITY . . . . 10·933

No. 95. △ SÚGET, IN TURKISTÁN.

Latitude North.	Longitude East Green.	Height.
36° 10′ 25″	77° 55′ 5″	12,960 feet.

On the left side of the Karakásh river. See p. 264.

Observers: Hermann and Robert.

DECLINATION.

1856, September 1, 4^h 15^m P.M. local time. Theodolite 2, Jones, and its needle; Chron. 3.

	° ′
Magnetic meridian	335 17·3
True meridian (see p. 266)	330 55·8
Declination East	4 21·5

DIP.

1856, September 1, 12^h Noon local time.

Dip needle: No. 2. Temp.: 11°·4 C., 52°·5 Fahr.

End *A*.

	° ′	
Face to instrument	50 7·0	Mean α = 50° 7′·5
Face reversed . . .	50 8·0	

End *B*.

	° ′	
Face to instrument	50 13·5	Mean β = 50 16·5
Face reversed . . .	50 19·5	

Mean of the dip $= \frac{\alpha + \beta}{2}$ = 50 12·0

Dip corrected for error of needle . . . . 50 12·35

No. 106. △ SÚMGAL, IN TÚRKISTÁN.

Latitude North.	Longitude East Green.	Height.
36° 8′ 0″	78° 5′ 0″	13,212 feet.

Observers: Hermann and Robert. (See p. 268.)

INTENSITY.

1. Horizontal Intensity.

A. *Vibration.*

1856, August 29, $4^h\ 50^m$ P.M. local time.

Magnet vibrated: *B* 5, reduced to *L* 1.[1] Temp.: 12°·1 C., 53°·9 Fahr.

Chron. *H*, losing $0^s·5$.

No. of vibrations	150	Time of 1 vibration	$2^s·967$
Semiarc beginning	250	q =	0·00020
Semiarc ending	210	μ =	0·00017
Torsion (90°)	0′	Time of 1 vibration corr.	$2^s·978$

log K = 0·43821 log mX = 0·48473

log m = 0·4374 log X = Horizontal Intensity = 6·980.

2. Dip.

1856, August 29, $8^h\ 50^m$ A.M. local time.

Dip needle: No. 2. Temp.: 0°·0 C., 32°·1 Fahr.

End *A*.

	° ′	
Face to instrument	50 0·0	Mean α = 50° 2′·75
Face reversed	50 5·5	

End *B*.

	° ′	
Face to instrument	50 20·3	Mean β = 50 7·30
Face reversed	49 54·3	

Mean of the dip = $\frac{\alpha + \beta}{2}$ = 50 5·03

Dip corrected for error of needle . . . . 50 5·38

3. Vertical Intensity . . . . 8·343

4. Total Intensity . . . . 10·879

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[1] See Note under Karakorúm, p. 455.

SECTION VI.

GENERAL CONSIDERATIONS ON THE TERRESTRIAL MAGNETISM OF INDIA AND THE SURROUNDING COUNTRIES.

A. MATERIALS OF OBSERVATIONS.

I. Stations of our magnetic survey, from 1854-7. II. Survey of the Indian Archipelago, from 1845-9, by Captain C. M. Elliot. III. Determinations of the declination, from 1835-49, by the Indian Navy. IV. Observations in 1833 along the eastern coasts of India, by de Blosseville. V. Declination in Central India and Hindostán, from 1813-28, by Major J. A. Hodgson. VI. Average declination in Rajvára, 1835, by Lieutenant A. H. E. Boileau. VII. Dip and relative horizontal intensity from 1837-9, by F. G. Taylor and J. Caldecott. VIII. Declination and dip in Kashmír and Ladák, by Major A. Cunningham. IX. Historical data for secular change. *a.* Declination, *b.* Dip.

B. CONSTRUCTION AND EXPLANATION OF THE MAGNETIC MAPS.

The systems of: 1. the isogonic lines; 2. the isoclinal lines; 3. the isodynamic lines.

C. RESULTS DEDUCED FROM THE ABSOLUTE DETERMINATION OF THE MAGNETIC ELEMENTS.

I. Declination: 1. Line of no declination; 2. Local disturbances; 3. Zones of greater deviations in Assám, in the Bhután Himálaya, in Bérma, and in the Nilgiris; 4. Zone of most rapid change; 5. Karakórum and Kuenlúen.

II. Dip: 1. Tropical zone of rapid increase; 2. Regularity of isoclinal lines in general; 3. Zones of increase and decrease; 4. Influence of height; 5. Local deviations.

III. Total Intensity. α. Modifications of the isodynamic lines in India: 1. Region of great increase in Central India; 2. Depression along the foot of the Himálaya; 3. Physical condition of the surface of the soil, produced by insolation and humidity; 4. Absolute minimum total intensity; 5. Average rate of increase with latitude. β. Horizontal Intensity. γ. Influence of height.

A. MATERIALS OF OBSERVATIONS.

For facilitating the general considerations on the magnetic conditions of India and the surrounding countries, we present a tabular abstract of our magnetic and geographical stations,[1] together with a compendious enumeration of the materials

[1] On the overland route we determined the following declination and dip, the results of which we add for the completion of the series of our observations:

					Declination.	Dip.
		° ′		° ′	° ′	° ′
1857, May 13, Aden,	Latitude North	12 46	Longitude East Green.	45 10	4 15 West	5 38·5 North
,, ,, 20 Suez,	,,	29 59	,, ,,	32 36	5 23 ,,	41 10·35 ,,
,, ,, 25 Cairo	,,	30 3			7 8 ,,	41 24·38 ,,

(In 1836, Captain Haines found at Aden: Declination West. 5° 2′.)

known to us up to this time, of which, however, by far the greatest part will be found limited to the coasts only. The works from which we have collected them are mentioned in connection with each respective table.

I. Stations of our Magnetic Survey, from 1854 to 1857, referable to the mean date of January 1, 1856.

All observations were made either in a tent, constructed for the purpose, or in the open air.

No. curr.	Station.	Geographical Co-ordinates. Latitude N.	Longitude East Green.	Height.	Magnetic Elements. Declin. East.	Horizon. Intensity.	Dip. North.	Vertical Intensity.	Total Intensity.
	A. INDIA.								
	Group I. Assám and Khássia Hills.								
		° ′ ″	° ′ ″	Engl. Feet.	° ′	Engl. Units.	° ′	Engl. Units.	Engl. Units.
1	Dibrugárh	27 32 0	94 57 35	395	0 46·4	7·733	38 30·35	6·150	9·882
2	Tézpur	26 34 35	92 46 45	239	0 22·5	7·758	37 14·93	5·898	9·746
3	Udelgúri	26 45 40	91 56 30	352	2 36·3	7·740	36 27·65	5·719	9·624
4	Gohátti	26 5 50	91 43 45	134	2 0·1	7·784	35 19·15	5·513	9·541
5	Chérra Púnji	25 14 15	91 40 30	4,164	2 20·4	7·869	33 37·27	5·231	9·449
	Group II. Delta of the Ganges and Brahmapútra.								
6	Surajgánj	24 22 50	89 43 20	L. a. L. S.[1]			32 3·50		
7	Dháka	23 42 44	90 20 15	L. a. L. S.	2 21·2		31 1·23		
8	Kúlna	22 45 55	89 36 55	L. a. L. S.	2 30·4		29 19·85		
9	Calcutta	22 33 1	88 20 34	L. a. L. S.	2 25·1	8·028	28 14·84	4·315	9·113
	Group III. Valley of the Ganges and its Tributaries.								
10	Rámpur Bólea . . .	24 21 46	88 34 20	54		6·703	32 0·77	4·190	7·904
11	Kissengánj	26 6 0	87 56 8	140	2 20·2	6·690	35 11·95	4·719	8·187
12	Pátna	25 37 12	85 7 32	170	1 53·9	7·678	33 32·96	5·094	9·215
13	Sigáuli	26 46 41	84 44 26	260			35 40·10		
14	Benáres	25 18 26	82 59 47	325	1 50·3	7·822	32 41·25	5·020	9·294
15	Lăkhnáu	26 51 10	80 55 32	520	2 37·4	8·176	35 18·55	5·789	10·019
16	Aligárh	27 53 50	78 3 55	760	1 37·3		36 58·90		
17	Ágra	27 10 26	78 1 39	657	1 20·0				
18	Míráth	29 0 41	77 41 48	865	1 48·4				

[1] L. a. L. S. Little above the level of the sea.

No. curr.	Station.	Geographical Co-ordinates.			Magnetic Elements.				
		Latitude N.	Longitude East Green.	Height.	Declin. East.	Horizon. Intensity.	Dip. North.	Vertical Intensity.	Total Intensity.
	Group iv. Pănjáb, Sindh, and Kăch.								
		° ′ ″	° ′ ″	Engl. Feet.	° ′	Engl. Units.	° ′	Engl. Units.	Engl. Units.
19	Ambála	30 21 25	76 48 49	1,026	2 26·2		40 48·40		
20	Lahór	31 34 5	74 14 37	790	2 2·3	7·175	43 17·44	6·758	9·856
21	Raulpíndi	33 36 30	72 59 49	1,674	3 5·5	6·889	45 55·71	7·115	9·904
22	Pesháur	34 3 10	71 33 19	1,250	2 27·9	7·505	46 25·75	7·889	10·889
23	Sháhpur	32 14 0	72 32 30	680	1 19·7				
24	Dóra Ismáel Khan	31 39 35	70 56 30	478	0 58·2	7·648	44 23·47	7·489	10·703
25	Multán	30 10 10	71 34 34	480	0 54·2				
26	Shikárpur	27 55 10	68 51 50	60		8·000	36 2·0	5·820	9·893
27	Sévan	26 25 0	67 56 40	140	0 35·0				
28	Kărráchi	24 45 30	67 0 51	L. a. L. S.	0 6·0				
29	Bhūj	23 17 0	69 40 0	283	0 12·0	8·012	28 25·0	4·335	9·109
30	Rajkót	22 13 0	71 7 0	325	0 13·3				
	Group v. Central and Southern India.								
31	Ságer	23 50 9	78 43 26	1,880			29 58·84		
32	Jáblpur	23 9 39	79 56 18	1,480	1 10·5	8·666	28 31·14	4·711	9·863
33	Nágri	20 25 25	78 52 50	850		8·633	22 49·99	3·634	9·367
34	Rajamándri	17 10 30	81 46 35	L. a. L. S.	1 24·8	8·817	16 23·53	2·590	9·197
35	Madras	13 4 11	80 13 56	L. a. L. S.	0 59·3	8·023	7 52·34	1·114	8·100
36	Bombay	18 53 30	72 49 5	L. a. L. S.	0 19·1	8·008	19 6·6	2·775	8·475
37	Púna	18 30 23	73 52 8	1,819			19 2·25		
38	Mahabaléshvar	17 55 25	73 38 42	4,396			16 25·50		
39	Kăládghi	16 12 55	75 29 55	1,720	0 30·0		14 27·25		
40	Bellári	15 8 57	76 53 45	1,580	0 21·0	8·641	11 59·68	1·838	8·834
41	Utakamánd	11 23 40	76 43 10	7,278	0 57·0	8·835	4 27·32	0·686	8·862
42	Utatúr	11 4 40	78 51 40	280			2 50·08		
43	Gálle	6 2 30	80 10 45	L. a. L. S.	0 41·0	8·003	7 40·90 S.	1·077	8·076

B. HIGH ASIA.

a. *Himálaya.*

Group VI. Bhután to Nepál.

No. curr.	Station.	Geographical Co-ordinates. Latitude N.	Longitude East Green.	Height.	Magnetic Elements. Declin. East.	Horizon. Intensity.	Dip. North.	Vertical Intensity.	Total Intensity.
		° ′ ″	° ′ ″	Engl. Feet.	° ′	Engl. Units.	° ′	Engl. Units.	Engl. Units.
44	Năригún	26 53 50	92 6 0	3,615	4 43·0	7·266	37 8·11	5·502	9·114
45	Darjíling	27 3 0	88 15 15	7,168	2 48·0	6·548	36 32·97	4·854	8·152
46	Răngít Bridge	27 4 50	88 10 15	3,130		6·632			
47	Tónglo	27 1 50	88 3 55	10,080	2 30·5	6·872	36 25·04	5·068	8·539
48	Fălút	27 6 20	87 59 0	12,042	2 24·8	6·648	36 54·96	4·995	8·316
49	Kathmándu	27 42 5	85 12 9	4,350	2 35·8	6·922	37 34·24	5·326	8·734

Group VII. Kămáon and Gărhvál.

No. curr.	Station.	Latitude N.	Longitude East Green.	Height.	Declin. East.	Horizon. Intensity.	Dip. North.	Vertical Intensity.	Total Intensity.
50	Nainitál	29 23 34	79 30 55	6,409	2 28·2	7·707	38 33·71	6·144	9·856
51	Mílum	30 34 35	79 54 49	11,640	2 40·3	7·972	40 31·91	6·815	10·489
52	Mána	30 47 0	79 20 50	10,670	2 44·9	7·894	41 25·24	6·965	10·528
53	Mána Pass	31 5 0	79 15 20	18,852					
54	Ussílla	31 7 40	78 18 10	8,940		8·116	42 13·24	7·366	10·960
55	Măssúri	30 28 30	77 59 58	7,549		8·125	41 15·12	7·127	10·807

Group VIII. Símla to Házara.

No. curr.	Station.	Latitude N.	Longitude East Green.	Height.	Declin. East.	Horizon. Intensity.	Dip. North.	Vertical Intensity.	Total Intensity.
56	Vángtu Bridge . . .	31 37 0	77 54 0	4,210			43 22·80		
57	Rámpur	31 31 0	77 37 0	3,215			42 46·43		
58	Símla	31 6 6	77 7 36	7,091	2 55·5	7·158	42 30·0	6·559	9·709
59	Sultánpur	31 57 50	77 5 50	3,830	3 2·6		43 52·19		
60	Kárdong	32 33 50	77 0 35	10,233	3 23·3	7·821	44 28·44	7·679	10·960
61	Srinágger	34 4 36	74 48 30	5,144	2 59·9	6·814	46 58·20	7·300	9·986
62	Dáver	34 34 5	74 46 0	7,718			47 41·65		
63	Mozăferabád	34 22 25	73 31 10	2,220	3 23·9	6·660	47 20·00	7·226	9·827
64	Márri	33 51 0	73 22 40	7,260	3 21·1	6·686	46 2·84	6·935	9·633

No. curr.	Station.	Geographical Co-ordinates.			Magnetic Elements.				
		Latitude N.	Longitude East Green.	Height.	Declin. East.	Horizon. Intensity.	Dip. North.	Vertical Intensity.	Total Intensity.
		b. *Tibet.*							
		Group ix. Gnári Khórsum.							
		° ′ ″	° ′ ″	Engl. Feet.					
65	△ Laptél	30 46 20	79 52 0	14,304					
66	△ Giúngul	31 14 0	79 44 40	13,420					
67	Gunshankár	31 23 30	80 18 0	19,980					
68	Cháko La Pass . . .	31 23 55	80 11 0	17,730					
69	Gártok	31 40 0	80 18 25	15,090	See p. 429.				
70	△ Díra	31 18 55	79 32 40	13,800					
71	△ Íbi Gãmin	30 56 10	79 19 30	16,910					
72	Púling	31 15 30	79 15 40	14,207					
73	Nélong Pass	31 7 30	79 0 40	18,475					
		Group x. Ladák.							
74	Mūd	31 55 35	78 1 20	12,421	3 43·5		44 17·83		
75	Tsomoríri	32 45 25	78 16 36	15,130	3 9·9		45 20·30		
76	Tsomognalarí	33 39 50	78 38 30	14,010	3 21·8	6·856	46 34·05	7·242	9·972
77	Lácha Lung Pass . .	33 3 50	77 35 35	16,750					
78	Leh	34 8 21	77 14 36	11,527	3 22·6	6·913	46 52·64	7·381	10·113
79	Pádum	33 28 0	76 54 15	11,590	3 40·8		45 51·97		
80	Dah	34 32 35	76 25 5	9,690					
81	Sásser Pass	35 6 0	77 27 35	17,753	3 31·9		48 17·68		
82	Kárgil	34 30 0	76 4 2	8,845	3 10·1	6·830	47 57·15	7·574	10·197
83	Dras	34 28 0	75 43 5	9,951		6·922	46 51·45	7·386	10·122
		Group xi. Bálti and Hasóra.							
84	Húshe	35 33 30	76 35 20	10,440					
85	△ Chorkónda	35 33 20	75 56 0	13,790	2 53·4		48 43·25		
86	△ Shinchakbi Biánga	35 56 35	76 0 20	13,553					
87	△ Tso Ka	35 58 0	76 3 0	15,724			49 18·92		
88	Askoli	35 41 20	75 56 0	9,710					
89	Chutrón	35 44 35	75 25 40	8,060					
90	Shígar	35 28 35	75 45 30	7,537					
91	Skárdo	35 20 12	75 44 0	7,250	4 5·1	7·274	48 20·52	8·174	10·943
92	Táshing	35 15 40	74 40 40	9,691	4 17·7	7·138	48 23·82	8·039	10·751

No. curr.	Station.	Geographical Co-ordinates.			Magnetic Elements.				
		Latitude N.	Longitude East Green.	Height.	Declin. East.	Horizon. Intensity.	Dip. North.	Vertical Intensity.	Total Intensity.
	c. Karakorúm and Kuenlúen.								
	GROUP XII. TURKISTÁN.								
		° ′ ″	° ′ ″	Engl. Feet.	° ′	Engl. Units.	° ′	Engl. Units.	Engl. Units.
93	Karakorúm Pass . .	35 46 55	77 30 21	18,341	3 33·6	7·140	49 13·75	8·280	10·933
94	Kiúk-Kiŏl	35 40 0	77 56 0	15,460					
95	△ Súget	36 10 25	77 50 5	12,960	4 21·5		50 12·35		
96	△ Búllu	35 49	77 31	16,889					
97	△ Chilgáne	35 58	77 35	16,416					
98	△ Kissilkorúm . . .	35 57	77 50	17,762					
99	△ Aksáe Chin . . .	35 52	77 51	16,620					
100	△ Karakásh valley .	35 49	77 51	14,820					
101	△ Káfir Déra	35 50	78 12	14,420					
102	⛺ Bashmalgún . . .	35 50	78 17	14,214					
103	△ Karakásh valley .	35 51	78 22	14,000					
104	△ Sikánder Mokám.	36 3	78 29	13,864					
105	△ Karakásh valley .	36 8	78 14	13,613					
106	△ Súmgal	36 8	78 5	13,212		6·979	50 5·38	8·343	10·879
107	△ Gulbagashén . . .	36 9	77 45	12,252					
108	Élchi Daván Pass . .	36 13	78 7	17,379					
109	Búshia	36 26	78 19	9,310					
110	Élchi	36 50	78 20						
111	Yárkand	38 10	74 0						
112	Káshgar	39 15	71 50						

II. SURVEY OF THE INDIAN ARCHIPELAGO, FROM 1845 TO 1849, BY CAPTAIN C. M. ELLIOT.

These observations, which are contained in the Philosophical Transactions for 1851, seem not to require as yet a minute reduction to one common period. Parts which our maps have in common differ very little from his, and that not always even in the same way, and within the last years, the secular changes are scarcely appreciable for the southern parts of India.[1]

[1] See pp. 280 and 298.

For the values of the periodical changes also no special correction is necessary; for Southern India in particular they could not, from their geographical position, be expected to be very great. Our observations, as well as Captain Elliot's, generally confirm this for the period of the last ten years, though they can only be considered as defined for some few rather isolated localities.

Some remarks about the probable secular changes since the year 1600 will be given below in connection with the observations collected by Hansteen (see p. 474).

Not being acquainted with the languages spoken in the territories examined by Captain Elliot, we have left his transcription unaltered. The heights are determined barometrically. S. L. = sea level, or a little above it; U. = height unknown.

Station.	Date.	Latitude North and South.	Longitude East Green.	Height.	Declination East.	Dip.	Horizontal Intensity.	Total Intensity.
		° ′ ″	° ′ ″	Engl. Feet.	° ′ ″	° ′	Engl. Units.	Engl. Units.
Singapur	1845				1 36 47		8·095	8·306
	1846	1 18 32 N.	103 56 30	S. L.		12 51·8 S.	8·121	8·333
	1847					12 56·2 S.	8·116	8·328
	1848				1 36 15	12 56·7 S.	8·114	8·326
Pulo Peesang	1846, January	1 27 53 N.	103 19 15	S. L.	1 31 7		8·092	
Carimons	„ „	0 59 22 N.	103 27 0	S. L.	1 23 5		8·077	
Pulo Booāya	„ February	0 9 9 N.	104 21 0	S. L.	1 28 49			
Lingin	„ „	0 11 39 S.	104 37 0	S. L.	1 19 7		8·062	
Sarāwak	„ May to July	1 33 54 N.	110 29 0	U.	1 9 40	11 14·9 S.	8·186	8·346
Sambas	„ July	1 22 0 N.	109 28 0	U.	1 15 50	11 31·0 S.	8·166	8·334
Permanket	„ July	1 10 29 N.	109 4 15	S. L.	1 9 33	12 35·8 S.	8·182	8·384
Pantiānak	„ August	0 1 19 S.	109 30 0	S. L.	1 31 19	12 45·0 S.	8·125	8·331
Succadāna	„ „	1 15 33 S.	109 57 0	S. L.	1 22 39	17 2·1 S.	8·086	8·457
Batavia	„ Sept.	6 9 52 S.	106 58 0	S. L.	0 47 7	27 5·4 S.	7·897	8·870
Ceram	„ „ 29	6 7 5 S.	106 15 0	S. L.	0 34 25	27 14·2 S.	7·850	8·829
Anjeer	„ Oct. 1	6 2 47 S.	106 1 0	S. L.	0 58 11	26 32·0 S.	7·887	8·815
Cheringin	„ „ 3	6 22 5 S.	105 46 45	S. L.	0 50 44	27 34·0 S.	7·886	8·895
Palambangan	„ „ 5	6 31 0 S.	105 54 45	U.	0 59 10	28 8·6 S.	7·855	8·909
Chebiliang	„ „ 7	6 47 0 S.	105 49 15	U.	0 20 36	28 41·1 S.	7·753	8·834
Chelangkahan	„ „ 10	6 54 0 S.	106 6 45	U.	0 13 46	28 23·9 S.	7·647	8·838
Goonong Dādap	„ „ 12	6 28 0 S.	106 6 0	U.	0 52 57	27 31·7 S.	7·943	8·958
Woorong Goonong	„ „ 15	6 11 0 S.	106 10 0	U.	0 40 4	27 23·2 S.	7·916	8·915

Station.	Date.	Latitude North and South.	Longitude East Green.	Height.	Declination East.	Dip.	Horizontal Intensity.	Total Intensity.
		° ′ ″	° ′ ″	Engl. Feet.	° ′ ″	° ′	Engl. Units.	Engl. Units.
Tegu	1846, Nov. 23	6 43 4 S.	106 58 45	U.	0 11 32	28 45·4 S.		
Pangerango	„ „ 27	6 51 0 S.	106 59 0	U.		29 45·7 S.		
Chunjūr	„ Dec. 1	6 50 8 S.	107 9 45	U.	1 35 28	28 26·1 S.	7·886	8·967
Kārang Tengga . . .	„ „ 4	6 58 16 S.	106 47 45	U.	1 13 18	28 24·1 S.	7·934	9·020
Chebrānok	„ „ 7	6 57 14 S.	106 25 30	S. L.	0 35 9	28 30·8 S.	7·916	9·009
Wyn Cooper's Bay .	„ „ 8	7 5 0 S.	106 36 30	S. L.	0 32 20	29 21·5 S.	7·873	9·033
Chilotoe	„ „ 10	7 11 17 S.	106 27 0	U.	0 27 38	28 54·3 S.	7·894	9·017
Pangangbahan . . .	„ „ 11	7 30 37 S.	106 19 0	U.	0 10 5	29 44·4 S.	7·907	9·106
Mooāro Chikasso . .	„ „ 13	7 28 0 S.	106 38 0	S. L.	0 13 14	30 8·3 S.	7·817	9·039
Sidang Bārang . . .	„ „ 15	7 30 0 S.	107 10 0	U.	0 5 13	30 15·0 S.	7·781	9·007
Pejong Petair	„ „ 16	7 13 36 S.	107 2 0	U.	0 16 23	29 36·5 S.	7·924	9·113
Bandong	„ „ 21	6 55 44 S.	107 40 30	U.	0 26 23	28 34·4 S.	7·939	9·040
Garoet	„ „ 24	7 13 54 S.	107 55 0	U.	0 25 21	29 1·5 S.	7·925	9·060
Permangpek	„ „ 29	7 39 23 S.	107 45 15	U.	0 20 20	30 14·8 S.	7·826	9·059
Cherūgnūktok	1847, Jan. 1	7 38 25 S.	108 9 45	U.	0 18 13	30 10·9 S.	7·894	9·132
Kālipoochen	„ „ 6	7 39 2 S.	108 52 30	S. L.	0 57 46	29 53·9 S.	7·907	9·121
Banjeer	„ „ 8	7 23 8 S.	108 42 0	U.	0 27 59	29 9·9 S.		
Chāwee	„ „ 10	7 9 34 S.	108 23 0	U.	0 33 23	28 41·9 S.	7·953	9·066
Samadang	„ „ 12	6 51 14 S.	108 4 45	U.	0 30 24	28 0·2 S.	7·948	9·002
Cheribon	„ „ 14	6 43 34 S.	108 42 0	S. L.	0 31 41	27 52·0 S.		
Indramāyu	„ „ 18	6 19 35 S.	108 25 45	S. L.	0 41 5	27 30·9 S.	7·944	8·957
Tegal	„ „ 26	6 51 57 S.	109 15 30	S. L.	0 37 59	28 5·1 S.	7·950	9·010
Samārang	„ „ 30	6 59 42 S.	110 30 45	S. L.	0 23 51	27 4·6 S.	7·937	8·915
Japara	„ Feb. 2	6 36 7 S.	110 38 15	S. L.	0 24 55	27 29·9 S.	7·964	8·978
Ambarāwa	„ „ 5	7 16 8 S.	110 28 45	U.	0 33 17	29 27·7 S.	7·963	9·146
Balembang	„ „ 10	7 24 0 S.	110 37 0	U.		29 2·4 S.		
Solo	„ „ 13	7 35 0 S.	110 53 30	U.	0 35 59	29 12·7 S.	7·958	9·118
Nyjāwee	„ „ 15	7 23 52 S.	111 29 15	U.	0 29 25	28 59·9 S.	8·040	9·193
Bankāwa, Solo river	„ „ 22	7 0 26 S.	112 21 0	U.	0 28 38	27 47·3 S.	8·025	9·072
Soorabāya	„ „ 25	7 16 1 S.	112 44 30	S. L.	0 51 55	28 53·0 S.	8·075	9·222
Sūmenap	„ March	7 0 26 S.	113 51 15	S. L.	0 44 15	27 45·8 S.	8·048	9·096
Pulo Kuneeang . . .	„ April	6 51 32 S.	115 16 30	S. L.	0 32 7	27 25·6 S.	8·064	9·086
Bezooki	„ „ 26	7 43 29 S.	113 42 45	S. L.	0 29 59	27 7·5 S.	8·011	9·000
Kedeeri	„ May	7 48 29 S.	112 0 0	U.	0 28 28	29 52·2 S.	7·905	9·115
Patchitan	„ „ 21	8 12 56 S.	111 5 30	S. L.	0 19 32	30 36·0 S.	7·887	9·163
Munoori	„ June 1	7 35 22 S.	110 4 0	U.	0 18 18	29 20·5 S.	7·960	9·130

Station.	Date.	Latitude North and South.	Longitude East Green.	Height.	Declination East.	Dip.	Horizontal Intensity.	Total Intensity.
		° ′ ″	° ′ ″	Engl. Feet.	° ′ ″	° ′	Engl. Units.	Engl. Units.
Kārang Bolong . . .	1847, June 6	7 45 44 S.	109 27 0	S. L.	0 32 13	29 55·9 S.	7·935	9·157
Chilāchap	„ „ 9	7 44 29 S.	108 57 15	S. L.	0 36 57	29 45·8 S.	7·915	9·118
Aji Bārang	„ „ 12	2 24 49 S.	109 3 30	U.	0 54 38	27 22·1 S.		
Kandang Aur	„ „ 25	6 23 46 S.	108 4 30	S. L.	0 18 13		7·944	
Lampongs	„ August	5 26 12 S.	105 20 15	S. L.	1 12 30	26 15·7 S.	7·916	8·827
Bencoolen	„ September	3 53 54 S.	102 28 45	S. L.	1 5 9	23 54·0 S.	7·913	8·655
Padang	„ October	0 58 58 S.	100 31 15	S. L.	1 24 26	18 32·2 S.	7·962	8·397
Solok	„ Nov. 1 & 2	0 47 5 S.	100 55 45	1232	1 39 5	17 50·8 S.		
Sijongong	„ „ 5	0 41 47 S.	101 19 30	458	1 21 38	17 49·8 S.		
Bua Pānjāng	„ „ 8	0 28 9 S.	101 8 0	U.	1 22 29	17 11·4 S.		
Pāyacombo	„ „ 10	0 13 16 S.	101 4 45	1631	1 29 46	16 38·2 S.		
Fort Vande Capellen	„ „ 11	0 27 34 S.	101 3 0	U.	1 28 13	17 12·3 S.		
Padang Panjang . .	„ „ 14	0 22 0 S.	100 42 30	2559	1 33 30	17 47·5 S.		
Fort de Kock . . .	„ „ 16	0 13 0 S.	100 27 15	3043	1 9 23	16 59·6 S.		
Menindjo	„ „ 17	0 13 0 S.	100 14 0	1492	1 31 48	17 0·8 S.		
Balembangan	„ „ 18	0 11 44 S.	100 10 15	2583	1 36 39	16 47·3 S.		
Peesang	„ „ 19	0 7 55 S.	100 12 0	U.	1 46 33	16 33·4 S.		
Bonjol	„ „ 20	0 0 52 S.	100 13 30	650	1 35 30	16 38·5 S.		
Loobisikapping . . .	„ „ 21	0 6 55 N.		1475		16 8·3 S.		
Batoo Bedindi . . .	„ „ 22	0 16 0 N.		909	1 35 45	15 49·2 S.		
Lender	„ „ 23	0 24 24 N.	100 4 0	695		15 35·2 S.		
Rau	„ „ 24 & 25	0 33 7 N.	99 56 45	848	1 37 27	15 37·4 S.		
Pionghay	„ „ 26	0 36 19 N.	99 52 15	1756	1 38 49	15 50·2 S.		
Batong	„ „ 27	0 39 0 N.	99 47 15	1941		15 41·5 S.		
Kotanopan	„ „ 28	0 42 0 N.	99 42 45	1420	1 34 30	15 19·9 S.		
Tāna Bātoo	„ „ 29	0 44 26 N.	99 30 45	1707		15 3·1 S.		
Fort Elout	„ Dec. 1	0 50 56 N.	99 32 20	680	1 43 35	14 48·1 S.		
Singalāngan	„ „ 3	1 14 48 N.		U.		14 11·9 S.		
Padang Sidompang	„ „ 6	1 22 33 N.	99 22 45	928		13 47·0 S.		
Sibogha	„ „ 12 to 16	1 44 42 N.	98 56 15	S. L.	1 40 38	13 2·5 S.		
Bāros	„ „ 19 to 20	2 0 51 N.	98 31 30	S. L.	1 16 42	12 58·0 S.		
Sinkel	„ „ 23 to 25	2 16 37 N.	97 51 35	S. L.	1 34 8	12 23·5 S.		
Goonong Satoolie, Pulonias	„ „ 31	1 17 35 N.	97 40 50	S. L.	1 43 38	14 5·8 S.		
Nātal	1848, Jan. 10 to 13	0 33 44 N.	99 20 15	S. L.	1 28 8	15 32·4 S.		
Mount Ophir, Malācca	„ March 28	2 22 0 N.	102 38 0	U.		9 55·1 S.	8·255	8·380

Station.	Date.	Latitude North and South.	Longitude East Green.	Height.	Declination East.	Dip.	Horizontal Intensity.	Total Intensity.
		° ′ ″	° ′ ″	Engl. Feet.	° ′ ″	° ′	Engl. Units.	Engl. Units.
Pulo Labooan	1848, May 3 to 5	5 16 59 N.	115 18 15	S. L.	1 36 27	2 51·6 S.	8·240	8·250
Sambooanga	„ „ 25 & 26	6 54 20 N.	122 13 45	S. L.	1 15 24	1 18·2 N.	8·162	8·164
Keemah	„ June 21	1 21 55 N.	125 7 59	S. L.	1 39 47	11 1·4 S.	8·253	8·408
Tondāno	„ „ 27	1 17 31 N.	124 50 11	2240	1 7 37	10 54·3 S.		
Manādo	„ „ 29	1 29 11 N.	124 51 11	S. L.	1 26 16	10 43·6 S.		
Cocos	„ Aug. & Sept.	12 5 38 S.	96 50 30	S. L.	1 10 42 W.	39 18·5 S.	7·275	9·400
Malācca	1849, Jan. 2	2 11 19 N.	102 17 0	S. L.	1 50 24	11 25·2 S.	8·114	8·278
Pulo Dinding	„ „ 10	4 12 47 N.	100 32 52	S. L.	1 48 34	7 31·2 S.	8·117	8·187
Pulo Penang	„ „ 20	5 25 36 N.	100 24 38	S. L.	1 48 48	4 52·8 S.	8·159	8·189
Nicobar	„ Feb. 5 to 12	9 10 12 N.	92 48 23	S. L.	1 53 21	1 14·8 N.	8·155	8·157
Noncowry Harbour	„ „ 17	8 1 42 N.	93 39 20	U.		0 54·4 S.		
Bompoko	„ „ 19	8 14 5 N.	93 19 20	S. L.		0 22·9 S.		
Hastings' Island . .	„ March 26	10 6 45 N.	98 21 15	S. L.	2 13 10	4 19·0 N.	8·177	8·200
Moulmén	„ April	16 29 46 N.	97 45 30	S. L.	2 20 25	17 45·6 N.	8·119	8·525
Madras	„ July & Aug.	13 4 11 N.	80 13 56	S. L.	0 56 8	7 34·2 N.	8·078	8·149

III. Determination of the Declination, from 1834 to 1849, by the Indian Navy.

The originals of these observations are deposited in the Records of the Admiralty Office. Though not all of equal accuracy, they form altogether a very interesting series for showing the gradual change of the declination along the Indian coasts. A few observations, extracted from various sources, have been added by us.

A. *Western Coast of India.*

Station.	Latitude N.	Long. E. Gr.	Year.	Declination East.
	° ′	° ′		° ′
Kărráchi[1]	24 46	67 1	1848-9	0 17
Mănúra[2]	three miles south of Kărráchi.		1848-9	0 30
Vári Creek[3]	23 52	67 49	1848-9	0 12
Lalchátta Tomb[3] .	23 47	68 36	1848-9	1 12
Mouth of Sir River[3]	23 38	68 5	1848-9	0 24
Near Mŏmda Point[3]	23 36	68 22	1848-9	0 51
Nerăni Creek[3] . . .	23 23	68 25	1848-9	0 18
Jáku Swamp[3] . . .	23 7	68 37	1848-9	0 29
Abdúllah Shah[2] .	22 55	69 0	1848-9	0 43
Tomb[2]	22 58	70 1	1848-9	1 27
Súrat[3]	21 6	72 57		1 0
Kalikắt[4]	11 15	75 45	1846	0 25
Tennevélli Coast[5] .	8 40	78 30	1846	0 51
	8 25	78 25	1846	1 58
	8 0	77 50	1846	0 10
Triváudram[6]. . . . (Dip 1° 55′ South)	8 29	76 56		0 3

Observers.

[1] W. A. Fenner, Acting Master.
[2] Commander C. D. Campbell.
[3] Lieutenant Grieve.
[4] Lieutenant Montrion.
[5] Surveyor Franklin.
[6] J. A. Broun, in Journal of the Triváudram Society, 1855.

B. *Ceylon and South and East Coast of India.*

Station.	Latitude N.	Long. E. Gr.	Year.	Declination.
	° ′	° ′		° ′
Adrampatám[1]	10 17	79 22	1838	1 20 E.
Palks' Strait[1]	10 5	79 35	1838	1 20 E.
Western Side of Palks' Strait	9 45	79 30	1838	0 30 E.
Delft Island[1]	9 30	79 48	1838	1 40 E.
Palks' Strait[1]	9 30	79 18	1838	0 30 E.
Páumben,[2] Ceylon	9 21	79 9	1837	0 35 W.
Palks' Strait[1]	9 3	78 35	1838	0 51 E.
Manár, Palks' Strait	9 5	79 55	1845	1 4 E.
Juttikórin	8 48	78 8	1842	0 51 E.
Koelramalái[3]	8 32	79 50	1845	1 15 E.
Trichendór[3]	8 30	78 8	1842	1 58 E.
Near Cape Komorín[1]	8 3	77 35	1843	1 10 E.
Mutokbándi[1]	7 41	79 44	1844	0 13 E.
Ceylon, West Coast[2]	6 15	80 10	1839	1 15 E.
Koringa Bay[4]	16 45	82 15	1848	0 50 E.
			1827	2 34 E.
Calcutta[5]	22 33	88 21	1828	2 41 E.
			1829	2 24 E.
Silhét[6]	24 53	91 47	1825	2 29 E.

Observers.

[1] Powell and Ethersey. [2] Powell. [3] Franklin.
[4] Fell. [5] J. A. Hodgson (Surveyor General). [6] Fisher.

IV. Observations in 1833, along the Eastern Coasts of India, by De Blosseville.

The declination was not yet determined by collimator magnets, but by two needles; the meridian by a Borda's circle. The dip circle used was particularly delicate. See Asiatic Researches, Vol. XVIII., part II., p. 4.

Station.	Latitude N.	Long. E. Gr.	Declination East.	Dip.
	° ′	° ′	° ′ ″	° ′ ″
Chandernagór . . .	22 50	88 23	2 39 52	26 47 3 N.
Calcutta	22 33	88 21	2 38 5	26 32 38 N.
Pondishérri	11 58	79 54	1 2 13	3 46 0 N.
Karikál	11 5	79 56	1 14 1	
Jafnapatám	9 32	80 3	1 16 0	0 39 45 S.
Áripo	8 27	80 1		2 17 34 S.
Trinkomalí	8 42	81 9	1 8 5	3 34 10 S.
Rangún	16 46	96 17	0 49 52	17 51 47 N.
Batavia	6 10 S.	106 58	0 31 8	25 50 1 S.

V. Declination in Central India and Hindostán, from 1813 to 1828, by J. A. Hodgson, Surveyor General.

This table, taken from the Asiatic Researches, Vol. XVIII., part II., p. 10, does not seem to be of equal accuracy throughout for the declination. The values, however, are given as they originally appeared.

Station.	Year of Observation.	Latitude N.	Long. E. Gr.	Declination East.
		° ′	° ′	° ′ ″
Bhopál	1828	23 16	77 22	0 39 0
Sirónj	1828	24 9	77 39	0 57 0
Nauagáū.	1323	25 56	79 32	1 19 0
Dhólpur	1823	26 45	77 55	1 25 0
Ágra	1823	27 10	78 2	1 23 0
Súkit	1813	27 21	78 47	0 42 0
Kóel	1813	27 53	78 3	0 59 0
Biráuli	1813	28 27	79 23	0 44 0
Káshipur	1817	29 12	78 58	0 47 15
Sukertál	1813	29 20	78 0	1 6 0
Goverdhanpúr .	1816	29 41	78 0	0 40 0
Chándi Pahár .	1813	29 55		0 37 0
Sahāranpur . . .	1816	29 57	77 33	0 54 0
Déra Dūn	1813	30 19	78 1	0 18 8
Móhen	1816	30 33	77 54	0 30 0
Chúr Station . . .	1816	30 51	77 29	0 50 50

VI. AVERAGE DECLINATION IN RAJVÁRA, 1835, BY LIEUTENANT A. H. E. BOILEAU.

Lieutenant Boileau's interesting book, "Personal Narrative of a Tour through the Western States of Rajvára, in 1834 and 1835, Calcutta, Baptist Mission Press," contains, pp. 302 to 328, some declinations determined with the needle of a theodolite. The latitudes are directly determined by the writer, the longitudes we have taken from his map.

Year.	Date.	Station.	Latitude N.	Long. E. Gr.	Declination East.
			° ′ ″		° ′
1834	Oct. 13	Camp Janth . .	28 15 21	70 3 30	1 2
1834	„ 27	Camp Piragpúra	27 36 30		0 36
1834	Nov. 5	Sámbhăr	26 54 53	72 0 0	0 57
1834	„ 6	„	„ „ „	„ „ „	1 16
1835	Jan. 8	Singhána	28 4 33		1 1
1835	Feb. 1	Údepur	27 43 26	75 37 0	1 8
1835	May 25	Phalódi	27 8 21	72 25 15	0 32
1835	June 3	Shío	26 11 31	71 18 30	0 32

Lieutenant Boileau himself concludes, p. 327, with the following remarks: "As the observations differ considerably among themselves, owing to the difficulty of accurately adjusting the needle of so small an instrument as a $3\frac{1}{2}$ inch theodolite, they are here collected into one place that their mean may be taken as the true magnetic declination in the upper parts of Rajvára, in about

Latitude N.	Long. E. Gr.	Mean Declination.
27° 0′	75° 0′	0° 52′ East."

VII. Dip and Relative Horizontal Intensity, from 1837 to 1839, by F. G. Taylor and J. Caldecott.

These observations are contained in the Madras Journal of Literature and Science, 1839. The transcription, with few exceptions, is left unaltered; the longitudes are referred to the Madras longitude of 80° 14′.

Station.	Latitude N.	Long. E. Gr.	Dip.	Relative Horizontal Intensity.
	° ′	° ′	° ′ ″	
Ongole	15 30	80 2	11 36 40 N.	0·9868
Ramapatan	15 3	80 3	10 44 14 N.	0·9834
Allúr	14 41	80 4	10 18 46 N.	0·9804
Nellúr	14 28	79 59	9 41 16 N.	0·9886
Woogilly	14 1	79 55	8 49 20 N.	0·9903
Sooloorpet	13 41	80 0	8 11 17 N.	0·9830
Poodway	13 21	80 8	7 16 46 N.	0·9913
Madras	13 4	80 14	6 50 4 N.	1·0000
Sadras	12 32	80 9	5 31 23 N.	1·0072
Allumparva	12 14	79 59	4 50 16 N.	0·9929
Pondishérri	11 56	79 49	4 27 12 N.	0·9972
Porto Novo	11 29	79 45	3 6 15 N.	0·9962
Sheally	11 16	79 47	2 28 13 N.	0·9936
Kalikát	11 15	75 45	2 42 43 N.	0·9942
Tranquebar	11 1	79 52	2 5 17 N.	0·9937
Penaney	10 47	75 55	1 11 25 N.	0·9956
Negapatam	10 46	79 48	1 42 10 N.	0·9958
Manargoody	10 40	79 29	0 39 8 N. 1 3 38 N.	0·9773
Chetwaye	10 32	76 1	1 12 34 N.	0·9880
Puttoocotah	10 27	79 20	0 55 0 N.	0·9746
Munamelegoody	10 3	79 12	0 10 34 N.	0·9826
Balghatty	9 59	76 14	0 18 46 N.	0·9929
Kalebennary	9 40	78 57	0 6 22 N.	0·9820
Allepee	9 31	76 18		0·9769
Ramnad	9 22	78 51	1 24 42 S.	0·9775
Paumben	9 21	79 9	1 35 30 S.	0·9953
Carryshandy	9 11	78 24	1 51 52 S.	0·9745
Vadinatrum	8 57	78 7	1 33 57 S.	0·9730
Quilon	8 54	76 40	2 21 35 S.	0·9762
Powani	8 49	77 54	2 46 10 S.	0·9763
Tutocorin	8 48	78 11	2 37 42 S.	0·9955
Palamcottah	8 44	77 45	2 46 1 S.	0·9869
Trivándram	8 29	76 56	3 15 24 S.	0·9863
Nagracoil	8 11	77 25	3 53 3 S.	0·9898

The preceding observations along the coast of Southern India were chiefly made to determine the position of the *magnetic equator* and the intensity along this line.

Messrs. Taylor and Caldecott determined the following three points of the magnetic equator:

Latitude North.	Longitude East Green.
° ′ ″	° ′ ″
9 37 28	80 6 47
9 56 46	79 27 23
10 1 51	77 3 38

Our own observations, referred to January 1, 1856, though differing very little for the position of the magnetic equator, give (as also do the lines on Captain Elliot's maps, 1848) decidedly greater inclinations for the latitudes at some distance north of the magnetic equator.

Taylor and Caldecott themselves often find uncertainties of more than 30′.

The relative horizontal intensity referred to Madras (= 1) will nearly represent the absolute values for 1856, if multiplied with 8·023.[1]

VIII. Declination and Dip in Kashmír and Ladák, in 1847, by Major A. Cunningham.

These values, the first determined in these regions, are contained in his "Ladák", London, 1854. No data in reference to the instruments, or the method of observation, are given. For the intensity no results can be deduced, the readings being given of the vibrations only, and being besides unconnected by any observations with India.

Station.	Latitude N.	Long. E. Gr.	Declination.	Dip.
	° ′	° ′	° ′ ″	° ′ ″
Srinágger, capital of Kashmír	34 5	74 49	2 44 29·96	46 39 39
Lára, in Spíti	32 9	79 9		43 36 52
Hánle, in Rúkchu	32 48	78 56		44 23 22
Ráldang, in Rúkchu	33 14	78 27		44 52 0
Púga, in Rúkchu	33 12	78 25		45 10 24
Leh, in Ladák	34 8	77 15	2 46 52·02	46 43 9
Múlbe, in Ladák	34 20	76 7	2 44 29·10	46 56 24

[1] Compare our values for Madras, p. 386.

IX. Historical Data for Secular Change.

The old observations on declination and dip, made since the beginning of the 17th century, we chiefly collected from the important work of Christopher Hansteen "Untersuchungen über den Magnetismus der Erde." Christiania, 1819. Though the editor, with his well known scientific accuracy, points out (p. 141) that observations made in so remote a period cannot be directly compared, in respect of accuracy, with the results obtained by the present improved instruments, yet the materials are of quite sufficient accuracy to deserve, by the importance of the object, our full attention.

We may avail ourselves of this occasion to remark that the few, but careful, observations of the East India Company's merchantmen furnished, with few exceptions, the first positive materials[1] which suggested to Halley's genius, that the admission of four, instead of two, maxima of forces alone allows of a satisfactory theory of the magnetic phenomena. These early contributions, due to a body which has added to the lustre of its political importance by unremitting attention to the interests of science and literature, formed the basis of Halley's fundamental work, "Theory of the Variation of the Magnetical Compass". Philosophical Transactions, Vol. XIII., 1683.[2]

We have brought into a geographical arrangement the old observations, from the beginning of the 17th up to the end of the 18th century, which, though covering a vast extent, are limited to points of the sea shore. In another column will be found the values of our own observations, deduced from our maps for the same places.

Corrections for periodical changes, instrumental errors, &c., could not be applied; but the latitudes and longitudes we corrected from the most recent charts. We also took means, when more than one observation was made within a short distance of time. The diagrams to illustrate these secular changes are contained on our magnetic maps, and drawn on a small scale, which allows all the materials to be compared at one glance.

For the declination in 1800, the reference to the more recent materials enables us considerably to modify Hansteen's views of the lines for those regions.

[1] Similar observations of the earlier periods may be still contained in the official naval records, deposited in the Marine Department of the India House.

[2] Amongst his successors we mention the well known observations and great works of Humboldt, Gauss and Weber, Sabine, Kupffer, &c.; and as books of more general reference, not without special interest for many scientific gentlemen in India: Humboldt's Cosmos, Vol. IV., 1858, Herschel's Admiralty Manual, Lamont's Handbuch des Magnetismus, 1849, and Babinet's Mémoires dans la Revue des Deux Mondes, Vols. 7 and 8 (1857), "De l'aimant et du magnétisme terrestre."

a. *Declination on the Coasts of India, and in the Indian Archipelago, from 1600 to 1856.*

Station and Observer.		Latitude North.	Longitude East Green.	Declination. 17th Century. Decl. West.	Declination. 18th Century. Decl. West.	Declination. 1856, Schlagintweit. Decl. East.
1. West Coast of India.						
		° ′ ″	° ′ ″	° ′	° ′	° ′
Diú:	*Payton*	20 42	70 52	1613; 16 45		0 11
Súrat:	*Best*	21 6	72 57	1611; 16 23		0 27
	Boners			1612; 16 50		
	Mathews				1722; 5 50	
	Mathews				1723; 5 40	
Damán:	*Best*	20 24	72 53	1612; 16 30		0 22
	Best			1676; 12 0		
Bombay:	*Mathews*	18 54	72 49		1721; 5 14	0 19
	Mathews				1722; 5 7	
	Mathews				1723; 5 10	
Cháūl:	*Mathews*	18 40	72 52		1721; 5 27	0 19
Dábul:	*Daunton*	17 32	73 2	1610; 15 34		0 17
	Daunton			1611; 16 30		
Rájapur:	*Mathews*	16 50	73 10			0 17
Góa:	*Alenisius*	15 25	73 46	1609; 16 0		0 18
	Noël				1706; 6 40	
	Mathews				1722; 4 57	
	Mathews				1723; 5 8	
	Mathews				1724; 5 41	
Agoáda:	*Mathews*	15 29	73 45		1722; 5 49	0 19
Karvár Bay:	*Mathews*	15 0	73 50		1722; 5 22	0 19
	Mathews				1723; 5 8	
	Mathews				1724; 5 41	
Mangalúr:	*Mathews*	12 52	74 49		1722; 5 30	0 20
	Mathews				1723; 5 5	
Tellichérri:	*Mathews*	11 45	75 28		1722; 4 12	0 21
Kóchin:	*Pring*	9 58	76 14	1614; 15 0		0 23
	Noël				1706; 6 20	
	Mathews				1722; 3 43	
	Mathews				1724; 3 51	
Anjéngo:	*Mathews*	8 41	76 46		1724; 4 17	0 21
	Panton				1776; 1 12	

Station and Observer.		Latitude North.	Longitude East Green.	Declination. 17th Century. Decl. West.	18th Century. Decl. West.	1856, Schlagintweit. Decl. East.
				2. Bay of Bengál.		
Áva:	*Duchatz*	21° 0′	96° 20′	1689; 5° 0′		
Calcutta:	*Mathews*	22 33	88 21		1722; 4° 7′	1° 54′
Chandernagór:	*Boudier*	22 50	88 23		1731; 3 0 1735; 2 0 1743; 1 20 1745; 1 0 1747; 0 0 1750; 0 0	2 20
Balasór:	*Mathews*	21 30	86 55	1680; 8 20		2 1
Pt. Palmyras:	*Mathews*	20 43	87 3		1722; 3 33	2 0
				3. Koromándel Coast and Ceylon.		
Masulipatám:	*Hippon*	16° 10′	81° 10′	1610; 12° 22′		1° 12′
Petapólli:	*Hippon* *Marlowe*	16 11	81 7	1611; 12 35 1613; 13 10		1 12
Madras:	. . . *Mathews* *Mathews*	13 4	80 14	1680; 8 10	1722; 2° 52′ 1723; 3 16	0 59·5
Pondichérri:	*Richaud*	11 56	79 49	1689; 7 0		0 57
Cape Komorín:	*Davis* *Best* *Bonners* . . . . . . *Mathews*	8 5	77 37	1601; 16 0 1612; 14 15 1620; 14 20 1680; 8 45 1688; 7 30	1723; 2 54	24
Freyer's Hood:	*Mathews*				1722; 2 16	
Gálle:	*Castleton* *Mathews*	6 3	80 11	1613; 13 24	1723; 2 45	0 41

Station and Observer.		Latitude North and South.	Longitude East Green.	Declination.		
				17th Century.	18th Century.	1847, Elliot's Survey. Decl. East.
4. Indian Archipelago.						
Nicobar:	*Davis*	9° 10′ N.	92° 48′	1605; 7° 5′ W.		1° 53′
Pulo Kondor:	*Dales* / *Cook*	8 40 N.	106 19	1620; 1 0 W.	1780; 0° 14′ W.	
Achin:	*Davis*	5 22 N.	95 34	1610; 6 25 W.		1 47
Priaman:	*Marlowe* / *Castleton*	0 45 S.	99 43	1612; 4 10 W. / 1613; 4 50 W.		1 32
Marlborough Fort:	*Macdonald* / *Macdonald*	3 45 S.	101 50		1794; 1 10 E. / 1795; 1 8 E.	
Banka Island:	*Marchaud*	3 0 S.	106 2		1791; 0 0	1 16
Sunda Strait:	*Milword*	6 15 S.	10 50	1615; 3 30 W.		0 38
Batavia:	*Wallis* / *Carteret*	6 10 S.	106 58		1767; 1 25 W. / 1758; 0 25 W.	0 47
Bantam:	*Saris*	6 20 S.	105 21	1619; 3 0 W.		0 43
Palambangan:	*Davis*	6 31 S.	105 55	1605; 3 20 W.		0 59
Prince's Island:	*Wallis* / *Cook*	6 36 S.	105 17		1767; 1 0 W. / 1780; 0 54 W.	0 42
Madúra Island:	*Cartaret*	7 7 S.	112 49		1768; 0 30 W.	0 34
Bontani, on Celebes:	*Cartaret*	5 30 S.	117 45		1767; 1 16 W.	0 48
Doa, Molukka:	*Saris*	2 S.	126	1613; 5 20 E.		

As some of the most characteristic features, we may mention that, in the beginning of 1600, the line of 16° to 17° westerly declination had a position nearly coinciding with that of the line of 0° declination in 1856; in 1800 the declination had already decreased to 3° to 4° west. The northern parts show oscillations of the lines much greater than the southern ones in 1800; the line of no declination passes

Station and Observer.		Latitude North.	Longitude East Green.	Declination. 17th Century. Decl. West.	18th Century. Decl. West.	1856, Schlagintweit. Decl. East.
2. Bay of Bengál.						
Áva:	*Duchatz*	21° 0′	96° 20′	1689; 5° 0′		
Calcutta:	*Mathews*	22 33	88 21		1722; 4° 7′	1° 54′
Chandernagór:	*Boudier*	22 50	88 23		1731; 3 0 1735; 2 0 1743; 1 20 1745; 1 0 1747; 0 0 1750; 0 0	2 20
Balasór:	*Mathews*	21 30	86 55	1680; 8 20		2 1
Pt. Palmyras:	*Mathews*	20 43	87 3		1722; 3 33	2 0
3. Koromándel Coast and Ceylon.						
Masulipatám:	*Hippon*	16° 10′	81° 10′	1610; 12° 22′		1° 12′
Petapólli:	*Hippon* *Marlowe*	16 11	81 7	1611; 12 35 1613; 13 10		1 12
Madras:	. . . *Mathews* *Mathews*	13 4	80 14	1680; 8 10	 1722; 2° 52′ 1723; 3 16	0 59·5
Pondichérri:	*Richaud*	11 56	79 49	1689; 7 0		0 57
Cape Komorín:	*Davis* *Best* *Bonners* . . . . . . *Mathews*	8 5	77 37	1601; 16 0 1612; 14 15 1620; 14 20 1680; 8 45 1688; 7 30	 1723; 2 54	24
Freyer's Hood:	*Mathews*				1722; 2 16	
Gálle:	*Castleton* *Mathews*	6 3	80 11	1613; 13 24	 1723; 2 45	0 41

Station and Observer.		Latitude North and South.	Longitude East Green.	Declination.		
				17th Century.	18th Century.	1847, Elliot's Survey. Decl. East.
4. Indian Archipelago.						
Nicobar:	*Davis*	9° 10′ N.	92° 48′	1605; 7° 5′ W.		1° 53′
Pulo Kondor:	*Dales* *Cook*	8 40 N.	106 19	1620; 1 0 W.	1780; 0° 14′ W.	
Achin:	*Davis*	5 22 N.	95 34	1610; 6 25 W.		1 47
Priaman:	*Marlowe* *Castleton*	0 45 S.	99 43	1612; 4 10 W. 1613; 4 50 W.		1 32
Marlborough Fort:	*Macdonald* *Macdonald*	3 45 S.	101 50		1794; 1 10 E. 1795; 1 8 E.	
Banka Island:	*Marchand*	3 0 S.	106 2		1791; 0 0	1 16
Sunda Strait:	*Milword*	6 15 S.	10 50	1615; 3 30 W.		0 38
Batavia:	*Wallis* *Carteret*	6 10 S.	106 58		1767; 1 25 W. 1758; 0 25 W.	0 47
Bantam:	*Saris*	6 20 S.	105 21	1619; 3 0 W.		0 43
Palambangan:	*Davis*	6 31 S.	105 55	1605; 3 20 W.		0 59
Prince's Island:	*Wallis* *Cook*	6 36 S.	105 17		1767; 1 0 W. 1780; 0 54 W.	0 42
Madúra Island:	*Cartaret*	7 7 S.	112 49		1768; 0 30 W.	0 34
Bontani, on Celebes:	*Cartaret*	5 30 S.	117 45		1767; 1 16 W.	0 48
Doa, Molukka:	*Saris*	2 S.	126	1613; 5 20 E.		

As some of the most characteristic features, we may mention that, in the beginning of 1600, the line of 16° to 17° westerly declination had a position nearly coinciding with that of the line of 0° declination in 1856; in 1800 the declination had already decreased to 3° to 4° west. The northern parts show oscillations of the lines much greater than the southern ones in 1800; the line of no declination passes in its northern part through Chandernagór, and assumes in its southern part, near Java, Flores, and Timor, a position that it has kept with very little alteration for the last fifty years.

b. *Dip on the Coasts of India, and in the Indian Archipelago, from 1768 to 1793.*

Station and Observer.		Latitude North and South.	Longitude East Green.	Dip.	
				18th Century.	Elliot and Schlagintweit, 1848 to 1856.
		° ′	° ′	° ′	° ′
Kóchin:	*Le Valois*	9 58 N.	76 14	1786; 10 15 N.	0 0
Madras:	*Abercrombie*	13 4 N.	80 14	1775; 5 5 N.	7 53 N.
Trinkomalí:	*Panton*	8 42 N.	81 9	1776; 4 37 S.	2 40 S.
Súnda Strait:	*Eheberg*	6 15 S.	105 0	1770; 27 30 S.	27 4 S.
Surrobaya, in Java:	*Dentreasteaux*	7 14 S.	112 39	1793; 25 40 S.	28 30 S.
Prince's Island:	*Cook*	6 36 S.	105 17	1780; 28 15 S.	27 0 S.
Pulo Penang:	*Le Gentil*	5 26 N.	100 25	1768; 6 22 N.	4 50 N.
Pulo Kondor:	*Cook*	8 40 N.	106 19	1780; 2 1 N.	1 58 N.

The data for this element are still less complete for remote periods, but it is evident, nevertheless, as a general result, that within nearly a century the magnetic equator, and the lines to both sides of it, have shifted their position considerably to the south.

B. CONSTRUCTION AND EXPLANATION OF THE MAGNETIC MAPS.

The maps, which form the basis of the various systems of magnetic declinations, are drawn in Mercator's projection, on a scale of 1 to 8,000,000; for the equator, the variation of the scale with latitude is added in a special diagram.[1] The river system and the mountain ranges, particularly in the northern parts, presented many novel features,[2] but in consequence of the size of the scale employed, we deemed it inexpedient to give more than the most predominant orographical characteristics,

[1] About the longitude of Madras = 80° 13′ 56″ East Green., see p. 127.

[2] We allude more especially to the fact of the Karakorúm being the principal chain, and its northern drainage intersecting the Kuenlúen, also to the well defined form of Tibet, as a longitudinal valley, and to the routes and river system in the north-western part of our route map.

as too many details would otherwise have interfered with the distinctness of the river system and the objects of the physical geography represented. The descriptive geography of the countries visited by us, and more particularly that of the regions of High Asia, will be given in Vols. II. and III., and will form the object of various detailed maps.

The construction of the lines of equal declination and dip presented no particular difficulties; the deviations also were in general neither great nor numerous. The isodynamic lines required a more detailed calculation.

1. Map of Isogonic Lines.

The map contains the lines from 10′ to 10′, and the names of all our stations, together with the values obtained; the stations, also, for which previous determinations of declination (though of variable scientific value) could be collected,[1] are marked by red rings.

Besides, the map contains:

a. Three diagrams to illustrate the secular changes for India and the Indian Archipelago from 1600 to 1800.

b. A reduction of Captain Elliot's chart of the Indian Archipelago, 1845 to 1849.

c. General Sabine's chart of the isogonic lines of the globe, reduced from the recent Admiralty edition, which has been most carefully revised under the superintendance of Mr. Evans.[2] This chart shows at the same time the four general groups formed by these lines, in consequence of their being gathered round two poles in the northern, and two poles in the southern hemisphere. (The lines also of total intensity, differing from those of the dip, show four corresponding maxima of the forces.)

2. Map of Isoclinal Lines.

The isoclinal lines are given for every degree of dip, from 10° S. to 55° N. The various points of the lines are deduced chiefly from those neighbouring stations which are nearest in value to the number sought for. This we have done in order to get the lines as much as possible directly defined.

[1] They are given pp. 467 to 473.

[2] Mr. Evans added in his map, on a smaller scale, the probable *annual* variation of the declination, but the numbers so carefully collected by him are not sufficient as yet to show distinct general laws.

In combining the observations of the dip for deducing the position, mean direction, and mean relative distance of the isoclinal lines, we employed the following method, which is the one now generally in use.[1]

If ϑ = the dip at the central position, u = the angle of the isoclinal line with the meridian, r = a constant, representing the rate of increase perpendicular to the isoclinal line, and if we put:

$$r \cos u = x$$
$$r \sin u = y,$$

we may make equations of condition of the form:

$$ax + by = \vartheta - \vartheta',$$

where a and b are co-ordinates of distance in longitude and latitude of the several stations from the mean, expressed in miles, ϑ' the inclination at these several stations, and ϑ the mean dip.

For constructing the isoclinal lines, we have, in addition to the direct observations, based our calculations upon the following groups:

Groups.	Mean Dip.	Mean Longitude East Green.	Mean Latitude North.	Stations, referred to
	° ′	° ′	° ′	
I.	0 0	79 40	9 50	Madras, Gálle.
II.	1 0	79 50	10 10	Madras, Utatúr, Gálle.
III.	9 18	78 0	14 0	Bellári, Madras, Utatúr, Kăládghi.
IV.	16 30	78 30	17 10	Kăládghi, Bellári, Nágri, Rajamăndri.
V.	18 50	76 0	18 30	Kăládghi, Bombay, Nágri.
VI.	30 10	89 20	23 20	Calcutta, Kúlna, Dháka, Rámpur, Bólea.
VII.	30 20	80 40	24 10	Jáblpur, Ságer, Benáres.
VIII.	35 30	72 40	27 30	Déra Ismáel Khan, Lahór, Bombay.
IX.	38 40	84 10	28 50	Nărigún, Darjíling, Kathmándu, Nainitál, Mílum, Mána.
X.	41 30	74 30	30 30	Déra Ismáel Khan, Lahór, Bombay.

It will be seen that irregular stations, such as Utakamánd, and Mahabaléshvar, have been excluded, in order that they may not interfere with the general means. In the

[1] It had been also employed by Captain Elliot, in his survey of the Indian Archipelago.

Western Himálaya the stations were numerous enough to deduce the lines as immediate result, without adding means, calculated for general groups.

The isoclinal map contains, besides our own stations and lines:

a. A diagram of the zone, surrounding the magnetic equator, as deduced from earlier observations, referred to 1700.

b. A reduction of the Indian Archipelago, in which we give the values obtained by Captain Elliot.

c. A sketch of the isoclinal lines on the surface of the earth, which have been transferred on a chart of smaller scale from General Sabine's map, contained in plate 23 of Johnston's Physical Atlas.

As the space does not allow of the projection of the polar part being separately added, it should be remembered that there are but two points of 90° inclination, one northern and one southern, occasionally called poles, though in a different sense from the ordinary one[1];— poles in the usual signification of the word being intended to express "*points of greatest attraction*" (Halley) = "*maxima of force*" (Sabine).

3. Map of Isodynamic Lines.

Our map contains the isodynamic lines of total intensity from 0·25 to 0·25 English units, referred to seconds of time and English measure of length and weight. The calculation of the points for the construction of the isodynamic lines has been based upon the same principle as the method above detailed for the isoclinal lines, but with this modification, that the values of such points only were sought for, which lay in the same longitude as the original stations. The map shows, moreover, the stations which we considered to be the leading ones. The results deduced are connected with the stations by dotted lines; the complicated question of the general form and direction of the isodynamic lines being thus rendered, as much as possible, an independent determination.

Spaces which fall below the average are marked by oblique lines of a blue colour, falling from right to left; those spaces, or single observations, exceeding the respective average, are marked by oblique lines of a red colour falling from left to right.[2]

[1] See "Gauss' Allgemeine Theorie des Erdmagnetismus." Leipzig, 1839.

[2] As shown by the detail referring to the instruments, observers, &c., which is given for each station in Section V., it so happens, that in the far extended space, where we found the remarkable depression of total intensity, instruments and observers are both so varied and unconnected, as to exclude any fear of a general personal or instrumental error.

Besides our own stations of total intensity the map contains:

a. A diagram of our observations of horizontal intensity. This sketch gives the results of the absolute determinations at the different stations, and some of the principal general lines, amongst which we particularly mention the dotted line of maximum horizontal intensity (but with variable absolute value), and the space of maximum horizontal intensity. It will be found, that we have most carefully excluded from the general consideration every station which presented a more than usual increase in these regions. A special diagram for the vertical intensity appeared unnecessary, as the *form* of these lines was found to differ but very little from the isogonic lines.

b. A diagram, on a reduced scale, of Captain Elliot's Survey in the Indian Archipelago, with the isodynamic lines of total and horizontal intensity.

c. For comparison, we have added a reduction of General Sabine's chart of the isodynamic lines from plate 23 of Johnston's Physical Atlas.

C. RESULTS DEDUCED FROM THE ABSOLUTE DETERMINATIONS OF THE MAGNETIC ELEMENTS.

The results of the astronomical determinations, made in immediate connection with the magnetic observations, are given pp. 270 to 273. In pointing out in this place the principal features of the magnetic curves, we refer to our magnetic maps.

I. Declination.

1. The line of no declination passes close to the north-western mouth of the Indus, and, in its southerly direction, runs nearly parallel to the western shore of India, at an average distance of 2½° of longitude. It keeps this direction as far south as the Indian Archipelago, where it takes a decided easterly turn.

2. Local disturbances were comparatively rare, and, with few exceptions, extremely limited in their extent; on all occasions observed, they were manifestly connected with the condition of the soil, or the rocks on the surface. When rocks showed signs of a polar magnetic nature, the poles were generally found to coincide with natural points and edges, formed by the intersection of joints or surfaces connected with the mechanical structure of the rocks. The traps of the Dékhan, the crystalline

rocks of the Parisnáth in Bengál, the granites of the Khássia Hills and of the eastern Himálaya, and the eruptive masses south of the Kuenlúen, presented many instances of such coincidence. The special researches on the magnetic conditions of these rocks (which, with proper care, could be avoided in the selection of our stations for absolute determinations) will be given later, in Vol. VI., Geology.

As examples, we may refer to some small, but not unfrequent disturbances in the environs of the magnetic equator, and other greater ones at the Kúlong rock, near Nankláu in the Khássia Hills, amounting to 6° of difference from the otherwise probable value.[1]

3. As deviations of a more general character we mention:

a. Assám on both sides of the Brahmapútra river; the declination being here considerably less to the east than might be expected by the general form of the isogonic lines.

b. A zone of attraction of very little breadth, which seems to coincide with a small ridge of granites at the base of the Bhután Himálaya. At least, already at Nărigún (Lat. N. 26° 53′ 50″, Long. E. Gr. 92° 6′ 0″), this zone is crossed, and the declination is there found to be too much to the east.

c. The line of 2° 30″ also seems to present some irregularity, when continued to the valley of the Iravádi. At Utakamánd, in the Nílgiris (Lat. N. 11° 23′ 40″, Long. E. Gr. 76° 43′ 10″), the declination is about 20′ too much to the east.

4. The zone of most rapid increase of declination is found between Lat. N. 29° to 34° and Long. E. Gr. 80° to 71°. The circumstance, that the *central mass* of the mountain systems of the Himálaya, Karakorúm, and Kuenlúen has a position, which as such may have an influence upon this deviation, seems not unconnected with such an irregularity, and this is corroborated by the declination increasing in general very little, when we approach at a corresponding distance the eastern end of the Himálaya.[2]

5. In the Karakorúm and Kuenlúen, for which no neighbouring places formerly

[1] An apparent disturbance at Chérra Púnji, mentioned in our official Report No. 4, Dec. 19, 1855, disappeared altogether when the true meridian was re-calculated by the strict formulæ.

The proceedings of the Trivándrăm Museum Society, Dec. 1855, contain a very interesting paper: "Experiments on the Magnetic Rock of Naiman Hill, or Mukunumálli", by Mr. J. A. Broun, to which we shall have occasion again to refer in Vol. VI., Geology.

[2] We add, that we are well aware that the Alps, so considerably smaller in extent, breadth, and elevation, than the vast mountain ranges of High Asia, do not show any well defined influence of a similar kind.

allowed of an approximate estimation, we find the easterly declination somewhat greater than has hitherto been laid down on general magnetic maps.

II. Dip.[1]

1. All India Proper is included within the zone of rapid increase of dip with the latitude, which more or less follows the magnetic equator all round the earth. Though in latitudes of about 15° to 25° North we find the dip somewhat smaller than had generally been calculated, in higher latitudes our lines seem to reach the values deduced from general calculations. We find the zone of rapid increase rather broader than it was formerly supposed to be.

The magnetic equator shows a decided, but very small, curvature to the north above Ceylon. It seems to have become a little more northerly since Captain Elliot's determinations.

2. The isoclinal lines, comparatively speaking, represent in India the most regular of the three elements, in reference to their general form; their mutual distance varies but very little, as is shown by the map, and the more so when it is remembered that the employment of Mercator's projection necessarily makes the distances appear a little greater in the higher latitudes.

3. The peculiar modification, which we shall hereafter have to point out for the total intensity, is not represented by the isoclinal lines in Southern and Central India; but the depression along the foot of the Himálaya, particularly in its eastern part, also occurs on the isoclinal lines, though to a much smaller extent.

Chérra Púnji and Mahabaléshvar seem to be local irregularities for themselves; it is perhaps worthy of note that these two stations are, at the same time, regions of extreme precipitation of rain.

The increase of intensity north of Símla seems equally to be represented for the dip by a few stations, amongst which we chiefly name Sultánpur and Vángtu Bridge; but the differences are much smaller than they will be seen to be for the total intensity. Whilst there they exceed values, corresponding to 10° of latitude, the following are the deviations from the average values, if we calculate the dip in round numbers corresponding to the single stations. We exclude from this table differences not reaching 10′, as they are comparatively not of sufficient importance.

[1] Compare the remarks on the vertical intensity, p. 488.

Station.	Observed Dip.	Dip deduced, for the same Latitude and Longitude, from the General Form of the respective Isoclinal Curve.	Difference in Dip.	Corresponding to a Difference in Latitude.
	° ′	° ′	′	′
Nărigún	37 8	37 30	— 22	11
Darjíling	36 33	37 5	— 32	16
Tónglo	36 25	37 2	— 37	18
Fălút	36 55	37 10	— 15	8
Nainitál	38 34	38 50	— 16	9
Chérra Púnji . . .	33 37	34 6	— 29	15
Mahabaléshvar . .	16 26	17 2	— 36	15
Sultánpur	43 52	43 16	+ 36	10
Vángtu Bridge . .	43 23	42 50	+ 33	9

4. An influence of height does not become apparent within 2′ or 3′[1], but such values must be considered as hardly within the limits of *absolute* determination with the instruments now in use, though the *direct* readings with Dr. Lloyd's excellent dip circles, which we had with us, are considerably more minute.

5. In reference to small local deviations, we found them not unfrequent, particularly when the dip circle itself was put on the ground for the purpose of ascertaining the existence, or amount, of such local influence. But detailed experiments, made in the environs of Símla, at Dounton, as well as in several localities in the trap districts of the Dékhan, showed that this influence is in general so weak, that it disappears altogether if the instrument is placed upon its regular stand, instead of the ground itself.[1]

III. Total Intensity.

This element has presented most unexpected results, which, we think, may not be without interest in theoretical considerations of terrestrial magnetism.

1. From the Arabian Sea down to the Indian Archipelago, the isodynamic lines

[1] Such experiments are easily made in localities which contain rocks in situ, and thick alluvial deposits, at not too great a distance from each other.

of total intensity have a mean easterly course, with a slight divergence to the south. But the lines, when passing over the interior of the Indian peninsula, present two marked modifications.

The first modification that occurs, is the existence of a region in Central India of great relative increase, including, amongst other stations, Jáblpúr,[1] Nágri, and Bellári, down to Utakamánd. But even if, for the construction of the general isodynamic lines, we do not directly include these places (considering them as exceptionally anomalous), the lines yet continue to show a most decided inflexion to the south, which, as far as we know, has never been preceded by a similar phenomenon extending over so large a surface, and being at the same time so well defined in its limits.

In consequence of the special interest taken by our late friend Baron Humboldt in this unexpected result, we communicated it soon after our return to the meeting of the British Association at Dublin, and to the French Academy at Paris.[2] We are able to add now, as another very important fact corroborating our observations, that Mr. J. A. Broun, the director of the observatory at Travankór, has since also obtained, quite independently of our own observations, intensities all along the western coast and in the south of India, which perfectly agree with the general form of the isodynamic lines mentioned above.[3]

The second modification is that, for the whole length of the southern border of the Himálaya, and particularly in its eastern parts, there exists a longitudinal zone of variable breadth, where the total intensity is decidedly too low, and to an amount which, under ordinary circumstances, would correspond in many cases to a difference of latitude[4] exceeding 10°. This zone also includes, in its easterly part, a small region of Bengál and Hindostán; in its western part it seems to extend into the higher regions of the mountains beyond Srinágger; a similar depression is also met with in the environs of Leh and the lake Tsomognalarí.

2. These facts, we feel, are extremely difficult to be explained. If, from the comparatively few data before us — few particularly in so far as they are limited to one

[1] Gválior also seems to have the intensity comparatively greater; our short stay, however, prevented us from making a determination of its absolute value.

[2] See Comptes rendus, Tome 45, Séance du 12 Octobre, 1857.

[3] See Mr. Broun's communications to the French Academy, in L'Institut, February 2, 1859, and his reports to the British Association at Oxford, June, 1860.

[4] The relative amount of disturbances can best be compared, if we consider the difference of latitude, which, within the regions examined, would correspond to a similar effect.

tropical country only — we are allowed to offer an explanation, we may direct attention principally to the following circumstances.

The powerful action of a tropical insolation considerably modifies the physical and magnetic conditions of the soil, particularly of the clayey strata, which cover, in variable thickness, such extensive tracts in Central India. By the influence of the insolation, these strata undergo decided changes, which, though very much less in amount, are similar to those which are observable between clay and burnt bricks.[1]

The extent of this disturbing cause, together with its vicinity to the surface, seems sensibly and uniformly to increase the magnetic intensity in these regions.[2] This opinion is perhaps supported by the circumstance, that the sub-tropical region of excessive rain, great humidity of the ground, and much more limited direct insolation, presents itself, on the contrary, as a zone of relative decrease of magnetic intensity. Though an increase of temperature would, as such, rather tend to produce a decrease of magnetism,[3] the modification of the isodynamic lines under consideration are connected but indirectly with the action of the sun, being dependent upon permanent alterations gradually produced in the physical nature of the soil. At the same time, there are few exclusively tropical countries which, by their size and configuration, are so well adapted to make apparent the influence of a large surface of tropical soil in contrast to oceans surrounding it. The circumstance, that the forms are not quite dissimilar to the modifications of the isothermal lines in India, can in general be considered only as one of the many instances of apparently accidental coincidence in nature.

If, instead of the resulting total intensity, we consider the *horizontal* and *vertical* intensity separately, we may mention particularly the following details:

[1] In reference to the magnetic action of the clay we often had occasion to make detailed, delicate experiments, the result of which will be given in Vol. VI. As mentioned above for the dip, the elevation of the instrument on its stand, and the selection of a convenient place, generally rendered insensible the action even of decidedly magnetic rocks, and on alluvial clayey soil, always easily excluded every fear of a purely local error, which, besides, could not have kept so uniform a value.

[2] It seems to be expected that, also in future periods, when isodynamic lines of another value run over India, they will undergo a change, analogous to the present curves. Perhaps the accuracy of the instruments now in use will allow of looking out for similar facts, important for our views, at not too distant a time.

[3] See General Sabine's interesting Address to the Belfast Meeting of the British Association, 1852, concerning the difference of the summary magnetic force for both hemispheres, compared for winter and summer, as well as the various fundamental researches of Professor Faraday on atmospheric magnetism. Philosophical Transactions, 1850, §§. 2847 to 3069. See also Erman's observations in the regions of extreme cold of northern Asia.

3. The *horizontal* intensity shows a line of maximum, but of a variable absolute value, which passes through India from the north of the Delta of the Indus, viâ Nágri, to Rajamándri. In the centre of India, we meet with an elliptic space, exceeding 8·8 Engl. units. As may be easily perceived from the formulæ employed in calculating the total intensity, the existence of this space of maximum horizontal intensity is in immediate connection with the remarkable curvature of the isodynamic lines of total intensity.

In the southern part of India, particularly along the western coast south of Bombay, the horizontal intensity seems to vary but very little; and this is, at the same time, the region which most decidedly shows, that there may exist a disagreement between the modification of horizontal and vertical intensity. The principal features, and the values obtained by the direct observations are given in a separate diagram on the intensity-map.

4. The *vertical* intensity varies, in the regions examined by us, in great analogy with the isoclinal lines. This can be easily seen, when the values of the vertical intensity, as given at the single stations themselves, are compared with those of the dip.[1] We, therefore, give no special diagram for this element.

a. On an average the vertical intensity varies from Madras up to the Kuenlúen about 0·4 Engl. units in the degree of latitude; in the more southern parts this value becomes rather greater; by this it differs from the type of the isoclinal lines, as also particularly by its changing very little in the region north and south of the minimum of vertical intensity (from Madras to Gálle).

b. The curvature of the isodynamic lines for the total intensity in the central and southern parts of India is not found to correspond to a sensible curvature of the lines of vertical intensity. The apparently loose connection of the modifications of the vertical intensity with those of the total becomes less unexpected, when we keep in mind that the absolute values of the vertical intensity are here still very small, whilst the horizontal intensity is about at its maximum.

We give as example the values of vertical and total intensity for some stations of about equal latitude, selected from the very regions where the peculiar modification of the total intensity is the most apparent.

[1] See the General Table of the magnetic elements, pp. 459 to 463.

	Station.	Latitude N.	Long. E. Gr.		Vertical Intensity. Engl. Units.	Total Intensity. Engl. Units.
		° ′	° ′			
I.	Bellári	15 9	76 54	observed	1·838	8·834
	Góa	15 25	73 46	calculated from Bombay and Madras	1·850	8·824
II.	Nágri	20 25	78 53	observed	3·634	9·367
	Súrat	21 6	72 57	calculated from Bombay and Bhūj	3·640	9·346
III.	Bhūj	23 17	69 40	observed	4·335	9·109
	Jáblpur	23 10	79 56	observed	4·711	9·863
	Calcutta	22 33	88 21	observed	4·315	9·113

c. As we proceed farther to the north, we also find (similar to what may be observed in Europe) that the horizontal and vertical intensity both show more analogous regions of relative increase or decrease. For the vertical intensity we particularise: a *decrease* in a zone along the outer regions of the eastern Himálaya, as also in a narrow zone from Leh to Kashmír; an *increase* in a nearly vertical region from Gărhvál to Lahól.

5. The line of minimum total intensity of 7·5 Engl. units in the regions examined by us, nearly coincides, in form and value, with the line of absolute minimum total intensity, and on an average, we found that for India (south of the Himálaya, from 15° to 30° of latitude) an increase in latitude of 36′ to 37′ corresponds to an increase in total intensity of 0·10 Engl. units.

The region of the Himálaya has a more rapid increase, particularly in the direction from Nainitál to Kárdong. For the irregularities east of Leh and south of Kárdong, we cannot find either a general or a local cause.

6. The influence of height on the total intensity of terrestrial magnetism seems to be scarcely appreciable. Our observations agree in this regard with the results obtained in other parts of the globe by most of the preceding observers, and also especially with those of Lamont.[2] Besides, even in the Himálaya, it is of much rarer occurrence than might be supposed, that great differences of heights present them-

[1] This line is the same to which the name of "dynamic equator" has sometimes been given. Sir James Ross, who first defined it in the southern hemisphere, called it "Equator of less Intensity". See his "Voyage to the Southern and Antarctic Regions", Vol. I, p. 22.

[2] According to previous observations made by Director Kreil, the Alps seem to have an appreciable influence on magnetic intensity. See "Kreil's Magnetische Ortsbestimmungen im Oesterreichischen Kaiserstaat." But Lamont's observations in the Alps (Magnetische Ortsbestimmungen in Bayern, &c.) do not show the existence of any such influence; he is of opinion that on former occasions the torsion probably had not been determined with sufficient accuracy. Some data, which, however, leave this question undecided, will be found collected in Humboldt's Cosmos, Vol. IV., p. 110, and in Bravais' "Sur l'intensité du magnétisme terrestre, en France, en Suisse, et en Savoie." Annales de Chimie, 3me Série, Tome XVIII., 1856.

selves without being modified by a considerable horizontal distance intervening.[1] Though our highest stations exceed an elevation of 18,000 feet above the sea, and though, also the relative height (as seen in the table, pp. 459 to 463), between many of our stations is rather considerable, we had but very seldom to observe a weak, indistinctly defined increase of the total intensity in heights from 10,000 to 12,000 feet. We quote as an example, Tónglo and Fălút, on the Singhalíla ridge, compared with Darjíling and Rangít; and Kárdong and Usílla, compared with Símla.

7. Finally, in reference to the connection of the territories we have examined with the general distribution of intensity over the globe, we may mention, as particularly important for us, that our most northern stations, the Karakorúm pass and △ Súmgal, perfectly agree with the average values of total intensity that might have been expected for these regions.

At the conclusion of this part of our work, it is impossible for us not to feel, that our researches—notwithstanding the great extent of the area, over which they have been carried on—must be considered as but a very modest contribution to terrestrial magnetism, a science to which have been devoted the successful labours of the many eminent natural philosophers, whose names we have repeatedly had occasion to mention. Yet perhaps we may be allowed to quote, at least with reference to the geographical position of the territories examined, the encouraging words of the celebrated Gauss: "Every new station will have for the general theory an importance proportionate, in great measure, to its distance from those we actually possess."

[1] Even in the central parts of High Asia, particularly in Tíbet, where the average height of the valleys is very great, a well defined form of plateaux is much rarer than had often been expected. The territories between the Karakorúm and the Kuenlúen, especially near the western end of the Kuenlúen, are those, which in the first line must be named as well defined plateaux of extraordinary height, a *form*, which is not the predominant feature of the topographical character of these countries in general. The extent of High Asia, the region of the greatest elevations, as well in the form of peaks and high valleys, as occasionally of plateaux, can be defined in its large features, as being limited: to the north by the depression south of the Sàyan Shan and its eastern continuations; to the east by the river systems, discharging themselves into the Indo-Chinese peninsula; to the south by the northern plains of India; and to the west by Badakhshán and Kábul.

END OF VOL. I.

INDEX TO VOLUME I.

In order to facilitate the use of the Index, it has been as much condensed as was possible, geographical names being excluded when occuring only in connection with the routes or the details of the magnetic observations.

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