Photogravure

Survey of India Offices, Calcutta, 1927.

COLONEL SIR G. P. LENOX-CONYNGHAM, Kt., R.E., F.R.S.

SUPERINTENDENT OF THE TRIGONOMETRICAL SURVEY 1912 - 21.

COLONEL SIR G. P. LENOX-CONYNGHAM, Kt., R.E., F.R.S., M.A.

Colonel Sir Gerald Ponsonby Lenox-Conyngham, whose portrait faces this page, joined the Survey of India in 1889 and most of his service was spent in the Trigonometrical—now called the Geodetic—Branch.

During the years 1894-96 he was associated with Captain S. G. Burrard in a determination of the fundamental longitude for India by means of several electro-telegraphic arcs extending from Greenwich to Karāchi, where connection was made with the longitude-arc system of India. Originally Indian longitudes depended on the value found for Madras by purely astronomical means. In 1877 a somewhat imperfect electro-telegraphic connection with Europe had been made *via* Suez, Aden and Bombay: Burrard and Conyngham's results were very superior and their determination is closely supported by observations made in 1926 by means of wireless telegraphy. It has been used for Survey of India maps since 1900.

For eleven years Captain Lenox-Conyngham was in charge of the Latitude Party and observed by the Talcott method at numerous stations over India. He also observed for latitude and azimuth at a group of stations round Kaliānpur, the origin of the Indian Survey, to determine the local anomalies of deflection.

In 1902 Captain Lenox-Conyngham published Professional Paper 6 in which are described certain experimental base line measures made by the then new Jäderin method of hanging wires. For this work special arrangements had to be made for determining the coefficients of expansion with temperature.

About this time it was decided to make a gravimetric survey of India. Between 1864 and 1871 a small number of gravity stations on the Great Arc had been occupied with the object of determining the ellipticity of the earth. Unfortunately the results were vitiated by neglect to correct the observations for flexure of the pendulum stand—a source of error not recognised at the time. Major Lenox-Conyngham took part in the acquisition and standardisation in Europe of the new pendulum apparatus by von Sterneck which had been selected. He brought the apparatus out to India and formed the Pendulum Party.

Trouble was experienced in determining the temperature of the pendulums, and Major Lenox-Conyngham overcame this by the introduction of a dummy pendulum, similar to the swinging pendulum, in the stem of which was placed a thermometer. He toured India for four years with the new apparatus and published the results of his work in Professional Paper 10 in 1908.

He went to Calcutta as Superintendent of Map Publication, after which he was placed in charge of the Levelling Party for two years.

In 1912 he succeeded Mr. Eccles as Superintendent of the Trigonometrical Survey holding the post until his retirement in August 1921, except for a short period during which he officiated as Surveyor General. In 1918 he visited Mesopotamia to advise on levelling in that country.

He was elected a Fellow of the Royal Society in 1918 and received the honour of Knighthood in 1919. On retirement he was appointed Reader in Geodesy at Cambridge and elected a fellow of Trinity College. The honorary degree of M.A. was conferred on him shortly afterwards by Cambridge University.

SURVEY OF INDIA

GEODETIC REPORT

VOL. I

From 1st October 1922
To 30th September 1925

PUBLISHED BY ORDER OF
COLONEL COMMANDANT E. A. TANDY, R.E.
SURVEYOR GENERAL OF INDIA

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CONTENTS

Chapter III

Astronomical Latitudes

Chapter IV

Gravity and Latitude

CHAPTER V

Levelling

1922-23

CHAPTER VI

Height of Mount Everest and other peaks

Charts and plates

Chapter I

INTRODUCTION AND SUMMARY

1. *Geodetic Reports.*

The present volume is the first of a new series of publications, styled the Geodetic Reports. Until 1921-22 geodetic work of the Survey of India was dealt with in the series of Record Volumes which contained also reports of topographical work and were published annually, there being occasional additional volumes. In this first volume a period of three seasons, 1922-25 is covered; but future volumes will contain an account of only one season's work.

The Geodetic Reports will describe the work of the Geodetic Branch of the Survey of India, excluding the work of the Drawing Office, Publication Office, etc., some account of which may be found in the Annual General Reports or Map Publication Reports.

2. *Amalgamation of Computing and Tidal Parties, Tidal prediction.*

On 1st April 1923, No. 16 (Tidal Party) was amalgamated with the Computing Office, the combined party being designated the Computing and Tidal Party. During the previous few years the tidal observatories had been maintained, but harmonic analysis of the tidal diagrams had been discontinued where adequate values of the harmonic constants had been obtained. On the other hand tidal prediction, formerly done in England, was taken up and "Tide-Tables for Indian Ports" have been prepared in this party, commencing with those for 1923.

3. *Reduction of magnetic work.*

In 1923, on the score of economy, magnetic work, until then carried out by No. 18 Party, was much cut down and no field work has been done since then. Toungoo Observatory was closed on 22nd October 1923 and Kodaikānal Observatory on 1st October 1923. Dehra Dūn Observatory has been maintained in operation by the Computing and Tidal Party (§ 61). An account of the work is given in §§ 60-103.

4. *Discontinuance of solar photography.*

Solar Photography, inaugurated in 1878 in collaboration with Sir Norman Lockyer, was discontinued with effect from 30th June 1925. Between the dates mentioned, photographs of the sun had been taken daily, weather permitting; and prints and plates were despatched week by week to the Director, Science Museum, South Kensington, London (*vide* § 54).

5. *International Union of Geodesy and Geophysics Rome, 1922.*

Dr. de Graaff Hunter was nominated a British Empire delegate to the International Union of Geodesy and Geophysics at Rome, May 1922, and represented the Government of India. In addition he attended all the meetings of the Committee of Tidal Prediction. He was appointed Reporter to the Section of Geodesy on the "Deviation of the vertical line" and also to serve on the International Committee of Longitudes, and on a select committee with Captain Buchwaldt (Denmark, since deceased) to report on certain questions relating to the reduction of gravity results. His report (1912-1922) on the deviation of the vertical line was submitted during 1923 to the Secretary, Section of Geodesy; and a second report (1923-25) during 1925.

6. *New tidal prediction methods; time service; standardisation of Indian magnetometers.*

While on leave in 1922 Dr. Hunter studied Dr. Doodson's methods of tidal analysis, spending a month at the Tidal Institute, Liverpool. Certain modifications in tidal prediction procedure are indicated below (*vide* §§ 49, 50). He also visited Edinburgh Observatory and was shown the clock installation and time service arrangements by Professor Sampson, F.R.S., Astronomer Royal for Scotland. Professor Sampson had very kindly undertaken a test on a new Riefler clock, No. 450, for Dehra Dūn, which was completed shortly afterwards. The clock has subsequently been received (15th Aug. 1923). Dr. Hunter also made comparative observations with Indian Magnetometer No. 10, both at Kew and at Val Joyeux (10 km. west of Versailles).

7. *International Union of Astronomy, Cambridge 1925.*

Dr. Hunter attended the meeting of the International Union of Astronomy at Cambridge in July 1925, in connection with the mixed Longitude Commission. He was also concerned in discussing and selecting suitable wireless reception and other equipment with a view to the participation of the Survey of India at Dehra Dūn in the International Longitude scheme, fixed for October and November 1926.

8 *Tidal observatories.*

A new tidal observatory was opened at Bassein in October 1923. Those at Moulmein and Port Blair were closed in November 1924 and April 1925 respectively (*vide* § 41).

9. *Longitude observatory.*

A special observatory for time determination was designed and constructed (*vide* § 59). The instrumental side of this work has also been improved by the acquisition of a high grade clock, Riefler No. 4[illegible] (*vide* § 56) and by the fitting of moving wire micrometer to the telescope eyepieces (*vide* § 57).

10 *Routine work.*

Progress has been made in the revision of professional forms and tables (*vide* § 27) and in the compilation and publication of triangulation data (*vide* § 30).

Tidal observatories were inspected as shown in (§ 40). Comparison of predicted and actual times and heights of high and low water at all tidal stations where observations were made have been tabulated on a new form and in some cases corrections to future prediction are based on these (*vide* § 48). Meteorological and Seismograph observations have been continued as usual (*vide* §§ 51, 52).

11. *Research items*

The results of all latitude, longitude and azimuth observations in India have been employed to determine the form of the geoid. This will be utilised for a redetermination of the Earth's Figure and for a general consideration of the hypothesis of isostasy (*vide* § 25). An inquiry was also made into the variation of the geoid with regard to the mean water level of the ocean, with negative results. From certain observations in the U.S.A. it had been suspected that such variation occurs. (*vide* § 26)

A new method of graphical adjustment of triangulation has been introduced (*vide* § 31).

A considerable amount of work was done in attempting to improve the accuracy of tidal predictions at riverain ports. It often happens, as in the case of Kidderpore (Calcutta) that important ports are situated at a considerable distance up an estuary: and at such places tidal prediction is far more intricate and less precise. Some progress was made but not sufficient as yet to be practically useful (*vide* §§ 46, 47). 11. *(Contd.)*

Mechanical additions have been made to the Tide Predicting Machine which assisted in the above inquiry and also facilitates the work of ordinary harmonic tidal prediction (*vide* § 49).

A lecture delivered in Madras in January 1922 at the meeting of the Indian Science Congress, entitled *"The height of Mount Everest and other peaks"*, is reproduced at the end of this volume (*vide* § 240).

12. *Resumption of latitude observations*

Latitude observations by the Talcott method had been in abeyance since 1915 until 1921 when Major Mason observed at four stations in Kashmīr. Observations were made next in season 1923-24 when No. 13 Party visited Bihār and Orissa. In the following season the party went to Assam. Values of plumb-line deflection at twenty-seven stations were obtained in the two seasons. Major Thompson's conclusion (*vide* §§ 116, 117) is that the results in these areas are not fully accounted for by the Hayford theory of isostasy. Further latitude results were obtained from the prismatic astrolabe observations made in Kashmīr in conjunction with the pendulum work.

13. *Prismatic astrolabe.*

Two prismatic astrolabes—large and small models—were obtained in 1921. Observations with these instruments yield both time and latitude, and results of very high precision may be obtained with the larger (geodetic) model. Though some differences of opinion exist as to the degree of this precision, it was considered that there would be a distinct gain in using this instrument in conjunction with pendulum observations, for which clock rate has to be accurately determined. For rate, the question of personality does not arise and so the astrolabe should be suitable for pendulum observations. In addition, good values of latitude—also impersonal—are derived simultaneously; so it was considered that if geodetic positions of pendulum stations were adequately fixed, useful values of deflection in meridian would also be arrived at. The complete project of determining also the deflection in longitude, requiring in addition the reception of wireless time signals, was deferred until a suitable wireless set had been obtained.

The larger prismatic astrolabe was used in Kashmīr in 1925 (*vide* §§ 141, 145, 146).

14. *Pendulum observations in a tent.*

In the past it has been an invariable rule to observe pendulums in a room rather than a tent because the temperature variations are usually much less. To extend the work to Himalayan areas, very interesting from the point of view of isostasy, it was necessary to break away from this practice; for in such regions houses are not to be found. It was hoped that this would be rendered possible by the use of the quartz

14. *(Contd.)* pendulums which had been obtained just before the war, but had never been used (*vide* § 126). Accordingly in 1924 a beginning was made to standardise these two pendulums. Unhappily both were broken in transport between Mussoorie and Dehra Dūn While this was very much regretted, it showed conclusively that these quartz pendulums were too fragile to withstand the rough transport conditions which are met with in the Himalayas. Captain Glennie went fully into the question of temperature effects and evolved a working method of dealing with the larger temperature changes unavoidable with observations in a tent: thus clearing the way for observations in any locality. The first trials were made in the summer of 1925 when pendulums were swung in Kashmīr (§ 139). As the old von Sterneck pendulums were then in Europe for standardisation, Captain Glennie also designed and supervised the construction of three brass pendulums (*vide* § 128) which were used with success in the Punjab and Kashmīr. Time and also astronomic latitude were derived from astrolabe observations.

15. *Resection used to fix astrolabe latitude stations.*

The sites of the pendulum stations did not coincide with points fixed by triangulation and so it was necessary to determine the geodetic position of each with fairly high precision, for deduction of the latitude deviation. This was done by theodolite resection from points fixed by triangulation. Captain E. A. Glennie and Lieut. G. H. Osmaston carried out the astrolabe as well as the resection observations, and satisfactory and valuable results were thereby obtained. Positions probably correct to 5 feet were deduced in this way (*vide* § 148).

16. *Standardisation of von Sterneck pendulums.*

The four von Sterneck pendulums, used in India between 1907 and 1915, were taken to England in the spring of 1924 by Lt.-Colonel H. McC. Cowie for re-standardisation. Colonel Cowie was not in good health at the time and so this work was somewhat delayed. However he made the necessary observations at Kew in June 1925 and some months later he also swung the pendulums at Cambridge (*vide* § 127). Colonel Cowie was bringing these pendulums back to India in September 1925 and had reached Marseilles when he became seriously ill and died on board P. & O. S. S. "Rāwalpindi" on 25th September, 1925.

17. *Bench mark maintenance policy.*

The levelling policy has been under consideration and the view arrived at is that the Survey of India should fix and maintain bench marks at regular intervals: while intermediate bench marks, whose height has been determined with the same precision would pass into the custody of local authorities to maintain as they find convenient.

18. *Indo-Burmese connection.*

The lines of levelling in India and Burma are as yet unconnected but some steps have been taken towards a reconnaissance of a route whereby the connection might be effected (*vide* § 206).

19. *History of Indian high precision levelling.*

A report was submitted to the International Union of Geodesy & Geophysics 1924 giving a brief history of Indian levelling of high precision since its introduction just before the war (*vide* § 206).

The new level net was begun in 1914. Since then 3638 miles of levelling have been completed in both directions and 949 miles in one direction only. 20 *Progress with the new level net.*

Eight new lines have been added to the original net.

A new departure has been made since 1922 in the carrying out of levelling for engineering projects with no other scientific object. For in some cases a lower order of precision is adequate, which can be conveniently covered by the designation tertiary levelling. Details will be found in § 156. 21. *Tertiary levelling.*

Lieut. J. B. P. Angwin R.E. and Lieut. D. R. Crone R.E. were under instruction from 28th October and 22nd October 1924 respectively until 10th September 1925 and 22nd May 1925 respectively. 22. *Training.*

Mr. H. B. Simons held charge of the Training School from 1st January to 14th April 1924 and Mr. S. F. Norman from 15th April 1924 to 30th September 1925. Four probationers of class II and fourteen probationers of upper subordinate service passed through the School.

PERSONNEL* OF THE GEODETIC BRANCH, 1922-25

23. *Personnel of the Geodetic Branch.*

Director, Geodetic Branch†

Lt.-Colonel H. McC. Cowie, r.e., from 1st Oct. 1922 to 30th March 1924.

Dr. J. de Graaff Hunter, m.a., Sc. D., F. Inst. P., from 31st March to 27th April 19

Lt.-Colonel R. H. Thomas, d.s.o., r.e., from 28th April 1924 to 30th September 19

COMPUTING AND TIDAL PARTY

Class I Officers.

Dr. J. de Graaff Hunter, m.a., Sc.D., F. Inst. P., in charge from 27th November 1922 to 20th March 1925.

Major C.M. Thompson, i.a., in charge from 1st October 1922 to 26th November 1922 and from 21st March 1925 to 30th September 1925.

Class II Officers.

Mr. D.H. Luxa, Tidal Assistant from 1st October 1922 to 23rd March 1925.

Mr. R.B. Mathur, b.a., Tidal Assistant from 24th March 1925 to 30th September 1925.

Upper Subordinate Service.

Mr. K.K. Das, b.a., from 1st May 1924 to 30th September 1925.

Computing Section.

Mr. Mukundananda Acharya, Head Computer and 11 Geodetic computers.

Tidal Section.

16 computers in 1922-23.
10 computers from 1923-24.

Magnetic Observatory.

Mr. K.N. Mukerjee, m.a. Magnetic Observer & 1 computer.

13 PARTY (ASTRONOMICAL)

Class I Officers.

Captain H.E. Roome, m.c., r.e., in charge from 1st October 1922 to 30th September 1923.

Major C.M. Thompson, i.a., from 1st October 1923 to 31st March 1925.

Captain G.H. Osmaston, m.c., r.e., in charge from 1st April 1925 to 30th September 1925.

14 PARTY (PENDULUMS)

Class I Officers.

Major W.E. Perry, m.c., r.e., in charge from 1st October 1922 up to 14th October 1923.

Major H.J. Couchman, d.s.o., m.c., r.e., in charge from 15th to 22nd October 192

Captain E A. Glennie, d.s.o., r.e., in charge from 23rd October 1923 to 30th September 1925.

Class II Officers.

Mr. R.B. Mathur, b.a., 1923-25.

Lower Subordinate Service.

3 Computers.

15 PARTY (TRIANGULATION)

Class I Officers.

Capt. E.A. Glennie, d.s.o., r.e., from 1st October to 23rd October 1922.

Major H.T. Morshead, d.s.o., r.e., from 24th October 1922 to 18th February 19

Major C.M. Thompson, i.a., from 1 February to 7th October 1923.

Mr. Hanuman Prasad, Rai Sahib, in charge from 8th October 1923 to 16th July 19

Major W.E. Perry, m.c., r.e., in charge from 17th July to 14th August 1924.

Captain O. Slater, m.c., r.e., in charge from 15th August 1924 to 31st October 19

Captain W.J. Norman, m.c., r.e., in charge from 1st November to 7th December 19

Captain O. Slater, m.c., r.e., from 8th December 1924 to 30th September 1925

Class II Officers.

Mr. G.J.S. Rae, up to November 1924.

Lower Subordinate Service.

6 computers in 1922-24.
4 ,, ,, 1924-25.

16 PARTY (TIDAL)

Class I Officers

Dr. J. de Graaff Hunter, m.a., Sc.D., F. Inst. P., in charge from 19th February to 31st March 1923.

Major C.M. Thompson, i.a., in charge from 27th November 1922 to 18th February 1923.

Rai Sahib Hanuman Prasad, in charge from 1st October 1922 to 26th November 1922.

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* Excluding No. 2 D.O., Publication and Stores, F.M.O. and Cantonment Party.

† The designation of the Superintendent Trigonometrical Survey was changed to Director of Geodetic Branch from 10th July 1924.

23. (Contd)

Class II Officers.

Mr. D.H. Luxa.

Lower Subordinate Service.

16 Computers etc.

17 PARTY (LEVELLING)

Class I Officers.

Major A.H. Gwyn, I.A., in charge from 19th March 1923 to 30th Sept. 1925.

Bt.-Major K. Mason, M.C., R.E., in charge from 1st October 1922 to 18th March 1923.

Captain E.A. Glennie, D.S.O., R.E., from 24th October 1922 to 18th April 1923.

Class II Officers.

Mr. G.J.S. Rae, 1922-23.
" O.N. Pushong, 1922-24.
" R.B. Mathur, B.A., 1922-23.
" K.S. Gopalachari, B.A., 1922-24.
" N.N. Chukerbutty, L.C.E. 1922-23.
" Jiya Lal Sahgal, 1923-25.
" N.R. Mazumdar, 1923-25
" D.N. Banerjee 1923-25

Upper Subordinate Service.

Mr. K.K. Das, B.A., from 1st Oct. 1922 to 30th April 1924.
" S.C. Mukerjee, 1922-25.
" P.B. Roy, 1922-25.
" A.A.S. Matlub Ahmad, 1922-25.
" Abdul Majid, 1922-25.
" H.C. Banerjea, 1923-25.
" H.K. Kar, 192-25.

Lower Subordinate Service.

22 Computers in 1922-24.
25 Computers in 1924-25.
41 Purely temporary levellers 1922-23.
64 " " " 1923-24.
77 " " " 1924-25.

18 PARTY (MAGNETIC)

Class I Officers.

Mr. E.C.J. Bond, V.D., in charge from 1st October 1922 to 30th September 1923.

Class II Officers.

Mr. N.R. Mazumdar.
" Jiya Lal Sahgal.

Upper Subordinate Service.

Mr. B.B. Shome.
" H.C. Banerjea, B.A.

Lower Subordinate Service.

1 Magnetic Observer.
10 Computers etc.

19 PARTY (BASE)

Class I Officers.

Major A.H. Gwyn, I.A., from 27th October 1922 to 20th April 1923.

Lt.-Colonel A.A. McHarg, D.S.O., R.E., from 21st to 30th April 1923.

Capt. H.E. Roome, M.C., R.E., in charge from 1st to 21st October 1923.

Lt.-Colonel H. McC. Cowie, R.E., in charge from 1st October 1922 to 26th October 1922, 1st May 1923 to 30th September 1923 and 22nd October 1923 to 30th March 1924.

Dr. J. deGraaff Hunter, M.A., Sc.D., F.Inst.P., in charge from 31st March to 11th April 1924.

Captain O. Slater, M.C., R.E., in charge from 12th April 1924 to 7th December 1924.

Captain W.J. Norman, M.C., R.E., in charge from 8th December 1924 to 10th September 1925.

Lieut. J.B.P. Angwin, R.E., in charge from 11th September to 30th September 1925.

TRAINING

Class I Officers under instruction.

Lieut. J.B.P. Angwin, R.E., from 28th Oct. 1924 to 10th September 1925.

Lieut. D.R. Crone, R.E., from 22nd Oct. 1924 to 22nd May 1925.

TRAINING SCHOOL

Mr. H.B. Simons Instructor from 1st January 1924 to 14th April 1924.
" S.F. Norman Instructor from 15th April to 30th Sept. 1925.

DEHRA DŪN,
July 1927.

J. DE GRAAFF HUNTER,
Offg. Director of the Geodetic Branch.

Chapter II

COMPUTING AND TIDAL PARTY

by J. de Graaff Hunter, m.a., Sc.D., F. Inst. P.

There are three sections of the Computing and Tidal Party :—

(i) Computing Section.
(ii) Tidal Section.
(iii) Observatory Section.

(i) Computing Section

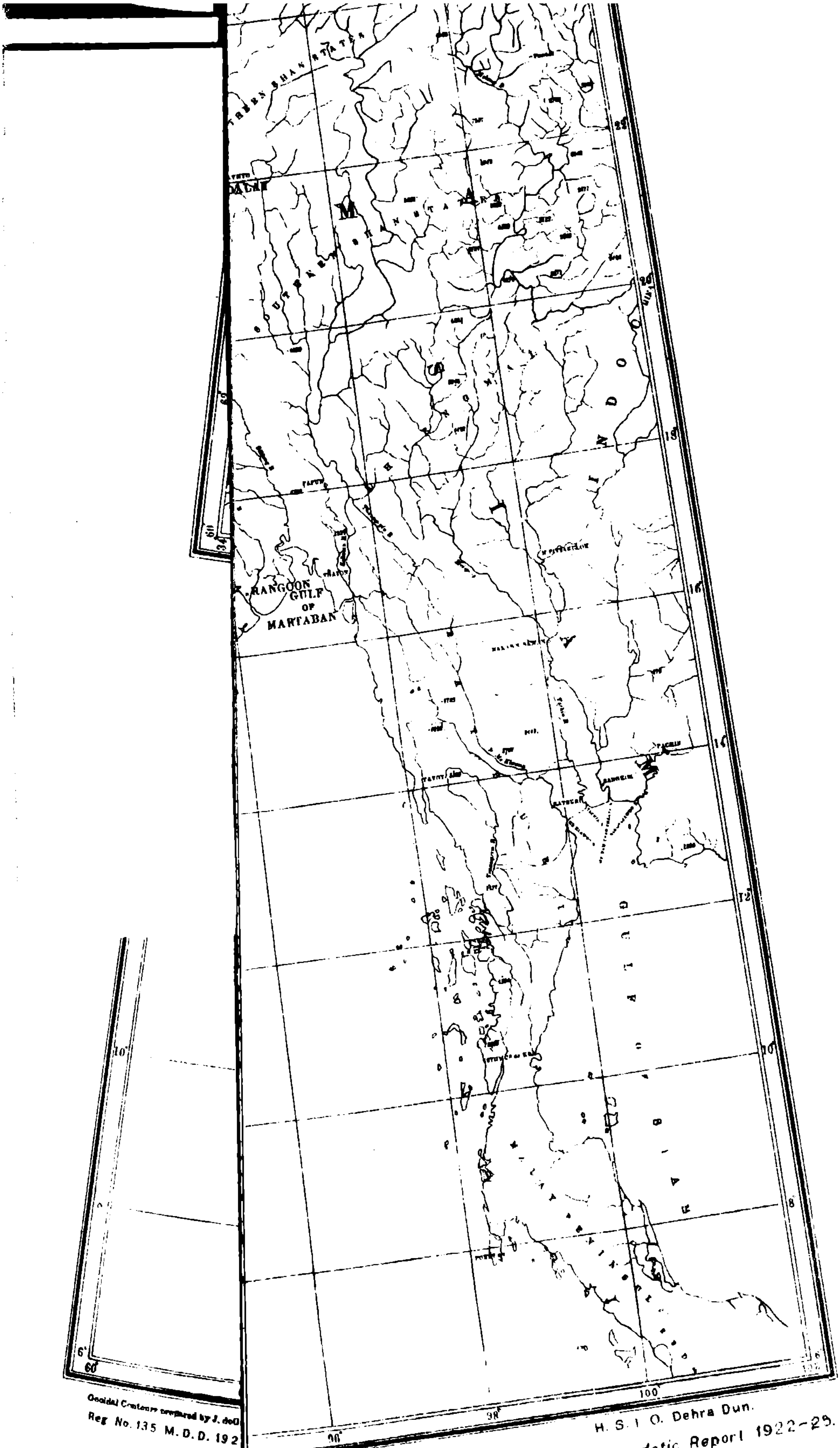
24. *Astronomical computations.* The reduction of the Talcott observations for latitude made in 1922 by Major K. Mason R.E., at Gogīpatri, Poshkar, Zebanwan and Reban in Kashmīr was completed. Observations made in 1860 at Poshkar and Gogīpatri had yielded results which were open to doubt : but the 1922 observations gave results almost identical. The deduced latitudes uncorrected for motion of pole are :—

Station	Astronomical value 1922	Astronomical value 1860	Value by triangulation 1856-57	Deflection
	° ′ ″	° ′ ″	° ′ ″	″
Gogīpatri ...	33 51 46·90	33 51 46·56	33 51 43·87	+ 3·0
Poshkar ...	34 2 2·78	34 2 3·38	34 1 48·98	+ 13·8
Zebanwan ...	34 3 33·50	...	34 3 59·14	− 25·6
Reban ...	33 45 17·74	...	33 45 25·76	− 8·0

Times of sunrise and sunset for Calcutta were computed for inclusion in Tide-Tables of 1925 as well as of 1926. They were also computed for other latitudes for non-departmental purposes.

Sun's bearings for every 5 degrees of latitude, and also for Ahmadnagar and Saharanpur for winter months, were computed taking refraction, parallax and semidiameter into consideration in compliance with extra departmental requisitions.

25. *The form of the geoid in India etc.* All the plumb-line deflections derived from upwards of five hundred latitude, longitude, and azimuth stations were utilized to produce charts on 1/5 M scale showing the lines of equal deflections in



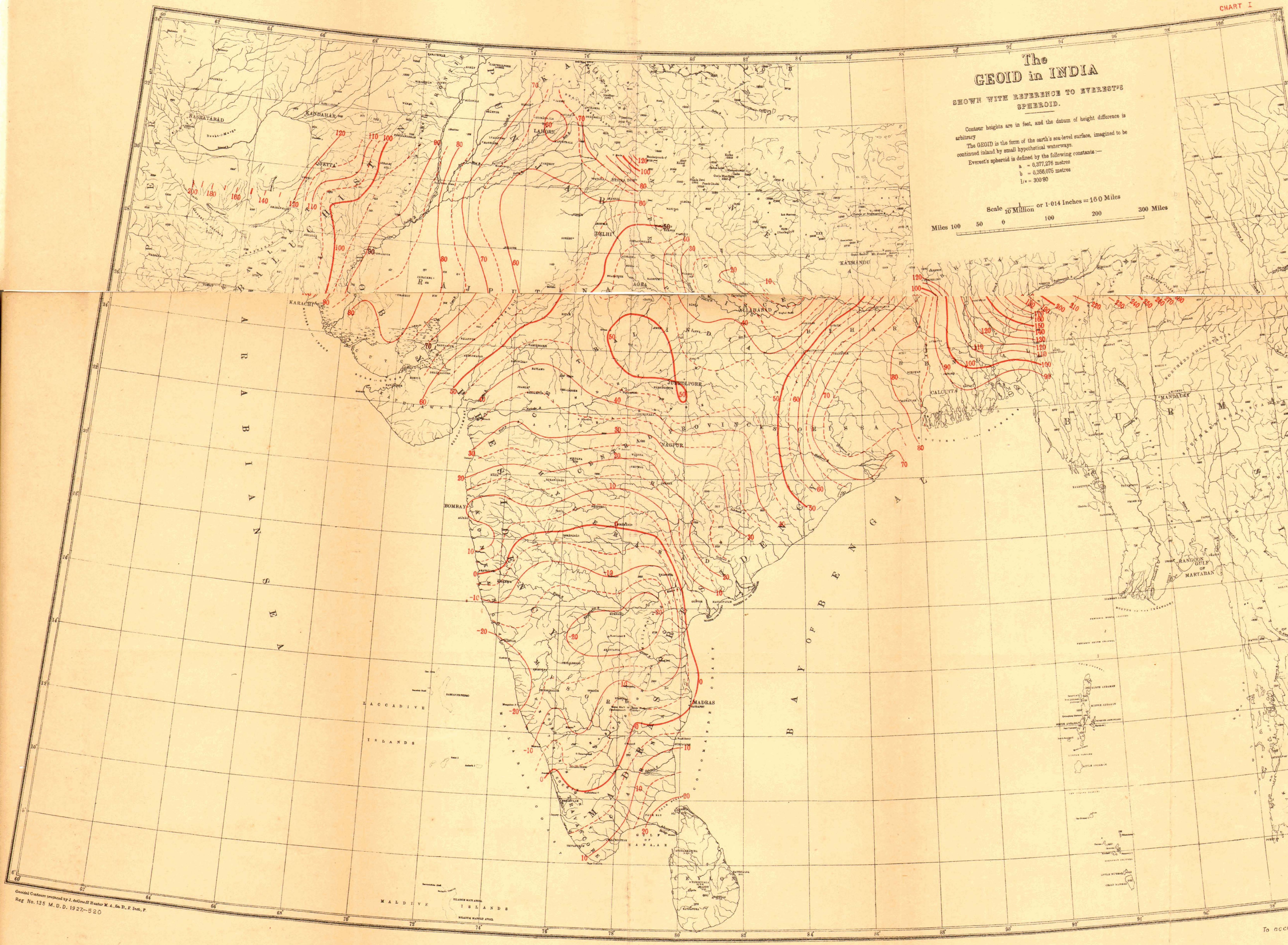
Geoidal Contours prepared by J. de G

Reg. No. 135 M. D. D. 192

H. S. I. O. Dehra Dun.

To accompany Geodetic Report 1922-25.

CHART I



Geoidal Contours prepared by J. deGraaff Hunter M.A., Sc.D., F.Inst., P.

Reg No. 135 M.D.D. 1927.—520

H. S. I. O. Dehra Dun.

To accompany Geodetic Report 1922–25.

Published under the direction of Colonel Commandant E.A. Tandy, R.E., Surveyor General of India, 1927

meridian or prime vertical over India. From these curves, the average deflections along one degree of meridian or prime vertical were estimated whence the separation of geoid and spheroid was computed. This separation was found for corners of all degree squares, and a final chart was drawn showing the geoidal contours with relation to Everest spheroid. A copy of this chart reduced to ½ scale is given opposite to page 9. Later on, the contours were redrawn on the Helmert-Hayford spheroid. The desirability of such representation of the geoid has been pointed out by the International Geodetic Association. 25. *(Contd.)*

Following on from this chart a beginning has been made in an investigation of the Figure of the Earth in India: at the same time an attempt is being made to estimate the degree of isostatic compensation in India and adjacent regions. The geoidal charts were sent to the British Empire Exhibition, Wembley, 1923.

Hayford isostatic corrections were computed for sixty-two gravity stations, completing the work begun by Captain Couchman, in Professional Paper No. 15.

26. ***Elevation of mean sea level above the geoid in general nil.***

Mr. R. L. Faris of the United States Coast and Geodetic Survey informed Mons. C. Lallemand, Reporter for Precise Levelling to the International Union of Geodesy and Geophysics, that in two cases of trans-continental levelling mean water level of the Atlantic and Pacific oceans at the American coasts differed by an amount much greater than could be accounted for by the usual accidental and systematic errors of levelling. Monsieur Lallemand asked for the matter to be investigated in India, which was done, the results being communicated to him.

In the first place it was necessary to compute out values of η_r and σ_R (probable accidental and systematic errors) for the inland levelling circuits of India. For this the formulæ given in the *Resolution concerning Levelling of Precision** adopted at the meeting of the 17th General Conference of the International Geodetic Association on 25th September 1912, were employed. The values found were :—

$$\eta_r = \pm 0 \cdot 0040 \quad \text{foot-mile units}$$
$$\sigma_R = \pm 0 \cdot 00071 \quad \text{,, ,, ,,}$$

These values were entered in the following formula to find the expected discrepancy between mean water levels (M. W. L.) as determined at two adjacent observatories :—

(Expected discrepancy)^2 $= \eta_r^2 L + \sigma_R^2 L^2 + E_1^2 + E_2^2$ where L is the length of levelling line in miles ; E_1, E_2 are the probable errors (p. e.) of the mean of annual determinations of M. W. L. from tidal observatories.

Table I. exhibits all quantities concerned and gives the ratio of the actual error to the expected error. In eight cases this ratio is less than one and in one only it is greater than one indicating that *there is no evidence at all that M. S. L. is different at adjacent tidal stations.*

There are also certain other tidal observatories which have been connected by levelling. In these there is every reason to expect that M. W. L. will vary, as the stations are situated up a narrow gulf or on a river. Such is the case actually found. Details are given in table II.

* Reproduced in Departmental Paper No. 6, Survey of India, 1914.

TABLE I.—$\eta_r^* = \pm\ 0\cdot0040\ ft$; $\eta_r^2 = 0\cdot0000158$; $\sigma_R = \pm\ 0\cdot00071\ ft$; $\sigma_R^2 = 0\cdot510 \times 10^{-6}$.

Name of Tidal station	Karāchi	Bombay	Kārwār	Beypore	Cochin	Negapatam	Madras	Vizagapatam
Probable error of *M.S.L.*	±0·0075 ft.	±0·0062 ft.	±0·0184 ft.	±0·0114 ft.	±0·0131 ft.	±0·0309 ft.	±0·0140 ft.	±0·0336 ft.
Station A ...	Bombay	Kārwār	Beypore	Cochin	Negapatam	Madras	Vizagapatam	False Point
Station B ...	Karāchi	Bombay	Kārwār	Beypore	Cochin	Negapatam	Madras	Vizagapatam
Distance L (in miles) ...	959·7	561·7	802·0	113·1	701·1	269·2	508·6	374·9
$\eta_r L$ ...	0·01516	0·00887	0·01267	0·00179	0·01108	0·00425	0·00804	0·00592
$\sigma_R^2 L^2$ ...	0·46972	0·16091	0·32803	0·00652	0·25069	0·03696	0·13192	0·07168
(p.e.)^2 of *M.S.L.* at station A ...	0·00004	0·00034	0·00013	0·00017	0·00095	0·00020	0·00113	0·00027
(p.e.)^2 of *M.S.L.* at station B ...	0·00006	0·00004	0·00034	0·00013	0·00017	0·00095	0·00020	0·00113
Sum ...	0·4850	0·1702	0·3412	0·0086	0·2629	0·0424	0·1413	0·0790
Square root of Sum = expected error (1) ...	±0·696 ft.	±0·413 ft.	±0·584 ft.	±0·093 ft.	±0·513 ft.	±0·206 ft.	±0·376 ft.	±0·281 ft.
Actual error (2) ...	+0·327 ft.	−0·078 ft.	−0·473 ft.	+0·084 ft.	−0·425 ft.	+0·504 ft.	−0·044 ft.	+0·125 ft.
Ratio (2) to (1) ...	0·47	0·19	0·81	0·90	0·83	2·45	0·12	0·45

TABLE II.—$\eta_r{}^* = \pm 0 \cdot 0040$ *ft*; $\eta_r{}^2 = 0 \cdot 0000158$; $\sigma_R{}^\dagger = \pm 0 \cdot 00071$ *ft*; $\sigma_R{}^2 = 0 \cdot 510 \times 10^{-6}$.

Name of Tidal station	Dublat	Diamond Harbour	Kidderpore	Tuticorin	Pamban	Marmagao	Port Albert Victor	Bhāvnagar
Probable error of M.W.L.	±0·0256 ft.	±0·0262 ft.	±0·0355 ft.	±0·015 ft.	±0·0130 ft	±0·0165 ft.	±0·0336 ft.	±0·0247 ft.
Station A ...	Diamond Harbour	Kidderpore	False Point	Pamban	Negapatam	Kārwār	Bhāvnagar	Bombay
Station B ...	Dublat	Diamond Harbour	Kidderpore	Tuticorin	Pamban	Marmagao	Port Albert Victor	Bhāvnagar
Distance L (in miles) ...	53·4	28·8	295·7	102·5	191·1	57·0	88·6	602·9
$\eta_r{}^2L$ ...	0·000844	0·000455	0·004672	0·001620	0·003019	0·000901	0·001400	0·009526
$\sigma_R{}^2L^2$ ...	0·001454	0·000423	0· 44594	0·005358	0·018625	0·001657	0·004003	0·185379
$(p.e.)^2$ of M. W. L. at station A ...	0·000686	0·001260	0·000272	0·000169	0·000955	0·000339	0·000610	0·000038
$(p.e.)^2$ of M. W. L. at station B ...	0·000655	0·000686	0·001260	0·000253	0·000169	0·000272	0·001128	0·000610
Sum ..	0·003639	0·002824	0·050793	0·007400	0·022768	0·003169	0·007142	0·195553
Square root of sum = expected error ...	±0·060 ft.	±0·053 ft.	±0·225 ft.	±0·086 ft.	±0·151 ft.	±0·056 ft.	±0·085 ft.	±0·442 ft.
Accepted height of M. W. L. at A above M. W. L. at B‡ ...	+0·748 ft	+1·990 ft.	−3·170 ft.	+0·182 ft.	+0·131 ft.	−0·219 ft.	+0·057 ft.	+0·247 ft.

* Probable accidental error. † Probable systematic error.

‡ This is the quantity which would appear as the closing error of the circuit if it were assumed that M.W.L's. (Mean Water Levels) at **A** and **B** were identical.

27. *Professional forms and tables.*

Tables were prepared for computation of barometric heights by the International Formula as well as for humidity and other related quantities.

A new set of traverse tables (41 Sur.) has been designed and computed; and a new form (14A. Trav.) introduced for use with these tables. The method is alternative to the use of such traverse tables as Shortrede's or Boileau's.

All these barometer and traverse tables are included in Part III, Auxiliary Tables, 5th edition, 1923.

R.A. and N.P.D. tables for star constants were arranged for reduction of star places in connection with astronomic latitude computations for inclusion in Part IV, Auxiliary Tables, 5th edition. These are modifications of the tables for facilitating the *Computations of star constants* by H. H. Turner, M.A.

Full editions of Part II and Part III, Auxiliary Tables, 5th edition have been printed.

The professional forms of the department are being gradually revised and reduced to uniform foolscap size. Twenty-four forms have been remodelled up to 1925.

28. *Special map projections*

Graticules were computed for a map of the world on the Zenithal Azimuth Projection, in which all distances and azimuths from a central point—in this case Agra—are correct. The map was drawn in No. 1 Drawing Office, Dehra Dūn. This was carried out at the request of the Director of Wireless Telegraphy.

Other computations were made for a two-centred and multi-centred Azimuthal Projection for Army Head Quarters.

29. *Various computations for extra departmental purposes.*

The coordinates of ten thousand points were converted from spherical to rectangular on behalf of Major General, Royal Artillery, Simla.

Several positions fixed by theodolite resection, were computed for Western Command, Quetta.

The observations of Captain Haycraft of the Aden Brigade to determine ranges and bearings of two forts were scrutinised.

A considerable amount of triangulation data was compiled for the Anglo-Persian Oil Company, Muhamarah, Persia.

Some triangulation computations of Commander C. M. L. Scott R.N. Rangoon Port Trust were examined.

30. *Triangulation pamphlets*

The triangulation pamphlets have undergone a few modifications since 1920. An introduction giving a brief account of the topography of the area has been added to some pamphlets. A layered map on a small scale is given at the end of the last pamphlet of each 1/M sheet.

Work of different observers is kept separate to facilitate future adjustment, if necessary. This is done by grouping all minor stations—both G.T. and topo—and intersected points according to party, season and observer, in 15-minute squares by decreasing latitudes. The descriptions of stations are given together at the end.

Azimuths and log sides are no longer given for minor stations, G.T. or topo. At geodetic stations only, the azimuths and log sides of Geodetic and minor G.T. stations and such peaks as are above 24,000 feet in height are given. 30. (Contd.)

The publication of topo data has been restricted to areas in the vicinity of frontiers. For areas, for which no topo data will be printed, the existence of topographical or traverse data is indicated in the chart accompanying the triangulation pamphlet by stipples and dotted boundary lines.

The Kashmīr series 1855-60 was adjusted in 1921 on the Gilgit series 1909-11, and the Russian triangulation (joining up with the Indo-Russian Connection), which was computed on the Bessel spheroid with an origin at Oche (Osh), was expressed in terms of the Indian triangulation and published.

Data for triangulation pamphlets were compiled and recompiled for one hundred and sixty-two degree sheets, including Mesopotamian triangulation and Turco-Persian Boundary Commission work. Ninety-three degree sheets have been published in pamphlet form during the period under report.

Twenty-one charts showing adjustment corrections by means of graphs to be applied to topo triangulation falling in 1/M sheets 92, 94, 95, 96, 102 and 103 were prepared and supplied to the Director, Burma Circle. The topo triangulation had been based on preliminary values of the Eastern Frontier series which was adjusted in 1915-18 along with the rest of the geodetic triangulation in Burma, and accordingly required adjustment to the final values of the geodetic work. 31. *Triangulation adjustment*

As mentioned in Records Vol. VII, page 149, a crinoline traverse from Dehra Dūn to Rajpur was executed by Lieuts. Almond and McKay in 1913-14, to fix carefully a number of stations in the vicinity of Rajpur for observation of plumb-line deflection. Triangulation connected the traverse to the side Kalanga-Gujrara, fixed by Mr. Bond in 1911-12. As this traverse was carefully executed, the discrepancy found was attributed to accumulated errors in the minor triangulation. More recent triangulation based on Kalanga-Gujrara base, as also Mr. Bond's triangulation of 1911-12, has justified this view as indicated below. 32. *Local triangulation (Dehra Dun)*

i. Correction to triangulation based on Kalanga-Gujrara ray as indicated by the traverse of 1913-14.

Traverse stations connected by triangulation	Traverse – Triangulation		Correction to	
	Northing	Easting	Latitude	Longitude
	Chs.	*Chs.*	″	″
II Church ...	−0·137 N.	−0·041 E.	− 0·090	− 0·031
III Bodyguard ...	−0·125 N.	−0·066 E.	− 0·082	− 0·050
IV ...	−0·128 N.	−0·058 E.	− 0·084	− 0·040
V ...	−0·101 N.	−0·047 E.	− 0·066	− 0·036
Mean ...			− 0·080	− 0·040

32. (*Contd.*) ii. Correction to Kalanga deduced from triangulation by Lieuts. Angwin and Crone (1924-25) and by Mr. Simons (1924-25).

Observer	Latitude	Longitude
(Angwin and Crone) Simons	− 0″·100 − 0·07	− 0″·068 0·00
Mean	− 0·085	− 0·034

These agree very closely with the mean corrections derived from the traverse.

Mr. Bond based his value of Kalanga on Timli and Satikadānda. Timli was fixed again by Angwin and Crone's triangulation of 1924-25 based on Banog-Top Tibba ray.

Station	Latitude			Longitude		
	°	′	″	°	′	″
Timli (Angwin and Crone, 1924-25)	30	22	19·602	78	7	44·939
Timli (Bond, 1911-12)	30	22	19·66	78	7	44·96
(Angwin and Crone)—Bond			−0·06			−0·02

The necessary corrections to local triangulation are collected below: they will be incorporated in the triangulation pamphlet 53 J when re-published.

	Station	Latitude	Longitude
1	Kalanga h.s.	−0″·08	−0″·04
2	Gujrara h.s. ...	−0·08	−0·04
3	Stations I to IX of the verificatory triangulation	−0·08	−0·04
4	Satikadānda	−0·04	0·00
5	Belkadānda h.s.	−0·05	−0·01
6	Timli h.s.	−0·06	−0·02
7	Dwara h.s.	−0·07	−0·03
8	Rajpur h.s.	−0·06	−0·02
9	Chauki h.s.	−0·04	0·00
10	Angaila No. 1 h.s. ...	−0·04	0·00
11	Angaila No. 2 h.s.	−0·04	0·00
12	Surveyor General's old office s. ...	0·07	−0·03
13	Dehra Dūn s.	−0·07	−0·03

Magnetic declinations with annual changes for London, Paris, Berlin and 16 Indian stations, to be incorporated in the Indian Military Almanac 1925, were compiled in response to a requisition from the Chief of the General Staff, Simla: also for 300 points for departmental use and for 30 stations for non-departmental officials. 33. *Magnetic declination.*

Magnetic declinations of more than 2,000 points were computed for the Director Map Publication, Calcutta, for entry on half-inch and quarter-inch maps.

Heights of 200 stations were computed in 1923 in connection with a survey carried out by Wazīristān detachment under Captain W. J. Norman, R.E. 34. *Height computation.*

Sir A. Stein's aneroid heights in Central Asia observed in 1915 were reduced. Results are published in Appendix B of Records of the Survey of India, Vol. XVII.

The Cantonment Survey executed by Major Thuillier at Abbottābād was completely reduced. 35. *Cantonment Survey.*

Six hundred and ninety-five requisitions for various data from departmental and non-departmental officials were complied with during the period. In some cases these requisitions were met by the supply of printed publications, in others it was necessary to extract the required information from manuscript records. 36. *Requisitions.*

(ii) Tidal Section

Tidal registrations by automatic tide-gauges were continued during the period under report at Aden, Karāchi, Bombay (Apollo Bandar), Madras, Kidderpore and Rangoon; and at Bombay (Prince's Dock) to May 1924, at Moulmein to November 1924 and at Port Blair to April, 1925. The tidal observatories at these last three ports were dismantled, further registration being deemed unnecessary to this department. At the request of the Bassein Port authorities, a tide-gauge was installed at Bassein in November 1923, since when tidal registrations have been obtained. Regular tidal registrations by an automatic tide-gauge have also been received from Basrah. The tide-gauge was not installed, nor has it ever been inspected, by this party. 37. *Observatories.*

Tidal registrations serve several purposes. In the first place they provide data on which prediction of future tides is based. For this purpose five years record is desirable. In the second place they enable harbour surveyors to reduce soundings, taken at any time, to datum of charts. Finally they allow a reliable comparison to be made between predicted values of times and heights of high and low water and the actual values: thereby confirming the former or occasionally showing need of modification of prediction constants. While harmonic analysis of the tidal observations is no longer carried out in the case of the long 38. *Tidal registration.*

38. (Contd.) established observatories, comparison of predicted with actual value is made (*vide* tables at pages 31-67).

Comparisons are also made in the case of the ports Bhāvnagar, Chittagong and Akyab, where tide-pole readings, during daylight only, are taken by the Port authorities.

39. **List of Tidal Stations.** A complete list of the stations at which tidal registrations have been carried out by this department since 1874, when tidal observations were inaugurated, is given below. Those now in operation are shown in italics. In the case of Basrah, the Survey of India has so far been concerned only with predicting tides from tidal records supplied by the Port authorities.

List of Tidal Stations

Serial No.	Station	Automatic or personal observations	Date of commencement of observations	Date of closing of observations	Number of years of observations	REMARKS
1	Suez ...	Automatic	1897	1903	7	
2	Perim ...	,,	1898	1902	5	
3	*Aden* ...	,,	1879	Still working	46	
4	Maskat ...	,,	1893	1898	5	
5	Bushire ...	,,	1892	1901	8	
6	*Karāchi* ...	,,	1868 1881	1880 Still working	*13 44 } 57	* Small tide-gauge working
7	Hanstal ...	,,	1874	1875	1	Tide-Tables not published
8	Navānar ...	,,	1874	1875	1	
9	Okha Point ...	,,	1874 Re-started 1904	1875 1906	1 1 } 2	Year 1904-05 is excluded
10	Porbandar ...	Personal	1893	1894	2	
10A	Porbandar ...	Automatic	1898	1902	2	Years 1898, 1899 & 1902 are excluded
11	Port Albert Victor (Kāthiāwār)	Personal	1881	1882	1	
11A	Port Albert Victor (Kāthiāwār)	Automatic	1900	1903	4	
12	Bhāvnagar ...	,,	1889	1894	5	
13	*Bombay* (Apollo Bandar)	,,	1878	Still working	47	
14	Bombay (Prince's Dock)	,,	1888	1924	37	Dismantled May 1924
15	Marmagao (Goa) ...	,,	1884	1889	5	
16	Kārwār ...	,,	1878	1883	5	
17	Beypore ...	,,	1878	1884	6	
18	Cochin ...	,,	1886	1892	6	
19	Tuticorin ...	,,	1888	1893	5	
20	Minicoy ...	,,	1891	1896	5	

List of Tidal Stations (Contd.)

39. *(Contd.)*

Serial No.	Station	Automatic or personal observations	Date of commencement of observations	Date of closing of observations	Number of years of observations	REMARKS
21	Galle ...	Automatic	1884	1890	6	
22	Colombo ..	,,	1884	1890	6	
23	Trincomalee ...	,,	1890	1896	6	
24	Pāmban Pass	,,	1878	1882	4	
25	Negapatam ..	,,	1881	1888	5	Years 1883 to 1885 are excluded
26	*Madras* ...	,,	1880 Re-started in 1895	1890 Still working	10 } 30 } 40	
27	Cocanāda ..	,,	1886	1891	5	
28	Vizagapatam ..	,,	1879	1885	6	
29	False Point ...	,,	1881	1885	4	
30	Dublat (Sāgar Island)	,,	1881	1886	5	
31	Diamond Harbour ..	,,	1881	1886	5	
32	*Kidderpore* ..	,,	1881	Still working	44	
33	Chittagong ...	,,	1886	1891	5	
34	Akyab ..	,,	1887	1892	5	
35	Diamond Island ...	,,	1895	1899	5	
36	*Bassein* (Burma) ...	,,	1902 1923	1903 Still working	2 } 2 } 4	Re-started 1923
37	Elephant Point ...	,,	1880 Re-started in 1884	1881 1888	5	Year 1880-81 is excluded
38	*Rangoon* ...	,,	1880	Still working	45	
39	Amherst ...	,,	1880	1886	6	
40	Moulmein ...	,,	1880 Re-started in 1909	1886 1924	6 } 16 } 22	Dismantled November 1924
41	Mergui	,,	1889	1894	5	
42	Port Blair ...	,,	1880	1925	45	Dismantled April 1925
43	Basrah ...	Personal	1916	1922	7	Tide Pole
43A	*Basrah* ...	Automatic	1922	Still working	3	Automatic recorder

Up till 1921 inspections of tidal observatories were always carried out, either by the Officer in Charge of Tidal Operations or by the Tidal Assistant. For reasons of economy it was decided in 1922, that inspections should be made by any suitable officer of the department who might be in the locality of a tidal observatory. During the period under review inspections as detailed on page 18 were carried out. 40. *Inspection of Observatories.*

40. (Contd.)

Station		Inspected by		Date of inspection
Aden	...	Lieut-Col. S.W.S Hamilton D.S.O., R.E.		October 1924
Karāchi	...	Mr. E.C.J. Bond V.D.	...	February 1923
"	..	Mr. D.H. Luxa	...	December 1924
Bombay (Apollo Bandar)	...	Mr. E. C. J. Bond V.D.	..	February 1923
		Mr. D.H. Luxa	...	December 1924
Bombay (Prince's Dock)	...	Mr. E. C. J. Bond V D.	...	February 1923
Madras	..	Mr. E. C. J. Bond V D.	...	February 1923
		Mr. D. H. Luxa	...	November 1924
Kidderpore	...	Mr. N. R. Mazumdar	...	November 1922
		Mr. D. H. Luxa	...	December 1923
		Mr. D. H. Luxa	...	November 1924
Rangoon	...	Mr. N. R. Mazumdar	...	December 1922
		Mr. D. H. Luxa	...	December 1923
		Mr D. H. Luxa	..	November 1924
Moulmein	...	Mr N. R. Mazumdar	...	December 1922
		Mr. D. H. Luxa	...	November 1924
Bassein	..	Mr. D. H Luxa	...	November 1924
Port Blair	...	Mr. D. H. Luxa	...	November 1923

41. *Changes in tidal observatories.*

Moulmein tidal observatory was closed in November 1924 and Port Blair observatory, in April 1925. The tide-gauges were dismantled and sent to Dehra Dūn.

A new tidal observatory was erected at Bassein in October 1923 by the Port Advisory Board, who were in favour of a resumption of tidal observations at this station after a lapse of 20 years. The selection of the site and the construction of the observatory was carried out by the Public Works Department, Bassein. Mr. D. H. Luxa, Tidal Assistant, Survey of India, inspected the observatory and installed a tide-gauge in it in November 1923. Tidal registrations were resumed at Bassein on 28th November 1923. The observatory was again inspected during November 1924, when the tide-gauge was found to have worked well: there had been no breaks in the tidal registrations. The heights recorded had a tendency at times to remain stationary, due to the counterpoise weight attached to the clock having been too heavy, and this was rectified during the inspection. A large quantity of mud and silt was found in the interior of the cylinder and also around its base, which was removed by divers who reported that the inlet holes were quite free, and that there was a clearance of at least a foot between the bottom of the cylinder and the river bed.

42. *Basrah observations.*

The Basrah observations originally consisted of hourly readings against a tide-pole of the height of the water taken throughout the day and night, copies of which were supplied to this department weekly by the Director, Inland Water Transport, Mesopotamia. This arrangement was continued until the 31st March 1922. Thereafter an automatic tide recorder was erected at Ma'qil, and weekly diagrams, showing the tidal registrations obtained by it, were received from the Port Director, Basrah, until 30th April 1922, after which date, owing to the very heavy silting during the floods, the tide recorder failed to function and was put out of action temporarily. On 2nd November 1922 registrations were resumed at Tanumah and the diagrams without any serious breaks have been received regularly since then. 42 *(Contd)*

With effect from the end of 1921 harmonic analysis of tidal observations at Aden, Karāchi, Bombay, Madras, Kidderpore, Rangoon, Moulmein and Port Blair was discontinued. This was decided on after consultation with Professor Horace Lamb, F.R.S. and Dr. Doodson, D.Sc. of the Tidal Institute, Liverpool. The latter considered that more useful results could be obtained by following his method, recently worked out, of intensive analysis of short periods of observations in preference to a continuance of the less complete harmonic analysis ordinarily used. No such intensive analysis has as yet been possible in India. 43. *Harmonic analysis.*

Ordinary harmonic analysis has been carried out for Basrah observations (in which a break in registration lasted from 1st May to 2nd November 1922) for the three yearly periods beginning 25th April 1921, 1st January 1923 and 1st January 1924. The middle period was analysed completely for 33 components and the other two periods for 10 components only. The results are given in tabular form on page 20.

Two adding machines made by Messrs. Burroughs & Co. of Detroit, Michigan, U.S. America, were employed for the first time in 1924 in connection with the long summations, resulting in considerable saving of time and labour. The more complete analysis of 1923 was carried out with the intention of attempting prediction of a riverain port by means of the Tide Predicting Machine in place of the usual empirical tables. Reference to this is made in § 45 *et seq.*

No harmonic analysis of the registrations of the newly installed tidal observatory at Bassein has been made so far.

TABLE III.—Values of the Tidal constants for Basrah

Tide Symbol	1921-22				1923*				1924			
	$A_0=6\cdot439$				$A_0=6\cdot085$				$A_0=5\cdot853$			
	R	ζ	H	κ	R	ζ	H	κ	R	ζ	H	κ
	feet		*feet*		*feet*		*feet*		*feet*		*feet*	
S_1	0·062	230°·38	0·062	230°·38	0·121	212°·18	0·121	212°·18	0·115	197°·29	0·115	197°·29
S_2	0·318	185·36	0·318	185·36	0·287	169·02	0·287	169·02	0·265	161·22	0·265	161·22
S_4					0·111	307·28	0·111	307·28				
S_6					0·004	25·35	0·004	25·35				
S_8					0·004	137·01	0·004	137·91				
M_1					0·074	143·64	0·049	263·91				
M_2	1·226	174·33	1·183	106·75	1·109	67·68	1·070	99·89	1·077	329·83	1·044	102·15
M_3					0·074	143·64	0·049	263·91				
M_4					0·152	45·45	0·141	100·88				
M_6					0·006	11·80	0·006	108·54				
M_8					0·002	275·71	0·002	44·58				
O_1	0·259	16·62	0·317	1·41	0·275	158·54	0·338	5·05	0·312	47·32	0·367	358·73
K_1	0·517	86·39	0·616	32·26	0·568	201·72	0·640	28·98	0·617	205·15	0·679	29·14
K_2					0·090	322·01	0·119	157·05				
P_1	0·170	314·10	0·170	11·36	0·203	183·97	0·203	353·99	0·185	200·86	0·185	11·11
J_1	0·045	148·09	0·053	221·05	0·037	230·98	0·045	310·06	0·040	348·94	0·046	151·95
Q_1	0·029	103·66	0·036	323·11	0·059	48·20	0·072	1·33	0·085	36·42	0·100	5·73
L_2					0·110	35·[illegible]6	1·177	133·36				
N_2					0·223	284·99	0·215	63·83				
ν_2					0·077	88·95	0·075	47·32				
μ_2					0·109	127·45	0·102	191·89				
T_2					0·012	300·32	0·012	301·96				
$(MS)_4$					0·105	153·51	0·101	185·73				
$(2SM)_2$					0·032	71·86	0·030	39·64				
$2N_2$					0·020	51·39	0·019	206·85				
$(M_2N)_4$					0·068	260·03	0·064	71·09				
$(M_2K_1)_3$	0·175	170·63	0·190	48·91	0·207	183·41	0·225	42·89	0·163	85·93	0·174	42·24
$(2M_2K_1)_3$	0·123	93·02	0·120	11·08	0·144	123·93	0·151	1·10	0·155	282·37	0·161	3·02
Long Period: Mm					0·115	156·52	0·129	49·89				
Long Period: Mf					0·021	331·44	0·033	130·63				
Long Period: MSf					0·249	93·62	0·240	61·40				
Long Period: Sa					1·853	140·07	1·853	60·05				
Long Period: SSa					1·853	296·29	1·853	136·26				

*The port was worked as an open sea port in 1923 only

Predictions of tides for the years 1924 and 1925, were made for the following ports :—Suez, Perim, Aden, Maskat, Basrah, Bushire, Karāchi, Okha Point and Bet Harbour, Porbandar, Port Albert Victor, Bhāvnagar, Bombay, Marmagao, Kārwār, Beypore, Cochin, Tuticorin, Minicoy, Pāmban Pass, Colombo, Galle, Trincomalee, Negapatam, Madras, Cocanāda, Vizagapatam, False Point, Dublat, Diamond Harbour, Kidderpore, Chittagong, Akyab, Diamond Island, Bassein, Elephant Point, Rangoon, Amherst, Moulmein, Mergui and Port Blair. 44. *Tidal predictions*

Predictions for the year 1926 were made for the same ports excepting Perim, Maskat and Minicoy; these ports being omitted as the demand for Tide-Tables for them was too small to justify the expenditure involved in prediction and publication.

The amounts realised by the sale of Tide-Tables were as follows :—

Rs. 10172- 7-0 in 1922-23
Rs. 12395-13-0 in 1923-24
Rs. 11241- 9-6 in 1924-25

These amounts are exclusive of the commission allowed to the Agents and the cost of Tide-Tables which are supplied gratis under Government orders. Advance copies in manuscript or proof stage of the Tide-Tables for the years 1924, 1925 and 1926 for Suez, Aden, Bushire, Karāchi, Bombay, Madras, Dublat (Sāgar Island), Diamond Harbour, Kidderpore (Calcutta), Chittagong, Rangoon, Elephant Point, Mergui, Marmagao, Trincomalee, Colombo, and Bhāvnagar were despatched to the Hydrographer to the Admiralty by about April of preceeding year for inclusion in the Admiralty Tide-Tables.

Similarly advance copies of the Hooghly River Tide-Tables were supplied to the Deputy Conservator of the Port of Calcutta and to the Port Officer, Calcutta, by about June. Additional advance information regarding the Hooghly tides during the months February to April 1925, 1926 and 1927 were supplied to Messrs. Thomas Cook and Son, Calcutta, in connection with their advance shipping American Tourist programme.

The tidal predictions are ordinarily carried out on the Tide Predicting Machine; but in the case of the riverain ports Dublat, Diamond Harbour, Kidderpore, Chittagong, Rangoon, Elephant Point, Amherst, Moulmein and Basrah, the machine is used only for the diurnal components whereby a correction is derived and applied to the times and heights given by empirical charts. This process of tidal prediction for riverain ports is about twice as laborious as that used for open sea ports and the results obtained are less precise. Considerable endeavour has been made to reduce this labour and to improve accuracy—so far without definite result; but it is still hoped that progress will be made in this direction. Some account of the work done is now given. 45 *Methods of Prediction.*

From consideration of the hydrodynamical equations of motion in a channel of small depth it was anticipated that in a river— 46. *Riverain ports prediction research.*

(1) the heights of high and low water would be predictable by ordinary machine methods.

46 (*Contd.*) (2) the times of these events would differ from those shown by the tide machine curve by amounts depending on the height of the tide.

Trials were made in the case of Kidderpore (Calcutta) which lies about 120 miles from the mouth of the Hooghly and where the average depth of water at low tide is only about 3 fathoms. Harmonic analysis of the observations of 40 years had been made for 33 components following the ordinary method for open sea ports.

It was recognised that as the process of analysis does not consider many tides which, though small in open seaports, are liable to be considerable in an estuary and more so in a shallow channel, the results could not be wholly trustworthy. Still it was hoped in consideration of the large period analysed that they would be adequate for a preliminary enquiry. Accordingly the 24 components of the Tide Predicting Machine were set to the values given by the analysis and the curves for a year were run off on the scale of 6″ = 1 day. In the first place the mean water levels were made to coincide and the differences of times of high and low water as given by the curves from those actually given by the tide-gauge records were determined and classified with respect to height of water.

Records for a month were dealt with and an empirical correction table was formed. This seemed to promise some satisfactory result: for the machine curves when corrected by the tabular amount in terms of the height were of about the same precision as those given by the ordinary empirical method for riverain ports. It was found however that the time scale of 6″ = 1 day was too small to admit of very satisfactory readings. Accordingly certain modifications were made on the Tide Predicting Machine enabling curves to be run on scale of 24″= 1 day. These were corrected for the mean water level as deduced from the actual daily means cleared from the effects of short period tides and η, and 2η only; and were then compared with actuals at every foot of height, and results classified. Here difficulty was experienced in that the mean water level was not truly predicted. Further the time correction deduced for various heights differed according as the water was rising or falling. A mean value of those found for rising and falling water was deemed to be applicable to high or low waters occurring at the particular height.

46. *(Contd.)*

	Height	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′	Average change in height per hour
		Actual *minus* Predicted in minutes										*feet*
Jany. 1st to 16 1920	Falling water	61	45	32	27	29	32	33	35	36	33	1·5
	Rising water	-3	-13	-17	-20	-20	-14	-14	-15	-18	-25	3
	Mean	29	16	8	4	5	9	10	10	9	4	
July 1st to 16 1920	Falling water	56	45	36	28	24	25	32	35	35	35	1·5
	Rising water	2	-18	-30	-37	-39	-37	-33	-26	-23	-23	4
	Mean	29	14	3	-4	-7	-6	-1	4	6	6	
General Mean ...		29	15	6	0	-1	2	4	7	8	5	

No explanation for the differences between results for rising and falling water was found. An attempt to explain this in terms of rate of rise or fall of water was unsuccessful.

Actual and harmonically predicted times of high and low water for the complete year 1920 were taken out afterwards, and their differences (A-P) classified according to predicted heights of high and low water with the result:—

Height	2′	3′	4′	5′	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′	16′	17′	18′	19′
A-P	+85	+77	+69	+62	+55	+49	+43	+37	+32	+27	+23	+10	+14	+10	+6	+2	-3	-7

With these tabular values the predicted times as obtained from the harmonic curves were corrected, and (A-P) computed out for the month of March. The errors were found to be about the same as in the riverain method in use now, but the predicted heights from the harmonic curves, even if corrected for the difference in the mean water level as obtained from the actual daily means cleared for short and long period tides, are slightly inferior.

Method	Time				Height			
	E_1		E_2		E_1		E_2	
	H.W.	L.W.	H.W.	L.W.	H.W.	L.W.	H.W.	L.W.
	minutes	*minutes*	*minutes*	*minutes*	*feet*	*feet*	*feet*	*feet*
Harmonic method	+3·1	+0·5	12·5	14·8	+0·1	+0·1	+0·8	0·6
Riverain method	-7·7	-4·0	12·4	9·8	0·0	+0·1	0·7	0·3

46. *(Contd.)*

$$E_1 = \frac{T_1 - T_2}{n} \qquad E_2 = \frac{T_1 + T_2}{n}$$

where n is the number of high or low waters and T_1 is the total of positive (+) errors, and T_2 is the total of negative (—) errors.

47. *Mean water level at Kidderpore.* An investigation of the mean water level at Kidderpore, which was in extreme cases as far as 3 feet in error by prediction (whether harmonic or by the ordinary riverain empirical method) was next taken up, as it was impossible to apply the time correction just considered unless the height could be predicted more accurately.

The actual daily means of Kidderpore were cleared from the effect of the usual short and long period tides, and then submitted to harmonic analysis to detect the presence of any other long period tides. Four years' observations 1916-19 were dealt with and the residual values plotted. No similarity in the curves for the several years existed. Irregular discrepancies lay within 1 foot for the first 8½ months but from September 15 to November 15, the discrepancies were larger: in October the curves of 1916 and 1917 were about 2 feet above the observed mean water level line and the other two curves of 1918 and 1919, 2 feet below.

Similar discrepancies which occur between actuals and values predicted by the old method are as follows:—

1916	3rd Oct.	A-P	+2′	7″	H.W.	2nd Nov.	A-P	+2′	9″	H.W.
		,,	+2′	6″	L.W.		,,	+2′	5″	L.W.
1917	13th Oct.	,,	+2′	11″	H.W.	2nd Nov.	,,	+2′	5″	H.W.
		,,	+3′	3″	L.W.		,,	+2′	3″	L.W.
1918	8th Oct.	,,	−1′	9″	H.W.	23rd Oct.	,,	−2′	5″	H.W.
		,,	−1′	6″	L.W.		,,	−2′	3″	L.W.
1919	3rd Oct.	,,	−1′	0″	H.W.	23rd Oct.	,,	−1′	11″	H.W.
		,,	−1′	3″	L.W.		,,	−1′	0″	L.W.

These irregularities seem to follow the rainfall in Bengal in October.

October 1916	11·65 inches
,, 1917	13·57 ,,
,, 1918	1·08 ,,
,, 1919	3·69 ,,

but in other months greater variations in rainfall have no corresponding change of mean water level.

Water levels on the Ganges from Allahābād downwards to Rajmahal were taken out; but no connection with mean water level at

Kidderpore could be established. Should subsequent investigation clear up these points, it is possible that the empirical method of time correction sketched above may become useful. 47. (*Contd.*)

48. *Comparison of actual with predicted value. Errors of prediction.*

At all stations at which self registering tide-gauges are maintained, and at Bhāvnagar Chittagong and Akyab where tide-pole readings are taken by day, predicted values are compared with the actual observed times and heights of high and low waters. These comparisons are abstracted in an improved form, with a view not only to indicate that satisfactory results are being obtained when such is the case, but also to indicate whether improvement in prediction is possible. These abstract comparisons are given at pages 31-67 and in the next Geodetic Report, certain corrections to predictions which have been deduced by their means will be mentioned.

For the purpose of continuity with the past, the comparison of actual and predicted values have also been taken out in the old manner.

Abstract of average errors in time and height

Station	Automatic or tide-pole	Average errors: of time in minutes						Average errors: of height in feet					
		1922		1923		1924		1922		1923		1924	
		H.W.	L.W.	H.W.	L.W.	H.W.	L.W.	H.W.	L.W.	H.W.	L.W.	H.W.	L.W.
Open coast													
Aden ...	Auto.	10	11	10	12	7	7	0·2	0·2	0·2	0·2	0·1	0·1
Karāchi	,,	9	13	13	13	9	9	0·3	0·3	0·3	0·3	0 2	0·2
Bhāvnagar ...	T.P.	2	2	5	6	5	5	0·2	0·2	0·3	0·3	0·4	0 4
Bombay (Apollo Bandar)	Auto.	9	12	9	10	8	7	0·3	0·3	0·3	0·4	0·3	0·3
Madras ...	,,	14	15	13	17	7	8	0·3	0·3	0·3	0·3	0·2	0·2
Akyab ...	T.P.	5	5	5	5	7	6	0·3	0·4	0·3	0·3	0·3	0·3
Port Blair .	Auto.	7	6	14	9	6	8	0·2	0·2	0·2	0·2	0·1	0·2
Riverain													
Kidderpore ...	Auto.	10	12	12	12	10	12	0 6	0·5	0·8	0·8	0 5	0·5
Chittagong ...	T.P.	16	17	17	17	14	15	0·5	0 8	0 5	0 8	0·5	0·9
Rangoon ...	Auto.	14	12	17	13	19	13	0·4	0·5	0·4	0 7	0·4	0 6
Moulmein ...	,,	10	15	13	20	12	14	0·6	0 5	0·6	0 7	0·5	1·9
Basrah ..	T.P. 1922 Auto 1923 & 1924	54	73	45	56	51	57	0·9	0·6	0·9	0·7	0·5	0·7
Bassein ...	Auto.	...	...	...	...	19	18	...	...	...	...	0 6	0·9

48. (*Contd.*) From comparisons made between the actual and predicted times and heights of high and low waters for the years 1922, 1923 and 1924, the predictions for each of the above years were found to be as accurate as those for the preceding years with the following exceptions:—

(1) Basrah predictions for 1922 had deteriorated as regards time.

(2) The 1923 predictions for Karāchi, Bhāvnagar, Port Blair, Kidderpore, Rangoon and Moulmein were not as good as those for the previous year (1922) as regards time, and to a lesser extent as regards height. A distinct improvement however had taken place as regards the predicted times of high and low waters at Basrah.

(3) The 1924 predictions showed a marked improvement as regards both time and height at all the stations, except at Akyab, Rangoon and Basrah where a slight deterioration in time had taken place, and at Moulmein as regards the heights of low waters.

The greatest differences between the actual and predicted heights of low water for the years 1922, 1923 and 1924 at the under mentioned riverain ports where automatic tide-gauges were at work, were as follows:—

Kidderpore, 2 feet 8 inches, on 21st September 1923.

Rangoon, 2 feet 11 inches, on 5th August 1924.

Moulmein, 4 feet 8 inches, on 14th February 1923.

Basrah, 3 feet 8 inches, on 4th and 5th February 1924.

Bassein, 5 feet 0 inch, on 3rd August 1924.

The predicted heights were higher in the case of Kidderpore and Moulmein and lower in that of others.

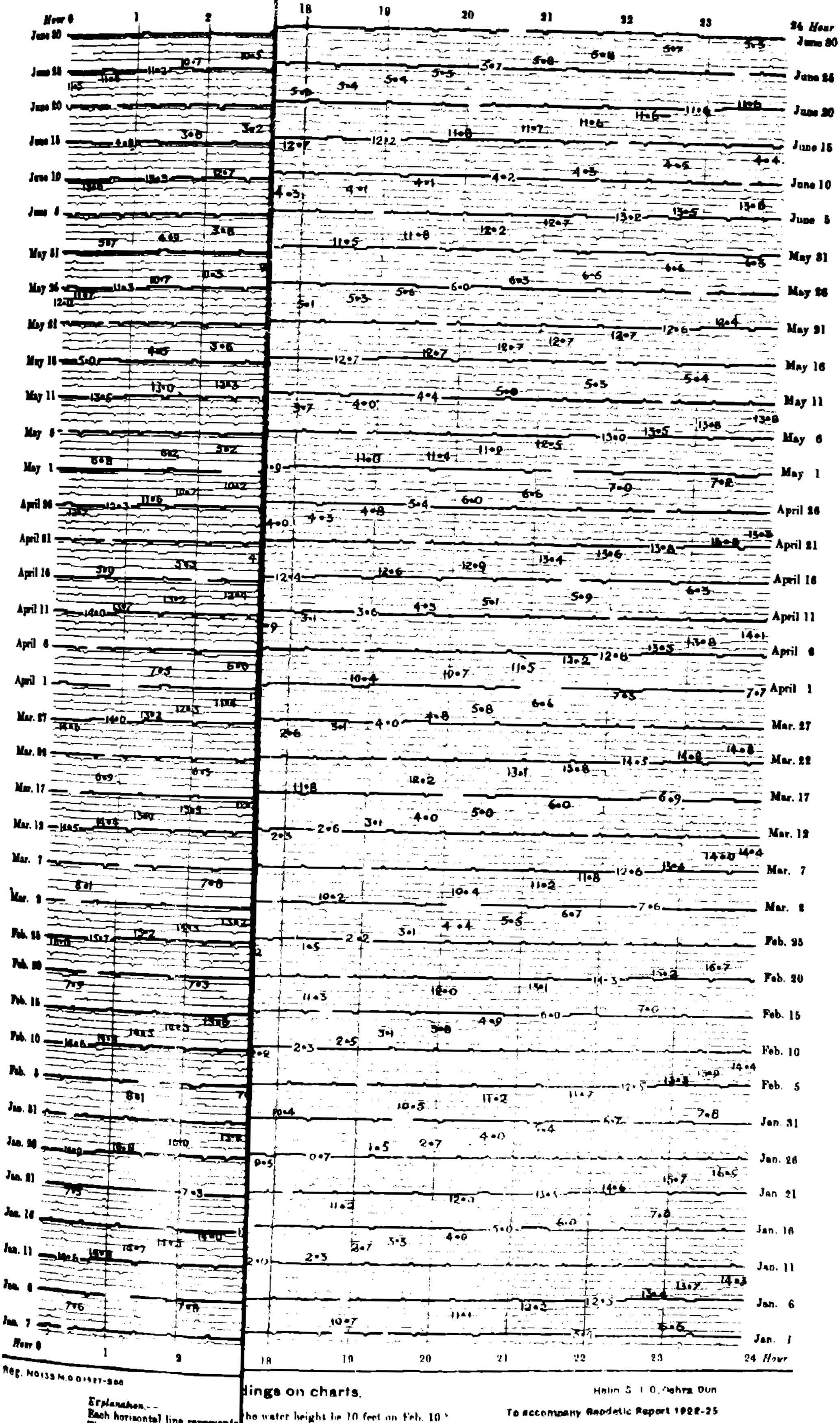
49. *Additions to Tide Predicting Machine* Certain additions have been made to the Tide Predicting Machine by Dr. Hunter which have led to some changes in procedure as compared with that followed in England. The height curve is now run on one fifth of the time scale formerly used and the times are read off on a separate chronograph sheet.

The following is an account of the new arrangement (reprinted from the Journal of Scientific Instruments for 1924).

'The Tide Predicting Machine, designed by Lord Kelvin and Mr. Edward Roberts and built for the India Office, was for many years at the National Physical Laboratory, where it has been seen by many people. In 1922 it was sent to India, and is now employed by the Survey of India at Dehra Dūn. The machine traces a height-time curve on a roll of paper some 22 inches wide, by means of a pen carried by a wire which passes over and under the wheels of the 24 "components". The time scale generally employed was 6 inches = 24 hours. It was found troublesome to the personnel available to read off times of high and low water from the curve with sufficient precision. There is naturally some vagueness as to the precise moment of maximum or minimum ; but though this does not necessarily cause any serious flaw in the resulting Tide-Tables, it renders the ordinary system of checking

1925, first half year

Chart II



Reg. No135 M.O 01977-800

...dings on charts.

Helio S. I. O. Dehra Dun

To accompany Geodetic Report 1922-25

Explanation.—

Each horizontal line representa... ...he water height be 10 feet on Feb. 10 ?

The vertical lines represent ho... ...Feb. 10 there is seen to occur— at 03h·12m on falling tide.

The horizontal lines have notch... 10·14 rising „

When the notches are upwards ... 14·22 falling „

falling. There are gaps in the horiz... 21·10 rising „

accordingly the height of an upward ... ...he time and height of first high water on Jan. 30 ?

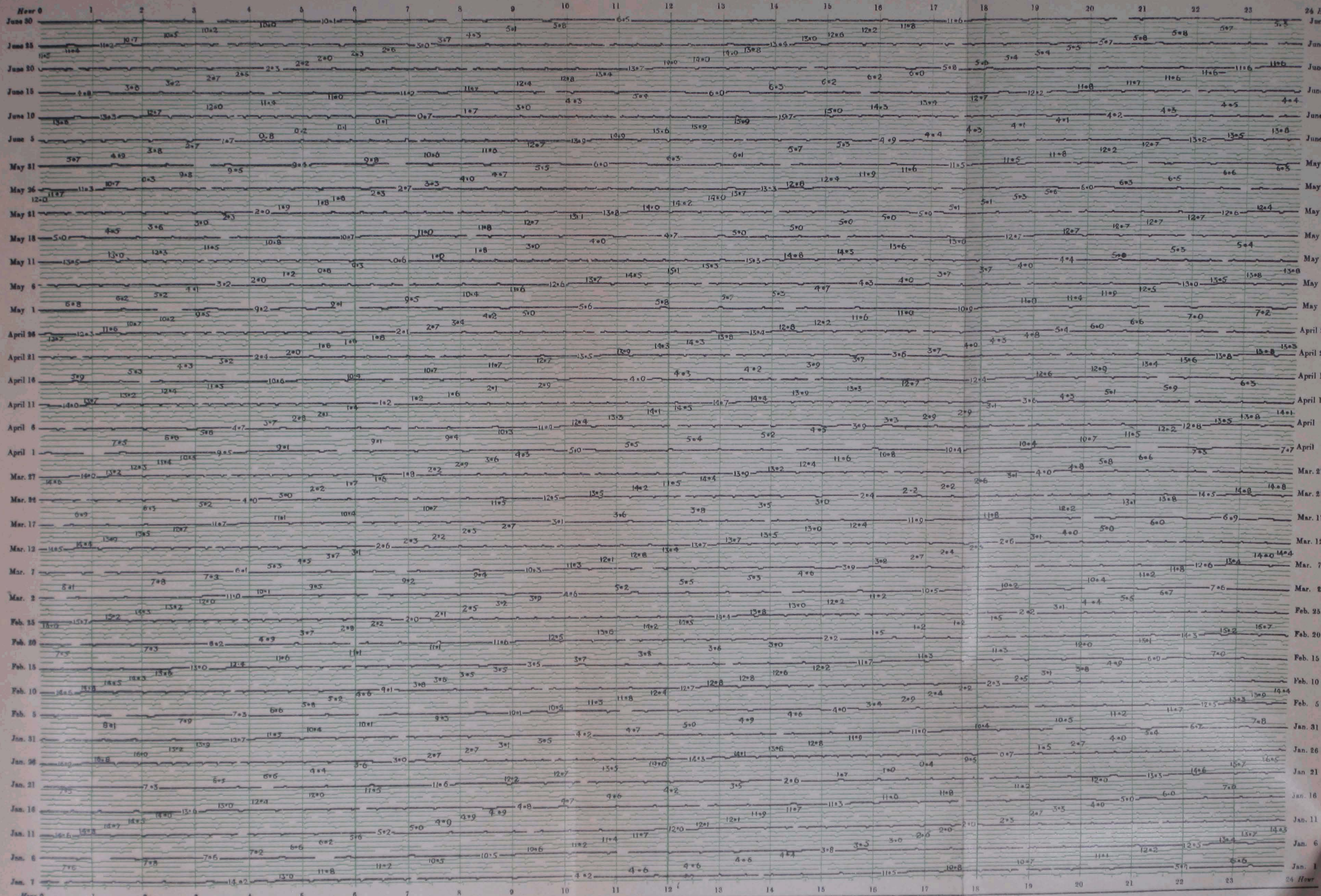
left of the gap is 8 feet above dat... ...the printed figure to be 13·9 feet and measurement (or estimation by eye) of the position of

8 feet and of one to the left of the ga... ...that this occurs at 03·12.

PREDICTION of HEIGHT of WATER at any time at BOMBAY (Apollo Bandar) and of TIMES and HEIGHTS of HIGH WATER and LOW WATER

1925, first half year

Chart II



Reg. No135 M.D.O1927-300

Local mean time (correction to Indian Standard Time, 5½ hours E. of Greenwich, is + 39 minutes). Heights refer to Datum of Soundings on charts.

Helio. S. I. O. Dehra Dun.

To accompany Geodetic Report 1922-25

Explanation.—

Each horizontal line represents one day, and the date of every fifth line (printed in black) is given.

The vertical lines represent hours from 0 to 24 (civil time).

The horizontal lines have notches which indicate the time at which the water is 1, 2, 3 ..... feet above datum. When the notches are upwards —^— the water is rising: when they are downwards —v— the water is falling. There are gaps in the horizontal line when the water level is 8·5 feet above datum (about mean-sea-level) accordingly the height of an upward notch to the right of a gap is 9 feet above datum and an upward notch to the left of the gap is 8 feet above datum: while for downward notches the height of one to the right of the gap is 8 feet and of one to the left of the gap is 9 feet. The height indicated by any notch may be found by counting from the nearest gap 9, 10, 11......... feet for rising water and 8, 7, 6...... feet for falling water. This process is illustrated in the bottom line of the chart for the day 31 Dec. 1924. The heights of high and low waters are entered in figures to one decimal of a foot. The position of the decimal point indicates the time of the occurrence.

Examples.

(i)—What is the height of water on January 26 at 10 hours and at 14 hours 20 minutes?

Follow horizontal line for Jan. 26 to meet vertical line for 10 hours. Here the notches are upward, indicating rising water and the height of the water is between 9 and 10 feet: by estimation it is seen to be 9·2 feet.

At 14 hours 20 minutes the water is falling and the height is 11·4 feet.

(ii)—When will the water height be 10 feet on Feb. 10?

Following line for Feb. 10 there is seen to occur— at $03^h \cdot 12^m$ on falling tide.

10 · 14	rising ,,
14 · 22	falling ,,
21 · 10	rising ,,

(iii)—What are the time and height of first high water on Jan. 30?

The height is shown by the printed figure to be 13·9 feet and measurement (or estimation by eye) of the position of the decimal point shows that this occurs at 03·12.

proofs (and the measurements and copy from which they have resulted), by the method of reading the differences of times of alternate high waters, much more troublesome On this account it was at first thought desirable to run off a second curve—the differential with regard to time of the height-time curve— whose ordinate vanishes at the time of high or low water. This was soon made more convenient by dispensing with tracing the curve, and causing the pen to break an electric contact when crossing the zero line, this event being recorded on a chronograph drum actuated by the S_1 component. It was then seen that a similar arrangement with multiple contacts corresponding to successive values of ordinate could conveniently be made to record the main character of the ordinary height-time curve. This arrangement indicates the times the predicted height of water reaches the various selected heights, e.g. with a tide range of 15 feet it may be conveniently arranged to show the times of the water reaching every whole foot of height above datum throughout the whole range. It was thought that this information would be of greater value to mariners than the bare statement of height and time of high and low waters, with no information regarding water heights at intervening times.' 49. (Contd.)

'The arrangement now to be described was made with this object in view. As will be seen from Chart* II given opposite to page 27 the time of water reaching each foot is shown by a notch in the day line. The notches are upwards for ascending water, and downwards for descending water; while a level near to mean water level is indicated by a break in the line.'

'The chief difficulties encountered were in making the contacts certain in action, while keeping friction forces very small, especially for those curves where the duration of contact was very small owing to rapid fall or rise of the curve. In this connection it may be noted that the wire which actuates the tide-curve pen is essentially of small diameter (·005 inch was generally used) and is 32 feet long. A small variation in tension of this wire extends it visibly, while if a thicker wire be used inaccuracy arises owing to this not being sufficiently flexible to fit close to all the wheels over which it passes. As regards duration of contact it is to be mentioned that the chrono-paper passes at the rate of about 23 mm. per second, and that a whole year's prediction is dealt with in about 2½ hours.'

* This chart for Bombay is reduced to ½ full size.

49 (*Contd.*) 'In Fig. 1 *AA* is a brass plate which is attached to the back of the pen of the tide machine, with which it moves up and down when the

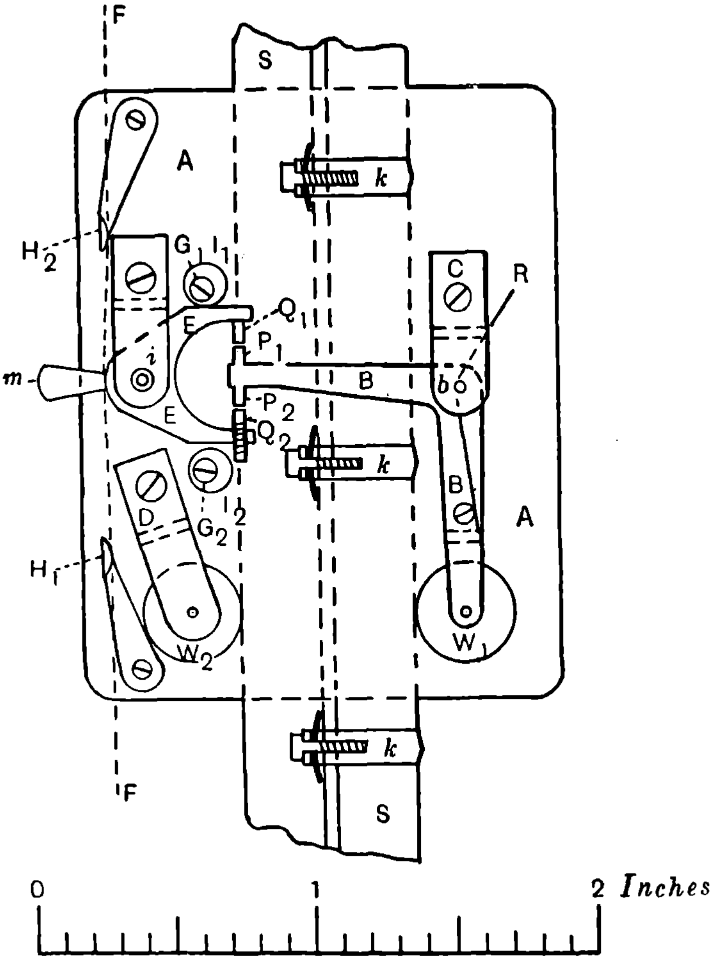


Fig. 1

machine is set in motion. *BB* is a bell-crank lever provided with a pivot *b* carried by the bracket *C* and the plate *AA*. The horizontal arm of *BB* carries two platinum points P_1, P_2 near its left end and the vertical arm carries at its lower extremity the wheel W_1. There is a second wheel W_2 whose pivots are carried by the plate *AA* and the bracket *D*. These two wheels W_1, W_2 roll on the edges of a fixed brass strip *SS*, being maintained in contact by the pressure of a spring *R*.'

'The strip *SS* is shown in dotted lines, being in front of the plate *AA* and the horizontal arm *B*; it is of accurately uniform breadth, and is slotted at intervals of an inch for the pieces *k*, *k*. It is made of T- section to secure rigidity, and the pieces *k*, *k* are adjusted laterally by screws working in the vertical member of the T. The pieces *k*, *k* are slightly pointed as shown, and can be made to project a small amount (actually about 0·3 mm.) beyond the right edge of the strip *SS*. As the plate AA is carried up and down with the pen, the wheel W_1 rides over the points of the pieces k, k and rocks the bell-crank lever, causing the platinum points P_1, P_2 to move slightly up and down.' 49. (*Contd.*)

'The part EE bears two platinum points Q_1, Q_2 in its upper and lower jaws, Q_2 being adjustable in the direction of its length. This part has a pivot i with insulating bush, and is balanced by the counter-weight m. Its motion is restricted by the insulators I_1, I_2 mounted excentrically on the two screws G_1, G_2. These screws are sufficiently tight-fitting to maintain their position, and by turning them to suitable positions the rotation of EE is regulated as desired. EE is actuated by the friction of the fixed wire FF, which lies in a groove cut in EE and also bears on the two pallets H_1, H_2. These pallets are borne on arms which can be rotated, and by this means the drag of the wire on EE can be adjusted; this can also be done by modifying the tension of the wire FF. The wire FF is attached to the frame of the machine at the top of the pen slide by means of an insulator and passes through another insulator at the lower end of the slide, being kept in tension by an attached weight. It makes metallic contact with EE and forms a portion of the chronograph electric circuit.'

'It will be seen that when the plate AA is ascending the upper jaw is pressed against the insulator I_1 by virtue of the drag of the wire FF, while when AA is descending the lower jaw of EE presses against I_2. The following events occur when AA is set in motion:

(1) AA ascending; E is pressed against I_1. Platinum points P_1, Q_1 and P_2, Q_2 are *not* in contact until wheel W_1 rides over one of the projections k, k, when P_2 *makes* contact with Q_2.

(2) AA descending; E is pressed towards I_2, but is held slightly away from it by the platinum point Q_1 bearing on P_1. When W_1 rides over one of the projections k, k, P_1 separates from Q_1 and E presses on I_2.'

'The terminals of the chronograph pen circuit are joined to the strip SS and the wire FF respectively. It is obvious that the effect of W_1 riding over a projection k is to *make circuit* in the case of AA rising; and to *break circuit* in the case of AA falling. This is represented on the chart by _|‾|_ and ‾|_|‾ respectively. A change of direction of motion of AA, which corresponds to high or low water, is indicated by _|‾ and ‾|_ ; but owing to variation in tension, and hence in length, of wire, the actual time of this event is somewhat displaced. In order to provide a reference point, frequently repeated on the chrono-sheet, an additional electromagnet has been introduced, which lifts the chrono-pen from the paper when contact is established, making the indication —— —— on the sheet. This is arranged for by the provision of a springy contact placed near mean water level, against which the wheel W_1 presses in passing.'

'The chronograph is of the drum variety, and its shaft can be coupled to the square shanks of any one of the 24 tidal components. Hitherto the component used has been S_1, so that the lines of chrono-sheet correspond to 24 hours.'

49. (*Contd.*) 'It may be of interest to state that a "Research Fountain Pen*" has been used with excellent results for the chronograph. This is a very light pen and has a very steady and ready flow of ink. Inking begins with very light pressure and there is no blotting or leaking. Ordinary fountain pen ink has been used; when photographic reproduction is intended a little lamp black is mixed with the ink.'

50. *Riverain tidal prediction.* In the case of predictions for riverain ports the empirical tables supplied from England have been used to prepare charts, which have been found more convenient in use than the tables. The monthly mean values of heights and times, corresponding to the apparent times of moon's transit are first brought in terms of mean times of transit. The values for height are plotted without alteration. In the case of the times however, the curves are drawn with the monthly mean values somewhat modified, so as to give the curves an easier gradient and enable the values to be read with more precision. For this purpose the monthly mean values relating to the mean times of transit are subtracted from the times of moon's transit in the case of low waters and *vice versa* in the case of high waters. With these residual values, after applying the correction to standard time, when necessary, the plotting of the curves is carried out. These residuals have been taken to represent the values for the 15th day of each particular month, so that no smoothing is required between the values obtained, for the end of one month and the beginning of the next. Two sets of charts are prepared, one for high water comprising 8 separate charts for heights and times of high waters and another similar 8 charts, for heights and times of low waters. Each chart exhibits 4 curves in 4 different inks covering a period of three months, and one set covers a whole year of heights or times of high or low waters.

As a further saving of labour, times of moon's transit etc. have only been worked out for alternate transits. This led to saving of 30% in preparation of Tide-Tables.

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* Supplied by Mr. A. Munro, 65 Preston Road Winson Green, Birmingham.

TABLE IV.—Mean errors E_1, E_2 for 1922

BASRAH

PERIOD 1922	MEAN ERRORS (E_1 is with regard to sign) E_1 H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	(E_2 is without regard to sign) E_2 H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	0·6 foot of height H. W.	0·6 foot of height L. W.
Jan. 1-16	13·5		0·7			26·8	0·8		40·7	0·7	62·6	0·9	18	24	15	14
17-31	7·6		0·2		2·8		0·3		37·9	0·5	51·4	0·5	18	20	8	7
Feb. 1-16	10·9		0·6		18·4		0·3		31·3	0·8	44·7	0·6	14	18	18	13
17-28		5·8	0·3		2·3			0·1	40·3	0·7	43·9	0·7	14	10	10	8
Mar. 1-16		35·2	1·1			66·3	0·0		68·6	1·1	73·8	0·6	22	23	23	15
17-31		44·0	0·6			116·8		0·6	55·8	0·7	116·8	0·6	17	27	15	13
April 1-16		29·8	1·4			77·1	0·4		38·2	1·4	78·5	0·4	14	24	30	7
17-30		118·3	1·4			113·1	0·4		120·2	1·4	113·1	0·4	25	27	26	7
May 1-16																
17-31																
June 1-16																
17-30																
July 1-16																
17-31																
Aug. 1-16																
17-31																
Sept. 1-16																
17-30																
Oct. 1-16																
17-31																
Nov. 1-16		22·1	1·2			14·1	1·1		42·0	1·2	42·0	1·1	17	18	26	25
17-30		44·1	0·9			45·1	1·1		52·3	1·0	58·7	1·1	15	19	18	20
Dec. 1-16		24·9	1·4			35·6	1·1		41·4	1·4	55·0	1·3	19	18	28	28
17-31		23·6	1·5			40·9	1·4		47·3	1·5	62·0	1·4	19	19	25	25
TOTALS ...	32·0	347·8	11·3	0·0	23·5	535·8	6·9	0·7	616·0	12·4	802·8	9·6	212	247	242	182
MEANS ...	− 26·3		+ 0·9		− 42·7		+ 0·5		51·3	1·0	66·9	0·8				

No registrations were available owing to automatic tide recorder having failed to function necessitating its removal from Ma'qil and its re-erection at Tanumah.

TABLE V.—Mean errors E_1, E_2 for 1923

BASRAH

PERIOD 1923	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	0·6 foot of height — H. W.	0·6 foot of height — L. W.
Jan. 1-16		17·4	0·9			33·4	0·5		33·8	1·0	56·2	0·6	15	16	22	12
17-31		8·8	0·9			20·3	0·5		26·2	1·0	43·4	0·9	8	18	20	[illegible]
Feb. 1-16	0·7		1·0			18·4	0·6		19·8	1·0	46·3	0·8	8	19	26	16
17-28	21·9		1·3		11·7		1·2		36·5	1·3	37·3	1·2	10	12	16	[illegible]
Mar. 1-16		3·4	1·1			12·3	0·8		32·8	1·1	45·0	0·9	8	12	17	12
17-31		6·6	0·8			18·5	0·4		42·5	0·9	34·3	0·4	14	11	14	6
April 1-16		15·0	0·7			31·2	0·2		38·2	0·8	37·4	0·4	13	11	19	[illegible]
17-30		6·8	0·8			15·3	0·5		46·4	0·9	23·1	0·5	17	7	19	12
May 1-16		27·2	1·0			38·4	1·0		58·5	1·0	46·3	1·0	25	18	27	25
17-31		11·7	1·0			33·2	0·9		43·5	1·0	45·5	0·9	17	16	26	25
June 1-16		24·0	0·6			34·0	0·5		53·9	0·6	52·5	0·6	24	19	15	13
17-30	28·9		0·4		8·2		0·0		52·6	0·5	51·4	0·5	23	20	7	[illegible]
July 1-16	13·9		0·4		5·4		0·1		47·2	0·4	65·2	0·4	24	29	9	[illegible]
17-31	32·6		0·8		23·6		0·4		37·9	0·8	52·0	0·5	13	15	19	[illegible]
Aug. 1-16		34·1	1·3			27·5	1·2		42·5	1·3	56·8	1·2	15	23	26	25
17-31		24·5	1·1			11·2	0·8		31·3	1·1	33·0	0·9	14	13	24	[illegible]
Sept. 1-16		35·8	1·1			34·1	0·8		39·6	1·1	45·3	0·8	17	18	25	19
17-30		49·0	0·5			54·7	0·5		65·4	0·6	63·0	0·5	22	17	11	[illegible]
Oct. 1-16		57·2	1·2			82·5	0·6		57·4	1·2	82·8	0·6	21	28	29	[illegible]
17-31		45·0	0·9			45·7	0·3		72·8	0·9	80·5	0·5	23	23	20	7
Nov. 1-16		59·8	0·6			104·8		0·1	69·3	0·7	109·2	0·5	28	3	18	8
17-30		54·1	0·7			87·7	0·7		55·0	0·7	87·7	0·7	19	22	16	[illegible]
Dec. 1-16		28·3	0·6			51·0		0·1	35·1	0·6	60·8	0·5	17	20	20	[illegible]
17-31		5·6	0·8			54·0	0·5		31·1	0·8	73·0	0·7	11	22	20	[illegible]
TOTALS ...	98·0	514·3	20·5	0·0	48·9	808·2	13·0	0·2	1069·3	21·3	1328·0	16·5	409	440	465	[illegible]
MEANS ...	− 17·3		+ 0·9		− 31·6		+ 0·5		44·6	0·9	55·3	0·7				

TABLE VI.—Mean errors E_1, E_2 for 1924

BASRAH

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	0·5 feet of height — H. W.	0·5 feet of height — L. W.
Jan. 1-15		23·7		0·4		35·2		0·7	32·4	0·5	48·7	0·8	14	19	11	16
16-31	24·5			0·8	21·7			1·0	43·7	1·0	47·4	1·3	19	19	23	24
Feb. 1-15	0·7			0·7		16·4		1·8	31·6	0·8	40·0	1·8	12	16	21	27
16-29		4·7		0·5		15·7		1·1	35·1	0·6	37·7	1·1	12	14	13	22
Mar. 1-15	13·6			0·6		0·5		1·1	36·3	0·6	30·7	1·1	12	11	13	21
16-31		0·7		0·7		26·6		1·2	38·1	0·7	35·0	1·2	16	14	19	28
April 1-15		7·2		0·2		15·4		0·5	37·0	0·4	31·5	0·6	15	12	8	11
16-30		23·9		0·0		48·1		0·1	50·1	0·6	53·1	0·5	11	10	6	10
May 1-15		25·9	0·6			22·4	0·7		60·3	0·7	51·2	0·7	17	16	13	15
16-31		29·3	0·4			41·7	0·8		40·6	0·4	50·8	0·8	12	15	9	18
June 1-15		10·3	0·5			16·1	0·7		45·0	0·5	46·0	0·8	16	18	11	18
16-30	0·5		0·2			14·4	0·5		41·1	0·4	55·5	0·7	16	22	5	15
July 1-15		7·3	0·0			38·5	0·1		9·4	0·3	59·8	0·4	15	21	4	8
16-31		42·7	0·1			30·4	0·2		50·7	0·3	58·5	0·4	18	23	5	5
Aug. 1-15		38·5	0·0			18·0	0·1		41·9	0·3	43·3	0·4	16	18	4	8
16-31		65·2		0·1		32·9		0·3	65·5	0·3	38·4	0·4	23	15	5	8
Sept. 1-15		78·6	0·1			80·7		0·2	78·6	0·4	83·6	0·4	28	22	6	6
16-30		45·3		0·1		51·3		0·3	58·7	0·3	69·1	0·5	24	25	3	13
Oct. 1-15		62·3	0·0			83·4		0·5	63·0	0·3	83·4	0·5	22	24	4	12
16-31		12·2		0·1		21·1		0·7	63·2	0·5	65·1	0·7	27	23	12	18
Nov. 1-15		38·6		0·1		60·7		0·3	67·4	0·5	77·5	0·5	22	21	9	11
16-30		91·1	0·4			110·0		0·2	94·0	0·6	113·8	0·5	22	25	13	10
Dec. 1-15		89·4	0·1			87·3		0·1	89·4	0·4	94·6	0·5	23	22	6	7
16-31		29·5		0·2		37·4		0·7	41·6	0·5	62·5	0·9	17	20	12	18
TOTALS	39·3	726·4	2·4	4·5	21·7	901·2	3·1	10·8	1214·7	11·9	1377·2	17·5	429	445	235	349
MEANS ...	− 28·6		− 0·1		− 36·8		− 0·3		50·6	0·5	57·4	0·7				

TABLE VII.—Mean errors E_1, E_2 for 1922

ADEN

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	0·7 foot of height — H. W.	0·7 foot of height — L. W.
Jan. 1-16	0·8		0·1		6·8		0·0		8·6	0·1	12·1	0·1	0	1	0	0
17-31		0·4	0·0		1·6		0·1		9·2	0·2	9·4	0·2	2	0	2	0
Feb. 1-16	2·5			0·1	5·9			0·1	8·8	0·2	9·6	0·2	0	0	0	0
17-28	1·0			0·2		0·7		0·1	7·2	0·2	10·5	0·2	0	2	0	0
Mar. 1-16	3·2		0·1		1·6		0·1		7·7	0·1	10·6	0·1	1	1	0	0
17-31	0·7			0·0		1·6	0·1		8·8	0·1	10·8	0·1	0	2	0	0
April 1-16	3·5			0·1	2·4		0·0		8·4	0·1	7·6	0·1	0	0	0	0
17-30	8·8			0·3		2·2		0·1	12·4	0·3	10·3	0·1	3	0	0	0
May 1-16	1·3			0·2	0·8			0·1	6·2	0·2	6·0	0·2	0	0	0	0
17-31	2·0			0·2	3·8			0·2	11·5	0·2	10·0	0·2	1	1	0	0
June 1-16	6·3			0·3	8·6			0·2	9·1	0·3	10·8	0·2	0	0	0	0
17-30	4·7			0·2	9·3			0·0	7·6	0·2	10·7	0·1	0	3	0	0
July 1-16	6·1			0·1	9·8		0·1		10·3	0·2	12·6	0·1	1	1	0	0
17-31	5·8			0·0	11·4		0·2		11·3	0·1	15·1	0·2	1	3	0	0
Aug. 1-16	10·8		0·2		10·4		0·3		12·9	0·2	12·8	0·3	1	4	0	0
17-31	6·8		0·1		9·6		0·2		10·5	0·1	11·2	0·2	1	2	0	0
Sept. 1-16	10·1		0·1		15·0		0·2		12·9	0·1	17·6	0·2	2	2	0	0
17-30	6·3			0·2	5·4			0·1	11·3	0·2	9·3	0·1	2	0	0	0
Oct. 1-16	8·3			0·1	1·1			0·0	11·0	0·1	13·8	0·1	2	5	0	0
17-31	9·2		0·1		3·8		0·1		12·0	0·1	7·8	0·1	2	1	0	0
Nov. 1-16	2·9		0·3		2·4		0·3		7·7	0·3	7·4	0·3	0	0	0	0
17-30	2·4		0·2			4·2	0·1		11·3	0·2	8·2	0·1	2	0	0	0
Dec. 1-16		5·1	0·1		1·3		0·2		10·2	0·1	8·0	0·2	1	1	0	0
17-31		3·1	0·2		3·3		0·2		10·5	0·2	9·6	0·2	1	1	0	0
TOTALS ...	103·5	8·6	1·5	2·0	114·3	8·7	2·2	0·9	236·9	4·1	251·8	3·9	23	30	2	0
MEANS ...	+ 4·0		0·0		+ 4·4		+ 0·1		9·9	0·2	10·5	0·2				

TABLE VIII.—Mean errors E_1, E_2 for 1923

ADEN

MEAN ERRORS — E_1 is with regard to sign; E_2 is without regard to sign

PERIOD 1923	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	0·7 foot of height H. W.	0·7 foot of height L. W.
Jan. 1-16		5·0		0·0		3·3	0·1		8·9	0·1	8·6	0·1	0	0	0	0
17-31		7·7		0·0		4·0	0·0		8·8	0·1	14·3	0·1	1	1	0	0
Feb. 1-16		4·7		0·2		7·7		0·1	7·7	0·2	11·3	0·1	0	2	0	0
17-28		3·7	0·1			6·0	0·1		13·0	0·2	11·0	0·1	0	0	0	0
Mar. 1-16		5·2		0·1		5·5	0·1		8·5	0·1	11·0	0·1	0	1	0	0
17-31		5·2		0·1		5·1		0·0	9·5	0·1	11·8	0·1	1	2	0	0
April 1-16	0·2			0·1		4·4	0·0		9·5	0·2	11·3	0·1	1	2	0	0
17-30		0·0	0·1			3·9	0·2		9·8	0·2	8·7	0·2	0	1	0	0
May 1-16		4·1	0·1			11·6	0·1		9·4	0·1	13·5	0·2	0	1	0	0
17-31		0·4	0·1		1·0		0·1		5·8	0·1	7·1	0·1	0	0	0	0
June 1-16		3·2		0·1		10·7	0·0		8·2	0·1	13·1	0·1	0	2	0	0
17-30		2·6		0·1		7·0	0·1		7·3	0·1	9·3	0·1	0	0	0	0
July 1-16		5·2	0·1		1·1		0·2		11·2	0·1	10·3	0·2	2	0	0	0
17-31		0·7		0·1		3·4	0·1		8·2	0·1	10·8	0·1	0	0	0	0
Aug. 1-16		4·6	0·2		4·3		0·3		9·1	0·2	9·5	0·3	2	2	0	0
17-31		3·1	0·1			7·7	0·3		9·6	0·2	10·0	0·3	0	0	0	0
Sept. 1-16		7·1		0·1		3·5		0·0	8·3	0·2	10·3	0·1	0	0	0	0
17-30		3·8		0·2		8·9		0·1	8·0	0·2	10·1	0·1	0	0	0	0
Oct. 1-16		7·2		0·1		11·6	0·1		12·2	0·1	11·9	0·1	1	1	0	0
17-31		5·1	0·1			11·1	0·1		10·0	0·1	11·6	0·1	0	1	0	0
Nov. 1-16		11·1		0·0		14·0	0·0		12·2	0·1	15·7	0·1	1	4	0	0
17-30		8·1	0·2			13·4	0·2		10·4	0·2	14·4	0·2	0	3	0	0
Dec. 1-16		13·7	0·2			17·5	0·0		15·9	0·2	18·7	0·1	2	5	0	1
17-31		10·7	0·1			15·7	0·1		15·1	0·1	15·9	0·1	2	5	0	0
TOTALS...	0·2	123·2	1·4	1·2	6·4	176·0	2·2	0·2	236·6	3·4	280·2	3·2	13	33	0	1
MEANS ...	− 5·1		0·0		− 7·1		+ 0·1		9·9	0·1	11·7	0·1				

TABLE IX.—Mean errors E_1, E_2 for 1924

ADEN

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign, E_2 is without regard to sign												Number of errors exceeding 30 minutes of time		0·7 foot of height	
	E_1								E_2							
	H. W. Time (minutes)		H. W. Height (feet)		L. W. Time (minutes)		L. W. Height (feet)		H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15		10·1	0·1			8·1	0·0		11·6	0·1	14·4	0·1	1	2	0	0
16-31		2·2	0·0		1·5		0·0		11·1	0·1	8·5	0·1	1	1	0	0
Feb. 1-15		5·0	0·0			4·0	0·0		8·6	0·1	12·1	0·1	0	3	0	0
16-29		2·3	0·0			3·5	0·1		8·1	0·1	9·2	0·1	0	0	0	0
Mar. 1-15		2·8	0·1		0·1		0·0		8·7	0·1	8·3	0·1	0	0	0	0
16-31		1·8		0·1	0·2		0·0		6·5	0·1	7·0	0·1	0	0	0	0
April 1-15		3·0	0·0		0·3		0·0		7·9	0·1	7·5	0·1	0	0	0	0
16-30		0·4		0·1	0·0			0·1	7·0	0·1	7·3	0·1	0	0	0	0
May 1-15		3·3		0·1	0·4			0·1	6·5	0·1	5·8	0·1	0	0	0	0
16-31		2·4		0·1	1·3			0·1	5·0	0·1	4·9	0·1	0	0	0	0
June 1-15	1·6			0·3	5·2			0·4	6·3	0·3	7·1	0·4	1	1	0	0
16-30	1·8			0·2	3·2			0·2	6·5	0·2	6·3	0·2	0	0	0	0
July 1-15	0·0			0·2	4·6			0·2	5·5	0·2	6·7	0·2	0	0	0	0
16-31	2·1		0·1		3·0		0·1		7·6	0·1	6·2	0·1	0	0	0	0
Aug. 1-15	4·5		0·1		7·1		0·0		6·1	0·1	8·6	0·1	0	0	0	0
16-31		0·6	0·0		3·9		0·0		4·4	0·1	5·9	0·1	0	0	0	0
Sept. 1-15	1·4			0·1	2·1			0·1	5·2	0·1	4·8	0·1	0	0	0	0
16-30		1·6		0·2	4·7			0·3	5·4	0·2	7·0	0·3	0	0	0	0
Oct. 1-15	0·3		0·0			1·2		0·0	4·9	0·1	6·6	0·1	0	0	0	0
16-31		2·7		0·0	4·8		0·0		5·6	0·0	6·3	0·1	0	0	0	0
Nov. 1-15		4·4	0·2			2·9	0·1		7·0	0·2	6·9	0·1	0	0	0	0
16-30		1·2	0·2		3·5		0·1		5·4	0·2	5·8	0·1	0	0	0	0
Dec. 1-15		4·5	0·3			0·4	0·2		6·9	0·3	5·3	0·2	0	0	0	0
16-31		4·8	0·0		4·1			0·1	6·9	0·1	6·9	0·1	0	0	0	0
TOTALS...	11·7	53·1	1·1	1·4	50·0	20·1	0·6	1·6	164·7	3·2	175·4	3·2	3	7	0	0
MEANS ...	− 1·7		0·0		+ 1·2		0·0		6·9	0·1	7·3	0·1				

TABLE X.—Mean errors E_1, E_2 for 1922

KARACHI

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign; E_1 H. W. Time (minutes) +	−	H. W. Height (feet) +	−	L. W. Time (minutes) +	−	L. W. Height (feet) +	−	E_2 is without regard to sign; E_2 H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time: H. W.	L. W.	0·9 foot of height: H. W.	L. W.
Jan. 1-16		6·0		0·1	6·2		0·0		11·4	0·2	16·7	0·1	1	4	0	0
17-31	1·5			0·5	4·4			0·2	10·8	0·5	10·5	0·2	2	0	0	0
Feb. 1-16		3·4		0·3	13·6			0·1	7·8	0·3	20·1	0·2	0	5	0	0
17-28	1·7			0·4		0·4		0·2	11·6	0·4	9·8	0·2	2	0	0	0
Mar. 1-16		4·9		0·3	9·6		0·0		9·4	0·3	17·8	0·2	0	5	0	0
17-31	6·1			0·4	6·2			0·1	9·0	0·4	10·0	0·2	0	0	0	0
April 1-16	3·3			0·4	12·2			0·1	6·5	0·4	17·1	0·2	1	2	0	0
17-30		3·6		0·6	6·3			0·4	10·4	0·6	13·1	0·5	0	2	1	0
May 1-16	0·7		0·2		8·3		0·5		5·1	0·2	11·4	0·5	0	3	0	0
17-31		6·1		0·6	4·5			0·4	9·0	0·6	10·8	0·5	0	0	7	5
June 1-16		1·0		0·5	8·3			0·2	8·4	0·5	13·6	0·2	0	1	0	0
17-30		3·0		0·5	7·3			0·3	8·9	0·5	12·4	0·3	0	1	0	0
July 1-16		2·1		0·5	2·9			0·1	9·6	0·5	9·3	0·2	2	1	0	0
17-31		1·8		0·3	12·7		0·0		14·0	0·3	14·8	0·2	2	4	1	0
Aug. 1-16		3·3		0·4	3·1			0·1	7·6	0·4	12·4	0·2	1	0	0	0
17-31		2·9		0·1	13·0		0·1		9·1	0·2	14·4	0·2	0	3	0	0
Sept. 1-16		4·3		0·4	1·3			0·1	8·7	0·4	11·3	0·2	0	2	0	0
17-30	2·5			0·2	10·7		0·1		8·9	0·2	14·9	0·2	1	1	0	0
Oct. 1-16	1·2		0·1		6·0		0·4		6·1	0·1	10·9	0·4	0	2	0	2
17-31	3·3			0·1	4·1		0·1		9·0	0·2	14·8	0·2	0	1	0	0
Nov. 1-16		2·2		0·3	6·9		0·1		7·4	0·4	12·0	0·3	0	0	0	0
17-30		7·9	0·1			3·7	0·3		9·7	0·3	8·8	0·4	2	0	0	0
Dec. 1-16		6·9		0·4		1·9		0·5	10·0	0·4	13·7	0·6	0	2	0	0
17-31		2·3		0·1	2·9		0·1		7·3	0·1	7·9	0·2	1	0	0	0
TOTALS ...	20·3	61·7	0·4	7·4	150·5	6·0	1·7	2·8	215·7	8·4	308·5	6·6	15	37	9	7
MEANS ...	− 1·7		− 0·3		+ 6·0		0·0		9·0	0·4	12·9	0·3				

TABLE XI.—Mean errors E_1, E_2 for 1923

KARACHI

PERIOD 1923	MEAN ERRORS: E_1 is with regard to sign; E_2 is without regard to sign — E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	0·9 foot of height H. W.	0·9 foot of height L. W.
Jan. 1-16		11·6		0·3	0·2			0·0	13·2	0·3	7·5	0·2	0	0	0	0
17-31		14·3		0·1	4·7		0·1		15·8	0·2	14·4	0·1	3	2	0	0
Feb. 1-16		7·7		0·3	1·0		0·1		11·5	0·3	8·0	0·2	0	0	0	0
17-28		14·4		0·1	2·9		0·2		15·2	0·2	16·2	0·2	2	3	0	0
Mar. 1-16		1·9		0·4	4·6		0·1		9·0	0·4	8·1	0·2	0	0	0	0
17-31		9·0		0·4	9·4			0·2	10·9	0·4	11·7	0·2	0	2	0	0
April 1-16	0·2			0·3	3·0		0·0		7·6	0·3	8·5	0·2	0	0	0	0
17-30		6·0	0·1		6·4		0·3		7·8	0·2	13·8	0·3	0	1	0	0
May 1-16		6·1	0·4			4·1	0·6		9·9	0·4	10·8	0·6	0	0	0	0
17-31		3·6	0·0		6·1		0·3		7·6	0·2	16·7	0·3	0	3	0	0
June 1-16		2·0		0·0		5·0	0·3		8·6	0·1	15·2	0·3	0	0	0	0
17-30		5·6	0·2		2·1		0·6		7·6	0·3	15·7	0·6	0	1	0	1
July 1-16		2·2		0·1		1·9	0·2		9·5	0·2	16·2	0·2	1	3	0	0
17-31		3·4		0·1	4·4		0·3		9·8	0·2	10·3	0·3	0	0	0	0
Aug. 1-16		10·3		0·4	5·8			0·2	12·3	0·4	17·6	0·3	2	2	0	0
17-31		12·5		0·6		4·9		0·2	14·0	0·6	11·5	0·2	3	3	0	0
Sept. 1-16		7·7		0·5	10·8			0·3	12·0	0·5	13·8	0·3	1	1	3	0
17-30		0·1	0·1			2·9	0·4		7·7	0·1	9·0	0·4	0	0	0	0
Oct. 1-16		4·9	0·2		9·3		0·4		10·0	0·2	11·7	0·4	2	0	0	0
17-31		15·3		0·1		7·2	0·2		15·8	0·3	10·6	0·2	1	0	0	0
Nov. 1-16		17·1	0·2			5·2	0·4		20·1	0·2	13·5	0·4	2	2	0	0
17-30		28·3	0·2			21·5	0·5		28·3	0·2	23·0	0·5	11	8	0	0
Dec. 1-16		14·6	0·2			5·2	0·3		15·5	0·2	11·8	0·3	2	1	0	0
17-31		19·5	0·1			9·4	0·4		23·3	0·2	14·5	0·4	4	5	0	3
TOTALS ...	0·2	218·1	1·7	3·7	70·7	67·3	5·7	0·9	302·5	6·6	310·1	7·3	34	37	3	4
MEANS ...	− 9·1		− 0·1		+ 0·1		+ 0·2		12·6	0·3	12·9	0·3				

TABLE XII.—Mean errors E_1, E_2 for 1924

KARACHI

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	0·9 foot of height — H. W.	0·9 foot of height — L. W.
Jan. 1-15	3·5		0·3		9·9		0·5		6·0	0·3	10·9	0·5	0	0	0	0
16-31		1·6	0·1		8·6		0·2		10·2	0·2	11·8	0·3	0	1	0	0
Feb. 1-15		4·4		0·1	5·3		0·1		9·6	0·2	7·9	0·1	1	0	0	0
16-29		2·2		0·1	6·7		0·3		5·8	0·2	9·4	0·3	0	0	0	0
Mar. 1-15		6·8		0·2	5·8		0·0		8·1	0·3	8·9	0·1	0	1	0	0
16-31		2·6		0·4	8·3			0·1	6·0	0·4	8·3	0·1	0	0	0	0
April 1-15		7·2		0·3	8·1			0·0	7·6	0·3	11·7	0·2	0	2	0	0
16-30		4·4		0·2	7·4		0·1		6·3	0·2	10·4	0·2	0	0	0	0
May 1-15		11·7		0·2		1·4	0·0		12·1	0·2	9·4	0·1	0	1	0	0
16-31		2·3	0·0		2·1		0·3		6·3	0·2	7·8	0·3	1	0	0	0
June 1-15		7·1		0·2	6·2			0·0	7·6	0·2	10·4	0·2	0	1	0	0
16-30		4·8		0·4		0·9		0·3	6·4	0·4	5·9	0·4	0	0	0	0
July 1-15		4·7		0·3	6·2			0·1	7·2	0·3	10·4	0·1	0	0	0	0
16-31		4·1		0·1	0·3			0·0	7·4	0·2	6·6	0·1	1	0	0	0
Aug. 1-15		4·0		0·3	4·3			0·1	7·6	0·3	8·6	0·2	0	0	0	0
16-31		3·6	0·2		3·0		0·2		7·4	0·2	7·9	0·2	0	0	0	0
Sept. 1-15		6·9		0·1	4·4		0·1		8·7	0·2	6·9	0·2	1	0	0	0
16-30		1·0		0·1	7·3			0·0	6·6	0·1	8·6	0·1	0	1	0	0
Oct. 1-15		2·0		0·0	7·3		0·2		7·6	0·1	8·2	0·2	0	0	0	0
16-31		4·9		0·0	9·3		0·1		8·6	0·1	10·9	0·2	0	2	0	0
Nov. 1-15		12·1	0·1		4·1		0·2		13·5	0·2	7·7	0·2	3	0	0	0
16-30		17·0	0·3		7·2		0·2		18·2	0·4	9·2	0·2	3	0	2	0
Dec. 1-15		10·7		0·2	1·1			0·1	11·1	0·2	7·9	0·2	1	0	0	0
16-31		1·6		0·1	9·4			0·0	6·9	0·2	12·6	0·1	0	1	0	0
TOTALS...	3·5	127·7	1·0	3·3	132·3	2·3	2·5	0·7	202·8	5·6	218·3	4·8	11	10	2	0
MEANS ...	− 5·2		− 0·1		+ 5·4		+ 0·1		8·5	0·2	9·1	0·2				

TABLE XIII.—Mean errors E_1, E_2 for 1922

BOMBAY

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	1·0 foot of height — H. W.	1·0 foot of height — L. W.
Jan. 1-16		7·4	0·1			16·5	0·1		10·5	0·2	16·5	0·3	1	4	0	0
17-31	4·7			0·0		9·4	0·1		10·3	0·3	10·9	0·3	0	0	0	0
Feb. 1-16		6·0		0·1		6·3	0·1		8·2	0·2	8·0	0·3	1	0	0	0
17-28	3·4			0·1		6·1	0·1		8·3	0·2	9·7	0·3	0	0	0	0
Mar. 1-16		0·7		0·2		0·7	0·0		6·4	0·3	5·6	0·2	0	1	0	0
17-31		3·4		0·3		9·5	0·0		8·6	0·3	14·1	0·2	0	3	0	0
April 1-16		7·0		0·5		15·0		0·1	8·7	0·5	15·4	0·4	0	1	0	0
17-30	1·9			0·7		5·1		0·5	10·1	0·7	8·7	0·7	2	1	2	2
May 1-16		2·8		0·0		13·9	0·3		9·9	0·2	14·3	0·3	0	2	0	0
17-31		2·5		0·7		13·1		0·5	7·3	0·7	19·8	0·6	0	5	5	5
June 1-16	1·4			0·4		6·9		0·2	5·0	0·4	10·0	0·2	0	0	0	0
17-30		9·3		0·5		7·5		0·4	12·0	0·5	10·1	0·4	1	0	1	0
July 1-16		0·8		0·4	0·6			0·1	8·7	0·4	7·0	0·2	0	0	0	0
17-31		5·0		0·4	2·3			0·2	10·2	0·4	10·0	0·2	1	1	0	0
Aug. 1-16	1·4			0·3	1·1			0·2	9·1	0·3	7·5	0·3	0	1	0	0
17-31	0·3			0·0	1·8		0·1		9·4	0·1	9·6	0·2	1	1	0	0
Sept. 1-16		8·3		0·1		12·1		0·1	11·3	0·3	12·6	0·2	0	0	0	0
17-30	3·9		0·2			0·2	0·1		6·7	0·3	6·8	0·2	1	0	0	0
Oct. 1-16	1·0		0·3			1·4	0·3		7·8	0·3	7·4	0·3	0	0	0	0
17-31	0·2		0·1			8·2	0·2		6·4	0·3	10·7	0·3	0	2	0	0
Nov. 1-16		4·4	0·0			7·3	0·1		7·9	0·2	8·1	0·3	0	0	0	0
17-30		8·9	0·1			14·6	0·2		9·6	0·4	16·5	0·4	1	3	0	0
Dec. 1-16		1·7		0·1		12·2	0·0		5·7	0·2	13·0	0·3	0	1	0	0
17-31		18·5	0·2			21·9	0·3		18·6	0·2	22·0	0·4	4	6	0	1
TOTALS ...	18·2	86·7	1·0	4·8	5·8	187·9	2·0	2·3	216·7	7·9	274·3	7·5	13	32	8	8
MEANS ...	− 2·9		− 0·2		− 7·6		0·0		9·0	0·3	11·4	0·3				

TABLE XIV.—Mean errors E_1, E_2 for 1923

BOMBAY

PERIOD 1923	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	1·0 foot of height — H. W.	1·0 foot of height — L. W.
Jan. 1-16		0·7		0·2		5·4	0·1		6·6	0·3	7·0	0·3	0	0	0	0
17-31		8·5	0·0			8·9	0·2		9·4	0·2	13·7	0·2	2	1	0	0
Feb. 1-16		4·1	0·1			11·1	0·3		7·7	0·2	11·9	0·3	0	0	0	0
17-28		9·3	0·2			12·5	0·4		11·0	0·3	13·8	0·4	0	1	0	0
Mar. 1-16		0·5		0·1	1·5		0·1		3·8	0·2	7·2	0·3	0	0	0	0
17-31		8·1		0·4		0·5		0·2	10·8	0·4	7·1	0·2	0	1	0	0
April 1-16	1·1			0·1		3·5		0·0	7·3	0·3	7·4	0·2	0	0	0	1
17-30		3·0	0·0			3·7	0·3		7·2	0·3	7·8	0·3	0	0	0	0
May 1-16	1·8		0·5			6·9	0·8		7·7	0·5	8·4	0·8	2	0	1	4
17-31		3·3	0·0			2·5	0·3		7·3	0·2	7·4	0·3	0	0	0	0
June 1-16		7·5	0·2			9·7	0·3		9·1	0·3	12·7	0·3	0	3	0	0
17-30		1·4	0·3		1·6		0·7		6·2	0·3	8·3	0·7	0	0	0	5
July 1-16		3·6		0·1	1·3			0·1	8·9	0·3	12·8	0·4	1	0	0	0
17-31	3·9			0·3	8·9			0·0	8·0	0·3	9·8	0·3	0	1	0	0
Aug. 1-16		1·0		0·3	6·5			0·3	10·6	0·4	12·2	0·3	0	1	0	0
17-31	6·3			0·2	7·3			0·1	7·3	0·3	7·8	0·2	0	0	0	0
Sept. 1-16	0·3		0·1		3·4		0·0		12·9	0·2	9·9	0·2	0	0	0	0
17-30		2·3	0·5		10·2		0·5		7·5	0·5	11·3	0·5	0	3	0	0
Oct. 1-16	1·8		0·6			0·8	0·6		6·7	0·6	8·5	0·6	0	0	0	0
17-31		8·4	0·2			5·1	0·3		11·2	0·2	10·0	0·2	0	1	0	0
Nov. 1-16		4·4	0·7			6·7	0·6		6·7	0·7	10·6	0·7	0	1	2	2
17-30		5·0	0·5			9·4	0·6		9·9	0·5	9·9	0·6	1	0	0	1
Dec. 1-16		10·6	0·3			10·2	0·3		11·8	0·3	12·4	0·4	0	3	0	0
17-31		7·0	0·3			12·0	0·5		10·1	0·4	13·1	0·5	1	0	0	2
TOTALS ...	15·2	88·7	4·5	1·7	40·7	108·9	6·9	0·7	205·7	8·2	241·0	9·2	7	16	3	15
MEANS ...	− 3·1		+ 0·1		− 2·8		+ 0·3		8·6	0·3	10·0	0·4				

TABLE XV.—Mean errors E_1, E_2 for 1924

BOMBAY

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign — E_1								E_2 is without regard to sign — E_2				Number of errors exceeding			
	H. W.				L. W.				H. W.		L. W.		30 minutes of time		1·0 foot of height	
	Time (minutes)		Height (feet)		Time (minutes)		Height (feet)		Time (minutes)	Ht. (feet)	Time (minutes)	Ht. (feet)	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15		8·4	0·3			7·1	0·5		9·6	0·3	8·9	0·5	1	1	0	4
16-31		5·9	0·1			7·7	0·4		7·6	0·2	9·2	0·4	0	1	0	0
Feb. 1-15		12·1	0·0			9·1	0·3		12·1	0·3	10·3	0·3	1	1	0	0
16-29		4·8	0·0		0·3		0·4		6·4	0·2	4·6	0·4	0	0	0	0
Mar. 1-15		6·8		0·2	0·4		0·0		8·0	0·3	4·8	0·3	0	0	0	0
16-31	1·4			0·2	7·7			0·2	4·7	0·3	8·3	0·2	0	0	0	0
April 1-15		6·7		0·2		1·8		0·0	7·1	0·4	5·1	0·2	0	0	0	0
16-30		5·6		0·1		5·7		0·1	8·0	0·2	7·1	0·3	0	0	0	0
May 1-15		7·8		0·2		2·6		0·0	8·4	0·2	6·7	0·2	0	0	0	0
16-31	1·5		0·1			2·7	0·2		6·2	0·3	5·9	0·3	0	0	0	0
June 1-15		4·2		0·2	3·6			0·1	7·9	0·2	5·7	0·3	0	0	0	0
16-30		5·3		0·5		4·9		0·6	8·1	0·5	7·1	0·6	0	0	1	0
July 1-15		1·4		0·3	4·9			0·1	5·2	0·3	7·9	0·2	0	0	0	0
16-31		2·5		0·1		4·3		0·2	6·1	0·2	6·3	0·3	0	0	0	0
Aug. 1-15	0·6			0·3	0·8			0·2	7·2	0·4	8·1	0·3	0	1	0	0
16-31		0·7	0·3		2·9		0·1		9·9	0·3	7·9	0·3	1	0	0	0
Sept. 1-15	0·7		0·1		6·9		0·1		6·4	0·2	8·0	0·2	0	0	0	0
16-30		3·6	0·0		4·4			0·0	7·4	0·1	9·0	0·2	0	1	0	0
Oct. 1-15	1·4		0·2		4·9		0·3		4·2	0·2	6·3	0·3	0	0	0	0
16-31		9·3	0·2			0·4	0·1		9·5	0·2	6·5	0·2	0	0	0	0
Nov. 1-15		7·4	0·4			3·3	0·3		8·5	0·4	5·7	0·3	0	0	0	0
16-30		10·0	0·5			0·2	0·4		10·7	0·5	7·2	0·4	2	0	0	0
Dec. 1-15		6·1	0·1			5·8		0·0	11·6	0·2	8·4	0·1	3	0	0	0
16-31		10·3	0·1			6·4		0·1	10·4	0·1	7·3	0·2	0	0	0	0
TOTALS ...	5·6	118·9	2·4	2·3	36·8	62·0	3·1	1·6	141·2	6·5	172·3	7·0	8	5	1	4
MEANS ...	− 4·7		0·		− 1·1		+ 0·1		8·0	0·3	7·2	0·3				

TABLE XVI. Mean errors E_1, E_2 for 1922

MADRAS

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	−	H. W. Height (feet) +	−	L. W. Time (minutes) +	−	L. W. Height (feet) +	−	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	L. W.	0·3 foot of height — H. W.	L. W.
Jan. 1-16	20·1			0·1	21·4			0·1	23·4	0·2	23·7	0·2	7	7	1	4
17-31	11·0			0·3	14·6			0·2	14·3	0·3	16·6	0·2	3	5	4	1
Feb. 1-16	7·1			0·6	13·5			0·5	12·7	0·6	16·6	0·5	2	6	26	21
17-28	9·1			0·4	8·7			0·4	17·0	0·4	18·9	0·4	4	4	13	14
Mar. 1-16	16·9			0·3	11·6			0·3	16·9	0·3	16·3	0·3	4	5	6	4
17-31	8·7			0·1	18·4			0·1	14·6	0·1	20·0	0·1	3	8	0	0
April 1-16	14·0			0·1	10·2			0·0	16·4	0·1	14·6	0·1	4	1	0	0
17-30	6·6			0·1	7·1			0·0	15·7	0·2	12·0	0·1	4	0	2	3
May 1-16	7·2			0·4	13·0			0·2	12·9	0·4	17·0	0·3	3	4	11	7
17-31	4·2			0·2	6·3			0·2	14·6	0·2	14·6	0·2	3	2	2	1
June 1-16	0·3			0·3	5·1			0·2	12·9	0·3	16·5	0·2	2	5	12	1
17-30	22·4			0·2	6·5			0·1	25·3	0·2	14·0	0·1	7	3	1	0
July 1-16	7·1		0·0		10·3		0·2		14·9	0·1	14·1	0·3	4	3	0	8
17-31	6·6			0·1	10·3			0·0	11·9	0·1	13·1	0·1	1	2	0	0
Aug. 1-16	4·3			0·2	10·3			0·1	8·0	0·2	11·3	0·1	1	2	6	0
17-31	16·0			0·4	15·7			0·2	17·8	0·4	17·0	0·2	5	6	16	3
Sept. 1-16	7·1			0·1	8·2		0·2		12·5	0·1	10·5	0·2	1	1	0	5
17-30	9·2		0·0		12·3		0·2		13·1	0·1	13·5	0·2	4	3	0	5
Oct. 1-16	1·6		0·1		10·5		0·2		9·5	0·1	12·7	0·2	0	2	0	6
17-31	12·3			0·2	16·1			0·1	13·2	0·2	18·6	0·1	3	7	7	2
Nov. 1-16	2·2			0·2	9·0			0·1	7·0	0·2	11·5	0·2	0	1	5	4
17-30	7·3			0·5	13·1			0·4	12·3	0·5	14·4	0·4	1	4	20	14
Dec. 1-16		3·9		0·1		2·3		0·1	9·5	0·2	9·0	0·2	0	0	3	1
17-31	6·0			0·1	5·7			0·1	10·7	0·2	7·9	0·2	1	0	5	2
TOTALS ...	207·3	3·9	0·1	5·0	257·9	2·3	0·8	3·4	337·1	5·7	354·4	5·1	67	81	140	106
MEANS ...	+ 8·5		− 0·2		+ 10·7		− 0·1		14·0	0·2	14·8	0·2				

TABLE XVII.—Mean errors E_1, E_2 for 1923

MADRAS

PERIOD 1923	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	0·3 foot of height — H. W.	0·3 foot of height — L. W.
Jan. 1-16	0·9		0·4		17·8			0·3	8·2	0·4	20·4	0·3	0	7	21	7
17-31		4·4		0·2	21·9			0·1	13·2	0·2	22·7	0·1	3	9	1	0
Feb. 1-16	8·0			0·2	17·6			0·1	12·5	0·2	18·0	0·2	0	5	1	0
17-28	4·6			0·1	23·0			0·1	13·7	0·2	23·4	0·1	1	8	0	0
Mar. 1-16	11·2			0·4	21·2			0·3	16·5	0·4	23·3	0·3	3	10	18	0
17-31	7·2			0·1	16·8			0·1	12·1	0·2	17·9	0·2	2	4	2	2
April 1-16	4·6		0·1		16·8		0·2		10·4	0·1	17·2	0·2	2	2	0	2
17-30	5·4		0·4		9·8		0·4		17·1	0·4	14·6	0·4	2	2	14	20
May 1-16	1·3			0·2	13·7			0·1	14·3	0·2	15·4	0·2	2	3	9	4
17-31	11·4			0·1	10·9			0·0	13·8	0·2	14·9	0·1	2	4	1	0
June 1-16	2·6		0·3		9·1		0·4		13·9	0·3	13·7	0·4	2	2	7	17
17-30	8·1		0·1		17·1		0·2		10·2	0·2	17·3	0·2	1	3	2	5
July 1-16	10·5		0·1		26·1		0·2		17·9	0·1	26·4	0·2	6	12	1	3
17-31	9·0			0·0	17·8		0·3		17·2	0·1	19·2	0·3	2	7	0	5
Aug. 1-16	0·5		0·2		17·2		0·4		12·3	0·2	18·0	0·4	3	4	2	18
17-31	0·0		0·3		9·9		0·5		8·0	0·3	13·3	0·5	0	4	3	21
Sept. 1-16	5·5		0·3		19·4		0·4		11·0	0·3	20·3	0·4	2	8	11	14
17-30		3·6	0·1		10·9		0·4		10·3	0·1	14·3	0·4	1	2	1	10
Oct. 1-16	6·2		0·3		13·4		0·4		11·2	0·3	16·2	0·4	0	2	14	16
17-31		4·4		0·3	8·2		0·1		12·4	0·3	14·9	0·2	1	3	7	4
Nov. 1-16	2·0		0·0		11·4		0·2		13·0	0·2	14·1	0·2	1	2	3	2
17-30		4·2	0·2		6·7		0·3		12·7	0·3	9·7	0·4	1	1	7	12
Dec. 1-16	4·1			0·0	11·8		0·1		11·2	0·1	14·3	0·1	1	1	0	1
17-31	3·3			0·1	14·1		0·1		10·3	0·1	17·3	0·1	2	4	0	0
TOTALS	106·4	16·6	2·8	1·7	362·6	0·0	4·6	1·1	303·4	5·4	416·8	6·3	40	109	125	163
MEANS ...	+ 3·7		0·0		+ 15·1		+ 0·1		12·6	0·2	17·4	0·3				

TABLE XVIII.—Mean errors E_1, E_2 for 1924

MADRAS

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	−	H. W. Height (feet) +	−	L. W. Time (minutes) +	−	L. W. Height (feet) +	−	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	L. W.	0·3 foot of height — H. W.	L. W.
Jan. 1-15	1·4		0·0		2·0		0·1		8·4	0·1	6·8	0·1	0	0	0	0
16-31	1·8		0·0		2·5		0·1		6·1	0·1	6·1	0·1	0	0	0	0
Feb. 1-15	2·6		0·0		3·2		0·0		6·3	0·1	7·2	0·1	0	0	0	0
16-29	1·7		0·0		2·9		0·0		5·4	0·0	6·1	0·1	0	0	0	0
Mar. 1-15	6·4			0·2	6·3			0·2	8·3	0·2	9·1	0·2	0	1	0	1
16-31		0·1		0·3	5·0			0·2	7·2	0·3	8·2	0·2	0	0	8	7
April 1-15	5·9		0·0		7·8		0·0		8·3	0·1	8·5	0·1	0	0	0	0
16-30	4·9		0·1		6·4		0·1		6·4	0·1	7·6	0·2	0	0	1	5
May 1-15	6·2		0·1		6·0		0·1		7·3	0·2	7·8	0·2	0	0	4	2
16-31	4·3			0·2	7·1			0·1	7·7	0·3	8·8	0·2	0	0	9	4
June 1-15	2·2			0·3	4·7			0·4	6·3	0·3	5·9	0·4	0	0	13	15
16-30	1·3		0·1		4·8		0·0		5·8	0·2	8·1	0·1	0	0	5	1
July 1-15	0·0		0·1		2·1		0·1		3·8	0·1	5·3	0·1	0	0	0	2
16-31		0·5	0·4		5·1		0·4		6·0	0·4	7·4	0·4	0	0	22	18
Aug. 1-15	2·4		0·4		3·1		0·5		5·4	0·4	7·1	0·5	0	0	19	23
16-31	1·5		0·2		7·2		0·3		4·1	0·2	8·4	0·3	0	0	2	7
Sept. 1-15		0·6		0·0	4·1		0·2		5·7	0·1	5·9	0·2	0	0	0	5
16-30		2·3	0·1		6·5		0·2		6·3	0·2	8·7	0·2	0	1	6	8
Oct. 1-15		3·7		0·1	6·2		0·0		7·4	0·2	7·1	0·2	0	0	3	2
16-31		5·5		0·3	4·8			0·2	7·1	0·3	6·3	0·2	0	0	10	5
Nov. 1-15		2·3		0·3	2·3			0·1	9·6	0·3	8·9	0·2	0	0	12	5
16-30	7·9			0·4	12·9			0·3	7·9	0·4	12·9	0·3	0	0	16	12
Dec. 1-15	0·6		0·0		6·7		0·0		6·0	0·1	8·7	0·2	0	0	2	4
16-31	5·0		0·0		10·8			0·1	6·4	0·1	11·7	0·1	0	0	0	0
TOTALS ...	56·1	15·0	1·5	2·1	130·5	0·0	2·1	1·6	159·2	4·8	188·6	4·9	0	2	132	126
MEANS ...	+ 1·7		0·0		+ 5·4		0·0		6·6	0·2	7·9	0·2				

TABLE XIX.—Mean errors E_1, E_2 for 1922

KIDDERPORE

MEAN ERRORS: E_1 is with regard to sign; E_2 is without regard to sign

PERIOD 1922	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceedin[g] 30 minutes of time H. W.	30 minutes of time L. W.	1·0 foot of height H. W.	1·0 foot of height L. W.
Jan. 1-16	4·4		0·0			1·1	0·2		8·8	0·2	9·2	0·4	0	0	0	0
17-31	2·9		0·2			5·3	0·4		10·0	0·3	9·3	0·4	0	0	0	3
Feb. 1-16	7·3			0·1		3·0	0·2		8·0	0·2	10·4	0·3	0	0	0	0
17-28	5·3			0·3		0·6	0·1		7·9	0·6	9·8	0·3	0	0	1	0
Mar. 1-16	1·6		0·2			5·7	0·2		7·0	0·3	12·5	0·3	0	0	0	0
17-31	1·4			0·2	1·9			0·1	9·5	0·3	13·1	0·3	0	0	0	0
April 1-16	3·7		0·1			7·7	0·0		11·5	0·5	12·0	0·3	1	1	5	0
17-30	14·9			0·6	17·8			0·5	16·6	0·6	18·5	0·6	3	4	4	9
May. 1-16		3·4		0·3		9·6		0·4	12·0	0·4	18·5	0·5	2	2	5	4
17-31	•	0·3	0·1		9·2			0·2	9·0	0·3	11·0	0·3	0	0	1	0
June 1-16		6·0	0·3			2·5	0·0		11·7	0·5	10·6	0·3	0	1	2	0
17-30		1·9		1·4		7·7		1·1	11·7	1·4	12·9	1·1	0	1	17	15
July 1-16		2·6		0·5	1·9		0·1		10·9	0·6	15·9	0·3	0	4	4	0
17-31	9·0			1·4	7·4			0·7	11·1	1·4	15·9	0·7	1	4	19	6
Aug. 1-16	3·2			1·0	3·0			0·7	9·1	1·0	9·0	0·7	0	1	11	5
17-31	7·3			0·1		1·1		0·6	10·9	0·6	12·2	0·6	0	2	4	3
Sept. 1-16		5·3	0·2		11·4			0·4	12·6	0·4	14·1	0·4	0	0	0	0
17-30		2·5	0·0			7·9		0·7	8·4	0·6	8·9	0·7	0	0	0	7
Oct. 1-16	3·8			1·1	1·3			1·7	7·0	1·1	10·4	1·7	0	0	25	6
17-31		3·8	0·0			4·8	0·8		11·2	1·0	7·9	0·9	0	0	12	14
Nov. 1-16		2·6	0·7		3·2		0·6		7·7	0·7	10·4	0·6	0	0	11	3
17-30	7·9		0·0		2·3		0·3		13·6	0·5	12·1	0·4	0	0	1	0
Dec. 1-16	8·0			0·3	3·8			0·1	10·8	0·4	11·0	0·4	1	0	0	0
17-31	1·2			0·2	5·9			0·1	8·7	0·2	11·6	0·3	0	2	0	0
TOTALS...	81·9	28·4	1·8	7·5	69·1	57·0	2·9	7·3	245·7	14·1	287·2	12·8	8	22	122	94
MEANS ...	+ 2·2		− 0·2		+ 0·5		− 0·2		10·2	0·6	12·0	0·5				

TABLE XX.—Mean errors E_1, E_2 for 1923

KIDDERPORE

PERIOD 1923	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding — 30 minutes of time — H. W.	L. W.	1·0 foot of height — H. W.	L. W.
Jan. 1-16	4·5		0·1		1·1			0·0	10·2	0·2	7·8	0·5	0	0	0	0
17-31	13·3		0·2		22·1		0·1		15·2	0·4	22·1	0·5	4	7	0	0
Feb. 1-16	14·0			0·2	10·2			0·2	14·3	0·3	13·5	0·5	1	0	1	1
17-28	15·7		0·3		22·6		0·1		16·5	0·4	22·6	0·4	3	3	0	2
Mar. 1-16	2·8		0·6			2·1	0·4		7·0	0·6	10·4	0·5	0	0	4	2
17-31	0·8		0·4		7·3		0·1		7·2	0·5	11·1	0·3	0	0	5	0
April 1-16	2·0		0·4			3·6	0·2		8·3	0·4	9·8	0·3	0	0	0	0
17-30		2·1	0·2			3·5	0·1		7·3	0·3	11·2	0·3	0	1	0	0
May 1-16	4·5			0·5	4·8			0·2	10·3	0·7	9·7	0·3	0	0	7	0
17-31		7·9	0·4			9·1	0·1		9·8	0·4	11·0	0·2	1	0	1	0
June 1-16		0·9	0·5		8·6		0·3		8·6	0·6	17·4	0·4	1	3	4	3
17-30		5·8	0·8			3·8	0·6		12·0	0·8	9·4	0·6	1	2	8	1
July 1-16		4·2	1·2		15·1		1·0		9·2	1·2	15·1	1·0	0	1	20	14
17-31		12·3	2·0		1·6		1·3		12·9	2·0	8·2	1·3	1	0	29	21
Aug. 1-16		8·7	0·9		3·1		1·1		11·6	1·0	7·5	1·1	0	0	16	21
17-31		9·7	0·5			4·1	0·9		11·7	0·6	14·0	0·9	0	4	3	14
Sept. 1-16		3·7	1·0			2·3	1·0		9·6	1·0	7·3	1·0	0	0	15	17
17-30		16·8	2·1		0·9		2·1		16·8	2·1	11·9	2·1	1	1	23	27
Oct. 1-16		19·5	0·8			10·8	1·0		19·5	0·8	15·1	1·0	3	1	8	14
17-31		25·4	1·4			10·7	1·5		25·4	1·4	11·4	1·5	8	2	22	29
Nov. 1-16		18·7	1·1			16·1	1·4		18·7	1·1	20·4	1·4	4	7	21	24
17-30		12·9	0·4		2·9		0·6		14·1	0·5	4·9	0·6	3	0	2	5
Dec. 1-16		4·5	0·7			11·7	0·5		9·0	0·7	14·4	0·5	0	1	3	3
17-31		3·9	0·2		7·1		0·2		8·0	0·3	10·6	0·4	0	0	0	0
TOTALS ...	57·6	157·0	16·2	0·7	107·4	77·8	14·6	0·4	293·2	18·3	296·8	17·[illegible]	31	33	192	198
MEANS ...	− 4·1		+ 0·6		+ 1·2		+ 0·6		12·2	0·8	12·4	0·7				

TABLE XXI.—Mean errors E_1, E_2 for 1924

KIDDERPORE

MEAN ERRORS: E_1 is with regard to sign; E_2 is without regard to sign. Number of errors exceeding 30 minutes of time and 1·0 foot of height.

PERIOD 1924	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	30 minutes of time H. W.	30 minutes of time L. W.	1·0 foot of height H. W.	1·0 foot of height L. W.
Jan. 1-15	7·4		0·2		4·4			0·0	9·8	0·3	11·3	0·3	0	3	0	0
16-31	10·7		0·1		13·2			0·0	11·3	0·4	18·9	0·3	0	3	1	0
Feb. 1-15	17·0		0·2		20·3			0·1	17·0	0·3	20·3	0·3	5	7	0	0
16-29	12·0		0·4		9·6		0·2		12·4	0·4	14·7	0·3	0	1	1	0
Mar. 1-15	10·8		0·5		16·4			0·2	12·3	0·7	16·9	0·4	2	4	8	0
16-31	2·1		0·4		0·7			0·1	7·3	0·5	10·2	0·3	0	0	3	0
April 1-15	4·3		0·2		12·8			0·4	6·9	0·6	13·9	0·4	0	1	3	2
16-30	1·3			0·0		3·8		0·4	7·9	0·3	8·5	0·4	0	1	0	0
May 1-15	0·5		0·0		7·3			0·4	6·3	0·3	10·9	0·4	0	1	1	1
16-31	1·2		0·1			4·5		0·1	6·8	0·3	13·7	0·4	0	0	0	0
June 1-15	4·4		0·1		12·2			0·3	8·6	0·2	13·3	0·3	0	1	0	0
16-30	6·3		0·5		3·8		0·1		9·0	0·5	11·1	0·5	0	0	4	1
July 1-15		6·7	1·1		4·1		0·7		10·5	1·1	10·6	0·7	0	0	16	5
16-31	5·4		0·2		5·8		0·5		8·5	0·5	10·1	0·5	0	0	1	4
Aug. 1-15		3·0	0·1			1·5	0·7		7·1	0·4	7·5	0·7	0	0	0	5
16-31	0·1		0·7		9·7		0·8		8·9	0·8	11·0	0·8	1	2	9	10
Sept. 1-15		9·6	0·6			1·5	0·5		10·3	0·6	9·3	0·6	0	0	4	5
16-30		5·8		0·3		0·0		0·7	10·5	0·4	5·8	0·7	2	0	0	4
Oct. 1-15		12·6		0·2		7·1		0·4	12·8	0·3	11·6	0·6	2	4	1	2
16-31		8·2	0·5			5·1	0·2		12·3	0·5	12·1	0·3	0	0	7	1
Nov. 1-15		17·4	0·9			10·0	0·6		17·4	0·9	13·4	0·7	2	2	9	7
16-30	2·2			0·9	5·7			0·4	8·0	0·9	13·7	0·5	0	1	10	2
Dec. 1-15		4·0		0·2	3·3			0·1	6·9	0·3	9·1	0·3	0	0	0	0
16-31	4·3			0·2	1·4		0·1		6·5	0·3	6·5	0·3	0	0	0	0
TOTALS ...	90·0	67·3	6·8	1·8	130·7	33·5	4·4	3·6	235·3	11·8	284·4	11·0	14	31	78	49
MEANS ...	+ 0·9		+ 0·2		+ 4·1		0·0		9·8	0·5	11·9	0·5				

TABLE XXII.—Mean errors E_1, E_2 for 1922

RANGOON

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign — E_1								MEAN ERRORS — E_2 is without regard to sign — E_2				Number of errors exceeding: 30 minutes of time		Number of errors exceeding: 1·0 foot of height	
	H. W. Time (minutes)		H. W. Height (feet)		L. W. Time (minutes)		L. W. Height (feet)		H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	H. W.	L. W.	H. W.	L. W.
	+	–	+	–	+	–	+	–								
Jan. 1-16	11·9			0·0	9·3		0·3		12·9	0·2	15·7	0·5	1	3	0	1
17-31	2·9			0·0		0·3	0·3		8·1	0·5	11·9	0·4	0	0	0	0
Feb. 1-16	12·2			0·0	2·5		0·0		12·6	0·3	14·5	0·5	0	1	0	3
17-28	6·1			0·0	0·8		0·4		10·0	0·2	14·6	0·5	0	1	0	0
Mar. 1-16	18·1		0·1		6·6		0·2		18·1	0·4	11·6	0·6	3	1	0	1
17-31	15·6			0·2	11·6		0·1		16·0	0·3	15·4	0·3	2	0	0	0
April 1-16	18·3		0·1		5·5		0·2		18·4	0·5	9·2	0·4	1	0	0	0
17-30	15·6			0·6	14·1			0·3	16·1	0·6	18·3	0·6	1	1	5	3
May 1-16	8·1			0·1	3·3			0·1	9·7	0·4	10·9	0·4	0	1	0	0
17-31	11·9		0·0		11·7			0·2	13·7	0·3	14·1	0·4	0	1	1	0
June 1-16	3·0		0·0		1·9			0·1	8·3	0·2	11·5	0·4	0	1	0	0
17-30	12·3		0·1		10·0		0·1		12·7	0·4	15·5	0·3	0	2	1	0
July 1-16	12·5		0·2		9·7		0·3		13·4	0·4	13·7	0·4	1	3	0	3
17-31	22·0			0·1	16·5			0·7	22·8	0·4	18·4	0·7	7	7	1	4
Aug. 1-16	20·4			0·4	7·4			0·5	21·5	0·4	11·0	0·5	9	0	0	0
17-31	30·5			0·1	0·2			0·8	30·5	0·4	10·3	0·8	16	2	3	10
Sept. 1-16	17·1			0·2	8·6		0·3		17·1	0·4	10·9	0·4	3	1	0	1
17-30	13·9		0·4			1·4	0·3		16·4	0·6	6·8	0·5	4	0	5	2
Oct. 1-16	9·4		0·2		9·0		1·1		12·0	0·4	10·2	1·1	0	0	0	20
17-31	5·2		0·7			1·1	0·5		8·5	0·7	9·2	0·7	0	0	4	6
Nov. 1-16	4·2			0·1	2·0		0·7		7·4	0·7	9·8	0·8	0	0	3	11
17-30	9·0		0·5			0·1	0·5		12·1	0·5	10·8	0·7	1	0	2	3
Dec. 1-16	6·3		0·1			1·7	0·2		9·4	0·4	10·3	0·5	0	0	0	6
17-31	7·4		0·3		7·3		0·2		9·0	0·4	15·6	0·4	1	1	3	0
TOTALS ...	293·9	0·0	2·7	1·8	138·0	4·6	5·7	2·7	336·7	10·0	300·2	12·8	50	26	28	74
MEANS ...	+ 12·2		0·0		+ 5·6		+ 0·1		14·0	0·4	12·5	0·5				

TABLE XXIII.—Mean errors E_1, E_2 for 1923

RANGOON

PERIOD 1923	MEAN ERRORS: E_1 is with regard to sign; E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 is without regard to sign; E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 90 minutes of time H. W.	90 minutes of time L. W.	1·0 feet of height H. W.	1·0 feet of height L. W.
Jan. 1-16	19·3		0·3		7·3		0·3		19·3	0·4	12·0	0·4	3	1	0	1
17-31	26·7			0·0	24·1		0·3		26·7	0·3	24·1	0·5	10	9	1	0
Feb. 1-16	26·2		0·0		15·9		0·1		26·2	0·3	15·9	0·5	8	2	0	1
17-28	28·7		0·2		22·2		0·6		28·7	0·3	22·3	0·7	9	7	0	2
Mar. 1-16	22·6		0·2		5·2		0·3		22·8	0·4	9·5	0·5	9	1	1	0
17-31	23·4		0·1		12·4		0·6		23·4	0·2	13·7	0·7	5	1	0	4
April 1-16	13·1		0·4			1·2	0·4		14·4	0·5	7·7	0·6	1	0	2	3
17-30	20·2			0·2	6·1		0·3		20·2	0·3	10·5	0·9	4	1	1	10
May 1-16	6·2			0·2	0·8			0·3	10·0	0·5	6·4	0·5	0	0	2	4
17-31	10·8		0·2		0·3		0·3		10·8	0·6	8·7	0·5	0	0	3	1
June 1-16	7·8		0·1		7·0			0·1	10·2	0·3	14·5	0·5	0	1	0	1
17-30	16·8			0·5	10·1			0·5	16·9	0·5	11·4	0·7	2	2	2	7
July 1-16	16·3		0·3		18·0		0·4		16·3	0·3	18·8	0·7	2	7	0	5
17-31	17·[illegible]		0·2		6·3		0·2		18·0	0·5	10·8	0·4	3	0	2	[illegible]
Aug. 1-16	38·7			0·3	17·5			1·0	38·7	0·4	18·7	1·0	25	6	3	12
17-31	8·6			0·1	2·2			0·2	19·4	0·3	8·4	0·5	4	0	1	5
Sept. 1-16	16·3		0·3		8·1		0·5		17·6	0·3	10·9	0·5	3	2	1	2
17-30		0·9	0·2			5·9	1·0		5·7	0·3	7·0	1·0	0	0	0	12
Oct. 1-16	0·6		0·3			10·5	0·5		8·2	0·5	17·2	0·6	1	5	3	7
17-31		10·0	0·4			10·9	1·1		10·4	0·4	13·1	1·1	0	0	1	14
Nov. 1-16		8·7	0·5			13·0	0·7		10·2	0·7	15·2	0·7	1	1	5	10
17-30		10·3	0·1			1·1	1·1		10·4	0·5	9·8	1·1	0	0	2	17
Dec. 1-16		0·3	0·7			8·7	0·7		4·3	0·7	13·5	0·8	0	0	4	14
17-31	11·6		0·0		5·1		0·6		11·7	0·4	13·3	0·6	0	0	1	5
TOTALS ...	341·8	30·2	4·5	1·3	163·6	51·3	10·0	2·1	400·5	9·9	313·4	16·0	90	46	35	136
MEANS ...	+ 13·0		+ 0·1		+ 4·7		+ 0·3		16·7	0·4	13·1	0·7				

TABLE XXIV.—Mean errors E_1, E_2 for 1924

RANGOON

MEAN ERRORS — E_1 is with regard to sign; E_2 is without regard to sign

PERIOD 1924	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	1·0 foot of height H. W.	1·0 foot of height L. W.
Jan. 1-15	20·3		0·3		11·2		0·1		20·3	0·3	16·7	0·5	2	4	0	0
16-31	25·6		0·0		17·4		0·4		25·6	0·3	17·6	0·5	8	8	0	5
Feb. 1-15	30·6		0·3		21·0		0·3		30·6	0·4	22·3	0·5	11	5	0	3
16-29	29·3		0·0		16·1		0·4		29·3	0·2	17·3	0·5	14	3	0	3
Mar. 1-15	29·2		0·0		20·0		0·3		29·2	0·3	20·0	0·5	9	7	0	2
16-31	18·6		0·2		4·3		0·2		19·4	0·4	8·9	0·4	5	0	3	0
April 1-15	18·3			0·2	13·1		0·3		18·9	0·3	13·1	0·4	2	2	0	0
16-30	10·6		0·1			6·9	0·0		15·0	0·3	9·1	0·3	0	0	0	1
May 1-15	12·3			0·1	10·0		0·4		12·8	0·3	11·3	0·5	1	1	0	4
16-31	11·3			0·1		0·1		0·5	14·8	0·3	9·7	0·6	0	0	0	9
June 1-15	17·1			0·2	13·7			0·2	17·1	0·3	13·9	0·6	2	0	0	5
16-30	19·6		0·2		8·3			0·3	19·6	0·2	12·8	0·5	2	1	0	5
July 1-15	18·7		0·0		10·1		0·4		18·7	0·2	11·7	0·6	3	0	0	6
16-31	31·7		0·0		15·2			0·5	31·7	0·3	15·8	0·5	17	4	1	4
Aug 1-15	38·8			0·6	8·4			1·3	38·8	0·6	12·7	1·3	23	1	4	19
16-31	27·3		0·0		11·3			0·2	27·5	0·3	15·3	0·4	12	3	0	1
Sept. 1-15	17·8		0·0			2·3		0·1	17·9	0·4	7·1	0·4	5	0	1	0
16-30	11·3		0·4		5·7		0·9		12·2	0·4	8·8	1·0	1	0	0	14
Oct. 1-15	0·9			0·2		4·3	0·1		7·9	0·5	5·9	0·5	0	0	3	2
16-31	4·1		0·5			2·5	0·7		6·6	0·5	12·8	0·7	0	1	2	5
Nov. 1-15		4·8	0·3			13·3	0·7		10·5	0·6	14·7	0·7	0	2	1	3
16-30	3·6			0·2		2·4	0·2		6·3	0·3	14·5	0·4	0	0	3	0
Dec. 1-15		2·9	0·1			3·4	0·5		5·7	0·3	9·8	0·5	0	1	2	7
16-31	7·2		0·3			1·4	0·4		8·8	0·4	10·1	0·6	0	0	0	1
TOTALS...	404·2	7·7	2·7	1·6	185·8	36·6	6·3	3·1	445·2	8·4	311·9	13·4	117	43	20	99
MEANS ...	+ 16·5		0·0		+ 6·2		+ 0·1		18·6	0·4	13·0	0·6				

TABLE XXV.—Mean errors E_1, E_2 for 1922

MOULMEIN

PERIOD 1922	MEAN ERRORS: E_1 is with regard to sign — E_1 H. W. Time (minutes) +		H. W. Height (feet) +		L. W. Time (minutes) +		L. W. Height (feet) +		E_2 is without regard to sign — E_2 H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	L. W.	1·0 foot of height — H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-16		2·3		0·1		3·3		0·1	9·1	0·3	12·0	0·3	0	1	0	2
17-31		4·6		0·3		7·6		0·0	7·7	0·7	13·1	0·3	0	3	6	0
Feb. 1-16		1·0		0·3		4·8		0·3	4·9	0·5	9·8	0·4	0	2	3	1
17-28		7·3		0·5		10·9	0·0		9·7	0·5	14·9	0·3	0	3	1	0
Mar. 1-16		9·9		0·5		17·6		0·2	11·7	0·7	17·9	0·3	0	6	7	0
17-31		14·1		0·7		14·0		0·2	15·9	0·7	14·7	0·3	1	5	5	0
April 1-16		5·5		0·1		13·6		0·1	8·3	0·8	13·6	0·3	0	3	11	0
17-30		2·7		0·7		1·4		0·4	8·3	0·7	12·2	0·4	1	4	6	2
May 1-16		6·0		0·4		15·0		0·4	7·3	0·7	16·0	0·5	0	5	8	0
17-31		2·8	0·0			1·1		0·2	6·9	0·5	10·7	0·5	0	1	2	1
June 1-16		7·1		0·3		9·3	0·5		9·6	0·5	12·9	0·6	0	1	2	1
17-30		5·1	0·2			6·6	0·6		9·0	0·6	10·8	0·7	0	0	2	8
July 1-16	2·5		0·2			10·5	0·9		8·2	0·5	14·4	0·9	0	0	2	13
17-31	12·8		0·1			8·6	0·2		18·1	0·5	15·6	0·7	4	0	3	6
Aug. 1-16	5·5			0·7		10·8		1·7	12·2	0·7	14·4	1·7	1	3	8	21
17-31	4·8			0·1		21·5		0·4	10·0	0·7	22·8	0·4	1	5	7	0
Sept. 1-16	9·7			0·7		17·5		0·6	11·4	0·7	17·8	0·6	0	6	8	2
17-30	3·9		0·0			23·3	0·0		13·2	0·7	23·5	0·4	2	6	7	0
Oct. 1-16		6·3		0·7		21·3	0·9		10·2	0·8	21·3	0·9	0	5	11	9
17-31		7·2	0·0			18·4	0·7		13·9	0·6	20·7	0·7	1	5	5	5
Nov. 1-16		5·0		1·0		12·8		0·0	8·1	1·1	14·6	0·5	0	3	15	0
17-30		4·6		0·3		10·9		0·2	7·9	0·5	14·0	0·5	1	2	3	5
Dec. 1-16		7·7		0·5		15·6		0·2	10·5	0·6	17·3	0·5	0	4	6	1
17-31		12·7		0·3		11·9		0·2	13·3	0·7	16·7	0·4	1	4	8	2
TOTALS...	39·2	111·9	0·5	8·2	0·0	288·3	3·8	5·2	245·4	15·3	371·7	13·1	13	77	136	79
MEANS ...	− 3·0		− 0·3		− 12·0		− 0·1		10·2	0·6	15·5	0·5				

TABLE XXVI.—Mean errors E_1, E_2 for 1923

MOULMEIN

MEAN ERRORS: E_1 is with regard to sign; E_2 is without regard to sign

PERIOD 1923	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	1·0 foot of height H. W.	1·0 foot of height L. W.
Jan. 1-16		0·6		0·2		11·2	0·1		7·8	0·3	15·7	0·4	0	3	0	0
17-31	8·6			0·4	7·9		0·1		12·1	0·4	13·4	0·4	3	2	1	0
Feb. 1-16	8·7			0·4		2·6		0·2	10·6	0·5	14·2	0·5	0	3	3	0
17-28	10·2			0·2	6·9		0·4		11·0	0·2	12·6	0·4	1	1	0	0
Mar. 1-16		0·9		0·3		13·5		0·1	8·0	0·6	15·5	0·5	0	5	2	0
17-31		3·7		0·2		10·5	0·3		8·3	0·4	11·4	0·3	0	2	1	0
April 1-16		4·9	0·2			17·3	0·1		7·5	0·5	18·1	0·4	2	7	3	0
17-30		4·0		0·3		11·6		0·0	8·4	0·4	12·1	0·4	0	3	0	1
May 1-16		6·1		0·5		16·6		0·4	7·3	0·6	16·8	0·4	0	6	6	4
17-31		9·1	0·0			16·9	0·3		10·6	0·7	17·1	0·5	0	3	5	1
June 1-16	1·7			0·3		13·4		0·3	11·1	0·6	15·8	0·7	1	2	6	10
17-30	10·6			0·8		9·9		0·7	11·6	0·8	11·9	0·7	0	0	8	5
July 1-16	6·9		0·2			10·1	0·9		12·4	0·5	10·8	1·1	1	0	4	16
17-31	7·2			0·1		16·5	0·4		15·2	0·4	17·3	0·8	2	4	1	8
Aug. 1-16	10·6			0·6		5·4		1·5	16·0	0·7	11·7	1·5	3	0	6	26
17-31	1·9			1·2		19·1		2·7	9·8	1·2	22·2	2·7	1	8	14	28
Sept. 1-16	2·8			0·2		20·9		0·3	6·6	0·4	21·5	0·4	0	6	1	3
17-30		12·0		0·4		38·1	0·8		14·0	0·6	38·1	0·8	0	16	4	7
Oct. 1-16		18·0		0·3		37·1	0·5		20·1	0·9	37·1	0·7	4	20	11	7
17-31		28·8		0·4		39·3	0·8		28·8	0·5	39·3	0·8	10	14	4	6
Nov. 1-16		22·7		0·3		35·1	0·4		22·7	0·7	35·1	0·6	5	19	7	5
17-30		21·9		0·6		22·5	0·5		21·9	0·7	22·5	0·5	4	6	9	2
Dec. 1-16		18·5	0·3			28·4	0·4		18·5	0·4	28·4	0·5	2	13	0	0
17-31		13·4		0·1		13·6	0·5		13·4	0·6	13·7	0·5	1	0	7	6
TOTALS ...	69·2	164·6	0·7	7·8	14·8	409·6	6·5	6·2	313·7	13·6	472·3	16·5	40	143	103	135
MEANS ...	− 4·0		− 0·3		− 16·5		0·0		13·1	0·6	19·7	0·7				

TABLE XXVII.—Mean errors E_1, E_2 for 1924

MOULMEIN

PERIOD 1924	MEAN ERRORS: E_1 is with regard to sign								E_2 is without regard to sign				Number of errors exceeding			
	E_1								E_2				30 minutes of time		1·0 foot of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time	H. W. Ht.	L. W. Time	L. W. Ht.	H. W.	L. W.	H. W.	L. W.
	minutes		feet		minutes		feet		minutes	feet	minutes	feet				
	+	−	+	−	+	−	+	−								
Jan. 1-15	2·0			0·1		3·8	0·1		9·3	0·3	15·3	0·4	1	3	0	0
16-31	3·0			0·3	2·1		0·3		7·9	0·4	13·2	0·4	0	1	0	1
Feb. 1-15	11·6		0·0		12·2		0·2		12·5	0·2	16·7	0·4	2	4	1	0
16-29	7·4			0·5	0·0		0·0		11·0	0·5	14·3	0·4	2	3	2	0
Mar. 1-15		0·2		0·5	0·0		0·1		7·3	0·6	10 0	0·3	0	3	4	0
16-31		8·5		0·4		17·6	0·1		11·4	0·6	18·7	0·3	2	8	4	0
April 1-15		4·5		0·5		1·3	0·2		9·9	0·6	7·7	0·2	1	0	5	0
16-30		3·8		0·2		16·2	0·0		14·7	0·6	20·1	0·3	2	7	2	0
May 1-15		9·3		0·4		6·1	0·5		11·8	0·5	8·8	0·5	2	2	3	0
16-31		11·5		0·2		14·3	0·4		12·3	0·5	16·4	0·5	1	3	3	1
June 1-15		5·7		0·3		2·4	1·0		8·2	0·4	6·8	1·1	1	0	1	12
16-30	0·1		0·0			13·2		0·2	6·1	0·5	13·2	0·7	0	1	4	7
July 1-15	5·6			0·2		9·6	12·7		9·9	0·5	10·9	12·7	1	0	4	15
16-31	10·9			0·2		1·9		0·4	16·5	0·5	11·5	0·6	3	1	2	0
Aug. 1-15	17·8			0·7		4·0		1·1	19·5	0·7	11·3	1·1	5	3	5	17
16-31	6·5			0·4	0·1			0·2	13·3	0·5	12·8	0·2	2	3	6	0
Sept. 1-15	3·3			0·3		18·0	0·7		8·8	0·6	18·8	0·8	0	5	4	9
16-30		0·1	0·0			9·1	15·0		8·1	0·3	11·4	15·0	0	0	0	24
Oct. 1-15		15·1		0·8		26·3	0·9		15·1	1·0	26·3	0·9	3	7	12	9
16-31		18·3		0·2		24 0	1·1		18·6	0·7	24 0	1·1	3	5	10	20
TOTALS...	68·2	77·3	0·0	6·2	14·4	167·8	33·3	1·9	232·2	10·5	288·2	37·9	31	59	72	115
MEANS ...	− 0·5		− 0·3		− 7·7		+ 1·6		11·6	0·5	14·4	1·9				

Note—The observatory was discontinued from 1st November 1924.

TABLE XXVIII.—Mean errors E_1, E_2 for 1922

PORT BLAIR

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign — E_1								MEAN ERRORS — E_2 is without regard to sign — E_2				Number of errors exceeding — 30 *minutes* of time		0·7 *foot* of height	
	H. W. Time (*minutes*)		H. W. Height (*feet*)		L. W. Time (*minutes*)		L. W. Height (*feet*)		H. W. Time (*minutes*)	H. W. Ht. (*feet*)	L. W. Time (*minutes*)	L. W. Ht. (*feet*)	H. W.	L. W.	H. W.	L. W.
	+	–	+	–	+	–	+	–								
Jan. 1-16		5·1		0·2	2·9			0·1	7·7	0·2	7·9	0·2	0	0	0	0
17-31		2·8		0·3		1·2		0·0	8·4	0·3	4·8	0·1	0	0	0	0
Feb. 1-16		3·5		0·2	3 6			0·2	5·3	0·2	6·2	0·2	0	0	0	0
17-28	5 9			0·3	1·5			0·2	8·9	0·3	6·4	0·2	1	0	0	0
Mar. 1-16	1·7			0·1	6·5			0·2	5·3	0·1	8·9	0·2	0	2	0	0
17-31	2·6			0·1	1·4			0·1	7·0	0·1	5·0	0·1	1	0	0	0
April 1-16	2·4			0·2	2·7			0·2	5·4	0·2	6·5	0·2	0	0	0	0
17-30	7·1			0·1	1·3			0·2	8·9	0·2	6·4	0·2	1	0	3	2
May 1-16		1·0		0·3	2·4			0·2	8·6	0·3	5·0	0·2	0	0	0	0
17-31	5·2			0·4	3·1			0·3	7·9	0·4	8·3	0·3	0	0	0	0
June 1-16	4·2			0·4	5·8			0·3	6·3	0·4	8 7	0·3	0	0	0	0
17-30	1·7			0·3	4·6			0·3	4·6	0·3	8·0	0·3	0	0	0	0
July 1-16	1·5			0·2	0·1			0·0	4·7	0·2	3·8	0·1	0	0	0	0
17-31		5·9	0·0		3·3			0·1	6·8	0·1	6·1	0·1	0	0	0	0
Aug. 1-16	3·8			0·1	4 5			0·0	7·1	0·1	5 6	0·1	0	0	0	0
17-31		0·6		0·2	1 7			0·1	6·3	0·2	4·8	0·2	1	0	0	0
Sept. 1-16		1·2		0·1		1·0		0·1	4·3	0·1	6·3	0·1	0	0	0	0
17-30	4·9			0·1		3·0		0·1	10·1	0·1	5·6	0·2	1	0	0	0
Oct. 1-16		0·7	0 0			0·6	0·2		3·1	0·1	6·1	0·2	0	0	0	0
17-31	3·6			0·1	0·7			0·0	10·8	0·1	6·7	0·1	1	0	0	0
Nov. 1-16		0·1		0·2		3·3		0·1	6·2	0·2	6·1	0·1	0	0	0	0
17-30		3·1		0·1		8·2		0·0	6·2	0·2	8·6	0·1	0	0	0	0
Dec. 1-16	2·5			0·3	2·0			0·2	5·2	0·3	6 7	0·2	0	0	0	0
17-31		1·6		0·2	1·6			0·1	7·2	0·2	5·8	0·1	0	0	0	0
TOTALS...	47·1	25·6	0·0	4·5	49·7	17·3	0·2	3·1	162·3	4·9	154·3	4·1	6	2	3	2
MEANS ...	+ 0·9		– 0·2		+ 1·4		– 0·1		6·8	0·2	6·4	0·2				

TABLE XXIX.—Mean errors E_1, E_2 for 1923

PORT BLAIR

PERIOD 1923	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	−	H. W. Height (feet) +	−	L. W. Time (minutes) +	−	L. W. Height (feet) +	−	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	L. W.	0·7 foot of height — H. W.	L. W.
Jan. 1-16		11·1		0·3	7·2			0·1	11·1	0·3	7·2	0·2	0	0	0	1
17-31		17·4		0·1	13·1			0·2	17·4	0·1	13·6	0·2	4	5	0	0
Feb. 1-16		17·3		0·2	2·6			0·1	17·3	0·2	5·5	0·1	1	0	0	0
17-28		14·6		0·0	14·8			0·2	14·6	0·2	15·1	0·2	3	4	0	0
Mar. 1-16		13·8		0·1	10·0			0·1	13·8	0·1	10·0	0·1	0	2	0	0
17-31		19·3		0·0	11·0			0·1	19·3	0·1	12·6	0·1	2	2	0	0
April 1-16		9·9		0·1	4·4			0·1	10·7	0·1	6·1	0·1	0	0	0	0
17-30		14·0		0·0	12·6			0·2	14·3	0·1	12·6	0·2	2	2	0	0
May 1-16		13·3	0·1		2·3		0·1		13·8	0·1	7·3	0·1	1	0	0	0
17-31		8·3		0·1	12·4			0·1	8·7	0·1	12·6	0·2	0	3	0	0
June 1-16		13·2		0·1	3·4			0·1	13·9	0·1	7·2	0·1	2	0	0	0
17-30		8·5		0·1	6·9			0·0	8·5	0·2	7·4	0·1	0	0	0	0
July 1-16		10·8		0·1	3·4			0·1	11·0	0·1	6·4	0·1	1	0	0	0
17-31		8·8		0·3	8·3			0·1	8·9	0·3	8·8	0·1	0	1	0	0
Aug. 1-16		14·1		0·1	11·6			0·1	14·1	0·1	11·8	0·1	2	1	0	0
17-31		9·3		0·0	8·4			0·0	9·6	0·0	8·6	0·1	1	1	0	0
Sept. 1-16		17·5		0·1	12·9			0·0	17·7	0·1	14·8	0·1	4	6	0	0
17-30		18·1	0·1			2·1	0·2		18·1	0·1	7·1	0·2	1	0	0	0
Oct. 1-16		15·9	0·1		2·6		0·1		16·5	0·1	6·8	0·1	3	1	0	0
17-31		15·4		0·1	5·1			0·0	15·4	0·1	7·8	0·1	1	0	0	0
Nov. 1-16		17·7	0·1		4·8			0·1	18·1	0·2	6·9	0·1	5	0	0	0
17-30		12·7		0·0	8·0			0·0	13·2	0·1	8·3	0·1	2	0	0	0
Dec. 1-16		11·8		0·2	5·0			0·2	11·8	0·2	9·1	0·2	0	0	0	0
17-31		16·0		0·1	1·5			0·1	16·0	0·2	6·2	0·1	2	0	0	0
TOTALS ...	0·0	328·8	0·4	2·1	172·3	2·1	0·4	2·0	333·8	3·3	219·8	3·1	37	28	0	1
MEANS ...	− 13·7		− 0·1		+ 7·1		− 0·1		13·5	0·1	9·2	0·1				

TABLE XXX.—Mean errors E_1, E_2 for 1924

PORT BLAIR

MEAN ERRORS — E_1 is with regard to sign; E_2 is without regard to sign

PERIOD 1924	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	0·7 foot of height H. W.	0·7 foot of height L. W.
Jan. 1-15	3·3			0·0	2·4		0·1		6·2	0·1	6·2	0·1	0	0	0	0
16-31		3·9		0·2	3·0			0·0	6·5	0·2	7·4	0·1	0	0	0	0
Feb. 1-15	2·2			0·3	8·9			0·2	6·4	0·3	11·9	0·2	0	3	0	0
16-29		2·4		0·1	4·1			0·1	5·5	0·1	8·1	0·1	0	0	0	0
Mar. 1-15	2·4			0·1	16·6			0·1	5·4	0·1	16·6	0·1	0	2	0	0
16-31		0·3		0·2	8·4			0·3	5·0	0·2	9·2	0·3	0	0	0	0
April 1-15	0·1			0·1	10·8			0·3	6·5	0·1	11·5	0·3	0	1	0	0
16-30		1·5		0·2	4·4			0·3	5·0	0·2	7·2	0·3	0	0	0	0
May 1-15	0·8		0·1		3·8			0·0	6·4	0·1	7·6	0·1	0	0	0	0
16-31		5·7	0·1			4·6	0·0		6·1	0·1	8·5	0·1	0	0	0	0
June 1-15		5·0		0·0		0·4		0·2	7·6	0·1	5·5	0·2	0	0	0	0
16-30		2·0		0·1		2·9		0·2	5·9	0·1	7·2	0·2	0	0	0	0
July 1-15		1·5		0·1	7·7			0·2	3·8	0·1	8·4	0·2	0	0	0	0
16-31	2·4			0·0		0·2		0·1	6·1	0·1	7·5	0·1	0	0	0	0
Aug. 1-15		3·1		0·1	4·7			0·0	5·3	0·1	6·9	0·1	0	0	0	0
16-31		4·6	0·1		1·5			0·0	7·3	0·2	9·8	0·1	1	2	0	0
Sept. 1-15	0·0			0·1	0·4			0·1	3·3	0·1	6·1	0·1	0	0	0	0
16-30		4·3		0·1		4·7		0·2	8·1	0·1	8·9	0·3	2	1	0	0
Oct. 1-15		3·2		0·0		1·7		0·0	5·8	0·1	5·2	0·1	0	0	0	0
16-31		10·0	0·0			2·2		0·0	10·1	0·1	5·5	0·1	1	0	0	0
Nov. 1-15	1·1			0·1	0·4			0·1	4·5	0·2	7·8	0·2	0	0	0	0
16-30		6·1		0·2	0·6			0·3	8·0	0·2	6·6	0·3	0	0	0	0
Dec. 1-15		0·2		0·3		0·9		0·3	4·4	0·3	5·1	0·3	0	0	0	0
16-31		13·4		0·1		4·5		0·2	13·5	0·1	7·5	0·2	0	0	0	0
TOTALS...	12·3	67·2	0·3	2·4	77·7	22·1	0·1	3·2	152·7	3·4	192·2	4·2	4	9	0	0
MEANS...	− 2·3		− 0·1		+ 2·8		− 0·1		6·4	0·1	8·0	0·2				

TABLE XXXI.—Mean errors E_1, E_2 for 1924

BASSEIN

PERIOD 1924	MEAN ERRORS: E_1 is with regard to sign — E_1 H. W. Time (minutes) +	−	H. W. Height (feet) +	−	L. W. Time (minutes) +	−	L. W. Height (feet) +	−	E_2 is without regard to sign — E_2 H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time: H. W.	L. W.	0·6 foot of height: H. W.	L. W.
Jan. 1-15	25·2			1·0	9·9		0·0		25·2	1·0	17·7	0·0	10	3	24	0
16-31	19·5			0·5	17·7		0·4		22·2	0·5	19·8	0·4	12	7	11	2
Feb. 1-15	28·4			0·3	11·6		0·6		28·4	0·6	21·8	0·6	8	7	11	13
16-29	19·1			0·3	19·8		0·8		20·9	0·4	20·6	0·8	4	6	5	18
Mar. 1-15	23·9			0·4	14·5		0·5		24·4	0·5	25·7	0·5	6	8	10	10
16-31	9·5			0·3	8·7		0·6		13·7	0·4	15·6	0·6	2	4	3	9
April 1-15	11·6			0·5	3·5		0·4		15·7	0·5	20·2	0·4	5	7	11	4
16-30		5·2		0·7		9·6	0·1		15·4	0·7	12·1	0·2	4	1	13	1
May 1-15	0·2			0·5		0·2	0·3		12·8	0·5	11·6	0·4	2	2	10	3
16-31		17·8		0·9		24·0		0·4	23·5	0·9	24·0	0·4	9	10	24	6
June 1-15		5·3		0·7	7·0			0·1	17·4	0·7	12·0	0·2	5	1	15	2
16-30	9·1			0·7		12·0		1·0	21·0	0·7	14·3	1·0	7	1	16	13
July 1-15	8·3			0·2	7·0			0·3	16·2	0·3	10·9	0·4	4	1	0	5
16-31		4·8		0·7	6·1			2·9	11·5	0·7	15·4	2·9	1	3	18	30
Aug. 1-15		26·0		0·7	15·9			3·5	27·9	0·7	21·1	3·5	11	7	19	23
16-31		3·9	0·4		2·6			1·7	18·2	0·4	11·8	1·7	2	1	8	30
Sept. 1-15		13·3	0·3			0·7		2·0	22·8	0·3	19·2	2·0	8	4	0	29
16-30		0·5	0·8			8·7		0·3	10·0	0·8	11·1	0·6	1	1	18	8
Oct. 1-15		15·0	0·0			22·6		1·2	18·8	0·3	22·8	1·2	8	8	1	21
16-31		12·7		0·1		18·5		0·5	16·2	0·4	21·3	0·7	1	9	8	19
Nov. 1-15		18·1		0·8		31·4		0·7	18·3	0·8	31·4	0·7	5	15	15	19
16-30		14·1		1·1		23·3		1·1	21·2	1·1	23·9	1·1	9	6	29	23
Dec. 1-15		3·4		1·1		19·6		0·6	11·2	1·1	21·0	0·6	3	8	28	10
16-31	4·0			1·0		4·7		0·4	15·6	1·0	14·5	0·4	5	3	31	7
TOTALS...	158·8	140·1	1·5	12·5	124·3	175·3	3·7	16·7	448·5	15·3	439·8	21·3	132	123	328	31
MEANS ...	+ 0·8		− 0·5		− 2·1		− 0·5		18·7	0·6	18·3	0·9				

NOTE.—The observatory was restarted in 1924.

TABLE XXXII.—Mean errors E_1, E_2 for 1922

BHAVNAGAR

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign								E_2 is without regard to sign				Number of errors exceeding			
	E_1								E_2				30 *minutes* of time		1·0 *foot* of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time	H. W. Ht.	L. W. Time	L. W. Ht.	H. W.	L. W.	H. W.	L. W.
	minutes		*feet*		*minutes*		*feet*		*minutes*	*feet*	*minutes*	*feet*				
	+	−	+	−	+	−	+	−								
Jan. 1-16		0·8		0·0		0·3	0·1		2·9	0·2	4·4	0·2	0	0	0	0
17-31		0·3	0·0		0·3		0·1		2·5	0·2	2·0	0·2	0	0	0	0
Feb. 1-16	1·3			0·1	1·9			0·3	4·3	0·4	3·5	0·4	0	0	0	2
17-28	0·3		0·1		0·2		0·1		2·3	0·2	3·7	0·2	0	0	0	0
Mar. 1-16	0·2		0·0		0·3			0·3	2·7	0·2	1·9	0·5	0	0	0	3
17-31	0·9		0·0		0·5		0·1		2·3	0·2	2·0	0·2	0	0	0	0
April 1-16	0·0		0·1		0·2			0·2	1·6	0·2	2·1	0·3	0	0	0	1
17-30	0·7			0·0	0·6			0·1	2·1	0·2	1·8	0·4	0	0	0	0
May 1-16	0·0		0·1			0·2		0·0	1·6	0·1	1·6	0·1	0	0	0	0
17-31	0·4			0·0	0·2		0·0		1·5	0·1	1·5	0·1	0	0	0	0
June 1-16	0·3		0·0		0·3		0·0		1·6	0·1	1·4	0·1	0	0	0	0
17-30	0·4		0·1		0·2		0·0		1·4	0·1	1·4	0·1	0	0	0	0
July 1-16		0·4	0·1		0·4		0·0		1·4	0·2	1·4	0·1	0	0	1	0
17-31	0·4		0·0		0·4			0·1	1·3	0·1	1·5	0·2	0	0	0	0
Aug. 1-16	0·3			0·0	0·5		0·0		1·4	0·1	1·5	0·1	0	0	0	0
17-31	0·1		0·0		0·1			0·C	1·3	0·1	1·1	0·1	0	0	0	0
Sept. 1-16	0·2		0·0		0·2		0·0		1·2	0·1	1·3	0·1	0	0	0	0
17-30	0·0		0·0		0·0			0·0	1·3	0·1	1·3	0·1	0	0	0	0
Oct. 1-16	0·3		0·0			0·1		0·0	1·5	0·1	1·5	0·1	0	0	0	0
17-31	0·3		0·0		0·3			0·0	1·5	0·1	1·5	0·2	0	0	0	0
Nov. 1-16	0·4		0·0		0·1		0·0		1·4	0·1	1·3	0·1	0	0	0	0
17-30		0·1	0·0			0·4	0·0		1·4	0·1	1·2	0·1	0	0	0	0
Dec. 1-16	0·1			0·0	0·4		0·0		1·3	0·1	1·4	0·1	0	0	0	0
17-31	0·2		0·0		0·1		0·0		1·3	0·1	1·2	0·1	0	0	0	0
TOTALS...	6·8	1·6	0·5	0·1	7·2	1·0	0·4	1·	43·1	3·5	43·5	4·2	0	0	1	6
MEANS ...	+ 0·2		0·0		+ 0·3		0·0		1·8	0·1	1·8	0·2				

TABLE XXXIII.—Mean errors E_1, E_2 for 1923

BHAVNAGAR

MEAN ERRORS: E_1 is with regard to sign; E_2 is without regard to sign

PERIOD 1923	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	1·0 feet of height H. W.	1·0 feet of height L. W.
Jan. 1-16		0·1		0·1		1·5		0·1	2·9	0·2	3·9	0·3	0	0	0	0
17-31		0·5	0·1			1·2		0·1	3·5	0·3	3·5	0·3	0	0	0	0
Feb. 1-16	1·0		0·1		0·9		0·1		4·9	0·4	5·2	0·4	0	0	0	0
17-28	3·3		0·0		2·3			0·4	6·0	0·4	6·8	0·7	0	0	1	3
Mar. 1-16		6·9		0·1		19·8		0·3	9·9	0·7	22·6	0·6	0	6	2	3
17-31		6·3		0·1		4·1		0·1	7·5	0·5	6·3	0·5	0	0	0	1
April 1-16		7·0		0·1		7·6		0·3	10·8	0·7	8·8	0·7	0	0	3	3
17-30		7·9		0·0		7·0		0·3	9·9	0·7	9·6	0·6	0	0	2	0
May 1-16		2·1		0·0		6·6		0·4	8·9	0·4	11·9	0·6	0	1	0	3
17-31		0·4		0·1		0·3		0·2	4·9	0·5	4·1	0·6	0	0	0	0
June 1-16	0·6			0·0	0·4		0·1		4·2	0·2	3·7	0·2	0	0	0	0
17-30	1·3			0·0		0·2	0·1		4·9	0·1	5·1	0·3	0	0	0	0
July 1-16	0·7			0·0	0·3			0·0	3·2	0·2	2·3	0·2	0	0	0	0
17-31		0·9		0·0	0·1			0·0	2·4	0·1	2·8	0·2	0	0	0	0
Aug. 1-16	0·7		0·1		0·1			0·0	3·7	0·2	3·8	0·1	0	0	0	0
17-31	0·5		0·0			0·6		0·0	3·4	0·2	3·5	0·1	0	0	0	0
Sept. 1-16	1·1			0·0		0·8		0·0	4·2	0·2	2·8	0·2	0	0	0	0
17-30	0·1			0·0		0·6		0·0	4·1	0·2	3·4	0·2	0	0	0	0
Oct. 1-16	0·1			0·0		1·0		0·1	4·0	0·2	4·6	0·2	0	0	0	0
17-31		0·4		0·0		0·1		0·0	4·3	0·2	2·5	0·1	0	0	0	0
Nov. 1-16		0·1		0·1		1·4		0·1	3·7	0·4	4·4	0·4	0	0	0	0
17-30		2·1		0·0	0·8		0·3		3·9	0·6	5·5	0·4	0	0	0	0
Dec. 1-16	2·7		0·1		2·1		0·1		5·3	0·4	4·8	0·5	0	0	0	0
17-31	2·4			0·1	0·9		0·2		5·6	0·4	4·1	0·4	0	0	0	0
TOTALS ...	14·5	34·7	0·4	0·7	7·9	53·8	0·9	2·4	126·1	8·4	136·0	8·8	0	7	8	1[illegible]
MEANS ...	− 0·8		0·0		− 1·9		− 0·1		5·3	0·4	5·7	0·4				

TABLE XXXIV.—Mean errors E_1, E_2 for 1924

BHAVNAGAR

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign								E_2 is without regard to sign				Number of errors exceeding			
	E_1								E_2				30 minutes of time		1·0 foot of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time	H. W. Ht.	L. W. Time	L. W. Ht.	H. W.	L. W.	H. W.	L. W.
	minutes		feet		minutes		feet		minutes	feet	minutes	feet				
	+	−	+	−	+	−	+	−								
Jan. 1-15		3·7		0·2		1·9		0·1	4·5	0·4	5·5	0·5	0	0	0	0
16-31		0·9	0·3			1·1	0·1		5·1	0·5	4·4	0·5	0	0	0	0
Feb. 1-15		0·1		0·1	1·3		0·1		5·9	0·4	4·8	0·4	0	0	0	0
16-29	1·3		0·2			0·3		0·1	5·1	0·5	4·9	0·5	0	0	1	0
Mar. 1-15		2·7	0·1			0·7		0·0	5·2	0·5	4·2	0·4	0	0	0	0
16-31		1·3		0·1	1·3			0·1	4·9	0·4	3·8	0·4	0	0	1	0
April 1-15	0·3			0·2	2·5		0·1		5·1	0·5	4·8	0·5	0	0	1	0
16-30	0·2			0·0		0·0		0·2	3·9	0·4	5·5	0·4	0	0	0	0
May 1-15	2·3			0·2		0·0		0·2	4·9	0·5	4·4	0·4	0	0	0	0
16-31		1·1	0·0		0·2			0·1	4·9	0·5	5·6	0·4	0	0	0	0
June 1-15		0·9	0·0		1·0		0·1		3·7	0·4	4·9	0·5	0	0	0	0
16-30		2·8	0·1		1·1			0·3	6·1	0·3	4·4	0·6	0	0	0	1
July 1-15	0·5			0·1	0·5		0·2		3·9	0·4	5·1	0·5	0	0	0	1
16-31		1·9	0·1			0·7	0·1		5·1	0·4	4·4	0·4	0	0	0	0
Aug. 1-15	1·0			0·0	1·1			0·1	3·8	0·4	5·1	0·4	0	0	0	0
16-31		0·5	0·1			1·0	0·1		4·5	0·4	4·6	0·4	0	0	1	0
Sept. 1-15	1·9		0·1			0·0		0·2	3·9	0·4	4·0	0·3	0	0	0	0
16-30		0·3	0·0			0·1		0·0	5·1	0·3	4·9	0·3	0	0	0	0
Oct. 1-15		0·3		0·1		1·8		0·2	4·8	0·4	4·1	0·4	0	0	0	0
16-31	0·3		0·1		0·5			0·1	4·1	0·3	4·9	0·4	0	0	0	0
Nov. 1-15		3·9		0·0		2·9		0·0	5·6	0·5	4·9	0·5	0	0	0	0
16-30		2·1	0·2			0·9	0·1		4·5	0·4	4·3	0·5	0	0	0	0
Dec. 1-15	0·3		0·0		2·7		0·2		2·9	0·4	4·7	0·4	0	0	0	0
16-31		1·1	0·1			2·2	0·2		4·6	0·5	5·2	0·4	0	0	2	0
TOTALS ...	8·1	23·6	1·4	1·0	12·2	13·6	1·3	1·7	112·1	10·1	113·4	10·4	0	0	6	2
MEANS ...	− 0·6		0·0		− 0·1		0·0		4·7	0·4	4·7	0·4				

TABLE XXXV.—Mean errors E_1, E_2 for 1922

CHITTAGONG

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	−	H. W. Height (feet) +	−	L. W. Time (minutes) +	−	L. W. Height (feet) +	−	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	L. W.	Number of errors exceeding 1·0 foot of height — H. W.	L. W.
Jan. 1-16		14·9		0·3		13·5		0·8	16·2	0·4	14·4	0·8	2	0	0	2
17-31		14·5		0·2		18·1		0·5	16·5	0·3	24·5	0·5	1	4	0	0
Feb. 1-16		9·8		0·3		15·4		0·8	11·3	0·4	15·6	0·8	0	1	0	6
17-28		16·3		0·7		17·3		0·8	16·3	0·7	17·3	0·8	0	0	2	1
Mar. 1-16		5·3	0·1			5·9		0·5	6·6	0·3	7·8	0·5	0	0	0	1
17-31		5·5		0·6		6·7		0·7	8·6	0·7	9·6	0·7	0	0	3	3
April 1-16		14·4	0·4			6·9		0·1	14·9	1·1	9·3	0·4	2	0	9	1
17-30		11·6		0·8		9·2		0·9	11·6	0·8	13·4	1·0	1	1	2	7
May 1-16		13·3	0·1			16·9		0·7	13·3	0·7	17·2	0·8	3	0	1	5
17-31		13·8	0·4			11·6		0·5	13·8	0·5	15·6	0·5	1	0	0	2
June 1-16		14·1	0·1			8·7		0·4	14·1	0·6	12·7	0·4	1	1	2	2
17-30		4·0		0·5		14·1		2·0	11·1	0·5	14·1	2·0	0	0	2	12
July 1-16		12·3	0·1			15·6		0·5	13·9	0·2	16·6	0·6	1	3	0	2
17-31		15·5		0·3		17·9		1·3	16·7	0·4	17·9	1·3	1	1	2	11
Aug. 1-16		21·9		0·6		19·8		1·5	21·9	0·6	20·1	1·5	4	2	2	11
17-31		19·7		0·2		26·3		1·1	19·7	0·8	26·3	1·1	1	5	6	9
Sept. 1-16		18·1		0·3		26·3		1·2	22·3	0·3	26·3	1·2	2	5	1	11
17-30		21·9	0·1			16·1		0·8	21·9	0·4	16·1	0·9	3	1	1	6
Oct. 1-16		18·6		0·4		19·9		1·2	18·6	0·5	19·9	1·2	2	0	0	7
17-31		25·2	0·3			24·2		0·6	25·2	0·4	25·9	0·6	4	8	0	3
Nov. 1-16		20·9		0·3		21·8		0·5	20·9	0·6	21·8	0·5	2	2	4	2
17-30		16·2		0·4		19·1		0·8	16·5	0·5	19·9	0·8	1	2	1	5
Dec. 1-16		14·1		0·6		16·9		0·9	14·1	0·6	16·9	0·9	0	1	3	5
17-31		11·3		0·6		19·5		1·0	16·9	0·6	19·5	1·0	0	2	2	5
TOTALS ...	0·0	353·2	1·6	7·1	0·0	387·7	0·0	20·1	382·9	12·9	418·7	20·8	32	39	43	119
MEANS ...	− 14·7		− 0·2		− 16·2		− 0·8		16·0	0·5	17·4	0·9				

TABLE XXXVI.—Mean errors E_1, E_2 for 1923

CHITTAGONG

MEAN ERRORS: E_1 is with regard to sign; E_2 is without regard to sign

PERIOD 1923	E_1 H. W. Time (minutes) +	E_1 H. W. Time (minutes) −	E_1 H. W. Height (feet) +	E_1 H. W. Height (feet) −	E_1 L. W. Time (minutes) +	E_1 L. W. Time (minutes) −	E_1 L. W. Height (feet) +	E_1 L. W. Height (feet) −	E_2 H. W. Time (minutes)	E_2 H. W. Ht. (feet)	E_2 L. W. Time (minutes)	E_2 L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time H. W.	30 minutes of time L. W.	1·0 foot of height H. W.	1·0 foot of height L. W.
Jan. 1-16		12·3		0·5		21·1		0·7	17·3	0·5	21·9	0·7	2	1	2	1
17-31		11·1		0·4		13·6		1·0	15·0	0·5	16·3	1·0	1	0	0	6
Feb. 1-16		2·6		0·6		14·6		1·1	19·4	0·7	17·0	1·1	2	3	2	9
17-28		7·4	0·1			2·3		0·2	11·3	0·3	8·3	0·5	1	0	0	0
Mar. 1-16		9·6	0·4			7·7		0·4	16·4	0·8	8·1	0·6	2	0	7	1
17-31		1·7		0·0	7·2			0·3	13·1	0·9	14·3	0·3	1	2	7	0
April 1-16	4·0			0·3	2·8			0·5	14·3	0·7	16·5	0·8	2	2	4	3
17-30		13·1	0·1			12·3		0·2	14·1	0·5	16·9	0·4	2	2	1	2
May 1-16		9·8		0·5		16·2		0·9	11·2	0·8	16·3	1·0	2	0	5	8
17-31		10·5	0·8			12·5	0·3		11·1	0·8	12·9	0·4	1	0	4	0
June 1-16		16·6	0·1			22·4		0·5	16·6	0·6	22·4	0·7	1	3	4	4
17-30		3·9		0·6		8·9		1·2	13·2	0·6	19·1	1·2	0	3	1	9
July 1-16		13·8	0·3			12·8		0·1	14·4	0·4	12·8	0·3	0	1	0	0
17-31		8·3	0·3			13·5		0·4	9·5	0·4	13·5	0·5	0	0	0	2
Aug. 1-16		9·6	0·0			5·3		0·6	10·9	0·3	10·7	0·6	0	0	0	0
17-31		15·4		0·3		17·1		1·1	16·9	0·5	17·1	1·1	3	3	2	9
Sept. 1-16		16·3		0·1		17·7		1·4	16·3	0·4	17·9	1·4	3	1	0	7
17-30		19·4		0·4		21·3		0·9	19·5	0·4	21·3	0·9	2	2	0	6
Oct. 1-16		11·0		0·3		15·3		1·0	20·4	0·6	22·4	1·2	3	3	2	8
17-31	7·7			0·2	6·1		0·2		29·1	0·5	23·4	0·7	6	4	2	3
Nov. 1-16		22·4	0·4			22·5		0·5	22·4	0·7	24·0	0·5	4	6	2	2
17-30		23·6		0·3		16·1		0·8	24·6	0·4	23·1	0·8	5	4	0	4
Dec. 1-16		28·6	0·3			19·9		0·5	28·6	0·4	22·4	0·5	7	2	1	0
17-31		12·7		0·4		9·5		0·6	12·7	0·5	10·4	0·6	1	0	0	1
TOTALS...	11·7	279·7	2·8	4·9	16·1	302·6	0·5	14·9	398·3	13·2	409·0	17·8	51	42	46	85
MEANS ...	− 11·2		− 0·1		− 11·9		− 0·6		16·6	0·6	17·0	0·7				

TABLE XXXVII.—Mean errors E_1, E_2 for 1924

CHITTAGONG

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. Time (minutes) +	H. W. Time (minutes) −	H. W. Height (feet) +	H. W. Height (feet) −	L. W. Time (minutes) +	L. W. Time (minutes) −	L. W. Height (feet) +	L. W. Height (feet) −	E_2 is without regard to sign — E_2 — H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time — H. W.	30 minutes of time — L. W.	1·0 foot of height — H. W.	1·0 foot of height — L. W.
Jan. 1-15		1·9		0·1		10·9		0·7	9·7	0·2	16·3	0·8	0	1	0	2
16-31		12·5		0·0		6·9		0·5	13·9	0·5	13·5	0·5	2	1	1	0
Feb. 1-15		4·1		0·1		5·3		0·8	11·7	0·4	10·7	0·8	1	0	0	5
16-29	9·6			0·0	5·4			0·2	11·9	0·4	7·2	0·4	1	1	0	0
Mar. 1-15	6·4		0·2		7·5			0·6	11·7	0·6	10·3	0·7	1	0	0	2
16-31		10·7	0·2			7·4		0·4	10·7	0·8	8·9	0·4	0	0	3	0
April 1-15		4·7		0·1		6·0		0·5	8·4	0·4	8·4	0·5	0	0	0	0
16-30		9·9	0·2			13·4		0·4	10·7	0·7	13·4	0·5	0	0	3	0
May 1-15		12·9	0·1			9·0		0·3	13·9	0·3	16·1	0·5	1	1	0	1
16-31		7·9	0·6			17·6		0·5	12·6	0·7	17·6	0·5	0	1	5	1
June 1-15		3·6		0·1		5·5		0·4	10·4	0·3	8·6	0·4	1	0	0	0
16-30	1·1			0·8		23·5		2·6	10·1	0·9	24·1	2·6	0	7	6	11
July 1-15		2·3		0·4		3·5		1·3	3·9	0·4	11·7	1·3	0	1	0	10
16-31		7·3		0·1		11·1		0·8	8·1	0·4	12·1	0·8	0	2	0	1
Aug. 1-15		1·5		0·2		15·1		1·0	10·1	0·5	16·4	1·1	0	2	0	5
16-31	8·0			0·2		6·6		1·4	12·1	0·3	9·3	1·4	0	0	0	8
Sept. 1-15		15·3	0·0			11·7		0·7	15·3	0·3	12·8	0·7	1	2	0	6
16-30		3·9	0·3			12·4		0·6	13·7	0·4	13·7	0·6	1	0	0	1
Oct. 1-15		29·1		0·6		21·7		1·1	29·1	0·7	21·7	1·1	7	3	2	7
16-31		25·3		0·2		22·3		1·1	25·3	0·6	22·3	1·1	5	2	3	7
Nov. 1-15		18·8		0·0		26·8		0·7	23·2	0·5	26·9	0·7	4	5	1	3
16-30		20·0		1·6		22·9		1·7	20·0	1·6	22·9	1·7	2	1	9	13
Dec. 1-15		21·5		0·5		14·4		0·9	21·5	0·5	20·4	0·9	2	4	1	6
16-31		9·3		0·6		8·6		0·9	10·6	0·6	10·5	0·9	0	0	0	7
TOTALS ...	25·1	322·5	1·6	5·6	12·9	282·6	0·0	20·1	328·6	13·0	355·8	20·9	29	34	34	99
MEANS ...	− 8·2		− 0·2		− 11·2		− 0·8		13·7	0·5	14·8	0·9				

TABLE XXXVIII.—Mean errors E_1, E_2 for 1922

AKYAB

PERIOD 1922	MEAN ERRORS — E_1 is with regard to sign — E_1 — H. W. — Time (minutes) +	−	H. W. — Height (feet) +	−	L. W. — Time (minutes) +	−	L. W. — Height (feet) +	−	E_2 is without regard to sign — E_2 — H. W. — Time (minutes)	H. W. — Ht. (feet)	L. W. — Time (minutes)	L. W. — Ht. (feet)	Number of errors exceeding — 30 minutes of time — H. W.	L. W.	0·8 foot of height — H. W.	L. W.
Jan. 1-16	4·4			0·0		5·6		0·1	4·9	0·2	5·6	0·2	0	0	0	0
17-31	5·0			0·1		5·3	0·2		5·0	0·3	5·3	0·3	0	0	1	1
Feb. 1-16	4·9			0·2		5·0		0·3	4·9	0·2	5·0	0·3	0	0	0	1
17-28	5·0			0·2		5·0	0·2		5·0	0·2	5·0	0·3	0	0	0	1
Mar. 1-16	4·8			0·3		3·8		0·2	4·8	0·3	6·2	0·2	0	0	0	0
17-31	5·0			0·3		5·0		0·1	5·0	0·4	5·0	0·2	0	0	0	0
April 1-16	4·8			0·2		3·8		0·1	4·8	0·2	5·0	0·3	0	0	0	0
17-30	5·0			0·6		4·6		0·5	5·0	0·6	4·6	0·5	0	0	2	3
May 1-16	4·9			0·4		5·2		0·3	4·9	0·4	5·2	0·5	0	0	0	0
17-31	5·0		0·1			5·0	0·3		5·0	0·2	5·0	0·3	0	0	1	2
June 1-16	5·0			0·3		4·9		0·1	5·0	0·4	4·9	0·2	0	0	0	0
17-30	4·9		0·2			5·0		0·1	4·9	0·2	5·0	0·2	0	0	0	0
July 1-16	4·4		0·1			5·1	0·1		5·0	0·2	5·1	0·2	0	0	0	0
17-31	4·3			0·2		5·0		0·6	5·0	0·3	5·0	0·7	0	0	1	5
Aug. 1-16	4·7			0·3		5·0		0·6	4·7	0·5	5·0	0·6	0	0	0	5
17-31	5·7		0·3			3·9		0·6	5·7	0·3	4·6	0·7	0	0	0	6
Sept 1-16	5·0		0·1			5·0	0·4		5·0	0·2	5·0	0·4	0	0	0	0
17-30	5·0		0·1			5·0		0·3	5·0	0·3	5·0	0·8	0	0	0	6
Oct. 1-16	4·7		0·0			4·4	0·0		4·7	0·2	5·0	0·5	0	0	0	2
17-31	5·0		0·1			5·0		0·3	5·0	0·2	5·0	0·7	0	0	0	5
Nov. 1-16	4·9			0·2		5·0	0·2		4·9	0·2	5·0	0·3	0	0	0	0
17-30	4·6		0·0			5·1	0·1		4·6	0·2	5·1	0·4	0	0	0	2
Dec. 1-16	5·0			0·3		4·4		0·2	5·0	0·4	5·1	0·4	0	0	2	2
17-31	4·3			0·3		4·3		0·1	5·0	0·3	4·9	0·2	0	0	0	0
TOTALS ...	116·3	0·0	1·0	3·9	0·0	115·4	1·5	4·5	118·8	6·9	121·6	9·4	0	0	7	41
MEANS ...	+ 4·8		− 0·1		− 4·8		− 0·1		5·0	0·3	5·1	0·4				

TABLE XXXIX.—Mean errors E_1, E_2 for 1923

AKYAB

PERIOD 1923	MEAN ERRORS: E_1 is with regard to sign — E_1 H. W. Time (minutes) +	−	H. W. Height (feet) +	−	L. W. Time (minutes) +	−	L. W. Height (feet) +	−	E_2 is without regard to sign — E_2 H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	Number of errors exceeding 30 minutes of time: H. W.	L. W.	0·8 foot of height: H. W.	L. W.
Jan. 1-16	5·3		0·0			4·4		0·1	5·3	0·1	5·0	0·2	0	0	0	1
17-31	5·0			0·2		5·3		0·1	5·0	0·2	5·3	0·2	0	0	0	0
Feb. 1-16	5·0			0·4		3·8		0·0	5·0	0·4	5·6	0·2	0	0	0	0
17-28	5·0		0·1			5·0	0·3		5·0	0·2	5·0	0·3	0	0	0	0
Mar. 1-16	5·0		0·2			5·3	0·3		5·0	0·3	5·3	0·4	0	0	0	1
17-31	5·0		0·0			5·0	0·0		5·0	0·2	5·0	0·2	0	0	0	0
April 1-16	5·0		0·1			4·4	0·7		5·0	0·2	5·0	0·7	0	0	0	3
17-30	5·0		0·2			5·0		0·1	5·0	0·2	5·0	0·6	0	0	0	5
May 1-16	5·0			0·5		4·4		0·3	5·0	0·8	5·0	0·5	0	0	5	2
17-31	5·0		0·5			5·0	0·2		5·0	0·5	5·0	0·2	0	0	1	0
June 1-16	5·0		0·2			5·6	0·2		5·0	0·3	5·6	0·3	0	0	1	0
17-30	5·0			0·2		5·4		0·3	5·0	0·3	5·4	0·4	0	0	0	0
July 1-16	5·0			0·0		5·0	0·0		5·0	0·4	5·0	0·2	0	0	0	0
17-31	5·0		0·0			3·0		0·1	5·0	0·3	5·0	0·4	0	0	0	0
Aug. 1-16	5·0		0·2			5·0		0·1	5·0	0·2	5·0	0·2	0	0	0	0
17-31	5·0		0·0			5·0	0·1		5·0	0·2	5·0	0·3	0	0	0	0
Sept. 1-16	5·0		0·4			5·0	0·3		5·0	0·4	5·0	0·3	0	0	0	0
17-30	5·0		0·1			5·0	0·3		5·0	0·2	5·0	0·3	0	0	0	0
Oct. 1-16	5·0		0·2			4·7		0·0	5·0	0·2	4·7	0·3	0	0	0	0
17-31	4·7		0·3			4·7	0·5		4·7	0·3	5·3	0·5	0	0	0	0
Nov. 1-16	4·9		0·4			5·1	0·2		4·9	0·4	5·1	0·4	0	0	1	1
17-30	5·0			0·1		5·0	0·2		5·0	0·1	5·0	0·3	0	0	0	0
Dec. 1-16	5·0		0·3			5·0	0·3		5·0	0·3	5·0	0·3	0	0	0	0
17-31	8·9		0·1		2·7		0·2		8·9	0·2	9·4	0·3	0	0	0	0
TOTALS ..	123·8	0·0	3·3	1·4	2·7	111·1	3·8	1·1	123·8	6·9	126·7	8·0	0	0	8	1[illegible]
MEANS ...	+ 5·2		+ 0·1		− 4·5		+ 0·1		5·2	0·3	5·3	0·3				

TABLE XL.— Mean errors E_1, E_2 for 1924

AKYAB

PERIOD 1924	MEAN ERRORS — E_1 is with regard to sign — E_1								MEAN ERRORS — E_2 is without regard to sign — E_2				Number of errors exceeding 30 minutes of time		Number of errors exceeding 0·8 foot of height	
	H. W. Time (minutes)		H. W. Height (feet)		L. W. Time (minutes)		L. W. Height (feet)		H. W. Time (minutes)	H. W. Ht. (feet)	L. W. Time (minutes)	L. W. Ht. (feet)	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15	15·6			0·1	12·0			0·1	15·6	0·2	12·0	0·2	0	0	0	0
16-31	9·6			0·0	9·6		0·0		9·6	0·2	9·6	0·2	0	0	0	0
Feb. 1-15	6·7			0·1	6·5		0·0		6·7	0·2	6·7	0·2	0	0	0	0
16-29	6·8			0·0	4·1		0·1		6·8	0·2	5·6	0·2	0	0	0	0
Mar. 1-15	5·9			0·3	4·2			0·2	5·9	0·3	4·9	0·2	0	0	0	0
16-31	6·1			0·3	3·9			0·3	6·1	0·3	4·3	0·4	0	0	0	1
April 1-15	6·1			0·3	3·7			0·0	6·1	0·3	4·8	0·3	0	0	0	0
16-30	5·2			0·2	4·7			0·2	5·2	0·2	4·7	0·4	0	0	0	0
May 1-15	6·6		0·0		5·5			0·2	6·6	0·2	5·5	0·2	0	0	0	0
16-31	6·3		0·1		4·6			0·1	6·3	0·1	5·0	0·3	0	0	0	0
June 1-15	5·5			0·1	4·3			0·2	5·5	0·2	4·3	0·4	0	0	0	2
16-30	5·6			0·3	5·7			0·2	5·6	0·3	5·7	0·3	0	0	0	1
July 1-15	6·9		0·1		6·8		0·2		6·9	0·2	6·8	0·3	0	0	0	1
16-31	7·1			0·2	6·6		0·0		7·1	0·2	6·6	0·1	0	0	0	0
Aug. 1-15	6·3			0·0	6·3			0·0	6·3	0·2	6·3	0·2	0	0	0	0
16-31	6·6		0·0		6·7		0·0		6·6	0·3	6·7	0·3	0	0	0	0
Sept. 1-15	7·5			0·0	5·5			0·0	7·5	0·3	5·5	0·2	0	0	0	0
16-30	6·1		0·0		5·9		0·2		6·1	0·2	5·9	0·3	0	0	0	0
Oct. 1-15	6·8			0·6	6·8			0·4	6·8	0·6	6·8	0·4	0	0	5	1
16-31	7·8			0·1	6·2		0·0		7·8	0·2	6·2	0·3	0	0	1	1
Nov. 1-15	7·7			0·1	7·2			0·0	7·7	0·3	7·2	0·4	0	0	0	1
16-30	7·1			0·7	6·5			0·8	7·1	0·7	6·5	0·9	0	0	4	9
Dec. 1-15	7·2			0·2	5·7			0·1	7·2	0·2	5·7	0·3	0	0	0	1
16-31	7·0			0·2	5·6			0·3	7·0	0·2	5·6	0·3	0	0	0	0
TOTALS...	170·1	0·0	0·2	3·8	144·6	0·0	0·5	3·1	170·1	6·3	148·9	7·3	0	0	10	18
MEANS ...	+ 7·1		− 0·2		+ 6·0		− 0·1		7·1	0·3	6·2	0·3				

(iii) Observatory Section

51. *Meteorological observations.* Meteorological observations were continued as usual, except that the hour of observation has been changed from 14 hours to 10 hours from February 1923.

52. *Seismograph observations.* The Omori Seismograph was in operation throughout the period 1922-25. Details of the earthquakes recorded are tabulated below, and the distances from Simla derived from the record of Simla seismographs are given where available.

Particulars of earthquakes recorded are sent to Professor H. H. Turner, F.R.S., University Observatory, Oxford, for inclusion in the British Association bulletins.

Earthquakes recorded at Dehra Dūn during the years 1922-25

No.	Month & date	Time of beginning		Duration	Distance of Epicentre		Remarks
		Dehra	Simla		Dehra	Simla	
		hr m	hr m	minutes	miles	miles	
1	15 - 10 - 1922	5 - 25	5 - 31	44	4000	2000	Moderate
2	17 - 10 - 1922	21 - 36	21 - 35	26	910	1000	"
3	11 - 11 - 1922	10 - 22½	10 - 23	...	3430	Anti-podes	Violent
4	6 - 12 - 1922	19 - 28½	19 - 27	43	500	300	Great
5	17 - 12 - 1922	6 - 24½	...	30	370	...	Moderate
6	3 - 2 - 1923	10 - 49	...	80	4500	...	Great
7	4 - 2 - 1923	21 - 43	...	180	2200	...	Violent
8	3 - 3 - 1923	22 - 29	22 - 28	66	3400	3500	Moderate
9	23 - 5 - 1923	7 - 2½	...	73	1600	...	Moderate
10	23 - 6 - 1923	12 - 18	...	81	1600	...	Great
11	14 - 7 - 1923	16 - 52	...	60	4500	...	"
12	1 - 9 - 1923	8 - 37½	...	120	3200	...	"
13	2 - 9 - 1923	8 - 27	...	76	4500	...	"
14	10 - 9 - 1923	3 - 37	...	60	1100	...	"
15	23 - 9 - 1923	2 - 21	...	...	1500	...	"
16	1 - 10 - 1923	4 - 42	...	15	200	...	Slight

Earthquakes recorded at Dehra Dūn during the years 1922-25—(Concld.) 52. *(Contd.)*

No.	Month & date	Time of beginning		Duration	Distance of Epicentre		Remarks
		Dehra	Simla		Dehra	Simla	
		hr m	hr m	minutes	miles	miles	
17	1 - 10 - 1923	13 - 47½	13 - 48	30	500	400	Moderate
18	2 - 10 - 1923	16 - 55	...	19	250	...	Slight
19	7 - 10 - 1923	9 - 08	...	...	1800	...	Moderate
20	15 - 1 - 1924	02 - 30	2 - 30	78	3800	3500	„
21	14 - 4 - 1924	21 - 59	...	196	1600	...	Great
22	26 - 6 - 1924	07 - 26	...	139	1800	...	Moderate
23	7 - 7 - 1924	0 - 3	0 - 4	48	600	600	„
24	12 - 7 - 1924	01 - 16	...	100	450	...	Violent
25	30 - 8 - 1924	8 - 44	8 - 44	69	3300	3500	Considerable
26	13 - 9 - 1924	20 - 10	20 - 10½	73	2800	2100	Moderate
27	16 - 9 - 1924	08 - 09	8 - 8	30	700	650	„
28	17 - 9 - 1924	15 - 52	15 - 53	16	650	500	Slight
29	9 - 10 - 1924	02 - 06	2 - 6	37	700	700	Moderate
30	13 - 10 - 1924	21 - 50	21 - 49·5	34	200	300	Moderate
31	18 - 1 - 1925	17 - 46	17 - 46	61	4600	4000	Moderate
32	16 - 3 - 1925	20 - 14	20 - 17	43	1700	1500	Moderate
33	19 - 8 - 1925	17 - 47	...	70	5500	...	Moderate
34	5 - 9 - 1925	22 - 36	...	16	700	...	Slight
35	9 - 9 - 1925	12 - 56	...	3½	140	...	Slight
36	24 - 9 - 1925	10 - 15	...	30	1800	...	Slight
37	29 - 9 - 1925	3 - 17	...	4	350	...	Very slight

53. *Solar photography.*

Photographs of the sun were taken in 1922-23 on 306 days; for the remaining days of the year no photograph could be taken as the sun was obscured by clouds. In 1923-24, photographs were taken only on 274 days, for 43 days the dome was under repair and for the remaining days the sun was not visible. In 1924-25, photographs were taken on 243 days from 1-10-24 to 30-6-25 when work was discontinued. For 30 days no photographs were taken as the sun was invisible.

54. **Cessation of solar photography.** After correspondence with the Director of the Science Museum, South Kensington, London, it was decided to discontinue the taking of solar photographs at Dehra Dūn with effect from 1st July 1925.

The work was originally taken up at the request of Mr. Norman Lockyer (afterwards Sir Norman Lockyer). The original object was a comparative study of terrestrial and solar spectra, the incidence of sun spots, their connection with magnetic storms and rainfall (Maldrum theory) and other terrestrial phenomena.

Observations were begun in 1878 under Mr. Hennessey's direction, Mr. C. Meins being appointed solar photographer by the Secretary of State for India on a salary of Rs. 250/- per mensem which was paid by the Imperial Department of Industry, Science and Art. On Mr. Meins' death, Mr. L. A. Clarke, Surveyor 2nd grade, was appointed solar photographer and the whole expense of maintenance devolved on the Survey of India.

The photographs were first taken in the Walker Observatory with a small instrument and the results were only 4 inches in diameter. An enlarging contrivance was afterwards fitted, by means of which photos of eight-inch diameter were obtained. A sun shine recorder was also set up in 1880 and actinometer observations were occasionally taken. In 1882, a larger telescope was received from England for taking photos 12 inches in diameter and this was erected in the Hennessey Observatory which was completed in 1883. The 8-inch pictures were utilised for measuring the areas of spots and faculae, while the 12-inch ones served for studying the mottling or granular appearance of the photosphere and the structure of the penumbra of the spots. Solar photographs were taken on every day of the year when the sun was visible and the negatives were sent to England every week. These photographs supplemented those taken at Greenwich and were utilised by the Solar Physics Committee, South Kensington, and the Astronomer Royal for obtaining the information and measurements they required.

As solar photography has little direct bearing on any of the activities of the Survey of India, and its upkeep necessitated a considerable amount of expenditure which could be more profitably spent on work in which the Survey of India is more directly interested, and moreover, as a much better equipped observatory has been established in the meantime at Kodaikānal, it was decided to discontinue the work with effect from 30th June 1925.

The part which the Dehra Dūn solar photo-observatory has played in the researches of solar physics may be gathered from the letter of Colonel H. G. Lyons, R.E., F.R.S., Director, Science Museum, South Kensington, quoted below.

"They (the Astronomer Royal and the Director of Solar Physics Observatory) both regret that it should be necessary to discontinue the invaluable contribution to solar physics which the Survey of India has made for the past 47 years. The work which was carried out at Dehra Dūn was of the greatest value to the Solar Physics Observatory while it was at South Kensington, and astronomical science is very deeply indebted to the Survey of India for the excellent scientific material it has contributed to the study of its problems during almost half a century." 54. (*Contd.*)

Solar photographs taken at Dehra Dūn during the years 1922-24

Month	No. of days	8" Negatives		No. of days on which sun was invisible
		Good	Bad	
October 1922 ...	31	57	3	nil
November ...	30	56	4	"
December ...	26	45	3	5 days
January 1923 ...	25	44	6	6 days
February ...	18	30	2	10 days
March ...	27	47	2	4 days
April ...	30	54	4	nil
May ...	30	56	2	1 day
June ...	29	47	2	1 day
July ...	22	33	1	9 days
August ...	17	23	3	14 days
September ...	21	34	8	9 days
October ...	25	44	3	6 days
November ...	30	55	6	nil
December ...	27	48	4	4 days
January 1924 ...	25	43	5	6 days
February ...	23	40	2	6 days
March ...	29	49	nil	2 days
*April ...	7	12	2	nil
*May ...	9	16	1	"
June ...	28	46	4	2 days
July ...	23	30	2	8 days
August ...	24	30	5	7 days
September ...	24	39	3	6 days
Total ...	580	978	77	106 days

* Work was not done for 45 days on account of making new dome of the Observatory.

54. *(Contd.)*

Solar photographs taken at Dehra Dūn during the year 1924-25

Month		No. of days	8″ Negatives		No. of days on which sun was invisible
			Good	Bad	
October 1924	...	30	55	3	1 day
November	...	29	52	3	1 day
December	...	24	40	5	7 days
January 1925	...	26	47	4	5 days
February	...	24	40	4	4 days
March	...	31	52	6	nil
April	..	30	55	5	,,
May	...	27	49	3	4 days
June	...	22	33	1	8 days
Total	...	243	423	34	30 days

55. *Time observations.*

For many years time observations have been made regularly in the Walker Observatory, the time service being used for magnetic observations and for general purposes. One of the two reversible transits by Messrs. Troughton and Simms obtained for the Indo-European longitude arcs of 1894-95-96 have been employed. Special observations for longitude have been made on two occasions.

(1) In 1913-14, work was done in connection with the De Filippi Expedition to the Kara-koram, wireless signals being received from Lahore by members of the expedition and simultaneously at Dehra Dūn whereby the longitude differences were deduced.

(2) In 1921, wireless time signals were received from Paris, Eiffel Tower, and a direct value of the Dehra Dūn longitude derived, as follows; it refers to the meridian pillar of transit instrument of the Walker Observatory. The Haig Observatory meridian is 7·46 seconds further to the east.

5 hrs. 12 mins. 11·220 seconds (weighted mean 5 successful nights) by Dr. Hunter
5 hrs. 12 mins. 11·383 seconds (weighted mean 2 successful nights) by Major Mason } by wireless.
5 hrs. 12 mins. 11·267 seconds by Sir Sidney Burrard, and Sir Gerald Lenox-Conyngham in 1894-96 by ordinary telegraph by land and sea. The weighted mean, Hunter, Mason, gives an identical result.

56. *New Riefler Clock.*

It had been felt with increasing force that the personal equation of the observer precluded the accuracy that was desirable in such operations. The transit instrument was not fitted with an impersonal micrometer, nowadays regarded as essential. Further the astronomical clocks, though excellent for their period, were old and of much lower precision than others now available. 56. (Contd.)

Accordingly after certain enquiries, a Riefler clock was indented for in August 1920. The Astronomer Royal for Scotland, Professor R. A. Sampson, F.R.S., an eminent authority on such matters, was invited to test this clock and report on its behaviour. This he most generously undertook and the clock was set up at the Royal Observatory, Edinburgh, in April 1922 and kept under observation for 11 months. A statement of its rate during this period was furnished by Professor Sampson ; and the clock was sent out to India, arriving at Dehra Dūn in August 1923. Special housing was necessary for this Riefler clock : for it must be kept in a room in which the temperature is controlled. In April 1924 an inner cell was built in the annular space in the base of the Hennessey Observatory : and this was enclosed in turn. The clock was erected in August 1924. The temperature in the inner cell is controlled by a thermostat which actuates alternatively a radiator or a fan. When the fan is in action, air is drawn in from the outer cell where temperature should be maintained somewhat lower than the perennially fixed temperature of the inner cell (80° F.). The outer cell is served by an excavating fan which during the hot weather draws out the air, and thereby causes the inflow of cold air from the outside of the building. This fan comes into action automatically when the outer temperature sinks below a certain value, provided the cell temperature is above another fixed value. Two thermostats are employed for this purpose This latter arrangement was not completed in the period under report, and some variations in the inner cell temperature have occurred. The clock rate and temperature of the clock cell are tabulated below :—

Date 1925		Cell temperature	Clock rate	Pressure	Clock temperature	Remarks
April	1	F.°			C.°	
	8	75·5	−0·16	607	24·0	
	14	75·8	−0·36	627	24·1	Pressure decreased to 590
	24	77·3	+0·01	604	25·0	„ increased to 582
	30	79·5	+0·14	597	26·0	
May	6	78·5	+0·03	603	25·5	
	13	77·4	−0·01	607	26·0	Pressure decreased to 590
	21	77·9	+0·03	591	25·8	} Artificial cooling from
	28	82·5	+0·04	596	27·8	} 21st to 27th May 1925
June	4	84·0	+0·09	598	28·5	}
	11	83·9	+0·12	599	28·5	} Wiring and electrical
	20	82·5	+0·08	599	27·8	} connections for ther-
	25	81·7	+0·10	600	27·3	} mostats in hand
July	7	81·1	+0·16	598	27·1	}
	18	80·8	+0·19	597	26·9	
Aug.	3	83·1	+0·18	601	28·4	
	18	80·3	+0·23	596	26·6	
	26	81·4	+0·12	597	27·3	
Sept.	4	81·6	+0·20	598	27·3	
	11	81·1	+0·24	597	27·1	
	28	80·8	+0·23	597	26·9	

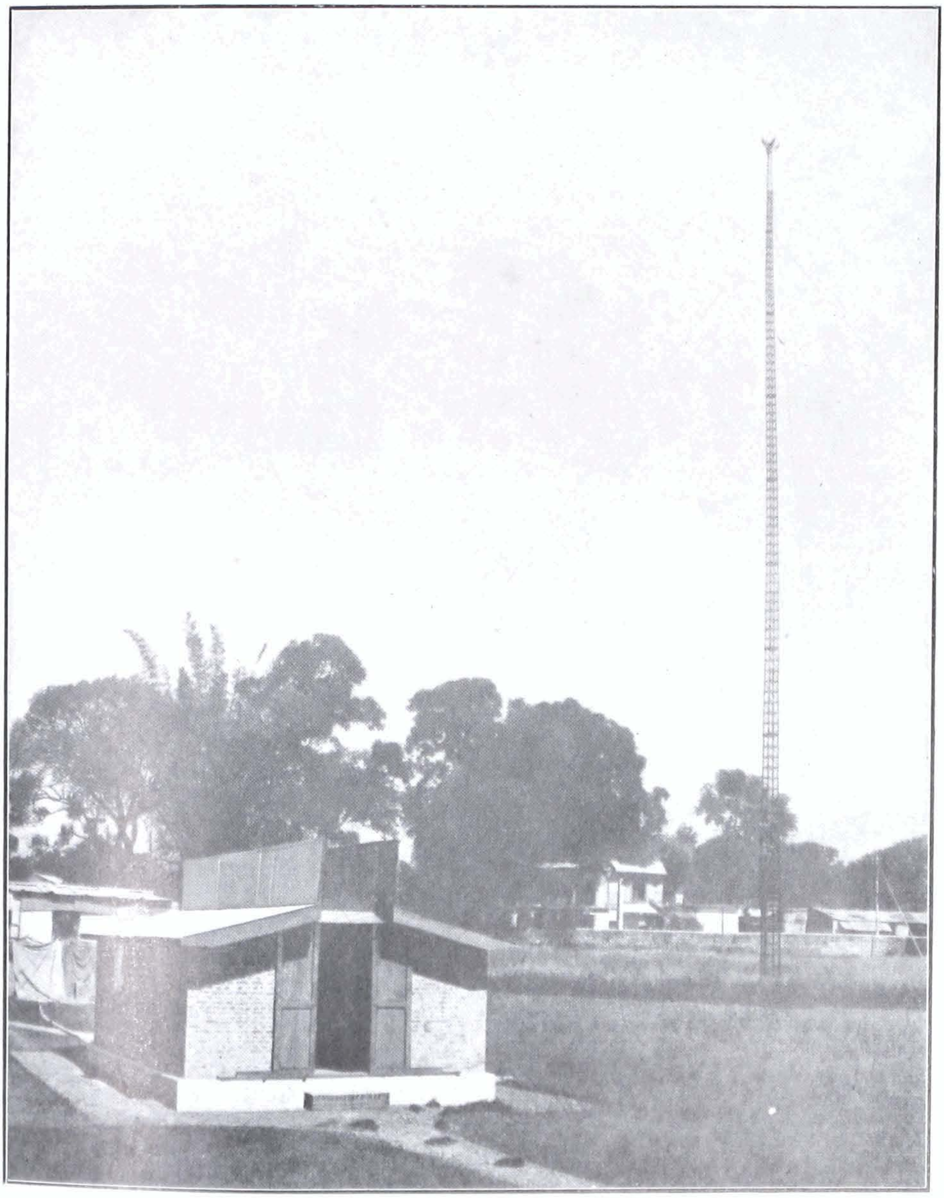
57. *Impersonal micrometers.* Impersonal micrometers were indented for, for the two reversible transits in 1924. They were received in 1925.

58. *International longitude project.* In recent years international action has been taken to secure the simultaneous determination of longitude arcs encircling the earth, by the greatly extended facilities provided by wireless telegraphy. General Ferrié put forward a tentative scheme at the meeting of the International Union of Geodesy and Geophysics at Rome in 1922. A mixed Commission was formed from members of this Union and that of the International Union of Astronomy, Dr. Hunter being one of the members of this commission. The matter was then reviewed and discussed at the geodetic meeting at Madrid in 1924, and at the astronomical meeting at Cambridge in 1925; and at the latter place a definite decision to execute the work in October and November 1926 was arrived at. Dehra Dūn is to be one of the principal receiving stations. Time signals will be emitted from Bordeaux, Honolulu, Saigon and Annapolis (Washington). They will be received and timed at the participating stations. This project has made the accurate determination and maintenance of time at Dehra Dūn of primary importance. It would not have been feasible without the recent instrumental additions briefly alluded to above.

59. *Hunter time observatory.* The transit room in the Walker Observatory was of old design and not really satisfactory for modern high class time determination. In other old established observatories, unexplained discrepancies in time determination have been brought to light by the reception, by several of them, of indentical wireless time signals. A possible source of error is lateral refraction. In the Walker Observatory there is the large dome of the solar telescope close by on the east; further, the room is unduly lofty. It was accordingly decided to erect a smaller but better placed time observatory. In the design of this, great importance was attached to complete symmetry and also to freedom from disturbance by large trees. A site was selected on the meridian of the Haig Observatory and midway between that and the Burrard Observatory: the new observatory begun in 1924 was completed in 1925.

Magnetic Observations

60. *Magnetic operations during the field season 1922-23.* For the purpose of comparison of instruments complete sets of magnetic observations were taken at the Dehra Dūn, Toungoo, Alibag (Bombay) and Kodaikānal observatories, the two latter being under the control of the Meteorological Department. Double sets of observations of dip, declination and horizontal force were taken during the field season at the following repeat stations :—Quetta, Karāchi, Bīna, Dibrugarh, Barrackpore, Waltair and Moulmein. The first 6 stations were also visited during the field season 1921-22 in order to supplement the 5-yearly observations at all the repeat stations in India for obtaining accurate values of the average annual changes in the magnetic elements



HUNTER OBSERVATORY.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1927.

The headquarters staff of the party was employed during the field season on the reduction of observations to the epochs 1909·0 and 1920·0. The observations of Dr. de Graaff Hunter taken in 1922 at Kew Observatory and Val Joyeux with Magnetometer No. 10 were now available, and afforded a means of reducing the results of the magnetic observations in India in terms of the British standard at Kew. The party also carried out the inspection of the tidal observatories at Bombay (Apollo Bandar), Karāchi, Madras, Kidderpore (Calcutta), Rangoon and Moulmein during the field season. 60. *(Contd.)*

The computations of the observations taken at some of the repeat stations and at observatories for the comparisons of instruments were completed. 61. *Work during the recess 1922-23.*

The final reduction of the observations at the observatories, in the field and at repeat stations to the epochs 1909·0 and 1920·0 was completed, and the tables of results with the necessary maps were sent to the press for publication in the Records of the Survey of India, Volume XIX (Magnetic Survey).

In the beginning of 1923, it was decided for reasons of economy to curtail magnetic work and accordingly the party and the magnetic observatory at Toungoo were closed in October 1923. The magnetic observatory at Dehra Dūn was the only observatory kept going, and was transferred to the control of the Officer in charge, Computing and Tidal Party.

Except for some stoppages in the driving clock of the H. F. and declination magnetographs during the months June-September 1923, the magnetographs worked very satisfactorily and required hardly any adjustments. The clock was removed, cleaned and repaired on two different occasions during the above period. 62. *Dehra Dun magnetic observatory 1922-23.*

The observatory was not inundated during the year though there was percolation of some water into the passage on 4th September 1923, which was promptly baled out.

The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and the accepted value of $\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$. The values of the moment "m" were derived from vibration observations taken with the chronograph. 63. *Mean values of the declination and H.F. constants.*

63
(Contd.)

Mean values of the constants of Magnet No. 17 at Dehra Dūn in 1922

Months	Declination constants	H. F. Constants				
	Mean magnetic collimation	Distribution factors			Mean values of m	
		$P_{1\cdot2}$	$P_{2\cdot3}$	$\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)-1$	Monthly means	Accepted m
January ...	− 6′ 58″	5·91	6·69	1·99407 throughout	806·92	806·91
February ..	− 7 02	5·98	6·70		·96	
March ...	− 7 07	5·99	6·90		85	
April ...	− 7 04	5·94	6·61		·95	
May ...	− 7 00	5·98	6·70		·67	806·49
June ...	− 7 07	5·99	6·61		·33	
July ...	− 7 03	6·10	6·70		·42	
August ...	− 7 01	6·20	6·66		·33	
September ...	− 6 59	6·24	6·65		·30	
October ...	− 7 06	6·09	7·00		·32	
November ...	− 6 58	6·07	6·85		·64	
December ...	− 6 51	6·15	6·81		·77	

64. *Mean base line values.*

The table below gives the mean monthly observed and accepted values of the declination and horizontal force base lines; the accepted values have been used to compute the values of the elements for 1922.

Base line values of magnetographs at Dehra Dūn in 1922

Months	Declination		Horizontal Force		Remarks
	Mean value of base line	Base line accepted	Mean value of base line	Base line accepted	
	° ′	° ′	C. G. S.	C. G. S.	
January ...	1 4·8	1 4·8	·32666	·32666	
February ...	1 5·0	1 5·0	·32662	·32662	
March ...	1 5·3	1 5·3	·32664	·32664	
April ...	1 5·2 (a) 1 5·7 (b)	(a) 1 5·2 (b) 1 5·7	·32667	·32667	(a) to 21st April (b) to 8th May
May ..	1 6·4 (c)	(c) 1 6·4	·32656	·32656	(c) from 9th May
June ..	1 6·4	1 6·4	·32657	·32657	
July ...	1 5·8	1 5·8	·32650	·32650	
August ...	1 6·0	1 6·0	·32652	·32652	
September ...	1 6·2	1 6·2	·32650	·32650	
October ...	1 6·6	1 6·6	·32649	·32649	
November ...	1 6·1	1 6·1	·32643	·32643	
December ...	1 5·7	1 5·7	·32637	·32637	

The mean scale values for 1922 for an ordinate of 1/25 inch are:— 65. *Mean scale values and temperature range.*

Horizontal Force	4·35 gammas.
Declination	1·03 minutes.
Vertical Force	6·17 to 7·94 gammas.

The mean temperature for the year was 27°·0 C., with maximum and minimum monthly values of 27°·3 C. and 26°·7 C. The temperature of reduction is 27°·0 C.

The following table shows the monthly mean values of the magnetic elements for 1921 and 1922 and the annual changes for that period. 66 *Mean monthly values and annual changes.*

Annual changes at Dehra Dūn in 1921-1922

Months	Horizontal Force ·32000 C.G.S. +			Declination E. 1° +			Dip N. 45° +			Vertical Force ·32000 C.G.S. +		
	1921	1922	Annual change	1921	1922	Annual change	1921	1922	Annual change	1921	1922	Annual change
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January ...	946	936	−10	48·9	44·8	−4·1	2·3	6·6	+4·3	990	1062	+72
February ..	953	933	−20	48·6	44·5	−4·1	2·2	6·9	+4·7	995	1066	+71
March ...	956	935	−21	48·3	44·4	−3·9	2·6	7·4	+4·8	1007	1076	+69
April ...	960	939	−21	47·7	43·9	−3·8	2·9	7·6	+4·7	1016	1084	+68
May ...	938	931	−7	47·5	44·1	−3·4	4·4	7·6	+3·2	1022	1076	+54
June ...	945	936	−9	47·2	43·8	−3·4	4·5	7·8	+3·3	1030	1086	+56
July ...	954	926	−28	46·7	43·0	−3·7	4·4	8·6	+4·2	1039	1092	+53
August ...	942	922	−20	46·4	42·9	−3·5	5·0	9·5	+4·5	1037	1105	+68
September .	940	917	−23	46·1	42·5	−3·6	5·3	9·7	+4·4	1041	1103	+62
October ..	936	916	−20	46·1	42·5	−3·6	5·5	10·4	+4·9	1042	1115	+73
November ...	935	919	−16	45·8	41·5	−4·3	5·6	10·1	+4·5	1042	1113	+71
December ...	929	915	−14	45·4	40·9	−4·5	6·1	10·6	+4·5	1046	1118	+72
Means ...	945	927	−17	47·1	43·2	−3·8	4·2	8·6	+4·3	1026	1091	+66

The magnetographs worked very satisfactorily during the year under report and there were only two adjustments for light in the vertical and one in the horizontal force magnetographs during this period. 67. *Toungoo magnetic Observatory 1922-23.*

Slight repairs to the magnetograph house were carried out on the 9th and 13th July 1923.

68. *Mean values of the declination and H. F. constants.*

The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and the provisional value of the factor $\log\left(1 + \frac{P}{r^2} + \frac{Q}{r^4}\right)^{-1}$. The values of the moment "m" were derived from vibration observations taken with the eye.

Mean values of the constants of Magnet No. 20 at Toungoo in 1922

Months	Declination constants	H. F. Constants				
	Mean magnetic collimation	Distribution factors			Mean values of m	
		$P_{1\cdot2}$	$P_{2\cdot3}$	$\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$	Monthly means	Accepted m
	′ ″					
January ...	−7 16	7·01	7·45	$\bar{1}$·99396 throughout	931·26	931·23 (January to July)
February ...	−7 20	7·02	7·49		·30	
March ...	−7 23	6·91	7·59		·27	
April ...	−7 27	6·84	7·56		·20	
May ...	−7 22	6·96	7·51		·10	
June ...	−7 26	6·93	7·55		·12	
July ...	−7 24	7·02	7·33		·33	
August ...	−7 24	6·92	7·41		18	931·14 (August to December)
September ...	−7 20	7·03	7·52		·10	
October ...	−7 23	7·10	7·38		·14	
November ...	−7 24	7·10	7·59		·13	
December ...	−7 26	7·07	7·50		·13	

69. *Mean base line values*

The table below gives the mean monthly observed and accepted base line values of the declination and horizontal force magnetographs: the accepted values have been used to compute the values of these elements for 1922. The horizontal force base line values have been derived from H as determined with the moment of inertia obtained for Magnet No. 20 at Toungoo in February 1921 and the provisional value of the distribution factor $\log\left(1 + \frac{P}{r^2} + \frac{Q}{r^4}\right)^{-1}$ mentioned in the previous table.

Base line values of magnetographs at Toungoo in 1922

Months	Declination		Horizontal Force		Remarks
	Mean value of base line	Base line accepted	Mean value of base line	Base line accepted	
	° ′	° ′	C. G. S.	C. G. S.	
January ...	1 14·5	1 14·5	·38911	·38911	Monthly base line values are used in computations.
February ...	1 13·9	1 13·9	·38914	·38914	
March ...	1 13·8	1 13·8	·38912	·38912	
April ...	1 13·6	1 13·6	·38919	·38919	
May ...	1 14·1	1 14·1	·38925	·38925	
June ...	1 14·1	1 14·1	38920	·38920	
July ...	1 14·2	1 14·2	·38917	·38917	
August ...	1 14·0	1 14·0	·38913	·38913	
September ...	1 14·3	1 14·3	·38916	·38916	
October ...	1 14·2	1 14·2	·38911	·38911	
November ...	1 14·1	1 14·1	·38909	38909	
December ...	1 14·0	1 14·0	·38906	·38906	

The mean scale values for 1922 for an ordinate of 1/25 inch are :— 70. *Mean scale values and temperature range.*

Horizontal Force	5·22 gammas.
Declination	1·04 mintues.
Vertical Force	5·88 gammas.

The mean temperature for the year was 89°·1 Fahr. with maximum and minimum monthly values of 90°·5 Fahr. and 88°·0 Fahr. The temperature of reduction is 89°·0 Fahr.

The table below shows the monthly mean values of the magnetic elements for 1921 and 1922 and the annual changes for that period. The annual changes for horizontal force are deduced from the values of H corrected for the moment of inertia and distribution factor as referred to in para 68. 71. *Mean monthly values and annual changes.*

Annual changes at Toungoo in 1921-22

Months	Horizontal Force ·39000 C.G.S. +			Declination W. 0° +			Dip N. 23° +			Vertical Force ·16000 C.G.S +		
	1921	1922	Annual change	1921	1922	Annual change	1921	1922	Annual change	1921	1922	Annual change
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January ...	125	131	+ 6	25·6	29·1	+ 3·5	7·2	7·4	+ 0·2	704	709	+ 5
February ...	139	137	− 2	25·6	28·8	+ 3·2	7·0	7·5	+ 0·5	707	713	+ 6
March ...	142	138	− 4	25·4	28·9	+ 3·5	6·8	7·5	+ 0·7	706	714	+ 8
April ...	143	150	+ 7	25·7	29·0	+ 3·3	6·8	7·2	+ 0·4	707	716	+ 9
May ...	117	162	+ 45	26·0	29·3	+ 3·3	6·4	7·4	+ 1·0	690	723	+ 33
June ...	122	165	+ 43	26·4	29·4	+ 3·0	6·7	7·0	+ 0·3	697	719	+ 22
July ...	132	160	+ 28	26·9	29·6	+ 3·0	6·7	7·0	+ 0·3	701	717	+ 16
August ...	128	157	+ 29	27·1	29·8	+ 2·7	7·1	7·2	+ 0·1	704	718	+ 14
September ...	132	163	+ 41	27·6	30·3	+ 2·7	7·3	7·0	− 0·3	708	718	+ 10
October ...	131	162	+ 31	28·0	30·5	+ 2·5	7·4	7·0	− 0·4	710	718	+ 8
November ...	135	172	+ 37	28·1	30·7	+ 2·6	7·2	6·9	− 0·3	708	720	+ 12
December ...	134	173	+ 39	28·6	30·9	+ 2·3	7·2	6·8	− 0·4	708	719	+ 11
Means ...	132	156	+ 25	26·8	29·7	+ 3·0	7·0	7·2	+ 0·2	704	717	+ 13

72 *Kodaikanal Observatory 1922-23.* Of the three magnetographs the declination one has worked very satisfactorily, and except for losses consequent on the stoppage of the common driving clock, has shown no interruption due to any other cause. This clock stopped for frequent intervals on five different occasions during the year, and the light failed for a few hours on 31st August 1923. The V.F. clock has given constant trouble by frequent stoppages, and although it was removed, cleaned and adjusted once in February and again in September 1923, has shown little improvement. The light of this magnetograph was adjusted several times during October and November 1922, due to the sudden falling down of the ordinates. The earth inductor and the galvanometer gave some trouble during July 1923 and were adjusted by the Director.

73. *Mean values of the declination and H. F. constants.* The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and the distribution factor $\log\left(1 + \frac{P}{r^2} + \frac{Q}{r^4}\right)^{-1}$. The values of the moment "m" in this table were derived from vibration observations taken with the chronograph and from the moment of inertia used for the computations in 1915.

Mean values of the constants of Magnet No. 16 at Kodaikānal in 1922 73. (*Contd.*)

Months	Declination constants	H. F. Constants				
	Mean magnetic collimation	Distribution factors			Mean values of m	
		$P_{1 \cdot 2}$	$P_{2 \cdot 3}$	$\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$	Monthly means	Accepted m
	′ ″					
January ...	−3 17	6·35	8·35	$\bar{1}$·99301 throughout	882·15	881·74 throughout
February ...	−3 17	6·35	8·51		·15	
March ...	−3 19	6·30	8·17		·07	
April ...	−3 18	6·32	8 38		·01	
May ..	−3 19	6·21	8 45		·02	
June ...	−3 20	6·33	8·25		·10	
July ...	−3 21	6·35	8·43		·15	
August ...	−3 20	6·26	8 35		·14	
September ...	−3 22	6·31	8·38		·15	
October ...	−3 20	6·40	8·29		·17	
November ...	−3 21	6·38	8 36		·17	
December ...	−3 22	6·35	8·70		·17	

74. *Mean base line values.*

The table below gives the mean monthly observed and accepted base line values of the declination and horizontal force megnetographs: the accepted values have been used to compute the values of the elements for 1922. The horizontal force base line values have been derived from H as determined with the moment of inertia used in the computations for 1915.

Base line values of magnetographs at Kodaikānal 1922

Months	Declination		Horizontal Force		Remarks
	Mean values of Base line	Base line accepted	Mean values of Base line	Base line accepted	
	° ′	° ′	C. G. S.	C. G. S.	
January ...	2 57·3 2 58·3	(*a*) 2 57·3 (*b*) 2 58·3	·37335	·37335	(*a*) up to 16h (*b*) to end. (*c*) to 10hr. on 21st. (*d*) from 11hr. on 21st. (*e*) to 8hr. on 24th. (*f*) from 9hr. on 24th. (*g*) for 1st. (*h*) up to 21st (*i*) to end.
February ...	2 58·4 2 57·4	(*c*) 2 58·4 (*d*) 2 57·4	·37335	·37335	
March ...	2 57·6	2 57·6	·37328 ·37601	(*g*) ·37328 (*h*) ·37598 (*i*) ·37607	
April ...	2 57·5	2 57·5	·37611	·37611	
May ...	2 57·6	2 57·6	·37610	·37610	
June ...	2 57·8	2 57·8	·37606	·37606	
July ...	2 57·6	2 57·6	·37603	·37603	
August ...	2 57·6	2 57·6	·37608	·37608	
September ...	2 57·9 2 50·1	(*e*) 2 57·9 (*f*) 2 50·1	·37601	·37601	
October ...	2 49·7	2 49·7	·37602	·37602	
November ...	2 49·4	2 49·4	·37600	·37600	
December ...	2 49·3	2 49·3	·37599	·37599	

The table below gives the monthly mean values of the magnetic elements for 1921 and 1922 and the annual changes for that period. The annual changes for horizontal force are derived from the moment of inertia used in the computations for 1915.

76. *Mean monthly values and annual changes.*

Annual changes at Kodaikānal in 1921-22

Months	Horizontal Force ·37000 C.G.S. +			Declination W. 1° +			Dip N. 4° +			Vertical Force ·03000 C.G.S. +		
	1921	1922	Annual change	1921	1922	Annual change	1921	1922	Annual change	1921	1922	Annual change
	γ	γ	γ	′	′		′	′	′	γ	γ	γ
January ...	812	852	+40	52·6	56·7	+4·1	37·2	39·5	+2·3	055	081	+29
February ...	827	855	+28	53·3	57·7	+4·4	37·3	40·0	+2·7	057	090	+33
March ..	832	861	+29	53·3	57·8	+4·5	37·5	39·9	+2·4	060	090	+30
April ...	831	873	+42	53·5	58·1	+4·6	38·0	40·0	+2·0	066	092	+26
May ...	813	876	+63	53·7	58·5	+4·8	38·7	39·8	+1·1	072	090	+18
June ..	818	879	+61	54·4	58·8	+4·4	38·8	40·0	+1·2	074	092	+18
July ...	833	876	+43	54·4	58·8	+4·4	39·1	40·2	+1·1	079	094	+15
August ..	833	883	+50	54·5	59·2	+4·7	39·1	40·6	+1·5	078	099	+21
September ..	844	884	+40	54·7	59·6	+4·9	38·9	40·5	+1·6	077	098	+21
October ...	842	892	+50	54·7	59·6	+4·9	38·8	40·3	+1·5	076	096	+20
November ...	848	900	+52	55·3	59·7	+4·4	39·0	40·3	+1·3	078	097	+19
December ...	852	902	+50	55·9	60·1	+4·2	39·1	40·4	+1·3	080	098	+18
Means .	832	878	+46	54·2	57·9	+4·5	38·5	40·1	+1·7	071	093	+22

77. *Mean values of magnetic elements in observatories in 1922.*

Mean values of magnetic elements at observatories in 1922

Observatory	Latitude and Longitude	Dip	Declination	H. F.	V. F.
	° ′ ″	° ′	° ′	C. G. S.	C. G. S.
Dehra Dūn .	30 19 19N. 78 03 19E.	N. 45 8·6	E. 1 43·2	·32927	·33091
Toungoo ..	18 55 45N. 96 27 03E.	N. 23 7·2	W. 0 29·7	·39156	·16717
Kodaikānal .	10 13 50N. 77 27 46E.	N. 4 40·1	W. 1 58·7	·37878	·03093

TABLE XLI.—*Classification and dates of Magnetic Disturbances in 1922*

D = Dehra Dūn. T = Toungoo. K = Kodaikānal. C = Calm. S = Slight. M = Moderate. G = Great. V. G. = Very Great. — = Trace lost.

Dates 1922	January D	January T	January K	February D	February T	February K	March D	March T	March K	April D	April T	April K	May D	May T	May K	June D	June T	June K
1	—	S	S	S	S	S	M	M	M	S	S	S	S	S	S	C	C	C
2	—	S	S	S	S	C	M	M	M	S	S	S	C	C	C	S	S	S
3	—	S	C	G	G	M	S	S	S	S	S	S	C	C	C	M	M	S
4	—	S	C	S	S	S	M	M	M	C	C	C	S	S	S	S	S	S
5	S	S	S	S	S	S	M	M	M	C	C	C	S	S	S	M	M	S
6	C	C	C	S	S	S	S	S	S	C	C	C	S	S	S	S	S	S
7	M	M	S	C	C	C	C	C	C	C	C	C	M	M	S	S	S	S
8	M	M	S	S	S	S	C	C	C	S	S	S	M	M	S	C	C	C
9	M	M	S	S	S	S	C	C	C	S	S	S	M	M	S	C	C	C
10	S	S	S	S	S	S	M	M	M	S	S	S	M	M	M	C	C	C
11	S	S	S	C	C	C	S	S	S	S	S	S	S	S	S	C	C	C
12	S	S	C	S	S	S	S	S	S	S	S	S	C	C	C	S	S	S
13	C	C	C	S	S	S	G	G	G	S	S	S	C	C	C	S	S	S
14	C	C	C	S	S	S	G	G	G	S	S	S	C	C	C	S	S	S
15	C	C	C	M	M	M	S	S	S	S	S	S	C	C	C	C	C	C
16	S	S	S	M	M	S	S	S	S	S	S	C	S	S	S	M	M	M
17	—	S	S	S	S	S	S	M	S	S	S	S	M	M	M	M	M	M
18	—	S	S	S	S	C	M	S	S	S	S	C	C	C	C	S	S	M
19	—	S	S	C	C	C	S	S	S	C	C	C	S	S	S	S	S	S
20	S	S	S	S	S	S	S	S	S	C	C	C	C	C	C	S	S	C
21	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
22	C	C	C	S	S	S	S	S	S	M	M	M	S	S	S	S	S	S
23	C	C	C	S	S	S	S	S	C	S	S	—	S	S	S	S	S	S
24	G	G	G	C	C	C	C	C	C	M	M	M	S	S	S	C	C	C
25	M	M	M	C	C	C	M	M	M	M	M	M	S	S	S	S	C	C
26	S	S	S	S	S	S	S	S	S	M	M	S	S	S	S	S	S	S
27	S	S	S	S	S	S	C	C	C	M	M	S	S	S	S	S	S	S
28	C	C	C	S	S	S	C	C	C	S	S	S	S	S	S	S	S	S
29	S	S	S	...	...	...	S	S	S	M	M	S	C	C	—	M	M	M
30	C	C	C	...	...	...	M	M	M	S	S	S	C	C	C	M	M	M
31	M	M	M	...	...	...	M	M	M	...	...	...	C	C	C	...	...	...
C ...	9	9	12	5	5	7	6	6	7	6	6	8	11	11	10	7	8	9
S ...	9	16	16	20	20	19	14	14	14	18	18	18	15	15	18	17	16	16
M ...	5	5	2	2	2	2	9	9	8	6	6	3	5	5	2	6	6	5
G ...	1	1	1	1	1	...	2	2	2	...	...	...	...	...	...	...	...	...
V.G. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Trace lost	7	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...

Dates 1922	July D	July T	July K	August D	August T	August K	September D	September T	September K	October D	October T	October K	November D	November T	November K	December D	December T	December K
1	S	S	S	S	S	S	S	S	S	C	C	C	M	M	S	S	S	S
2	S	S	S	C	C	C	C	C	C	S	S	C	M	M	S	S	S	S
3	S	S	S	C	C	C	C	C	C	S	S	S	S	S	S	C	C	C
4	S	S	S	S	S	S	C	C	C	S	S	S	S	S	S	C	C	C
5	S	C	C	S	S	S	S	S	C	G	G	G	C	C	C	S	S	S
6	C	C	C	S	S	S	C	C	C	S	S	S	C	C	C	S	S	S
7	C	C	C	C	C	C	M	M	M	S	S	S	C	C	C	C	C	C
8	C	C	C	C	C	C	M	M	M	S	S	S	C	C	C	C	C	C
9	C	C	C	S	S	S	S	S	S	S	S	S	S	C	C	C	C	C
10	S	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
11	C	C	C	M	M	M	S	S	S	C	C	C	C	C	C	S	S	S
12	C	C	C	M	M	M	S	S	S	S	S	C	C	C	C	S	S	S
13	C	C	C	M	M	M	S	S	S	S	S	C	C	C	C	C	C	C
14	M	M	S	M	M	S	G	G	G	S	S	S	C	C	C	S	S	S
15	S	S	S	S	S	S	M	S	S	C	C	C	S	S	C	S	S	S
16	M	M	S	S	S	S	S	S	S	C	C	C	S	S	S	C	C	C
17	S	S	S	C	C	C	S	S	C	S	S	C	S	S	S	C	C	C
18	S	S	S	C	C	C	S	S	S	C	S	S	C	C	C	C	C	C
19	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
20	S	S	—	S	C	C	S	S	S	S	S	—	S	S	S	C	C	C
21	C	C	—	S	S	M	S	S	S	C	C	—	S	S	S	C	C	C
22	C	C	C	S	S	S	C	C	C	C	C	C	S	S	S	C	C	C
23	C	C	C	M	M	S	C	C	S	C	C	C	C	C	C	C	C	C
24	S	S	S	S	S	S	C	C	C	S	S	S	C	C	C	C	C	C
25	C	C	C	S	S	S	C	C	C	S	S	S	C	C	C	S	S	S
26	S	S	S	S	S	S	C	C	C	C	C	C	C	S	C	M	M	M
27	M	M	M	S	S	S	M	M	S	S	S	S	S	S	C	S	S	C
28	M	M	M	S	S	S	M	M	M	C	C	C	S	S	C	C	C	C
29	M	M	M	S	S	S	S	S	S	S	S	C	S	S	S	S	S	C
30	S	S	S	S	S	S	S	S	S	C	C	C	S	S	S	S	S	C
31	S	S	S	S	S	S	...	...	..	G	G	M	...	...	...	C	C	C
C ...	11	12	12	7	8	8	10	10	11	12	11	15	14	14	18	17	17	20
S ...	15	14	14	19	18	19	14	15	15	17	18	12	14	14	12	13	13	10
M ...	5	5	3	5	5	4	5	4	3	...	...	1	2	2	...	1	1	1
G ...	...	...	...	...	...	...	1	1	1	2	2	1	...	...	...	...	...	...
V.G. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Trace lost	...	...	2	...	...	..	...	...	...	...	...	2	...	...	...	...	...	...

TABLE XLII.—Hourly means of the Declination at Dehra Dūn in 1922, (determined from all available days)

DECLINATION = E 1° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	45·0	45·0	44·9	44·0	44·5	44·3	44·2	**44·0**	44·6	45·4	**45·5**	44·7	44·2	44·4	44·8	45·1	45·4	45·1	45·1	45·1	45·1	45·0	45·1	45·0	45·0	44·8
Feb.	44·8	44·8	44·8	44·9	44·7	44·6	44·4	44·4	44·5	44·4	43·9	43·4	**43·1**	43·4	44·3	45·2	**45·5**	45·2	44·8	44·8	44·6	44·5	44·6	44·6	44·7	44·5
Mar.	44·5	44·5	44·5	44·6	44·3	44·4	44·4	45·0	46·2	**46·6**	46·3	44·8	43·1	**42·2**	42·8	43·3	44·2	44·6	44·3	44·3	44·1	44·3	44·5	44·6	44·5	44·4
Oct.	42·9	42·9	42·6	42·6	42·6	42·3	42·3	42·9	**43·8**	43·8	43·2	42·0	40·9	**40·4**	41·0	42·0	42·7	42·7	42·7	42·5	42·6	42·6	42·6	42·8	42·8	42·5
Nov.	41·8	41·7	41·6	41·4	41·3	41·1	40·9	**40·7**	41·2	41·9	41·9	41·5	41·0	41·2	41·5	41·8	**41·9**	41·7	41·8	41·8	41·6	41·6	41·7	41·7	41·8	41·5
Dec.	41·1	40·9	40·9	40·7	40·6	40·4	40·4	**40·3**	40·4	40·9	41·0	40·5	40·3	40·4	40·9	41·3	**41·6**	41·5	41·3	41·3	41·2	41·2	41·1	41·2	41·0	40·9
Winter Means	43·4	43·3	43·2	43·1	43·0	42·9	42·8	42·9	43·5	**43·8**	43·6	42·8	42·1	**42·0**	42·5	43·1	43·6	43·5	43·3	43·3	43·2	43·2	43·3	43·3	43·3	43·1
April	44·1	44·3	44·3	44·2	44·2	44·1	44·3	45·4	46·6	**46·8**	45·5	43·4	41·8	**41·1**	41·4	42·2	43·1	43·6	43·8	43·5	43·4	43·7	43·9	44·0	44·2	43·9
May	44·3	44·5	44·6	44·6	44·5	44·6	45·7	46·7	**47·1**	46·2	44·7	42·9	41·7	**41·2**	41·6	42·3	43·1	43·7	44·0	43·8	43·8	43·9	44·0	44·2	44·2	44·1
June	44·1	44·3	44·4	44·5	44·6	44·7	45·9	46·8	**46·8**	46·0	44·5	42·8	41·5	**40·6**	40·7	41·4	42·2	43·0	43·6	43·5	43·5	43·5	43·7	43·9	44·1	43·8
July	43·1	43·5	43·6	43·7	43·8	44·0	45·1	45·9	**45·9**	45·1	43·8	42·1	40·8	**40·3**	40·3	40·9	41·8	42·4	42·9	42·8	42·7	42·7	42·8	42·9	43·1	43·0
Aug.	43·2	43·4	43·5	43·6	43·6	43·8	44·9	45·6	**45·6**	44·2	42·4	40·9	39·9	**39·8**	40·4	41·5	42·5	43·1	43·2	42·9	42·8	42·8	42·8	43·0	43·1	42·9
Sept.	42·9	43·0	43·2	43·2	43·2	43·3	43·6	44·4	**44·8**	44·0	42·3	40·8	39·9	**39·8**	40·5	41·5	42·5	42·8	42·7	42·5	42·4	42·5	42·6	42·7	42·8	42·5
Summer Means	43·6	43·8	43·9	44·0	44·0	44·1	44·9	45·8	**46·1**	45·4	43·9	42·2	40·9	**40·5**	40·8	41·6	42·5	43·1	43·4	43·2	43·1	43·2	43·3	43·5	43·6	43·4

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE XLIII.—*Diurnal Inequality of the Declination at Dehra Dūn in 1922*, (deduced from **TABLE XLII**)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
Jan.	+0·2	+0·2	+0·1	−0·2	−0·3	−0·5	−0·6	−0·8	−0·2	+0·6	+0·7	−0·1	−0·6	−0·4	0	+0·3	+0·6	+0·3	+0·3	+0·3	+0·3	+0·2	+0·3	+0·2	+0·2
Feb.	+0·3	+0·3	+0·3	+0·4	+0·2	+0·1	−0·1	−0·1	0	−0·1	−0·6	−1·1	−1·4	−1·1	−0·2	+0·7	+1·0	+0·7	+0·3	+0·3	+0·1	0	+0·1	+0·1	+0·2
Mar.	+0·1	+0·1	+0·1	+0·2	−0·1	0	0	+0·6	+1·8	+2·2	+1·9	+0·4	−1·3	−2·2	−2·1	−1·1	−0·2	+0·2	−0·1	−0·1	−0·3	−0·1	+0·1	+0·2	+0·1
Oct.	+0·4	+0·4	+0·1	+0·1	+0·1	−0·2	−0·2	+0·4	+1·3	+1·3	+0·7	−0·5	−1·6	−2·1	−1·5	−0·5	+0·2	+0·2	+0·2	0	+0·1	+0·1	+0·1	+0·3	+0·3
Nov.	+0·3	+0·2	+0·1	−0·1	−0·2	−0·4	−0·6	−0·8	−0·3	+0·4	+0·4	0	−0·5	−0·3	0	+0·3	+0·4	+0·2	+0·3	+0·3	+0·1	+0·1	+0·2	+0·2	+0·3
Dec.	+0·2	0	0	−0·2	−0·3	−0·5	−0·5	−0·6	−0·5	0	+0·1	−0·4	−0·6	−0·5	0	+0·4	+0·7	+0·6	+0·4	+0·4	+0·3	+0·3	+0·2	+0·3	+0·1
Winter Means	+0·3	+0·2	+0·1	0	−0·1	−0·2	−0·3	−0·2	+0·4	+0·7	+0·5	−0·3	−1·0	−1·1	−0·6	0	+0·5	+0·4	+0·2	+0·2	+0·1	+0·1	+0·2	+0·2	+0·2
April	+0·2	+0·4	+0·4	+0·3	+0·3	+0·2	+0·4	+1·5	+2·7	+2·9	+1·6	−0·5	−2·1	−2·8	−2·5	−1·7	−0·8	−0·3	−0·1	−0·4	−0·5	−0·2	0	+0·1	+0·3
May	+0·2	+0·4	+0·5	+0·5	+0·4	+0·5	+1·6	+2·6	+3·0	+2·1	+0·6	−1·2	−2·4	−2·9	−2·5	−1·8	−1·0	−0·4	−0·1	−0·3	−0·3	−0·2	−0·1	+0·1	+0·1
June	+0·3	+0·5	+0·6	+0·7	+0·8	+0·9	+2·1	+3·0	+3·0	+3·2	+0·7	−1·0	−2·3	−3·2	−3·1	−2·4	−1·6	−0·6	−0·2	−0·3	−0·3	−0·3	−0·1	+0·1	+0·3
July	+0·1	+0·5	+0·6	+0·7	+0·8	+1·0	+2·1	+2·9	+2·9	+2·1	+0·8	−0·9	−2·2	−2·7	−2·7	−2·1	−1·2	−0·6	−0·1	−0·2	−0·3	−0·3	−0·2	−0·1	+0·1
Aug.	+0·3	+0·5	+0·6	+0·7	+0·7	+0·9	+2·0	+2·7	+2·7	+1·3	−0·5	−2·0	−3·0	−3·1	−2·5	−1·4	−0·4	+0·2	+0·3	0	−0·1	−0·1	−0·1	+0·1	+0·2
Sept.	+0·4	+0·5	+0·7	+0·7	+0·7	+0·8	+1·1	+1·9	+2·3	+1·5	−0·2	−1·7	−2·6	−2·7	−2·0	−1·0	0	+0·3	+0·2	0	−0·1	0	−0·1	+0·2	+0·3
Summer Means	+0·2	+0·4	+0·5	+0·6	+0·6	+0·7	+1·5	+2·4	+2·7	+2·0	+0·5	−1·2	−2·5	−2·9	−2·6	−1·8	−0·9	−0·3	0	−0·2	−0·3	−0·2	−0·1	+0·1	+0·2

NOTE.—The magnet points to the east or west of the mean position as sign is + or —.

TABLE XLIV.—Hourly means of Horizontal Force in C.G.S. units corrected for temperature at Dehra Dūn in 1922, (from all available days)

HORIZONTAL FORCE = ·32000 C.G.S. + tabular quantity

Hours.	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	933	932	**931**	932	932	935	937	940	944	942	939	943	945	**945**	943	937	934	932	933	933	932	934	933	934	934	936
Feb.	926	931	931	931	931	932	932	932	931	932	936	941	947	**950**	947	939	930	926	**925**	925	928	925	926	929	930	933
Mar.	929	932	934	932	933	933	931	931	931	934	942	948	946	949	**949**	940	932	928	**926**	929	931	927	930	931	933	935
Oct.	914	913	917	917	916	916	918	916	914	911	914	921	924	**929**	926	923	916	910	910	**908**	910	909	911	913	915	916
Nov.	916	917	917	917	916	917	918	922	926	928	929	933	**933**	927	921	919	916	913	911	**910**	913	911	912	916	916	919
Dec.	909	912	912	912	913	914	916	918	921	923	925	**927**	924	922	920	917	912	909	909	908	907	**906**	908	909	910	915
Winter Means	921	923	924	924	924	925	925	927	928	928	931	936	937	**937**	934	929	923	920	919	**919**	930	919	920	922	923	926
April	935	939	937	938	937	937	938	935	932	935	941	948	951	**954**	951	943	939	933	931	**929**	934	934	939	937	936	939
May	931	930	929	928	929	931	930	927	926	926	930	938	942	**946**	942	938	933	926	**924**	926	926	927	929	930	931	931
June	936	936	938	937	936	937	939	938	934	934	934	935	940	943	**945**	942	936	932	**931**	931	934	935	934	937	936	936
July	928	926	925	925	924	925	926	924	922	924	924	927	930	932	**933**	932	928	925	924	**920**	922	923	925	927	927	926
Aug.	922	923	924	922	922	923	923	917	**911**	912	915	921	928	931	931	**931**	927	918	918	922	921	922	922	923	923	922
Sept.	918	920	920	919	920	920	918	913	907	**906**	906	913	921	925	**930**	923	916	914	915	917	916	917	919	920	921	917
Summer Means	928	929	929	928	928	929	929	926	**922**	923	925	930	935	939	**939**	935	930	925	924	924	926	926	928	929	929	929

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE XLV.—Diurnal Inequality of the Horizontal Force at Dehra Dūn in 1922, (deduced from *TABLE XLIV*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	− 3	− 4	− 5	− 4	− 4	− 1	+ 1	+ 4	+ 8	+ 6	+ 3	+ 7	+ 9	+ 9	+ 7	+ 1	− 2	− 4	− 3	− 3	− 4	− 2	− 3	− 2	+ 2
Feb.	− 7	− 2	− 2	− 2	− 2	− 1	− 1	− 1	− 2	− 1	+ 3	+ 8	+14	+17	+14	+ 6	− 3	− 7	− 8	− 8	− 5	− 7	− 7	− 4	− 3
Mar.	− 6	− 3	− 1	− 3	− 2	− 2	− 4	− 4	− 4	− 1	+ 7	+13	+11	+14	+14	+ 5	− 3	− 7	− 9	− 6	− 4	− 8	− 5	− 4	− 2
Oct.	− 2	− 3	+ 1	+ 1	0	0	+ 2	0	− 2	− 5	− 2	+ 5	+ 8	+13	+10	+ 7	0	− 6	− 6	− 8	− 6	− 7	− 5	− 3	− 1
Nov.	− 3	− 2	− 2	− 2	− 3	− 2	− 1	+ 3	+ 7	+ 9	+10	+14	+14	+ 8	+ 2	0	− 3	− 6	− 8	− 9	− 6	− 8	− 7	− 3	− 3
Dec.	− 6	− 3	− 3	− 3	− 2	− 1	+ 1	+ 3	+ 6	+ 8	+10	+12	+ 9	+ 7	+ 5	+ 2	− 3	− 6	− 6	− 7	− 8	− 9	− 7	− 6	− 5
Winter Means	− 5	− 3	− 2	− 2	− 2	− 1	− 1	+ 1	+ 2	+ 2	+ 5	+10	+11	+11	+ 8	+ 3	− 3	− 6	− 7	− 7	− 6	− 7	− 6	− 4	− 3
April	− 4	0	− 2	− 1	− 2	− 2	− 1	− 4	− 7	− 4	+ 2	+ 9	+12	+15	+12	+ 4	0	− 6	− 8	−10	− 5	− 5	0	− 2	− 3
May	0	− 1	− 2	− 3	− 2	0	− 1	− 4	− 5	− 5	− 1	+ 7	+11	+15	+11	+ 7	+ 2	− 5	− 7	− 5	− 5	− 4	− 2	− 1	0
June	0	0	+ 2	− 1	0	− 1	+ 3	+ 2	− 2	− 2	− 2	− 1	+ 4	+ 7	+ 9	+ 6	0	− 4	− 5	− 5	− 2	− 1	− 2	+ 1	0
July	+ 2	0	− 1	− 1	− 2	− 1	0	− 2	− 4	− 2	− 2	+ 1	+ 4	+ 6	+ 7	+ 6	+ 2	− 1	− 2	− 6	− 4	− 3	− 1	+ 1	+ 1
Aug	0	+ 1	+ 2	0	0	+ 1	+ 1	− 5	−11	−10	− 7	− 1	+ 6	+ 9	+ 9	+ 9	+ 5	− 4	− 4	0	− 1	0	+ 2	+ 1	+ 1
Sept.	+ 1	+ 3	+ 3	+ 2	+ 3	+ 3	+ 1	− 4	−10	−11	−11	− 4	+ 4	+ 8	+13	+ 6	− 1	− 3	− 2	0	− 1	0	0	+ 3	+ 4
Summer Means	− 1	0	0	− 1	− 1	0	0	− 3	− 7	− 6	− 4	+ 1	+ 6	+10	+10	+ 6	+ 1	− 4	− 5	− 5	− 3	− 3	− 1	0	0

NOTE—The Horizontal Force is greater or less than the mean as sign is + or —.

TABLE XLVI.—Hourly means of Vertical Force in C.G.S. units corrected for temperature at Dehra Dun in 1922, (from available days)

VERTICAL FORCE = ·33000 C.G.S. + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	062	061	060	061	060	061	061	062	064	063	**059**	060	063	**064**	064	062	062	062	064	063	062	062	062	062	062	062
Feb.	065	066	065	065	065	064	065	066	065	064	**061**	064	066	068	**069**	069	067	065	065	066	066	066	065	065	065	066
Mar.	080	080	081	079	080	079	079	082	**083**	079	072	063	**061**	066	071	073	076	076	076	078	078	078	079	079	079	076
Oct.	117	117	117	116	116	116	116	**118**	118	115	112	106	**104**	107	112	115	116	115	116	116	117	117	117	117	117	115
Nov.	113	113	112	112	112	112	111	112	113	112	**109**	112	112	113	114	115	**116**	115	115	115	115	114	114	114	113	113
Dec.	117	116	116	115	115	115	115	115	116	117	**114**	118	121	**122**	122	121	120	119	119	118	118	117	117	117	117	118
Winter Means	092	092	092	091	091	091	091	093	**093**	092	088	**087**	088	090	092	093	093	092	093	093	093	092	092	092	092	092
April	087	088	088	087	087	087	088	**090**	090	083	073	**068**	070	074	079	082	084	085	086	087	088	088	089	089	089	084
May	080	080	080	080	080	081	**084**	082	077	071	064	**061**	064	068	072	075	077	078	079	079	079	080	080	081	081	076
June	090	091	091	091	091	093	**096**	094	088	083	077	**069**	070	073	077	081	085	088	090	090	090	091	091	092	091	086
July	095	095	095	095	095	096	**099**	097	094	089	083	**076**	077	080	085	088	092	093	095	094	096	096	097	098	097	092
Aug.	107	107	108	107	107	108	**111**	110	107	102	098	**092**	094	098	102	106	106	105	105	106	106	107	108	108	108	105
Sept.	103	104	104	104	104	104	105	**107**	105	100	095	**093**	095	097	101	102	103	104	104	105	105	106	106	106	106	103
Summer Means	094	094	094	094	094	095	**097**	097	094	088	082	**077**	078	082	086	089	091	092	093	094	094	095	095	096	095	091

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE XLVII.—Diurnal Inequality of the Vertical Force at Dehra Dun in 1922, (deduced from *TABLE XLVI.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
Jan.	γ 0	γ −1	γ −2	γ −1	γ −2	γ −1	γ −1	γ 0	γ +2	γ +1	γ −3	γ −2	γ +1	γ +2	γ +2	γ 0	γ 0	γ 0	γ +2	γ +1	γ 0	γ 0	γ 0	γ 0	γ 0
Feb.	−1	0	−1	−1	−1	−2	−1	0	−1	−2	−5	−2	0	+2	+3	+3	+1	−1	−1	0	0	0	−1	−1	−1
Mar.	+4	+4	+5	+3	+4	+3	+3	+6	+7	+3	−4	−13	−15	−10	−5	−3	0	0	0	+2	+2	+2	+3	+3	+3
Oct.	+2	+2	+2	+1	+1	+1	+1	+3	+3	0	−3	−9	−11	−8	−3	0	+1	0	+1	+1	+2	+2	+2	+2	+2
Nov.	0	0	−1	−1	−1	−1	−2	−1	0	−1	−4	−1	−1	0	+1	+2	+3	+2	+2	+2	+2	+1	+1	+1	0
Dec.	−1	−2	−2	−3	−3	−3	−3	−3	−2	−1	−4	0	+3	+4	+4	+3	+2	+1	+1	0	0	−1	−1	−1	−1
Winter Means	0	0	0	−1	−1	−1	−1	+1	+1	0	−4	−5	−4	−2	0	+1	+1	0	+1	+1	+1	0	0	0	0
April	+3	+4	+4	+3	+3	+3	+4	+6	+6	−1	−11	−16	−14	−10	−5	−2	0	+1	+2	+3	+4	+4	+5	+5	+5
May	+4	+4	+4	+4	+4	+5	+8	+6	+1	−5	−12	−15	−12	−8	−4	−1	+1	+2	+3	+3	+3	+4	+4	+5	+5
June	+4	+5	+5	+5	+5	+7	+10	+8	+2	−3	−9	−17	−16	−13	−9	−5	−1	+2	+4	+4	+4	+5	+5	+6	+5
July	+3	+3	+3	+3	+3	+4	+7	+5	+2	−3	−9	−16	−15	−12	−7	−4	0	+1	+3	+2	+4	+4	+5	+6	+5
Aug	+2	+2	+3	+2	+2	+3	+6	+5	+2	−3	−7	−13	−11	−7	−3	+1	+1	0	0	+1	+1	+2	+3	+3	+3
Sept.	0	+1	+1	+1	+1	+1	+2	+4	+2	−3	−8	−10	−8	−6	−2	−1	0	+1	+1	+2	+2	+3	+3	+3	+3
Summer Means	+3	+3	+3	+3	+3	+4	+6	+6	+3	−3	−9	−14	−13	−9	−5	−2	0	+1	+2	+3	+3	+4	+4	+5	+4

NOTE.—Vertical Force is greater or less than the mean as sign is + or −.

TABLE XLVIII.—*Hourly mean of the Dip at Dehra Dun in 1922,* (determined from available days)

Dip = N. 45° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	6·7	6·7	6·7	6·7	6·7	6·6	6·5	6·4	6·3	6·3	6·3	**6·1**	6·1	6·2	6·3	6·5	6·7	6·8	**6·9**	6·8	6·8	6·7	6·7	6·7	6·7	6·6
Feb.	7·3	7·1	7·0	7·0	7·0	6·9	6·9	7·0	7·0	6·9	6·5	6·4	6·2	**6·1**	6·3	6·8	7·1	7·3	7·3	**7·3**	7·2	7·3	7·3	7·1	7·1	6·9
Mar.	7·9	7·7	7·7	7·6	7·7	7·6	7·7	7·9	**7·9**	7·6	6·8	**6·0**	6·0	6·1	6·4	6·9	7·5	7·7	7·8	7·8	7·7	7·9	7·8	7·7	7·6	7·4
Oct.	10·6	10·6	10·4	10·4	10·4	10·4	10·3	10·5	10·6	10·6	10·3	9·7	9·4	**9·3**	9·7	10·0	10·4	10·7	10·7	**10·9**	10·8	10·9	10·7	10·6	10·5	10·4
Nov.	10·3	10·2	10·2	10·2	10·2	10·2	10·1	9·9	9·7	9·6	9·4	**9·3**	9·3	9·7	10·1	10·2	10·4	10·5	10·6	**10·7**	10·5	10·6	10·5	10·3	10·3	10·1
Dec.	10·9	10·7	10·7	10·6	10·5	10·5	10·3	10·3	10·2	10·1	**9·8**	9·9	10·3	10·4	10·5	10·6	10·9	**11·0**	11·0	10·9	11·0	11·0	10·9	10·9	10·8	10·6
Winter Means	9·0	8·8	8·8	8·8	8·8	8·7	8·6	8·7	8·6	8·5	8·2	7·9	**7·9**	8·0	8·2	8·5	8·8	9·0	9·1	**9·1**	9·0	9·1	9·0	8·9	8·8	8·7
April	7·9	7·8	7·9	7·8	7·8	7·8	7·8	8·1	**8·2**	7·7	6·9	6·3	**6·2**	6·3	6·7	7·3	7·6	7·9	8·1	8·2	8·0	8·0	7·8	7·9	8·0	7·6
May	7·8	7·8	7·9	7·9	7·9	7·8	8·0	**8·1**	7·9	7·6	7·0	6·4	**6·4**	6·4	6·8	7·1	7·5	7·9	8·1	8·0	8·0	8·0	7·9	7·9	7·8	7·6
June	8·0	8·1	8·0	8·0	8·1	8·2	8·2	8·1	8·0	7·8	7·5	7·0	**6·8**	6·8	6·9	7·3	7·8	8·1	**8·3**	8·3	8·2	8·1	8·2	8·1	8·1	7·8
July	8·7	8·8	8·8	8·8	8·9	8·9	9·0	9·0	9·0	8·6	8·3	7·8	**7·7**	7·7	7·9	8·1	8·5	8·8	8·9	**9·1**	9·1	9·0	9·0	8·9	8·9	8·6
Aug.	9·6	9·6	9·6	9·6	9·6	9·6	9·8	10·1	**10·2**	9·9	9·5	8·9	**8·6**	8·7	8·9	9·2	9·3	9·7	9·7	9·6	9·7	9·6	9·7	9·6	9·6	9·5
Sept	9·7	9·6	9·6	9·6	9·6	9·6	9·7	10·1	**10·3**	10·1	9·8	9·4	9·1	9·0	**8·9**	9·3	9·7	9·9	9·9	9·8	9·8	9·9	9·7	9·7	9·7	9·7
Summer Means	8·6	8·6	8·6	8·6	8·7	8·7	8·8	8·9	**8·9**	8·6	8·2	7·6	**7·5**	7·5	7·7	8·1	8·4	8·7	8·8	8·8	8·8	8·8	8·7	8·7	8·7	8·5

Note—Figures in thick type represent the maximum and minimum values during the month.

TABLE XLIX.—Diurnal Inequality of the Dip at Dehra Dun in 1922 (deduced from *TABLE XLVIII*).

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	+0·1	+0·1	+0·1	+0·1	+0·1	0	−0·1	−0·2	−0·3	−0·3	−0·3	−0·5	−0·5	−0·4	−0·3	−0·1	+0·1	+0·2	+0·3	+0·2	+0·2	+0·1	+0·1	+0·1	+0·1
Feb.	+0·4	+0·2	+0·1	+0·1	+0·1	0	0	+0·1	+0·1	0	−0·4	−0·5	−0·7	−0·8	−0·6	−0·1	+0·2	+0·4	+0·4	+0·4	+0·3	+0·4	+0·4	+0·2	+0·2
Mar.	+0·5	+0·3	+0·3	+0·2	+0·3	+0·2	+0·3	+0·5	+0·5	+0·2	−0·6	−1·4	−1·4	−1·3	−1·0	−0·5	+0·1	+0·3	+0·4	+0·4	+0·3	+0·5	+0·4	+0·3	+0·2
Oct.	+0·2	+0·2	0	0	0	0	−0·1	+0·1	+0·2	+0·2	−0·1	−0·7	−1·0	−1·1	−0·7	−0·4	0	+0·3	+0·3	+0·5	+0·4	+0·5	+0·3	+0·2	+0·1
Nov.	+0·2	+0·1	+0·1	+0·1	+0·1	+0·1	0	−0·2	−0·4	−0·5	−0·7	−0·8	−0·8	−0·4	0	+0·1	+0·3	+0·4	+0·5	+0·6	+0·4	+0·5	+0·4	+0·2	+0·2
Dec.	+0·3	+0·1	+0·1	0	−0·1	−0·1	−0·3	−0·3	−0·4	−0·5	−0·8	−0·7	−0·3	−0·2	−0·1	0	+0·3	+0·4	+0·4	+0·3	+0·4	+0·4	+0·3	+0·3	+0·2
Winter Means	+0·3	+0·1	+0·1	+0·1	+0·1	0	−0·1	0	−0·1	−0·2	−0·5	−0·8	−0·8	−0·7	−0·5	−0·2	+0·1	+0·3	+0·4	+0·4	+0·3	+0·4	+0·3	+0·2	+0·1
April	+0·3	+0·2	+0·3	+0·2	+0·2	+0·2	+0·2	+0·5	+0·6	+0·1	−0·7	−1·3	−1·4	−1·3	−0·9	−0·3	0	+0·3	+0·5	+0·6	+0·4	+0·4	+0·2	+0·3	+0·4
May	+0·2	+0·2	+0·3	+0·3	+0·3	+0·2	+0·4	+0·5	+0·3	0	−0·6	−1·2	−1·2	−1·2	−0·8	−0·5	−0·1	+0·3	+0·5	+0·4	+0·4	+0·4	+0·3	+0·3	+0·2
June	+0·2	+0·3	+0·2	+0·2	+0·3	+0·4	+0·4	+0·3	+0·2	0	−0·3	−0·8	−1·0	−1·0	−0·9	−0·5	0	+0·3	+0·5	+0·5	+0·4	+0·3	+0·4	+0·3	+0·3
July	+0·1	+0·2	+0·2	+0·2	+0·3	+0·3	+0·4	+0·4	+0·4	0	−0·3	−0·8	−0·9	−0·9	−0·7	−0·5	−0·1	+0·2	+0·3	+0·5	+0·5	+0·4	+0·4	+0·3	+0·3
Aug.	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·3	+0·6	+0·7	+0·4	0	−0·6	−0·9	−0·8	−0·6	−0·3	−0·2	+0·2	+0·2	+0·1	+0·2	+0·1	+0·2	+0·1	+0·1
Sept.	0	−0·1	−0·1	−0·1	−0·1	−0·1	0	+0·4	+0·6	+0·4	+0·1	−0·3	−0·6	−0·7	−0·8	−0·4	0	+0·2	+0·2	+0·1	+0·1	+0·2	0	0	0
Summer Means	+0·1	+0·1	+0·1	+0·1	+0·2	+0·2	+0·3	+0·4	+0·4	+0·1	−0·3	−0·9	−1·0	−1·0	−0·8	−0·4	−0·1	+0·2	+0·3	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2

TABLE L.—Hourly means of the Declination at Toungoo in 1922 (determined from available days)

DECLINATION W. 0° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	29·1	29·1	29·2	29·1	29·3	29·5	29·7	**29·9**	29·5	28·7	28·6	29·2	29·5	29·2	28·9	28·7	**28·4**	28·4	28·9	28·8	28·8	28·9	29·0	29·0	29·1	29·1
Feb.	28·8	28·8	28·7	28·8	28·7	28·8	29·0	28·9	29·1	29·3	29·7	**29·7**	29·6	28·9	28·1	27·7	**27·6**	28·1	28·6	28·6	28·6	28·9	28·9	28·8	28·8	28·8
Mar.	29·0	28·9	28·9	29·0	29·0	29·1	29·0	28·4	27·7	**27·5**	27·6	28·3	29·5	**30·2**	30·0	29·3	28·6	28·5	28·9	29·1	29·0	29·0	29·0	29·0	29·0	28·9
Oct.	30·4	30·4	30·4	30·5	30·6	30·6	30·6	30·0	**29·5**	29·7	30·5	31·2	31·8	**31·8**	31·3	30·5	30·0	30·2	30·5	30·4	30·5	30·6	30·5	30·5	30·5	30·5
Nov.	30·7	30·6	30·7	30·9	31·1	31·2	31·5	**31·5**	31·1	30·5	30·2	30·5	30·5	**30·2**	30·3	30·4	30·3	30·4	30·5	30·5	30·6	30·7	30·7	30·6	30·7	30·7
Dec.	30·8	30·9	31·1	31·2	31·3	31·4	31·5	**31·6**	31·4	31·0	30·8	30·8	30·8	30·7	30·6	30·4	**30·2**	30·2	30·4	30·5	30·6	30·7	30·8	30·8	30·8	30·9
Winter Means	29·8	29·8	29·8	29·9	30·0	30·1	30·2	30·1	29·7	29·5	29·6	30·0	**30·3**	30·2	29·9	29·5	**29·2**	29·3	29·6	29·7	29·7	29·8	29·8	29·8	29·8	29·8
April	28·9	28·8	28·7	28·8	28·8	28·8	28·5	27·6	**27·2**	27·4	28·3	29·5	30·6	**30·9**	30·5	29·8	29·1	28·7	29·1	29·1	29·2	29·2	29·1	29·0	28·9	29·0
May	29·3	29·2	29·1	29·1	29·1	28·9	27·9	27·0	**26·9**	27·7	29·2	30·3	**31·2**	31·1	30·7	30·3	29·5	29·2	29·2	29·5	29·6	29·6	29·5	29·5	29·3	29·3
June	29·5	29·3	29·1	29·1	29·1	28·8	27·8	27·1	**27·1**	27·7	28·9	30·2	31·2	**31·5**	31·4	30·8	30·2	29·6	29·6	29·8	29·7	29·7	29·6	29·6	29·4	29·4
July	29·6	29·5	29·3	29·2	29·1	28·9	28·0	**27·3**	27·4	28·0	29·0	30·0	31·2	31·4	**31·5**	31·1	30·3	29·6	29·6	29·9	30·0	30·0	30·0	29·8	29·6	29·6
Aug.	29·9	29·7	29·6	29·5	29·4	29·2	28·1	**27·3**	27·6	28·7	30·1	31·1	31·7	**31·8**	31·2	30·3	29·8	29·4	29·8	30·0	30·1	30·1	30·1	30·0	29·9	29·8
Sept.	30·4	30·2	30·0	29·9	30·0	30·0	29·2	**28·2**	28·2	29·4	30·6	31·6	**32·3**	32·2	31·7	30·8	30·0	29·8	30·3	30·4	30·5	30·5	30·5	30·5	30·4	30·3
Summer Means	29·6	29·5	29·3	29·3	29·3	29·1	28·3	27·4	**27·4**	29·2	29·4	30·5	31·4	**31·5**	31·2	30·5	29·8	29·4	29·6	29·8	29·9	29·9	29·8	29·7	29·6	29·6

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LI.—Diurnal Inequality of the Declinatoin at Toungoo in 1922, (deduced from *TABLE L*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	0	0	-0·1	0	-0·2	-0·4	-0·6	-0·8	-0·4	+0·4	+0·5	-0·1	-0·4	-0·1	+0·2	+0·4	+0·7	+0·7	+0·2	+0·3	+0·3	+0·2	+0·1	+0·1	0
Feb.	0	0	+0·1	0	+0·1	0	-0·2	-0·1	-0·3	-0·5	-0·9	-0·9	-0·8	-0·1	+0·7	+1·1	+1·2	+0·7	+0·2	+0·2	+0·2	-0·1	-0·1	0	0
Mar.	-0·1	0	0	-0·1	-0·1	-0·2	-0·1	+0·5	+1·2	+1·4	+1·3	+0·6	-0·6	-1·3	-1·1	-0·4	+0·3	+0·4	0	-0·2	-0·1	-0·1	-0·1	-0·1	-0·1
Oct.	+0·1	+0·1	+0·1	0	-0·1	-0·1	-0·1	+0·5	+1·0	+0·8	0	-0·7	-1·3	-1·3	-0·8	0	+0·5	+0·3	0	+0·1	0	-0·1	0	0	0
Nov.	0	+0·1	0	-0·2	-0·4	-0·5	-0·8	-0·8	-0·4	+0·2	+0·5	+0·2	+0·2	+0·5	+0·4	+0·3	+0·4	+0·3	+0·2	+0·2	+0·1	0	0	+0·1	0
Dec.	+0·1	0	-0·2	-0·3	-0·4	-0·5	-0·6	-0·7	-0·5	-0·1	+0·1	+0·1	+0·1	+0·2	+0·3	+0·5	+0·7	+0·7	+0·5	+0·4	+0·3	+0·2	+0·1	+0·1	+0·1
Winter Means	0	0	0	-0·1	-0·2	-0·3	-0·4	-0·3	+0·1	+0·3	+0·2	-0·2	-0·5	-0·4	-0·1	+0·3	+0·6	+0·5	+0·2	+0·1	+0·1	0	0	0	0
April	+0·1	+0·2	+0·3	+0·2	+0·2	+0·2	+0·5	+1·4	+1·8	+1·6	+0·7	-0·5	-1·6	-1·9	-1·5	-0·8	-0·1	+0·3	-0·1	-0·1	-0·2	-0·2	-0·1	0	+0·1
May	0	+0·1	+0·2	+0·2	+0·2	+0·4	+1·4	+2·3	+2·4	+1·6	+0·1	-1·0	-1·9	-1·8	-1·4	-1·0	-0·2	+0·1	+0·1	-0·2	-0·3	-0·3	-0·2	-0·2	0
June	-0·1	+0·1	+0·3	+0·3	+0·3	+0·6	+1·6	+2·3	+2·3	+1·7	+0·5	-0·8	-1·8	-2·1	-2·0	-1·4	-0·8	-0·2	-0·2	-0·4	-0·3	-0·3	-0·2	-0·2	0
July	0	+0·1	+0·3	+0·4	+0·5	+0·7	+1·6	+2·3	+2·2	+1·6	+0·6	-0·4	-1·6	-1·8	-1·9	-1·5	-0·7	0	0	-0·3	-0·4	-0·4	-0·4	-0·2	0
Aug.	-0·1	+0·1	+0·2	+0·3	+0·4	+0·6	+1·7	+2·5	+2·2	+1·1	-0·3	-1·3	-1·9	-2·0	-1·4	-0·5	0	+0·4	0	-0·2	-0·3	-0·3	-0·3	-0·2	-0·1
Sept.	-0·1	+0·1	+0·3	+0·4	+0·3	+0·3	+1·1	+2·1	+2·1	+0·9	-0·3	-1·3	-2·0	-1·9	-1·4	-0·5	+0·3	+0·5	0	-0·1	-0·2	-0·2	-0·2	-0·2	-0·1
Summer Means	0	+0·1	+0·3	+0·3	+0·3	+0·5	+1·3	+2·2	+2·2	+1·4	+0·2	-0·9	-1·8	-1·9	-1·6	-0·9	-0·2	+0·2	0	-0·2	-0·3	-0·3	-0·2	-0·1	0

NOTE.—Magnet points to east or west of the mean position as sign is + or —.

TABLE LII.*—*Hourly means of Horizontal Force in C.G.S. units corrected for temperature at Toungoo in 1922 (from available days)

HORIZONTAL FORCE = ·39000 C.G.S. + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	**122**	124	124	123	124	126	128	134	139	143	148	**151**	151	146	139	133	127	125	125	124	124	123	125	123	125	131
Feb.	126	127	129	133	133	134	135	136	141	149	156	**162**	161	156	149	142	135	129	128	127	**124**	128	126	128	131	137
Mar.	126	**125**	128	130	131	130	131	131	137	149	161	171	**175**	165	156	145	135	130	128	126	127	126	125	127	129	138
Oct.	152	154	154	155	159	159	159	159	162	169	178	187	**190**	183	175	165	161	157	154	152	**149**	149	151	151	155	162
Nov.	167	166	168	169	170	169	171	173	179	185	190	**195**	194	187	179	172	167	164	162	160	**160**	162	161	163	167	172
Dec.	165	166	168	168	169	171	173	176	178	183	188	**193**	190	184	179	176	172	168	164	164	**163**	164	164	165	166	173
Winter Means	143	144	145	146	148	148	150	152	156	163	170	177	**177**	170	163	156	150	146	144	142	**141**	142	142	143	146	152
April	142	138	142	141	141	142	141	142	149	164	179	**184**	183	176	168	158	145	139	137	137	**134**	139	137	141	142	150
May	152	154	154	154	153	154	156	153	164	175	186	**190**	189	184	176	167	157	151	**149**	150	151	151	151	153	154	162
June	159	158	158	160	160	160	162	165	171	177	185	**188**	187	183	177	170	162	155	**151**	153	154	156	156	156	158	165
July	153	157	154	153	153	153	156	158	163	167	175	179	**179**	177	172	165	158	**150**	152	152	152	151	152	153	155	160
Aug.	152	152	153	153	154	153	155	154	155	161	168	171	**174**	173	166	158	156	152	**147**	148	150	151	150	151	152	157
Sept.	159	159	159	161	161	162	161	158	157	165	175	179	**180**	178	171	168	161	154	**153**	154	156	156	156	159	161	163
Summer Means	153	153	153	154	154	154	155	156	160	168	178	182	**182**	179	172	164	157	150	**148**	149	150	151	150	152	154	160

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LIII.—*Diurnal Inequality of the Horizontal Force at Toungoo in 1922* (deduced from *TABLE LII.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	− 9	− 7	− 7	− 8	− 7	− 5	− 3	+ 3	+ 8	+12	+17	+20	+20	+13	+ 8	+ 2	− 4	− 6	− 6	− 7	− 7	− 8	− 6	− 8	− 6
Feb.	−11	−10	− 8	− 4	− 4	− 3	− 2	− 1	+ 4	+12	+19	+25	+24	+19	+12	+ 5	− 2	− 8	− 9	−10	−13	− 9	−11	− 9	− 6
Mar.	−12	−13	−10	− 8	− 7	− 8	− 7	− 7	− 1	+11	+23	+33	+37	+27	+18	+ 7	− 3	− 8	−10	−12	−11	−12	−13	−11	− 9
Oct.	−10	− 8	− 8	− 7	− 3	− 3	− 3	− 3	0	+ 7	+16	+25	+28	+21	+13	+ 3	− 1	− 5	− 8	−10	−13	−13	−11	−11	− 7
Nov.	− 5	− 6	− 4	− 3	− 2	− 3	− 1	+ 1	+ 7	+13	+18	+23	+22	+15	+ 7	0	− 5	− 8	−10	−12	−12	−10	−11	− 9	− 5
Dec.	− 8	− 7	− 5	− 5	− 4	− 2	− 0	+ 3	+ 5	+10	+15	+20	+17	+11	+ 6	+ 3	− 1	− 5	− 9	− 9	−10	− 9	− 9	− 8	− 7
Winter Means	− 9	− 8	− 7	− 6	− 4	− 4	− 2	0	+ 4	+11	+18	+25	+25	+18	+11	+ 4	− 2	− 6	− 8	−10	−11	−10	−10	− 9	− 6
April	− 8	−12	− 8	− 9	− 9	− 8	− 9	− 8	− 1	+14	+29	+34	+33	+26	+18	+ 8	− 5	−11	−13	−13	−16	−11	−13	− 9	− 8
May	−10	− 8	− 8	− 8	− 9	− 8	− 6	− 4	+ 2	+13	+24	+28	+27	+22	+14	+ 5	− 5	−11	−13	−12	−11	−11	−11	− 9	− 8
June	− 6	− 7	− 7	− 5	− 5	− 5	− 3	0	+ 6	+12	+20	+23	+22	+18	+12	+ 5	− 3	−10	−14	−12	−11	− 9	− 9	− 9	− 7
July	− 7	− 3	− 6	− 7	− 7	− 7	− 4	− 2	+ 3	+ 7	+15	+19	+19	+17	+12	+ 5	− 2	−10	− 8	− 8	− 8	− 9	− 8	− 7	− 5
Aug.	− 5	− 5	− 4	− 4	− 3	− 4	− 2	− 3	− 2	+ 4	+11	+14	+17	+16	+ 9	+ 1	− 1	− 5	−10	− 9	− 7	− 6	− 7	− 6	− 5
Sept.	− 4	− 4	− 4	− 2	− 2	− 1	− 2	− 5	− 6	+ 2	+12	+16	+17	+15	+ 8	+ 5	− 2	− 9	−10	− 9	− 7	− 7	− 7	− 4	− 2
Summer Means	− 7	− 7	− 7	− 6	− 6	− 6	− 5	− 4	0	+ 8	+18	+22	+22	+19	+12	+ 4	− 3	−10	−12	−11	−10	− 9	−10	− 8	− 6

NOTE—Horizontal Force is greater or less than the mean as sign is + or −.

TABLE LIV.—Hourly means of Vertical Force in C.G.S. units corrected for temperature at Toungoo in 1922 (from available days)

HORIZONTAL FORCE = ·16000 C.G.S. + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
Jan.	γ 711	γ 711	γ 711	γ 711	γ 711	γ 711	γ 711	γ 710	γ 712	γ 709	γ 703	γ **700**	γ 700	γ 704	γ 706	γ 709	γ 710	γ 710	γ 709	γ 710	γ 711	γ 711	γ 711	γ **712**	γ 712	γ 709
Feb.	716	716	716	**716**	716	716	715	715	711	707	**704**	704	706	712	716	716	715	713	713	715	715	715	716	716	716	713
Mar.	718	718	719	718	718	718	718	**720**	717	711	705	700	**698**	702	709	715	715	714	713	714	715	716	717	718	718	714
Oct.	722	722	722	722	722	722	723	**723**	718	710	705	**704**	706	712	718	722	721	718	719	719	720	720	721	722	722	718
Nov.	722	722	722	721	721	721	721	722	722	720	717	**716**	716	717	716	717	718	719	720	721	721	721	722	**723**	722	720
Dec.	**721**	721	721	721	721	721	721	721	720	718	716	715	**713**	715	718	719	719	720	720	720	720	720	720	721	721	719
Winter Means	718	718	719	718	718	718	718	719	717	713	708	**707**	707	710	714	716	716	716	716	717	717	717	718	**719**	719	716
April	720	721	720	720	720	720	**722**	722	716	708	701	**698**	701	707	713	717	720	720	718	718	718	719	720	720	720	716
May	**727**	726	726	726	726	727	**730**	728	722	713	**708**	709	712	717	721	724	727	726	724	724	724	725	726	726	727	723
June	723	723	723	723	723	724	**727**	725	720	713	708	**705**	706	710	715	719	722	723	721	721	721	722	722	723	723	719
July	721	721	721	721	721	722	**724**	723	718	711	705	**703**	705	708	712	717	720	720	719	718	719	720	721	721	722	717
Aug.	722	722	722	723	722	723	**726**	724	717	709	704	**704**	707	711	716	721	723	722	719	720	720	721	722	722	723	718
Sept.	722	722	722	722	722	722	**726**	724	715	705	701	**700**	705	712	718	723	723	721	719	720	721	721	722	723	723	718
Summer Means	723	723	722	723	722	723	**726**	724	718	710	705	**703**	706	711	716	720	723	722	720	720	721	721	722	723	723	719

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LV.—Diurnal Inequality of the Vertical Force at Toungoo in 1922 (deduced from *TABLE LIV.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 1	+ 3	0	− 6	− 9	− 9	− 5	− 3	0	+ 1	+ 1	0	+ 1	+ 2	+ 2	+ 2	+ 3	+ 3
Feb.	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 2	+ 2	− 2	− 6	− 9	− 9	− 7	− 1	+ 3	+ 3	+ 2	0	0	+ 2	+ 2	+ 2	+ 3	+ 3	+ 3
Mar.	+ 4	+ 4	+ 5	+ 4	+ 4	+ 4	+ 4	+ 6	+ 3	− 3	− 9	−14	−16	−12	− 5	+ 1	+ 1	0	− 1	0	+ 1	+ 2	+ 3	+ 4	+ 4
Oct.	+ 4	+ 4	+ 4	+ 4	+ 4	+ 4	+ 5	+ 5	0	− 8	−13	−14	−12	− 6	0	+ 4	+ 3	0	+ 1	+ 1	+ 2	+ 2	+ 3	+ 4	+ 4
Nov.	+ 2	+ 2	+ 2	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2	0	− 3	− 4	− 4	− 3	− 4	− 3	− 2	− 1	0	+ 1	+ 1	+ 1	+ 2	+ 3	+ 2
Dec.	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 1	− 1	− 3	− 4	− 6	− 4	− 1	0	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2
Winter Means	+ 2	+ 2	+ 3	+ 2	+ 2	+ 2	+ 2	+ 3	+ 1	− 3	− 8	− 9	− 9	− 6	− 2	0	0	0	0	+ 1	+ 1	+ 1	+ 2	+ 3	+ 3
April	+ 4	+ 5	+ 4	+ 4	+ 4	+ 4	+ 6	+ 6	0	− 8	−15	−18	−15	− 9	− 3	+ 1	+ 4	+ 4	+ 2	+ 2	+ 2	+ 3	+ 4	+ 4	+ 4
May	+ 4	+ 3	+ 3	+ 3	+ 3	+ 4	+ 7	+ 5	− 1	−10	−15	−14	−11	− 6	− 2	+ 1	+ 4	+ 3	+ 1	+ 1	+ 1	+ 2	+ 3	+ 3	+ 4
June	+ 4	+ 4	+ 4	+ 4	+ 4	+ 5	+ 8	+ 6	+ 1	− 6	−11	−14	−13	− 9	− 4	0	+ 3	+ 4	+ 2	+ 2	+ 2	+ 3	+ 3	+ 4	+ 4
July	+ 4	+ 4	+ 4	+ 4	+ 4	+ 5	+ 7	+ 6	+ 1	− 6	−12	−14	−12	− 9	− 5	0	+ 3	+ 3	+ 2	+ 1	+ 2	+ 3	+ 4	+ 4	+ 5
Aug.	+ 4	+ 4	+ 4	+ 5	+ 4	+ 5	+ 8	+ 6	− 1	− 9	−14	−14	−11	− 7	− 2	+ 3	+ 5	+ 4	+ 1	+ 2	+ 2	+ 3	+ 4	+ 4	+ 5
Sept.	+ 4	+ 4	+ 4	+ 4	+ 4	+ 4	+ 8	+ 6	− 3	−13	−17	−18	−13	− 6	0	+ 5	+ 5	+ 3	+ 1	+ 2	+ 3	+ 3	+ 4	+ 5	+ 5
Summer Means	+ 4	+ 4	+ 3	+ 4	+ 3	+ 4	+ 7	+ 5	− 1	− 9	−14	−16	−13	− 8	− 3	+ 1	+ 4	+ 3	+ 1	+ 1	+ 2	+ 2	+ 3	+ 4	+ 4

NOTE—Vertical Force is greater or less than the mean as sign is + or —.

TABLE LVI.—Hourly means of the Dip at Toungoo in 1922 (determined from available days)

DIP N. 23° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	7·8	7·7	7·7	7·8	7·7	7·6	7·6	7·4	7·3	7·0	6·4	6·1	6·1	6·5	6·9	7·3	7·6	7·6	7·6	7·7	7·7	7·8	7·7	7·8	7·8	7·4
Feb.	8·0	8·0	7·9	7·8	7·8	7·8	7·7	7·6	7·2	6·6	6·2	6·0	6·2	6·8	7·3	7·5	7·7	7·7	7·7	7·9	8·0	7·9	8·0	8·0	7·9	7·5
Mar.	8·2	8·2	8·2	8·0	8·0	8·0	8·0	8·2	7·8	6·9	6·1	5·4	5·1	5·8	6·6	7·4	7·7	7·8	7·7	7·9	7·9	8·0	8·2	8·1	8·1	7·5
Oct.	7·7	7·6	7·6	7·6	7·4	7·4	7·5	7·5	7·0	6·2	5·6	5·2	5·2	5·9	6·6	7·2	7·3	7·2	7·4	7·4	7·6	7·6	7·6	7·7	7·6	7·0
Nov.	7·2	7·2	7·2	7·0	7·0	7·0	7·0	7·0	6·8	6·5	6·1	5·8	5·9	6·2	6·4	6·6	6·9	7·0	7·2	7·3	7·3	7·3	7·4	7·4	7·2	6·9
Dec.	7·2	7·1	7·1	7·1	7·0	7·0	6·9	6·8	6·7	6·4	6·1	5·8	5·8	6·1	6·5	6·7	6·8	7·0	7·1	7·1	7·2	7·1	7·1	7·2	7·1	6·8
Winter Means	7·7	7·6	7·6	7·6	7·5	7·5	7·5	7·4	7·1	6·6	6·1	5·7	5·7	6·2	6·7	7·1	7·3	7·4	7·5	7·6	7·6	7·6	7·7	7·7	7·6	7·2
April	7·8	8·0	7·8	7·9	7·9	7·8	8·0	8·0	7·3	6·1	5·2	4·8	5·1	5·8	6·5	7·1	7·7	7·9	7·8	7·8	7·9	7·5	8·0	7·9	7·8	7·2
May	8·0	7·9	7·9	7·9	7·9	8·0	8·1	7·9	7·3	6·2	5·5	5·5	5·8	6·3	6·8	7·3	7·9	8·0	7·9	7·9	7·8	7·9	8·0	7·9	8·0	7·4
June	7·5	7·5	7·5	7·5	7·5	7·6	7·7	7·5	6·9	6·2	5·6	5·3	5·4	5·8	6·4	6·9	7·4	7·6	7·6	7·5	7·5	7·5	7·5	7·6	7·5	7·0
July	7·5	7·4	7·5	7·5	7·5	7·6	7·7	7·5	7·0	6·4	5·7	5·4	5·6	5·8	6·3	6·9	7·3	7·6	7·4	7·4	7·4	7·6	7·6	7·5	7·6	7·0
Aug.	7·7	7·7	7·6	7·7	7·6	7·7	7·8	7·7	7·2	6·4	5·8	5·7	5·8	6·2	6·8	7·4	7·6	7·7	7·6	7·6	7·6	7·6	7·7	7·7	7·7	7·2
Sept.	7·4	7·4	7·4	7·4	7·4	7·4	7·7	7·6	7·0	6·0	5·4	5·2	5·5	6·1	6·8	7·2	7·4	7·5	7·4	7·4	7·4	7·4	7·5	7·5	7·4	7·0
Summer Means	7·7	7·7	7·6	7·7	7·6	7·7	7·8	7·7	7·1	6·2	5·5	5·3	5·5	6·0	6·6	7·1	7·6	7·7	7·6	7·6	7·6	7·6	7·7	7·7	7·7	7·1

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LVII.—Diurnal Inequality of the Dip at Toungoo in 1922 (deduced from *TABLE LVI*).

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	+0·4	+0·3	+0·3	+0·4	+0·3	+0·2	+0·2	0	−0·1	−0·4	−1·0	−1·3	−1·3	−0·9	−0·5	−0·1	+0·2	+0·2	+0·2	+0·3	+0·3	+0·4	+0·3	+0·4	+0·4
Feb.	+0·5	+0·5	+0·4	+0·3	+0·3	+0·3	+0·2	+0·1	−0·3	−0·9	−1·3	−1·5	−1·3	−0·7	−0·2	0	+0·2	+0·2	+0·2	+0·4	+0·5	+0·4	+0·5	+0·5	+0·4
Mar.	+0·7	+0·7	+0·7	+0·5	+0·5	+0·5	+0·5	+0·7	+0·3	−0·6	−1·4	−2·1	−2·4	−1·7	−0·9	−0·1	+0·2	+0·3	+0·2	+0·4	+0·4	+0·5	+0·7	+0·6	+0·6
Oct.	+0·7	+0·6	+0·6	+0·6	+0·4	+0·4	+0·5	+0·5	0	−0·8	−1·4	−1·8	−1·8	−1·1	−0·4	+0·2	+0·3	+0·2	+0·4	+0·4	+0·6	+0·6	+0·6	+0·7	+0·6
Nov.	+0·3	+0·3	+0·3	+0·1	+0·1	+0·1	+0·1	+0·1	−0·1	−0·4	−0·8	−1·1	−1·0	−0·7	−0·5	−0·3	0	+0·1	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5	+0·3
Dec.	+0·4	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1	0	−0·1	−0·4	−0·7	−1·0	−1·0	−0·7	−0·3	−0·1	0	+0·2	+0·3	+0·3	+0·4	+0·3	+0·3	+0·4	+0·3
Winter Means	+0·5	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·2	−0·1	−0·6	−1·1	−1·5	−1·5	−1·0	−0·5	−0·1	+0·1	+0·2	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5	+0·4
April	+0·6	+0·8	+0·6	+0·7	+0·7	+0·6	+0·8	+0·8	+0·1	−1·1	−2·0	−2·4	−2·1	−1·4	−0·7	−0·1	+0·5	+0·7	+0·6	+0·6	+0·7	+0·6	+0·8	+0·7	+0·6
May	+0·6	+0·5	+0·5	+0·5	+0·5	+0·6	+0·7	+0·5	−0·1	−1·2	−1·9	−1·9	−1·6	−1·1	−0·6	−0·1	+0·5	+0·6	+0·5	+0·5	+0·4	+0·5	+0·6	+0·5	+0·6
June	+0·5	+0·5	+0·5	+0·5	+0·5	+0·6	+0·7	+0·5	−0·1	−0·8	−1·4	−1·7	−1·6	−1·2	−0·6	−0·1	+0·4	+0·6	+0·6	+0·5	+0·5	+0·5	+0·5	+0·6	+0·5
July	+0·5	+0·4	+0·5	+0·5	+0·5	+0·6	+0·7	+0·5	0	−0·6	−1·3	−1·6	−1·4	−1·2	−0·7	−0·1	+0·3	+0·6	+0·4	+0·4	+0·4	+0·6	+0·6	+0·5	+0·6
Aug.	+0·5	+0·5	+0·4	+0·5	+0·4	+0·5	+0·6	+0·5	0	−0·8	−1·4	−1·5	−1·4	−1·0	−0·4	+0·2	+0·4	+0·5	+0·4	+0·4	+0·4	+0·4	+0·5	+0·5	+0·5
Sept.	+0·4	+0·4	+0·4	+0·4	+0·4	+0·6	+0·7	+0·6	0	−1·0	−1·6	−1·8	−1·5	−0·9	−0·2	+0·2	+0·4	+0·5	+0·4	+0·4	+0·4	+0·4	+0·5	+0·5	+0·4
Summer Means	+0·6	+0·6	+0·5	+0·6	+0·5	+0·6	+0·7	+0·6	0	−0·9	−1·6	−1·8	−1·6	−1·1	−0·5	0	+0·5	+0·6	+0·5	+0·5	+0·5	+0·5	+0·6	+0·6	+0·6

NOTE—Dip is greater or less than the mean as sign is + or −.

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
Jan.	56·7	56·7	56·7	56·8	57·0	57·2	57·4	**57·7**	57·3	56·7	56·8	56·9	58·8	56·4	56·2	56·1	**56·0**	56·2	56·4	56·4	56·5	56·5	56·6	56·7	56·7	56·7
Feb.	57·6	57·5	57·5	57·5	57·5	57·6	57·6	57·9	58·3	58·6	58·8	**58·9**	58·6	58·0	57·2	56·7	**56·6**	57·0	57·3	57·3	57·4	57·5	57·6	57·6	57·6	57·7
Mar.	57·8	57·8	57·8	57·9	57·9	57·9	57·9	57·7	57·4	57·3	57·3	57·5	58·0	**58·5**	58·3	57·6	**57·2**	57·4	57·7	57·8	57·9	57·9	57·9	57·9	57·8	57·8
Oct.	59·4	59·4	59·4	59·5	59·6	59·8	59·7	59·3	59·1	59·3	59·9	**60·5**	60·5	60·2	59·8	59·3	**59·0**	59·1	59·3	59·4	59·5	59·5	59·6	59·5	59·4	59·6
Nov.	59·6	59·7	59·8	59·9	60·0	60·2	60·4	**60·7**	60·4	59·9	59·9	59·8	59·7	59·2	59·0	59·0	**58·9**	59·2	59·2	59·4	59·5	59·6	59·6	59·6	59·6	59·7
Dec.	59·9	60·1	60·2	60·4	60·5	60·7	60·7	**60·9**	60·8	60·6	60·5	60·4	60·2	60·0	59·7	59·4	**59·3**	59·5	59·7	59·8	59·8	59·9	60·0	59·9	60·0	60·1
Winter Means	58·5	58·5	58·6	58·7	58·8	58·9	59·0	**59·0**	58·9	58·7	58·9	59·0	59·0	58·7	58·4	58·0	**57·8**	58·1	58·3	58·4	58·4	58·5	58·6	58·5	58·5	58·6
April	58·0	58·0	57·9	57·9	57·9	57·9	57·8	57·1	**57·0**	57·3	57·8	58·5	59·2	**59·6**	59·1	58·6	58·0	57·9	58·0	58·4	58·5	58·3	58·3	58·2	58·0	58·1
May	58·5	58·3	58·2	58·2	58·2	58·2	57·6	**57·0**	57·0	57·8	58·7	59·4	59·9	**59·9**	59·5	59·0	58·5	58·3	58·4	58·8	58·8	58·8	58·8	58·6	58·5	58·5
June	58·9	58·7	58·5	58·5	58·4	58·3	57·7	**57·1**	57·1	57·7	58·7	59·5	60·2	**60·4**	60·1	59·7	59·2	58·9	59·0	59·2	59·2	59·2	59·1	59·0	58·9	58·8
July	59·0	58·7	58·6	58·5	58·4	58·2	57·7	**57·1**	57·2	57·8	58·6	59·5	60·2	**60·2**	60·0	59·6	58·9	58·9	58·9	59·2	59·3	59·3	59·2	59·1	59·0	58·8
Aug.	59·2	59·1	59·0	58·9	58·9	58·7	57·9	**57·3**	57·6	58·5	59·6	60·5	**61·0**	60·9	60·3	59·6	58·9	58·7	59·0	59·2	59·4	59·4	59·5	59·3	59·2	59·2
Sept.	59·6	59·4	59·3	59·4	59·3	59·2	58·7	**58·0**	58·3	59·1	60·1	60·9	**61·3**	61·3	60·6	59·9	59·4	59·3	59·5	59·6	59·8	59·8	59·8	59·7	59·6	59·6
Summer Means	58·9	58·7	58·6	58·6	58·5	58·4	57·9	**57·3**	57·4	58·0	58·9	59·7	60·3	**60·4**	59·9	59·4	58·8	58·7	58·8	59·1	59·2	59·1	59·1	59·0	58·9	58·8

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LIX.—Diurnal Inequality of the ***Declination at Kodaikānal*** *in* ***1922,*** (deduced from *TABLE LVIII*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	0	0	0	−0·1	−0·3	−0·5	−0·7	−1·0	−0·6	0	−0·1	−0·2	−0·1	+0·3	+0·5	+0·6	+0·7	+0·5	+0·3	+0·3	+0·2	+0·2	+0·1	0	0
Feb.	+0·1	+0·2	+0·2	+0·2	+0·2	+0·1	+0·1	−0·2	−0·6	−0·9	−1·1	−1·2	−0·9	−0·3	+0·5	+1·0	+1·1	+0·7	+0·4	+0·4	+0·3	+0·2	+0·1	+0·1	+0·1
Mar.	0	0	0	−0·1	−0·1	−0·1	−0·1	+0·1	+0·4	+0·5	+0·5	+0·3	−0·2	−0·7	−0·5	+0·2	+0·6	+0·4	+0·1	0	−0·1	−0·1	−0·1	−0·1	0
Oct.	+0·2	+0·2	+0·2	+0·1	0	−0·2	−0·1	+0·3	+0·5	+0·3	−0·3	−0·9	−0·9	−0·6	−0·2	+0·3	+0·6	+0·5	+0·3	+0·2	+0·1	+0·1	0	+0·1	+0·2
Nov.	+0·1	0	−0·1	−0·2	−0·3	−0·5	−0·7	−1·0	−0·7	−0·2	−0·2	−0·1	0	+0·5	+0·7	+0·7	+0·8	+0·5	+0·5	+0·3	+0·2	+0·1	+0·1	+0·1	+0·1
Dec.	+0·2	0	−0·1	−0·3	−0·4	−0·6	−0·6	−0·8	−0·7	−0·5	−0·4	−0·3	−0·1	+0·1	+0·4	+0·7	+0·8	+0·6	+0·4	+0·3	+0·3	+0·2	+0·1	+0·2	+0·1
Winter Means	+0·1	+0·1	0	−0·1	−0·2	−0·3	−0·4	−0·4	−0·3	−0·1	−0·3	−0·4	−0·4	−0·1	+0·2	+0·6	+0·8	+0·5	+0·3	+0·2	+0·2	+0·1	0	+0·1	+0·1
April	+0·1	+0·1	+0·2	+0·2	+0·2	+0·2	+0·3	+1·0	+1·1	+0·8	+0·3	−0·4	−1·1	−1·5	−1·0	−0·5	+0·1	+0·2	+0·1	−0·3	−0·4	−0·2	−0·2	−0·1	+0·1
May	0	+0·2	+0·3	+0·3	+0·3	+0·3	+0·9	+1·5	+1·5	+0·7	−0·2	−0·9	−1·4	−1·4	−1·0	−0·5	0	+0·2	+0·1	−0·3	−0·3	−0·3	−0·3	−0·1	0
June	−0·1	+0·1	+0·3	+0·3	+0·4	+0·5	+1·1	+1·7	+1·7	+1·1	+0·1	−0·7	−1·4	−1·6	−1·3	−0·9	−0·4	−0·1	−0·2	−0·4	−0·4	−0·4	−0·3	−0·2	−0·1
July	−0·2	+0·1	+0·2	+0·3	+0·4	+0·6	+1·1	+1·7	+1·6	+1·0	+0·2	−0·7	−1·4	−1·4	−1·2	−0·8	−0·1	−0·1	−0·1	−0·4	−0·5	−0·5	−0·4	−0·3	−0·2
Aug.	0	+0·1	+0·2	+0·3	+0·3	+0·5	+1·3	+1·9	+1·6	+0·7	−0·4	−1·3	−1·8	−1·7	−1·1	−0·4	+0·3	+0·5	+0·2	0	−0·2	−0·2	−0·3	−0·1	0
Sept.	0	+0·2	+0·3	+0·2	+0·3	+0·4	+0·9	+1·6	+1·3	+0·5	−0·5	−1·3	−1·7	−1·7	−1·0	−0·3	+0·2	+0·3	+0·1	0	−0·2	−0·2	−0·2	−0·1	0
Summer Means	−0·1	+0·1	+0·2	+0·2	+0·3	+0·4	+0·9	+1·5	+1·4	+0·8	−0·1	−0·9	−1·5	−1·6	−1·1	−0·6	0	+0·1	0	−0·3	−0·4	−0·3	−0·3	−0·2	−0·1

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
Jan.	γ 840	γ 841	γ **839**	γ 841	γ 840	γ 842	γ 844	γ 850	γ 860	γ 875	γ 887	γ **892**	γ 882	γ 871	γ 860	γ 850	γ 847	γ 845	γ 845	γ 843	γ 842	γ 842	γ 840	γ 841	γ 842	γ 852
Feb.	**839**	844	845	846	846	847	847	853	868	889	**904**	901	890	869	851	842	842	848	847	843	843	842	841	843	843	855
Mar.	**839**	842	846	844	846	846	843	847	866	891	914	**923**	912	893	876	860	855	853	851	847	844	841	841	842	844	861
Oct.	873	875	878	881	880	880	880	884	903	928	947	**952**	939	919	899	888	883	880	879	874	873	**873**	873	875	876	892
Nov.	890	891	892	892	891	891	893	898	909	919	929	**932**	928	920	910	903	896	891	888	**886**	888	887	887	889	890	900
Dec.	891	893	894	895	895	896	897	901	910	922	**931**	930	925	918	911	904	897	893	892	891	890	**889**	890	890	889	902
Winter Means	862	864	866	867	866	867	867	872	886	904	919	**922**	913	898	885	875	870	868	867	864	863	862	**862**	863	864	877
April	855	858	858	860	858	857	857	863	883	909	929	**934**	924	903	883	867	860	859	858	855	856	**853**	856	856	855	873
May	863	863	863	862	863	864	864	869	886	907	923	**926**	920	905	885	871	864	861	861	862	861	**860**	860	862	863	876
June	867	868	870	870	870	870	873	878	887	905	917	**921**	917	906	892	877	865	**862**	864	864	864	864	863	866	867	879
July	866	865	865	865	865	866	869	872	881	895	906	**913**	910	903	891	878	865	**861**	865	863	862	862	862	867	867	876
Aug.	871	872	873	873	873	873	876	880	892	909	918	**920**	917	902	888	878	872	871	873	872	871	870	**870**	871	872	883
Sept.	**870**	872	873	873	874	875	874	878	896	920	931	**932**	918	898	885	876	873	874	873	872	871	870	871	872	873	884
Summer Means	865	866	867	867	867	868	869	873	888	908	921	**924**	918	903	887	875	867	865	866	865	864	**863**	864	866	866	879

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LXI.—Diurnal Inequality of the Horizontal Force at Kodaikanal in 1922 (deduced from *TABLE LX.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	−12	−11	−13	−11	−12	−10	− 8	− 2	+ 8	+23	+35	+40	+30	+19	+ 8	− 2	− 5	− 7	− 7	− 9	−10	−10	−12	−11	−10
Feb.	−16	−11	−10	− 9	− 9	− 8	− 8	− 2	+13	+34	+49	+46	+35	+14	− 4	−13	−13	− 7	− 8	−12	−12	−13	−14	−12	−12
Mar.	−22	−19	−15	−17	−15	−15	−18	−14	+ 5	+30	+53	+62	+51	+32	+15	− 1	− 6	− 8	−10	−14	−17	−20	−20	−19	−17
Oct.	−19	−17	−14	−11	−12	−12	−12	− 8	+11	+36	+55	+60	+47	+27	+ 7	− 4	− 9	−12	−13	−18	−19	−19	−19	−17	−16
Nov.	−10	− 9	− 8	− 8	− 9	− 9	− 7	− 2	+ 9	+19	+29	+32	+28	+20	+10	+ 3	− 4	− 9	−12	−14	−12	−13	−13	−11	−10
Dec.	−11	− 9	− 8	− 7	− 7	− 6	− 5	− 1	+ 8	+20	+29	+28	+23	+16	+ 9	+ 2	− 5	− 9	−10	−11	−12	−13	−12	−12	−13
Winter Means	−15	−13	−11	−10	−11	−10	−10	− 5	+ 9	+27	+42	+45	+36	+21	+ 8	− 2	− 7	− 9	−10	−13	−14	−15	−15	−14	−13
April	−18	−15	−15	−13	−15	−16	−16	−10	+10	+36	+56	+61	+51	+30	+10	− 6	−13	−14	−15	−18	−17	−20	−17	−17	−18
May	−13	−13	−13	−14	−13	−12	−12	− 7	+10	+31	+47	+50	+44	+29	+ 9	− 5	−12	−15	−15	−14	−15	−16	−16	−14	−13
June	−12	−11	− 9	− 9	− 9	− 9	− 6	− 1	+ 8	+26	+38	+42	+38	+27	+13	− 2	−14	−17	−15	−15	−15	−15	−16	−13	−12
July	−10	−11	−11	−11	−11	−10	− 7	− 4	+ 5	+19	+30	+37	+34	+27	+15	+ 2	−11	−15	−11	−13	−14	−14	−14	− 9	− 9
Aug.	−12	−11	−10	−10	−10	−10	− 7	− 3	+ 9	+26	+35	+37	+34	+19	+ 5	− 5	−11	−12	−10	−11	−12	−13	−13	−12	−11
Sept.	−14	−12	−11	−11	−10	− 9	−10	− 6	+12	+36	+47	+48	+34	+14	+ 1	− 8	−11	−10	−11	−12	−13	−14	−13	−12	−11
Summer Means	−14	−13	−12	−12	−12	−11	−10	− 6	+ 9	+29	+42	+45	+39	+24	+ 8	− 4	−12	−14	−13	−14	−15	−16	−15	−13	−13

NOTE—Horizontal Force is greater or less than the mean as sign is + or −.

TABLE LXII.—Hourly means of Vertical Force in C.G.S. units corrected for temperature at Kodaikanal in 1922 (from available days)

VERTICAL FORCE = ·03000 C.G.S. + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	**088**	083	087	088	087	088	088	087	086	080	074	**073**	076	078	079	082	084	083	085	085	086	086	086	088	088	084
Feb.	094	096	095	**096**	095	095	095	092	087	080	073	**069**	075	084	093	**097**	095	090	090	091	092	093	092	094	094	090
Mar.	**096**	**097**	**097**	096	096	096	097	**098**	095	089	081	073	**070**	074	080	084	087	088	089	091	093	094	096	097	98	090
Oct.	**104**	**105**	106	105	**104**	105	106	**106**	101	092	082	**075**	075	080	086	092	095	095	096	098	099	100	101	103	104	096
Nov.	**101**	101	100	100	099	100	099	099	099	098	**097**	096	095	094	**092**	093	093	093	095	096	098	098	099	100	**101**	097
Dec.	102	**103**	102	**102**	101	102	102	100	098	**095**	093	092	094	093	**091**	094	095	095	097	098	099	099	100	101	102	098
Winter Means	098	**098**	098	098	097	098	098	097	094	089	083	**080**	081	084	087	090	092	091	092	093	095	095	096	097	098	093
April	099	100	100	100	099	100	**103**	102	097	089	083	073	**067**	072	079	087	092	092	092	092	095	095	098	098	098	092
May	095	095	095	094	095	097	099	**099**	095	088	082	074	**072**	073	078	085	090	092	091	091	091	093	093	094	095	090
June	096	**096**	097	096	096	097	**100**	099	096	090	084	078	**076**	080	085	090	094	094	092	**092**	093	094	094	096	095	092
July	**098**	098	098	097	097	099	**100**	099	094	089	086	**081**	081	084	087	091	096	096	096	094	095	096	097	099	099	094
Aug.	105	106	107	106	107	108	**111**	107	099	091	087	**079**	081	086	092	099	103	101	099	101	102	103	102	104	105	099
Sept.	104	105	105	105	105	106	**108**	106	098	088	081	**072**	077	085	095	098	099	098	099	101	101	103	103	105	105	098
Summer Means	100	100	100	100	100	101	**104**	102	097	089	084	076	**076**	080	086	092	096	**096**	095	095	096	097	098	099	100	094

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LXIII.—Diurnal Inequality of the Vertical Force at Kodaikanal, in 1922 (deduced from *TABLE LXII*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	+ 4	+ 4	+ 3	+ 4	+ 3	+ 4	+ 4	+ 3	+ 2	− 4	−10	−11	− 8	− 6	− 5	− 2	0	− 1	+ 1	+ 1	+ 2	+ 2	+ 2	+ 4	+ 4
Feb.	+ 4	+ 6	+ 5	+ 6	+ 5	+ 5	+ 5	+ 2	− 3	−10	−17	−21	−15	− 6	+ 3	+ 7	+ 5	0	0	+ 1	+ 2	+ 3	+ 2	+ 4	+ 4
Mar.	+ 6	+ 7	+ 7	+ 6	+ 6	+ 6	+ 7	+ 8	+ 5	− 1	− 9	−17	−20	−16	−10	− 6	− 3	− 2	− 1	+ 1	+ 3	+ 4	+ 6	+ 7	+ 8
Oct.	+ 8	+ 9	+10	+ 9	+ 8	+ 9	+10	+10	+ 5	− 4	−14	−21	−21	−16	−10	− 4	− 1	− 1	0	+ 2	+ 3	+ 4	+ 5	+ 7	+ 8
Nov.	+ 4	+ 4	+ 3	+ 3	+ 2	+ 3	+ 2	+ 2	+ 2	+ 1	0	− 1	− 2	− 3	− 5	− 4	− 4	− 4	− 2	− 1	+ 1	+ 1	+ 2	+ 3	+ 4
Dec.	+ 4	+ 5	+ 4	+ 4	+ 3	+ 4	+ 4	+ 2	0	− 3	− 5	− 6	− 4	− 5	− 7	− 4	− 3	− 3	− 1	0	+ 1	+ 1	+ 2	+ 3	+ 4
Winter Means	+ 5	+ 5	+ 5	+ 5	+ 4	+ 5	+ 5	+ 4	+ 1	− 4	−10	−13	−12	− 9	− 6	− 3	− 1	− 2	− 1	0	+ 2	+ 2	+ 3	+ 4	+ 5
April	+ 7	+ 8	+ 8	+ 8	+ 7	+ 8	+11	+10	+ 5	− 3	− 9	−19	−25	−20	−13	− 5	0	0	0	0	+ 3	+ 3	+ 6	+ 6	+ 6
May	+ 5	+ 5	+ 5	+ 4	+ 5	+ 7	+ 9	+ 9	+ 5	− 2	− 8	−16	−18	−17	−12	− 5	0	+ 2	+ 1	+ 1	+ 1	+ 3	+ 3	+ 4	+ 5
June	+ 4	+ 4	+ 5	+ 4	+ 4	+ 5	+ 8	+ 7	+ 4	− 2	− 8	−14	−16	−12	− 7	− 2	+ 2	+ 2	0	0	+ 1	+ 2	+ 2	+ 4	+ 3
July	+ 4	+ 4	+ 4	+ 3	+ 3	+ 5	+ 6	+ 5	0	− 5	− 8	−13	−13	−10	− 7	− 3	+ 2	+ 2	+ 2	0	+ 1	+ 2	+ 3	+ 5	+ 5
Aug.	+ 6	+ 7	+ 8	+ 7	+ 8	+ 9	+12	+ 8	0	− 8	−12	−20	−18	−13	− 7	0	+ 4	+ 2	0	+ 2	+ 3	+ 4	+ 3	+ 5	+ 6
Sept.	+ 6	+ 7	+ 7	+ 7	+ 7	+ 8	+10	+ 8	0	−10	−17	−26	−21	−13	− 3	0	+ 1	0	+ 1	+ 3	+ 3	+ 5	+ 5	+ 7	+ 7
Summer Means	+ 6	+ 6	+ 6	+ 6	+ 6	+ 7	+10	+ 8	+ 3	− 5	−10	−18	−18	−14	− 8	− 2	+ 2	+ 2	+ 1	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6

NOTE.—Vertical Force is greater or less than the mean as sign is + or −.

TABLE LXIV.—Hourly means of the Dip at Kodaikanal in 1922 (determined from available days)

DIP = N. 4° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	**39·9**	39·9	39·9	39·9	39·8	39·9	39·9	39·8	39·6	39·0	38·3	**38·2**	38·5	38·8	39·0	39·3	39·5	39·4	39·6	39·6	39·7	39·7	39·8	39·9	39·9	39·5
Feb.	40·5	40·6	40·5	40·6	40·5	40·5	40·5	40·2	39·6	38·9	38·1	**37·8**	38·4	39·4	40·3	**40·7**	40·6	40·1	40·1	40·2	40·3	40·4	40·3	40·4	40·4	40·0
Mar.	40·7	40·7	40·7	40·6	40·6	40·6	40·7	**40·8**	40·4	39·6	38·8	38·0	**37·8**	38·3	38·9	39·4	39·7	39·8	39·9	40·2	40·4	40·5	40·6	40·7	40·8	39·9
Oct.	41·1	41·2	**41·3**	41·2	41·1	41·2	41·3	41·2	40·6	39·6	38·6	**37·9**	38·0	38·6	39·3	39·9	40·2	40·3	40·4	40·6	40·7	40·8	40·9	41·0	41·1	40·3
Nov.	**40·7**	40·7	40·6	40·6	40·5	40·6	40·5	40·5	40·4	40·2	40·1	40·0	39·9	39·9	**39·8**	39·9	40·0	40·0	40·2	40·3	40·5	40·5	40·6	40·7	40·7	40·3
Dec.	40·8	**40·9**	40·8	40·8	40·7	40·8	40·8	40·6	40·3	40·0	39·7	**39·6**	39·8	39·8	39·7	40·0	40·1	40·2	40·4	40·5	40·6	40·6	40·6	40·7	40·8	40·4
Winter Means	40·6	**40·7**	40·6	40·6	40·5	40·6	40·6	40·5	40·2	39·6	38·9	**38·6**	38·7	39·1	39·5	39·9	40·0	40·0	40·1	40·2	40·4	40·4	40·5	40·6	40·6	40·1
April	40·8	40·9	40·9	40·9	40·8	40·9	**41·2**	41·0	40·4	39·5	38·8	37·9	**37·4**	38·0	38·8	39·6	40·1	40·2	40·2	40·2	40·4	40·5	4 ·7	40·7	40·7	40·0
May	40·4	40·4	40·4	40·3	40·4	40·6	**40·7**	40·7	40·2	39·4	38·8	38·0	**37·9**	38·1	38·7	39·4	39·9	40·1	40·0	40·0	40·0	40·2	40·2	40·3	40·4	39·8
June	40·5	40·4	40·5	40·4	40·4	40·5	**40·8**	40·6	40·3	39·6	39·0	38·4	**38·3**	33·7	39·3	39·8	40·3	40·3	40·1	40·1	40·2	40·3	40·3	40·5	40·4	40·0
July	40·6	40·6	40·6	40·6	40·6	40·7	**40·8**	40·7	40·2	39·6	39·3	**38·8**	38·8	39·1	39·5	39·9	40·5	40·5	40·5	40·3	40·4	40·5	40·6	40·7	40·7	40·2
Aug.	41·2	41·3	41·4	41·3	41·4	41·5	**41·7**	41·3	40·5	39·7	39·3	**38·5**	38·7	39·3	39·9	40·6	41·0	40·9	40·7	40·9	41·0	41·1	41·0	41·1	41·2	40·6
Sept.	41·1	41·2	41·2	41·2	41·2	41·3	**41·5**	41·3	40·4	39·3	38·6	**37·8**	38·4	39·2	40·2	40·6	40·7	40·6	40·7	40·9	40·9	41·1	41·1	41·2	41·2	40·5
Summer Means	40·8	40·8	40·8	40·8	40·8	40·9	**41·1**	40·9	40·3	39·5	39·0	**38·2**	38·3	38·7	39·4	40·0	40·4	40·4	40·4	40·4	40·5	40·6	40·7	40·8	40·8	40·2

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LXV—Diurnal Inequality of the Dip at Kodaikanal in 1922 (deduced from *TABLE LXIV.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	+0·4	+0·4	+0·4	+0·4	+0·3	+0·4	+0·4	+0·3	+0·1	−0·5	−1·2	−1·3	−1·0	−0·7	−0·5	−0·2	0	−0·1	+0·1	+0·1	+0·2	+0·2	+0·3	+0·4	+0·4
Feb.	+0·5	+0·6	+0·5	+0·6	+0·5	+0·5	+0·5	+0·2	−0·4	−1·1	−1·9	−2·2	−1·6	−0·6	+0·3	+0·7	+0·6	+0·1	+0·1	+0·2	+0·3	+0·4	+0·3	+0·4	+0·4
Mar.	+0·8	+0·8	+0·8	+0·7	+0·7	+0·7	+0·8	+0·9	+0·5	−0·3	−1·1	−1·9	−2·1	−1·6	−1·0	−0·5	−0·2	−0·1	0	+0·3	+0·5	+0·6	+0·7	+0·8	+0·9
Oct.	+0·8	+0·9	+1·0	+0·9	+0·8	+0·9	+1·0	+0·9	+0·3	−0·7	−1·7	−2·4	−2·3	−1·7	−1·0	−0·4	−0·1	0	+0·1	+0·3	+0·4	+0·5	+0·6	+0·7	+0·8
Nov.	+0·4	+0·4	+0·3	+0·3	+0·2	+0·3	+0·2	+0·2	+0·1	−0·1	−0·2	−0·3	−0·4	−0·4	−0·5	−0·4	−0·3	−0·3	−0·1	0	+0·2	+0·2	+0·3	+0·4	+0·4
Dec.	+0·4	+0·5	+0·4	+0·4	+0·3	+0·4	+0·4	+0·2	−0·1	−0·4	−0·7	−0·8	−0·6	−0·6	−0·7	−0·4	−0·3	−0·2	0	+0·1	+0·2	+0·2	+0·2	+0·3	+0·4
Winter Means	+0·5	+0·6	+0·5	+0·5	+0·4	+0·5	+0·5	+0·4	+0·1	−0·5	−1·2	−1·5	−1·4	−1·0	−0·6	−0·2	−0·1	−0·1	0	+0·1	+0·3	+0·3	+0·4	+0·5	+0·5
April	+0·8	+0·9	+0·9	+0·9	+0·8	+0·9	+1·2	+1·0	+0·4	−0·5	−1·2	−2·1	−2·6	−2·0	−1·2	−0·4	+0·1	+0·2	+0·2	+0·2	+0·4	+0·5	+0·7	+0·7	+0·7
May	+0·6	+0·6	+0·6	+0·5	+0·6	+0·8	+0·9	+0·9	+0·4	−0·4	−1·0	−1·8	−1·9	−1·7	−1·1	−0·4	+0·1	+0·3	+0·2	+0·2	+0·2	+0·4	+0·4	+0·5	+0·6
June	+0·5	+0·4	+0·5	+0·4	+0·4	+0·5	+0·8	+0·6	+0·3	−0·4	−1·0	−1·6	−1·7	−1·3	−0·7	−0·2	+0·3	+0·3	+0·1	+0·1	+0·2	+0·3	+0·3	+0·5	+0·4
July	+0·4	+0·4	+0·4	+0·4	+0·4	+0·5	+0·6	+0·5	0	−0·6	−0·9	−1·4	−1·4	−1·1	−0·7	−0·3	+0·3	+0·3	+0·3	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5
Aug.	+0·6	+0·7	+0·8	+0·7	+0·8	+0·9	+1·1	+0·7	−0·1	−0·9	−1·3	−2·1	−1·9	−1·3	−0·7	0	+0·4	+0·3	+0·1	+0·3	+0·4	+0·5	+0·4	+0·5	+0·6
Sept.	+0·6	+0·7	+0·7	+0·7	+0·7	+0·8	+1·0	+0·8	−0·1	−1·2	−1·9	−2·7	−2·1	−1·3	−0·3	+0·1	+0·2	+0·1	+0·2	+0·4	+0·4	+0·6	+0·6	+0·7	+0·7
Summer Means	+0·6	+0·6	+0·6	+0·6	+0·6	+0·7	+0·9	+0·7	+0·1	−0·7	−1·2	−2·0	−1·9	−1·5	−0·8	−0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+0·6	+0·6

78. *Dehra Dun Observatory 1923-24.*

The torsion head of the declination magnetograph was adjusted by turning the micrometer head by two complete revolutions in November 1923.

Except for the above and a few other slight adjustments for light in both the declination and V. F. magnetographs these continued to function well throughout the year. The H. F. magnetograph clock gave occasional trouble and was thoroughly cleaned and oiled on two different occasions during the year.

During the heavy floods in Upper India in October 1924, the observatory was flooded from the 30th September to 7th October, necessitating a complete stoppage of work for that period.

79. *Mean values of the declination and H.F. constants.*

The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and the accepted value of the distribution factor $\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$. The values of the moment "m" in the table were derived from vibration observations taken with the chronograph.

Mean values of the constants of Magnet No. 17 at Dehra Dūn in 1923

Months	Declination constants	H. F. Constants				
		Distribution factors			Mean values of m	
	Mean magnetic collimation	$P_{1\cdot2}$	$P_{2\cdot3}$	Accepted values of $\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$	Monthly means	Accepted m
January ..	− 7′ 1″	6·08	7·28	$\bar{1}$·99431 up to 30th September; $\bar{1}$·99414 from 1st October	806·36	806·18 throughout
February ...	− 7 6	6·11	7·40		·28	
March ..	− 7 2	6·16	7·45		·25	
April ...	− 7 2	6·20	7·36		·34	
May ..	− 7 0	6·17	7·31		·27	
June ..	− 6 59	6·17	7·58		·12	
July ...	− 6 59	6·06	7·19		·19	
August ..	− 6 56	6·18	7·49		·38	
September ..	− 6 35	6·22	7·33		·34	
October ...	− 6 40	5·91	7·18		·38	
November .	− 6 51	5·95	7·27		·34	
December ...	− 6 55	5·92	7·20		·46	

80. *Mean base-line values.*

The table below gives the mean monthly observed and accepted values of the declination and horizontal force base lines: the accepted values have been used to compute the values of these elements for 1923.

Base line values of magnetographs at Dehra Dūn in 1923

Months	Declination		Horizontal Force	
	Mean value of Base line	Base line accepted	Mean value of Base line	Base line accepted
January ...	1° 5′·4	1° 5′·4	·32633	·32633
February ...	1 5·8	1 5·8	·32631	·32631
March ...	1 6·0	1 6·0	·32633	·32633
April ...	1 6·1	1 6·1	·32629	·32629
May ...	1 6·4	1 6·4	·32632	·32632
June ...	1 6·2	1 6·2	·32637	·32637
July ...	1 6·3	1 6·3	·32640	·32640
August ...	1 6·2	1 6·2	·32636	·32636
September ...	1 6·1	1 6·1	·32649	·32649
October ...	1 5·9	1 5·9	·32650	·32650
November ...	1 6·1 0 43·8	1 6·1* 0 43·8†	·32651	·32651
December ...	0 44·2	0 44·2	·32676‡	·32676

* up to 10 hr. on 16th.
† from 11 hr. on 16th.
‡ Change from 29th Nov.

The mean scale values for 1923 for an ordinate of 1/25 inch are:— **81.** *Mean scale values and temperature range.*

Horizontal Force	4·35 gammas.
Declination	1·03 minutes.
Vertical Force	7·44 to 10·05 gammas.

The mean temperature for the year was 27°·0 C., with maximum and minimum monthly values of 27°·7 C. and 26°·7 C. The temperature of reduction is 27°·0 C.

The following table shows the monthly mean values of the magnetic elements for 1922 and 1923 and the annual changes for that period. **82.** *Mean monthly values and annual changes.*

Annual changes at Dehra Dūn in 1922-23

Months	Horizontal Force ·32000 C.G.S. +			Declination E. 1° +			Dip N. 45° +			Vertical Force ·33000 C.G.S. +		
	1922	1923	Annual change	1922	1923	Annual change	1922	1923	Annual change	1922	1923	Annual change
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January ...	936	919	−17	44·8	40·1	−4·7	6·6	10·1	+3·5	062	115	+53
February ..	933	919	−14	44·5	40·2	−4·3	6·9	10·7	+3·8	066	125	+59
March ...	935	917	−18	44·4	40·0	−4·4	7·4	11·3	+3·9	076	134	+58
April ...	939	914	−25	43·9	39·5	−4·4	7·6	11·4	+3·8	084	133	+49
May ...	931	926	− 5	44·1	39·3	−4·8	7·6	11·6	+4·0	076	150	+74
June ...	936	924	−12	43·8	38·7	−5·1	7·8	11·6	+3·8	086	149	+63
July ...	926	929	+ 3	43·0	38·5	−4·5	8·6	13·3	+4·7	092	184	+92
August ...	922	930	+ 8	42·9	37·9	−5·0	9·5	13·3	+3·8	105	186	+81
September ...	917	941	+24	42·5	37·5	−5·0	9·7	13·5	+3·8	103	200	+97
October ...	916	929	+13	42·5	37·3	−5·2	10·4	14·5	+4·1	116	209	+94
November ...	919	939	+20	41·5	37·3	−4·2	10·1	14·3	+4·2	113	212	+99
December ...	915	935	+20	40·9	37·4	−3 5	10·6	14·4	+3·8	118	211	+93
Means ...	927	927	0	43·2	38·6	−4·6	8·6	12·5	+3·9	091	167	+76

83. *Toungoo observatory 1923.*

For reasons of economy the observatory was dismantled in October 1923 when the instruments were removed to Dehra Dūn and the buildings were handed over to the Director, Burma Circle.

84. *Mean values of declination and H.F. constants.*

The magnetographs have functioned satisfactorily for the few months they were working.

The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and the accepted value of log $\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$ the distribution factor.

Mean values of the constants of Magnet No. 20 at Toungoo in 1923

Months	Declination constants	H. F. Constants				
	Mean magnetic collimation	Distribution factors			Mean values of m	
		$P_{1\cdot2}$	$P_{2\cdot3}$	$\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$	Monthly means	Accepted m
	′ ″					
January ...	− 7 23	7·16	7·23	$\bar{1}$·99363 throughout	930·83	930·85 throughout
February ...	− 7 20	7·15	7·11		·84	
March ...	− 7 26	7·21	7·17		·88	
April ...	− 7 30	7·19	7·26		·83	
May ...	− 7 30	7·19	7·14		·75	
June ...	− 7 28	7·15	{6·84 8·95		·69	
July ...	− 7 34	7·09	9·11		·77	
August ...	− 7 32	7·12	8·97		·82	
September ...	− 7 30	7·13	9·05		·84	

Note.—The observatory was discontinued from October 1923.

The table below gives the mean monthly observed and accepted values of the declination and horizontal force base lines. 85. *Mean base line values.*

Base line values of magnetographs at Toungoo in 1923

Months	Declination		Horizontal Force	
	Mean value of base line	Base line accepted	Mean value of base line	Base line accepted
	° ′	° ′	C.G.S.	C.G.S.
January ...	1 14·0	1 14·0	·38920	·38920
February ...	1 13·9	1 13·9	·38917	·38917
March ...	1 13·8	1 13·8	·38918	·38918
April ...	1 13·7	1 13·7	·38912	·38912
May ...	1 13·8	1 13·8	·38914	·38914
June ...	1 13·8	1 13·8	·38914	·38914
July ...	1 13·7	1 13·7	·38905	·38905
August ...	1 13·6	1 13·6	·38901	·38901
September ...	1 13·6	1 13·6	·38901	·38901

Note.—The observatory was discontinued from October 1923.

86. *Mean scale values and temperature range.*

The mean scale values for 1923 for an ordinate of 1/25 inch are:—

Horizontal Force	5·25 gammas.
Declination	1·04 minutes.
Vertical Force	5·87 to 5·91 gammas.

The mean temperature for the year was 89°·0 Fahr., with maximum and minimum values of 89°·6 and 88°·4 Fahr. The temperature of reduction is 89°·0 Fahr.

87. *Mean monthly values and annual changes.*

The table below shows the monthly mean values of the magnetic elements for 1922 and 1923 and the annual changes for that period.

Annual changes at Toungoo in 1922-23

Months	Horizontal Force ·39000 C.G.S. +			Declination W. 0° +			Dip N. 23° +			Vertical Force ·16000 C.G.S. +		
	1922	1923	Annual change	1922	1923	Annual change	1922	1923	Annual change	1922	1923	Annual change
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January ...	131	201	+70	29·1	31·1	+2·0	7·4	6·4	−1·0	709	726	+[illegible]
February ...	137	201	+64	28·8	31·6	+2·8	7·5	6·3	−1·2	713	725	+[illegible]
March ...	138	200	+62	28·9	31·5	+2·6	7·5	6·3	−1·2	714	724	+[illegible]
April ...	150	198	+48	29·0	31·7	+2·7	7·2	6·3	−0·9	716	724	+[illegible]
May ...	162	211	+49	29·3	31·8	+2·5	7·4	6·0	−1·4	723	725	+[illegible]
June ...	165	212	+47	29·4	32·1	+2·7	7·0	6·0	−1·0	719	725	+[illegible]
July ...	160	209	+49	29·6	32·2	+2·6	7·0	6·1	−0·9	717	724	+[illegible]
August ...	157	216	+59	29·8	32·5	+2·7	7·2	5·9	−1·3	718	725	+[illegible]
September ...	163	219	+56	30·3	32·9	+2·6	7·0	5·9	−1·1	718	726	+[illegible]
October ...	162	...	...	30·5	...	...	7·0	...	...	718	...	...
November ...	172	...	...	30·7	...	...	6·9	...	...	720	...	...
December ...	173	...	...	30·9	...	...	6·8	...	...	719	...	...
Means ...	156	...	...	29·7	...	...	7·2	...	...	717	...	...

Note.—The observatory was discontinued from October 1923.

As the observatory was closed in October 1923, the magnetographs for only the first nine months of 1923 were received in this office.

88. *Kodaikanal observatory 1923.*

The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot 2}$ and $P_{2\cdot 3}$ and the value of the distribution factor $\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$.

89. *Mean values of the declination and H.F. constants.*

Mean values of the constants of Magnet No. 16 at Kodaikānal in 1923

Months	Declination constants	H.F. Constants				
	Mean magnetic collimation	Distribution factors			Mean values of m	
		$P_{1\cdot 2}$	$P_{2\cdot 3}$	$\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$	Monthly means	Accepted m
	′ ″					
January ...	− 3 22	6·40	8·49	1·99291 throughout	882·07	881·74 throughout
February ...	− 3 22	6·34	8·30		881·95	
March ...	− 3 22	6·44	8·45		882·06	
April ...	− 3 21	6·42	8·38		882·03	
May ...	− 3 19	6·40	8·54		881·96	
June ...	− 3 21	6·39	8·32		881·96	
July ...	− 3 21	6·33	8·16		882·10	
August ...	− 3 21	6·41	8·38		882·11	
September	− 3 22	6·51	8·59		882·09	

Note.—The observatory was discontinued from October 1923.

90. **Mean base line value** The table below gives the mean monthly observed and accepted base line values of the declination and horizontal force magnetographs.

Base line values of magnetographs at Kodaikānal in 1923

Months	Declination		Horizontal Force	
	Mean value of base line	Base line accepted	Mean value of base line	Base line accepted
	° ′	° ′	C.G.S.	C.G.S.
January ...	2 48·6	2 48·6	·37613	·37613
February ...	2 48·4	2 48·4	·37618	·37618
March ...	2 48·5	2 48·5	·37617	·37617
April ...	2 48·6	2 48·6	·37621	·37621
May ...	2 48·4	2 48·4	·37620	·37620
June ...	2 48·4	2 48·4	·37620	·37620
July ...	2 48·3	2 48·3	·37614	·37614
August ...	2 48·3	2 48·3	·37610	·37610
September ...	2 48·1	2 48·1	·37617	·37617

Note.—The observatory was discontinued from October 1923.

91. *Mean scale values and temperature range.*

The mean scale values for 1923 for an ordinate of 1/25 inch are:—

Horizontal Force	5·89 gammas.
Declination	1·03 minutes.
Vertical Force	12·94 to 13·13 gammas.

The mean temperature for the year was 17°·3 C, with maximum and minimum monthly values of 18°·2 C and 16°·0 C. The temperature of reduction is 19°·0 C.

92. *Mean monthly values and annual changes.*

The table below gives the monthly mean values of the magnetic elements for 1922 and 1923 and the annual changes for that period.

Annual changes at Kodaikānal in 1922-23

Months	Horizontal Force ·37000 C.G.S. +			Declination W. 1° +			Dip N. 4° +			Vertical Force ·03000 C.G.S. +		
	1922	1923	Annual change	1922	1923	Annual change	1922	1923	Annual change	1922	1923	Annual change
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January ...	852	929	+77	56·7	59·7	+3·0	39·5	40·7	+1·2	084	104	+20
February ...	855	942	+87	57·7	59·8	+2·1	40·0	40·5	+0·5	090	103	+13
March ...	861	938	+77	57·8	60·0	+2·2	39·9	41·1	+1·2	090	109	+19
April ...	873	945	+72	58·1	60·6	+2·5	40·0	41·0	+1·0	092	108	+16
May ...	876	950	+74	58·5	60·7	+2·2	39·8	41·7	+1·9	090	117	+27
June ...	879	954	+75	58·8	60·9	+2·1	40·0	41·8	+1·8	092	118	+26
July ...	876	953	+77	58·8	61·0	+2·2	40·2	42·0	+1·8	094	120	+26
August ...	883	962	+79	59·2	61·4	+2·2	40·6	41·6	+1·0	099	117	+18
September ...	884	978	+94	59·6	62·4	+2·8	40·5	41·4	+0·9	098	116	+18
October ...	892			59·6			40·3			096		
November ...	900			59·7			40·3			097		
December ...	902			60·1			40·4			098		
Means ...	878			57·9			40·1			093		

Note.—The observatory was discontinued from October 1923.

93. *Mean values of magnetic elements at observatories in 1923.*

Mean values of the magnetic elements at observatories in 1923

Observatory	Latitude and Longitude	Dip	Declination	H. F.	V. F.
	° ′ ″	° ′	° ′	C. G. S.	C. G. S.
Dehra Dūn ...	30 19 19 N. 78 3 19 E.	N. 45 12·5	E. 1 38·6	·32927	·33167
Toungoo ...	18 55 45 N. 96 27 3 E.	N. 23 6·1	W. 0 31·9	·39207	·16725
Kodaikānal ...	10 13 50 N. 77 27 46 E.	N. 4 41·3	W. 2 0·7	·37950	·03112

Note.—Means for 9 months only in case of Toungoo and Kodaikānal.

TABLE LXVI.—Classification and dates of Magnetic Disturbances in 1923

D = Dehra Dūn T = Toungoo K = Kodaikānal C = Calm. S = Slight. M = Moderate. G = Great. V. G. = Very Great. — = Trace lost.

Dates	January			February			March			April			May			June			July			August			September			Oct	Nov.	Dec.
1923	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	D	D
1	C	C	C	S	C	S	C	C	C	C	C	C	C	C	C	S	C	C	—	S	S	C	C	C	—	S	S	S	S	—
2	S	S	S	S	S	S	S	S	S	C	C	C	S	S	S	C	S	C	—	S	S	—	C	C	S	S	C	S	S	C
3	C	S	S	S	S	S	C	C	C	S	C	S	S	S	S	C	C	S	S	S	S	—	S	S	—	S	S	C	S	S
4	S	S	S	C	C	S	S	S	S	S	S	C	S	S	S	S	S	S	C	C	C	—	S	S	—	S	S	S	C	—
5	S	S	S	S	S	S	C	C	C	C	C	C	S	C	S	—	S	S	C	C	C	C	S	S	—	C	S	S	C	—
6	S	S	S	S	S	S	C	C	C	C	C	C	C	C	C	—	S	C	—	S	S	S	S	S	C	C	C	S	S	C
7	S	S	S	S	S	S	S	S	S	C	C	C	C	C	C	S	C	S	—	S	S	S	S	S	C	C	C	S	S	C
8	C	C	C	S	S	S	C	C	C	S	S	S	S	S	S	C	C	C	S	S	C	S	C	C	C	C	C	S	C	S
9	S	S	S	C	C	C	C	C	C	S	S	S	S	S	S	C	C	C	S	C	C	S	S	C	C	C	C	C	C	S
10	S	C	S	S	S	S	C	C	C	S	S	S	S	S	C	C	C	C	M	M	M	—	S	S	S	S	S	S	C	S
11	C	S	S	S	S	C	C	S	S	S	S	S	C	C	C	S	S	S	S	S	S	C	C	C	S	S	S	M	S	C
12	C	S	S	C	C	S	S	S	S	S	S	S	C	C	C	C	C	C	S	S	S	C	C	C	S	C	C	S	S	C
13	S	S	S	C	C	C	C	C	S	S	S	S	C	C	C	G	M	M	S	C	C	S	S	S	S	S	C	S	S	S
14	S	S	S	C	S	—	S	C	C	S	S	S	S	S	S	M	S	S	C	C	C	M	S	S	S	S	S	C	C	S
15	S	S	S	S	S	S	S	—	S	S	S	S	S	S	S	S	S	S	C	C	C	—	S	C	S	S	C	VG	C	S
16	S	S	S	S	S	S	S	—	S	C	C	C	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C	VG	S	S
17	C	C	S	S	S	S	S	—	S	C	C	C	M	M	M	C	C	C	—	C	C	S	S	C	C	C	C	G	C	C
18	C	C	S	S	S	S	S	C	S	S	S	S	M	M	M	C	C	C	—	S	S	C	C	C	S	S	S	M	S	C
19	C	C	C	S	S	C	S	S	S	C	C	C	S	S	S	S	C	C	S	S	S	S	S	C	S	C	C	G	C	S
20	M	M	M	S	S	C	C	C	C	S	S	S	S	S	S	S	C	C	—	C	C	S	S	S	S	S	C	S	C	S
21	S	S	S	C	C	C	S	S	S	M	M	M	S	C	C	M	M	S	C	C	C	C	C	C	S	C	C	S	S	C
22	S	S	—	C	C	C	C	C	C	M	M	S	C	C	C	S	S	S	—	C	C	C	C	C	C	C	C	S	S	C
23	S	S	—	C	C	C	C	C	C	S	S	S	S	S	S	S	S	C	S	S	S	S	S	S	S	S	C	C	S	S
24	S	S	S	C	C	C	G	G	G	S	S	S	C	C	C	C	C	C	C	C	C	S	S	S	S	S	S	C	C	M
25	C	C	S	G	G	G	G	G	G	S	S	S	S	S	S	C	C	C	C	C	C	S	S	S	S	S	S	C	C	M
26	C	C	S	G	M	M	M	M	M	C	C	C	S	C	C	C	C	C	C	C	C	C	C	C	M	S	M	S	C	G
27	C	C	C	G	M	M	S	S	S	C	C	C	C	C	C	S	S	S	S	S	S	C	C	C	G	G	G	M	M	M
28	C	C	C	S	S	S	S	S	S	C	C	C	C	C	C	S	S	S	S	C	—	C	C	C	G	G	M	S	S	S
29	M	M	M				S	S	S	C	C	C	S	S	S	C	C	C	S	S	S	C	C	C	S	S	S	C	M	S
30	S	S	M				S	C	C	S	S	C	S	S	S	M	M	M	C	C	—	C	C	C	S	S	S	C	—	S
31	S	S	C				C	C	C				S	C	S				C	C	—	—	S	—				S		S
C ...	12	10	6	9	9	9	13	15	13	12	13	14	11	15	14	12	15	16	10	17	15	13	14	18	7	11	15	8	13	9
S ...	17	19	20	16	16	15	15	10	15	16	15	15	18	14	15	12	12	12	12	13	12	11	17	12	16	17	12	16	14	15
M ...	2	2	3	...	2	2	1	1	1	2	2	1	2	2	2	3	3	2	1	1	1	1	...	...	1	...	2	3	2	3
G ...	...	...	...	3	1	1	2	2	2	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	2	2	1	2	...	1
V.G. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
Trace lost	...	...	2	...	...	1	...	3	...	...	...	...	...	...	...	2	...	...	8	...	3	6	...	1	4	...	...	...	1	3

Note.—Toungoo and Kodaikānal observatories were discontinued from October 1923.

TABLE LXVII.—Hourly means of the Declination at Dehra Dun, in 1923 (determined from 5 selected quiet days)

DECLINATION = E. 1° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	40·3	40·4	40·3	40·2	39·9	39·6	39·4	**39·2**	39·8	40·7	**40·9**	40·0	39·5	39·8	40·3	40·4	40·4	40·3	40·3	40·3	40·2	40·2	40·2	40·1	40·1	40·1
Feb.	40·2	40·2	40·0	40·0	39·9	39·8	**39·6**	39·7	40·9	41·8	**41·9**	41·2	40·3	39·7	39·8	39·9	39·9	39·9	39·9	39·9	40·1	40·3	40·2	40·1	40·1	40·2
Mar.	40·3	40·4	40·3	40·2	40·1	40·0	39·9	40·4	41·4	**41·9**	41·5	40·2	38·6	**37·9**	38·4	39·2	40·0	40·3	39·9	39·9	39·8	40·0	40·0	40·1	40·1	40·0
Oct.	37·5	37·5	37·5	37·5	37·5	37·5	37·4	38·0	**39·1**	39·0	38·0	36·6	35·8	**35·4**	35·9	36·9	37·4	37·5	37·3	37·2	37·2	37·2	37·3	37·3	37·3	37·3
Nov.	37·5	37·4	37·4	37·4	37·2	37·2	37·3	37·3	37·9	**38·1**	37·6	37·1	**36·7**	37·0	37·5	37·7	37·4	37·2	37·2	37·3	37·3	37·2	37·3	37·3	37·4	37·3
Dec.	**37·7**	37·4	37·4	37·2	37·1	37·0	36·9	**36·8**	36·9	37·4	37·6	37·1	36·9	37·3	37·6	37·7	37·7	37·7	37·6	37·6	37·6	37·5	37·5	37·6	37·7	37·4
Winter Means	38·9	38·9	38·8	38·8	38·6	38·5	38·4	38·6	39·3	**39·8**	39·6	38·7	38·0	**37·9**	38·3	38·6	38·8	38·8	38·7	38·7	38·7	38·7	38·8	38·8	38·8	38·7
April	39·6	39·7	39·8	39·8	39·8	39·9	40·1	40·8	41·7	**41·8**	40·6	38·8	37·5	**37·0**	37·3	38·1	38·9	39·5	39·5	39·4	39·3	39·5	39·6	39·7	39·8	39·5
May	39·5	39·6	39·8	39·8	39·7	39·9	40·7	41·4	**41·6**	41·0	39·9	38·1	37·2	**36·8**	36·9	37·8	38·5	39·1	39·4	39·1	39·0	39·1	39·2	39·3	39·6	39·3
June	39·0	39·2	39·2	39·2	39·2	39·3	40·3	41·2	**41·5**	40·9	39·7	38·2	36·8	**36·3**	36·5	36·8	37·5	38·2	38·6	38·3	38·2	38·4	38·6	38·7	38·8	38·7
July	38·6	38·9	39·1	39·1	39·2	39·4	40·2	40·7	**40·9**	40·5	39·6	38·3	37·3	36·5	**36·3**	36·8	37·5	38·1	38·2	38·1	37·9	37·9	38·0	38·0	38·2	38·5
Aug.	38·1	38·2	38·2	38·2	38·3	38·4	39·5	40·4	**40·6**	39·7	38·0	36·7	35·8	**35·5**	36·1	36·9	37·4	37·8	38·1	37·7	37·6	37·5	37·7	37·9	38·0	37·9
Sept.	37·7	38·0	38·0	38·0	38·0	38·0	38·4	39·1	**39·8**	39·0	37·4	36·2	35·3	**34·9**	35·8	37·0	37·7	37·8	37·4	37·3	37·4	37·5	37·6	37·7	37·8	37·5
Summer Means	38·8	38·9	39·0	39·0	39·0	39·2	39·9	40·6	**41·0**	40·5	39·2	37·7	36·7	**36·2**	36·5	37·2	37·9	38·4	38·5	38·3	38·2	38·3	38·5	38·6	38·7	38·6

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LXVIII.—Diurnal Inequality of the Declination at Dehra Dun in 1923 (deduced from *TABLE LXVII*).

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
Jan.	+0·2	+0·3	+0·2	+0·1	−0·2	−0·5	−0·7	−0·9	−0·3	+0·6	+0·8	−0·1	−0·6	−0·3	+0·2	+0·3	+0·3	+0·2	+0·2	+0·2	+0·1	+0·1	+0·1	0	0
Feb.	0	0	−0·2	−0·2	−0·3	−0·4	−0·6	−0·5	+0·7	+1·6	+1·7	+1·0	+0·1	−0·5	−0·4	−0·3	−0·3	−0·3	−0·3	−0·3	−0·1	+0·1	0	−0·1	−0·1
Mar.	+0·3	+0·4	+0·3	+0·2	+0·1	0	−0·1	+0·4	+1·4	+1·9	+1·5	+0·2	−1·4	−2·1	−1·6	−0·8	0	+0·3	−0·1	−0·1	−0·2	0	0	+0·1	+0·1
Oct.	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1	+0·7	+1·8	+1·7	+0·7	−0·7	−1·5	−1·9	−1·4	−0·4	+0·1	+0·2	0	−0·1	−0·1	−0·1	0	0	0
Nov.	+0·2	+0·1	+0·1	+0·1	−0·1	−0·1	0	0	+0·6	+0·8	+0·3	−0·2	−0·6	−0·3	+0·2	+0·4	+0·1	−0·1	−0·1	0	0	−0·1	0	0	+0·1
Dec.	+0·3	0	0	−0·2	−0·3	−0·4	−0·5	−0·6	−0·5	0	+0·2	−0·3	−0·5	−0·1	+0·2	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·1	+0·1	+0·2	+0·3
Winter Means	+0·2	+0·2	+0·1	+0·1	−0·1	−0·2	−0·3	−0·1	+0·6	+1·1	+0·9	0	−0·7	−0·8	−0·4	−0·1	+0·1	+0·1	0	0	0	0	+0·1	+0·1	+0·1
April	+0·1	+0·2	+0·3	+0·3	+0·3	+0·4	+0·6	+1·3	+2·2	+2·3	+1·1	−0·7	−2·0	−2·5	−2·2	−1·4	−0·6	0	0	−0·1	−0·2	0	+0·1	+0·2	+0·3
May	+0·2	+0·3	+0·5	+0·5	+0·4	+0·6	+1·4	+2·1	+2·3	+1·7	+0·6	−1·2	−2·1	−2·5	−2·4	−1·5	−0·8	−0·2	+0·1	−0·2	−0·3	−0·2	−0·1	0	−0·3
June	+0·3	+0·5	+0·5	+0·5	+0·5	+0·6	+1·6	+2·5	+2·8	+2·2	+1·0	−0·5	−1·9	−2·4	−2·2	−1·9	−1·2	−0·5	−0·1	−0·4	−0·5	−0·3	−0·1	0	+0·1
July	+0·1	+0·4	+0·6	+0·6	+0·7	+0·9	+1·7	+2·2	+2·4	+2·0	+1·1	−0·2	−1·2	−2·0	−2·2	−1·7	−1·0	−0·4	−0·3	−0·4	−0·6	−0·6	−0·5	−0·5	−0·3
Aug.	+0·2	+0·3	+0·3	+0·3	+0·4	+0·5	+1·6	+2·5	+2·7	+1·8	+0·1	−1·2	−2·1	−2·4	−1·8	−1·0	−0·5	−0·1	+0·2	−0·2	−0·3	−0·4	−0·2	0	+0·1
Sept.	+0·2	+0·5	+0·5	+0·5	+0·5	+0·5	+0·9	+1·6	+2·3	+1·5	−0·1	−1·3	−2·2	−2·6	−1·7	−0·5	+0·2	+0·3	−0·1	−0·2	−0·1	0	+0·1	+0·2	+0·3
Summer Means	+0·2	+0·3	+0·4	+0·4	+0·4	+0·6	+1·3	+2·0	+2·4	+1·9	+0·6	−0·9	−1·9	−2·4	−2·1	−1·4	−0·7	−0·2	−0·1	−0·3	−0·4	−0·3	−0·1	0	+0·1

NOTE—**Magnet** points to east or west of the mean position as sign is + or −.

TABLE LXIX.—Hourly means of Horizontal Force in C.G.S. units corrected for temperature at Dehra Dun in 1923 (from 5 selected quiet days)

HORIZONTAL FORCE = ·32000 C.G.S. + tabular quantity

Hours.	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	919	915	916	915	917	919	921	923	927	929	928	930	929	929	926	923	921	918	917	916	915	915	917	918	918	919
Feb.	915	915	915	917	918	918	919	920	924	936	925	927	924	925	920	918	916	916	917	918	918	918	915	915	918	919
Mar.	909	909	910	910	912	912	914	915	916	918	922	928	931	936	934	928	921	916	914	913	913	912	911	912	912	917
Oct.	929	929	930	929	929	928	928	929	927	927	930	935	936	936	931	929	925	925	926	927	928	928	929	928	930	929
Nov.	935	935	935	936	936	937	936	940	943	943	945	948	949	944	939	936	936	933	936	936	936	935	935	936	937	939
Dec.	931	933	931	932	932	932	934	937	944	945	941	942	942	939	937	935	935	933	931	930	930	930	929	929	930	935
Winter Means	923	923	923	923	924	924	925	927	930	931	932	935	935	935	931	928	926	924	924	923	923	923	923	923	924	926
April	910	910	910	910	910	910	910	910	909	916	922	928	928	929	926	921	917	909	909	908	906	907	907	906	907	914
May	920	921	920	919	918	920	922	921	920	923	928	938	944	945	942	937	929	924	921	921	922	924	924	924	922	926
June	923	924	924	922	923	925	926	924	922	921	926	932	939	941	939	933	927	922	921	922	923	924	925	925	925	924
July	923	924	923	924	923	923	925	926	927	931	936	937	939	943	940	938	932	928	925	925	924	925	926	927	929	929
Aug.	924	923	924	924	925	926	925	923	924	928	932	935	939	941	942	941	938	934	930	930	930	930	930	929	930	930
Sept.	939	939	939	940	940	941	940	936	933	933	937	944	949	951	950	946	943	943	942	941	940	941	941	942	942	941
Summer Means	923	924	923	923	923	924	925	923	923	925	930	936	940	942	940	936	931	927	925	925	924	925	926	926	926	927

TABLE LXX.—Diurnal Inequality of the Horizontal Force at Dehra Dun in 1923 (deduced from *TABLE LXIX.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	0	− 4	− 3	− 4	− 2	0	+ 2	+ 4	+ 8	+10	+ 9	+11	+10	+10	+ 7	+ 4	+ 2	− 1	− 2	− 3	− 4	− 4	− 2	− 1	− 1
Feb.	− 4	− 4	− 4	− 2	− 1	− 1	0	+ 1	+ 5	+ 7	+ 6	+ 8	+ 5	+ 6	+ 1	− 1	− 3	− 3	− 2	− 1	− 1	− 1	− 4	− 4	− 1
Mar.	− 8	− 8	− 7	− 7	− 5	− 5	− 3	− 2	− 1	+ 1	+ 5	+11	+14	+19	+17	+11	+ 4	− 1	− 3	− 4	− 4	− 5	− 6	− 5	− 5
Oct.	0	0	+ 1	0	0	− 1	− 1	0	− 2	− 2	+ 1	+ 6	+ 7	+ 7	+ 2	0	− 4	− 4	− 3	− 2	− 1	− 1	0	− 1	+ 1
Nov.	− 4	− 4	+ 4	− 3	− 3	− 2	− 3	+ 1	+ 4	+ 4	+ 6	+ 9	+10	+ 5	0	− 3	− 3	− 6	− 3	− 3	− 3	− 4	− 4	− 3	− 2
Dec.	− 4	− 2	− 4	− 3	− 3	− 3	− 1	+ 2	+ 9	+10	+ 9	+ 7	+ 7	+ 4	+ 2	0	0	− 2	− 4	− 5	− 5	− 5	− 6	− 6	− 5
Winter Means	− 3	− 3	− 3	− 3	− 2	− 2	− 1	+ 1	+ 4	+ 5	+ 6	+ 9	+ 9	+ 9	+ 5	+ 2	0	− 2	− 2	− 3	− 3	− 3	− 3	− 3	− 2
April	− 4	− 4	− 4	− 4	− 4	− 4	− 4	− 4	− 5	+ 2	+ 8	+14	+14	+15	+12	+ 7	+ 3	− 5	− 5	− 6	− 8	− 7	− 7	− 8	− 7
May	− 6	− 5	− 6	− 7	− 8	− 6	− 4	− 5	− 6	− 3	+ 2	+12	+18	+19	+16	+11	+ 3	− 2	− 5	− 5	− 4	− 2	− 2	− 2	− 4
June	− 1	0	0	− 2	− 1	+ 1	+ 2	0	− 2	− 3	+ 2	+ 8	+15	+17	+15	+ 9	+ 3	− 2	− 3	− 2	− 1	0	+ 1	+ 1	+ 1
July	− 6	− 5	− 6	− 5	− 6	− 6	− 4	− 3	− 2	+ 2	+ 7	+ 8	+10	+14	+11	+ 9	+ 3	− 1	− 4	− 4	− 5	− 4	− 3	− 2	0
Aug.	− 6	− 7	− 6	− 6	− 5	− 4	− 5	− 7	− 6	− 2	+ 2	+ 5	+ 9	+11	+12	+11	+ 8	+ 4	0	0	0	0	0	− 1	0
Sept.	− 2	− 2	− 2	− 1	− 1	0	− 1	− 5	− 8	− 8	− 4	+ 3	+ 8	+10	+ 9	+ 5	+ 2	+ 2	+ 1	0	− 1	0	0	− 1	− 1
Summer Means	− 4	− 3	− 4	− 4	− 4	− 3	− 2	− 4	− 4	− 2	+ 3	+ 9	+13	+15	+13	+ 9	+ 4	0	− 2	− 2	− 3	− 2	− 1	− 1	− 1

NOTE—Horizontal Force is greater or less than the mean as sign is + or −.

TABLE LXXI.—Hourly means of Vertical Force in C.G.S. units corrected for temperature at Dehra Dun in 1923 (from 5 selected quiet days)

VERTICAL FORCE = ·33000 C.G.S. + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	117	116	115	115	115	115	115	114	116	116	112	**110**	115	117	118	115	117	**118**	117	116	115	115	115	115	114	115
Feb.	125	124	124	124	124	124	123	125	126	124	**122**	125	124	126	126	123	124	124	126	**127**	126	126	126	126	125	125
Mar.	138	137	138	138	138	137	138	139	**139**	136	132	123	**120**	123	129	133	133	134	132	133	134	134	135	135	136	134
Oct.	210	210	210	210	209	209	209	212	211	208	203	199	**198**	200	204	207	209	209	211	213	214	**214**	214	214	214	209
Nov.	216	216	216	216	216	216	216	**218**	217	214	213	206	**205**	206	208	210	210	211	211	211	211	211	212	212	211	212
Dec.	**212**	212	211	212	212	211	212	211	211	211	210	**208**	208	209	209	209	210	210	210	211	211	211	211	211	212	211
Winter Means	170	169	169	169	169	169	169	170	**170**	168	165	162	**162**	164	166	166	167	168	168	169	169	169	169	169	169	168
April	133	134	134	134	134	134	135	136	**137**	131	125	**120**	122	126	130	133	135	135	135	135	136	136	136	137	136	133
May	148	149	149	148	148	149	151	151	147	143	**138**	140	140	143	146	150	151	152	151	151	152	152	**152**	152	152	150
June	149	149	150	151	149	153	**157**	155	151	146	140	**135**	137	140	143	147	149	151	151	152	152	154	154	154	154	149
July	188	187	188	188	188	189	**192**	191	188	186	182	174	172	**171**	173	179	182	183	184	185	185	186	187	187	188	184
Aug.	188	189	189	189	189	189	191	**191**	188	184	180	177	**175**	178	183	186	187	187	186	186	187	188	188	188	188	186
Sept.	200	199	200	200	200	200	201	**203**	202	198	**194**	195	195	196	199	202	202	202	201	201	202	202	203	203	202	200
Summer Means	168	168	168	168	168	169	**171**	171	169	165	160	**157**	157	159	162	166	168	168	168	168	169	170	170	170	170	167

NOTE—Figures in thick type represent the maximum and minimum values during the month.

TABLE LXXII.—Diurnal Inequality of the Vertical Force at Dehra Dun in 1923 (deduced from *TABLE LXXI.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
Jan.	γ + 2	γ + 1	γ 0	γ 0	γ 0	γ 0	γ 0	γ − 1	γ + 1	γ + 1	γ − 3	γ − 5	γ 0	γ + 2	γ + 3	γ 0	γ + 2	γ + 3	γ + 2	γ + 1	γ 0	γ 0	γ 0	γ 0	γ − 1
Feb.	0	− 1	− 1	− 1	− 1	− 1	− 2	0	+ 1	− 1	− 3	0	− 1	+ 1	+ 1	− 2	− 1	− 1	+ 1	+ 2	+ 1	+ 1	+ 1	+ 1	0
Mar.	+ 4	+ 3	+ 4	+ 4	+ 4	+ 3	+ 4	+ 5	+ 5	+ 2	− 2	−11	−14	−11	− 5	− 1	− 1	0	− 2	− 1	0	0	+ 1	+ 1	+ 2
Oct.	+ 1	+ 1	+ 1	+ 1	0	0	0	+ 3	+ 2	− 1	− 6	−10	−11	− 9	− 5	− 2	0	0	+ 2	+ 4	+ 5	+ 5	+ 5	+ 5	+ 5
Nov.	+ 4	+ 4	+ 4	+ 4	+ 4	+ 4	+ 4	+ 6	+ 5	+ 2	+ 1	− 6	− 7	− 6	− 4	− 2	− 2	− 1	− 1	− 1	− 1	− 1	0	0	− 1
Dec.	+ 1	+ 1	0	+ 1	+ 1	0	+ 1	0	0	0	− 1	− 3	− 3	− 2	− 2	− 2	− 1	− 1	− 1	0	0	0	0	0	+ 1
Winter Means	+ 2	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2	0	− 3	− 6	− 6	− 4	− 2	− 2	− 1	0	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1
April	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 3	+ 4	− 2	− 8	−13	−11	− 7	− 3	0	+ 2	+ 2	+ 2	+ 2	+ 3	+ 3	+ 3	+ 4	+ 3
May	− 2	− 1	− 1	− 2	− 2	− 1	+ 1	+ 1	− 3	− 7	−12	−10	−10	− 7	− 4	0	+ 1	+ 2	+ 1	+ 1	+ 2	+ 2	+ 2	+ 2	+ 2
June	0	0	+ 1	+ 2	0	+ 4	+ 8	+ 6	+ 2	− 3	− 9	−14	−12	− 9	− 6	− 2	0	+ 2	+ 2	+ 3	+ 3	+ 5	+ 5	+ 5	+ 5
July	+ 4	+ 3	+ 4	+ 4	+ 4	+ 5	+ 8	+ 7	+ 4	+ 2	− 2	−10	−12	−13	−11	− 5	− 2	− 1	0	+ 1	+ 1	+ 2	+ 3	+ 3	+ 4
Aug.	+ 2	+ 3	+ 3	+ 3	+ 3	+ 3	+ 5	+ 5	+ 2	− 2	− 6	− 9	−11	− 8	− 3	0	+ 1	+ 1	0	0	+ 1	+ 2	+ 2	+ 2	+ 2
Sept.	0	− 1	0	0	0	0	+ 1	+ 3	+ 2	− 2	− 6	− 5	− 5	− 4	− 1	+ 2	+ 2	+ 2	+ 1	+ 1	+ 2	+ 2	+ 3	+ 3	+ 2
Summer Means	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 4	+ 4	+ 2	− 2	− 7	−10	−10	− 8	− 5	− 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 3	+ 3	+ 3	+ 3

NOTE—Vertical Force is greater or less than the mean as sign is + or −.

TABLE LXXIII.—Hourly means of the Dip at Dehra Dun in 1923 **(determined from 5 selected quiet days)**

Dip = 45° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	10·3	**10·5**	10·3	10·4	10·3	10·2	10·1	9·9	9·9	9·7	9·6	**9·4**	9·7	9·8	10·0	10·0	10·2	10·4	10·4	10·4	10·4	10·4	10·3	10·3	10·2	10·1
Feb.	11·0	10·9	10·9	10·8	10·7	10·7	10·6	10·7	10·5	10·3	**10·3**	10·3	10·4	10·5	10·7	10·7	10·8	10·8	10·9	10·9	10·9	10·9	**11·0**	11·0	10·8	10·7
Mar.	**12·0**	11·9	11·9	11·9	11·8	11·7	11·7	11·7	11·6	11·4	10·9	10·1	9·9	**9·7**	10·2	10·7	11·1	11·3	11·4	11·4	11·5	11·6	11·7	11·6	11·7	11·3
Oct.	14·6	14·6	14·6	14·6	14·6	14·6	14·6	14·7	14·8	14·6	14·2	13·7	**13·6**	13·7	14·2	14·3	14·8	14·8	14·8	**14·9**	14·9	14·9	14·8	14·9	14·8	14·5
Nov.	**14·6**	14·6	14·6	14·6	14·6	14·5	14·6	14·3	14·3	14·1	13·9	13·4	**13·3**	13·6	14·0	14·3	14·3	14·5	14·3	14·3	14·3	14·3	14·4	14·4	14·3	14·3
Dec.	**14·7**	14·5	14·6	14·6	14·6	14·5	14·5	14·3	13·9	**13·8**	13·8	13·8	13·8	14·1	14·2	14·3	14·3	14·4	14·5	14·6	14·6	14·6	14·7	14·7	14·7	14·4
Winter Means	**12·9**	12·8	12·8	12·8	12·8	12·7	12·7	12·6	12·5	12·3	12·1	**11·8**	11·8	11·9	12·2	12·4	12·6	12·7	12·7	12·8	12·8	12·8	12·8	12·8	12·8	12·5
April	11·6	11·6	11·6	11·6	11·6	11·6	11·7	11·8	11·9	11·2	10·6	**10·0**	10·1	10·3	10·6	11·1	11·4	11·8	11·8	11·8	12·0	11·9	11·9	**12·0**	11·9	11·4
May	11·9	11·9	11·9	11·9	**12·0**	11·9	11·9	12·0	11·8	11·4	10·9	10·5	**10·2**	10·3	10·6	11·1	11·6	11·9	12·0	12·0	12·0	11·9	11·9	11·9	12·0	11·6
June	11·8	11·7	11·8	11·9	11·8	11·8	**12·0**	12·0	11·9	11·7	11·1	10·6	**10·3**	10·3	10·6	11·1	11·6	11·9	12·0	12·0	11·9	12·0	11·9	11·9	11·9	11·6
July	13·8	13·7	13·8	13·7	13·8	13·8	**13·9**	13·8	13·6	13·3	12·8	12·4	12·1	**11·9**	12·1	12·5	13·0	13·3	13·5	13·5	13·6	13·5	13·6	13·5	13·5	13·3
Aug.	13·7	13·8	13·8	13·8	13·7	13·7	13·8	**13·9**	13·7	13·3	12·9	12·6	**12·3**	12·3	12·6	12·7	13·0	12·8	13·3	13·3	13·4	13·4	13·4	13·5	13·4	13·3
Sept.	13·6	13·5	13·6	13·5	13·5	13·5	13·6	13·9	**14·0**	13·8	13·4	13·0	12·8	**12·8**	13·0	13·3	13·5	13·5	13·5	13·5	13·6	13·5	13·6	13·6	13·5	13·5
Summer Means	12·7	12·7	12·8	12·7	12·7	12·7	12·8	**12·9**	12·8	12·5	12·0	11·5	11·3	**11·3**	11·6	12·0	12·4	12·5	12·7	12·7	12·8	12·7	12·7	12·7	12·7	12·5

Note.—Figures in thick type represent the maximum and minimum values during the month.

TABLE LXXIV.—*Diurnal Inequality of the Dip at Dehra Dun in 1923* (deduced from *TABLE LXXIII.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	+0·2	+0·4	+0·2	+0·3	+0·2	+0·1	0	−0·2	−0·2	−0·4	−0·5	−0·7	−0·4	−0·3	−0·1	−0·1	+0·1	+0·3	+0·3	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1
Feb.	+0·3	+0·2	+0·2	+0·1	0	0	−0·1	0	−0·2	−0·4	−0·4	−0·4	−0·3	−0·2	0	0	+0·1	+0·1	+0·2	+0·2	+0·2	+0·2	+0·3	+0·3	+0·1
Mar.	+0·7	+0·6	+0·6	+0·6	+0·5	+0·4	+0·4	+0·4	+0·3	+0·1	−0·4	−1·2	−1·4	−1·6	−1·1	−0·6	−0·2	0	+0·1	+0·1	+0·2	+0·3	+0·4	+0·3	+0·4
Oct.	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·2	+0·3	+0·1	−0·3	−0·8	−0·9	−0·8	−0·3	−0·2	+0·3	+0·3	+0·3	+0·4	+0·4	+0·4	+0·3	+0·4	+0·5
Nov.	+0·3	+0·3	+0·3	+0·3	+0·3	+0·2	+0·3	0	0	−0·2	−0·4	−0·9	−1·0	−0·7	−0·3	0	0	+0·2	0	0	0	0	+0·1	+0·1	0
Dec.	+0·3	+0·1	+0·2	+0·2	+0·2	+0·1	+0·1	−0·1	−0·5	−0·6	−0·6	−0·6	−0·6	−0·3	−0·2	−0·1	−0·1	0	+0·1	+0·2	+0·2	+0·2	+0·3	+0·3	+0·3
Winter Means	+0·4	+0·3	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1	0	−0·2	−0·4	−0·7	−0·7	−0·6	−0·3	−0·1	+0·1	+0·2	+0·2	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3
April	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	−0·2	−0·8	−1·4	−1·3	−1·1	−0·8	−0·3	0	+0·4	+0·4	+0·4	+0·6	+0·5	+0·5	+0·6	+0·5
May	+0·3	+0·3	+0·3	+0·3	+0·4	+0·3	+0·3	+0·4	+0·2	−0·2	−0·7	−1·1	−1·4	−1·3	−1·0	−0·5	0	+0·3	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·4
June	+0·2	+0·1	+0·2	+0·3	+0·2	+0·2	+0·4	+0·4	+0·3	+0·1	−0·5	−1·0	−1·3	−1·3	−1·0	−0·5	0	+0·3	+0·4	+0·4	+0·3	+0·4	+0·3	+0·3	+0·3
July	+0·5	+0·4	+0·5	+0·4	+0·5	+0·5	+0·6	+0·5	+0·3	0	−0·5	−0·9	−1·2	−1·4	−1·2	−0·8	−0·3	0	+0·2	+0·2	+0·3	+0·2	+0·3	+0·2	+0·2
Aug.	+0·4	+0·5	+0·5	+0·5	+0·4	+0·4	+0·5	+0·6	+0·4	0	−0·4	−0·7	−1·0	−1·0	−0·7	−0·6	−0·3	−0·5	0	0	+0·1	+0·1	+0·1	+0·2	+0·1
Sept.	+0·1	0	+0·1	0	0	0	+0·1	+0·4	+0·5	+0·3	−0·1	−0·5	−0·7	−0·7	−0·5	−0·2	0	0	0	0	+0·1	0	+0·1	+0·1	0
Summer Means	+0·2	+0·2	+0·3	+0·2	+0·2	+0·2	+0·3	+0·4	+0·3	0	−0·5	−1·0	−1·2	−1·2	−0·9	−0·5	−0·1	0	+0·2	+0·2	+0·3	+0·2	+0·2	+0·2	+0·2

NOTE—Dip is greater or less than the mean as sign is + or −.

TABLE LXXV.—*Hourly means of the Declination at Toungoo in 1923* (determined from 5 selected quiet days)

DECLINATION = W 0° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	31·3	31·2	31·2	31·3	31·4	31·6	32·0	**32·2**	31·5	30·4	**29·9**	30·4	31·1	31·1	31·1	30·9	30·6	30·8	31·1	31·2	31·2	31·3	31·3	31·4	31·4	31·1
Feb.	31·5	31·6	31·6	31·7	31·8	31·9	**32·3**	32·2	31·7	31·0	**30·6**	30·9	31·6	31·6	31·9	32·0	31·8	31·7	31·7	31·6	31·6	31·5	31·4	31·4	31·6	31·6
Mar.	31·5	31·5	31·5	31·6	31·6	31·7	31·7	31·3	30·6	**30·5**	30·8	31·6	32·4	**32·7**	32·4	31·5	31·0	30·9	31·5	31·6	31·6	31·6	31·6	31·5	31·5	31·5
April	31·7	31·7	31·6	31·6	31·6	31·6	31·3	30·6	**30·3**	30·3	30·9	32·0	**33·1**	32·9	32·8	32·3	31·8	31·6	32·0	31·9	32·0	32·0	31·9	31·7	31·6	31·7
May	32·0	31·9	31·8	31·8	31·6	31·6	30·7	**30·0**	30·1	30·8	31·7	32·7	**33·2**	33·1	32·6	32·2	31·7	31·3	31·8	32·2	32·3	32·3	32·2	32·2	32·1	31·8
June	32·2	32·0	32·0	32·0	32·0	32·0	31·1	30·1	**29·9**	30·6	31·5	32·4	33·3	**33·6**	33·4	33·1	32·6	32·2	32·3	32·4	32·4	32·4	32·4	32·3	32·3	32·1
July	32·3	32·2	32·1	32·1	32·1	32·7	31·0	**30·5**	30·8	31·0	31·5	32·3	**33·2**	33·2	33·1	32·8	32·5	32·4	32·6	32·7	33·0	32·9	32·7	32·5	32·5	32·2
Aug.	32·6	32·4	32·5	32·4	32·3	32·2	31·4	30·6	**30·5**	31·3	32·4	33·4	33·7	**33·8**	33·5	33·2	32·6	32·4	32·5	32·8	33·0	33·0	33·0	32·8	32·6	32·5
Sept	32·8	32·8	32·8	32·6	32·6	32·6	32·0	31·2	**31·2**	31·8	32·9	33·6	34·5	**34·7**	33·9	33·1	32·5	32·6	33·3	33·1	33·1	33·1	33·0	33·0	32·9	32·9
Summer Means	32·3	32·2	32·1	32·1	32·0	32·0	31·3	30·5	**30·5**	31·0	31·8	32·7	33·5	**33·6**	33·2	32·8	32·3	32·1	32·4	32·5	32·6	32·6	32·5	32·4	32·3	32·2

NOTE—Figures in thick type represent the maximum and minimum values during the month.
The observatory was dismantled in October 1923.

TABLE LXXVI.—Diurnal Inequality of the Declination at Toungoo in 1923, (deduced from *TABLE LXXV*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	−0·2	−0·1	−0·1	−0·2	−0·3	−0·5	−0·9	−1·1	−0·4	+0·7	+1·2	+0·7	0	0	0	+0·2	+0·5	+0·3	0	−0·1	−0·1	−0·2	−0·2	−0·3	−0·3
Feb.	+0·1	0	0	−0·1	−0·2	−0·3	−0·7	−0·6	−0·1	+0·6	+1·0	+0·7	0	0	−0·3	−0·4	−0·2	−0·1	−0·1	0	0	+0·1	+0·2	+0·2	0
Mar.	0	0	0	−0·1	−0·1	−0·2	−0·2	+0·2	+0·9	+1·0	+0·7	−0·1	−0·9	−1·2	−0·9	0	+0·5	+0·6	0	−0·1	−0·1	−0·1	−0·1	0	0
April	0	0	+0·1	+0·1	+0·1	+0·1	+0·4	+1·1	+1·4	+1·4	+0·8	−0·3	−1·4	−1·2	−1·1	−0·6	−0·1	+0·1	−0·3	−0·2	−0·3	−0·3	−0·2	0	+0·1
May	−0·2	−0·1	0	0	+0·2	+0·2	+1·1	+1·8	+1·7	+1·0	+0·1	−0·9	−1·4	−1·3	−0·8	−0·4	+0·1	+0·5	0	−0·4	−0·5	−0·5	−0·4	−0·4	−0·3
June	−0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+1·0	+2·0	+2·2	+1·5	+0·6	−0·3	−1·2	−1·5	−1·3	−1·0	−0·5	−0·1	−0·2	−0·3	−0·3	−0·3	−0·3	−0·2	−0·2
July	−0·1	0	+0·1	+0·1	+0·1	+0·5	+1·2	+1·7	+1·4	+1·2	+0·7	−0·1	−1·0	−1·0	−0·9	−0·6	−0·3	−0·2	−0·4	−0·5	−0·8	−0·7	−0·5	−0·3	−0·3
Aug	−0·1	+0·1	0	+0·1	+0·2	+0·3	+1·1	+1·9	+2·0	+1·2	+0·1	−0·9	−1·2	−1·3	−1·0	−0·7	−0·1	+0·1	0	−0·3	−0·5	−0·5	−0·5	−0·3	−0·1
Sept.*	+0·1	+0·1	+0·1	+0·3	+0·3	+0·3	+0·9	+1·7	+1·7	+1·1	0	−0·7	−1·6	−1·8	−1·0	−0·2	+0·4	+0·3	−0·4	−0·2	−0·2	−0·2	−0·1	−0·1	0
Summer Means	−0·1	0	+0·1	+0·1	+0·2	+0·2	+0·9	+1·7	+1·7	+1·2	+0·4	−0·5	−1·3	−1·4	−1·0	−0·6	−0·1	+0·1	−0·2	−0·3	−0·4	−0·4	−0·3	−0·2	−0·1

NOTE—Magnet points to east or west of mean position as sign is + or −.

* The observatory was dismantled in October 1923.

TABLE LXXVII.—Hourly means of Horizontal Force in C.G.S. units corrected for temperature at Toungoo in 1923 (from 5 selected quiet days)

HORIZONTAL FORCE = ·39000 C.G.S. + tabular quantity

Hours.	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	196	195	194	194	195	194	198	202	206	213	218	**220**	216	213	210	206	199	195	194	193	194	191	**191**	193	195	201
Feb.	192	**191**	192	192	193	195	196	200	207	215	221	**223**	222	214	209	200	198	195	196	195	194	193	193	193	192	201
Mar.	187	188	**186**	187	187	189	190	193	201	212	225	**231**	228	223	216	208	200	196	194	192	190	190	190	188	189	200
April	188	190	191	190	191	192	191	191	193	211	221	**225**	224	217	210	205	197	194	189	188	186	185	**184**	185	185	198
May	**201**	201	202	201	201	202	203	205	211	222	231	**236**	234	231	225	217	212	204	201	202	203	204	205	205	206	211
June	207	206	206	206	206	207	209	211	214	220	226	232	**233**	230	226	216	207	202	**202**	204	204	205	206	207	208	212
July	**196**	197	198	199	199	200	201	205	211	218	223	232	**234**	230	224	217	211	204	199	199	201	201	201	202	203	209
Aug.	**202**	206	207	207	207	209	210	211	213	222	229	233	**238**	236	228	222	216	212	210	211	211	211	212	212	211	216
Sept.*	**211**	212	213	213	214	215	216	213	213	223	231	235	**236**	235	229	223	216	215	215	216	214	213	212	213	214	219
Summer Means	**201**	202	203	203	203	204	205	206	210	219	228	232	**233**	230	224	217	210	205	203	203	203	203	203	204	205	211

NOTE—Figures in thick type represent the maximum and minimum values during the month.

* The observatory was dismantled in October 1923.

TABLE LXXVIII.—Diurnal Inequality of the Horizontal Force at Toungoo, in 1923 (deduced from *TABLE LXXVII.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	− 5	− 6	− 7	− 7	− 6	− 7	− 3	+ 1	+ 5	+12	+17	+19	+15	+12	+ 9	+ 5	− 2	− 6	− 7	− 8	− 7	−10	−10	− 8	− 6
Feb.	− 9	−10	− 9	− 9	− 8	− 6	− 5	− 1	+ 6	+14	+20	+22	+21	+13	+ 8	− 1	− 3	− 6	− 5	− 6	− 7	− 8	− 8	− 8	− 9
Mar.	−13	−12	−14	−13	−13	−11	−10	− 7	+ 1	+12	+25	+31	+28	+23	+16	+ 8	0	− 4	− 6	− 8	−10	−10	−10	−12	−11
April	−10	− 8	− 7	− 8	− 7	− 6	− 7	− 7	0	+13	+23	+27	+26	+19	+12	+ 7	− 1	− 4	− 9	−10	−12	−13	−14	−13	−13
May	−10	−10	− 9	−10	−10	− 9	− 8	− 6	0	+11	+20	+25	+23	+20	+14	+ 6	+ 1	− 7	−10	− 9	− 8	− 7	− 6	− 6	− 5
June	− 5	− 6	− 6	− 6	− 6	− 5	− 3	− 1	+ 2	+ 8	+14	+20	+21	+18	+14	+ 4	− 5	−10	−10	− 8	− 8	− 7	− 6	− 5	− 4
July	−13	−12	−11	−10	−10	− 9	− 8	− 4	+ 2	+ 9	+19	+23	+25	+21	+15	+ 8	+ 2	− 5	−10	−10	− 8	− 8	− 8	− 7	− 6
Aug.	−14	−10	− 9	− 9	− 9	− 7	− 6	− 5	− 3	+ 6	+13	+17	+22	+20	+12	+ 6	0	− 4	− 6	− 5	− 5	− 5	− 4	− 4	− 5
Sept.*	− 8	− 7	− 6	− 6	− 5	− 4	− 3	− 6	− 6	+ 4	+12	+16	+17	+16	+10	+ 4	− 3	− 4	− 4	− 3	− 5	− 6	− 7	− 6	− 5
Summer Means	−10	− 9	− 8	− 8	− 8	− 7	− 6	− 5	− 1	+ 8	+17	+21	+22	+19	+13	+ 6	− 1	− 6	− 8	− 8	− 8	− 8	− 8	− 7	− 6

Note—Horizontal Force is greater or less than the mean as sign is + or −.

* The observatory was dismantled in October 1923.

TABLE LXXIX.—Hourly means of Vertical Force in C.G.S. units corrected for temperature at Toungoo in 1923, (from 5 selected quiet days)

VERTICAL FORCE = ·16000 C.G.S. + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	729	729	729	729	729	729	728	729	**730**	729	722	715	**714**	716	721	726	727	727	727	727	727	727	727	728	728	726
Feb.	728	728	**728**	728	728	728	727	728	726	724	719	**714**	714	717	721	723	725	725	726	726	727	727	727	728	728	725
Mar.	729	729	729	729	729	729	729	**730**	726	718	710	**704**	706	714	722	727	727	726	725	727	728	728	729	730	730	724
April	726	726	726	726	726	726	**729**	728	724	718	712	**711**	714	719	723	726	727	726	724	725	725	725	726	726	726	724
May	728	727	727	727	727	727	**732**	731	726	719	715	713	**712**	717	723	728	731	729	725	726	726	726	727	727	727	725
June	727	727	727	727	727	728	**732**	732	727	721	716	714	**713**	717	721	723	725	726	726	726	726	727	728	728	729	725
July	728	728	728	728	727	729	**730**	729	726	721	717	**715**	717	718	718	722	725	725	726	726	726	727	728	729	729	724
Aug.	729	729	729	729	729	729	**733**	732	726	718	715	**713**	714	718	721	725	726	726	724	726	727	727	728	729	729	725
Sept.*	730	730	730	730	730	730	**732**	731	725	716	711	**709**	713	720	729	732	732	729	726	728	729	730	730	731	730	726
Summer Means	728	728	728	728	728	728	**731**	731	726	719	714	**713**	714	718	723	726	728	727	725	726	727	727	728	728	728	725

NOTE—Figures in thick type represent the maximum and minimum values during the month.

* The observatory was dismantled in October 1923.

TABLE LXXX.—Diurnal Inequality of the Vertical Force at Toungoo in 1923, (deduced from *TABLE LXXIX.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 2	+ 3	+ 4	+ 3	− 4	−11	−12	−10	− 5	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2
Feb.	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 2	+ 3	+ 1	− 1	− 6	−11	−11	− 8	− 4	− 2	0	0	+ 1	+ 1	+ 2	+ 2	+ 2	+ 3	+ 3
Mar.	+ 5	+ 5	+ 5	+ 5	+ 5	+ 5	+ 5	+ 6	+ 2	− 6	−14	−20	−18	−10	− 2	+ 3	+ 3	+ 2	+ 1	+ 3	+ 4	+ 4	+ 5	+ 6	+ 6
April	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 5	+ 4	0	− 6	−12	−13	−10	− 5	− 1	+ 2	+ 3	+ 2	0	+ 1	+ 1	+ 1	+ 2	+ 2	+ 2
May	+ 3	+ 2	+ 2	+ 2	+ 2	+ 2	+ 7	+ 6	+ 1	− 6	−10	−12	−13	− 8	− 2	+ 3	+ 6	+ 4	0	+ 1	+ 1	+ 1	+ 2	+ 2	+ 2
June	+ 2	+ 2	+ 2	+ 2	+ 2	+ 3	+ 7	+ 7	+ 2	− 4	− 9	−11	−12	− 8	− 4	− 2	0	+ 1	+ 1	+ 1	+ 1	+ 2	+ 3	+ 3	+ 4
July	+ 4	+ 4	+ 4	+ 4	+ 3	+ 5	+ 6	+ 5	+ 2	− 3	− 7	− 9	− 7	− 6	− 6	− 2	+ 1	+ 1	+ 2	+ 2	+ 2	+ 3	+ 4	+ 5	+ 5
Aug.	+ 4	+ 4	+ 4	+ 4	+ 4	+ 4	+ 8	+ 7	+ 1	− 7	−10	−12	−11	− 7	− 4	0	+ 1	+ 1	− 1	+ 1	+ 2	+ 2	+ 3	+ 4	+ 4
Sept.*	+ 4	+ 4	+ 4	+ 4	+ 4	+ 4	+ 6	+ 5	− 1	−10	−15	−17	−13	− 6	+ 3	+ 6	+ 6	+ 3	0	+ 2	+ 3	+ 4	+ 4	+ 5	+ 4
Summer Means	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 6	+ 6	+ 1	− 6	−11	−12	−11	− 7	− 2	+ 1	+ 3	+ 2	0	+ 1	+ 2	+ 2	+ 3	+ 3	+ 3

NOTE—Vertical Force is greater or less than the mean as sign is + or −.

* The observatory was dismantled in October 1923.

TABLE LXXXI.—*Hourly means of the Dip at Toungoo in 1923,* (determined from 5 selected quiet days)

DIP = N 23° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	6·8	6·8	6·8	6·8	6·8	**6·8**	6·6	6·6	6·6	6·2	5·6	**5·0**	5·0	5·3	5·7	6·2	6·5	6·7	6·7	6·7	6·7	6·8	6·8	6·8	6·7	6·4
Feb.	6·8	**6·8**	6·8	6·8	6·8	6·7	6·6	6·6	6·2	5·8	5·2	**4·8**	4·8	5·3	5·8	6·2	6·4	6·5	6·6	6·6	6·7	6·7	6·7	6·8	6·8	6·3
Mar.	7·1	7·0	7·1	7·1	7·1	7·0	7·0	7·0	6·4	5·4	4·5	**3·8**	4·1	4·8	5·6	6·3	6·5	6·6	6·6	6·8	6·9	6·9	7·0	**7·1**	7·1	6·3
April	6·8	6·7	6·7	6·7	6·7	6·7	**6·9**	6·8	6·4	5·5	4·7	**4·5**	4·8	5·4	5·9	6·3	6·6	6·6	6·6	6·8	6·8	6·8	6·9	6·9	6·9	6·3
May	6·5	6·5	6·4	6·5	6·5	6·4	**6·8**	6·6	6·1	5·2	4·6	**4·3**	4·3	4·8	5·4	6·0	6·4	6·5	6·3	6·4	6·3	6·3	6·4	6·4	6·3	6·0
June	6·3	6·3	6·3	6·3	6·3	6·4	**6·6**	6·5	6·1	5·4	4·9	4·5	**4·4**	4·8	5·2	5·7	6·2	6·4	6·4	6·3	6·3	6·4	6·4	6·4	6·4	6·0
July	**6·7**	6·7	6·6	6·6	6·5	6·6	6·7	6·5	6·1	5·5	4·9	**4·6**	4·7	4·9	5·1	5·6	6·0	6·2	6·4	6·4	6·4	6·5	6·5	6·6	6·6	6·1
Aug.	6·6	6·5	6·4	6·4	6·4	6·4	**6·6**	6·5	6·0	5·1	4·7	4·4	**4·3**	4·7	5·2	5·7	5·9	6·0	6·0	6·1	6·2	6·2	6·2	6·3	6·3	5·9
Sept.*	**6·4**	6·4	6·3	6·3	6·3	6·3	6·4	6·4	6·0	5·0	4·3	**4·1**	4·3	4·9	5·7	6·2	6·4	6·2	6·0	6·1	6·2	6·3	6·4	6·4	6·3	5·9
Summer Means	6·6	6·5	6·5	6·5	6·5	6·5	**6·7**	6·6	6·1	5·3	4·7	**4·4**	4·5	4·9	5·4	5·9	6·3	6·3	6·3	6·4	6·4	6·4	6·5	6·5	6·5	**6·0**

NOTE—Figures in thick type represent the maximum and minimum values during the month.

* The observatory was dismantled in October 1923.

TABLE LXXXII.—Diurnal Inequality of the Dip at Toungoo in 1923, (deduced from *TABLE LXXXI.*).

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·2	+0·2	+0·2	−0·2	−0·8	−1·4	−1·4	−1·1	−0·7	−0·2	+0·1	+0·3	+0·3	+0·3	+0·3	+0·4	+0·4	+0·4	+0·3
Feb.	+0·5	+0·5	+0·5	+0·5	+0·5	+0·4	+0·3	+0·3	−0·1	−0·5	−1·1	−1·5	−1·5	−1·0	−0·5	−0·1	+0·1	+0·2	+0·3	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5
Mar.	+0·8	+0·7	+0·8	+0·8	+0·8	+0·7	+0·7	+0·7	+0·1	−0·9	−1·8	−2·5	−2·2	−1·5	−0·7	0	+0·2	+0·3	+0·3	+0·5	+0·6	+0·6	+0·7	+0·8	+0·8
April	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·6	+0·5	+0·1	−0·8	−1·6	−1·8	−1·5	−0·9	−0·4	0	+0·3	+0·3	+0·3	+0·5	+0·5	+0·5	+0·6	+0·6	+0·6
May	+0·5	+0·5	+0·4	+0·5	+0·5	+0·4	+0·8	+0·6	+0·1	−0·8	−1·4	−1·7	−1·7	−1·2	−0·6	0	+0·4	+0·5	+0·3	+0·4	+0·3	+0·3	+0·4	+0·4	+0·3
June	+0·3	+0·3	+0·3	+0·3	+0·3	+0·4	+0·6	+0·5	+0·1	−0·6	−1·1	−1·5	−1·6	−1·2	−0·8	−0·3	+0·2	+0·4	+0·4	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4
July	+0·6	+0·6	+0·5	+0·5	+0·4	+0·5	+0·6	+0·4	0	−0·6	−1·2	−1·5	−1·4	−1·2	−1·0	−0·5	−0·1	+0·1	+0·3	+0·3	+0·3	+0·4	+0·4	+0·5	+0·5
Aug.	+0·7	+0·6	+0·5	+0·5	+0·5	+0·5	+0·7	+0·6	+0·1	−0·8	−1·2	−1·5	−1·6	−1·2	−0·7	−0·2	0	+0·1	+0·1	+0·2	+0·3	+0·3	+0·3	+0·4	+0·4
Sept.*	+0·5	+0·5	+0·4	+0·4	+0·4	+0·4	+0·5	+0·5	+0·1	−0·9	−1·6	−1·8	−1·6	−1·0	−0·2	+0·3	+0·5	+0·3	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5	+0·4
Summer Means	+0·6	+0·5	+0·5	+0·5	+0·5	+0·5	+0·7	+0·6	+0·1	−0·7	−1·3	−1·6	−1·5	−1·1	−0·6	−0·1	+0·3	+0·3	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5	+0·5

NOTE—Dip is greater or less than the mean as sign is + or −.

* The observatory was dismantled in October 1923.

TABLE LXXXIII.—Hourly means of the Declination at Kodaikānal in 1923, (determined from 5 selected quiet days)

DECLINATION = W 1° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	59·7	59·6	59·6	59·8	60·0	60·1	60·6	**60·9**	60·6	59·9	59·4	59·4	59·8	59·3	**59·3**	59·3	59·0	59·3	59·4	59·7	59·6	59·6	59·7	59·7	59·7	59·7
Feb.	59·9	59·9	60·0	60·0	60·0	60·2	**60·5**	60·4	59·9	59·4	**59·0**	59·1	59·1	59·1	59·5	59·7	59·7	60·0	60·1	59·9	59·9	59·8	59·8	59·8	59·9	59·8
Mar.	60·1	60·0	60·0	60·0	60·1	60·1	60·1	60·0	59·8	59·6	**59·5**	59·8	60·3	**60·5**	60·1	59·8	59·6	59·6	60·0	60·2	60·2	60·2	60·1	60·1	60·1	60·0
April	60·5	60·4	60·4	60·4	60·3	60·4	60·2	**59·7**	59·9	60·0	60·4	60·8	61·7	**61·8**	61·5	61·0	60·6	60·4	60·5	60·5	60·9	60·6	60·5	60·4	60·4	60·C
May	60·7	60·5	60·4	60·3	60·3	60·3	59·8	**59·4**	59·7	60·3	61·1	61·8	**62·1**	62·1	61·5	61·0	60·5	60·4	60·5	60·9	61·0	61·0	61·0	60·8	60·7	60·7
June	60·9	60·8	60·8	60·7	60·8	60·8	60·2	59·5	**59·4**	60·0	60·9	61·7	62·2	**62·3**	61·9	61·2	61·0	60·Ṣ	61·0	61·1	61·2	61·2	61·2	61·1	61·0	60·9
July	61·0	60·8	60·8	60·8	60·7	60·7	60·2	**59·9**	60·0	60·5	60·8	61·0	61·8	**61·9**	61·6	61·2	60·8	60·9	61·0	61·1	61·6	61·6	61·5	61·4	61·2	61·0
Aug.	61·5	61·5	61·4	61·4	61·3	61·2	60·7	60·0	**59·9**	60·6	61·4	62·1	**62·5**	62·4	62·0	61·4	61·0	61·7	61·1	61·7	61·8	61·9	61·9	61·7	61·6	61·4
Sept.*	62·6	62·5	62·4	63·4	62·4	62·3	61·7	**60·9**	61·0	61·5	62·6	63·3	**63·6**	63·6	63·3	62·5	62·0	62·1	62·6	62·7	62·7	62·7	62·7	62·6	62·5	62·4
Summer Means	61·2	61·1	61·0	61·0	61·0	61·0	60·5	**59·9**	60·0	60·5	61·2	61·8	62·3	**62·4**	62·0	61·4	61·0	61·1	61·1	61·3	61·5	61·5	61·5	61·3	61·2	61·2

NOTE—Figures in thick type represent the maximum and minimum values during the month.

* The observatory was dismantled in October 1923.

TABLE LXXXIV.—Diurnal Inequality of the Declination at Kodaikānal in 1923, (deduced from *TABLE LXXXIII*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	0	+0·1	+0·1	−0·1	−0·3	−0·4	−0·9	−1·2	−0·9	−0·2	+0·3	+0·3	−0·1	+0·4	+0·4	+0·4	+0·7	+0·4	+0·3	0	+0·1	+0·1	0	0	0
Feb.	−0·1	−0·1	−0·2	−0·2	−0·2	−0·4	−0·7	−0·6	−0·1	+0·4	+0·8	+0·7	+0·7	+0·7	+0·3	+0·1	+0·1	−0·2	−0·3	−0·1	−0·1	0	0	0	−0·1
Mar.	−0·1	0	0	0	−0·1	−0·1	−0·1	0	+0·2	+0·4	+0·5	+0·2	−0·3	−0·5	−0·1	+0·2	+0·4	+0·4	0	−0·2	−0·2	−0·2	−0·1	−0·1	−0·1
April	+0·1	+0·2	+0·2	+0·2	+0·3	+0·2	+0·4	+0·9	+0·7	+0·6	+0·2	−0·2	−1·1	−1·2	−0·9	−0·4	0	+0·2	+0·1	+0·1	−0·3	0	+0·1	+0·2	+0·2
May	0	+0·2	+0·3	+0·4	+0·4	+0·4	+0·9	+1·3	+1·0	+0·4	−0·4	−1·1	−1·4	−1·4	−0·8	−0·3	+0·2	+0·3	+0·2	−0·2	−0·3	−0·3	−0·3	−0·1	0
June	0	+0·1	+0·1	+0·2	+0·1	+0·1	+0·7	+1·4	+1·5	+0·9	0	−0·8	−1·3	−1·4	−1·0	−0·3	−0·1	0	−0·1	−0·2	−0·3	−0·3	−0·3	−0·2	−0·1
July	0	+0·2	+0·2	+0·2	+0·3	+0·3	+0·8	+1·1	+1·0	+0·5	+0·2	0	−0·8	−0·9	−0·6	−0·2	+0·2	+0·1	0	−0·1	−0·6	−0·6	−0·5	−0·4	−0·2
Aug.	−0·1	−0·1	0	0	+0·1	+0·2	+0·7	+1·4	+1·5	+0·8	0	−0·7	−1·1	−1·0	−0·6	0	+0·4	−0·3	+0·3	−0·3	−0·4	−0·5	−0·5	−0·3	−0·2
Sept *	−0·2	−0·1	0	0	0	+0·1	+0·7	+1·5	+1·4	+0·9	−0·2	−0·9	−1·2	−1·2	−0·9	−0·1	+0·4	+0·3	−0·2	−0·3	−0·3	−0·3	−0·3	−0·2	−0·1
Summer Means	0	+0·1	+0·2	+0·2	+0·2	+0·2	+0·7	+1·3	+1·2	+0·7	0	−0·6	−1·1	−1·2	−0·8	−0·2	+0·2	+0·1	+0·1	−0·1	−0·3	−0·3	−0·3	−0·1	0

NOTE—Magnet points to the east or west of the mean position as sign is + or −.

* The observatory was dismantled in October 1923.

TABLE LXXXV.—*Hourly means of Horizontal Force in C.G.S. units corrected for temperature at Kodaikānal in 1923,* (from 5 selected quiet days)

HORIZONTAL FORCE = ·37000 C.G.S. + tabular quantity

Hours.	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	920	**917**	919	919	917	919	920	925	936	952	959	**961**	958	951	936	925	920	920	920	919	918	918	919	921	919	929
Feb.	**924**	925	925	927	927	928	929	936	951	972	986	**993**	985	969	948	938	934	933	933	931	932	928	926	927	928	942
Mar.	**916**	916	917	918	920	922	922	924	940	968	993	**1046**	1039	978	952	930	921	924	926	924	922	921	920	919	919	938
April	931	932	933	931	932	931	932	938	956	982	998	**1001**	991	975	953	935	930	930	932	930	928	927	927	**927**	927	945
May	**936**	938	938	937	938	939	941	942	956	978	**993**	986	981	968	964	948	941	939	940	940	941	941	941	941	940	950
June	943	944	945	944	945	944	945	947	959	975	989	**997**	992	980	964	950	944	942	942	**941**	942	943	943	944	945	954
July	**940**	942	942	943	942	942	943	947	953	966	979	**990**	986	978	967	957	946	940	940	943	943	942	943	944	946	953
Aug.	**946**	947	947	948	948	948	948	950	961	980	995	**1003**	1001	993	982	967	954	950	952	954	953	953	951	951	952	962
Sept. *	**962**	962	962	963	962	965	964	968	985	1014	1030	**1033**	1023	1005	984	969	965	971	971	968	965	964	964	964	964	978
Summer Means	**943**	944	945	944	945	945	946	949	962	983	997	**1002**	996	983	969	954	947	945	946	946	945	945	945	945	946	957

NOTE—Figures in thick type represent the maximum and minimum values during the month.

* The observatory was dismantled in October 1923.

TABLE LXXXVI.—Diurnal Inequality of the Horizontal Force at Kodaikānal in 1923, (deduced from *TABLE LXXXV.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	− 9	−12	−10	−10	−12	−10	− 9	− 4	+ 7	+23	+30	+32	+29	+22	+ 9	− 4	− 9	− 9	− 9	−10	−11	−11	−10	− 8	−10
Feb.	−18	−17	−17	−15	−15	−14	−13	− 6	+ 9	+30	+44	+51	+43	+27	+ 6	− 4	− 8	− 9	− 9	−11	−10	−14	−16	−15	−14
Mar.	−22	−22	−21	−20	−18	−16	−16	−14	+ 2	+30	+55	+108	+101	+40	+14	− 8	−17	−14	−12	−14	−16	−17	−18	−19	−19
April	−14	−13	−12	−14	−13	−14	−13	− 7	+11	+37	+53	+56	+46	+30	+ 8	−10	−15	−15	−13	−15	−17	−18	−18	−18	−18
May	−14	−12	−12	−13	−12	−11	− 9	− 8	+ 6	+28	+43	+36	+31	+18	+14	− 2	− 9	−11	−10	−10	− 9	− 9	− 9	− 9	−10
June	−11	−10	− 9	−10	− 9	−10	− 9	− 7	+ 5	+21	+35	+43	+38	+26	+10	− 4	−10	−12	−12	−13	−12	−11	−11	−10	− 9
July	−13	−11	−11	−10	−11	−11	−10	− 6	0	+13	+26	+37	+33	+25	+14	+ 4	− 7	−13	−13	−10	−10	−11	−10	− 9	− 7
Aug.	−16	−15	−15	−14	−14	−14	−14	−12	− 1	+18	+33	+41	+39	+31	+20	+ 5	− 8	−12	−10	− 8	− 9	− 9	−11	−11	−10
Sept.*	−16	−16	−16	−15	−16	−13	−14	−10	+ 7	+36	+52	+55	+45	+27	+ 6	− 9	−13	− 7	− 7	−10	−13	−14	−14	−14	−14
Summer Means	−14	−13	−12	−13	−12	−12	−11	− 8	+ 5	+26	+40	+45	+39	+26	+12	− 3	−10	−12	−11	−11	−12	−12	−12	−12	−11

NOTE—Horizontal Force is greater or less than the mean as sign is + or −.

* The observatory was dismantled in October 1923.

TABLE LXXXVII.—Hourly means of Vertical Force in C.G.S. units corrected for temperature Kodaikanal 1923,

VERTICAL FORCE = ·03000 C.G.S. + tabular quantity (from 5 selected quiet days)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	107	105	103	106	106	107	107	107	106	104	099	098	099	098	**098**	103	106	102	104	104	105	106	107	**107**	109	104
Feb.	110	109	110	110	110	**110**	109	109	107	101	093	084	**082**	084	088	096	100	102	106	109	110	110	108	109	112	103
Mar.	112	112	113	113	114	114	116	**118**	116	108	099	094	**090**	092	101	111	116	113	111	111	112	112	114	114	115	109
April	115	116	116	116	116	116	**117**	**119**	116	110	100	087	**083**	084	094	104	111	109	109	108	109	109	110	111	111	108
May	121	121	121	121	120	121	**125**	124	119	112	107	102	**100**	106	110	115	119	121	118	118	118	118	119	120	119	117
June	119	119	120	120	119	121	126	**129**	127	121	113	112	**109**	110	112	116	116	116	116	118	119	120	120	121	121	118
July	119	122	121	122	121	121	123	122	124	119	117	112	**111**	115	121	**124**	124	122	121	118	119	119	120	121	121	120
Aug.	121	121	121	121	121	122	125	**128**	122	113	108	**100**	101	106	111	114	120	121	118	117	118	119	118	120	120	117
Sept.*	117	120	120	121	119	122	123	121	113	101	**094**	098	100	102	111	118	122	120	121	121	122	124	124	**125**	124	116
Summer Means	119	120	120	120	119	121	123	**124**	120	113	107	102	**101**	104	110	115	119	118	117	117	118	118	119	120	119	116

NOTE—Figures in thick type represent the maximum and minimum values during the month.

* The observatory was dismantled in October 1923.

TABLE LXXXVIII.—Diurnal Inequality of the Vertical Force at Kodaikānal in 1923, (deduced from *TABLE LXXXVII.*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	+ 3	+ 1	+ 2	+ 2	+ 2	+ 3	+ 3	+ 3	+ 2	0	− 5	− 6	− 5	− 6	− 6	− 1	+ 2	− 2	0	0	+ 1	+ 2	+ 3	+ 3	+ 5
Feb.	+ 7	+ 6	+ 7	+ 7	+ 7	+ 7	+ 6	+ 6	+ 4	− 2	−10	−19	−21	−19	−15	− 7	− 3	− 1	+ 3	+ 6	+ 7	+ 7	+ 5	+ 6	+ 9
Mar.	+ 3	+ 3	+ 4	+ 4	+ 5	+ 5	+ 7	+ 9	+ 7	− 1	−10	−15	−19	−17	− 8	+ 2	+ 7	+ 4	+ 2	+ 2	+ 3	+ 3	+ 5	+ 5	+ 6
April	+ 7	+ 8	+ 8	+ 8	+ 8	+ 8	+ 9	+11	+ 8	+ 2	− 8	−21	−25	−24	−14	− 4	+ 3	+ 1	+ 1	0	+ 1	+ 1	+ 2	+ 3	+ 3
May	+ 4	+ 4	+ 4	+ 4	+ 3	+ 4	+ 8	+ 7	+ 2	− 5	−10	−15	−17	−11	− 7	− 2	+ 2	+ 4	+ 1	+ 1	+ 1	+ 1	+ 2	+ 3	+ 2
June	+ 1	+ 1	+ 2	+ 2	+ 1	+ 3	+ 8	+11	+ 9	+ 3	− 5	− 6	− 9	− 8	− 6	− 2	− 2	− 2	− 2	0	+ 1	+ 2	+ 2	+ 3	+ 3
July	− 1	+ 2	+ 1	+ 2	+ 1	+ 1	+ 3	+ 2	+ 4	− 1	− 3	− 8	− 9	− 5	+ 1	+ 4	+ 4	+ 2	+ 1	− 2	− 1	− 1	0	+ 1	+ 1
Aug.	+ 4	+ 4	+ 4	+ 4	+ 4	+ 5	+ 8	+11	+ 5	− 4	− 9	−17	−16	−11	− 6	− 3	+ 3	+ 4	+ 1	0	+ 1	+ 2	+ 1	+ 3	+ 3
Sept.*	+ 1	+ 4	+ 4	+ 5	+ 3	+ 6	+ 7	+ 5	− 3	−15	−22	−18	−16	−14	− 5	+ 2	+ 6	+ 4	+ 5	+ 5	+ 6	+ 8	+ 8	+ 9	+ 8
Summer Means	+ 3	+ 4	+ 4	+ 4	+ 3	+ 5	+ 7	+ 8	+ 4	− 3	− 9	−14	−15	−12	− 6	− 1	+ 3	+ 2	+ 1	+ 1	+ 2	+ 2	+ 3	+ 4	+ 3

NOTE—Vertical Force is greater or less than the mean as sign is + or −.

* The observatory was dismantled in October 1923.

TABLE LXXXIX.—Hourly means of the Dip at Kodaikānal in 1923, (determined from 5 selected quiet days)

DIP = N 4° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	41·1	40·9	41·0	41·0	41·0	**41·1**	41·1	41·0	40·8	40·6	40·0	**39·9**	40·1	40·0	40·1	40·7	41·0	40·6	40·8	40·8	40·9	41·0	41·1	41·0	41·2	40·7
Feb.	**41·3**	41·2	41·3	41·3	41·3	41·3	41·2	41·1	40·8	40·1	39·3	38·5	**38·3**	38·6	39·1	39·9	40·3	40·5	40·9	41·8	41·2	41·3	41·1	41·2	41·4	40·5
Mar.	41·5	41·5	41·6	41·6	41·7	41·7	41·9	**42·0**	41·7	40·8	39·8	39·0	**38·7**	39·3	40·3	41·3	41·9	41·6	41·4	41·4	41·5	41·5	41·7	41·7	41·8	41·1
April	41·7	41·8	41·8	41·8	41·8	41·8	41·9	**42·0**	41·6	40·9	39·9	38·7	**38·4**	38·6	39·6	40·7	41·3	41·2	41·1	41·1	41·2	41·2	41·3	41·4	41·4	41·0
May	42·2	42·2	42·2	42·2	42·1	42·2	**42·5**	42·4	41·9	41·1	40·5	40·1	**40·0**	40·8	41·0	41·6	42·0	42·2	41·9	41·9	41·9	41·9	42·0	42·1	42·0	41·7
June	42·0	42·0	42·0	42·0	42·0	42·1	42·6	**42·8**	42·6	41·9	41·1	40·9	**40·7**	40·9	41·2	41·7	41·7	41·7	41·7	41·9	42·0	42·1	42·1	42·1	42·1	41·8
July	42·0	42·2	42·2	42·2	42·2	42·2	42·3	42·2	**42·3**	41·8	41·5	41·6	**40·9**	41·3	42·0	42·3	42·4	42·3	42·2	41·9	42·0	42·0	42·1	42·1	42·1	42·0
Aug.	42·1	42·1	42·1	42·1	42·1	42·2	42·5	**42·7**	42·1	41·1	40·6	**39·8**	39·9	40·4	41·0	41·3	42·0	42·1	41·8	41·7	41·8	41·9	41·8	42·0	42·0	41·6
Sept.*	41·6	41·9	41·9	42·0	41·8	42·1	42·2	42·0	41·1	39·8	**39·1**	39·4	39·7	40·0	40·9	41·7	42·1	41·8	41·9	42·0	42·1	42·3	42·3	**42·4**	42·3	41·4
Summer Means	41·9	42·0	42·0	42·1	42·0	42·1	42·3	**42·4**	41·9	41·1	40·5	40·1	**39·9**	40·3	41·0	41·6	41·9	41·9	41·8	41·8	41·8	41·9	41·9	42·0	42·0	41·6

NOTE—Figures in thick type represent the maximum and minimum values during the month.

* The observatory was dismantled in October 1923.

TABLE XC.—Diurnal Inequality of the Dip at Kodaikānal in 1923, (deduced from ***TABLE LXXXIX.***)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	+0·4	+0·2	+0·3	+0·3	+0·3	+0·4	+0·4	+0·3	+0·1	−0·1	−0·7	−0·8	−0·6	−0·7	−0·6	0	+0·3	−0·1	+0·1	+0·1	+0·2	+0·3	+0·4	+0·3	+0·5
Feb.	+0·8	+0·7	+0·8	+0·8	+0·8	+0·8	+0·7	+0·6	+0·3	−0·4	−1·2	−2·0	−2·2	−1·9	−1·4	−0·6	−0·2	0	+0·4	+1·3	+0·7	+0·8	+0·6	+0·7	+0·9
Mar.	+0·4	+0·4	+0·5	+0·5	+0·6	+0·6	+0·8	+0·9	+0·6	−0·3	−1·3	−2·1	−2·4	−1·8	−0·8	+0·2	+0·8	+0·5	+0·3	+0·3	+0·4	+0·4	+0·6	+0·6	+0·7
April	+0·7	+0·8	+0·8	+0·8	+0·8	+0·8	+0·9	+1·0	+0·6	−0·1	−1·1	−2·3	−2·6	−2·4	−1·4	−0·3	+0·3	+0·2	+0·1	+0·1	+0·2	+0·2	+0·3	+0·4	+0·4
May	+0·5	+0·5	+0·5	+0·5	+0·4	+0·5	+0·8	+0·7	+0·2	−0·6	−1·2	−1·6	−1·7	−0·9	−0·7	−0·1	+0·3	+0·5	+0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·3
June	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·8	+1·0	+0·8	+0·1	−0·7	−0·9	−1·1	−0·9	−0·6	−0·1	−0·1	−0·1	−0·1	+0·1	+0·2	+0·3	+0·3	+0·3	+0·3
July	0	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·2	+0·3	−0·2	−0·5	−0·4	−1·1	−0·7	0	+0·3	+0·4	+0·3	+0·2	+0·1	0	0	+0·1	+0·1	+0·1
Aug.	+0·5	+0·5	+0·5	+0·5	+0·5	+0·6	+0·9	+1·1	+0·5	−0·5	−1·0	−1·8	−1·7	−1·2	−0·6	−0·3	+0·4	+0·5	+0·2	+0·1	+0·2	+0·3	+0·2	+0·4	+0·4
Sept.*	+0·2	+0·5	+0·5	+0·6	+0·4	+0·7	+0·8	+0·6	−0·3	−1·6	−2·3	−2·0	−1·7	−1·4	−0·5	+0·3	+0·7	+0·4	+0·5	+0·6	+0·7	+0·9	+0·9	+1·0	+0·9
Summer Means	+0·3	+0·4	+0·4	+0·5	+0·4	+0·5	+0·7	+0·8	+0·3	−0·5	−1·1	−1·5	−1·7	−1·3	−0·6	0	+0·3	+0·3	+0·2	+0·2	+0·2	+0·3	+0·3	+0·4	+0·4

NOTE—Dip is greater or less than the mean as the sign is + or −.

* The observatory was dismantled in October 1923.

94. *Dehra Dun observatory 1924-25.*

The magnetographs have worked satisfactorily during the year 1924-25 except for the following minor interruptions which may be divided under three main heads :—

Accidental.
Stoppage of driving clocks.
Failure of light.

95. *H.F. magnetograph.*

There were two accidental interruptions in the H.F. magnetograph clock, the first following the dropping of the drum shutter between 24th and 25th March 1925 and the second caused for a few hours on 15th July 1925, by the breakage of the directing lever of the clock.

The clock stopped on several occasions for periods, not exceeding 3 hours in any case before it was noticed, cleaned and restarted. The lamp platform and the light slit were adjusted on three different occasions, whenever due to secular change the light was falling off the drum.

96 *Declination magnetograph.*

Besides the loss to traces consequent on the stoppage of the clock as enumerated under the working of the H.F. magnetograph, there was only one interruption to the Declination magnetograph lasting for a day and caused by the falling of the shutter between 16th and 17th February 1925 and another by the failing of light on 11th November 1924. The light slit and the lamp platform were adjusted on 7th February 1925 and between 16th and 20th of the same month. The condensing lens of this magnetograph gave some trouble about the early part of this year and was cleaned and adjusted on three different occasions.

97. *V.F. magnetograph.*

There was no loss of trace in V. F. magnetograph clock and only one adjustment for better light was made on 29th July 1925.

The temperature inside the observatory was maintained by the burning of two lamps during the period 12th November 1924 to 31st May 1925 and by the occasional introduction for a few hours of a brass stove during the winter months. Only one lamp was kept burning during the rest of the year.

98. *Observatory and electric tramway in Dehra Dun.*

Some water appeared in the passage outside the observatory about the middle of August 1925, but was pumped out before it could accumulate and do any damage. The fears entertained about the abandonment of the observatory consequent on the introduction of electric trams in Dehra Dūn have been set aside at least temporarily due to the Tramway Company going into liquidation. The standard sidereal Clock named A having been removed for the purpose of installation in the Riefler Clock room, the observatory chronometer was compared weekly beginning from March 1925, against Clock B, of which the error and rate were supplied as usual by the time observer. The vibration times for the absolute observations were however recorded on the chronograph against the seconds of the Riefler Clock.

The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and of the distribution factor $\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$. The values of the moment "m" in the table were derived from vibration observations taken with the chronograph. 99

Mean values of declination and H.F. constants.

Mean values of the constants of Magnet No. 17 at Dehra Dūn in 1924

Months	Declination constants	H.F. Constants				
	Mean magnetic collimation	Distribution factors			Mean values of m	
		$P_{1\cdot2}$	$P_{2\cdot3}$	$\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$	Monthly means	Accepted m
	′ ″					
January ...	6 49	5·91	6·15	$\bar{1}$·99385 throughout	806·52	806·18 throughout
February ...	6 41	6·02	7·01		·51	
March ...	6 43	6·00	6·89		·44	
April ...	6 37	5·94	6·88		·30	
May ...	6 45	5·83	7·03		·41	
June ...	6 40	5·90	7·14		·36	
July ...	6 49	6·04	6·14		·24	
August ...	6 54	5·79	6·54		·16	
September ...	6 55	6·00	6·46		·33	
October ...	6 54	6·07	6·61		·27	
November ...	6 51	5·79	6·46		·31	
December ...	6 55	5·86	6·12		·36	

100. *Mean base line values.* The table below gives the mean monthly observed and accepted values of the declination and horizontal force base lines. The accepted values have been used to compute the values of these elements for 1924. The horizontal force base lines have been derived from H as determined with the moment of inertia of Magnet No. 17 obtained from observations in 1919 and the distribution factor as given in the section.

Base line values of magnetograph at Dehra Dūn in 1924

Months	Declination		Horizontal Force	
	Mean value of Base line	Base line accepted	Mean value of Base line	Base line accepted
			C.G.S.	C.G.S.
January ..	0° 43′·7	0° 43′·7	·32670(*a*) ·32632(*b*)	·32670 (*a*) ·32632 (*b*)
February ..	0 44·0	0 44·0	·32633	·32633
March ...	0 44·1	0 44·1	·32639	·32639
April ...	0 44·4	0 44·4	·32645	·32645
May ...	0 44·6	0 44·6	·32646	·32646
June ...	0 44·6	0 44·6	·32648	·32648
July ...	0 44·9	0 44·9	·32652	·32652
August ...	0 44·7	0 44·7	·32650	·32650
September ...	0 44·7	0 44·7	·32641	·32641
October ..	0 45·2	0 45·2	·32641	·32641
November ...	0 45·3	0 45·3	·32638	·32638
December ...	0 45·3	0 45·3	·32666	·32666

(*a*) up to 12th. (*b*) from 13th.

101. *Mean scale values and temperature range.* The mean scale values for 1924 for an ordinate of 1/25 inch are:—

Horizontal force	4·35 gammas.
Declination	1·03 minutes.
Vertical Force	8·80 to 10·90 gammas.

The mean temperature for the year was 26°·7 C. with maximum and minimum monthly values of 26°·9 and 26°·5 C. The temperature of reduction is 27°·0 C.

The following table shows the monthly mean values of the magnetic elements for 1923 and 1924 and the annual changes for that period. **102.** *Mean monthly values and annual changes.*

Annual changes at Dehra Dūn in 1923-1924

Months		Horizontal Force ·32000 C.G.S. +			Declination E. 1° +			Dip N. 45° +			Vertical Force ·33000 C.G.S. +		
		1923	1924	Annual change	1923	1924	Annual change	1923	1924	Annual change	1923	1924	Annual change
		γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January	..	919	923	+ 4	40 1	36·4	− 3·7	10·1	15·4	+ 5·3	115	219	+ 104
February	...	919	927	+ 8	40·2	36·2	- 4 0	10·7	15·9	+ 5·2	125	232	+ 107
March	..	917	941	+ 24	40·0	35·7	− 4·3	11·3	15·6	+ 4·3	134	241	+ 107
April	...	914	946	+ 32	39·5	35·4	− 4·1	11·4	16·2	+ 4·8	133	259	+ 126
May	...	926	946	+ 20	39·3	35·2	− 4·1	11·6	16·4	+ 4·8	150	262	+ 112
June	...	924	944	+ 20	38·7	34·7	− 4·0	11·6	17·0	+ 5·4	149	271	+ 122
July	..	929	950	+ 21	38·5	34·8	− 3·7	13·3	17·0	+ 3·7	184	277	+ 93
August	...	930	950	+ 20	37·9	33·9	− 4 0	13·3	17·5	+ 4·2	186	288	+ 102
September	..	941	932	− 9	37·5	33·5	− 4·0	13·5	18·4	+ 4 9	200	286	+ 86
October	..	929	942	+ 13	37·3	33·5	− 3·8	14·5	18·3	+ 3·8	209	295	+ 86
November	...	939	939	0	37·3	33·2	− 4·1	14·3	18·4	+ 4·1	212	294	+ 82
December	...	935	938	+ 3	37·4	32·8	− 4·6	14·4	19·3	+ 4·9	211	310	+ 99
Means	...	927	940	+ 13	38·6	34·6	− 4·0	12·5	17·1	+ 1·7	167	270	+ 102

103. *Mean values of magnetic elements at Dehra Dun 1924.*

Mean values of the magnetic elements at Dehra Dūn in 1924

Observatory	Latitude and Longitude	Dip	Declination	H. F.	V. F.
	° ′ ″	° ′	° ′	C. G. S.	C. G. S.
Dehra Dūn ...	30 19 19N. 78 3 19E	N. 45 17·1	E. 1 34·6	·32940	·33[illegible]

TABLE XCI—Classification and dates of Magnetic Disturbances in 1924.

D = Dehra Dūn. T = Toungoo. K = Kodaikānal. C = Calm. S = Slight. M = Moderate. G = Great. V. G. = Very Great. — = Trace lost.

Dates	January			February			March			April			May			June			July			August			September			October			November			December		
1924	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K	D	T	K
1	C			S			C			S			S			C			S			S			M			—			S			C		
2	S			S			S			C			C			S			C			S			S			—			S			C		
3	S			S			S			S			C			C			S			S			S			—			S			S		
4	S			S			C			S			C			S			C			S			S			—			C			S		
5	C			S			S			C			C			C			C			M			S			—			C			S		
6	S			M			S			S			C			C			S			S			—			—			S			C		
7	S			S			S			S			C			C			S			S			—			—			S			S		
8	S			S			M			S			C			C			S			S			—			—			C			S		
9	S			C			S			S			S			S			M			C			S			S			S			S		
10	M			S			S			C			C			VG			S			S			S			S			—			C		
11	M			S			S			C			S			G			S			C			C			C			S			C		
12	S			C			S			C			S			G			C			C			S			C			S			M		
13	C			C			C			S			S			S			S			C			S			C			S			M		
14	C			C			C			S			C			C			C			C			S			C			M			C		
15	S			C			C			S			C			S			S			C			S			S			C			S		
16	S			M			S			C			S			S			S			S			C			M			S			S		
17	S			S			C			S			S			S			S			S			C			—			S			S		
18	S			C			S			S			C			M			S			M			S			S			C			M		
19	S			C			S			S			S			M			S			S			S			C			G			S		
20	—			G			S			S			C			M			S			C			C			C			S			M		
21	—			G			S			C			G			C			S			C			S			S			—			M		
22	S			S			S			S			G			S			C			S			S			S			—			S		
23	M			S			S			C			G			S			C			C			S			G			C			S		
24	S			S			S			C			S			S			C			S			M			G			VG			S		
25	S			S			S			M			S			S			S			C			S			M			G			C		
26	S			S			C			M			C			S			M			C			S			C			S			S		
27	C			S			S			S			S			S			S			S			M			S			M			C		
28	S			C			C			C			S			S			M			S			M			M			M			S		
29	G			C			S			S			S			S			C			S			S			C			M			C		
30	G						M			S			S			S			C			M			—			C			C			C		
31	S						M						S						—			S						S						S		
C ...	5			9			8			10			13			8			10			11			4			9			7			10		
S ...	19			16			20			18			15			16			17			17			18			8			13			16		
M ...	3			2			3			2			...			3			3			3			4			3			4			5		
G ...	2			2			...			...			3			2			...			...			...			2			2			...		
V.G. ...	...			...			...			...			...			1			...			...			...			...			1			...		
Trace lost	2			...			...			...			...			...			1			...			4			9			3			...		

NOTE—Toungoo and Kodaikānal observatories were discontinued from October 1923.

TABLE XCII.—Hourly means of the Declination at Dehra Dūn in 1924, (determined from 5 selected quiet days)

DECLINATION = E 1° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	36·6	36·4	36·5	36·5	36·4	36·2	36·1	36·1	36·7	37·2	**37·3**	36·3	35·8	**35·8**	35·9	36·2	36·5	36·9	36·5	36·6	36·6	36·4	36·3	36·3	36·3	36·4
Feb.	36·2	36·5	36·4	36·4	36·2	36·2	36·2	36·2	36·9	**37·5**	37·1	36·1	**35·1**	35·1	35·5	36·1	36·0	36·5	36·2	36·3	36·2	36·1	36·2	36·2	36·2	36·2
Mar.	35·9	35·7	35·7	35·7	35·6	35·6	35·6	36·0	37·1	**37·9**	37·3	35·7	34·3	**33·9**	34·5	35·1	35·9	36·1	35·8	35·7	35·6	35·6	35·6	35·7	35·6	35·7
Oct.	33·9	34·0	34·0	33·9	33·8	33·8	33·8	34·5	35·2	**34·7**	33·9	32·5	31·4	**31·1**	32·1	33·1	33·8	33·7	33·4	33·4	33·4	33·5	33·5	33·6	33·6	33·5
Nov.	33·5	33·5	33·4	33·3	33·3	33·1	33·2	33·3	33·5	**33·6**	33·1	32·5	**32·1**	32·6	33·0	33·0	33·2	33·3	33·3	33·2	33·2	33·1	33·2	33·3	33·4	33·2
Dec.	33·0	33·1	32·9	32·8	32·7	32·6	32·5	32·4	33·0	33·7	**33·8**	33·7	32·2	**32·1**	32·4	32·6	32·9	33·0	33·0	33·0	32·9	32·8	32·8	32·9	32·9	32·8
Winter Means	34·9	34·9	34·8	34·8	34·7	34·6	34·6	34·8	35·4	**35·8**	35·4	34·5	33·5	**33·4**	33·9	34·4	34·8	34·9	34·7	34·7	34·7	34·6	34·6	34·7	34·7	34·6
April	35·6	35·6	35·7	35·7	35·6	35·7	36·3	37·6	**38·9**	38·4	36·3	34·1	32·9	**32·6**	33·2	34·1	35·1	35·5	35·5	35·3	35·2	35·3	35·4	35·5	35·6	35·4
May	35·5	35·5	35·6	35·5	35·5	35·7	36·6	37·8	**38·5**	37·9	36·2	34·3	33·0	**32·6**	33·1	33·4	34·1	34·5	35·0	35·1	34·8	34·9	35·1	35·3	35·3	35·2
June	35·2	35·4	35·4	35·3	35·2	35·5	36·8	37·8	**37·9**	37·2	35·7	33·9	32·7	31·9	**31·9**	32·5	32·8	33·7	34·5	34·4	34·2	34·5	34·7	34·9	35·0	34·7
July	34·7	35·0	35·0	35·1	35·2	35·4	36·5	37·5	**38·2**	37·4	35·8	33·7	32·2	**31·6**	31·8	32·9	34·0	34·5	34·9	34·4	34·3	34·4	34·6	34·7	34·8	34·8
Aug.	34·0	34·1	34·2	34·2	34·2	34·6	35·8	36·8	**37·0**	36·0	34·2	32·7	31·8	**31·2**	31·3	32·2	33·1	33·9	34·1	33·8	33·5	33·5	33·8	33·9	34·0	33·9
Sept.	33·8	34·1	34·0	33·8	33·9	33·9	34·1	35·2	36·0	35·4	33·7	31·8	30·7	30·4	31·0	32·2	33·3	34·0	33·8	33·5	33·4	33·5	33·5	33·6	33·9	33·5
Summer Means	34·8	35·0	35·0	34·9	34·9	35·1	36·0	37·1	**37·8**	37·1	35·3	33·4	32·2	**31·7**	32·1	32·9	33·7	34·4	34·6	34·4	34·2	34·4	34·5	34·7	34·8	34·6

NOTE.—Figures in thick type represent the maximum and minimum values during the month.

TABLE XCIII.—Diurnal Inequality of the Declination at Dehra Dūn in 1924, (deduced from *TABLE XCII*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan	+0·2	0	+0·1	+0·1	0	−0·2	−0·3	−0·3	+0·3	+0·8	+0·9	−0·1	−0·6	−0·6	−0·5	−0·2	+0·1	+0·5	+0·1	+0·2	+0·2	0	−0·1	−0·1	−0·1
Feb.	0	+0·3	+0·2	+0·2	0	0	0	0	·0·7	+1·3	+0·9	−0·1	−1·1	−1·1	−0·7	−0·1	+0·4	+0·3	0	+0·1	0	−0·1	0	0	0
Mar	+0·2	0	0	0	−0·1	−0·1	−0·1	+0·3	+1·4	+2·2	+1·6	0	−1·4	−1·8	−1·2	−0·6	+0·2	+0·4	+0·1	0	−0·1	−0·1	−0·1	0	−0·1
Oct.	+0·4	+0·5	+0·5	+0·4	+0·3	+0·3	+0·3	+1·0	+1·7	+1·2	+0·4	−1·0	−2·1	−2·4	−1·4	−0·4	+0·3	+0·2	−0·1	−0·1	−0·1	0	0	+0·1	+0·1
Nov.	+0·3	+0·3	+0·2	+0·1	+0·1	−0·1	0	+0·1	+0·3	+0·4	−0·1	−0·7	−1·1	−0·6	−0·2	−0·2	0	+0·1	+0·1	0	0	−0·1	0	+0·1	+0·2
Dec.	+0·2	+0·3	+0·1	0	−0·1	−0·2	−0·3	−0·4	+0·2	+0·9	+1·0	+0·9	−0·6	−0·7	−0·4	−0·2	+0·1	+0·2	+0·2	+0·2	+0·1	0	0	+0·1	+0·1
Winter Means	+0·3	+0·3	+0·2	+0·2	+0·1	0	0	+0·2	+0·8	+1·2	+0·8	−0·1	−1·1	−1·2	−0·7	−0·2	+0·2	+0·3	+0·1	+0·1	+0·1	0	0	+0·1	+0·1
April	+0·2	+0·2	+0·3	+0·3	+0·2	+0·3	+0·9	+2·2	+3·5	+3·0	+0·9	−1·3	−2·5	−2·8	−2·2	−1·3	−0·3	+0·1	+0·1	−0·1	−0·2	−0·1	0	+0·1	+0·2
May	+0·3	+0·3	+0·4	+0·3	+0·3	+0·5	+1·4	+2·6	+3·3	+2·7	+1·0	−0·9	−2·2	−2·6	−2·1	−1·8	−1·1	−0·7	−0·2	−0·1	−0·4	−0·3	−0·1	+0·1	+0·1
June	+0·5	+0·7	+0·7	+0·6	+0·5	+0·8	+2·1	+3·1	+3·2	+2·5	+1·0	−0·8	−2·0	−2·8	−2·8	−2·2	−1·9	−1·0	−0·2	−0·3	−0·5	−0·2	0	+0·2	+0·3
July	−0·1	+0·2	+0·2	+0·3	+0·4	+0·6	+1·7	+2·7	+3·4	+2·6	+1·0	−1·1	−2·6	−3·2	−3·0	−1·9	−0·8	−0·3	+0·1	−0·4	−0·5	−0·4	−0·2	−0·1	0
Aug.	+0·1	+0·2	+0·3	+0·3	+0·3	+0·7	+1·9	+2·9	+3·1	+2·1	+0·3	−1·2	−2·1	−2·7	−2·6	−1·7	−0·8	0	+0·2	−0·1	−0·4	−0·4	−0·1	0	+0·1
Sept	+0·3	+0·6	+0·5	+0·3	+0·4	+0·4	+0·6	+1·7	+2·5	+1·9	+0·2	−1·7	−2·8	−3·1	−2·5	−1·3	−0·2	+0·5	+0·3	0	−0·1	0	0	+0·1	+0·4
Summer Means	+0·2	+0·4	+0·4	+0·3	+0·3	+0·5	+1·4	+2·5	+3·2	+2·5	+0·7	−1·2	−2·4	−2·9	−2·5	−1·7	−0·9	−0·2	0	−0·2	−0·4	−0·2	−0·1	+0·1	+0·2

NOTE.—The magnet points to the east or west of the mean position as sign is + or −.

TABLE XCIV.—*Hourly means of Horizontal Force in C.G.S. units corrected for temperature at Dehra Dūn in 1924,* (from 5 selected quiet days)

HORIZONTAL FORCE = ·32000 C.G.S. + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	**916**	920	920	920	919	920	922	924	929	**929**	922	923	923	923	924	925	927	926	923	924	921	921	923	925	928	923
Feb.	924	922	922	**922**	923	924	925	926	926	925	926	928	936	**938**	937	934	930	924	925	927	926	925	926	925	926	927
Mar.	**932**	934	936	937	938	938	938	937	938	942	945	949	950	**951**	948	946	942	941	940	939	939	937	937	938	938	941
Oct.	**937**	938	937	938	938	939	**939**	939	938	941	945	950	955	**956**	953	948	915	939	939	937	939	940	940	940	942	942
Nov.	934	**934**	934	934	934	935	935	938	941	941	943	948	**951**	949	945	941	940	939	938	937	938	937	938	937	937	939
Dec.	935	933	933	933	**932**	934	935	939	913	945	943	947	**949**	943	940	939	938	937	936	933	936	937	935	936	936	938
Winter Means	**930**	930	930	931	931	932	932	934	936	937	937	941	**944**	943	941	939	937	934	934	933	933	933	933	934	935	935
April	942	942	941	943	945	943	944	939	**931**	933	942	952	960	**961**	958	952	949	948	948	946	946	947	947	946	946	946
May	947	944	943	944	946	943	944	942	938	**937**	942	950	953	957	**958**	955	952	919	944	943	945	944	945	945	946	946
June	941	941	941	940	939	941	940	940	942	944	946	951	953	**959**	958	953	945	942	942	940	939	**939**	940	941	942	944
July	**944**	945	945	945	945	946	949	949	949	950	950	951	954	959	961	**961**	956	948	945	946	946	948	951	951	950	950
Aug.	950	950	949	949	950	950	950	947	942	**939**	940	949	957	960	**960**	958	953	949	950	950	950	950	950	953	952	950
Sept.	929	929	931	933	932	933	932	928	922	**919**	920	923	930	938	944	**945**	941	939	938	936	934	932	935	934	935	932
Summer Means	942	942	942	942	943	943	943	941	937	**937**	940	946	951	956	**957**	954	919	946	945	944	943	943	945	945	945	945

NOTE—Figures in thick type represent the maximum and minimum values during the month. γ = 0·00001 C.G.S.

TABLE XCV.—Diurnal Inequality of the Horizontal Force at Dehra Dūn in 1924, (deduced from *TABLE XIV*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	− 7	− 3	− 3	− 3	− 4	− 3	− 1	+ 1	+ 6	+ 6	− 1	0	0	0	+ 1	+ 2	+ 4	+ 3	0	+ 1	− 2	− 2	0	+ 2	+ 5
Feb.	− 3	− 5	− 5	− 5	− 4	− 3	− 2	− 1	− 1	− 2	− 1	+ 1	+ 9	+ 11	+ 10	+ 7	+ 3	− 3	− 2	0	− 1	− 2	− 1	− 2	− 1
Mar.	− 9	− 7	− 5	− 4	− 3	− 3	− 3	− 4	− 3	+ 1	+ 4	+ 8	+ 9	+ 10	+ 7	+ 5	+ 1	0	− 1	− 2	− 2	− 4	− 4	− 3	− 3
Oct.	− 5	− 4	− 5	− 4	− 4	− 3	− 3	− 3	− 4	− 1	+ 3	+ 8	+ 13	+ 14	+ 11	+ 6	+ 3	− 3	− 3	− 5	− 3	− 2	− 2	− 2	0
Nov.	− 5	− 5	− 5	− 5	− 5	− 4	− 4	− 1	+ 2	+ 2	+ 4	+ 9	+ 12	+ 10	+ 6	+ 2	+ 1	0	− 1	− 2	− 1	− 2	− 1	− 2	− 2
Dec.	− 3	− 5	− 5	− 5	− 6	− 4	− 3	+ 1	+ 5	+ 7	+ 5	+ 9	+ 11	+ 5	+ 2	+ 1	0	− 1	− 2	− 5	− 2	− 1	− 3	− 2	− 2
Winter Means	− 5	− 5	− 5	− 4	− 4	− 3	− 3	− 1	+ 1	+ 2	+ 2	+ 6	+ 9	+ 8	+ 6	+ 4	+ 2	− 1	− 1	− 2	− 2	− 2	− 2	− 1	0
April	− 4	− 4	− 5	− 3	− 1	− 3	− 2	− 7	− 15	− 13	− 4	+ 6	+ 14	+ 15	+ 12	+ 6	+ 3	+ 2	+ 2	0	0	+ 1	+ 1	0	0
May	+ 1	− 2	− 3	− 2	0	− 3	− 2	− 4	− 8	− 9	− 4	+ 4	+ 7	+ 11	+ 12	+ 9	+ 6	+ 3	− 2	− 3	− 1	− 2	− 1	− 1	0
June	− 3	− 3	− 3	− 4	− 5	− 3	− 4	− 4	− 2	0	+ 2	+ 7	+ 9	+ 15	+ 14	+ 9	+ 1	− 2	− 2	− 4	− 5	− 5	− 4	− 3	− 2
July	− 6	− 5	− 5	− 5	− 5	− 4	− 1	− 1	− 1	0	0	+ 1	+ 4	+ 9	+ 11	+ 11	+ 6	− 2	− 5	− 4	− 4	− 2	+ 1	+ 1	0
Aug	0	0	− 1	− 1	0	0	0	− 3	− 8	− 11	− 10	− 1	+ 7	+ 10	+ 10	+ 8	+ 3	− 1	0	0	0	0	0	+ 3	+ 2
Sept.	− 3	− 3	− 1	+ 1	0	+ 1	0	− 4	− 10	− 13	− 12	− 9	− 2	+ 6	+ 12	+ 13	+ 9	+ 7	+ 6	+ 4	+ 2	0	+ 3	+ 2	+ 3
Summer Means	− 3	− 3	− 3	− 3	− 2	− 2	− 2	− 4	− 8	− 8	− 5	+ 1	+ 6	+ 11	+ 12	+ 9	+ 4	+ 1	0	− 1	− 2	− 2	0	0	0

Note—The Horizontal Force is greater or less than the mean as sign is + or −.

TABLE XCVI.—Hourly means of Vertical Force in C.G.S. units corrected for temperature at Dehra Dūn in 1924,
VERTICAL FORCE = ·33000 C.G.S. + tabular quantity
(from 5 selected quiet days)

Hours.	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Jan.	223	223	223	223	223	224	224	225	**225**	223	218	210	**209**	212	214	217	219	219	219	219	219	219	219	219	220	219
Feb.	233	232	233	233	233	233	233	234	235	234	231	228	**226**	228	229	231	232	231	232	234	234	233	235	**235**	235	232
Mar.	244	244	244	243	243	243	244	246	**247**	245	240	233	**231**	232	235	238	240	240	241	240	242	243	243	243	243	241
Oct.	**300**	300	300	300	300	299	299	300	300	296	293	284	**283**	285	290	294	295	294	294	294	294	295	295	296	295	295
Nov.	297	296	296	296	**297**	296	295	297	295	295	293	290	**289**	291	293	292	294	294	295	295	295	295	295	295	296	294
Dec.	313	313	313	312	312	312	312	312	**314**	314	309	**302**	302	303	305	308	309	310	311	310	310	311	311	311	311	310
Winter Means	268	268	268	268	268	268	268	269	**269**	268	264	258	**257**	259	261	263	265	265	265	265	266	266	266	267	267	265
April	261	261	261	261	262	262	264	**266**	264	257	250	**244**	246	251	255	259	261	261	259	258	260	260	261	261	261	259
May	263	264	264	263	264	265	268	**268**	264	257	254	**250**	252	255	259	261	263	264	265	265	266	266	267	268	267	262
June	275	276	276	276	276	277	**280**	278	274	266	261	**254**	257	259	260	264	266	271	274	275	276	276	278	277	277	271
July	280	281	281	281	281	282	**285**	283	280	273	267	**261**	262	267	270	276	280	281	280	280	281	282	283	282	281	277
Aug.	287	287	287	287	287	287	291	289	288	284	**279**	279	280	283	288	290	292	292	**293**	290	292	292	292	292	292	288
Sept.	288	288	289	289	289	290	290	**290**	290	285	280	**274**	276	279	283	287	288	288	287	287	287	287	287	288	289	286
Summer Means	276	276	276	276	277	277	**280**	279	277	270	265	**260**	262	266	269	273	275	276	276	276	277	277	278	278	278	274

NOTE.—Figures in thick type represent the maximum and minimum values during the month.

TABLE XCVII—Diurnal Inequality of the Vertical Force at Dehra Dūn in 1924, (deduced from *TABLE XCVI*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
Jan.	γ + 4	γ + 4	γ + 4	γ + 4	γ + 4	γ + 5	γ + 5	γ + 6	γ + 6	γ + 4	γ − 1	γ − 9	γ −10	γ − 7	γ − 5	γ − 2	γ 0	γ 0	γ 0	γ 0	γ 0	γ 0	γ 0	γ 0	γ + 1
Feb.	+ 1	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 3	+ 2	− 1	− 4	− 6	− 4	− 3	− 1	0	− 1	0	+ 2	+ 2	+ 1	+ 3	+ 3	+ 3
Mar.	+ 3	+ 3	+ 3	+ 2	+ 2	+ 2	+ 3	+ 5	+ 6	+ 4	− 1	− 8	−10	− 9	− 6	− 3	− 1	− 1	0	− 1	+ 1	+ 2	+ 2	+ 2	+ 2
Oct.	+ 5	+ 5	+ 5	+ 5	+ 5	+ 4	+ 4	+ 5	+ 5	+ 1	− 2	−11	−12	−10	− 5	− 1	0	− 1	− 1	− 1	− 1	0	0	+ 1	0
Nov.	+ 3	+ 2	+ 2	+ 2	+ 3	+ 2	+ 1	+ 3	+ 1	+ 1	− 1	− 4	− 5	− 3	− 1	− 2	0	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2
Dec.	+ 3	+ 3	+ 3	+ 2	+ 2	+ 2	+ 2	+ 2	+ 4	+ 4	− 1	− 8	− 8	− 7	− 5	− 2	− 1	0	+ 1	0	0	+ 1	+ 1	+ 1	+ 1
Winter Means	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 4	+ 4	+ 3	− 1	− 7	− 8	− 6	− 4	− 2	0	0	0	0	+ 1	+ 1	+ 1	+ 2	+ 2
April	+ 2	+ 2	+ 2	+ 2	+ 3	+ 3	+ 5	+ 7	+ 5	− 2	− 9	−15	−13	− 8	− 4	0	+ 2	+ 2	0	− 1	+ 1	+ 1	+ 2	+ 2	+ 2
May	+ 1	+ 2	+ 2	+ 1	+ 2	+ 3	+ 6	+ 6	+ 2	− 5	− 8	−12	−10	− 7	− 3	− 1	+ 1	+ 2	+ 3	+ 3	+ 4	+ 4	+ 5	+ 6	+ 5
June	+ 4	+ 5	+ 5	+ 5	+ 5	+ 6	+ 9	+ 7	+ 3	− 5	−10	−17	−14	−12	−11	− 7	− 5	0	+ 3	+ 4	+ 5	+ 5	+ 7	+ 6	+ 6
July	+ 3	+ 4	+ 4	+ 4	+ 4	+ 5	+ 8	+ 6	+ 3	− 4	−10	−16	−15	−10	− 7	− 1	+ 3	+ 4	+ 3	+ 3	+ 4	+ 5	+ 6	+ 5	+ 4
Aug.	− 1	− 1	− 1	− 1	− 1	− 1	+ 3	+ 1	0	− 4	− 9	− 9	− 8	− 5	0	+ 2	+ 4	+ 4	+ 5	+ 2	+ 4	+ 4	+ 4	+ 4	+ 4
Sept.	+ 2	+ 2	+ 3	+ 3	+ 3	+ 4	+ 4	+ 4	+ 4	− 1	− 6	−12	−10	− 7	− 3	+ 1	+ 2	+ 2	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 3
Summer Means	+ 2	+ 2	+ 2	+ 2	+ 3	+ 3	+ 6	+ 5	+ 3	− 4	− 9	−14	−12	− 8	− 5	− 1	+ 1	+ 2	+ 2	+ 2	+ 3	+ 3	+ 4	+ 4	+ 4

NOTE—Vertical Force is greater or less than the mean as sign is + or −,

TABLE XCVIII.—Hourly means of the Dip at Dehra Dūn in 1924, (determined from 5 selected quiet days)

DIP = N 45° + tabular quantity

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0	Means
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	**16·0**	15·8	15·8	15·8	15·8	15·8	15·7	15·7	15·4	15·3	15·4	14·9	**14·9**	15·1	15·1	15·2	15·2	15·2	15·4	15·4	15·5	15·5	15·4	15·3	15·2	15·4
Feb.	16·1	16·1	**16·2**	16·2	16·1	16·1	16·0	16·0	16·1	16·0	15·8	15·6	15·1	**15·1**	15·2	15·4	15·7	16·0	16·0	16·0	16·0	16·0	16·1	16·1	15·7	15·9
Mar.	**16·2**	16·1	16·0	15·9	15·8	15·8	15·9	16·1	16·0	15·8	15·3	14·8	**14·6**	14·6	14·9	15·2	15·5	15·5	15·6	15·6	15·8	15·9	15·9	15·8	15·8	15·6
Oct.	**18·8**	18·8	18·8	18·8	18·8	18·7	18·7	18·7	18·8	18·4	18·1	17·3	**17·0**	17·1	17·5	18·0	18·2	18·3	18·3	18·6	18·5	18·5	18·5	18·5	18·3	18·3
Nov.	**18·9**	18·8	18·8	18·8	18·9	18·7	18·7	18·6	18·4	18·4	18·2	17·7	**17·5**	17·8	18·1	18·2	18·4	18·5	18·5	18·6	18·5	18·6	18·5	18·6	18·6	18·4
Dec.	19·4	**19·7**	19·7	19·7	19·7	19·6	19·6	19·4	19·3	19·2	19·0	18·4	**18·3**	18·7	19·0	19·2	19·3	19·4	19·5	19·6	19·4	19·4	19·5	19·5	19·5	19·3
Winter Means	**17·6**	17·6	17·6	17·5	17·5	17·5	17·4	17·4	17·3	17·2	17·0	16·5	**16·2**	16·4	16·6	16·9	17·1	17·2	17·2	17·3	17·3	17·3	17·3	17·3	17·2	17·2
April	16·6	16·6	16·6	16·6	16·5	16·6	16·6	17·0	**17·3**	16·8	16·0	15·2	**14·9**	15·0	15·4	16·0	16·2	16·3	16·2	16·2	16·3	16·2	16·3	16·4	16·4	16·2
May	16·4	16·6	16·7	16·6	16·5	16·7	16·8	**16·9**	16·9	16·6	16·2	15·6	15·5	**15·5**	15·6	15·9	16·2	16·4	16·7	16·7	16·7	16·7	16·7	16·8	16·7	16·4
June	17·3	17·4	17·4	17·5	17·5	17·4	**17·7**	17·6	17·3	16·7	16·4	15·7	15·8	**15·6**	15·7	16·1	16·7	17·1	17·3	17·4	17·5	17·5	17·6	17·4	17·4	17·0
July	17·4	**17·5**	17·5	17·5	17·5	17·5	17·5	17·3	17·2	16·7	16·4	16·1	**16·0**	16·0	16·0	16·4	16·8	17·3	17·4	17·3	17·4	17·3	17·2	17·2	17·2	17·0
Aug.	17·5	17·5	17·5	17·5	17·5	17·5	17·7	17·7	**18·0**	17·9	17·6	17·1	**16·7**	16·7	17·0	17·2	17·6	17·8	17·8	17·6	17·7	17·7	17·7	17·6	17·7	17·5
Sept.	18·6	18·6	18·6	18·5	18·5	18·5	18·6	18·8	**19·1**	19·0	18·7	18·3	18·0	17·7	**17·6**	17·7	18·0	18·1	18·1	18·2	18·3	18·4	18·3	18·4	18·4	18·4
Summer Means	17·3	17·4	17·4	17·4	17·3	17·4	17·5	17·6	**17·6**	17·3	16·9	16·3	16·2	**16·1**	16·2	16·5	16·9	17·2	17·3	17·2	17·3	17·3	17·3	17·3	17·3	17·1

NOTE.—Figures in thick type represent the maximum and minimum values during the month.

TABLE XCIX.—Diurnal Inequality of the Dip at Dehra Dūn in 1924, (deduced from *TABLE XCVIII*)

Hours	0	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	0
	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	+0·6	+0·4	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	0	−0·1	0	−0·5	−0·5	−0·3	−0·3	−0·2	−0·2	−0·2	0	0	+0·1	+0·1	0	−0·1	−0·2
Feb.	+0·2	+0·2	+0·3	+0·3	+0·2	+0·2	+0·1	+0·1	+0·2	+0·1	−0·1	−0·3	−0·8	−0·8	−0·7	−0·5	−0·2	+0·1	+0·1	+0·1	+0·1	+0·1	+0·2	+0·2	−0·2
Mar.	+0·6	+0·5	+0·4	+0·3	+0·2	+0·2	+0·3	+0·5	+0·4	+0·2	−0·3	−0·8	−1·0	−1·0	−0·7	−0·4	−0·1	−0·1	0	0	+0·2	+0·3	+0·3	+0·2	+0·2
Oct.	+0·5	+0·5	+0·5	+0·5	+0·5	+0·4	+0·4	+0·4	+0·5	+0·1	−0·2	−1·0	−1·3	−1·2	−0·8	−0·3	−0·1	0	0	+0·3	+0·2	+0·2	+0·2	+0·2	0
Nov.	+0·5	+0·4	+0·4	+0·4	+0·5	+0·3	+0·3	+0·2	0	0	−0·2	−0·7	−0·9	−0·6	−0·3	−0·2	0	+0·1	+0·1	+0·2	+0·1	+0·2	+0·1	+0·2	+0·2
Dec.	+0·1	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·1	0	−0·1	−0·3	−0·9	−1·0	−0·6	−0·3	−0·1	0	+0·1	+0·2	+0·3	+0·1	+0·1	+0·2	+0·2	+0·2
Winter Means	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1	0	−0·2	−0·7	−1·0	−0·8	−0·6	−0·3	−0·1	0	0	+0·1	+0·1	+0·1	+0·1	+0·1	0
April	+0·4	+0·4	+0·4	+0·4	+0·3	+0·4	+0·4	+0·8	+1·1	+0·6	−0·2	−1·0	−1·3	−1·2	−0·8	−0·2	0	+0·1	0	0	+0·1	0	+0·1	+0·2	+0·2
May	0	+0·2	+0·3	+0·2	+0·1	+0·3	+0·4	+0·5	+0·5	+0·2	−0·2	−0·8	−0·9	−0·9	−0·8	−0·5	−0·2	0	+0·3	+0·3	+0·3	+0·3	+0·3	+0·4	+0·3
June	+0·3	+0·4	+0·4	+0·5	+0·5	+0·4	+0·7	+0·6	+0·3	−0·3	−0·6	−1·3	−1·2	−1·4	−1·3	−0·9	−0·3	+0·1	+0·3	+0·4	+0·5	+0·5	+0·6	+0·4	+0·4
July	+0·4	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·3	+0·2	−0·3	−0·6	−0·9	−1·0	−1·0	−1·0	−0·6	−0·2	+0·3	+0·4	+0·3	+0·4	+0·3	+0·2	+0·2	+0·2
Aug.	0	0	0	0	0	0	+0·2	+0·2	+0·5	+0·4	+0·1	−0·4	−0·8	−0·8	−0·5	−0·3	+0·1	+0·3	+0·3	+0·1	+0·2	+0·2	+0·2	+0·1	+0·2
Sept.	+0·2	+0·2	+0·2	+0·1	+0·1	+0·1	+0·2	+0·4	+0·7	+0·6	+0·3	−0·1	−0·4	−0·7	−0·8	−0·7	−0·4	−0·3	−0·3	−0·2	−0·1	0	−0·1	0	0
Summer Means	+0·2	+0·3	+0·3	+0·3	+0·2	+0·3	+0·4	+0·5	+0·5	+0·2	−0·2	−0·8	−0·9	−1·0	−0·9	−0·6	−0·2	+0·1	+0·2	+0·1	+0·2	+0·2	+0·2	+0·2	+0·2

NOTE.—The Dip is greater or less than the mean as sign is + or −.

CHAPTER III

ASTRONOMICAL LATITUDES

(No. 13 Party)

BY MAJOR C. M. THOMPSON I.A.

104. *Latitude operations 1923-1925.*

Latitude observations in abeyance since 1915 were resumed in 1921 when Major Mason observed at 4 stations in Kashmīr. Next during the seasons 1923-24 and 1924-25 latitude was observed at 27 stations, 4 in Bihār and Orissa, 9 in the United Provinces, 3 in Eastern Bengal, 3 in the Surma valley, 7 in the Brahmaputra valley and 1 in the Khāsi and Jaintia hills.

The stations in Bihār and Orissa lay along the B. &. N.W. Railway to the NE. & SE. of Gorakhpur; those in the United Provinces along the B. & N.W. Railway and O. & R. Railway, N. of Gorakhpur and along the line Gorakhpur, Benares, Partābgarh, Ajodhya (Lakarmandi Ghāt).

105. *Selection of latitude stations.*

The selection of geodetic stations near railway lines and river steamer routes as sites for latitude stations was made with a view to economy. As only one officer was available, the sites were chosen by the observer and low brick pillars were constructed with quick drying cement on which the zenith telescope could be set up on its wooden stand.

106. *Stations in Bihar and Orissa and in the United Provinces.*

The stations in Bihār and Orissa and in the United Provinces lay in the Gangetic plain where the attraction of the Himalayas on the north and of the mass of hills to the south were likely to cause variations in deflection according to the relative positions of the stations with reference to the hill ranges on either side.

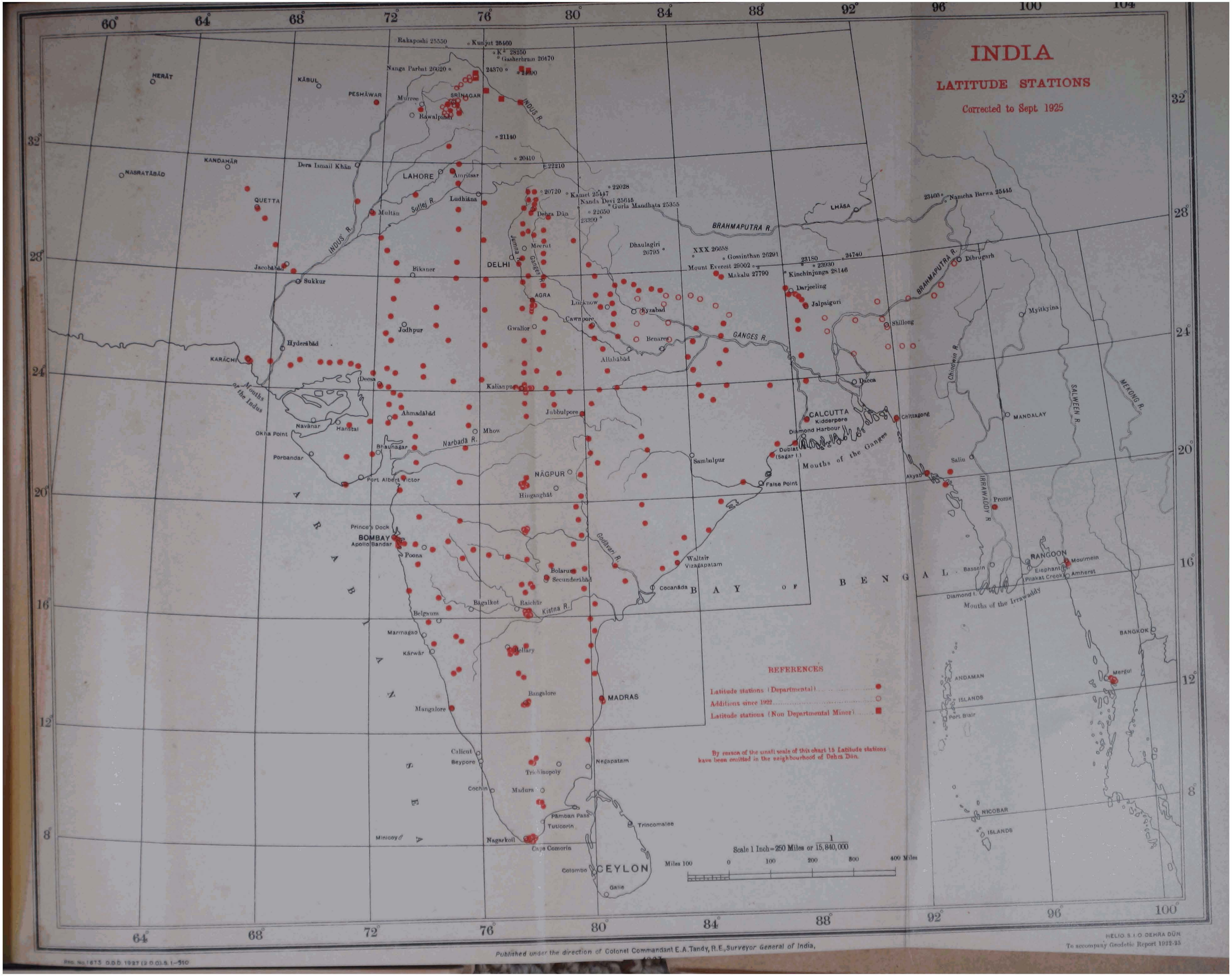
107. *Stations in Assam.*

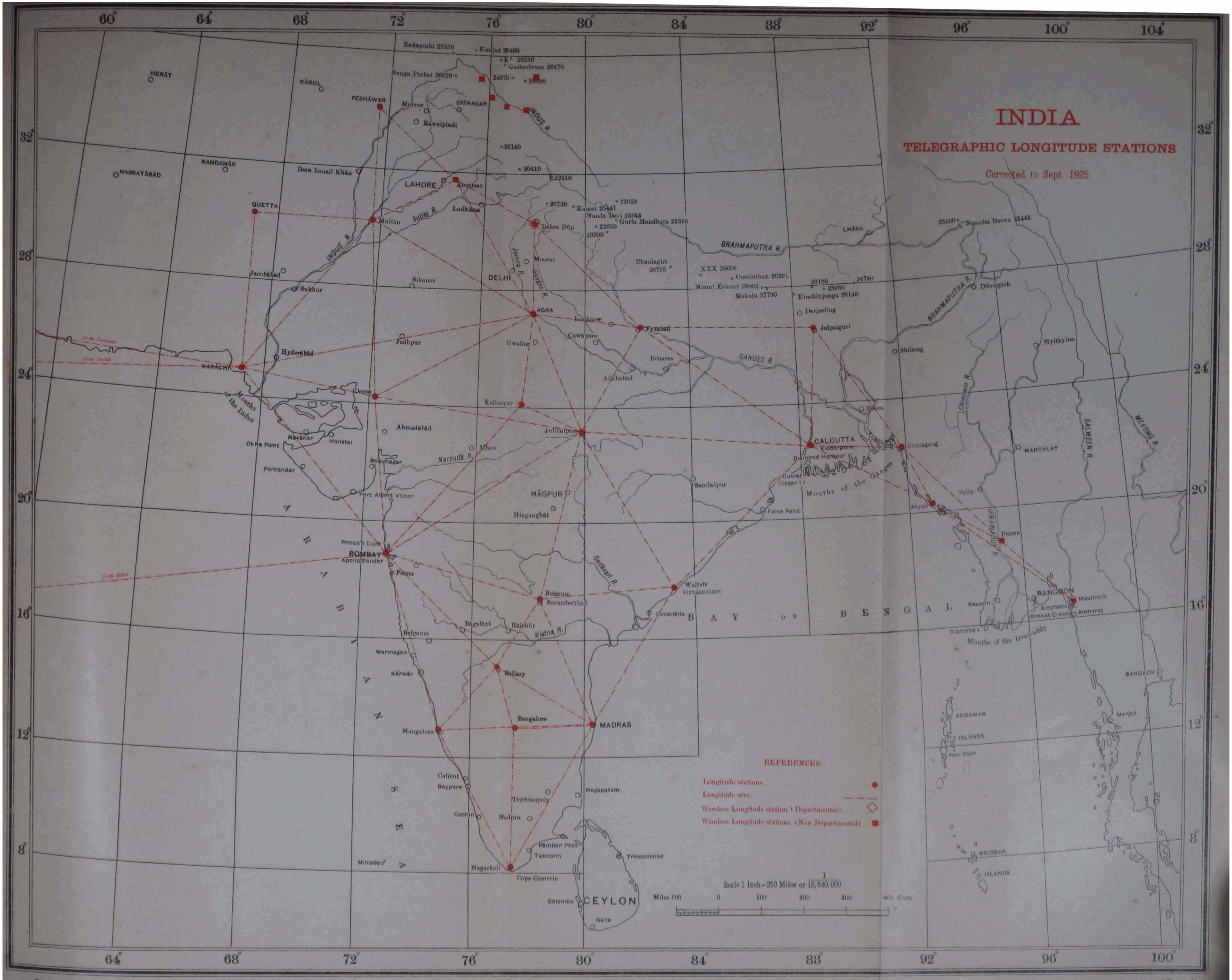
Similarly in the case of the latitude observations taken for the first time in Assam, the close attractions of the Himalayas as well as of the Khāsi and Jaintia hills were likely to show interesting effects on the derived deflections.

108. *Instruments*

The Zenith Telescope No. I by Messrs. Troughton and Simms was used throughout the period, except at Kāshdaha Tower Station where owing to the flooded state of the country, and difficulty of transporting bricks for pillars etc. the large prismatic astrolabe by M. Jobin was used. This zenith telescope, of which a photo appears in G.T.S. Vol. XVIII has been in use for the last 20 years.

The diaphragm of the zenith telescope had been rewired before the field season, and the new wiring was much finer and clearer than formerly.


INDIA
LATITUDE STATIONS
Corrected to Sept 1925
REFERENCES
Latitude stations (Departmental)
Additions since 1922
Latitude stations (Non Departmental Minor)
By reason of the small scale of this chart 15 Latitude stations have been omitted in the neighbourhood of Dehra Dūn.
Scale 1 Inch=250 Miles or 1/15,840,000
Miles 100 0 100 200 300 400 Miles
BAY OF BENGAL
ARABIAN SEA
CEYLON
BRAHMAPUTRA R.
GANGES R.
INDUS R.
Mouths of the Ganges
Mouths of the Indus
Mouths of the Irrawaddy
IRRAWADDY R.
SALWEEN R.
MEKONG R.
Narbada R.
Godāvari R.
Kistna R.
ANDAMAN ISLANDS
NICOBAR ISLANDS
HERĀT
KĀBUL
PESHĀWAR
KANDAHĀR
QUETTA
LAHORE
DELHI
AGRA
Lucknow
Cawnpore
Allahābād
Benares
Jodhpur
Hyderābād
KARĀCHI
Bikaner
Jubbulpore
NĀGPUR
BOMBAY
Poona
Bellary
Bangalore
MADRAS
Trichinopoly
Madura
CALCUTTA
Dacca
Chittagong
Darjeeling
Shillong
Dibrugarh
LHĀSA
Myitkyina
MANDALAY
RANGOON
Moulmein
BANGKOK
Mergui
Colombo
Galle
Trincomalee
Mount Everest 29002
Kinchinjunga 28146
Nanga Parbat 26620
Rakaposhi 25550
Gasherbrum 26470
Nanda Devi 25645
Dhaulagiri 26795
HELIO. S.I.O. DEHRA DŪN
To accompany Geodetic Report 1922-25
Published under the direction of Colonel Commandant E.A.Tandy, R.E., Surveyor General of India,



Reg. No. 1674 D.D.D. 1923 (2 D.D.)-&1-510
Published under the direction of Colonel Commandant E.A. Tandy, R.E., Surveyor General of India.
HELIO S.I.O. DEHRA DŪN

Reference numbers and Values of "*m*" and "M" for all Geodetic Series of the Indian Triangulation. (*See* Records of the Survey of India Vol. IX, p. 137).

For 42 Series entering the Simultaneous Grinding (shown in italics below) Mean Square M = ±1·04
For Series up to No. 94 ... ... Mean Square M = ±1·51

No.	Name of Series	Seasons	±*m*	±M
1	South Pārasnāth Mer.	1831-39	3·308	3·26
2	Budhon Meridional ...	1833-43	2·242	2·46
3	*Amūa Meridional* ...	1834-38	1·647	1·88
4	*Rangir Meridional* ...	1834-64	1·643	1·79
5	*Calcutta Longitudinal*	1834-69	0·369	0·32
6	*Great Arc Meridional, Section 24°-30°* ...	1835-66	0·708	0·71
7	*Bombay Longitudinal*	1837-63	0·844	0·74
8	*Great Arc Meridional, Section 18°-24°* ...	1838-41	0·567	0·59
9	*Great Arc Meridional, Section 8°-18°* ...	1840-74	0·390	0·36
10	*Singi Meridional* ...	1842-62	1·187	1·14
11	*South Konkan Coast*	1842-67	2·176	1·93
12	*Karāra Meridional* ...	1843-45	1·507	1·81
13	*North Malūncha Mer.*	1844-46	1·266	1·42
14	*Chendwār Meridional*	1844-69	0·841	1·06
15	*Gora Meridional* ...	1845-47	0·973	1·21
16	*Calcutta Meridional*...	1845-48	1·173	1·09
17	South Malūncha Mer.	1845-53	1·606	1·97
18	*Khānpisura Meridional*	1845-62	1·227	1·07
19	*Gurwāni Meridional*...	1846-47	1·165	1·55
20	*North-East Lon.* ...	1846-56	0·446	0·65
21	*Hurilāong Meridional*	1848-52	1·502	1·92
22	*North-West Himālaya*	1848-53	0·641	0·55
23	*Gurhāgarh Meridional*	1848-62	0·914	1·21
24	*East Coast* ...	1848-63	0·608	0·70
25	*Karāchi Longitudinal*	1849-53	0·558	0·60
26	*Abu Meridional* ...	1851-52	0·617	0·68
27	*North Pārasnāth Mer.*	1851-52	0·895	1·25
28	*Kāthiāwār Meridional*	1852-56	0·990	1·11
29	*Gujarāt Longitudinal*	1852-62	0·850	1·12
30	Kāthiāwār Lon.	1853	1·481	1·34
31	Sābarmati	1853-54	1·348	2·84
32	*Great Indus* ...	1853-61	0·359	0·43
33	*Rāhon Meridional* ...	1853-63	0·327	0·37
34	*Assam Longitudinal*...	1854-60	0·579	0·71
35	*Cutch Coast* ...	1855-58	0·986	1·27
36	Kashmīr Principal ...	1855-60	0·884	0·86
37	*Jogi-Tīla Meridional*	1855-63	0·481	0·59
38	Sambalpur Lon. ...	1856-57	0·806	0·87
39	(Cutch) Coast Line	1856-60	0·975	1·47
40	Kāthiāwār Meridional No. 1 ...	1858-59	0·930	1·51
41	Kāthiāwār Meridional No. 2 ...	1859-60	1·247	1·75
42	Kāthiāwār Meridional No. 3 ...	1859-60	0·9[illegible]	1·43
43	*Bidar Longitudinal* ...	1859-72	0·311	0·30
44	*Eastern Frontier or Shillong Meridional*	1860-64	0·409	0·49
45	*Sutlej Meridional* ...	1861-63	0·346	0·53
46	*Madras Mer. and Coast*	1861-68	0·428	0·40
47	Kāthiāwār Meridional No. 4 ...	1863-64	1·154	1·73
48	*East Calcutta Lon.* ...	1863-69	0·379	0·57

No.	Name of Series	Seasons	±*m*	±M
49	*Mangalore Meridional*	1863-73	0·440	0·45
50	Kumaun and Garhwāl	1864-65	1·742	1·60
51	Nāsik ...	1864-65	2·033	3·12
52	Burma Coast ...	1864-82	0·380	0·39
53	*Jubbulpore Meridional*	1865-67	0·340	0·31
54	*Madras Longitudinal*	1865-80	0·334	0·37
55	Assam Valley Triangulation ...	1867-78	1·690	2·65
56	*Brahmaputra Mer.* ...	1868-74	0·564	0·70
57	Coimbatore No. 1	1869-71	1·547	2·07
58	*Bilāspur Meridional*...	1869-73	0·302	0·33
59	Cuddapah ...	1871-72	0·826	0·96
60	Hyderābād ...	1871-72	1·405	1·56
61	Malabar Coast ...	1871, 74, 80	1·532	1·82
62	Jodhpore Meridional	1873-76	0·291	0·32
63	*South East Coast* ...	1876-79	0·522	0·65
64	Eastern Sindh Mer. ...	1876-81	0·244	0·30
65	Siam Branch Triangulation ...	1878-81	3·711	4·34
66	Mandalay Meridional	1889-95	0·418	0·35
67	Mong Hsat	1891-93	3·054	3·01
68	Manipur Longitudinal	1894-99	0·453	0·36
69	Makrān Longitudinal	1895-97	0·285	0·26
70	Mandalay Lon. ...	1899-1900	1·698	1·96
71	Manipur Mer.	1899-1902 } 1915-16 }	0·750	0·81
72	Great Salween ...	1900-11	0·404	0·32
73	Kidarkanta	1902-03	1·323	1·62
74	Kalāt Longitudinal ...	1904-08	0·365	0·25
75	Baluchistān Triangulation ...	1908-09	1·348	1·08
76	North Baluchistān ...	1908-10	0·221	0·17
77	Gilgit ...	1909-11	0·443	0·37
78	Khāsi Hills	1909-11	2·038	3·01
79	Mawkmai	1909-11	1·576	2·35
80	Upper Irrawaddy ...	1909-11	0·596	0·40
81	Jaintia Hills ...	1910-11	0·986	1·86
82	Bhīr ...	1911-12	0·794	0·94
83	Rānchi ...	1911-12	1·840	2·34
84	Villupuram	1911-12	1·184	1·78
85	Sambalpur Meridional	1911-14	0·250	0·21
86	Indo-Russian Connection ...	1912-13	2·790	3·92
87	Khandwa	1912-13	0·999	1·27
88	Ashta ...	1913-15	1·048	1·33
89	Buldāna ...	1913-14	0·304	0·43
90	Naldrug ...	1913-14	1·465	1·85
91	Nāga Hills	1913-14	0·[illegible]13	0·96
92	Middle Godāvari	1914-15	[illegible]18	1·08
93	Kohima ...	1914-15	1·[illegible]34	1·39
94	Cachār ...	1914-15	1·[illegible]77	1·65
95	Bombay Island	1911-14		
96	Madura	1916-17	1·148	1·59
97	Bāgalkot	1916-17	0·701	0·83
98	Sind Sagar Triangulation	1917-18	1·875	3·24

Mer. = Meridional. Lon. = Longitudinal.

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During the Assam observations the weather was not favourable. The observations were sometimes hampered by rain and clouds; humidity was generally excessive. As a result of the humidity, the weather during the later portion of the nights was generally misty, and the mist used to condense thickly on the objective of the telescope or the prism of the astrolabe so that observations had usually to be stopped at 2·30 a.m. The astrolabe was found particularly troublesome in this respect as not only did all the faces of the prism become clouded with moisture, but the surface of the mercury in the trough also became sullied and required cleaning every few minutes. 109. *Weather during Assam observations.*

Determinations of the value of one division of each of the level scales were made at the beginning and end of each field season. They gave the following results :— 110 *Value of one division of level scale.*

	1923-24			1924-25		
	Beginning	End	Value adopted	Beginning	End	Value adopted
Level No. 6	0″·8067	0″·8366	0″·822	0″·8010	0″·8816	0″·841
Level No. 9	0·9186	0·9082	0·913	0·9352	0·8904	0·913

In 1923-24, the micrometer value was obtained by observations of 80 couples of stars, the mean value of one division being determined as 0″·69159. This value proved satisfactory for all the stations except Rāmnagar which was recomputed with a lower value (0″·69040). This gave an unchanged value of latitude but closer accordance between results. 111. *Micrometer value 1923-24.*

In 1924-25 the micrometer value was obtained by observations of 41 couples of stars the mean value of one division being determined as 0″·69160. This value proved satisfactory for all the stations. 112. *Micrometer value 1924-25.*

The results of the observations are shown in Tables I and II. 113. *Results of observations.*

TABLE I.—Results of observation, season 1923-24

Name of station	Seconds of mean colat. E W (1)	Seconds of mean colat W E (2)	Difference (1) − (2)	Seconds of mean colat. from obsns. giving + ve micrometer corrections = C +	Mean + ve micrometer corrections = M +	Seconds of mean colat. from obsns. giving − ve micrometer corrections = C −	Mean − ve micrometer corrections = M −	Apparent error of micrometer $\frac{(C+) - (C-)}{(M+) + (M-)}$	Probable error of unit weight
Shāhpur ...	17·13	17·39	−0·26	17·12	1609	17·38	1182	−0″·000093	±0″·308
Sināria ...	53·72	53·74	−0·02	53·67	398	53·80	402	+0·000163	±0·185
Sikta ...	28·22	27·88	+0·34	27·94	1018	28·14	2039	+0·000065	±0·388
*Rāmnagar ...	9·79	9·34	+0·45	9·53	1265	9·59	712	−0·000030	±0·388
Mathia ...	6·28	5·45	+0·83	6·07	1586	5·76	865	+0·000126	±0·303
Rājābari ...	58·03	57·78	+0·25	57·50	1284	58·11	1100	−0·000256	±0·344
Saunbarsa ...	43·86	43·51	+0·35	43·81	1449	43·52	1452	−0·000100	±0·364
Baniāpar ...	44·85	44·25	+0·60	44·57	619·5	44·46	1225·5	−0·000060	±0·338
Kanaun ..	47·00	46·26	+0·74	46·44	964	46·87	1811	+0·000155	±0·295
Rāmāpura ...	57·04	56·56	+0·48	56·73	773	56·79	1456	+0·000027	±0·291
Sirwāra ...	26·66	25·91	+0·75	26·12	857	26·38	1027	+0·000138	±0·293
Bisanl ...	17·13	17·31	−0·18	16·96	1623	17·44	1261	−0·000166	±0·298
Kopā ...	58·77	58· 0	−0·03	58·50	1658	59·02	1662	+0·000157	±0·348

TABLE II.—Results of observation season 1924-25

Name of station	Seconds of mean colat. E W (1)	Seconds of mean colat. W E (2)	Difference (1) − (2)	Seconds of mean colat. from obsns. giving + ve micrometer corrections = C +	Mean + ve micrometer corrections = M +	Seconds of mean colat. from obsns. giving − ve micrometer corrections = C −	Mean − ve micrometer corrections = M −	Apparent error of micrometer $\frac{(C+)-(C-)}{(M+)+(M-)}$	Probable error of unit weight
Kāshdaha ...	...	...	...	(taken by	Astrolabe)	...	...	"	"
*Mymensingh...	14·12	14·44	−0·32	14·12	1726	14·40	1103	−0·000099	±0·279
Abangi Tila ...	51·85	51·55	+0·30	51·82	1303	51·66	1164	+0·000065	±0·263
Dali Tila ...	44·99	44·92	+0·07	44·95	1242	44·98	1162	−0·000012	±0·274
Salāma Tila ...	8·60	8·47	+0·13	8·53	1365	8·52	1171	+0·000004	±0·290
Golāghāt ...	59·44	59·63	−0·19	59·72	797	59·24	1593	+0·000201	±0·314
Phakwādal ...	18·50	18·17	+0·33	18·35	1078	18·36	1417	−0·000004	±0·201
Dibrugarh ...	54·00	53·89	+0·11	54·09	1017	53·78	1118	+0·000145	±0·243
Sildubi ...	56·17	55·67	+0·50	56·02	1738	55·76	1434	+0·000082	±0·309
†Gauhāti ...	32·21	31·82	+0·39	32·00	1113	31·99	1919	+0·000003	±0·236
Jāmtolla ...	42·34	41·67	+0·67	42·14	1427	41·88	1582	+0·000086	±0·253
Shillong ...	7·71	7·58	+0·13	7·68	2158	7·62	1899	+0·000015	±0·254
Raikusni ...	45·55	45·34	+0·21	45·47	1782	45·45	1611	+0·000006	±0·248
Atāro Bānki ...	13·53	13·39	+0·14	13·65	2002	13·29	2028	+0·000089	±0·256

* The clock tower of the *kachahri* on which this station was situated fell in the earthquake of 1897. Its site was located as closely as possible by enquiry from the local authorities, and correction to the latitude station applied accordingly.

† The Church Steeple which marked this point fell in the earthquake of 1897. Its site was located as closely as possible by enquiry from the local inhabitants, and the latitude station was also connected by measurement of a base line and azimuth, with Gauhāti obelisk, and with an intersected point about 400 yards distant on a rock in the Brahmaputra river.

TABLE III.—Deflections of the plumb-line, season 1923-24

Name of station	Instrument used	Height	Number of stars	Number of observations taken	Longitude	Geodetic latitude	Seconds of astronomical latitude	Probable error	Deflections (A − G)*
		feet			° ′ ″	° ′ ″		″	″
Shāhpur ...	Z. Telescope	173	53	61	85 47 25·37	26 24 42·37	42·73	±0·070	+ 0·36
Sināriā ...	,,	239	41	40	85 15 54·25	26 45 12·55	6·26	±0·082	− 6·29
Sikta ...	,,	267	35	36	84 40 54·56	27 1 44·04	31·98	±0·121	− 12·06
Rāmnagar ...	,,	312	40	41	84 19 35·56	27 9 4·09	50·42	±0·108	− 13·67
Mathia ...	,,	334	42	46	83 51 32·13	27 8 4·37	54·11	±0·075	− 10·26
Rājābari ...	,,	267	56	70	83 15 35·49	26 54 3·04	2·12	±0·077	− 0·92
Saunbarsa ...	,,	315	50	54	83 21 18·45	27 11 26·33	16·33	±0·084	− 10·00
Baniāpar ...	,,	267	48	52	83 23 2·28	26 15 7·72	15·45	±0·084	+ 7·73
Kanaun ...	,,	270	53	54	83 23 51·38	25 43 3·62	13·38	±0·065	+ 9·76
Rāmāpura ...	,,	356	50	53	82 5 40·58	25 44 55·09	3·24	±0·065	+ 8·15
Sirwāra ...	,,	348	47	51	82 7 30·01	26 16 23·86	33·74	±0·066	+ 9·88
Bisaul ...	,,	342	43	43	82 20 54·43	26 40 37·38	42·77	±0·076	+ 5·39
Kopā ...	,,	365	56	66	82 12 48·22	27 7 3·74	1·24	±0·071	− 2·50

* A positive value of (A − G) denotes a southerly deflection of the plumb-line.

TABLE IV.—Deflections of the plumb-line, season 1924-25

Name of station	Instrument used	Height	Number of stars	Number of observations taken	Longitude			Geodetic latitude			Seconds of astronomical latitude	Probable error	Deflections (A – G)*
		feet			°	′	″	°	′	″		″	″
Kāshdaha ...	Astrolabe	77	40	80	89	31	57·94	25	29	48·63	44·89	±0·120	– 3·74
Mymensingh ...	Z. Telescope	47	43	37	90	24	27·70	24	45	49·42	45·71	±0·068	– 3·71
Abangi Tila ...	,,	251	32	36	91	51	37·36	24	56	23·89	8·26	±0·068	–15·63
Dali Tila ...	,,	154	49	49	92	21	41·62	24	51	26·21	15·02	±0·060	–11·19
Salāma Tila ...	,,	220	47	50	92	48	36·93	24	51	7·72	51·47	±0·062	–16·25
Golāghāt ...	,,	315	48	39	93	57	27·88	26	30	47·64	0·43	±0·083	+12·79
Phakwādal ...	,,	302	46	45	94	12	41·18	26	50	33·88	41·63	±0·048	+ 7·75
Dibrugarh ...	,,	342	40	39	94	54	35·84	27	29	13·36	6·05	±0·060	– 7·31
Sildubi ...	,,	240	46	47	92	47	0·62	26	37	3·32	4·11	±0·068	+ 0·79
Gauhāti ...	,,	177	38	34	91	45	0·00	26	11	17·11	28·02	±0·059	+10·91
Jāmtolla ...	,,	188	38	39	91	35	33·89	26	28	14·75	17·98	±0·065	+ 3·23
Shillong ...	,,	6441	33	34	91	51	9·65	25	31	48·84	52·09	±0·072	+ 3·25
Raikusni ...	,,	803	38	31	90	39	47·24	26	8	11·37	14·51	±0·063	+ 3·14
Atāro Bānki ...	,,	113	34	32	89	28	3·10	26	4	50·62	46·53	±0·070	– 4·09

* A positive value of (A – G) denotes a southerly deflection of the plumb-line.

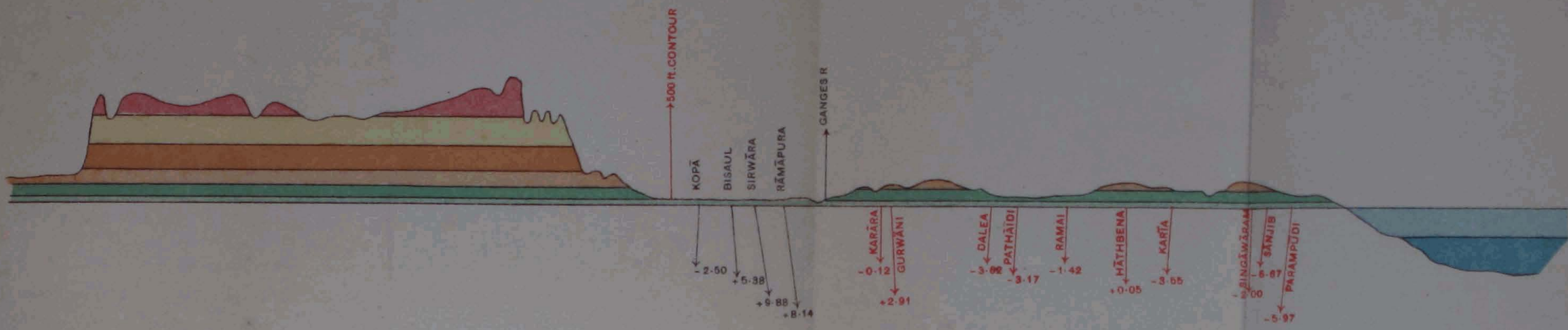
113. (*Contd.*) The 1923-24 stations were all situated in flat country, so that there were apparently no local causes for plumb-line deflection at any of them.

114. *Hayford residuals.* The topographical effects attributable to visible masses have been estimated from maps, and the Hayford deflections deduced therefrom on the hypothesis of a uniform isostatic compensation at the depth of 113·7 kilometres. The following table shows the residuals for the above stations unexplained by the Hayford hypothesis :—

TABLE V.—Values of Hayford Residuals, seasons 1923-25

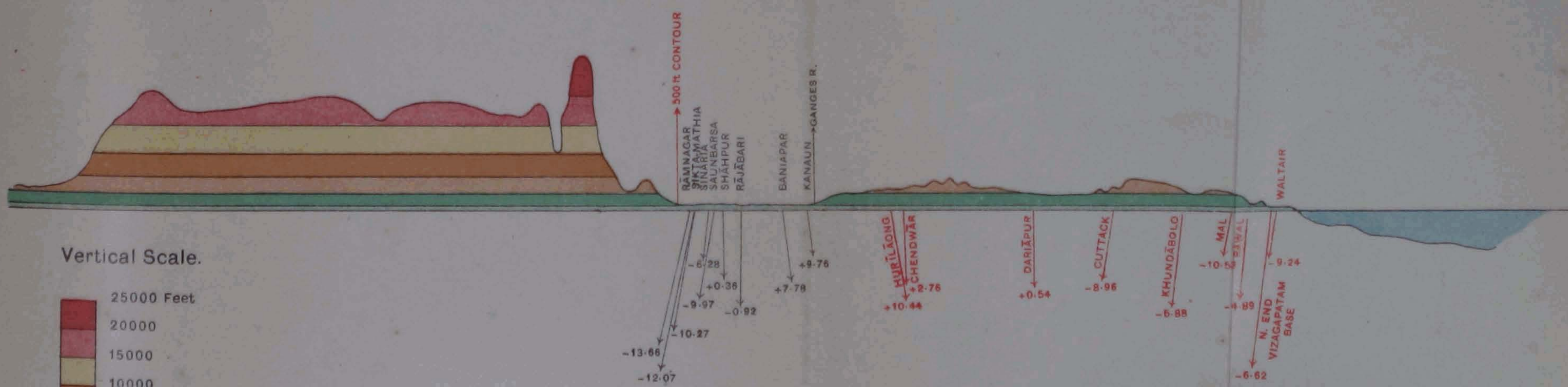
Name of station	Observed astronomical deflections (1)	Estimated topo deflections (2)	Hayford deflections (3)	Unexplained residuals (1) − (3)
1923-24				
Rāmnagar ...	−13·67	−86·36	− 7·18	− 6·49
Saunbarsa ...	−10·00	−77·02	− 4·37	− 5·63
Sikta ..	−12·06	−85·91	− 6·59	− 5·47
Mathia ...	−10·26	−81·39	− 5·27	− 4·99
Sināria ...	− 6·29	−83·20	− 5·57	− 0·72
Kopā ..	− 2·50	−66·29	− 2·59	+ 0·09
Rājābari ...	− 0·92	−70·19	− 3·05	+ 2·13
Shāhpur ..	+ 0·36	−77·64	− 3·94	+ 4·30
Bisaul ...	+ 5·39	−58·82	− 1·38	+ 6·77
Rāmāpura ...	+ 8·15	−47·18	− 0·32	+ 8·47
Baniāpar ...	+ 7·73	−57·92	− 1·12	+ 8·85
Kanaun ...	+ 9·76	−51·58	− 0·17	+ 9·93
Sirwāra ...	+ 9·88	−51·73	− 0·77	+10·65
1924-25	In order of observed deflections			
Salāma Tila ...	−16·25	−57·44	− 3·18	−13·07
Abangi Tila ...	−15·63	−60·14	− 4·31	−11·32
Dali Tila ...	−11·19	−56·02	− 2·79	− 8·40
Dibrugarh ..	− 7·31	−70·02	− 4·29	− 3·02
Atāro Bānki ...	− 4·09	−79·32	− 3·97	− 0·12
Kāshdaha	− 3·74	−64·91	− 2·03	− 1·71
Mymensingh ...	− 3·71	−55·48	− 1·74	− 1·97
Sildubi ...	+ 0·79	−77·20	− 5·63	+ 6·42
Raikusni ...	+ 3·14	−72·04	− 2·38	+ 5·52
Jāmtolla ...	+ 3·23	−80·64	− 5·40	+ 8·63
Shillong ...	+ 3·25	−59·62	+ 1·96	+ 1·29
Phakwādal ...	+ 7·75	−61·50	− 1·29	+ 9·04
Gauhāti ...	+10·91	−65·47	+ 0·43	+10·48
Golāghāt ...	+12·79	−59·05	− 0·03	+12·82

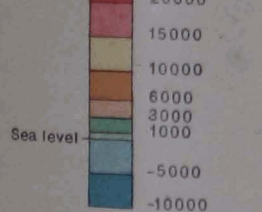
Average Section due N and S through KOPĀ, (Bisaul, Sirwāra and Rāmāpura). Meridians of 81°-82° roughly.



These stations have been plotted at their relative distances from the 500ft. contour and not by latitude, as they lie between longitude 81° and 82° and not actually on one meridian.

Average Section due N. and S. through MATHIA, (Ramnagar, Sikta, Sinaria, Saunbarsa, Shahpur, Rajabari, Baniapar and Kanaun). Meridians of 83°-86° roughly.





These stations have been plotted at their relative distances from the 500ft. contour and not by latitude, as they lie between longitude 83° and 86° and not actually on one meridian.

Deflections at old latitude stations from table at p. 14 of Professional Paper 5 plotted in red for meridians 81°-82° and 84°-86°.

Horizontal Scale 1 Inch = 192 miles approximately.

Deflections exaggerated.

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To accompany Geodetic Report 1922-25

The position of the stations of Table V is shown on the latitude Chart No. III. In addition two average or representative sections (Plate VI) have been prepared running due north and south through the west and east groups of the stations, Rāmnagar to Sirwāra. On these sections the vertical scale of heights as well as the deflections have been shown on an exaggerated scale. 115. *Representative Sections.*

The stations Salāma Tila to Golāghāt have been arranged in order of their deflections from the greatest negative to the greatest positive deflections. The large residuals i.e. differences between Hayford and observed deflections, both negative and positive, would show that this theory cannot account for the deflections actually found at the various stations, and that the condition of uniform isostatic compensation is far from being realised in this area.

The deflections at the old latitude stations on approximately the same meridians have been shown in red on these sections in order to illustrate roughly the changes of deflections met with from north to south.

It will be seen from a comparison of the Tables No. V and the sections, that on the Gangetic plain, the Hayford residuals increase steadily from north to south viz:—from $-6''\cdot49$ to $+10''\cdot65$. The Hayford theory, though reducing the large estimated negative deflections of the topography, does not account for the positive or negative deflections actually observed. To analyse typical instances, the total positive or southerly effect of the topographical deflection at Rāmāpura has been only estimated at $+6''\cdot26$, the negative deflection due to sea areas totals $-4''\cdot87$, and northerly negative deflections total $-46''\cdot37$. The reduction by multiplication by Hayford factors (less than 1) of the total positive value of $+6''\cdot26$, even when accompanied by a decrease of the negative totals of $-4''\cdot87$ and $-46''\cdot37$ in the same manner, merely reduces the Hayford result to $-0''\cdot32$, a negative value, whereas a deflection of $+8''\cdot15$ was actually observed. Similarly at Rāmnagar Hayford factors merely reduce an estimated total topographical deflection of $-86''\cdot36$ to $-7''\cdot18$, whereas a deflection of $-13''\cdot67$ was actually observed. 116. *Comparison with sections.*

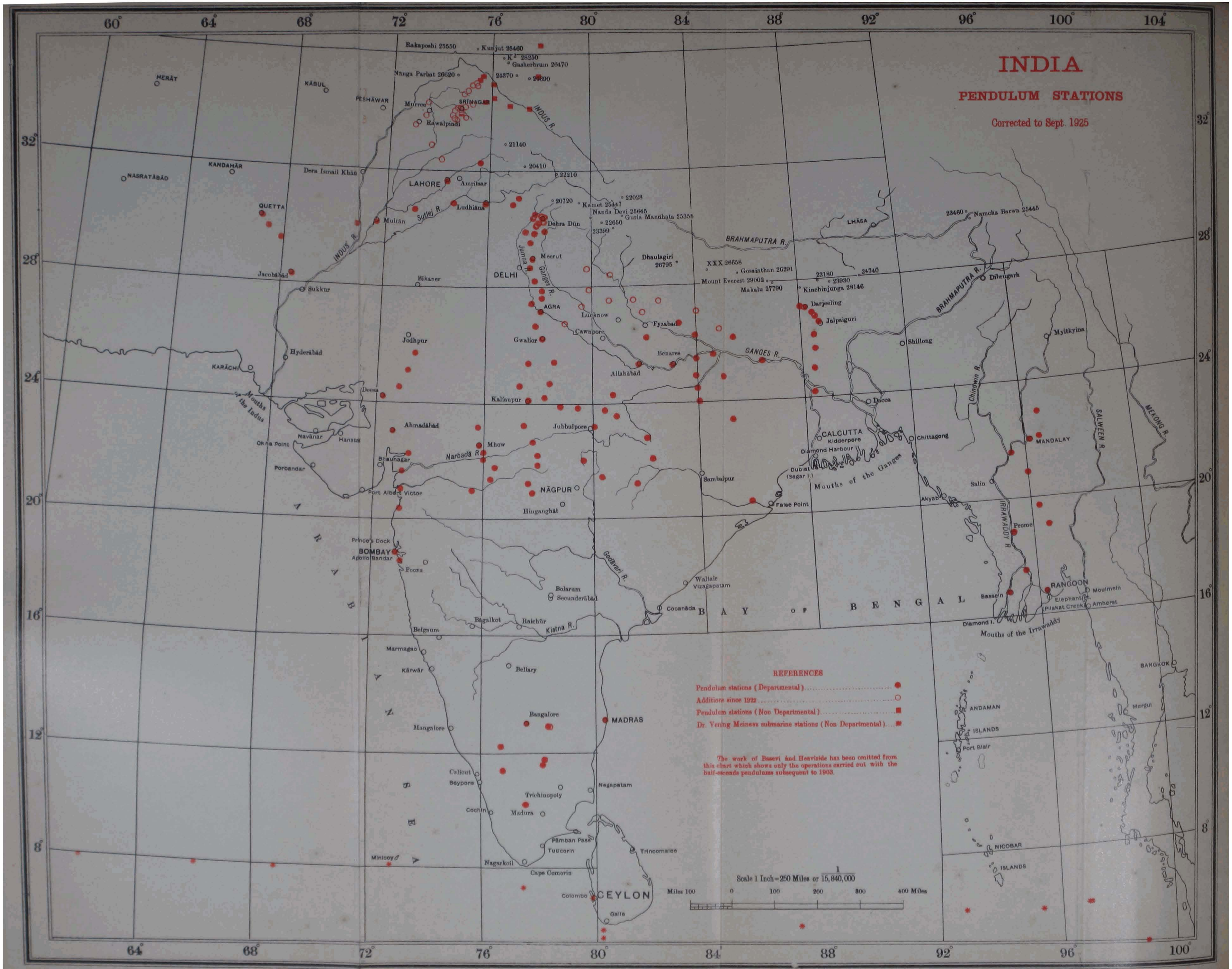
If the average width of the Gangetic plain in this area be taken as 172 miles from the 500-feet contour on the Himalayan side to the 500-feet contour to the north of the southern mountain mass, the average distances at which deflections occur, reduced to this width, are approximately as shown in table at page 166. 117. *Summary.*

117. (*Contd.*)

Deflections	Whence derived	At an average distance from the 500-feet contour on Himalayan side of miles	Remarks
− 13″·67	Rāmnagar ...	12·0	Decrease of negative deflections from − 13″·67 to 0″ fairly uniform at a rate of 1″ deflections per 2·4, 3·3 and 2·5 miles successively
− 11·16	Mean of Mathia and Sikta ...	18·1	
− 8·15	Mean of Sinārīa and Saunbarsa ...	28·1	
− 1·02	Mean of Kopa, Shāhpur, and Rājābari ...	45·7	Increase of positive values at a decreasing rate of 1″ deflections per 3·3 and 6·5 miles successively
+ 5·39	Bisaul ...	66·5	
+ 8·81	Mean of Baniapar and Sirwāra ...	88·9	
+ 8·96	Mean of Kanaun and Rāmāpura ...	123·5	Increase of positive value very slow, only 0″·15 in 34·6 miles

From the above summary of the rate of change of deflections from negative to positive values, and particularly from the evidence of the slow rate of increase of positive values in the case of the last 4 stations, it would appear that the stations, as we proceed southwards, are gradually coming more vertically above the "hidden chain" or subterranean protuberance of excessive density, referred to in Professional Paper No. 5, which is indicated as occurring in the neighbourhood of latitude 22° in this part.

The difference of densities : i.e. deficiencies under the Himalaya and excesses under the plains and southern masses, postulated by the system of uniform isostatic compensation, are inadequate to account for the deflections actually observed. The Himalayan attraction would appear to emanate from a greater depth and material of lesser density, and the attraction of the "hidden chain" would appear to emanate from a lesser depth and denser material than can be accounted for on the Hayford hypothesis.



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HELIO S.I.O. DEHRA DŪN

CHAPTER IV

GRAVITY AND LATITUDE

(No. 14 Party)

BY

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AND

CAPTAIN G. H. OSMASTON M.C., R.E.

Pendulum observations, in abeyance since 1915, were resumed in season 1923-24 when eleven stations extending from Pīlībhīt (U.P.) to Motīhāri (Bihār) were occupied. A list of the stations is given in Table VI. They are all in the Gangetic plain and their immediate surroundings are flat. All these pendulum observations were made by Captain Glennie. **118.** *Pendulum stations 1923-24.*

Thanks to the kindness of the local officials good observing rooms were available at every station. The hourly changes in temperature are shown in Table I. These changes give an indication of the temperature control, but bear no definite relation to the lag in temperature of the pendulum behind the air temperature in the pendulum case. The temperature of the pendulum has been determined throughout by reading a thermometer in a dummy pendulum, so no lag corrections have been necessary. **119.** *Temperature control.*

TABLE I.—Hourly changes in temperature, season 1923-24

Name of station	Night		Day		Mean	
	Average tempera-ture	Hourly change	Average tempera-ture	Hourly change	Average tempera-ture	Hourly change
	°	°	°	°	°	°
Dehra Dūn ...	19·4	+0·08	19·2	+0·11	19·3	+0·10
Etāwah ...	22·9	+0·13	22·8	+0·19	22·8	+0·16
Fatehgarh ...	19·4	+0·09	19·3	+0·14	19·3	+0·12
Pīlībhīt ...	17·6	+0·11	17·3	+0·26	17·4	+0·19
Shāhjahānpur ...	16·8	+0·02	16·0	+0·21	16·4	+0·12
Sītāpur ...	15·6	−0·22	14·4	+0·40	15·0	+0·09
Sonārīpur ...	15·1	+0·15	14·7	+0·33	14·9	+0·24
Bahraich ...	18·8	+0·10	18·4	+0·19	18·6	+0·15
Gondā ...	19·7	+0·11	19·2	+0·18	19·4	+0·15
Gainsari ...	18·9	+0·09	18·5	+0·28	18·7	+0·19
Bagaha Ghāt ...	19·9	+0·16	19·4	+0·35	19·7	+0·26
Motīhāri ...	21·7	+0·23	21·6	+0·31	21·6	+0·27
Dehra Dūn ...	20·1	+0·19	19·8	+0·21	19·9	+0·20

120. *Flexure measurements.* Observations for the flexure of the stand were made at the commencement and close of work at each station, two sets being taken as a rule. The mean values before and after work and the adopted values are shown in Table II.

TABLE II.—Mean and adopted values of flexure, season 1923-24
(The unit is 10^{-7}sec.)

Name of station	Date	Mean observed flexure	Differences	Adopted flexure
	1923			
Dehra Dūn ...	Nov. 9th	52·41	1·36	53
	„ 14th & 15th	53·77		
Etāwah ...	Nov. 26th & 27th	54·11	1·07	54
	Dec. 1st	53·04		
Fatehgarh ...	„ 6th	58·72	1·00	58
	„ 10th	57·72		
Pīlibhit ...	„ 16th	54·22	2·05	55
	„ 20th	56·27		
Shāhjahānpur ...	„ 26th	52·27	2·64	51
	„ 30th	49·63		
	1924			
Sītāpur ...	Jan. 12th	52·54	1·14	52
	„ 16th	51·40		
Sonārīpur ...	„ 22nd	83·87	1·79	85
	„ 26th	85·66		
Bahraich ...	Feb. 2nd	49·95	1·13	49
	„ 5th	48·82		
Gondā ...	„ 7th	49·18	2·04	48
	„ 10th	47·14		
Gainsari ...	„ 11th	53·15	0·07	53
	„ 14th	53·22		
Bagaha Ghāt ...	„ 19th	59·45	0·41	59
	„ 22nd	59·04		
Motīhāri ...	„ 26th	46·23	0·31	46
	„ 29th	46·54		
Dehra Dūn ...	Mar. 5th	45·04	2·86	44
	„ 16th & 17th	42·18		

121. *Clock rate.* The clock rate was determined by Mr. R. B. Mathur. At the commencement of the field season a break-circuit chronometer (No. 6688 by Victor Kölhberg) was employed. From the beginning this showed big fluctuations in rate, and after the 1st day's observations at Shāhjahānpur (the 4th field station) the fluctuations became so big that the results were useless. The old pendulum clock (No. 238 by Strasser and Rohde) was then taken into use for the remainder of the season. This clock had a very steady rate but gave trouble owing to a defective electric circuit through the clock, which was remedied on return to Dehra Dūn. The mean probable error of clock rate, determined from observations on two successive nights, was $\pm 0 \cdot 02$ seconds; and the mean probable error of the rate derived from observations to one star on two successive nights was $\pm 0 \cdot 07$ seconds. The corresponding error in the mean time of vibration is only $\pm 1 \times 10^{-7}$ seconds.

122. *Probable error of an observation.* The probable error of a single observation of the mean pendulum is $\pm 7 \times 10^{-7}$ seconds. The differences between individual and mean pendulums are given in Table III. There appears to have been an abrupt change in the times of vibration of pendulum No. 138 commencing at Sonārīpur and remaining fairly constant thereafter. No reason has been found for this change which is comparable to the change in pendulum No. 137 in December 1906 (*vide* Professional Paper No. 10, p. 160). At Gondā the times of vibration of pendulum No. 137 were inconsistent with the others. This is believed to be due to an exceptional accumulation of errors in clock rate, temperature observations etc. and not to a temporary change in length. This pendulum has been ignored when deducing the results at this station.

TABLE III.—Differences between individual and mean pendulums, season 1923-24. (The unit is 10^{-7} sec.)

Name of station	137	*v*	138	*v*	139	*v*	140	*v*
Dehra Dūn ...	−60	+5	−2478	−16	+909	−2	+1627	−7
Etāwah ...	−63	+2	−2487	−25	+919	−12	+1631	−11
Fatehgarh ...	−73	−8	−2469	−7	+920	−13	+1623	−3
Pīlībhīt ...	−59	+6	−2482	−20	+918	−11	+1624	−4
Shāhjahānpur ...	−70	−5	−2480	−18	+913	−6	+1637	−17
Sītāpur ...	−79	−14	−2436	+26	+904	+3	+1613	+7
Sonārīpur ...	−69	−4	−2462	0	+909	−2	+1623	−3
Bahraich ...	−57	+8	−2450	+12	+894	+13	+1613	+7
Gondā ...	−25	+40	−2465	−3	+889	+18	+1602	+18
Gainsari ...	−74	−9	−2441	+21	+904	+3	+1611	+9
Bagaha Ghāt ...	−71	−6	−2441	+21	+901	+6	+1611	+9
Motihāri ...	−68	−3	−2455	+7	+903	+4	+1620	0
Dehra Dūn	−71	−6	−2456	+6	+907	0	+1620	0
Means ...	−65		−2462		+907		+1620	

123. *Times of vibration at Dehra Dun.*

The times of vibration of the pendulum at Dehra Dūn are given in Table IV. Since there has been a change in pendulum No. 138 from Sītāpur onwards, the value of the mean pendulum at Dehra Dūn must be considered changed also. Pendulums No. 137, 139 and 140 have remained unchanged: the mean of their values at Dehra Dūn at beginning and end of season has therefore been adopted for all stations. For pendulum No. 138 the value obtained at Dehra Dūn in November i.e., 0·5074986 seconds has been adopted for the first four stations and the value at Dehra Dūn obtained in March for the remainder.

TABLE IV.—Times of vibration at Dehra Dūn, season 1923-24

Date	137	138	139	140	Mean
1923	s	s	s	s	s
Nov. 9th & 10th	0·5072557	0·5074995	0·5071587	0·5070866	0·5072501
„ 10th & 11th	2580	4987	1620	0879	2517
„ 11th & 12th	2572	4977	1597	0882	2507
„ 13th & 14th	2564	4984	1590	0895	2508
Means ...	0·5072568	0·5074986	0·5071599	0·5070881	0·5072508
1924					
March 10th & 11th	0·5072561	0·5074941	0·5071592	0·5070876	0·5072493
„ 11th & 12th	2576	4955	1598	0880	2502
„ 14th & 15th	2577	4968	1587	0879	2503
„ 16th & 17th	2574	4963	1600	0890	2507
Means ...	0·5072572	0·5074957	0·5071594	0·5070881	0·5072501
Adopted mean times of vibration					
Nov. & Dec. 1923	0·5072570	0·5074986	0·5071597	0·5070881	0·5072509
Jan. to Mar. 1924	0·5072570	0·5074957	0·5071597	0·5070881	0·5072501

In Table V are shown the mean times of vibration at each field station with the value of g deduced therefrom. 124. *Values of g.*

TABLE V.—Observed values of g, season 1923-24

Name of station	Times of vibration	Difference from Dehra Dūn (unit is 10^{-7} sec.)	Observed value of g
	s		*dynes*
Dehra Dūn ...	*0·5072509	0	979·063
Etāwah ...	0·5072677	+ 168	978·998
Fatehgarh ...	0·5072612	+ 103	979·023
Pīlībhīt ...	0·5072556	+ 47	979·045
Shāhjahānpur ...	0·5072567	+ 59	979·040
Sītāpur ...	0·5072657	+ 156	979·003
Sonārīpur ...	0·5072631	+ 130	979·013
Bahraich ...	0·5072724	+ 223	978·977
Gondā ...	†0·5072773	+ 295	978·949
Gainsari ...	0·5072813	+ 312	978·943
Bagaha Ghāt ...	0·5072865	+ 364	978·923
Motihāri ...	0·5072937	+ 436	978·895
Dehra Dūn ...	0·5072501	0	979·063

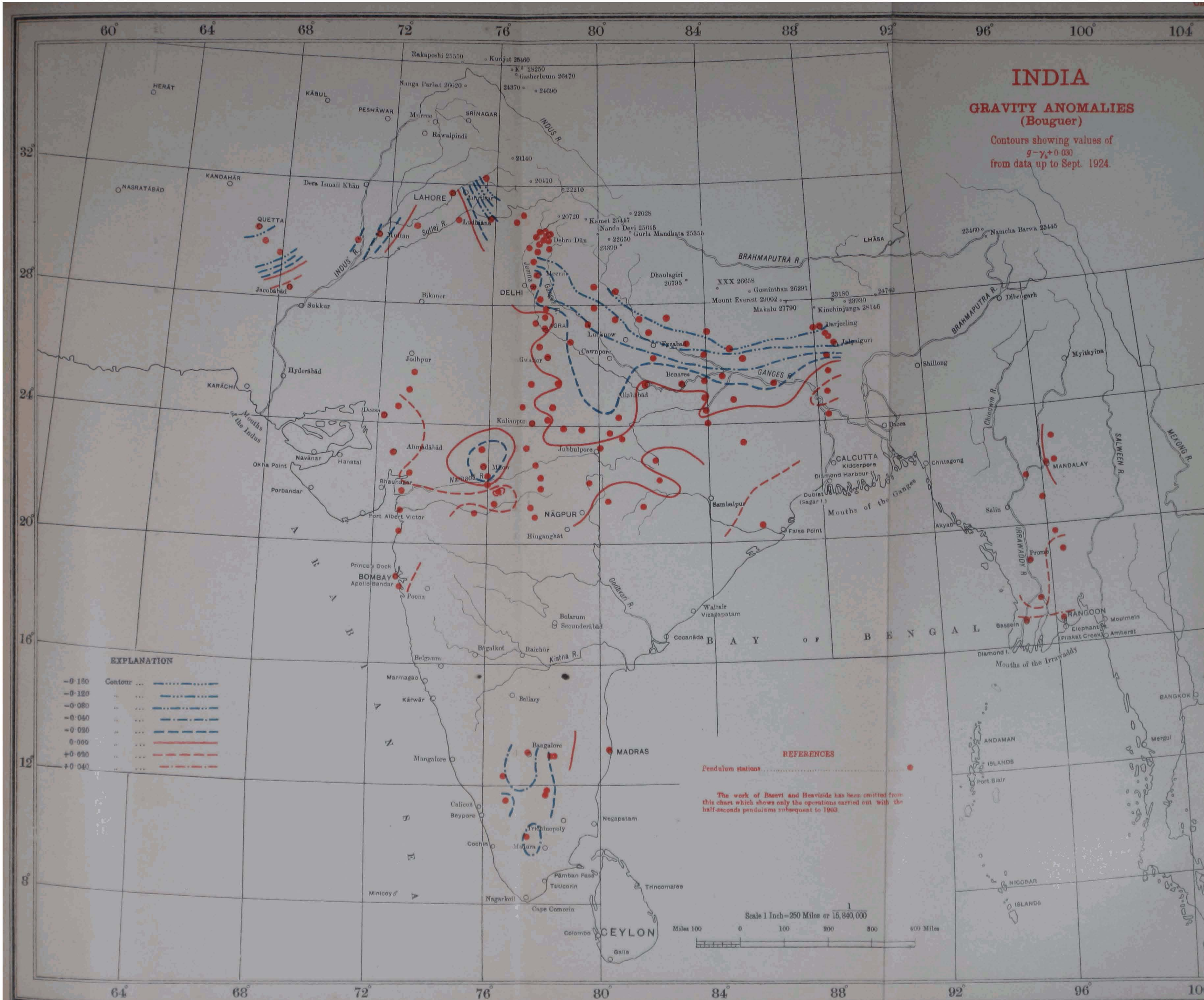
The summary of the results of 1923-24 season's work is given in Table VI. 125. *Summary.*

* The exact value is 0·50725085 seconds.

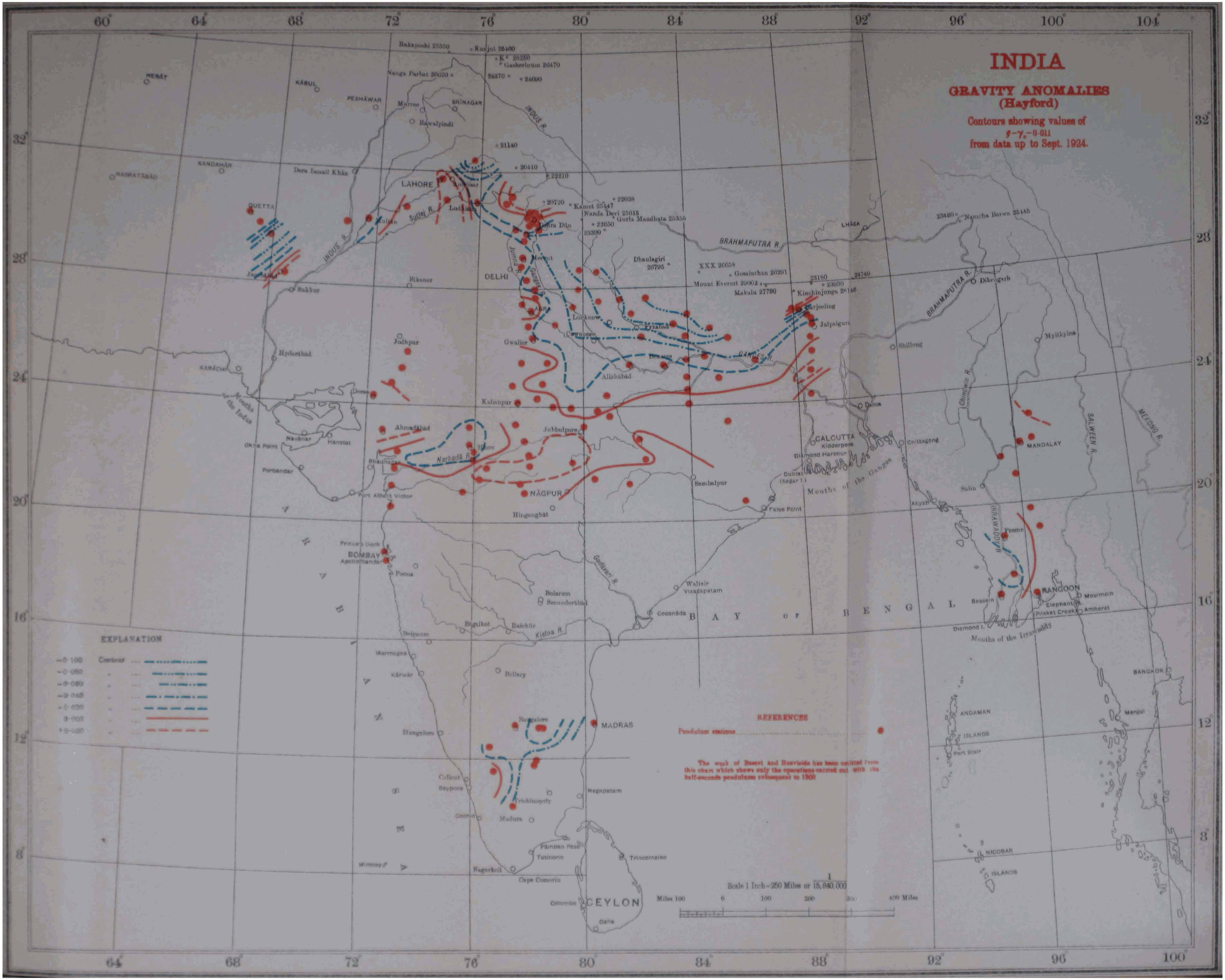
† Mean of pendulums Nos. 138, 139 and 140 only, the value for Dehra Dūn for those three pendulums being 0·5072478 seconds.

TABLE VI.—Abstract of results, season 1923-24

Name of station	Latitude N	Longitude E	Height above M.S.L.	Corrections: For height	Corrections: Bouguer	Corrections: Hayford	γ_o	γ_A (Free air)	γ_B (Bouguer)	γ_C (Hayford)	g	$g-\gamma_A$	$g-\gamma_B$	$g-\gamma_C$
	° ′ ″	° ′ ″	*feet*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*
Etāwah ...	26 47 00	79 00 55	492	−046	+017	−022	979·079	979·033	979·050	979·011	978·998	−0·035	−0·052	−0·013
Fatehgarh ...	27 22 06	79 38 00	493	−046	+017	−023	979·121	979·075	979·092	979·052	979·023	−0·052	−0·069	−0·029
Pīlībhīt ...	28 39 05	79 49 31	610	−057	+021	−059	979·216	979·159	979·180	979·100	979·045	−0·114	−0·135	−0·055
Shāhjahānpur	27 54 21	79 55 52	510	−048	+017	−034	979·161	979·113	979·130	979·079	979·040	−0·073	−0·090	−0·039
Sītāpur ...	27 33 13	80 41 08	449	−042	+015	−036	979·135	979·093	979·108	979·057	979·003	−0·090	−0·105	−0·054
Sonāripur ...	28 27 39	80 44 24	514	−048	+017	−075	979·203	979·155	979·172	979·080	979·013	−0·142	−0·159	−0·067
Bahraich ...	27 34 02	81 35 41	403	−038	+014	−059	979·136	979·098	979·112	979·039	978·977	−0·121	−0·135	−0·062
Gondā ...	27 08 21	81 56 25	352	−033	+012	−038	979·105	979·072	979·084	979·034	978·949	−0·123	−0·135	−0·085
Gainsari ...	27 31 43	82 35 45	364	−034	+012	−065	979·133	979·099	979·111	979·034	978·943	−0·156	−0·168	−0·091
Bagaha Ghāt	27 08 06	84 03 05	298	−028	+010	−065	979·104	979·076	979·086	979·011	978·923	−0·153	−0·163	−0·088
Motihāri ...	26 39 10	84 54 35	220	−021	+007	−054	979·069	979·048	979·055	978·994	978·895	−0·153	−0·160	−0·099



INDIA
GRAVITY ANOMALIES
(Bouguer)
Contours showing values of
g−γ_b+0·030
from data up to Sept. 1924.
EXPLANATION
−0·160 Contour ...
−0·120 " ...
−0·080 " ...
−0·040 " ...
−0·020 " ...
0·000 " ...
+0·020 " ...
+0·040 " ...
REFERENCES
Pendulum stations
The work of Basevi and Heaviside has been omitted from this chart which shows only the operations carried out with the half-seconds pendulums subsequent to 1903.
Scale 1 Inch=250 Miles or 1/15,840,000
Miles 100 0 100 200 300 400 Miles
60° 64° 68° 72° 76° 80° 84° 88° 92° 96° 100° 104°
32° 28° 24° 20° 16° 12° 8°
HERĀT
KĀBUL
PESHĀWAR
SRĪNAGAR
Rawalpindi
KANDAHĀR
NASRATĀBĀD
QUETTA
Dera Ismail Khān
LAHORE
Multān
Ludhiāna
Jacobābād
Sukkur
Hyderābād
KARĀCHI
Bikaner
Jodhpur
DELHI
Dehra Dūn
Meerut
AGRA
Gwalior
Lucknow
Cawnpore
Fyzabad
Benares
Allahabad
Kaliānpur
Jubbulpore
Deesa
Ahmadābād
Navānar
Okha Point
Porbandar
Bhaunagar
Port Albert Victor
NĀGPUR
Hinganghāt
Sambalpur
CALCUTTA
Kidderpore
Diamond Harbour
False Point
Darjeeling
Jalpaiguri
Shillong
Dacca
Chittagong
Akyab
Dibrugarh
Myitkyina
MANDALAY
Prome
RANGOON
Bassein
Moulmein
Amherst
Princes Dock
BOMBAY
Apollo Bandar
Poona
Bolarum
Secunderābād
Waltair
Vizagapatam
Cocanāda
Belgaum
Bāgalkot
Raichūr
Marmagao
Kārwār
Bellary
Bangalore
MADRAS
Mangalore
Calicut
Beypore
Cochin
Trichinopoly
Madura
Negapatam
Minicoy
Nagarkoil
Tuticorin
Cape Comorin
Pāmban Pass
CEYLON
Colombo
Trincomalee
Galle
LHĀSA
BRAHMAPUTRA R.
GANGES R.
INDUS R.
Sutlej R.
Jumna
Godāvari R.
Kistna R.
IRRAWADDY R.
SALWEEN R.
MEKONG R.
Chindwin R.
Narbada R.
Mouths of the Indus
Mouths of the Ganges
Mouths of the Irrawaddy
A R A B I A N S E A
B A Y O F B E N G A L
ANDAMAN ISLANDS
NICOBAR ISLANDS
Port Blair
BANGKOK
Mergui
Rakaposhi 25550
Kunjut 25460
K² 28250
Gasherbrum 26470
Nanga Parbat 26620
Mount Everest 29002
Makalu 27790
Kinchinjunga 28146
Gosainthan 26291
Dhaulagiri 26795
Kamet 25447
Nanda Devi 25645
Gurla Mandhata 25355
Namcha Barwa 25445


INDIA
GRAVITY ANOMALIES
(Hayford)
Contours showing values of
g−γc−0·011
from data up to Sept. 1924.
EXPLANATION
−0·100 Contour
−0·080
−0·060
−0·040
−0·020
0·000
+0·020
REFERENCES
Pendulum stations
The work of Basevi and Heaviside has been omitted from this chart which shows only the operations carried out with the half-seconds pendulums subsequent to 1908
Scale 1 Inch=250 Miles or 1/15,840,000
Miles 100 0 100 200 300 400 Miles
LAHORE
DELHI
CALCUTTA
BOMBAY
MADRAS
NĀGPUR
MANDALAY
RANGOON
CEYLON
QUETTA
KANDAHĀR
KĀBUL
PESHĀWAR
HERĀT
SRĪNAGAR
Rawalpindi
Murree
Dera Ismail Khān
Amritsar
Ludhiāna
Dehra Dūn
Meerut
Bikaner
Sukkur
Jodhpur
Gwalior
Lucknow
Fyzabad
Cawnpore
Allahābād
Benares
Hyderābād
KARĀCHI
Kalianpur
Jubbulpore
Ahmadābād
Mhow
Sambalpur
Hinganghāt
Poona
Bolarum
Secunderābād
Cocanāda
Belgaum
Bellary
Bangalore
Mangalore
Calicut
Trichinopoly
Madura
Negapatam
Cochin
Nagarkoil
Cape Comorin
Tuticorin
Pāmban Pass
Colombo
Galle
Trincomalee
Darjeeling
Jalpaiguri
Shillong
Dacca
Chittagong
Dibrugarh
Myitkyina
Prome
Bassein
Moulmein
Amherst
Elephant Pt.
Diamond Harbour
Diamond I.
False Point
Port Albert Victor
Porbandar
Okha Point
Navānar
Hanstal
Bhaunagar
Prince's Dock
Apollo Bandar
Kārwār
Marmagao
Bāgalkot
Raichūr
Walṭair
Vizagapatam
Akyab
Salin
LHASA
Dhaulagiri 26795
Mount Everest 29002
Makalu 27790
Kinchinjunga 28146
Gosainthan 26291
Nanda Devi 25645
Kamet 25447
Gurla Mandhata 25355
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INDUS R.
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GANGES R.
Jumna R.
BRAHMAPUTRA R.
Narbadā R.
Godāvari R.
Kistna R.
Chindwin R.
IRRAWADDY R.
SALWEEN R.
MEKONG R.
Mouths of the Indus
Mouths of the Ganges
Mouths of the Irrawaddy
BAY OF BENGAL
ARABIAN SEA
ANDAMAN ISLANDS
Port Blair
NICOBAR ISLANDS
BANGKOK
Mergui
Minicoy I.
60° 64° 68° 72° 76° 80° 84° 88° 92° 96° 100° 104°
32° 28° 24° 20° 16° 12° 8°

The results clear up various doubtful features referred to in Professional Paper No. 15, page 137. It is now evident that there are no belts of high density running eastward from Agra or Jhānsi to Allahābād and the large low density area south east of Jhānsi is connected directly to the main trough at the foot of the Himalayas with no ridge of higher density intervening. This causes a smoothing out of the main irregularities in the contours and makes the apparent trough of low density between Gesupur and Hathras quite an insignificant feature. The revised contours are shown in Charts VIII and IX. 125. *(Contd.)*

During recess an attempt was made to determine the constants of two quartz pendulums by observations in Dehra Dūn and Mussoorie. Most unfortunately just at the completion of the work both pendulums were broken while being carried down to Dehra Dūn. The work was not entirely wasted, as it led to a reconsideration of all the various conditions of observation (more particularly the temperature effects) and as a result it may be possible in future to get good results with brass pendulums in a tent, which had previously been considered impossible. 126. *Quartz Pendulums.*

The four brass von Sterneck pendulums Nos. 137, 138, 139 and 140 obtained in 1902 were taken to England in April 1924 to redetermine their times of vibration at Kew. The results of these observations are given below :— 127. *Observations in England.*

Times of vibrations at Kew

Pendulum No.	137	138	139	140
June & October 1903	s 0·5067066	s 0·5069486	s 0·5066100	s 0·5065335
June 1925	0·5067023	0·5069411	0·5066040	0·5065329

The times were obtained by wireless time signals from the Eiffel Tower. The pendulums were also swung at Cambridge, which is to be the base station for the new gravity survey of England. Details of the original observations are to be found in Professional Paper No. 10, Chap. I. The 1925 observations were made by Lt.-Colonel H. McC. Cowie, R.E.

It had been intended to make observations in Assam during the winter season 1924-25 and in Kashmīr during the summer of 1925. As however, the pendulums had not arrived back from England by October 1924, the Assam programme was abandoned and the design and manufacture of new pendulums was put in hand. 128. *Design and manufacture of new pendulums.*

The three pendulums were of brass cast with the stem and bob in one piece. Through the kindness of Colonel W. Bell, Electrical En-

128. (*Contd.*) gineer to the Mussoorie Municipality, the casting and rough turning was done in the Mussoorie Electrical Workshops; the wooden templates for the pendulums and the fine turning and fitting were done in the Geodetic Branch Workshops; the gun metal knife-heads were made by the Mathematical Instrument Office, Calcutta, the knives were agate in the case of No. 1 pendulum and stainless steel for Nos. 2 and 3 pendulums. Unfortunately hard stainless steel was not available at that time in Calcutta, and changes occurred in the times of vibration of Nos. 2 and 3 pendulums during the field season as a result of the blunting of the knife-edges.

The pendulums were not annealed and changes occurred which were probably due to the adjustment of strains set up in the casting.

The pendulums were lacquered.

129. *Modifications in design.* The design of the pendulums followed generally that of the old von Sterneck pendulums, the chief modifications being:—

(*i*) The stem projected about an inch above the knife-head. This obviated all handling of the knife-head itself when putting the pendulums in position for observation.

(*ii*) The stem was thicker, as it showed a tendency to whip on the lathe.

(*iii*) The knife-head fitted on a squared portion of the stem with the upper part pressing against a flange on the stem and was clamped in this position by means of a setscrew.

A new dummy pendulum for the thermometer and a new driving pendulum for the flexure observations were also made in the Geodetic Branch Workshops.

130. *Constants of the new pendulums.* Observations were made at Dehra Dūn in a cold room and in a specially heated room and also at Evelyn Hall, Mussoorie, so as to obtain a low air density, there being no suitable vacuum apparatus available.

The ranges of temperatures and densities so obtained were:—

Temperature from 10°·20 C to 25°·44 C
Density from 0·737 to 0·885

As the density was not constant at Dehra Dūn, results were expressed in the form—

$$S_0 + KT + K^1 D = S$$

and values for S_0, K, and K^1 obtained by the method of least squares

The results of the pendulums compared :— 130. *(Contd.)*

Pendulum No.	Reduced times of vibration $= s_0$	Temperature factor $= k$ (unit is 10^{-7} sec.)	Density factor $= k^1$ (unit is 10^{-7} sec.)
	s		
No. 1	0·5070460	46	667
„ 2	0·5075733	50	638
„ 3	0·5060075	47	576
No. 137	0·5072594	49	594
„ 138	0·5075016	49	572
„ 139	0·5071620	49	606
„ 140	0·5070864	49	606

As observations in Kashmīr would have to be carried out in a tent, temperature conditions were likely to be bad; investigations made during the recess of 1924 showed that results would still be satisfactory if the temperatures were obtained from a thermometer placed in a suitably designed dummy pendulum. No such dummy pendulum had been used for the tent observations in 1904-05, which were considered unsatisfactory. 131. *Effect of temperature conditions in Kashmir observations.*

However in order to reduce temperature changes as much as possible the old routine of observing four pendulums each day was abandoned. One pendulum only was observed each day so that the pendulum case could remain closed.

A lengthy comparison of the pendulum clock (Strasser and Rohde No. 238) with the newly installed Riefler clock showed that the former had a regular change of rate. This being so, the old system of observing twice in 24 hours with the 1st observation shortly after the evening star observations was not satisfactory. Three observations in the 24 hours were adopted, the middle observation being just 12 hours after the star observations, the other two equally before and after the middle one, (in practice shortly before and after the evening star observations).

In order not to depend entirely on one timepiece, the pendulum clock, (S & R 238) and the box chronometer (Victor Köhlberg No. 6688) were used. The method was as follows :—

	1st series of coincidences	with S & R 238, then immediately	
	1st „ „ „	with No. 6688	
then	2nd „ „ „	with S & R 238 and	
	2nd „ „ „	„ No. 6688	

131. (*Contd.*) allowing as usual an interval of 60 coincidences between the 1st and 2nd series of each clock.

The two results are equally affected by temperature, density and flexure errors, so if they differ it is solely the result of irregular fluctuations in clock rate: this method therefore is an excellent check on the behaviour of the clocks.

132. *A sub base and circuits.* As the pendulums were new it was anticipated that they might change; so after observations had been made at the first five stations the pendulums were reswung at Dehra Dūn; and in Kashmīr a sub base was established at Gandarbal, the work being divided into two other circuits beginning and ending at the sub base.

133. *Transport and Health.* The programme for the season 1924-25 commenced with two stations in the plains of the Punjab followed by a line of stations running from Rāwalpindi northwards into the Himalayas as far as the Deosai Plains; in addition a number of stations were occupied in the valley of Kashmīr itself.

The party consisting of two officers, two computers and twenty men left Dehra Dūn early in March 1925. All went well with the new apparatus and Captain Glennie returned to Dehra Dūn after completing the first five stations and reswung the pendulums to check any change.

From this time Lieut. Osmaston replaced Mr. Mathur in the party as the latter was required for observatory work at Dehra Dūn.

The party had the misfortune to resume work at Bāramūla just at the time when the cholera epidemic which afterwards spread all over Kashmīr, broke out there. A *tindal* died at Bāramūla and observations were abandoned, the party moving at once to Shādipur at the junction of the Sind and Jhelum rivers. One *khalasi* died of cholera at Shādipur; the contacts were then isolated for 14 days on a small island in the Sind river below Gandarbal. The whole personnel of the party were inoculated by Captain and Mrs. Glennie, as no medical aid was available nearer than Srīnagar, where the doctors were fully occupied.

The headquarters camp was established at Gandarbal, and remained there for the rest of the season; only the eight fittest *khalasis* being taken for the hill work. The transport was engaged locally and consisted of about forty ponies and ten coolies.

No further cases of cholera developed, and the party proceeded up the Sind valley; unfortunately the *Daffadar* died of heart disease on the way; otherwise, from this time forward the health of the party remained good.

134. *Journey to the Deosai.* Having completed observations at 2 stations in the Sind valley, at the beginning of June the party struck north, *via* the Satsaran Sar Gali and Mashid Gali passes, both snow covered, thence across the Kishenganga at Badogām joining the main route to Gilgit a few miles north of Gurais. No serious difficulties were experienced on the way as the weather was fine, and there was deep hard snow on the passes

The Gilgit road was followed as far as Burzil *chowki*, and the Skardu route, which branches to the right over the Sarsangi and San Sangri passes on to the Deosai Plains. Considerable difficulty was encountered between Burzil and the Deosai; the passes were not open and the weather was unsettled with clouds at night; thus in spite of marching before daybreak the ponies constantly fell through the soft snow, and progress was extremely slow and laborious; 12 miles being covered in three days. 134. *(Contd.)*

135. *The Deosai.*

During three weeks on the Deosai, observations were taken at three stations at an average height of 13,000 feet. At first the weather was cold and windy with a minimum temperature of 27° F., but later the weather conditions improved and it was fine and warm during the day.

The two views of the Deosai show the type of the country to some extent; consisting of round-topped, low, rolling hills with flat luxuriant moorland between, traversed by many streams and covered with innumerable small lakes and pools. The numerous streams combine to flow out at the south east corner of the Deosai which is otherwise a complete basin, 20 miles across, surrounded by a wall of mountains whose steep and rugged outline is in marked contrast to the gentle slopes of the plain.

No supplies of food could be obtained locally, although large flocks of sheep and goats are brought up later for the excellent grazing.

136. *Return to Gandarbal and Dehra Dun.*

Having completed the work in this region the party returned to Gandarbal by the Gilgit road; while passing Minmarg, a small village of some 20 dilapidated log huts, it was noticed that the cairn erected to mark the latitude station on the way up, had disappeared; on inquiry the station proved to be in the middle of the local polo ground and it was agreed that the mark stone should remain at ground level, with no cairn over it.

Pendulums were reswung at Gandarbal, and three other stations were occupied in the valley of Kashmīr and three at varying altitudes in the Pir Panjal range to the south. During this period clouds and rain interfered with the star observations; fortunately the Astrolabe programme, necessary for determining the time, was very short, otherwise pendulum work would have been almost impossible.

The whole programme was successfully completed early in September and the party proceeded back to recess headquarters in Dehra Dūn.

137. *Circuits.*

A sub base and circuits

Circuit I	Circuit II (Sind & Burzil Valleys and Deosai Plains)	Circuit III (Kashmīr Valley & Pir Panjal)
Dehra Dūn (1) ...	Gandarbal (1) ...	Gandarbal (2)
Wazīrābād ...	Hayan ...	Lālpur
Jhelum ...	Sonāmarg ...	Srīnagar
Rāwalpindi ...	Churawan ..	Pingalan
Domel ...	Minmarg ...	Yūs Maidan
Dehra Dūn (2) ...	Deosai I ...	Korag
	„ II ...	Tosh Maidan
	„ III ...	Gandarbal (3)
	Gandarbal (2) ...	Dehra Dūn (3)

138. *Flexure corrections 1924-25.* In addition, observations at Shādipur in the Kashmīr Valley made between Circuits I and II are grouped with Circuit II in Table VII.

TABLE VII.—Flexure corrections, season 1924-25

Circuit I	unit is 10^{-7}sec.	Circuit II	unit is 10^{-7} sec.	Circuit III	unit is 10^{-7} sec.
Dehra Dūn (1) (*a*)	− 98	Shādipur (*b*)	−116	Gandarbal (2) (*c*)	[illegible]
Wazīrābād (*a*)	−135	Gandarbal (1) (*b*)	−117	Lālpur (*b*)	[illegible]
Jhelum (*a*)	−100	Hayan (*b*)	−164	Srīnagar (*a*)	[illegible]
Rāwalpindi (*a*)	− 89	Sonāmarg (*b*)	−229	Pingalan (*b*)	[illegible]
Domel (*a*)	−103	Churawan (*b*)	−101	Yūs Maidan (*b*)	[illegible]
Dehra Dūn (2) (*a*)	− 60	Minmarg (*b*)	−193	Korag (*d*	[illegible]
		Deosai I (*d*)	− 62	Tosh Maidan (*b*)	[illegible]
		„ II (*d*)	− 62	Gandarbal (3) (*c*)	[illegible]
		„ III (*d*)	− 58	Dehra Dūn (3) (*a*)	[illegible]

In the above table (*a*), (*b*), (*c*) and (*d*) denote the various methods of setting up the iron pendulum stand.

(*a*) Iron pendulum stand set up on a concrete floor with plaster of Paris.

(*b*) A pit 5 inches deep made in the ground, three stout wooden pegs about 15 inches long driven in with their tops flush with the bottom of this pit and the iron pendulum stand set up on these with plaster of Paris.

(*c*) Stand set up on a large millstone embedded in the ground. **138.** *(Contd.)*

(*d*) Stand set up on a large stone boulder *in situ.*

Method (*b*) appears to be the best way of setting up the stand on earth without large stones.

At Pingalan the ground though apparently firm, was found to be continually vibrating, possibly owing to pulsations in an underground water channel. There was a strong spring about 100 yards away.

139. *Observations in tents.*

The pendulums were swung in rooms at Dehra Dūn, Wazīrābād, Jhelum, Rāwalpindi and Murree. At Domel pendulums were swung in a verandah screened off by *kanats*; at all the other Kashmīr stations pendulums were swung in the pendulum tent. This double fly tent was 14 ft. by 11 ft. and is known as the "1905 pattern light mess tent" made by the Elgin Mills. It is exceptionally convenient, very light and portable and can, if required, be converted into two separate tents. The chronograph was set up at one end of the pendulum tent.

Temperatures experienced ranged from a minimum of 5°·83 C at Deosai I to a maximum of 32°·20 C at Gandarbal (2). The average rate of change of temperature in the tent was :—

Night observations	—0°·61 C	per hour
Morning „	+1 ·39 C	„
Evening „	+0 ·09 C	„

140. *Heights of stations.*

Heights in Circuit I were obtained by levelling, in Circuits II and III by theodolite observations to triangulated points. The heights of the stations are given in Table XII at page 191.

141. *Clock rates by transit and astrolabe*

The clock rates for Circuit I were obtained by observations with the bent transit instrument as in the previous season by Mr. R. B. Mathur B. A., and for Circuits II and III by observations with the geodetic model prismatic astrolabe by Captain E. A. Glennie and Lieut. G. H. Osmaston at alternate stations.

The average probable errors were :—

Instruments	Single observation	Mean observation
	s	s
Bent transit instrument	±0·022	±0·007
Astrolabe	±0·023	±0·012

For the transit instrument a portable iron stand, designed by Dr. de Graaff Hunter was used, and proved a great convenience and steadier than a hurriedly made pillar.

As already stated by using two clocks an indication of their relative steadiness can be obtained from an examination of the pendulum results; since the differences of times of vibration obtained for a given pendulum from the two clocks is altogether unaffected by temperature and flexure errors. Table VIII shows the difference of the times of vibration

141. *(Contd.)* obtained with chronometer 6688 from the mean of the times obtained from both clocks. The daily change of rate of each clock is also shown. Table VIII shows plainly the effect on the clocks due to the adverse temperature conditions in a tent. At the first four stations in the table, observations were made in rooms with good temperature control, the agreement $(S_1 - S_m)$ between clocks is plainly much better than at the rest of the stations. Clock S & R 238 failed altogether at Churawan, it was overhauled at Minmarg and new springs put in. The effect of the new springs is shown by the greatly increased changes of rate at Minmarg and Deosai I; after which the springs appear to have settled down to their work. In spite of the excessive change of rate at Minmarg the value $(S_1 - S_m)$ is no bigger than at other stations showing that the method of observing three times in the 24 hours is quite satisfactory. The mean daily change of rate of the box chronometer 6688 is $0^{s}\cdot 45$ and of the pendulum clock S & R 238 (after excluding the bad changes at Minmarg and Deosai I) is $0^{s}\cdot 70$. The box chronometer besides being better in performance is very much more portable and convenient in every way. Its weight in a special travelling box is 40 lbs. and that of the pendulum clock and stand is 210 lbs.

TABLE VIII.—Difference of the individual times of vibration from mean and diurnal change of clock rate, season 1924-25

Name of station	Pendulum	$(S_1 - S_m)^{*} \times 10^{-7}$	Daily changes of rate	
			6688	S&R 238
Wazīrābād ...	3	− 12	...	...
	2	0	− 0·71	+ 1·37
	1	− 3	+ 0·18	+ 1·65
Jhelum ...	3	0	..	...
	2	+ 3	− 0·03	+ 0·17
	1	− 3	0 00	0·00
Rāwalpindi ...	1	− 4	...	...
	2	− 3	+ 0·33	+ 0·38
	3	+ 3	− 0·37	+ 0·36
Murree ...	1	+ 1	...	...
	2	+ 3	+ 0·28	− 0·11
	3	+ 1	− 0·52	− 0·23
Domel † ...	1	+ 7	...	...
	2	0	− 0·14	+ 0·42
	3	+ 8	− 0·22	+ 0·11
Shādipur ...	3	...	...	...
	2	− 10	+ 0·32	+ 0·58
	1	+ 4	− 0·13	+ 0·67

* The difference has been obtained from a comparison of the times of vibration of individnal pendnlum as obtained from chronometer No. 6688 with the mean as obtained from both clocks.

† At Domel No. 2 Pendulum appeared to suddenly change length in the middle of an observation.

TABLE VIII.—(Contd.)

Name of station	Pendulum	$(S_1 - S_m) \times 10^{-7}$	Daily changes of rate	
			6688	S&R 238
Gandarbal (1) ...	3	− 7	...	...
	2	+ 10	+ 0·05	...
	1	+ 5	− 0·69	...
Hayan ...	1	− 1	...	...
	2	− 3	+ 0·78	+ 1·04
	3	− 20	− 0·09	− 0·48
Sonāmarg ...	1	0	...	...
	2	− 10	− 0·43	+ 0·25
	3	− 22	− 0·30	+ 0·26
Churawan ...	2	...	...	...
	3	...	+ 0·07	...
	1	...	− 0·44	...
Minmarg* ...	1	− 10	...	
	2	+ 6	+ 0·74	− 9·89†
	3	+ 4	+ 1·69	− 6·09†
Deosai I ...	1	− 5	...	
	2	− 3	− 0·04	− 1·16†
	3	− 12	+ 0·37	− 3·43†
Deosai II ...	1	− 2	...	...
	2	− 22	+ 0·82	− 1·10
	3	− 15	+ 0·21	− 0·37
Gandarbal (2) ...	1	+ 17	...	...
	2	+ 6	− 0·11	0·00
	3	− 5	...	...
Lālpur ...	1	0	...	...
	2	+ 9	+ 1·02	+ 1·27
	3	− 10	...	+ 1·62
Srinagar ...	1	+ 5	...	...
	2	+ 14	− 0·87	+ 0·14
	3	+ 14	− 0·07	− 0·07
Pingalan ...	1	+ 28	...	...
	2	+ 4	− 0·39	− 1·75
	3	− 7	+ 0·20	− 0·06
Yūs Maidan ...	1	− 3	...	...
	2	+ 31	− 0·01	+ 0·14
	3	− 26	− 0·86	− 1·64
Korag ...	1	− 8	...	...
	2	− 1	− 0·57	− 0·43
	3	− 7	− 0·22	− 0·45

* New springs put in at Minmarg.
† These values are omitted from mean.

TABLE VIII.—(Contd.)

Name of station	Pendulum	$(S_1-S_m)\times 10^{-7}$	Daily changes of rate	
			6688	S&R 236
Tosh Maidan ...	1	−29	...	...
	2	+14	+1·90	+2·43
	3	0	−0·90	...
Gandarbal (3) ...	1	−26	...	...
	2	+19	+0·44	+1·76
	3	−5	0·00	−0·61
Mean* ..		9	0·45	0·70

142. *Variation from mean & Dehra Dun values of Individual Pendulums.*

The method of observing only one pendulum each day has the effect that the result obtained for each pendulum contains different clock rate, temperature and flexure errors etc. so that the differences of individual pendulums from the mean or from the Dehra Dūn value of the pendulums will vary more than was the case before, when all pendulums were observed each day. Table IX shows the differences of individual pendulums from the mean pendulum, and the differences from the first Dehra Dūn value of each pendulum from the various stations. A line indicates where a change in the pendulum has occurred between two stations. The following deductions regarding the pendulums have been made from consideration of table IX at page 184.

No. 1 Pendulum—Circuit I. A change of $-28^s\times 10^{-7}$ occurred between Jhelum and Rāwalpindi. No changes occurred in Circuits II and III. There has been no noticeable deterioration of the knife-edge, which is made of agate. The change in Circuit I was probably due to adjustment of strains set up in casting.

No. 2 Pendulum—Circuit I. A change of $-116^s\times 10^{-7}$ occurred between Jhelum and Rāwalpindi. At Domel No. 2 Pendulum appeared to be changing during the observation; possibly any tendency to change was increased by the move from Murree which was under snow to Domel where it was very hot. The value obtained at Dehra Dūn in March 1925 shows a change of $-214^s\times 10^{-7}$ after Murree. Circuits II and III.—Since No. 1 Pendulum remained unchanged in Kashmir it can be used as a means of standardising the other two pendulums. Gandarbal is the sub base, the three values for No. 1 Pendulum at Gandarbal show a mean difference from Dehra Dūn of $-43^s\times 10^{-7}$. Hence No. 2 Pendulum is assumed to have changed by $+130^s\times 10^{-7}$ for the stations Gandarbal (2), Lālpur, Srīnagar, Pingalan and to have remained unchanged for the other stations. A further change occurred between Gandarbal (3) and Dehra Dūn. The knife-edge has deteriorated, as is evidenced by the more rapid waning of the amplitude. It is of soft stainless steel.

* Without regard to signs.

No. 3 Pendulum—Circuit I. A change of $-109^{s} \times 10^{-7}$ occurred between Jhelum and Rāwalpindi. Circuits II and III—There was a change of $-125^{s} \times 10^{-7}$ for the stations Sonāmarg, Churawan, Minmarg, Deosai I, and Deosai II, otherwise no change in Kashmīr. A further change occurred between Gandarbal (3) and Dehra Dūn. The knife-edge has deteriorated; it is of soft stainless steel. 142. (Contd.)

TABLE IX.—Differences from mean and Dehra Dūn values, season 1924-25. (The unit is 10^{-7}sec.)

Name of station	Differences from the mean						Differences from Dehra Dūn		
	No. 1	*v*	No. 2	*v*	No. 3	*v*	No. 1	No. 2	No. 3
Dehra Dūn (1) ...	−1629	−130	+3644	+098	−2014	+033	.	.	...
Wazīrābād .	−1610	−111	+3642	+096	−2033	+014	− 838	− 859	−87[illegible]
Jhelum ..	−1595	−096	+3629	+083	−2034	+013	− 828	− 877	−8[illegible]
Rāwalpindi ..	−1568	−069	+3595	+049	−2026	+021	− 755	− 865	−82[illegible]
Murree ...	−1574	−075	+3596	+050	−2021	+026	+ 071	− 032	+0[illegible]
Domel ...	...		...		...		− 634	...	−71[illegible]
Dehra Dūn (2) ...	−1501	−002	+3470	−076	−1967	+080	− 028	− 330	−10[illegible]
Shādipur ...	−1511	−012	+3532	−014	−2020	+027	− 030	+ 042	−07[illegible]
Gandarbal (1) ..	−1488	+011	+3491	−055	−2004	+043	− 069	− 061	−119
Hayan ...	−1452	+047	+3486	−060	−2033	+014	+ 205	+ 172	+09[illegible]
Sonāmarg ...	−1448	+051	+3547	+001	−2099	−052	+ 635	+ 659	+45[illegible]
Churawan ...	−1441	+058	+3511	−035	−2069	−022	+ 458	+ 439	+2[illegible]
Minmarg ...	−1440	+059	+3550	+004	−2111	−064	+ 662	+ 681	+45[illegible]
Deosai I ...	...	...	...		...		+1144	...	+9[illegible]
Deosai II ...	−1421	+078	+3550	+004	−2128	−081	+1135	+1135	+89[illegible]
Deosai III ...	−1476	+023	+3503	−043	−2026	+021	+1001	+1009	+91[illegible]
Gandarbal (2) ...	−1533	−034	+3597	+051	−2064	−017	− 072	+ 087	−13[illegible]
Lālpur ...	−1452	+047	+3545	−001	−2093	−046	+ 016	+ 042	−15[illegible]
Srīnagar ...	−1504	−005	+3579	+033	−2075	−028	− 076	+ 036	−18[illegible]
Pingalan ...	−1561	−062	+3627	+081	−2065	−018	− 077	+ 140	−11[illegible]
Yūs Maidan ...	−1482	+017	+3501	−045	−2018	+029	+ 361	+ 373	+29[illegible]
Korag ...	−1480	+019	+3530	−016	−2049	−002	+ 792	+ 831	+68[illegible]
Tosh Maidan ...	−1430	+069	+3472	−074	−2042	+005	+ 699	+ 630	+5[illegible]
Gandarbal (3) ...	−1445	+054	+3497	−049	−2052	−005	− 009	− 038	−1[illegible]
Dehra Dūn (3) ...	−1435	+064	+3464	−082	−2029	+018	− 015	− 087	−1[illegible]
Mean ...	−1499		+3546		−2047				

The Dehra Dūn value (s_0) of the pendulums from the above deductions for the various stations are tabulated below :— 143. *Value (s_0) of the pendulums at different stations.*

Value (s_0) of the pendulums at different stations

Pendulums	Stations	Value of (s_0)
		s
No. 1 Pendulum ...	Wazīrābād & Jhelum ...	0·5070460
	Rāwalpindi, Murree and Domel ...	0·5070433
	All the other stations in Circuits II and III ...	0·5070425
No. 2 Pendulum ...	Wazīrābād & Jhelum ...	0·5075733
	Rāwalpindi, Murree and Domel ...	0·5075617
	Gandarbal (2) Lālpur, Srīnagar & Pingalan ...	0·5075533
	All the other stations in Circuits II and III ...	0·5075403
No. 3 Pendulum ...	Wazīrābād & Jhelum ...	0·5070075
	Rāwalpindi, Murree and Domel ...	0·5069966
	Sonāmarg, Churawan, Minmarg, Deosai I, Deosai II	0·5069749
	All the other stations in Circuits II and III ...	0·5069874

The differences from the mean pendulum are retabulated in Table X with the adjusted Dehra Dūn values. The times of vibration and deduced values of g are given in Table XI. An abstract of the results is given in Table XII. Owing to the unsatisfactory behaviour of the two pendulums with stainless steel knife-edges, the values of g and the corresponding anomalies should be taken as correct to 0·01 dynes only. A determination of the value of gravity at Srīnagar was made by De Filippi Expedition in 1914 with eight pendulums. The results are compared below :— 144. *Values of g in 1914 & 1925 compared.*

		dynes
De Filippi Expedition in 1914	$g =$	979·090
Survey of India in 1925	$g =$	979·095

TABLE X.—Differences from the mean and individual pendulums, season 1924-25. (The unit is 10^{-7}sec.)

Name of station	Differences from the mean					
	No. 1	v	No. 2	v	No. 3	v
Dehra Dūn (1) ...	− 1629	− 18	+ 3644	+ 06	− 2014	+ 13
Wazīrābād ...	− 1610	+ 01	+ 3642	+ 04	− 2033	− 06
Jhelum ...	− 1595	+ 16	+ 3629	− 09	− 2034	− 07
Mean ...	− 1611		+ 3638		− 2027	
Dehra Dūn (adjusted)	− 1573	− 01	+ 3612	+ 11	− 2039	− 10
Rāwalpindi ...	− 1568	+ 04	+ 3595	− 06	− 2026	+ 03
Murree ...	− 1574	− 02	+ 3596	− 05	− 2021	+ 08
Domel ...	..		..		...	
Mean ...	− 1572		+ 3601		− 2029	
Dehra Dūn (2) ...	− 1501		+ 3470		− 1967	
Dehra Dūn (adjusted) ...	− 1476	− 05	+ 3502	00	− 2027	+ 03
Shādipur ..	− 1511	− 40	+ 3532	+ 30	− 2020	+ 10
Gandarbal (1) ...	− 1488	− 17	+ 3491	− 11	− 2004	+ 26
Hayan ...	− 1452	+ 19	+ 3486	− 16	− 2033	− 03
Deosai III ..	− 1476	− 05	+ 3503	+ 01	− 2026	+ 04
Yūs Maidan ...	− 1482	− 11	+ 3501	− 01	− 2018	+ 12
Korag ...	− 1480	− 09	+ 3530	+ 28	− 2049	− 19
Tosh Maidan ...	− 1430	+ 41	+ 3472	− 30	− 2042	− 12
Gandarbal (3) ...	− 1445	+ 26	+ 3497	− 05	− 2052	− 22
Mean ...	− 1471		+ 3502		− 2030	
Dehra Dūn (adjusted) ..	− 1434	+ 03	+ 3544	+ 04	− 2110	− 07
Sonāmarg ...	− 1448	− 11	+ 3547	+ 07	− 2099	+ 04
Churawan ...	− 1441	− 04	+ 3511	− 29	− 2069	+ 34
Minmarg ...	− 1440	− 03	+ 3550	+ 10	− 2111	− 08
Deosai I ...	...	...	.	...	...	...
Deosai II ...	− 1421	+ 16	+ 3550	+ 10	− 2128	− 25
Mean ...	− 1437		+ 3540		− 2103	
Dehra Dūn (adjusted) ...	− 1519	− 05	+ 3589	+ 02	− 2070	+ 03
Gandarbal (2) ...	− 1533	− 19	+ 3597	+ 10	− 2064	+ 09
Lālpur ...	− 1452	+ 62	+ 3545	− 42	− 2093	− 20
Srīnagar .	− 1504	+ 10	+ 3579	− 08	− 2075	− 02
Pingalan ...	− 1561	− 47	+ 3627	+ 40	− 2065	+ 08
Mean ...	− 1514	...	+ 3587		− 2073	...
Dehra Dūn (3) ...	− 1435	...	+ 3464		− 2029	.

TABLE XI.—Mean times of vibration and deduced values of g, season 1924-25

Name of station		1	2	3	Means
Wazīrābād	s	0·5069622	0·5074874	0·5069199	0·5071232
	$s-s_0$	−838	−859	−876	−857
	g	979·387	979·394	979·401	979·394
Jhelum	s	0·5069632	0·5074856	0·5069193	0·5071227
	$s-s_0$	−828	−877	−882	−862
	g	979·383	979·401	979·404	979·396
Rāwalpindi	s	0·5069705	0·5074868	0·5069247	0·5071273
	$s-s_0$	−728	−749	−719	−732
	g	979·344	979·352	979·341	979·346
Murree	s	0·5070531	0·5075701	0·5070084	0·5072105
	$s-s_0$	+098	+084	+118	+100
	g	979·025	979·031	979·017	979·024
Domel	s	0·5069826	...	0·5069356	0·5069591
	$s-s_0$	−607	...	−610	−609
	g	979·297	...	979·299	979·298
Shādipur	s	0·5070402	0·5075445	0·5069893	0·5071913
	$s-s_0$	−23	+42	+19	+12
	g	979·072	979·047	979·056	979·058
Gandarbal (2)	s	0·5070363	0·5075342	0·5069847	0·5071851
	$s-s_0$	−62	−61	−27	−50
	g	979·087	979·087	979·073	979·082
Hayan	s	0·5070637	0·5075575	0·5070056	0·5072089
	$s-s_0$	+212	+172	+182	+188
	g	978·981	978·997	978·993	978·990
Sonāmarg	s	0·5071067	0·5076062	0·5070416	0·5072515
	$s-s_0$	+642	+659	+667	+656
	g	978·815	978·809	978·805	978·810
Churawan	s	0·5070890	0·5075842	0·5070262	0·5072331
	$s-s_0$	+465	+439	+513	+472
	g	978·883	978·894	978·865	978·881
Minmarg	s	0·5071094	0·5076084	0·5070423	0·5072534
	$s-s_0$	+669	+681	+674	+675
	g	978·805	978·800	978·803	978·803
Deosai I	s	0·5071576	...	0·5070866	0·5071221
	$s-s_0$	+1151	...	+1117	+1134
	g	978·618	...	978·632	978·625
Deosai II	s	0·5071567	0·5076538	0·5070860	0·5072988
	$s-s_0$	+1142	+1135	+1111	+1129
	g	978·622	978·625	978·634	978·627

TABLE XI.—Mean times of vibration and deduced values of g, season 1924-25—(Concld.)

Name of station		1	2	3	Means
Deosai III	s	0·5071433	0·5076412	0·5070883	0·5072909
	$s-s_0$	+1008	+1009	+1009	+1009
	g	978·674	978·674	978·673	978·674
Gandarbal (2)	s	0·5070360	0·5075490	0·5069829	0·5071893
	$s-s_0$	−65	−43	−45	−51
	g	979·088	979·080	979·080	979·083
Lālpur	s	0·5070448	0·5075445	0·5069807	0·5071900
	$s-s_0$	+23	−88	−67	−44
	g	979·054	979·097	979·089	979·080
Srīnagar	s	0·5070356	0·5075439	0·5069785	0·5071860
	$s-s_0$	−69	−94	−89	−84
	g	979·090	979·099	979·097	979·095
Pingalan	s	0·5070355	0·5075543	0·5069851	0·5071916
	$s-s_0$	−70	−10	−23	−28
	g	979·090	979·063	979·072	979·075
Yūs Maidan	s	0·5070793	0·5075776	0·5070257	0·5072275
	$s-s_0$	+368	+373	+383	+374
	g	978·921	978·919	978·915	978·918
Korag	s	0·5071224	0·5076234	0·5070655	0·5072704
	$s-s_0$	+799	+831	+781	+803
	g	978·754	978·742	978·761	978·752
Tosh Maidan	s	0·5071131	0·5076033	0·5070519	0·5072561
	$s-s_0$	+706	+630	+645	+660
	g	978·790	978·820	978·814	978·808
Gandarbal (3)	s	0·5070423	0·5075365	0·5069816	0·5071868
	$s-s_0$	−02	−38	−58	−33
	g	979·064	979·078	979·085	979·076

The observations for time with the prismatic astrolabe made to obtain the clock rates (*vide* §146), also determined the astronomical latitude. In this way astronomical latitudes were obtained without extra labour at all the stations in Circuits II and III. Observations for latitude were made at Bāramūla also. Usually at each station there were four nights of observations, averaging two hours each night; longer programmes would have interfered with the pendulum work. The average probable errors in the astronomical latitude were :— 145. *Simultaneous latitude determination by astrolabe.*

p.e. of a single determination $\pm$ 0″·55

p.e. of the mean $\pm$ 0″·13

This is not as good as the Talcott results in previous seasons but the astrolabe programme was much shorter.

Evidently with this instrument a short series of observations on a single night are unreliable; but under favourable conditions the method gives results comparable in accuracy with those obtained by the Talcott method.

The great advantages of the prismatic astrolabe are :— 146. *Advantages & disadvantages of astrolabe*

(*i*). Simultaneous determination of time and latitude.

(*ii*). Great portability of the instrument and easy erection.

(*iii*). Simplicity of observation.

A disadvantage is that results are noticeably affected by differential refraction effects when there is a marked change in the weather. Probably such effects are much greater in the Himalayan regions than in the plains: they lead to a persistent error, so long as the unequal conditions prevail. Persistent errors of this nature were found at the following stations, always when the weather was changing, one part of the sky being clear and the other part misty and unsettled. The observations on these unsettled days were rejected.

Name of station	Error
Minmarg	−3″·03
Deosai I	+4″·06
Deosai III	+4″·89
Yūs Maidan	−3″·52

For the calculation of star places use has been made throughout of the American Ephemeris; the short period terms have been included and also the corrections to star places given in Table XIII of the Ephemeris 1925. 147. *Star catalogue.*

Geodetic latitudes were obtained by theodolite resection at all stations; in most cases at least four well defined triangulated points were visible either from the pendulum camp itself, or from some point not more than a mile distant. The resected point was then connected to the astrolabe station by direct measurement or, if this was not possible, by measuring a small triangle formed by the astrolabe, resected point, and any third point in camp. 148. *Geodetic latitudes by theodolite resection.*

148. (*Contd.*) Observations were made on three zeros using a 5-inch micrometer theodolite; and an azimuth taken to Polaris before dark.

The coordinates of the resected point were found graphically as follows:—Using the azimuth found, and the approximate distances to the points measured from a map, a large scale diagram is drawn of the area in which the resected point lies, showing each of the observed rays; these will not meet in a point, due to error in the observed azimuth, and errors in identifying the exact triangulated fixed points. The first of these errors can be entirely eliminated by swinging each ray through a distance on the diagram proportional to its length, as in plane tabling. The second error is then easy to detect as the ray from any wrongly identified point will disagree with the majority, and can be discarded.

Plate No. X shows a typical diagram; the resection at Tosh Maidan.

It is important to note at the time of observation, which triangulated points are really definite, in order that no mistake is made in discarding a correct ray. A badly defined point is seldom of any use whatsoever, as the error of intersecting off the mark is reproduced in magnitude at the resected point, and if used, only complicates the result.

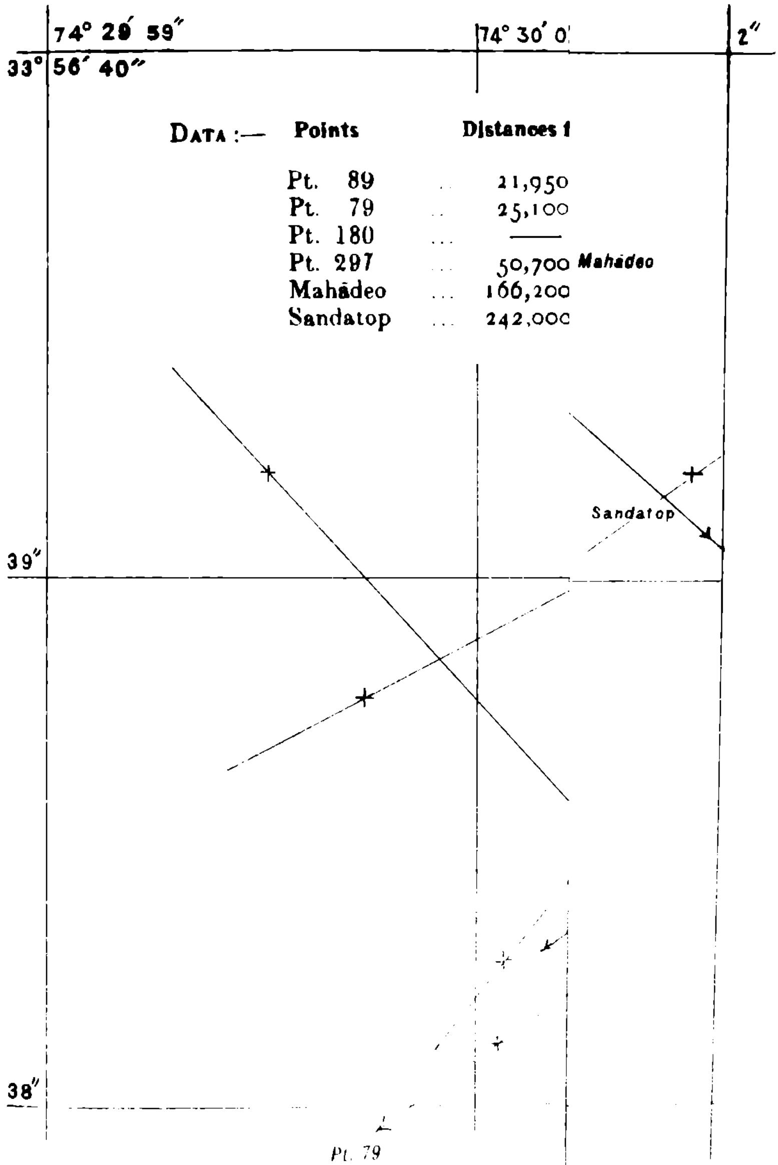
The resection was unsatisfactory at one station only, i.e. at Sonāmarg. At this station only two points were visible, one badly defined; and the heights obtained from these did not agree. The geodetic latitude of Sonāmarg is therefore given to the nearest second only in Table XIII.

The latitude stations were marked with a large stone at ground level, with a circle and dot cut on its upper surface, and a rough cairn of stones 5 or 6 feet high built over it.

The astronomical results are given in Table XIII. These are not corrected for latitude variation.

PLATE X

SHOWING GRA



Data :—

Points		Distances f
Pt. 89	..	21,950
Pt. 79	..	25,100
Pt. 180	...	——
Pt. 297	...	50,700
Mahâdeo	...	166,200
Sandatop	...	242,000

Explanations :—

The computed points are marked +

By inspection, and rejecting the ray to

The thick black lines are then drawn at at distances from them proportional to the

By further inspection, and throwing ned through which the 4 red rays pass.

Coordinates of O are { λ 33° 56′ 38 / L 74° 30′ 00

REG. No 151 M D D 1927 500

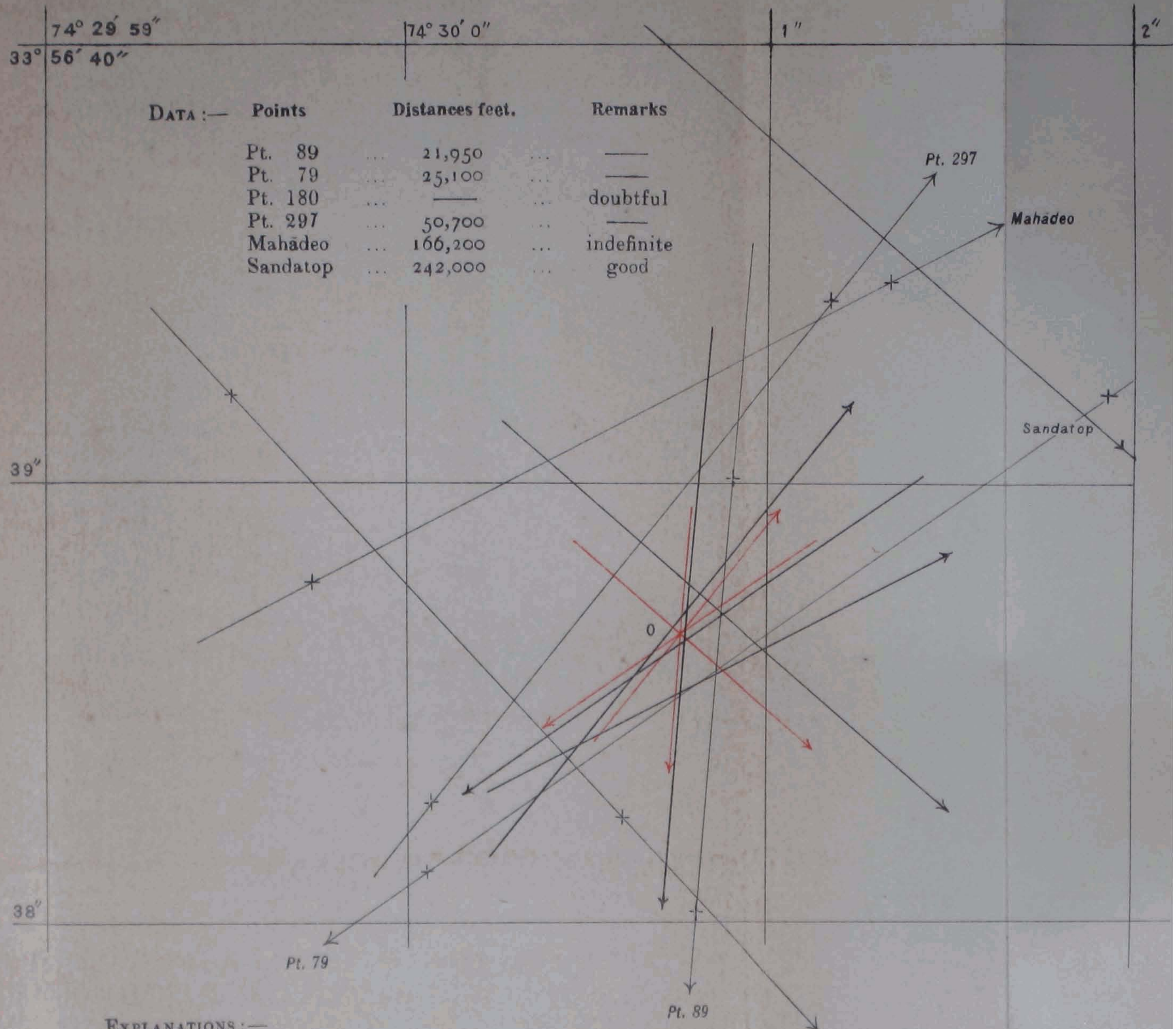
DIAGRAM

SHOWING GRAPHICAL SOLUTION OF RESECTION

AT TOSH MAIDAN

DATA :—

Points		Distances feet.		Remarks
Pt. 89	...	21,950	...	——
Pt. 79	...	25,100	...	——
Pt. 180	...	——	...	doubtful
Pt. 297	...	50,700	...	——
Mahādeo	...	166,200	...	indefinite
Sandatop	...	242,000	...	good



EXPLANATIONS :—

The computed points are marked +

By inspection, and rejecting the ray to Pt. 180 the position for the resected point is near O.

The thick black lines are then drawn as a 1st approximation, parallel to the first rays, and at distances from them proportional to the length of each ray concerned.

By further inspection, and throwing out the ray to Mahádeo, the exact position O is obtained through which the 4 red rays pass.

Coordinates of O are $\begin{cases} \lambda & 33^\circ\ 56'\ 38''\cdot 653. \\ L & 74^\circ\ 30'\ 00''\cdot 749. \end{cases}$

Heliozincographed at the Survey of India Offices Dehra Dūn

REG. No 151 M.D.D.1927-500

(To accompany Geodetic Report 1922-25)

Name of station	Latitude N	Longitude E	Height	γ_O	Corrections: for height	Corrections: for mass (Bouguer)	γ_A	γ_B	g	$g-\gamma_A$	$g-\gamma_B$
Wazīrābād ...	32° 26′ 48″	74° 06′ 28″	756	979·517	−0·071	+0·025	979·446	979·471	979·39$_4$	−0·05$_2$	−0·07$_7$
Jhelum ...	32 55 20	73 42 41	764	979·556	−0·072	+0·026	979·484	979·510	979·39$_6$	−0·08$_8$	−0·11$_4$
Rāwalpindi ...	33 36 41	73 01 07	1754	979·613	−0·164	+0·059	979·449	979·508	979·34$_6$	−0·10$_3$	−0·16$_2$
Murree ...	33 54 07	73 23 15	6885	979·637	−0·645	+0·217	978·992	979·209	979·02$_4$	+0·03$_2$	−0·18$_5$
Domel ...	34 21 08	73 28 07	2239	979·675	−0·210		979·465		979·29$_8$	−0·16$_7$	
Shādipur ...	34 11 14	74 41 00	5193	979·661	−0·487		979·174		979·05$_8$	−0·11$_6$	
Gandarbal ...	34 12 48	74 46 09	5200	979·663	−0·487		979·176		979·08$_2$	−0·09$_4$	
Hayan ...	34 13 54	74 58 29	6084	979·665	−0·570		979·095		978·99$_0$	−0·10$_5$	
Sonāmarg ...	34 18 00	75 16 15	9050	979·671	−0·848		978·823		978·81$_0$	−0·01$_3$	
Churawan ...	34 39 32	74 54 01	8151	979·701	−0·764		978·937		978·88$_1$	−0·05$_6$	
Minmarg ...	34 47 30	75 04 49	9351	979·712	−0·876		978·836		978·80$_3$	−0·03$_3$	
Deosai I ...	34 57 21	75 14 41	13311	979·726	−1·247		978·479		978·62$_5$	+0·14$_6$	
Deosai II ...	35 02 04	75 23 47	12805	979·733	−1·120		978·533		978·62$_7$	+0·09$_4$	
Deosai III ...	34 55 47	75 25 38	12391	979·724	−1·161		978·563		978·67$_4$	+0·11$_1$	
Lālpur ...	34 05 37	74 32 12	5633	979·653	−0·528		979·125		979·08$_0$	−0·04$_5$	
Srīnagar ...	34 04 36	74 49 27	5198	979·652	−0·487		979·165		979·09$_5$	−0·07$_0$	
Pingalan ...	33 54 23	74 55 59	5227	979·638	−0·490		979·148		979·07$_5$	−0·07$_3$	
Yūs Maidan ...	33 49 57	74 39 57	7867	979·631	−0·737		978·894		978·91$_8$	+0·02$_4$	
Korag ...	33 48 32	74 33 19	10952	979·629	−1·026		978·603		978·75$_2$	+0·14$_9$	
Tosh Maidan ...	33 55 18	74 29 58	10315	979·639	−0·966		978·673		978·80$_8$	+0·13$_5$	

TABLE XIII.—Latitude observations with prismatic astrolabe in Kashmīr, season 1925

Name of station	Observer	Geodetic Latitude	Longitude	Astronomic Latitude	Probable Errors of the mean	Plumb-line deflections A – G*
Bāramūla	G.H.O.	34° 12′ 25″	74° 21′ 01″·12	34° 12′ 23″·95	±″·210	–1″
Shādipur	G.H.O.	34 11 12·59	74 41 00·35	34 10 56·70	±·114	–15·8
Gandarbal	G.H.O. & E.A.G.	34 12 48·03	74 46 08·57	34 12 29·79	±·090	–18·2
Hayan	E.A.G.	34 13 54·49	74 58 28·94	34 13 33·68	±·226	–20·8
Sonāmarg	G.H.O.	34 18 03	75 16 19	34 17 51·15	±·140	–12
Churawan	E.A.G.	34 39 31·69	74 54 00·01	34 39 15·64	±·141	–16·0
Minmarg	G.H.O.	34 47 30·21	75 04 34·57	34 47 22·67	±·074	–07·5
Deosai I	E.A.G.	34 57 20·76	75 14 41·24	34 57 21·20	±·188	+00·4
Deosai II	G.H.O.	35 02 03·82	75 23 46·32	35 02 11·78	±·160	+07·9
Deosai III	E.A.G.	34 55 47·20	75 25 38·30	34 56 05·42	±·123	+18·2
Lālpur	E.A.G.	34 05 36·93	74 32 11·69	34 05 40·19	±·057	+03·2
Srīnagar	G.H.O.	34 04 36·61	74 49 27·27	34 04 19·42	±·133	–17·1
Pingalan	E.A.G.	33 54 22·49	74 55 59·16	33 54 06·32	±·166	–16·
Yūs Maidan	G.H.O.	33 49 56·55	74 39 57·26	33 49 59·08	±·106	+02·
Korag	E.A.G.	33 48 31·37	74 33 20·90	33 48 33·36	±·181	+01·
Tosh Maidan	G.H.O.	33 55 17·33	74 29 58·13	33 55 19·01	±·180	+01·

* A positive value of (A – G) denotes southerly deflections of the Plumb-line.

Plate XI

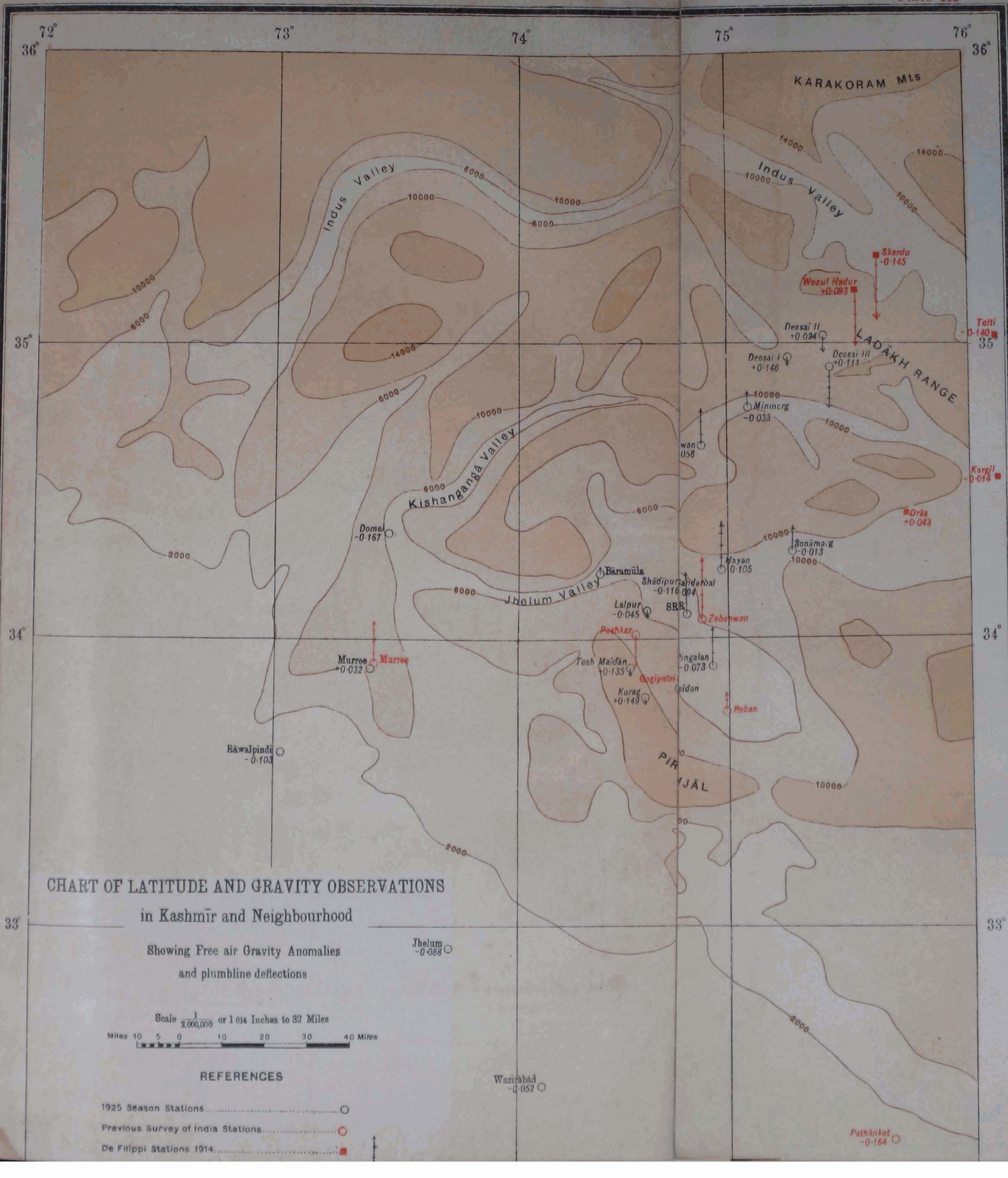
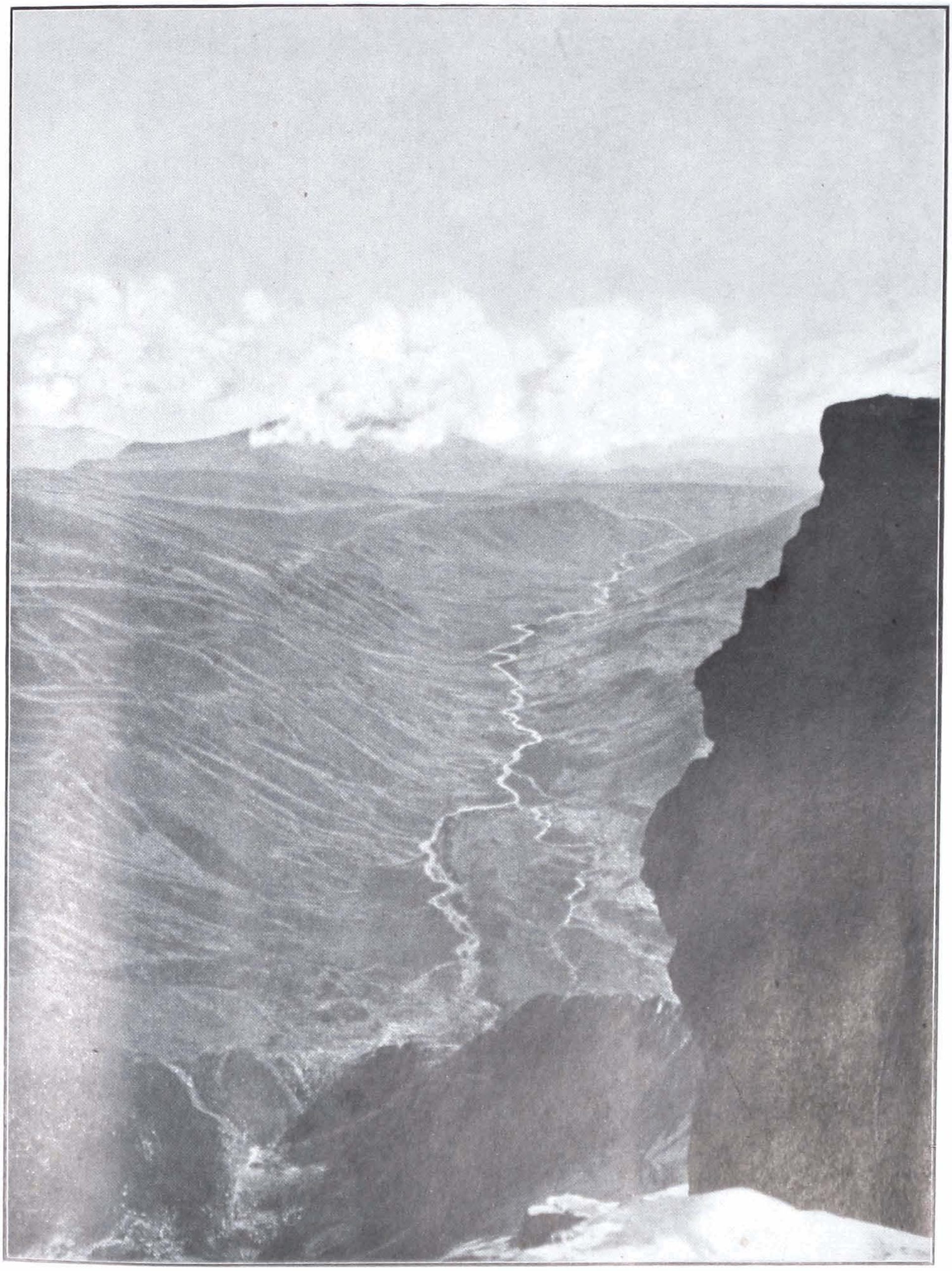
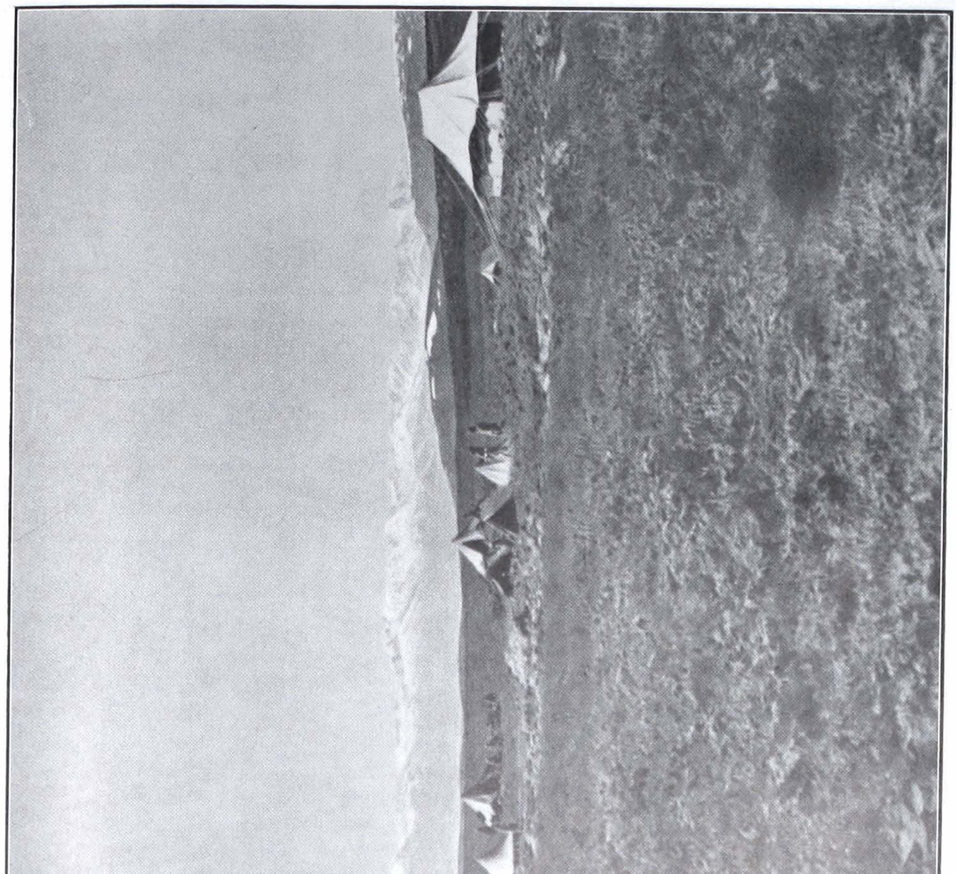


CHART OF LATITUDE AND GRAVITY OBSERVATIONS
in Kashmīr and Neighbourhood
Showing Free air Gravity Anomalies
and plumbline deflections
Scale 1/2,000,000 or 1·014 Inches to 32 Miles
Miles 10 5 0 10 20 30 40 Miles
REFERENCES
1925 Season Stations
Previous Survey of India Stations
De Filippi Stations 1914
72° 73° 74° 75° 76°
36° 35° 34° 33°
KARAKORAM Mts
Indus Valley
Indus Valley
LADĀKH RANGE
Kishangangā Valley
Jhelum Valley
PIR PANJĀL
Skardu -0·145
Wozul Hadur +0·093
Tolti -0·140
Deosai II +0·094
Deosai I +0·146
Deosai III +0·111
Minimerg -0·033
Kargil -0·014
Drās +0·043
Sonāmarg -0·013
Dome! -0·167
Bāramūla
Shādipur
SRR
Lalpur -0·045
Zebanwan
Poshkar
Murree +0·032
Murree
Tosh Maidān +0·135
Gogipatri
Korag +0·149
Reban
Rāwalpindi -0·103
Jhelum -0·088
Wazirābād -0·052
Pathānkot -0·164
14000
10000
6000
2000

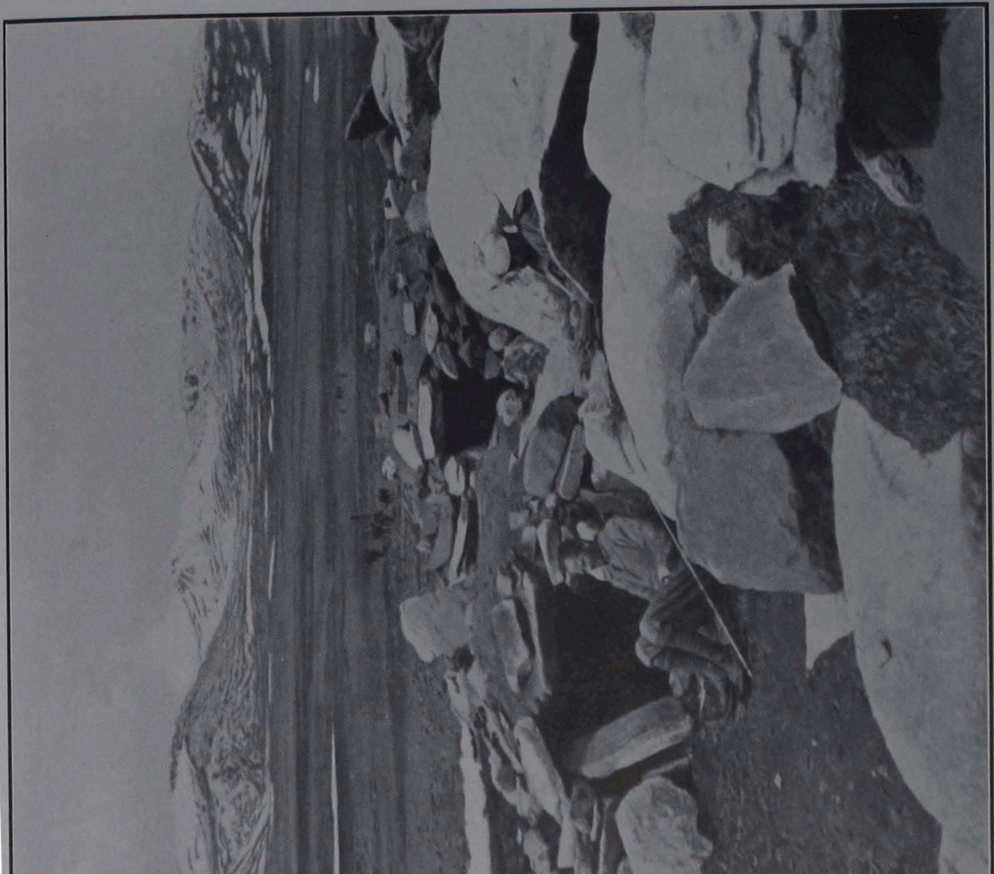


Kashmir. View from the summit of Tatakuti in the Pir Panjal, 15,600 feet.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1927.



THE DEOSAI. LOOKING S.E. FROM NO. 2 CAMP.



The Deosai. Looking S.W. towards San Sangri La.

Corrections for topography and isostatic compensation have not yet been computed, so it is not advisable at this stage to attempt to make any definite deductions from the results. 149. *Corrections for topography and isostatic compensation.*

In Plate No. XI the mountain masses are shown diagrammatically and all the stations of the observations with the Free Air gravity anomalies and plumb-line deflections; previous latitude work in Kashmīr is also shown.

The southerly deflections obtained at Deosai I and II confirm the striking southerly deflections obtained by the De Filippi Expedition at Skardu and Wozul Hadur (Skardu 28″·3 S, Wozul Hadur 25″·7 S) and appear to indicate that the Ladakh range is not compensated isostatically, whereas the degree of compensation of the Kara-koram range is very considerable.

A start has been made on the "Average height map of India". About one third of India has been completed, the average of heights of all 30-minute squares being determined. Besides being of considerable general interest, this map will very greatly facilitate the computation of topographical and isostatic compensation effects, and enable them to be taken out or checked by ordinary computers. 150. *Average height map of India and forms.*

Various new forms and tables have been prepared for the astrolabe computations; and the extension of the Hayford reduction tables for heights above 12,000 feet has been put in hand.

CHAPTER V

LEVELLING

(No. 17 Party)

BY MAJOR A. H. GWYN, I A.

1922-23

151. *Season 1922-23.* The party office closed at Mussoorie on 23rd September 1922, and moved to Dehra Dūn. Six detachments took the field; of which No. 1 comprised all the Sutlej tertiary levellers, and No. 6, after completing a high precision line by single levelling, was raised to a double detachment; the remaining four were double detachments. The recess season opened at Mussoorie on 5th April 1923, detachments arriving at various dates afterwards; No. 1 recessed in Dehra Dūn.

152. *Field organization.* The field organization was as follows:—

(*a*) Sutlej Valley Group under Captain E. A. Glennie, D.S.O., R.E., comprising:

No. 1 detachment under Captain Glennie.
„ 2 detachment under Mr. O. N. Pushong.
„ 3 detachment under Mr. P. B. Roy.

(*b*) No. 4 detachment (Bombay and Madras) under Mr. K. S. Gopalachari and later under Babu Mohd. Ishak Khan.

(*c*) No. 5 detachment (Burma) under Mr. S. C. Mukerjee.

(*d*) No. 6 detachment (Sind and Punjab) under Mr. Abdul Majid.

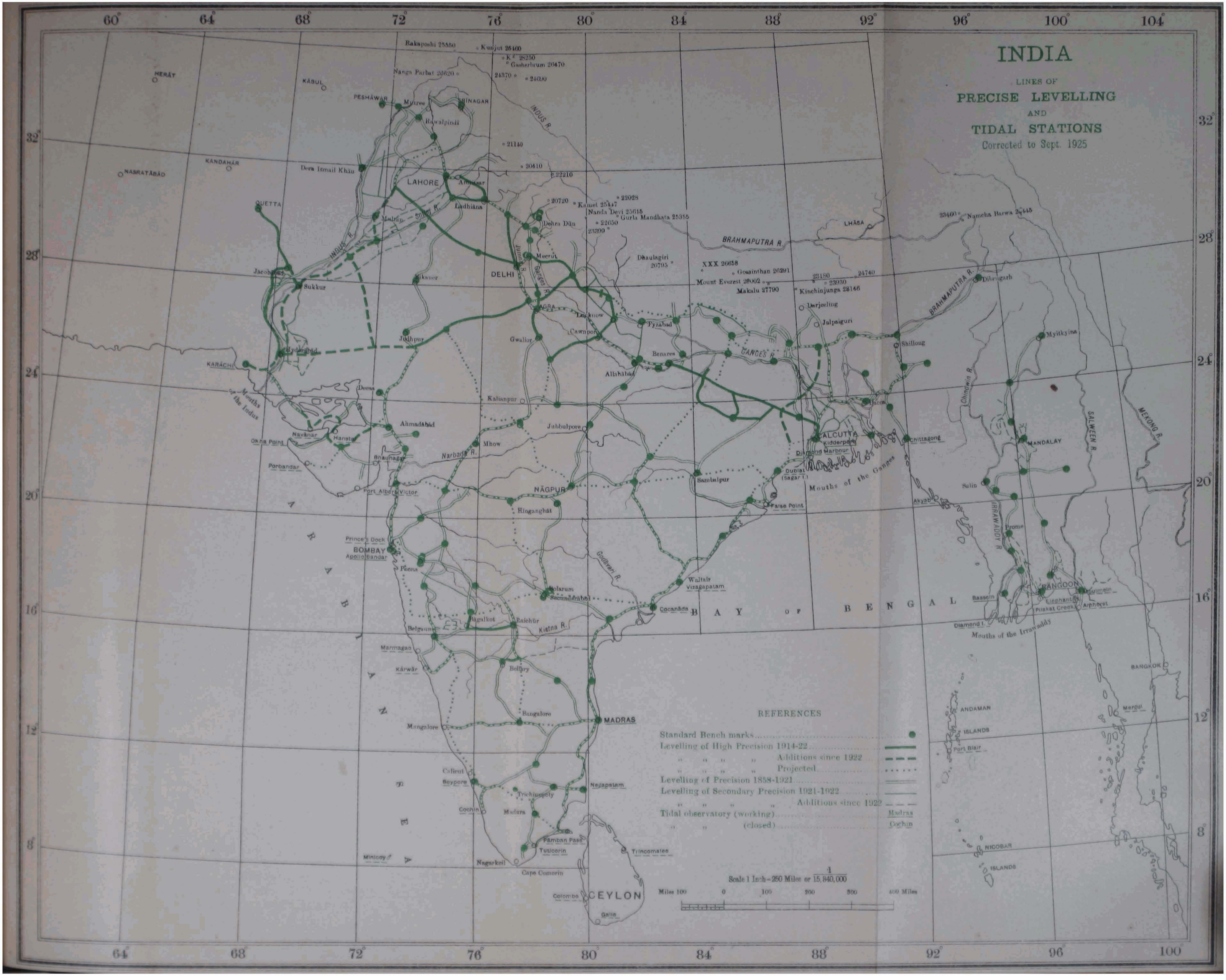
153. *Outturn of work.* The Sutlej Valley Group commenced a close network of levelling for the Sutlej Valley Irrigation Project.

No. 1 detachment executed 13,889 linear miles of tertiary levelling in the Multān and Montgomery districts, covering 2045 square miles; while Nos. 2 and 3 detachments ran 609 and 661 miles of secondary (double) levelling, to control the tertiary work of the present and subsequent seasons.

No. 4 detachment, on the simultaneous double levelling system, ran 72 miles of secondary levelling from Ahmadnagar to Dhond, 241 miles from Gooty to Ongole, and 208 miles in the Ghātprabha irrigation area in Bombay, for the local government.

No. 5 detachment executed 610 miles of secondary (double) levelling, for the Public Works Department (Irrigation), Burma, in connection with the Irrawaddy embankment scheme, correlated with the tide gauges in the Irrawaddy Delta.

No. 6 detachment executed 205 miles of high precision (single) levelling from Khānpur to Jacobābād, this being the reverse direction, and completed the work on that portion of line 101 of the new



INDIA
LINES OF
PRECISE LEVELLING
AND
TIDAL STATIONS
Corrected to Sept. 1925
REFERENCES
Standard Bench marks
Levelling of High Precision 1914-22
" " " " Additions since 1922
" " " " Projected
Levelling of Precision 1858-1921
Levelling of Secondary Precision 1921-1922
" " " " Additions since 1922
Tidal observatory (working) Madras
" " (closed) Cochin
Scale 1 Inch=250 Miles or 1/15,840,000
Miles 100 0 100 200 300 400 Miles
BAY OF BENGAL
ARABIAN SEA
CEYLON
ANDAMAN ISLANDS
NICOBAR ISLANDS
BRAHMAPUTRA R.
GANGES R.
INDUS R.
LAHORE
DELHI
NAGPUR
BOMBAY
MADRAS
CALCUTTA
RANGOON
MANDALAY
KARACHI
QUETTA
PESHAWAR
SRINAGAR
LHASA
BANGKOK

net for India. It was then expanded into a double detachment which carried out 392 miles of secondary double levelling about Mīrpur Khās, for the Bombay Government, in connection with the Sukkur Barrage Project. •153 *(Contd.)*

154. *Summary.*

The total work done was :—

(*a*) 205 miles of primary levelling for the new net.

(*b*) 313 miles of secondary levelling, for breaking up a circuit and for checking the standard bench mark at Ahmadnagar.

(*c*) 2480 miles of secondary levelling for local governments.

(*d*) 13,889 miles of tertiary levelling for the Punjab Government.

The work done was satisfactory, except that of No. 4 detachment, whose records were brought into recess so incomplete that the computation was not finished at the end of the recess season. The results of the work done for the local government were however sent out.

No. 6 detachment was delayed by relevelments and by high winds in Sind, and had to close work in June, leaving 41 miles of its programme undone.

Otherwise, the party's programme was completed.

155. *The new level net.*

As predicted in the Records Volume 1921-22, it was not found possible to devote more than one detachment this year to the net; details of the work are given under No. 6 detachment (*vide* § 180).

156 *Details of field work Sutlej Valley.*

No. 1 detachment.—tertiary levelling.

Captain E. A. Glennie, D.S.O., R.E., was in charge; four sections, each of about 10 levellers, under Mr. R. B. Mathur, Mr. A. A. S. Matlub Ahmad, Babu H. K. Kar and Babu Faizul Hasan.

This work, which was taken up at the request of the Punjab Government, was a new departure.

Only a short time remained for training and equipping the detachment for the field, when organization orders issued at the end of July 1922; the training of new levellers, all engaged on "purely temporary" agreements began at Dehra Dūn in September 1922, under Mr. R. B. Mathur and Mr K. K. Das. All four sections left Dehra Dūn during the latter half of October 1922.

The detachment headquarters office opened at Bahāwalpur on 6th November. The recess office opened at Dehra Dūn on 5th April 1923, under Mr. R. B. Mathur.

2045 square miles of tertiary levelling were executed in sheets 39 N/16, 39 O/6, 9, 10, 11, 13, 14, 44 B/4, 8, 11, 12, 15, 16, 44C/1, 2, and 44 F/3, 4.

The outturn would have been greater if there had been a complete stock of levels at the start.

157. *Rectangulation of areas to be developed*

The whole area of 13,514 square miles to be developed by the Sutlej Valley Project is being marked out into 100-acre rectangles by No. 23 (Punjab Rectangulation) Party, and of this area 10,030 square miles is being further subrectangulated by the Civil Department to 25-acre rectangles. The corners of rectangles are marked on the ground by numbered stone pillars.

The work of No. 1 detachment consisted in determining the ground level at each pillar and at fixed intermediate points. About 77 ground levels per square mile are required for the area subrectangulated to 25-acre rectangles, and 38 ground levels per square mile for the remaining area, or 904,090 ground levels in all.

158. *System of work.*

Lines of bench marks on the tops of rectangulation pillars running north and south about 6¼ miles apart are established by tertiary double levelling, and formed into a grid by double levellers' lines running east and west about 15 miles apart or less.

Single levellers work along east and west lines between the bench marks on the north and south lines; each single leveller's line represents about 9 miles of actual levelling.

The grid of tertiary bench marks is connected at frequent intervals to interred bench marks on the secondary lines run by Nos. 2 and 3 detachments.

The proportion of tertiary double to single levelling is about 1:11.

159. *Instruments used.*

Dumpy and light Zeiss pattern levels were taken into the field; but it was soon found that work with Dumpy levels would not be satisfactory, and by the end of December the whole detachment was equipped with light Zeiss pattern levels.

At the beginning the shortage of levels made it necessary to *double back* in some cases. This did not result in a good rate of outturn.

Only one staff per level was employed at first, but subsequently two of the four sections were equipped with two staves per level.

Instead of pegs, small iron level plates were used and gave excellent results.

160. *Outturn and probable error of tertiary single levelling.*

The outturn is as follows :—

Area levelled over.

(i). Subrectangulated to 25-acre rectangles 1200 square miles.
(ii). Rectangulated to 100-acre only........ 845 " "

Miles of levelling :—

(i). Double levelling..........................1234
(ii). Single " 12655

Points :—

(i). Ground levels..........................126342
(ii). Bench marks on tops of pillars..........8152

The probable error of a ground level of tertiary single levelling is ±0·043 ft. 160 (*Contd.*)

The rates worked from the actual figures of the work done in season 1922-23 are as follows :— 161. *Cost rates.*

Cost rates of work in 1922-23

Field work	Recess work	Total	Remarks
RS.	RS.	RS.	
5·9	1·1	7·0	Cost per mile of levelling
0·6	0·1	0·7	,, .. ground level
			Cost per square mile
47·5	8·8	56·3	,, ,, 25-acre area—
23·8	4·4	28·2	,, ,, 100-acre area—

The above rates do not include any percentage for supervision, instruments, or mapping costs.

The Chief Engineer (Construction) was provided with volumes of heights computed in recess. A form of chart was devised, on the four-inch scale, showing (*i*) in blue, the rectangulation framework, and accessory work; (*ii*) in black, spot levels, and (*iii*) in brown, one-foot contours and some external reference letters. The detachment produced level and contour guides, from which fair drawings were made for reproduction. 162. *Charts.*

No. 2 double detachment.—secondary levelling. 163 *Sutlej Valley secondary levelling*

Mr. O. N. Pushong was in charge, and Babu Mohd. Ibrahim worked as second leveller. The lines that were run to control tertiary work were :—

(*a*) Kasūr to Lodhrān *via* Khudiān, Pākpattan and Ratta Tibba, along the dismantled railway.

(*b*) Ratta Tibba to Kaim Rais-ki-got, by road *via* Luddan, across the Sutlej near the proposed Islāmweir, direct to Nūrkot, and thence by road.

(*c*) Kutabpur to Ādamwāhan : south west direct to Khān Bela, then east. This line goes through much scrub and grass land, and a large tract of sand west of Ādamwāhan.

(*d*) Lodhrān to Bahāwalpur, by road. The Sutlej was crossed by the railway bridge near Ādamwāhan.

(*e*) Bahāwalpur to Fāzilka; south *via* Rājāwāla to Dingarh, then east to Marot, Shāhswār Toba, Dhāb Sarkāri, Kandhyawāla and Walar; north along and west of the Bikaner

163. (*Contd.*) boundary, to the Sādikīyah canal; along the canal to the railway near McLeodganj Road then to Fāzilka. This line passes through the Bahāwalpur desert.

(*f*) Kandhyawāla to Hāsilpur. The line lay along typical *cholistan*, flat desert with sandy ridges.

The detachment left Dehra Dūn on 15th October 1922, and started levelling at Kasūr on 22nd October. Work closed at Fāzilka on 14th March 1923, when the detachment proceeded to Mussoorie.

164. *Outturn.* The outturn including branch lines and check levelling was 609¼ miles; instruments were set up at 5530 stations; the total rise and fall was 5624 feet. Bench marks connected were 3 primary, 210 secondary, and 30 tertiary. Details are given in Table I.

Differences between Levellers (1st—2nd)

Line	mile	*feet*	mile	*feet*
(*a*) Kasūr to Lodhrān ...	at 25th mile ,, 50th ,, ,, 75th ,, ,, 98th ,,	+0·069 +0·148 +0·055 +0·079	at 125th mile ,, 150th ,, ,, 175th ,, ,, 214th ,, (end of line)	+0·060 +0·080 +0·064 +0·113
(*b*) Ratta Tibba to Kaim Rais-ki-got ...	at 15th mile	+0·047	at 31st mile (end of line)	+0·029
(*c*) Kutabpur to Ādamwāhan ..	at 25th mile ,, 49th ,,	−0·037 −0·035	at 75th mile ,, 90th ,, (end of line)	−0·040 −0·011
(*d*) Lodhrān to Bahāwalpur ...	at 12th mile	−0·046		..
(*e*) Bahāwalpur to Fāzilka	at 25th mile ,, 50th ,, ,, 73rd ,, ,, 98th ,,	+0·022 −0·023 −0·048 −0·107	at 122nd mile ,, 151st ,, ,, 175th ,, ,, 208th ,, (end of line)	−0·121 −0·108 −0·211 −0·195
(*f*) Kandhyawāla to Hāsilpur ...	at 16th mile	−0·025	at 38th mile (end of line)	+0·011

165. *Probable accidental error.* The probable accidental error per mile according to the formula $\pm 0\cdot 6745 \sqrt{\frac{\Sigma d^2}{4M}}$, where 'd' is the discrepancy between two levellers in the values of two consecutive bench marks, and 'M' the length of the line in miles, is given below. The average for the wholeof India is ±0·0042 ft.

Probable accidental error 165. (Contd.)

Line	Probable accidental error	Remarks
	feet	
(*a*) Kasūr to Lodhrān	±0·00367	
(*b*) Katta Tibba to Kaim Rais-ki-got	...	Branch line to (*a*)
(*c*) Kutabpur to Ādamwāhan	±0·00341	
(*d*) Lodhrān to Bahāwalpur	±0·00522	
(*e*) Bahāwalpur to Fāzilka	±0·00271	
(*f*) Kandhyawāla to Hāsilpur	...	Branch line to (*e*)

The embedded benchmarks laid down in all these lines are of the type B design of the Survey of India, except that the letters "G.T.S." both on the stone block and on the referring pillar, are replaced by the letters "S.V.C." (Sutlej Valley Canals). They were put down by the Irrigation Engineers.

Zeiss level No. 3488 and Zeiss pattern level No. 16298 by Cooke, and Survey Committee Pattern staves Nos. 19A, 19B, 1 and 01 were used. 166. *Instruments, weather, and health.*

Except for a few cloudy days and a shower or two, the weather remained clear and dry throughout. In the latter half of February and the first week of March high winds were experienced very frequently, and sand storms on two or three occasions.

The health of the detachment was good.

No. 3 double detachment.—secondary levelling. Mr. P. B. Roy in charge; Babu Indra Singh Rawat second leveller. The following lines were run, to control tertiary work :— 167. *Secondary levelling.*

(*a*) Khudiān to Lodhrān, *via* Chūniān, Dīpālpur, Pakhi Miān and Kutabpur, by road and railway, and across country.

(*b*) Dīngarh to Khānpur, *via* Derāwar Fort and Mithra, across the desert.

(*c*) Mithra to Khānpur, *via* Reti and Chacharan, across the desert.

(*d*) Chacharan to Khān Bela, across country.

(*e*) Fāzilka to Ferozepore; this was a revision of part of main line 57.

The detachment left Dehra Dūn on 15th October 1922, and closed work at Ferozepore on 29th March 1923, proceeding to Mussoorie.

The outturn, including branch lines and check levelling was 661 miles; instruments were set up at 5846 stations. Bench marks connected were 6 primary, 249 secondary and 27 tertiary. Details are given in Table I. 168. *Outturn.*

169. *The country levelled.* The country was flat throughout, except from Dīngarh to Khānpur, and from Mithra to Reti on the line Mithra to Khānpur, which were through the desert and full of sand hills.

The rivers Chenāb and the Sutlej were crossed at their junction near Bakhri village, by direct levelling, the greatest breadth being 13·30 chains of 66 feet.

Differences between levellers (1st – 2nd)

Line	mile	*feet*	mile	*feet*
(*a*) Khudiān to Lodhrān ...	at 22nd mile „ 38th „ „ 60th „ „ 81st „ „ 100th „ „ 120th „	−0·021 +0·052 +0·084 +0·153 +0·043 +0·043	at 140th mile „ 159th „ „ 180th „ „ 200th „ „ 223rd „ (end of line)	+0·037 +0·037 +0·008 −0·009 −0·005
(*b*) Dīngarh to Khānpur ...	at 18th mile „ 38th „ „ 60th „	−0·024 −0·029 −0·005	at 79th mile „ 109th „ (end of line)	−0·001 0·000
(*c*) Mithra to Khānpur .	at 21st mile „ 43rd „ „ 62nd „ „ 79th „ „ 102nd „	+0·009 −0·070 −0·042 −0·045 −0·073	at 122nd mile „ 141st „ „ 160th „ „ 180th „ (end of line)	−0·078 −0·065 −0·038 −0·018
(*d*) Chacharan to Khān Bela ...	at 19th mile „ 43rd „	−0·036 −0·049	at 63rd mile „ 77th „ (end of line)	−0·032 −0·060
(*e*) Fāzilka to Ferozepore ...	at 20th mile „ 40th „	−0·056 −0·067	at 54th mile (end of line)	−0·076

170. *Probable accidental error.* The probable accidental error of the mean results per mile of double levelling according to the formula $\pm 0\cdot 6745\sqrt{\frac{\Sigma d^2}{4M}}$, where 'd' is the discrepancy between two levellers in the values of two consecutive bench marks, and 'M' the length of the line in miles, is given below:—

Line	*feet*
(*a*) Khudiān to Lodhrān ...	±0·0038
(*b*) Dīngarh to Khānpur ...	±0·0025
(*c*) Mithra to Khānpur ...	±0·0028
(*d*) Chacharan to Khān Bela ...	±0·0028
(*e*) Fāzilka to Ferozepore ...	±0·0024

The usual types of type A (zinc pipe), type B inscribed, tree (zinc plate), and rectangulation pillar bench marks were connected. The type B interred bench mark is of the usual type, except for the inscriptions. **171.** *Instruments used.*

The levels used were Zeiss levels No. 3342 and 16313. The staves used were Nos. D, D′, 22 A and 23 A; standard steel tape No. 7.

The health of the detachment was exceptionally good.

No. 4 double detachment.—secondary levelling.—Mr. K. S. Gopalachari, B.A. was in charge; Babu Mohd. Ishak Khan was second leveller, and was in charge later on, with a "purely temporary" recorder as second leveller. The lines levelled were (*a*) from Ahmadnagar to Dhond, to break up a circuit of the old level net of India and especially to check the height of the standard bench mark at Ahmadnagar; the 72 miles of the line contain 4 primary and 78 secondary bench marks; (*b*) irrigation levelling in the Ghātprabha area in Dhārwār; from Gotūr to Kalādgi, from Mudhol to Jodhatti, and from Hukeri Road railway station to Mudhol, a total of 208 miles, connecting 1 primary and 176 secondary bench marks; and (*c*) from Gooty to Ongole, to break up a circuit of the old level net, with a branch line from Nandyāl to Atmakūr; 241 miles of levelling, connecting 2 primary and 192 secondary bench marks. **172.** *Levelling in Bombay and Madras.*

The detachment left Dehra Dūn on 19th October 1922. It closed at Ongole on 26th May, and returned to recess in Mussoorie.

During May it was found necessary to recall the officer in charge, and let the second leveller take over the detachment.

During recess the computations of (*b*) were carried through but those of (*a*) and (*c*) had to stand over. Work on (*b*) was very slow, owing to the careless manner in which the sheets were treated in the field. Binocular levels Nos. 6728 and 7952, staves Nos. E_1, E_2, B_1 and C_1, and standard steel tape No. 8 were used by the detachment. **173.** *Recess work and instruments used.*

The p. e. per $(\text{mile})^{\frac{1}{2}}$ for the simultaneous double levelling lines from Ahmadnagar to Dhond and from Gooty to Ongole is respectively $\pm 0{\cdot}00485$ and $\pm 0{\cdot}00421$ ft.

It was found unadvisable to accept the results of the 1921-22 levelling from Manmād to Ahmadnagar, owing to the deficient check levelling near Manmād; consequently the adjustment of the height of the standard bench mark at Ahmadnagar could not be carried out. It is hoped to rectify this in 1926-27, so as to allow the publication of the line, and also the revision of published heights, on the lines Poona to Ahmadnagar and Ahmadnagar to Dhond. **174.** *Manmad to Ahmadnagar levelling of 1921-22 and of subsequent seasons.*

The heights on the Ghātprabha lines of 1922-23 will not be published, as the levelling was of a secondary standard. They were duly sent to the Executive Engineers.

The heights of the bench marks on the Gooty-Ongole line have been sent for publication.

174. (Contd.) Weather conditions became trying in April and May, especially in the waterless tract on the Eastern Ghâts, in sheets 57 I and M.

The health of the detachment was good.

175. *Levelling in Burma.* No. 5 double detachment—secondary levelling, Mr. S. C. Mukerjee in charge; and P. John second leveller. The lines levelled were:—

(*a*) from Nyaungzaye to Yandoon, with branch line to Maletto;
(*b*) „ Yandoon to Kandin;
(*c*) „ Ma-ubin to Bassein;
(*d*) „ Sagamya to Pantanaw.

All the work was for the Public Works Department (Irrigation)—(*a*) and (*b*) in connection with a scheme for *double embanking* the Irrawadday River, and (*c*) and (*d*) in order to correlate tide gauges in the Irrawaddy delta.

The detachment left Dehra Dūn on 14th October 1922; work started at Nyaungzaye on 15th November, and closed at Pantanaw on 8th May 1923, recessing in Mussoorie.

176. *Outturn and the country levelled.* The total outturn including branch lines and check levelling was 610 miles; instruments were set up at 4666 stations; the bench marks connected were 3 primary and 301 secondary. Details are given in Table I.

The country through which the lines of levelling were carried was mostly flat, full of tidal creeks and swampy grass jungles, and wide rivers had to be crossed during work.

Differences between levellers (1st—2nd)

Line	mile	*feet*	mile	*feet*
(*a*) Nyaungzaye to Yandoon ...	at 21st mile „ 40th „ „ 65th „ „ 81st „	+0·005 −0·006 +0·051 +0·091	at 100th mile „ 120th „ „ 138th „ (end of line)	+0·057 +0·047 +0·045
(*b*) Yandoon to Kandin ..	at 24th mile „ 41st „ „ 60th „ „ 79th „ „ 99th „	−0·063 −0·022 −0·042 −0·014 −0·004	at 120th mile „ 140th „ „ 160th „ „ 181st „ (end of line)	−0·019 −0·007 +0·008 −0·013
(*c*) Ma-ubin to Bassein ..	at 20th mile „ 43rd „ „ 61st „ „ 82nd „	+0·016 +0·035 −0·006 +0·016	at [illegible] mile „ [illegible]nd „ „ [illegible]st „ (end of line	−0·025 −0·053 −0·053
(*d*) Sagamya to Pantanaw ...	at 19th mile „ 42nd „	+0·034 +0·052	at [illegible]nd mile (end of line)	+0·088

The probable accidental error of the mean results per $(\text{mile})^{\frac{1}{2}}$ of double levelling according to the formula $\pm 0 \cdot 6745 \sqrt{\frac{\Sigma d^2}{4M}}$, where 'd' is the discrepancy between two levellers in the value of two consecutive bench marks, and 'M' the length of the line in miles, is given below :— 177. *Probable accidental error.*

Probable accidental error

Line	*feet*
(*a*) Nyaungzaye to Yandoon ...	±0·0031
(*b*) Yandoon to Kandin ...	±0·0027
(*c*) Ma-ubin to Bassein ...	±0·0018
(*d*) Sagamya to Pantanaw ...	±0·002

In addition to the usual type B interred and ordinary inscribed bench marks, cement concrete pillars with or without iron plugs fixed in the centre were connected. The interred bench marks were mostly constructed only a few days before connection by levelling, and their heights therefore may undergo a change. 178. *Bench marks connected and their heights.*

In addition to innumerable tidal creeks and small rivers, the following big rivers had to be crossed during the operations :—

Rivers	No. of times crossed	Length of shot	Method of crossing
Panhlaing ...	2	Varying from 8 to 13 chains	Direct levelling
Kok-ko-wa ...	3	,,	,,
Bawle ...	2	,,	,,
Hlaing ...	7	,,	,,
Kyonto or Gonnyindan	1	,,	,,
Irrawaddy ...	1	,,	,,
Yewe or Sagamya ...	3	,,	,,
Pantanaw ...	2	,,	,,
Maungdi ...	1	,,	,,
Myaungmya ...	1	,,	,,
Panmawadi ..	1	,,	,,
Pebin ...	1	,,	,,
Pyamalaw ...	1	,,	,,
,, ...	1	20 chains	Target
Bogale ...	1	22 ,,	,,
Yazudaing ...	1	17 ,,	,,
Kynnpyathat ...	1	32 ,,	,,
Kanyintabin ...	1	20 ,,	,,

The detachment used Binocular levels Nos. 6726 and 3, staves Nos. 23B, 22B and 13A, 13B and standard steel tape No. 2. 179. *Instruments used and health.*

The health of the detachment was on the whole good, except for one case of cholera and a few cases of dysentery.

180. *Levelling in Sind and Punjab.*

No. 6 detachment.—Primary and secondary levelling. Mr. Abdul Majid in charge; Babu B. B. Som, second leveller (for the secondary work only). The primary work consisted of single levelling in the back direction, on part of line No. 101 of the new level net of India from Khānpur to Jacobābād, (the forward direction was levelled in 1921-22). The secondary lines were:—

(*a*) Shāhpur to Mīrpur Purāna, *via* Khadro and the Jāmrao Canal.
(*b*) Landhi canal bungalow (39th mile, Jāmrao) to Khipro.
(*c*) Khipro to Ghulām Bhhurgari, *via* Kāhi.
(*d*) Mīrpur Khās to Tando Ghulām Ali, *via* Nabisar.
(*e*) Mīrpur Khās to Tando Ghulām Ali, *via* Dīgri.
(*f*) Dīgri to Dādāh.

The country generally is quite flat.

The detachment left Dehra Dūn on 21st October 1922, and returned to recess in Mussoorie on 26th June 1923.

181. *Outturn.*

The outturn of primary levelling was 195 miles of main line, excluding 40 miles relevelment, 10 miles of branch lines, and check levelling.

The secondary levelling comprised 392 miles, including branch lines and check levelling. Bench marks connected were 9 primary and 441 secondary.

Details are given in Table I.

Differences between levellers (1st – 2nd)

Line	mile	*feet*	mile	*feet*
(*a*) Shāhpur to Mīrpur Purāna	at 20th mile ,, 40th ,,	−0·005 −0·040	at 54th mile (end of line)	−0·016
(*b*) Landhi Canal Bungalow to Khipro	at 16th mile ,, 32nd ,,	+0·027 +0·034	at 47th mile end of line)	−0·057
(*c*) Khipro to Ghulām Bhhurgari	at 14th mile	−0·013	at 27th mile (end of line)	+0·046
(*d*) Mīrpur Khās to Tando Ghulām Ali *via* Nabisar	at 22nd mile ,, 40th ,, ,, 59th ,, ,, 79th ,, ,, 98th ,,	−0·028 −0·007 +0·037 +0·023 +0·052	at 120th mile ,, 143rd ,, ,, 160th ,, ,, 193rd ,, (end of line)	+0·013 +0·014 +0·018 −0·034
(*e*) Mīrpur Khās to Tando Ghulām Ali *via* Dīgri	at 22nd mile	+0·035	at 43rd mile	+0·033
(*f*) Dīgri to Dādāh	at 6th mile	−0·005	at 15th mile (end of line)	+0·020

The probable accidental error of the mean results per $(\text{mile})^{\frac{1}{2}}$ of double levelling according to the formula $\pm 0\cdot6745\sqrt{\frac{\Sigma d^2}{4M}}$, where 'd' is the discrepancy between two levellers in the values of two consecutive bench marks, and 'M' the length of the line in miles, is given below:— 182. *Probable accidental error.*

Probable accidental error

Line	*feet*
(*a*) Shāhpur to Mīrpur Purāna ...	± 0·0031
(*b*) Landhi canal bungalow to Khipro ...	± 0·0023
(*c*) Khipro to Ghulām Bhhurgari ...	± 0·0028
(*d*) Mīrpur Khās to Tando Ghulām Ali *via* Nabisar ...	± 0·0026
(*e*) Mīrpur Khās to Tando Ghulām Ali *via* Dīgri ...	± 0·0029
(*f*) Dīgri to Dādāh ...	± 0·0015

Binocular levels Nos. 6727 and 2698, staves Nos. 20 A, 20 B, 16 A and 16 B, and standard steel tape No. 3 were used. 183. *Instruments used and health.*

The health of the detachment was on the whole good, except for a few cases of influenza and malaria. The heat in Sind in June was trying.

The following passed through the press :— 184. *Publications.*

New Edition of levelling pamphlet No. 63
" " " " No. 78
" " " " No. 79
A correction slip to
Addendum to the levelling pamphlet No. 47

The Preservation and Maintenance section for G.T.S. stations has been transferred to No. 15 Party's supervision. 185. *Preservation and Maintenance.*

The question of the preservation of bench marks by local authorities has again received attention. The Survey of India is responsible for the expenses of repair, whereas most of the marks are of use to engineers only. It is thought that through handing over the upkeep of inscribed and embedded bench marks entirely to local governments and railways, who would pay the costs, more care would be exercised in preserving the marks.

TABLE I.—Tabular statement of outturn of work, season 1922-23

Detachments and Lines levelled	Months	Distance levelled									Total number of feet		Mean number of stations at which the instruments were set up	Number of bench marks connected																	
		Main-Line			Extras and branch-lines			Total			Rises	Falls		Primary						Secondary						Tertiary					
														Rock-cut Protected		Standard		Primary stations of triangulation		Embedded		Rock-cut or Irrigation		Inscribed		P. W. D.		Railway	
		Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	feet	feet		old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new
No. 2 Detachment.																													
Kasūr to Lodhrān	Oct. 22 to Feb. 23	213	50	12	34	47	96	248	18	08	878·246	1185·497	2120	...	...	...	...	...	...	8	50	...	1	8	47	...	18	..	...
Kutabpur to Ādamwāhan	Dec. 22 to Jan. 23		...		89	64	10	89	64	10	376·813	402·187	884	...	...	...	...	...	...	...	16	...	...	...	5	...	9	...	...
Lodhrān to Bahāwalpur	Jan. 23	12	11	00	...	...	...	12	11	00	102·792	103·572	136	...	...	1	...	...	...	...	1	...	...	11	...	...	1	...	...
Bahāwalpur to Fāzilka	Jan. 23 to Mar. 23	208	03	90	51	07	60	259	11	50	1409·727	1165·413	2390	...	.	...	1	...	1	1	50	...	1	...	16	...	2	...	...
No. 3 Detachment.																													
Khudiān to Lodhrān	Oct. 22 to Dec. 22	223	07	00	10	59	00	233	66	00	720·380	965·643	1994	...	...	...	...	1	...	1	47	...	...	1	50	...	24	...	...
Dīugarh to Khānpur	Dec. 22 to Jan. 23	99	70	00	6	74	00	106	64	00	518·357	604·544	962	...	...	1	...	...	...	...	21	...	...	7	2	...	2	...	...
Mithra to Khānpur	Jan. 23 to Feb. 23	179	66	00	4	17	00	184	03	00	1787·933	1792·499	1628	...	...	1	...	...	2	1	34	...	...	3	14	...	1	...	...
Chacharan to Khān Bela	Feb. 23 to Mar. 23	76	50	00	...	...	...	76	50	00	428·286	384·267	694	...	...	...	...	...	...	...	12	...	...	...	7	...	1	...	...

TABLE I.—Tabular statement of outturn of work, season 1922-23—(Contd).

Detachments and Lines levelled	Months	Distance levelled									Total number of feet		Mean number of stations at which the instruments were set up	Number of bench marks connected															
		Main-Line			Extras and branch-lines			Total			Rises	Falls		Primary						Secondary						Tertiary			
														Rock-cut Protected		Standard		Primary stations of triangulation		Embedded		Rock-out or Irrigation		Inscribed		P. W. D.		Railway	
		Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	feet	feet		old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new
No. 3 Detachment. —(contd.)																													
Fāzilka to Ferozepore	Mar. 23	53	70	00	5	43	00	59	33	00	244·189	173·979	568	...	...	1	...	...	...	5	...	...	...	3	40	...	...	...	...
No. 4 Detachment.																													
Ahmadnagar	Nov 22	48	58	40	0	46	00	49	24	40	1222·742	1604·493	756 }	...	...	1	...	1	2	4	...	1	3	12	56	2	...	...	...
to Dhond	Dec. 22	2	78	50	19	22	80	22	21	30	23·007	129·118	330 }	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...
Gotūr to Kalādgi	Dec. 22	...	...	...	21	16	00	21	16	00	364·938†	138·513†	238 }	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Jan. 23	46	51	70	47	28	22	93	79	92	{ 1103·851† 1308·806	1337·797† 1361·369 }	1292 }	1	...	...	...	1	...	1	17	...	6	9	135	...	1	...	...
	Feb. 23	44	55	00	10	09	40	54	64	40	{ 733·795† 1071·919	319·516† 1389·159 }	834 }	...	...	...	...	..	..	...	...	...	...	...	...	...	...	...	...
	Mar. 23	...	...	...	36	03	50	36	03	50	904·575†	978·130†	744 }	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	..
Gooty to Ongole and branch line to Atmakur	Mar. 23	15	70	30	2	10	00	18	00	30	378·875	156·229	168 }	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	April 23	111	46	90	...	...	...	111	46	90	1853·077	2922·801	362 }	...	1	...	...	1	...	3	20	1	43	11	118	...	1	...	...
	May 23	27	52	50	35	57	10	63	29	60	{ 468·727† 1065·747	232·979† 785·795 }	936 }	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	June 23	49	30	10	...	...	...	49	30	10	632·735	1201·163	550 }	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...

† Branch lines.

TABLE I.—*Tabular statement of outturn of work, season 1922-23*—(*Contd.*)

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Main-Line Chs.	Main-Line Lks.	Extras and branch-lines Mls.	Extras and branch-lines Chs.	Extras and branch-lines Lks.	Total Mls.	Total Chs.	Total Lks.	Total number of feet: Rises (feet)	Falls (feet)	Mean number of stations at which the instruments were set up	Number of bench marks connected: Primary: Rock-cut Protected old	Rock-cut Protected new	Primary: Standard old	Standard new	Primary: Primary stations of triangulation old	Primary stations of triangulation new	Secondary: Embedded old	Embedded new	Secondary: Rock-cut or Irrigation old	Rock-cut or Irrigation new	Secondary: Inscribed old	Inscribed new	Tertiary: P. W. D. old	P. W. D. new	Tertiary: Railway old	Railway new
No. 5 Detachment.																													
Nayaungzaye to Yandoon.(1) and Branch line to Maletto	Nov. 22 to Jan. 23	137	52	00	32	73	70	170	45	70	1039·130	1116·756	1542	...	...	...	...	...	...	2	19	..	...	1	70	1	25	...	...
Yandoon to Kandin	Jan. 23 to Mar. 23	180	72	90	44	16	90	225	09	80	1222·451	1053·566	1630	...	...	...	...	..	2	3	19	...	..	2	88	...	..	...	1
Ma-ubin to Bassein (2)	Mar. 23 to Apr. 23	141	12	50	20	73	90	162	06	40	423·481	421·409	1102	...	...	1	...	...	...	1	17	...	...	2	15	5	17	...	...
Sagamya to Pantanaw	Apr. 23 to May 23	52	23	90	...	...	...	52	23	90	188·339	176·575	392	...	...	...	...	..	...	1	6	..	...	2	2	1	1	...	...
No. 6 Detachment.																													
Net line No. 101 Jacobābād to Khānpur (3) (Fore and Back)	Oct. 22 to Jan. 23	194	46	38	13	69	20	208	35	58	818·078	928·423	1934	3	...	3	...	3	...	18	...	2	...	130	34	21	...	9	9
Shāhpur to Mirpur Purāna	May 23 to June 23	53	76	10	5	01	90	58	78	00	239·109	270·587	352	...	...	...	...	...	...	2	...	4	13	1	21	...	...	...	...

TABLE I.—Tabular statement of outturn of work, season 1922-23—(Concld.)

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Main-Line Chs.	Main-Line Lks.	Extras and branch-lines Mls.	Extras and branch-lines Chs.	Extras and branch-lines Lks.	Total Mls.	Total Chs.	Total Lks.	Total number of feet: Rises (feet)	Falls (feet)	Mean number of stations at which the instruments were set up	Number of bench marks connected: Primary: Rock-cut Protected old	Rock-cut Protected new	Standard old	Standard new	Primary stations of triangulation old	Primary stations of triangulation new	Secondary: Embedded old	Embedded new	Rock-cut or Irrigation old	Rock-cut or Irrigation new	Inscribed old	Inscribed new	Tertiary: P. W. D. old	P. W. D. new	Railway old	Railway new
No. 6 Detachment.—(contd.)																													
Landhi to Khipro	May 23 to June 23	47	35	50	0	37	90	47	73	40	166·685	198·650	364	...	...	...	...	...	...	...	12	...	...	3	5	...	...	...	...
Khipro to Ghulām Bhhurgari	May 23	27	14	90	0	58	59	27	73	40	86·984	107·925	224	...	...	...	...	...	...	1	6	...	...	1	14	...	...	...	...
Mīrpur Khās to Tando Ghulām Ali *via* Nabisar	Feb. 23 to April 23	192	50	80	4	75	62	197	46	42	1067·779	1072·320	1626	...	...	...	...	...	1†	2	39	1	...	3	69	...	...	...	...
Mīrpur Khās to Tando-Ghulām Ali *via* Digri	Feb. 23 to April 23	42	60	20	2	02	00	44	62	20	168·629	172 981	372	...	...	...	...	...	...	...	8	...	...	2	26	...	...	...	...
Digri to Dādāh	March 23 to April 23	14	10	10	...	...	...	14	40	10	43·228	50·415	114	...	...	...	...	...	...	...	3	...	...	...	7	...	...	...	...

† Secondary G.T. Station.

TABLE II.—CHECK LEVELLING

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check−original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1922-23	
		At Kasūr					
			miles	*feet*	date	*feet*	*feet*
177	44 I	At catch water tank ...	0·0	0·000	1866-67	0·000	
176	,,	On top of mile stone ...	0·9	+ 0·206	1905-07	+ 0·197	−0·009
175	,,	Embedded, Kasūr ...	1·2	− 1·230	and	− 1·242	−0·012
173	,,	On well ...	1·4	+ 2·924	1913-14	+ 2·905	−0·019
		At Basirpur					
45	44 F	Embedded at Rest House	0·0	0·000	1915-16	0 000	
43	,,	On culvert ...	1·2	− 0·290	,,	− 0·333	−0·043
42	,,	On bridge ...	1·8	− 1·773	,,	− 1·785	−0·012
		At Lodhrān					
58	390	At Police Station ...	0·0	0·000	1914-15	0·000	
59	,,	On bridge ...	0·1	+ 4 868	,,	+ 4·833	−0·035
60	,,	At Rest House ...	0·3	− 0·499	,,	− 0·515	−0·016
61	,,	Embedded, Lodhrān ...	0·3	− 0 813	,,	− 0·833	−0·020
		At Fāzilka					
98	44 J	Embedded, Fāzilka ...	0·0	0·000	1915-16	0·000	
99	,,	Rest House verandah (zinc plate) ...	0·1	+ 5·211	,,	+ 5·208	−0 003
97	,,	On bridge ...	0·3	+ 6·952	,,	+ 6·924	−0·028
96	,,	,, ...	0·7	+ 4·763	,,	+ 4·754	−0·009
95	,,	,, ...	1·5	+ 4·334	,,	+ 4·313	−0·021
		At Khānpur					
15	39 L	Standard, Khānpur ...	0·0	0·000	1860-61	0·000	
17	,,	On bridge No. 2 ...	0·1	+ 1·780	,,	+ 1·762	−0·018
16	,,	On bridge ..	0·2	+ 3·685	,,	+ 3·674	−0·011
18	,,	On stone block ...	0·5	+ 6·602	,,	+ 6·555	−0·047
19	,,	On bridge No. 1 ...	0·8	+ 1·998	,,	+ 2·009	+0·011
14	,,	At *Masjid* ...	0·9	+ 0·365	,,	+ 0·320	−0·045
13	,,	On stone ...	3·2	− 2·814	,,	− 2·836	−0·022
12	,,	,, ...	4·6	− 4·486	,,	− 4·489	−0·003
7	,,	Lālūwāli T. S. ...	6·1	+ 2·852	,,	+ 2·858	+0·006

TABLE II.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check-levelling 1922-23	
		At Ferozepore					
			miles	*feet*	date	*feet*	*feet*
5	44 J	Standard, Ferozepore ...	0·0	0·000	1860-62	0·000	
7	"	At temple ...	0·2	− 1·391	"	− I·398	0·007
6	"	" ...	0·2	+ 1·645	"	+ 1·643	− 0·002
144	"	At Post Office ...	0·6	− 3·091	"	− 3·093	−0·002
145	"	At Rest House ...	0·8	− 0·375	"	− 0·376	−0·001
146	"	On culvert ...	1·5	+ 5·758	"	+ 5·749	−0·009
27	"	Embedded Ferozepore ...	2·9	− 2·683	"	− 2·710	− 0·027
		At Nyaungzaye					
21	85 N	Zinc plate ...	0·0	0·000	1911-12	0·000	
22	"	Embedded ...	0·9	− 4·454	"	− 4·691	−0·237
		At Yandoon					
106	85 O	Iron plug ...	0·0	0·000	1911-12	0·000	
107	"	Embedded ...	0·0	− 4·069	"	− 4·036	+0·033
		At Kandin					
17	85 N	Embedded ...	0·0	0·000	1911-12	0·000	
16	"	Zinc plate ...	2·7	− 15·207	"	− 15·200	+0·007
14	"	Embedded ...	8·2	− 88·813	"	− 88·941	−0·128
12	"	Zinc plate ...	11·2	− 79·584	"	− 79·641	−0·057
		At Ma-ubin					
44	85 P	Embedded ...	0·0	0·000	1911-12	0·000	
43	"	Iron plug ...	0·1	+ 2·746	"	+ 2·740	−0·006
45	"	" ...	1·3	+ 4·020	"	+ 4·048	+ 0·028
46	"	" ...	2·5	+ 3·823	"	+ 3·860	+0·037
47	"	" ...	3·6	+ 2·094	"	+ 2·075	−0·019
48	"	" ...	4·7	+ 3·495	"	+ 3·517	+0·022

TABLE II.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check−original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check-levelling 1922-23	
		At Pantanaw					
			miles	*feet*	date	*feet*	*feet*
7	85 P	Zinc plate ...	0·0	0·000	1912-13	0·000	
6	,,	,, ...	0·1	+ 3·528	,,	+ 3·474	−0·054
3	,,	Iron plug ...	1·0	+ 0·093	,,	+ 0·064	−0·029
4	,,	Embedded ...	1·0	− 2·998	,,	− 3·024	−0·026
		At Bassein					
7	85 L	Verandah ...	0·0	0·000	1911-12	0·000	
8	,,	Step ...	0·1	+ 3·864	,,	+ 3·863	−0·001
10	,,	Standard, Bassein ...	0·3	− 7·015	,,	− 7·016	−0·001
		At Mīrpur Khās					
26	40 G	Iron pipe, Mīrpur khās R.S.	0·0	0·000	1921-22	0·000	
25	,,	Bridge over Mīrpur minor	1·6	+ 5·473	,,	+ 5·437	+0·014
24	,,	Iron pipe Mīrpur Purāna	4·9	− 0·600	,,	− 0·580	+0·020
28	,,	Verandah Ex. Engineer ...	0·9	− 1·294	,,	− 1·288	+0·006
27	,,	,, Civil Hospital	1·6	− 1·183	,,	− 1·176	+0·007
		At Tando Ghulām Ali					
274	40 C	Plinth of School ...	0·0	0·000	1921-22	0·000	...
273	,,	On bridge E. of Tando Ghulām Ali ...	1·4	+ 2·319	,,	+ 2·333	+0·014
272	,,	,, ,, Over Alībar Wāh...	2·0	+ 2·411	,,	+ 2·415	+0·004
		At Khipro					
10	40 G	Verandah, Mukhtiārkar's Office ...	0·0	0·000	1921-22	0·000	...
9	,,	,, ,, ,, ...	0·0	− 0·017	,,	− 0·014	+0·003
8	,,	Sluice, 1 mile W. of Khipro	1·1	− 0·085	,,	− 0·068	+0·017
7	,,	Iron pipe, 3 miles khipro	3·3	+ 0·607	,,	+ 0·650	+0·043
6	,,	Plinth Lūn khā School ...	5·9	+ 7·188	,,	+ 7·274	+0·086

TABLE II.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check-levelling 1922-23	
		At Shāhpur					
			miles	*feet*	date	*feet*	*feet*
99	40B	Step. 1 Bungalow Shāhpur	0·0	0·000	1921-22	0·000	...
100	,,	Bridge Over Canal ,,	0·1	+ 6·535	,,	+ 6·535	0·000
105	,,	Verandah 1, bungalow Khadro ...	3·7	− 2·658	,,	− 2·649	+0·009
106	,,	Bridge over Jāmrao Canal	3·8	+10·368	,,	+10·337	−0 031
		At Mīrpur Purāna					
24	40G	Iron pipe Mīrpur Purāna	0·0	0·000	1921-22	0·000	...
23	,,	Verandah 1, Bungalow 71st mile ...	1·5	+ 2·037	,,	+ 2·127	+0·090
22	,,	Bridge over 71st mile Jāmrao ...	1 6	+14·818	,,	+14·834	+0·016
		At Ahmadnagar					
14	47 I	Standard bench mark Ahmadnagar ...	0·0	0·000	1910-11	0·000	0·000
13	,,	B.M. on stone ...	0·2	− 8·693	,,	− 8·679	+0·014
12	,,	B.M. ,, ,, ...	0·6	−36·166	,,	36·151	+0·015
		At Boribyāl					
16	47 J	E.B.M. at Boribyāl ...	0·0	0·000	1906-07	0·000	0·000
18	,,	G.T.S. O B.M. at bridge ...	0·5	+10·487	,,	+10·484	−0·003
19	,,	G.T.S. O B.M. at bridge ...	1·8	− 9·717	,,	− 9·732	−0·015
		At Gotūr					
60	47 L	E.B.M. at Gotūr ...	0·0	0·000	1877-79	0·000	0·000
63	,,	Bridge No. 95 ...	0·5	−51·498	,,	−51·514	−0·016
64	,,	Coping of bridge No. 96	1·8	−64·013	,,	−64·048	−0 035

TABLE II.—CHECK LEVELLING—(*Concld*).

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check-original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check-levelling 1922-23	
		At Kalādgi					
			miles	*feet*	date	*feet*	*feet*
65	47 P	G.T.S. ○ B.M. (Type C) on rock	0·0	0·000	1910-11	0·000	0·000
66	"	G.T.S. ○ B.M. " bridge 42	0·5	+ 5·522	"	+ 5·523	+0·001
67	"	G.T.S. ○ B.M. " culvert 37	2·1	+35·133	"	+35·101	−0·032
68	"	G.T.S. ○ B.M. " 34	3·2	+35·626	"	+35·592	−0·034
		At Gooty					
195	57 E	B.M. + M.S.L. 1165·71 at Gooty tank	0·0	0·000	1914-15	0·000	0·000
194	"	G.T.S. ○ B.M. on rock	0·3	− 2·688	"	− 2·689	−0·001
183	"	○ on stone pillar	0·4	+ 2·346	1907-08 1914-15	+ 2·341	−0·005
182	"	G.T.S. ○ B.M. at *Chattram* Gooty	0·9	+26·467	"	+26·460	−0·007
180	"	G.T.S. ○ B.M. Munro civil dispensary	1·1	+12·943	"	+12·926	−0·017

TABLE III.—REVISION LEVELLING

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected during revisionary operation.			Distance from starting bench mark	Difference between orthometric heights, above (+) or below (—) the starting bench-mark			Difference (Revision—Original). The sign + denotes that the height was greater and the sign less in 1922-23 than when originally levelled
No.	Degree sheet	Description		From published heights	Date of original levelling	From revision 1922-23 (Unadjusted)	
Revision of Part of branch line No. 57 D (Multān-Bahāwalpur).							
			miles	*feet*	date	*feet*	*feet*
61	39 O	Embedded, Lodhrān ...	0·0	0·000	1914-15	0·000	...
59	"	On bridge ...	0·2	+ 5·681	"	+ 5·666	−0·015
62	"	" ...	0·8	+ 5·845	"	+ 5·839	−0·006
63	"	On culvert ...	1·1	+ 0·030	"	+ 0·039	+0·009
65	"	On bridge ...	2·2	+ 6·458	"	+ 6·458	0·000
69	"	On railway bridge ...	6·4	+17·092	"	+17·073	−0·019
70	"	" ...	7·3	+17·041	"	+17·015	−0·026
22	"	On regulator bridge ...	9·3	+ 1·277	"	+ 1·218	−0·059*
72 (20)	"	At bathing ghāt ...	10·1	+ 1·668	"	+ 1·602	−0·066*
19	"	At guest house ...	10·4	− 0·875	"	− 0·964	−0·089*
18	"	At Municipal office ...	11·3	− 1·655	"	− 1·727	−0·072*
17	"	At Egerton Cottage ...	11·7	− 1·523	"	− 1·571	−0·048
27	"	Standard, Bahāwalpur ...	12·1	− 0·725	"	− 0·757	−0·032
Revision of Part of main line No. 57 (Murghai-Ferozepore).							
98	44 J	Embedded, Fāzilka ...	0·0	0·000	1860-61	0·000	...
99	"	Zinc plate, at Railway Stn.	0·1	+ 5·211	"	+ 5·206	−0·005
104	"	Well at encamping ground	0·3	+ 8·292	"	+ 8·291	−0·001
100	"	Railway culvert ...	1·3	+ 6·954	"	+ 6·966	+0·012
191 (24)	"	Stone B.M. Amira ...	23·9	+33·908	"	+33·893	−0·015
25	"	" " Lakha ...	37·9	+45·694	"	+45·874	+0·180
207 (26)	"	" " Nawankila ...	43·5	+56·592	"	+56·846	+0·254
1	"	" " Ferozepore ...	53·6	+65·831	"	+66·008	+0·177
5	"	Standard, Ferozepore ...	53·9	+70·010	"	+70·217	+0·207

* These old benchmarks all show a slight subsidence, and it is noteworthy that all are inscribed on stone slabs let into existing masonry work, immediately previous to connection. Their published values are not being altered, as this line is being done by the precise system, and any alterations necessary will be made then.

TABLE IV.—*List of Great Trigonometrical Survey stations connected by spirit levelling, season 1922-23*

Name of station		Height above mean sea level			Difference	Remarks
		New spirit levelling	Old spirit levelling	Triangu-lation	Trian.-Lev.	
Jodhpur Meridional Series						
		feet	*feet*	*feet*	*feet*	
Marot	**S.**	539·125	...	542	+ 3	
Jogi Tīla Meridional Series						
Dogra	**T.S.**	560·977	...	562·4	+ 1	Ground floor mark stone
Great Indus Series						
Sarhīn	T.S.	273·306	...	277	+ 4	
Eastern Sind Meridional Series						
Dāowāla	T.S.	254·132	...	260	+ 6	
Umarkot	S.	94·628	...	96	+ 1	Upper mark stone
Sutlej Meridional Series						
Lālūwāli	T.S.	295·851	295·845	297	+ 1	
Burma Coast Series						
Kyedaw	T.S.	68·253	...	68	+ 0	Ground floor mark stone
Kyaingbyingyi	T.S.	88·521	...	86	− 3	Ground floor mark stone

TABLE IV.—(*Concld.*) *List of Great Trigonometrical Survey stations connected by spirit levelling season 1922-23*

Name of station	Height above mean sea level			Difference	Remarks
	New spirit levelling	Old spirit levelling	Triangu-lation	Trian.-Lev.	
Bombay Longitudinal Series					
	feet	*feet*	*feet*	*feet*	
Boribyāl or Bori H.S. λ 18° 25′ 7″·76 L 74° 37′ 48″·09	2002·982	...	2002	−1	On rectangular protecting pillar (most probably upper mark stone)
Mangalore Meridional Series					
Māvinhūnda H.S. λ 16° 25′ 4″·19 L. 74° 47′ 40″·38	2583·130	...	2582	−1	
Madras Meridional and Coast Series					
Ongole H.S. λ 15° 29′ 56″·85 L. 80° 2′ 26″·72	250·072	249·878	249	−1	Upper mark stone

TABLE V.—*Results of comparisons of staves with standard steel tape No. 8, season 1922-23*

Place and date	Difference of length of staves from 10 feet				Remarks
	No. of staff				
	E_1	E_2	B_1	C_1	
	Line Ahmadnagar—Dhond				
Ahmadnagar 4-11-22	−0·003889	−0·002539	−0·002230	−0·001014	Clear
Ghavgāon 20-11-22	−0·002475	−0·000415	−0·000189	+0·000403	do.
Belnandi 1-12-22	−0·000778	−0·000288	+0·000547	+0·000652	do.
Dhond 13-12-22	−0·001862	−0·001310	−0·001194	−0·000460	do.
	Line Gotūr—Kalādgi				
Dhond 13-12-22	−0·001862	−0·001310	−0·001194	−0·000460	Clear
Rāybāg R.S. 29-12-22	−0·003740	−0·002915	−0·001533	−0·001565	...
Hukeri 8-1-23	−0·004772	−0·003622	−0·002947	−0·003072	...
Gotūr 13-1-23	−0·003746	−0·002730	−0·001669	−0·002287	Clear
Mudhol 29-1-23	−0·004875	−0·004573	−0·003738	−0·002725	...
Kalādgi 4-2-23	−0·005772	−0·004172	−0·004065	−0·003681	...
Mudhol 23-2-23	−0·005289	−0·003664	−0·003521	−0·002871	...
Terdal 9-3-23	−0·002956	−0·002484	−0·001985	−0·002064	...
Gooty R.S. 23-3-23	−0·005630	−0·004875	−0·003224	−0·002681	...
	Line Gooty—Ongole				
Gooty R.S. 23-3-23	−0·005630	−0·004875	−0·003224	−0·002681	...
Paniem 16-4-23	−0·003973	−0·003517	−0·002792	−0·002375	...
Nandyāl 7-5-23	−0·007002	−0·006709	−0·005266	−0·005291	...
Velgudu 17-5-23	−0·005458	−0·005790	−0·003504	−0·003950	Clear
Nandyāl 22-5-23	−0·006067	−0·006017	−0·003942	−0·003992	do.
Kalgotta 24-5-23	−0·006363	−0·006197	−0·004497	−0·004151	do.
Gotalgathu 1-6-23	−0·005035	−0·004495	−0·003960	−0·003910	Rain last night
Ongole R.S. 12-6-23	−0·006006	−0·005983	−0·004151	−0·004510	Clear
Ongole R.S. 12-6-23	−0·004738	−0·004638	−0·004006	−0·004040	Scattered clouds

1923-24

The party office closed at Mussoorie on 13th October 1923 and moved to Dehra Dūn. The recess season opened at Mussoorie on 15th April 1924. The Sutlej Group recessed at Dehra Dūn and No. 1 detachment at Maymyo. 186. *Season 1923-24.*

The field organization was as follows:—

(*a*) Sutlej Valley Group under Mr. O. N. Pushong, with field headquarters at Bahāwalpur East. 187. *Field Organization.*

(*b*) No. 1 double detachment (Burma), under Mr. S.C. Mukerjee.

(*c*) No. 2 single net detachment (Punjab), under Mr. Jiya Lal Sahgal.

(*d*) No. 3 single net detachment (Bombay), under Mr. P. B. Roy.

(*e*) No. 4 single net detachment under Mr. N. R. Mazumdar.

(*f*) No. 5 special detachment under Mr. K. K. Das.

The Sutlej Valley Group having already completed its secondary levelling lines, was entirely occupied with tertiary levelling, of which 31,865 linear miles were run, covering 4,795 square miles in the Multān and Ferozepore districts and in the Bahāwalpur State. 188. *Outturn*

No. 1 detachment (Late No. 5) executed 659 miles of secondary double levelling for the Public Works Department (Irrigation) Burma.

No. 2 detachment (Late No. 6) carried out the back levelling of the lines Khānpur-Bahāwalpur and Multān-Jhang, a combined distance of 236 miles. These form part of the line No. 105 of the new net.

No. 3 detachment carried out back levelling from Nakhtrana Mota to Viramgām, part of line No. 104 of the new net; a distance of 449 miles.

No. 4 detachment carried out back levelling from Mārwār Pāli *via* Barmer and Jaisalmer to Govardhanla, part of line No. 102 of the new net; a distance of 290 miles.

No. 5 detachment was occupied under the orders of the Superintendent Trigonometrical Survey, in assisting with a special gravity survey with an Eötvös torsion balance. The work was done for the Burma Oil Company in Sind.

The levelling done was:— 189. *Summary.*

984 miles of primary levelling in the back direction for the new net.

659 miles of secondary levelling for the Burma Government.

31,865 miles (4,795 square miles) of tertiary levelling for the Punjab Government (Sutlej Valley Project). The work is generally satisfactory and outturn good.

Relevelment is still required along small portions of new net lines 101 and 105, of which the back levelling was run in 1922-23 and

189. (*Contd.*) 1923-24 respectively; and of a branch line from new net line 104. The two former lines will be dealt with during the season 1924-25.

The back levelling of line 102 was stopped at Govardhanla by excessive heat and absence of water; leaving 55 miles between that place and Mithra (near Khānpur) to be completed.

190. *The new level net.* Three single detachments are at present engaged in the new net, the primary work of the party. The outturn should average 600 miles per annum of completed main lines. A new line has been added to the programme, from Hyderābād (Sind) to Barmer, and numbered 150. Old line 52 from Sukkur to Hyderābād, will be revised by fore and back levelling of high precision, next field season, and may enter into any future adjustment of the new net.

191. *Details of field work. Sutlej Valley Group, Tertiary levelling.* (*a*) Sutlej Valley tertiary levelling.—Mr. O. N. Pushong held charge in the field. There were five sections to begin with, each of about 14 levellers. One section was disbanded later, the personnel being transferred to other sections.

The Group headquarters office opened at Bahāwalpur East on 15th October 1923 and the recess office under Mr. N. R. Mazumdar, opened at Dehra Dūn on 8th May 1924.

Outturn of tertiary levelling

	Sind and Punjab	Bahāwalpur State	Total
100-acre rectangles	993 sq. miles	931 sq. miles	1,924 sq. miles
25-acre rectangles	1,452 ,,	1,419 ,,	2,871 ,,
Totals	2,445 ,,	2,350 ,,	4,795 ,,

2,236 linear miles of double and 29,629 of single levelling were run, a total of 31,865 miles.

192. *Cost rates.* The cost rates were greatly reduced, through more time being available in the 1923 recess for making arrangements, there being a longer field season, and lastly through there being a greater number of levellers and computers under approximately the same central staff.

Comparison of cost rates

Date	Field work		Recess work		Total		Remarks
	100-acre	25-acre	100-acre	25-acre	100-acre	25-acre	
1922-23	RS. 23·8	RS. 47·5	RS. 4·4	RS. 8·8	RS. 28·2	RS. 56·3	Excluding percentages for supervision and cost of instruments.
1923-24	17·9	35·7	3·0	6·0	20·9	41·7	

These figures exclude the cost of fair drawing which was done by No. 2 Drawing Office. 192. *(Contd.)*

The officer in charge was able to devote over half his time to visiting the sections and various officials of the Bahāwalpur State and of the Sutlej Valley Project. A field computing section was instituted at the group headquarters, consisting of an upper subordinate officer and three computers. The field sheets as received from the levellers were at once computed to mean sea level height, so that work in recess was correspondingly expedited. This prevented undue delay in furnishing data to No. 2 Drawing Office for fair drawing the 4-inch charts. 193. *Computation in field.*

Statement of field work

Section No.	Officer in charge	No. of levellers	Date of commencement of work in blocks	Date of completion in block	Area in square miles		
					100 acre	25-acre	Total
1	B. Mohammad Ishaq Khan 1 Camp recorder	13 increased to 17 in January	Block R″ 28th Oct.	Block T¹ 26th April	236	543	779
*2	S. Nayar Hasan 1 Camp recorder	14	Block M 15th Oct.	—	—	349	349
3	Mr. H. K. Kar 1 Camp recorder increased to 2 in February	13 increased to 19 in January	Block S 17th Oct.	Block J 20th April	914	710	1624
4	B. Mohd. Faizul Hasan 1 Camp recorder	14 increased to 16 for 1 month	Block N 15th Oct.	Block T¹ 26th April	377	682	1059
5	Mr. Abdul Majid up to January Syd. Nayar Hasan from February 1 Camp recorder	14 increased to 16 in January	Block B″ 23rd Oct.	Block T¹ 26th April	397	587	984

Nos. 1 and 5 sections had difficult country, with much reed and thorn bushes, and it necessitated line clearing, as the rectangulation party had not cut any East-West lines. No. 2 section was disbanded owing to the shortage of qualified supervising officers, when one of them had to go on sick leave. 194. *Different sections and country and the sub rectangulation party.*

Some inconvenience was felt when the subrectangulators who break down the 100-acre rectangles for the 25-acre portions of the survey, were not kept sufficiently in advance of the levellers; some of whom had consequently to be shifted to other areas, to avoid their being kept only spasmodically occupied. This should not be necessary. The subrectangulation is unfortunately the work of an agency independent of

* No. 2 section was disbanded in January.

194. (*Contd.*) the Survey of India, though working on No. 23 Party's field marks and providing further marks which No. 17 Party must use. Steps have been taken to urge more speed and to try to obtain more frequent information as to subrectangulation progress. It is presumed that the Bahāwalpur State subrectangulation has been going forward during the summer.

The recess work consisted of :—

(*i*) completing the reduction of field heights to mean sea level,

(*ii*) compiling books of heights for the Chief Engineer, Sutlej Valley Project,

(*iii*) compiling manuscript charts of heights for No. 2 Drawing Office. All work was finished by the end of September 1924.

The copying of a duplicate set of books for departmental use was discontinued, as the new charts contain the information in a more convenient form.

195. *The charts.* These charts are briefly referred to in § 162. The fair drawing has been taken over by No. 2 Drawing Office. Each chart contains all the bench marks and tertiary heights falling in its area.

196. *Burma secondary levelling.* No. 1 detachment (Mr. S. C. Mukerjee in charge, P. John second leveller, two recorders and twenty-six menials) left Dehra Dūn for the field on 6th October 1923, commencing work at Kyaukse on 24th October 1923. Work closed at Natchaung (Moulmein) on 28th May 1924, and the detachment proceeded to recess in Maymyo on 2nd June 1924. The season's work consisted of secondary double levelling for the P.W.D. (Irrigation). The bench marks were provided by that department after their own pattern. The resulting heights were sent to the officials concerned by the end of recess. They will not be published in the pamphlets, being derived from secondary levelling only, but communicated to the Director Burma Circle, for departmental use.

Secondary levelling in Burma, season 1923-24 196. (*Contd.*)

Line	Miles	p.e. per mile	Number of bench marks	Remarks
(*a*) Kyaukse to Minzu	62	±0·0030	49 secondary	(Permissible limit of p.e. for primary simultaneous double levelling is ±0·0042 ft. per mile) N.B.—It is to be remembered that these figures are derived only from differences between levellers from bench mark to bench mark and that secondary field methods having been used. These figures of p.e. cannot class any line as of other than secondary precision.
(*b*) Ywakainggyi to Amarapura ...	97	±0·0029	46 "	
(*c*) Kyaukse to Mandalay	107	±0·0030	55 " & 1 primary	
(*d*) Meiktila to Yewe...	50	±0·0025	28 secondary & 2 primary	
(*e*) Kyauktaga to Myitkyo	80	±0·0023	65 secondary & 1 primary	
(*f*) Dalanun to Pazunmyaung ...	37	±0·0019	27 secondary	
(*g*) Moulmein to Pa-an	42	±0·0034	23 " & 1 primary	
(*h*) Moulmein to Wekali	24	±0·0025	7 secondary & 1 primary	
(*i*) Ba-Bu-Kon to Kawmyat Kyi ...	78	±0·0022	33 secondary & 1 primary	
(*j*) Nyaungbinzeik to Natchaung ...	82	±0·0017	38 secondary	
Total ...	659			

The outturn is good especially as the lines were scattered over a large area of country, including the coastal tract in Amherst and Thaton.

The health of the detachment was generally good.

The recess in Maymyo was undertaken with a view to lessening expense. The saving effected is roughly Rs. 500, assuming that for a recess in Mussoorie, a field *khamal* would be kept in Burma. On the whole it seems disadvantageous.

Levelling on line 105 of the new net of India.—No. 2 detachment (Mr. Jiya Lal Sahgal in charge, one recorder and fifteen menials) left Dehra Dūn on 26th October 1923, and commenced work at Jhang-Maghiāna on 31st October 1923. It closed at Khānpur on 18th February 1924, when the personnel joined the Sutlej Valley Group. 197. *Levelling on the new net of India.*

197. *(Contd.)* The work consisted of the back levelling from Jhang-Maghiāna to Multān, and from Bahāwalpur to Khānpur. The old bench marks being mainly found unaltered in height, the computations have been carried out as for a revision. The heights (outside 1/M sheet 44) have not been finally computed, owing to relevelment of some short stretches being left over till the field season 1924-25 for No. 4 detachment. For this reason also the probable error of the line does not at present satisfy the requirements of levelling of high precision.

198. *Instruments.* The outturn is shown in Table No. VI. The instruments were Binocular level No. 6728, staves Nos. 20A and 20B, and standard steel tape No. 3.

The health of the detachment was good.

199. *Net line, relevelment and probable accidental and systematic error.* Line 104.—No. 3 detachment (Mr. P. B. Roy in charge, one recorder and fifteen menials) left Dehra Dūn on 8th October 1923, and commenced work at Nakhtrana Mota, Cutch, on 25th October 1923. It closed at Viramgām on 19th June 1924, and proceeded to Mussoorie.

The work consisted of back levelling throughout.

Further relevelment is required on a branch line near Anjār, Cutch, which was run at the request of the Geological Survey, and which crosses a known fault in a tract subject to earthquakes. This relevelment may be done in 1925-26.

The probable accidental error of the line

$$\eta_r^2 = \frac{1}{9}\left(\frac{\Sigma\Delta^2}{\Sigma L} - \frac{\Sigma r^2}{(\Sigma L)^2} \cdot \Sigma \frac{S^2}{L}\right) \text{ is } \pm 0\cdot00370 \text{ ft.}$$

And probable systematic error

$$\sigma_r^2 = \left(\frac{1}{9\Sigma L} \cdot \Sigma \frac{S^2}{L}\right) \text{ is } \pm 0\cdot000324 \text{ ft.}$$

both being within the limits for high precision levelling.

200. *Instruments, weather and health.* The outturn is shown in Table No. VI. The instruments were Zeiss pattern level No. 16298, staves Nos. 16A and 16B, and standard steel tape No. 7.

High winds caused much inconvenience during levelling.

The health of the detachment was fairly good; there was some sickness among the *khalasis* owing to heat and water scarcity, towards the end of the field season.

The heights have been adjusted between Nakhtrana Mota and Rājkot standard bench marks, and between Rājkot and Viramgām.

201. *Net work Marwar Pali Govardhanla.* Line 102.—No. 4 detachment (Mr. N. R. Mazumdar in charge, one recorder and fifteen menials) commenced work at Mārwār Pāli on 26th November 1923, (being delayed by late posting of Mr. N. R. Mazumdar) and closed at Govardhanla on 30th April 1924, leaving a gap of 55 miles between there and Mithra, near Khānpur. This was necessitated by extreme heat which rendered the *khalasis* unfit for work, and by the impossibility, at that season, of procuring local labour.

The work consisted of back levelling throughout. The probable errors for the line accidental and systematic, are $\pm 0\cdot00413$ and $\pm 0\cdot00018$ ft. per mile respectively, which satisfy high precision requirements. 201. *(Contd.)*

The outturn is shown in Table No. VI. The instruments were Zeiss pattern level No. 16313, staves Nos. 19A and 19B, and standard steel tape No. 4. 202. *Instruments and weather.*

Heat, storms and lack of water delayed the work after mid April; until then the health of the detachment was good.

The number of the triangulation stations connected by levelling is shown in Table No. VIII.

With a view to further construction of standard bench marks, and to avoid having to run long lines of levels to connect them, many inscribed bench marks were put down and observed at Jhang-Maghiāna, Bhūj, Jorya, Wadhwān, Barmer and Jaisalmer.

The details of the work of old No. 4 detachment in 1922-23 in Bombay and Madras are given in Tables VI, VII.

Squads have been reduced to 26 menials for a double, and 15 for a single detachment including personal men. The extra recorders have also been abolished. 203. *Squads.*

Investigation of the frequency of relevelling during the back levelling of net lines during the last few years, shows that 38°/₀ of the mileage has had to be relevelled in the field; for two thirds of this, the fore leveller's values were discarded. The first inference is that the fore leveller's work ought to be made more accurate. He has no running check during the field work on his observed heights, as the back leveller has. In future, therefore, every leveller on a high precision line must at each station obtain two sets of readings giving values of rise or fall within $0\cdot003$ ft. instead of $0\cdot004$ ft. 204. *Investigation with frequency of relevelling.*

One alternative reason for so much of the fore levelling having to be rejected, might be the movements of bench marks in the period of time elapsed between the observations. Bench marks are usually built before the monsoon rains in order that the fore levelling in the following cold weather may find them settled into stable positions. The one or two rainy seasons intervening before the back levelling might in wet countries, defeat this intention; but in dry areas as well the fore levelling is discarded much more often than the back levelling.

The levelling policy of the future has been under reconsideration. A great number of standard bench marks are to be erected, and as in the past these will be properly maintained. The preservation of other bench marks is considered to be the work rather of local engineers who derive the main benefit from them. There will be required in India a total of over 600 standard bench marks. The question still remains whether the new net lay-out will be discarded, and the high precision 205. *Levelling policy.*

205. (*Contd.*) levelling programme be governed by the necessity, from year to year, for lines connecting these new standards to existing level lines.

A new type of standard bench mark is being designed with a view to curtailing expense, and to providing concealed subsidiary marks, in addition to the point of reference for public use.

In the meantime, the new net is being advanced in 1924-25 by the fore levelling from Karāchi to Barmer. The remaining levelling of high precision is being run partly for local irrigation purposes and partly for the purpose of fixing standards; of which 6 of the old type and 23 of a provisional design for smaller towns are for immediate construction. The standard bench mark at Sādikganj was provided with its slab showing height above mean sea level.

206. *History of Indian high precision levelling.*

A report was written for the International Geodetic and Geophysical Union 1924, giving the history in brief of Indian high precision levelling since its introduction just before the war.

Preliminary steps have been taken towards the reconnaissance of a route over which might be run a connecting line between the level systems of India and Burma.

207. *Handbook of levelling and other Publications.*

The Handbook "Levelling of Precision" 1920, has been revised with a view to republication. A form has been printed for use in bar tape comparisons at Dehra Dūn. A new form was devised and printed for use as a field sheet of Sutlej Valley tertiary levelling. The following press copies were sent to press.

Pamphlet for 1/M Sheet 44.

Correction slips sent to press

Line	Degree sheet
33 B	47 I and J
14 A	57 E, 57 I, 57 M and 66 A
14 B	57 I

The arrears of publication are :—

Jacobābād to Jhang (requires relevelments in 1924-25; portion in 1/M sheet 44 sent to press). Manmād to Ahmadnagar (awaits check levelling near Manmād. Ahmadnagar to Dhond, and Poona to Ahmadnagar will then require readjustment and republication). Surat-Dhūlia (fore levelling only as yet). Mārwār Pāli-Khānpur (back levelling will be completed next season). Branch line at Anjār (Cutch) requires some relevelling.

TABLE VI.—*Tabular statement of outturn of work, season 1923-24*

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Chs.	Lks.	Extras and branch-lines Mls.	Chs.	Lks.	Total Mls.	Chs.	Lks.	Total number of feet: Rises feet	Falls feet	Mean number of stations at which the instruments were set up	Number of bench marks connected: Primary: Rock-cut Protected old	new	Standard old	new	Primary stations of triangulation old	new	Secondary: Embedded old	new	Rock-cut or Irrigation old	new	Inscribed old	new	P. W. D. old	new	Railway old	new
No. 1 Detachment.																													
Kyaukse-Minzu	October	16	56	30	0	48	50	17	24	80	178·558	93·968	156	...	...	...	...	...	...	1	2	...	...	...	14	...	1	...	...
	& Nov.	39	32	70	5	42	00	44	74	70	335·404	410·191	424	...	...	...	...	...	...	1	3	...	...	2	18*	...	8	...	...
Ywakainggyi-Amarapura	November	32	41	90	5	66	80	38	28	70	253·536	239·737	318	...	...	...	...	...	...	2	1	...	...	6	14	...	...	...	...
	& Dec.	58	26	80	...	...	...	58	26	80	693·872	820·477	536	...	...	...	...	...	...	1	4	...	...	3	15	...	...	...	...
Meiktila-Yewe	December	20	00	90	0	57	10	20	58	00	372·943	568·442	242	...	...	1	...	...	1	2	2	...	...	...	12	...	1	...	...
	& Jan.	21	43	30	7	79	40	29	42	70	129·618	338·645	224	...	...	...	...	...	...	...	5	...	...	...	6	...	...	...	...
Kyaukse-Mandalay	October,	4	27	50	...	...	...	4	27	50	381·979	435·997	32	...	...	...	...	...	...	2	...	...	...	2	...	...	...	...	...
	January &	60	66	20	31	69	70	92	55	90			754	...	...	...	...	...	...	*	14	...	...	*	15	...	20	...	...
	February	9	39	30	0	44	40	10	03	70	79·578	51·651	74	...	...	1	...	...	...	1	...	...	...	1	2	...	...	...	..
Kyauktaga Myitkyo	February	69	19	20	5	66	80	75	06	00	458·977	517·373	626	...	...	...	...	...	1	2	14	...	...	3	41	...	1	...	...
	& March	4	21	20	0	66	00	5	07	20	22·821	19·637	44	...	...	...	...	...	...	1	2	...	...	1	...	...	...	...	...
Dalanun-Pazunmyaung	March	33	01	90	4	33	90	37	35	80	181·008	169·630	298	...	...	...	...	...	...	1	6	...	...	2	5	...	13	...	..
Moulmein-Pa-an	March &	32	65	40	3	19	70	36	05	10	220·805	211·790	290	...	...	...	...	...	...	...	4	...	...	...	13	...	2	...	...
	April	5	74	80	...	...	...	5	74	80	116·192	161·714	70	...	...	1	...	...	...	...	1	...	...	2	1	...	...	...	...
Moulmein-Wekali	April	24	04	40	...	...	...	24	04	40	112·654	172·496	172	...	...	1	...	...	...	...	3	...	...	...	4	...	...	...	...

* Check levelling.

TABLE VI.—*Tabular statement of outturn of work, season 1923-24*—(*Contd.*)

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Main-Line Chs.	Main-Line Lks.	Extras and branch-lines Mls.	Extras and branch-lines Chs.	Extras and branch-lines Lks.	Total Mls.	Total Chs.	Total Lks.	Total number of feet: Rises (feet)	Falls (feet)	Mean number of stations at which the instruments were set up	Number of bench marks connected: Primary: Rock-cut / Protected old	Rock-cut / Protected new	Standard old	Standard new	Primary stations of triangulation old	Primary stations of triangulation new	Secondary: Embedded old	Embedded new	Rock-cut or Irrigation old	Rock-cut or Irrigation new	Inscribed old	Inscribed new	P. W. D. old	P. W. D. new	Railway old	Railway new
No. 1 Detachment. —(contd.)																													
Ba-Bu-kon-Kawmyat-kyi	April &	53	17	20	20	44	70	73	61	90	148·270	154·840	542	...	...	...	...	...	1	...	8	...	...	...	23	...	...	...	...
	May	3	64	40	...	...	...	3	64	40	35·365	34·135	26	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...
Nyaungbinzeik-Natchaung	May	65	48	40	15	77	30	81	45	70	585·472	575·380	726	...	...	...	...	...	...	...	10	...	...	...	23	...	...	...	...
No. 2 Detachment.																													
Jhang to Multān	November	48	18	84	1	57	50	49	76	34	186·707	232·179	516	...	...	..	...	...	...	9	...	...	...	41	3	...	...	...	...
	December	17	43	70	32	31	50	49	75	20	212·848	254·667	498	...	..	...	...	...	...	5	...	1	..	45	...	...	...	1	...
Bahāwalpur to Khānpur	January	65	19	90	3	14	60	68	34	50	310·232	377·810	694	...	...	2	...	1	...	3	...	...	...	52	...	1	...	7	...
	February	64	56	20	3	38	10	68	14	30	169·990	227·033	646	...	...	1	...	1	...	...	...	...	...	41	3	...	...	2	...
No. 3 Detachment.																													
"Fore and Back" Viramgām to Nakhtrana Mota (Part of Viramgām-Tatta)	October	6	51	10	...	...	...	6	51	10	159·065	236·969	132	...	...	...	...	...	...	1	...	...	2	2	2	...	...	...	..
	November	26	16	40	28	52	70	54	69	10	528·933	518·147	872	...	4	...	...	...	1	3	...	3	7	8	30	...	...	...	...
	December	33	31	50	5	46	90	38	78	40	680·997	965·191	490	...	1	...	...	...	...	4	...	1	1	15	8	...	...	...	...
	January	35	72	80	22	46	00	58	38	80	563·757	545·315	694	...	2	...	...	1	...	2	...	...	8	5	16	...	...	...	...

TABLE VI.—Tabular statement of outturn of work, season 1923-24—(Contd.)

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Main-Line Chs.	Main-Line Lks.	Extras and branch-lines Mls.	Extras and branch-lines Chs.	Extras and branch-lines Lks.	Total Mls.	Total Chs.	Total Lks.	Total number of feet: Rises feet	Falls feet	Mean number of stations at which the instruments were set up	Primary: Rock-cut Protected old	Rock-cut Protected new	Standard old	Standard new	Primary stations of triangulation old	Primary stations of triangulation new	Secondary: Embedded old	Embedded new	Rock-cut or Irrigation old	Rock-cut or Irrigation new	Inscribed old	Inscribed new	P. W. D. old	P. W. D. new	G.T.S. Secondary old	G.T.S. Secondary new
No. 3 Detachment.—(contd.)																													
"Fore and Back" Viramgām to Nakhtrana Mota (Part of Viramgām-Tatta).	February	77	01	70	4	72	60	81	74	30	865·455	943·171	976	...	2	...	...	3	...	7	...	...	4	1	14	...	...	...	...
	March	64	53	50	11	40	20	76	13	70	957·194	558·375	950	1	1	1	...	...	...	10	...	...	5	15	32	...	...	1	...
	April	53	35	30	...	...	...	53	35	30	774·427	867·202	624	...	...	...	...	...	...	5	...	...	13	3	15	...	...	...	...
	May	31	69	70	3	39	90	35	29	60	72·234	320·601	494	...	...	...	...	1	...	3	...	...	4	5	34	...	...	1	...
	June	17	62	20	25	29	90	43	12	10	99·372	88·648	478	...	...	...	...	1	...	3	...	...	...	8	20	...	...	...	...
No. 4 Detachment.																													
Mārwār Pāli to Govardhanla	Nov.	11	30	50	...	...	...	11	30	50	46·714	103·143	120	...	...	...	...	...	...	2	...	...	...	6	...	...	...	...	...
	December	47	44	00	1	76	46	49	40	46	127·154	344·371	540	...	...	...	...	...	...	2	2	...	1	7	29	...	...	1	...
	January	74	39	10	...	...	...	74	39	10	559·475	445·753	780	...	...	...	...	...	...	...	8	...	...	...	60	...	...	...	...
	February	26	48	20	8	05	40	34	53	60	319·079	159·999	464	...	...	...	...	...	...	...	8	...	2	...	39	...	...	1	...
	March	68	16	20	3	32	50	71	48	70	1165·395	1004·675	906	...	...	...	...	...	...	...	3	...	3	...	41	...	...	1	...
	April	56	52	50	0	62	50	57	35	00	535·991	1001·922	662	...	1	...	...	...	...	...	2	...	20	...	4	...	...	...	...

TABLE VI.—Tabular statement of outturn of work, season 1923-24—(Concld.)

Detachments and Lines levelled	Months	Distance levelled									Total number of feet		Mean number of stations at which the instruments were set up	Number of bench marks connected															
		Main-Line			Extras and branch-lines			Total			Rises	Falls		Primary						Secondary									
														Rock-cut	Protected	Standard		Primary stations of triangulation		Embedded		Rock-cut or Irrigation		Inscribed		M. W. S.		P.W.D.	
		Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	feet	feet		old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new
No. 4 Detachment.—(contd.)																													
Ahmadnagar† to Dhond	November	48	58	40	0	46	00	49	24	40	1222·742	1604·493	756	...	...	1	...	1	2	4	...	1	3	12	56	2	...	...	...
	December	2	78	50	19	22	80	22	21	30	23·007	129·118	330																
	December	...	...	...	21	16	00	21	16	00	364·938*	138·513*	238																
Gotūr † to Kalādgi	January	46	51	70	47	28	22	93	79	92	{ 1103·851* 1308·806	1337·797* 1361·369 }	1292	1	...	...	...	1	...	1	17	...	6	9	135	...	...	...	1
	February	44	55	00	10	09	40	54	64	40	{ 733·795* 1071·919	319·516* 1389·159 }	834																
	March	...	...	...	36	03	50	36	03	50	904·575*	978·130*	744																
Gooty † to Ongole	March	15	70	30	2	10	00	18	00	30	378·875	156·229	168																
	April	111	46	90	...	...	...	111	46	90	1853·077	2922·801	362	...	1	...	...	1	...	3	20	1	43	11	118	...	...	...	1
	May	27	52	50	35	57	10	63	29	60	{ 468·727 1065·747	232·979 785·795 }	936																
	June	49	30	10	...	...	...	49	30	10	632·735	1201·168	550																

† The work of these lines was carried out by old No. 4 detachment in 1922-23. * Branch lines.

TABLE VII.—CHECK LEVELLING

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1923-24	
		At Kyaukse					
			miles	*feet*	date	*feet*	*feet*
30	93 C	E.B.M. Kyaukse ...	0·00	0·000	1903-04	0·000	...
32	"	Bridge ...	0·98	− 6·287	"	− 6·239	+0·048
33	"	" ...	1·60	− 6·710	"	− 6·680	+0·030
35	"	E.B.M. Belin ...	4·24	−14·612	"	−14·821	−0·209
		At Minzu					
26	93 C	E.B.M. Minzu ...	0·00	0·000	1903-04	0·000	...
24	"	Bridge ...	2·48	+ 4·665	"	+ 4·674	+0·009
27	"	" ...	1·78	+ 1·546	"	− 1·535	+0·011
		At Samon					
8	93 C	Pipe ...	0·00	0·000	1903-04	0·000	...
9	"	Bridge ...	1·17	− 7·098	"	− 7·034	+0·064
10	"	Culvert ...	2·07	−13·553	"	−13·455	+0·098
11	"	E.B.M. Samon ...	3·36	−26·587	"	−26·681	−0·094
12	"	Bridge ...	4·23	−43·973	"	−43 973	0·000
7	"	Pipe ...	1·26	+11·530	,	+11·514	−0·016
5	"	E.B.M. Thedaw ...	3·56	+32·511	"	+32·299	−0·212
13	"	Pipe ...	6·70	−58·213	"	−58·347	−0·134
		At Amarapura					
68	93 C	Pillar ...	0·00	0·000	1902-04	0·000	...
67	"	Signal ...	1·22	−44·967	1909-10	−45·206	−0·239
66	"	Embedded ...	1·25	−45·377	"	−45·581	−0 204
63	,	Verandah ...	3·95	−34·916	"	−34·979	−0·063
		At Mandalay					
2	93 B	Standard ...	0·00	0·000	1903-04	0·000	...
5	"	Culvert ...	1·02	−10·847	"	−10·804	+0·043
56	"C"	Embedded ...	1·37	−10·404	"	−10·373	+0·031

TABLE VII.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check−original) The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1923-24	
				At Meiktila			
			miles	*feet*	date	*feet*	*feet*
12	84 P	Standard ...	0·00	0·000	1902-03	0·000	...
13	"	Embedded ...	0·32	+ 0·459	"	+ 0·486	+0·027
11	"	" ...	0·65	− 5·572	"	− 5·537	+0·035
				At Kyauktaga			
12	94 B	Bridge ...	0·00	0·000	1909-10	0·000	...
15	"	Embedded ...	2·12	− 1·171	"	− 1·516	+0·345
19	"	Bridge ...	5·04	+ 5·267	"	+ 5·245	−0·022
20	"	Culvert ...	6·61	+11·834	"	+11·791	−0·043
22	"	Embedded ...	7·63	+18·892	"	+18·719	−0·173
				At Myitkyo			
111	94 C	Embedded ...	0·00	0·000	1912-13	0·000	...
112	"	Lock ...	0·01	− 1·709	"	− 1·679	+0·030
				At Pyuntaza			
86	94 C	Embedded ...	0·00	0·000	1909-10	0·000	...
87	"	Well ...	0·08	+ 2·319	"	+ 2·400	+0·081
95	"	Step ...	4·82	− 0·400	"	− 0·140	+0·260
				At Moulmein			
24	94 H	Standard ...	0·00	0·000	1913-14	0·000	-
22	"	Verandah ...	1·12	−47·227	"	−47·223	+0·004
21	"	" ...	1·14	−49·487	"	−49·480	+0·007
				At Khānpur			
22	39L	Bridge 477 ...	0·0	0·000	1909-10	0·000	...
19	"	Bridge No. 1 ...	1·7	+1·006	"	+1·047	+0·041
18	"	Khānpur R.S. ...	2·0	+5·610	"	+5·577	−0·033
17	"	Bridge No. 2 ...	2·3	+0·768	"	+0·791	+0·023
15	"	Standard ...	2·5	−0·992	"	−0·967	+0·025

TABLE VII.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above(+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree Sheet	Description		Original levelling		Check levelling 1923-24	
At Bahāwalpur							
			miles	*feet*	date	*feet*	*feet*
27	39 O	Standard ...	0·0	0·000	1860-61	0·000	...
73	"	Record office ...	0·1	−3·426	and	−3·449	−0·023
18	"	Municipal office ...	0·8	−0·930	1914-15	−0·978	−0·048
19	"	Guest house ...	1·7	−0·150	"	−0·218	−0·068
20	"	Bathing ghat ...	2·0	+2·393	"	+2·333	−0·060
21	"	Godri T. S. ...	2·7	−1·986	"	−2·056	−0·070
At Jhang-Maghiāna							
71	44 A	Sessions house ...	0·0	0·000	1911-12	0·000	..
70	"	Bridge ...	0·3	+6·139	and 1912-13	+6·154	+0·015
At Viramgām							
1	46 A	Embedded ...	0·0	0·000	1875-76	0·000	...
7	"	Hāsalpur T.S. ...	3·9	+43·279	"	+43·394	+0·115
4	"	Bridge No 2 ...	2·1	+ 2·600	"	+ 2·260	−0·340
3	"	" 3 ...	2·9	+ 0·954	"	+ 0·930	−0·024
2	"	" 4 ...	3·9	− 1·136	"	− 1·162	−0·026
42	41 M	" 5 ...	4·4	− 1·602	"	− 1·337	+0·265
41	"	" 7 ...	4·9	− 2·464	"	− 2·488	−0·024
38	"	" 11 ...	7·0	− 9·888	"	− 9·879	+0·009
37	"	" 12 ...	7·7	−11·549	"	−11·423	+0·126
35	"	E.B.M. Jhund R S. ...	8·4	−15·615	"	−15·526	+0·089
At Rājkot							
75	41 J	Embedded ...	0·0	0·000	1890-91	0·000	...
42	"	Clock Tower ...	0·3	+11·493	1909 10	+11·506	+0·013
76	"	Standard ...	0·4	+19·061	"	+19·089	+0·028
77	"	Boundary pillar ...	0·7	+ 1·505	"	+ 1·528	+0·023
78	"	(Type C) ...	1·1	− 4·549	"	− 4·532	+0·017

TABLE VII.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check−original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1923-24	
			miles	*feet*	date	*feet*	*feet*
		At Nakhtrana Mota					
37	41E	E.B.M. at Nakhtrana ...	0·0	0·000	1889-90	0·000	..
39	„	Trikamdās-kā-dehri ...	...	+72·384	„	+72·359	−0·025
		At Mārwār Pāli					
17	45G	E.B.M. ...	0·0	0·000	1907-08	0·000	...
16	„	M.S. 182 ...	0·3	+ 1·459	& 1909	+ 1·460	+0·001
15	„	„ 180 ...	2·3	− 2·605	„	− 2·579	+0·026
14	„	„ 178 ...	4·0	−15·004	„	−14·963	+0·041
		At Ahmadnagar *					
14	47 I	Standard ...	0·0	0·000	1910-11	0·000	...
13	„	Stone ...	0·2	− 8·693	„	− 8·679	+0·014
12	„	„ ...	0·6	−36·166	„	−36·151	+0·015
		At Boribyāl *					
16	47 J	Embedded ...	0·0	0·000	1906-07	0·000	...
18	„	Bridge ...	0·5	+10·487	„	+10·484	−0·003
19	„	„ ...	1·8	− 9·717	„	− 9·732	−0·015
		At Gotūr *					
60	47 L	Embedded ...	0·0	0·000	1877-78 & 79	0·000	...
63	„	Bridge No. 95 ...	0·5	−51·498	„	−51·514	−0·016
64	„	„ „ 96 ...	1·8	−64·013	„	−64·048	−0·035

* The work was done by old No. 4 detachment in 1922-23.

TABLE VII.—CHECK LEVELLING—(*Concld.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1923-24	
				At Kalādgi*			
			miles	*feet*	date	*feet*	*feet*
65	47 P	(Type C) Rock ...	0·0	0·000	1910-11	0·000	...
66	,,	Bridge No. 42 ...	0·5	+ 5·522	,,	+ 5·523	+ 0·001
67	,,	,, ,, 37 ...	2·1	+ 35·133	,,	+ 35·101	− 0·032
68	,,	Culvert ,, 34 ...	3·2	+ 35·626	,,	+ 35·592	− 0·034
				At Gooty*			
95	57 E	Tank ...	0·0	0·000	1914-15	0·000	...
94	,,	Rock ...	0·3	− 2·688	..	− 2·689	− 0·001
83	,,	Pillar ...	0·4	+ 2·346	1907-08 1914-15	+ 2·341	− 0·005
82	,,	*Chattram* ..	0·9	+ 26·467	,,	+ 26·460	− 0·007
80	,,	Civil dispensary ...	1·1	+ 12·943	,,	+ 12·926	− 0·017

* The work was done by old No. 4 detachment in 1922-23.

TABLE VIII.—*List of Great Trigonometrical Survey stations connected by spirit levelling, season 1923-24*

Name of station		Height above mean sea level			Difference	Remarks
		New spirit levelling	Old spirit levelling	Triangu-lation	Trian-Lev.	
Mandalay Meridional Series						
		feet	*feet*	*feet*	*feet*	
Taungnyo	H.S.	981·883		981	−1	Upper mark stone
Lat. 21° 3′ 49″·19 Long. 95 49 56·89						
Burma Coast Series						
Gyongyongya	H.S.	285·646		291	+5	do.
Lat. 17° 39′ 54″·31 Long. 96 54 39·82						
Shwesandaw	H.S.	316·720		322	+5	do.
Lat. 16° 37′ 4″·63 Long. 97 59 22·84						
Sutlej Series						
Godri	H.S.	378·898	378·992	381	+2	Ground floor mark stone
Lat. 29° 25′ 2″·00 Long. 71 40 24·13						
The Gujarāt Longitudinal Series						
Hāsalpur	T.S.	132·964	132·821	134	+1	Upper mark stone
Lat. 23° 5′ 3″·88 Long. 72 4 33·11						
Ingrodi	T.S.	141·581		142	+1	Middle mark stone
Lat. 22° 57′ 7″·58 Long. 71 48 34·12			151·018	152	+1	Upper mark stone

TABLE VIII.—*List of Great Trigonometrical Survey stations connected by spirit levelling, season 1923-24*—(*Contd.*)

Name of station	Height above mean sea level: New spirit levelling	Old spirit levelling	Triangulation	Difference Trian-Lev.	Remarks
The Kāthiāwār Minor Meridional Series					
	feet	*feet*	*feet*	*feet*	
Chamārej H.S. Lat. 22° 43′ 59″·22 Long. 71 34 32·89	329·088	331·101	332*	+3	Lower mark stone connected as upper mark was loose and shaky.
The Kāthiāwār Meridional Series					
Bālambha T.S. Lat. 22° 44′ 19″·13 Long. 70 25 36·41	85·882	86·157	87*	+1	Upper mark stone
Vāndhia S. Lat. 23° 14′ 44″·22 Long. 70 36 51·41	115·491	115 846	116	+1	Top of rectangular pillar
The Cutch Coast Series					
Bhachāu H.S. Lat. 23° 17′ 58″·16 Long. 70 20 47·93	302·860	303·148	301*	−2	Upper mark stone
Sukhpur H.S. Lat. 23° 16′ 49″·77 Long. 70 9 51·99	356·480	356·636	357	+1	do.
Charakda H.S. Lat. 23° 9′ 3″·84 Long. 69 59 28·34	417 620	417·958	419	+1	do.
Mundra T.S. Lat. 22° 50′ 32″·04 Long. 69 43 24·77	78·326	78·914	80*	+2	do.
Sāmatra H.S Lat. 23° 9′ 48″·79 Long. 69 30 47·53	963·486		964	+1	do.

* This value is obtained by old spirit levelling done in conjunction with the triangulation.

TABLE VIII.—*List of Great Trigonometrical Survey stations connected by spirit levelling, season 1923-24*—(*Concld.*)

Name of station	Height above mean sea level: New spirit levelling	Old spirit levelling	Triangulation	Difference Trian-Lev.	Remarks
Jodhpur Meridional Series					
	feet	*feet*	*feet*	*feet*	
Mandai h.s. Lat. 26° 20′ 59″·81 Long. 71 10 36·23	1115·246		1110	−5	Ground floor mark stone
Nimla h.s. Lat. 26° 3′ 9″·56 Long. 71 19 58·40	791·014		789	−2	do.
Samdari H.S. Lat. 25° 48′ 59″·55 Long. 72 34 20·84	846·585		846	−1	do.
Bombay Longitudinal Series					
Boribyāi or Bori H.S. Lat. 18° 25′ 7″·76 Long 74 37 48·09	2002·982	...	2002	−1	On rectangular protecting pillar (most probably upper mark stone)
Mangalore Meridional Series					
Māvinhūnda H.S. Lat. 16° 25′ 4″·19 Long. 74 47 10·38	2583·130	...	2582	−1	On rectangular protecting pillar (most probably upper mark stone)
Madras Meridional and Coast Series					
Ongole H.S. Lat. 15° 29′ 56″·85 Long. 80 2 26·72	250·072	249·878	249	−1	Upper mark stone

TABLE IX.—*Results of comparisons of staves with standard steel tape No. 2, season 1923-24*

Place and date	Difference of length of staves from 10 feet				Remarks
	No. of Staff				
	23B	22B	13A	13B	
Kyaukse 25-10-23	+0·001882	+0·001116	−0·000903	−0·000921	Light scattered clouds and cool breeze.
Nagu 4-11-23	+0·001638	+0·000564	−0·001168	−0·000588	Scattered clouds.
Myittha 15-11-23	+0·002195	+0·001314	−0·000462	−0·000365	Cloudy.
Kyngyi 26-11-23	+0·000697	−0·000288	−0·000735	−0·000817	Scattered clouds.
Taungdwin 8-12-23	+0·000869	−0·000413	−0·001727	−0·001388	Clear.
Amarapura Shore 22-12-23	+0·001815	+0·001014	−0·001069	−0·000543	"
Seywa 2-1-24	+0·002164	+0·001587	−0·000328	+0·000327	Light scattered clouds and cool breeze.
Tadainshe 14-1-24	+0·001663	+0·001249	−0·000608	−0·000385	Clear.
Pinywa 26-1-24	+0·005842	+0·000972	−0·000373	+0·000073	Light scattered clouds.
Kyauktaga 8-2-24	+0·000969	−0·000801	−0·001558	−0·000539	Clear and cool breeze.
Dalazeik 17-2-24	+0·000551	+0·000206	−0·000786	−0·000656	Clear.
Dalanun 2-3-24	+0·001015	+0·000665	−0·001100	−0·000926	Clear and cool breeze.
Nyaunglebin 16-3-24	−0·000156	−0·000476	−0·001944	−0·001847	Scattered clouds.
Payapyu 30-3-24	+0·000176	+0·000042	−0·001927	−0·001820	Clear and cool breeze.
Tarana 11-4-24	+0·001160	+0·000843	−0·000651	−0·000777	"
Kyain 24-4-24	+0·000305	−0·000073	−0·001377	−0·000095	Light scattered clouds.
Peinnegon 6-5-24	+0·002587	+0 002321	+0·000654	+0·000590	Scattered clouds and cool breeze.
Nawlon Kwin 21-5-24	+0·002318	+0·002517	+0·000600	+0·000574	Scattered clouds.
Natchaung 23-5-24	+0·002577	+0·002240	+0·000659	+0·000684	"

TABLE IX.—*Results of comparisons of staves with standard steel tape No. 3, season 1923-24—(Contd.)*

Place and date		Difference of length of staves from 10 feet — No. of Staff 20A	20B	Remarks
Jhang-Maghiāna	2-11-23	−0·000137	+0·000191	Clear
Rustam Sargana	10-11-23	+0·000560	−0·000041	"
Rustam Sargana	20-11-23	0·001655	−0·001443	"
Darkhana	28-11-23	−0·001108	−0·002059	Cloudy
Abdul Hakīm	6-12-23	−0·001734	−0·001008	Clear
Chak 14 (Thal Chumu)	16-12-23	−0·001856	−0·001633	"
Abdul Hakīm	28-12-23	−0·001893	−0·000818	"
Kabīrwāla	5-1-24	−0·002554	−0·001880	Scattered clouds
Kādirpur Rann	13-1-24	−0·001626	−0 000632	"
Kādirpur Rann	21-1-24	−0·002756	−0·001743	Clear and windy
Bahāwalpur	24-1-24	−0·002112	−0·001374	Scattered clouds
Mubārakpur	31-1-24	−0·002396	−0·001696	Light scattered clouds
Chāudri	10-2-24	−0·002514	−0·002032	Clear
Khānpur	19-2-24	−0·002743	−0·002162	"

TABLE IX.—*Results of comparisons of staves with standard steel tape No. 7, season 1923-24—(Contd.)*

Place and date		Difference of length of staves from 10 feet		Remarks
		No. of staff		
		16A	16B	
Nakhtrana Mota	24-10-23	−0·005757	+0·000098	Scattered clouds
"	1-11-23	−0·006992	−0·000722	Clear
Majal	8-11-23	−0·007078	−0·000945	"
Samatra	16-11-23	−0·009588	−0·002313	"
Bhuj	24-11-23	−0·009131	−0·002588	Light scattered clouds
Balakhavas-ka-Talav.	3-12-23	−0·010454	−0·003294	Clear and cool breeze
Kālāghogha	10-12-23	−0·009573	−0·002882	"
Mundra	19-12-23	−0·009170	−0·002117	Clear
"	31-12-23	−0·010762	−0·003271	Clear and cool breeze
Khedoi	10-1-24	−0·010419	−0·003190	"
Anjār	23-1-24	−0·011429	−0·003673	Clear and high breeze
"	30-1-24	−0·010795	−0·003391	" " cool "
Bhachāu	6-2-24	−0·010265	−0·003084	Cloudy and cool breeze
Shikārpur (Cutch)	17-2-24	−0·010722	−0·003131	Clear
Bhela Mota	25-2-24	−0·010663	−0·003067	Scattered clouds & high breeze
Bālambha	4-3-24	−0·010440	−0·002942	Clear and high wind
Dhrol	13-3-24	−0·011055	−0·004117	Clear and high breeze
Targari	23-3-24	−0·010385	−0·002149	Clear
Anandpur	2-4-24	−0·012212	−0·004450	"
Chotila	9-4-24	−0·011527	−0·004361	Clear and high wind
Molri	17-4-24	−0·011399	−0·003304	Clear
Muli	25-4-24	−0·011942	−0·003952	Clear and high wind
Wadhwān	8-5-24	−0·011502	−0·003712	Clear and hot wind
Sheikhpur	18-5-24	−0·010446	−0·003221	Scattered clouds and breeze
Bāla	28-5-24	−0·010532	−0·002941	Clear and high wind
Lilāpur	8-6-24	−0·010810	−0·003494	" " breeze
Viramgām	15-6-24	−0·009999	−0·003521	Light clouds and high breeze
"	19-6-24	−0·009391	−0·002285	Drizzling

TABLE IX.—*Results of comparison of staves with standard steel tape No. 4, season 1923-24*—(*Concld.*)

Place and date		Difference of length of staves from 10 feet — No. of staff — 19A	19B	Remarks
Mārwār Pāli	26-11-23	−0·001792	−0·001958	
Rohat	3-12-23	−0·001656	−0·001814	
Luni	14-12-23	−0·002349	−0·002286	
Dundara	24-12-23	−0·001946	−0·002030	
Samdari	30-12-23	−0·001920	−0·001760	
Balotra	8- 1-24	−0·002926	−0·002562	
Baitu	16- 1-24	−0·002962	−0·003112	
Bhimarlai	22- 1-24	−0·004127	−0·003877	
Barmer	31- 1-24	−0·002768	−0·002864	
Barmer	9- 2-24	−0·003700	−0·003411	
Bhadleo	16- 2-24	−0·004526	−0·004860	
Shew	3- 3-24	−0·003989	−0·003810	
Bhailani	15- 3-24	−0·005013	−0·004763	
Jaisalmer	1- 4-24	−0·004344	−0·004519	
Bayasaki	11- 4-24	−0·005173	−0·004909	
”	24- 4-24	−0·005519	−0·005269	
Govardhanla	30- 4-24	−0·005389	−0·005475	

1924-25

The field office opened at Bahāwalpur East Railway Station on 29th October 1924, and the recess office opened at Mussoorie on 20th April 1925. No. 1 detachment recessed in Mussoorie, the Burma programme having apparently been finished with this season's work. The Sutlej Valley Group recessed in Dehra Dūn as usual. 208. *Season 1924-25.*

The field organization was as follows :— 209. *Field organization.*

(*a*) Sutlej Valley Group under Mr. N. R. Mazumdar, with field headquarters at Bahāwalpur East Railway Station.

(*b*) No. 1 double detachment under Mr. S. C. Mukerjee, in Burma.

(*c*) No. 2 single detachment (net) under Mr. A. A. S. Matlub Ahmad, in Sind and Western Rājputāna.

(*d*) No. 3 single detachment (net) under Mr. H. C. Banerjea B.A., in Bengal, Bihār and Orissa.

(*e*) No. 4 single detachment (net) under Mr. Jiya Lal Sahgal, in the Punjāb and Sind.

(*f*) No. 5 double detachment under Mr. P. B. Roy, in Bengal, Bihār and Orissa.

The Sutlej Valley Group continued its tertiary levelling in the Multān, Montgomery, Lahore and Ferozepore districts and in the Bahāwalpur State. 37,525 linear miles were run, covering 4900 square miles. 210. *Outturn.*

No. 1 detachment executed 367 linear miles of simultaneous double levelling of secondary precision for the Chief Engineer, P.W.D. (Irrigation) Burma, in the Shwebo, Sagaing, Tharrawaddy, Insein, and Pegu districts (precision methods however being employed for the check levelling at Rangoon and Pegu), and 327 linear miles (6 square miles) of tertiary levelling on the Yenangyaung oil field for the Burma Oil Company.

No. 2 detachment executed 198 miles of levelling of high precision in the fore direction from Sukkur to Hyderābād; this line, referred to in § 190 as old line 52, has been given a new number 101 A; and 213 miles of levelling from Hyderābād to Barmer, along line 150.

No. 3 detachment executed 143 miles of levelling of high precision in the fore direction on line 121 from Howrah *viâ* Midnapore to Jaleswar; 108 miles on new line 121 A from Mohanpur (Midnapore) to Rānīganj; 239 miles on new line 151 Rānīganj to Dinājpur.

No. 4 detachment executed 123 miles of levelling of high precision in the fore direction on line 101 from Karāchi to Kotri, and 5 miles on line 150 from Kotri to Hyderābād, and 86 miles in

210. (*Contd.*) the back direction on line 102 from Govardhanla to Bhutta Sheikh, and 198 miles on line 101 A from Hyderābād to Sukkur. It also carried out the relevelments of short lengths of lines 101 and 105 (*vide* § 189).

No. 5 detachment executed 150 miles of simultaneous double levelling of secondary precision for the Calcutta Corporation, in the 24 Parganas district, and 168 miles for the Chief Engineer, East Indian Railway, between Howrah and Hazāribāgh Road.

Officers under training at Dehra Dūn executed a short length of fore and back levelling of high precision along line 61 A, connecting 4 new secondary bench marks.

Topographical levelling was carried out in Mussoorie by a leveller lent to the Director, Northern Circle.

211. *Summary.* The levelling done was :—

284* miles of primary levelling in the back direction.
1029 „ „ „ „ „ „ fore „
685 „ „ secondary levelling.
37,852 „ „ tertiary levelling, covering 4906 square miles.

The secondary and tertiary work was done for local governments. The calculated probable errors of the completed portions of main lines of the net satisfy high precision requirements. The relevelment necessary on the branch line from 104 will probably be done in 1926-27. The back levelling of 102 had to be continued past Mithra, to Bhutta Sheikh, as the values of bench mark at Mithra did not agree.

The results of the work on line 101 A are not satisfactory. This line along old line 52 was undertaken for the Lloyd Barrage Engineers. There was poor levelling in both directions, which unfortunately did not show up as disagreements between fore and back. On other lines there are large discordances between the fore levelling of this season and the old published height differences. These will probably be cleared up by the 1925-26 back levelling.

212. *The new level net.* The following new lines have been added to the net:—

101 A from Sukkur to Hyderābād (branch line).
121 A from Mohanpur (Midnapore) to Rānīganj (branch line).
150 from Kotri ((Hyderābād) to Barmer.
151 „ Rānīganj to Dinājpur.
152 „ Rājkot to Porbandar.
136 now runs from Jhang to Lahore.
137 „ „ „ Ambāla to Lahore.
138 „ „ „ Delhi to Ambāla.
139 „ „ „ Ambāla to Morādābād.
153 „ „ „ Delhi to Meerut and Bareilly.

But otherwise the net stands as shown in Record Volume XV. The programme of the next two seasons is the completion of 101,

* This includes 198 miles of back levelling of line Sukkur to Hyderābād of which fore levelling was done the same season.

108, 113 (Surat-Dhūlia portion), 119, 121, 121 A, 150 and 151, and the fore levelling of 104 (remaining portion), 106 (remaining portion), 136, 137 (remaining portion), 139 (remaining portion) and 152. 212. *(Contd.)*

213. *Details of field work. Sutlej valley tertiary levelling.*

(a) Sutlej Valley tertiary levelling—Mr. N. R. Mazumdar in charge. There were five sections, one of which had to be broken up and the staff sent to other sections, owing to the section officer having to go on medical leave.

There was much delay in starting the field work, the railway line from Dehra Dūn having been broken by floods; the spare time in Dehra Dūn was spent in training new levellers, and giving practice to others. The season opened at Bahāwalpur on 19th October 1924, and field work closed at the end of March 1925.

The outturn was as follows, all being tertiary levelling:—

	Punjab	Bahāwalpur State	Total
	sq. miles	*sq. miles*	*sq. miles*
100-acre area ...	542	–	542
25-acre area ...	1106	3252	4358
Total	1648	3252	4900

1855 linear miles of double and 35,670 of single levelling were run, a total of 37,525 miles. Ground heights were given to 354,300 points.

214. *Cost rates compared.*

The cost rates were again reduced, owing probably to the fact that the bulk of the men were fully trained, and also to there being good supervision. The outturn was very good.

Cost rates compared—

Season	Field work		Recess work		Total		Remarks
	100 acre	25 acre	100 acre	25 acre	100 acre	25 acre	
	RS.	RS.	RS.	RS.	RS.	RS.	
1922-23	23·8	47·5	4·4	8·8	28·2	56·3	Cost per square miles excluding percentage charged to the project for supervision, use of instruments, and mapping
1923-24	17·9	35·7	3·0	6·0	20·9	41·7	
1924-25	16·5	32·9	2·1	4·3	18·6	37·2	

215. *Computation in the field.* The Officer in charge was able to inspect his men constantly. The computing section at the group headquarters was reinforced in the middle of the season, in order to meet the Chief Engineer's demand for the rapid supply of charts. 72 manuscript spot height charts were supplied to the Officer in charge No. 2 Drawing Office during the field season.

The sections were organized as below:—

Section No.	Officer in charge	No. of leveller and recorder	Blocks No.	Date of commencement of work in block
1	Mr. H. K. Kar	1 Camp recorder 15 levellers later on 17	I′,J′,K,N′,O′,R′, B‴,C‴,D‴,S′,T′.	1st November 1924.
2	Babu Muhammad Ishak Khan	1 Camp recorder 12 levellers later on 17	y″, v″, (half) Z,F′,A′,C′,G′,H′,Z′. (half)	29th October 1924.
3	Babu Muhammad Faizul Hasan	1 Camp recorder 16 levellers later on 17	C″,D″,Z′,E″,F″,Z″. (half)	30th October 1924.
4	Babu Saiyid Nayar Hasan	1 Camp recorder 16 levellers later on 14	I″,J″,K″,N″,O″, P″;R″.	29th October 1924.
5	Mr. Nabidad Khan	1 Camp recorder 14 levellers. This section was dispersed at the end of February.	W″,T″,S″,R″,V″. (half)	28th October 1924.

216. *Condition of the country levelled.* No. 2 section had the most difficult ground with much jungle. Nos. 3, 4 and 5 worked in very easy country with large expanses of flat *pat* and sand ridges running generally east and west. Water had to be carried from *tobās* (small ponds), sometimes for long distances. Health was generally very good.

There was no difficulty this year as regards being held back by the subrectangulators.

217. *Recess work.* The recess office opened at Dehra Dūn on 11th April. The field work covered 329 four-inch charts, of which the data for 72 were sent to the Drawing Office from the field; the remaining 257 were finished during the recess.

(b) Burma secondary levelling.—No. 1 detachment under Mr. S. C. Mukerjee, left recess quarters at Maymyo on 1st November 1924; the second leveller P. John and the squad, joining them at Tangôn (Shwebo district). The lines of secondary precision, all run for the Chief Engineer P. W. D. (Irrigation) Burma, were as follows:— 218. *Burma secondary levelling*

Line	Miles	No. of new bench marks
(*a*) Tangôn to Shwebo ...	65	21
(*b*) Kabo to Myittaw ...	92	67
(*c*) Okshitkan to Paukkan ...	78	31
(*d*) Thonze to Rangoon ...	110	69
(*e*) Pegu to Zenyaungbin ...	5	1
(*f*) Myitkyo to Okpo ...	7	2
(*g*) R. D. No. 25 of Yenwe embankment to Uaw .	10	4
Total .	367	195

The lines lay along the following routes :—

(*a*). Along the railway line to Tantabin, thence along the road to Kabo, thence along the Shwebo main canal to Okshitkan and thence along the road to Shwebo.

(*b*). Along the Ye-u main canal to Tantabin, thence along a distributary and across country to Thayetkan, thence along Mayagan branch canal to Nyaunghla and thence along the road to Myittaw.

(*c*). Along Hladaw branch canal to Shwebangon, thence along road and distributary No. 3 of Hladaw branch canal to Thayetkyi, thence along village cart track to Sadaung and thence along the road and railway *viâ* Padu to Paukkan.

(*d*). Along Rangoon-Prome road *viâ* Insein to Rangoon. The branch line to Paunggyi was run along Rangoon-Pegu and Hlegu-Paunggyi road.

(*e*). Along Pegu-Tawa road *bund*.

(*f*). Across country along right bank of Sittang river.

(*g*). Across country *viâ* Daiku along Kawlia stream.

The bench marks were built by the P.W.D. after their own pattern. The resulting heights were sent to the Chief Engineer during the recess. The detachment closed work at Pegu on 26th May 1925, and proceeded to recess in Mussoorie. Health was good throughout the season.

(*c*). Burma tertiary levelling.—Yenangyaung (Magwe district). This was carried out by No. 1 detachment in the interval between the Shwebo and Insein secondary lines. It consisted of single levelling, in conjunction with the topographical survey under the Director, 219. *Burma tertiary levelling*

219. *(Contd.)* Burma Circle. The country was hilly and much cut up by *nālās.* The area was first enclosed in two double levelling circuits, connected to bench mark 6/84 L; no other mark remained undisturbed within practicable distance. These circuits were divided and subdivided by means of single levelling. Lines had to be run along the banks and also the bottoms of *nālās.* The heights were adjusted in the field on closing each line, and at once given to the topographical surveyors; no work being left for recess. The results are probably correct to 0·1 ft. A good deal of time was lost through the levellers having to revisit places already levelled over, it having been found that they had given too few heights. It had not been possible, in the time available, for the topographical surveyors to mark on the ground beforehand all the points for which they required values.

220. *Results of levelling carried out, and closing errors*

The results are as follows:—

6-square mile area:
327 linear miles of levelling. { 2 main circuits, 21 miles.
9 sub circuits, 23 „
minor lines, 283 „

Number of heights:—

1. Iron pipes about 3 inches in diameter, embedded in masonry blocks; masonry pillars with iron plates on top; circles on plinths and structures 275
2. Wooden platforms of oil wells 1048
3. Very temporary heights, iron pipes and ground levels 3039

4362

Sets up 4606

93 working days for two levellers, including rest.

Closing errors

Circuits	Greatest	Least	Average	Remarks
	feet	*feet*	*feet*	
Main circuits ...	0·054	0·001	...	...
Sub circuits ...	0·040	0·003	0·013	On tying to main circuits, average length 24 miles.
Minor lines ...	0·081	...	0·021	On tying to main circuits or sub circuits.

221. *Calcutta Corporation Drainage secondary levelling.* (*d*). Calcutta Corporation (Drainage)—secondary levelling.—To undertake this and also the East Indian Railway Company's work as given in § 222, No. 5 double detachment was formed in January 1925, under Mr. P. B. Roy, with second leveller Babu Indra Singh, two recorders and twenty-six menials. The programme as carried out, consisted of 150 miles of double levelling, mainly along

the Bidyādharī, Piāli and Mātla rivers. Work commenced at Calcutta on 28th January, and closed at Nārāyanpur on 22nd March 1925. 268 new secondary bench marks were connected including 118 Marine sockets. These were as described in G.T.S. Volume XIX page 58, except that their length was only 4½ feet. They were generally found to be somewhat loosely driven into the ground, and consequently unstable. The whole country is low lying alluvial land. 221. (Contd.

The work consisted of the following circuits:—

Line No. 77 Q. Bench mark 368/79 B south-eastwards *viā* Sealdah to Nārāyanpur and back over the same marks to Calcutta, ...	59 miles
Line No. 77 R. Nārāyanpur, Port Canning, Kultali, Piāli to Nārāyanpur along Bidyādharī, Mātla and Piāli rivers	91 „
Total	150 miles

The p.e. for the first circuit, on which the rest of the work depended, is ±0·0025 ft. per (mile)$^{\frac{1}{2}}$ and for the other it is ±0·0040.

The health of the detachment was good.

The heights were computed in recess and sent to the Executive Engineer (Drainage) of the Corporation.

222. *East Indian Railway secondary levelling*

(*e*). East Indian Railway—secondary levelling.—This double levelling of secondary precision was carried out by No. 5 detachment. Work commenced at Howrah on 23rd March 1925, and closed at Sitārāmpur Junction on 5th June 1925, when the detachment proceeded to recess in Mussoorie.

It forms the first season's work of a large programme of levelling from G.T.S. bench marks to marks made by the Railway Administration along their lines.

The following lines were run:—

Line	Miles
No. 74 C. from Bench mark $\frac{453}{79B}$ at Howrah, along the railway to Uttarpāra station, and closing on bench mark $\frac{447}{79B}$	13
Branch lines to Sheorāphūli, Bāndel, Pandua, Saktigarh, Burdwān, Khāna, Galsi, Mānkar, Pānagar, Durgapur, Rānīganj, Kālīpāhāri, Asansol, Churūlia	50
Branch line No. 70 J (Barākar to Hazāribāgh Road) along East Indian Railway grand chord line	105
Totals ...	168

222. (*Contd.*) The p.e. for lines 74 C and 70 J from the formula $p.e. = \frac{2}{3}\sqrt{\frac{\Sigma\delta^2}{4M}}$ is $\pm 0{\cdot}0036$ ft. and $\pm 0{\cdot}0033$ ft. per $(mile)^{\frac{1}{2}}$ respectively. 1 new primary and 268 new secondary, and 1 old primary and 78 old secondary bench marks were connected.

The railway bench marks consist of:—

(1) the vertical type of inscribed bench marks, *i.e.* inscribed stones fixed vertically in the walls of railway buildings.

(2) the pillar type; stone blocks 2′ × 2′ × 9″ resting on *pakka* masonry pillars about 3 feet high and 2 feet square.

The health of the detachment was good until the close of the season.

223. *Levelling of the new net line 101.* (*f*) No. 4 detachment.—Levelling on the new net line 101.

The fore levelling of the portion between Karāchi standard bench mark and Kotri was carried out by No. 4 detachment (Mr. Jiya Lal Sahgal), work commencing at Karāchi on 8th December 1924, and closing at Kotri on 21st January 1925. The detachment then took up lines 150 and 101 A. The fore levelling from Manora T.O. to Karāchi, involving the crossing of the harbour, has been left until next season, as also the fore levelling to 3 new standard bench marks (Gharo, Tatta and Jerruck) still under construction.

224. *Instruments used.* The instruments used were:—level Zeiss No. 3488; staves Nos. 19 A and 19 B and tape No. 4.

The back levelling of the portion between Jacobābād and Bahāwalpur in 1922-24 was found to require some revision, in order to satisfy high precision requirements; this was also done by No. 4 detachment. The probable accidental and systematic errors of the completed portion of this line (Kotri to Bahāwalpur) are now $\pm 0{\cdot}00338$ ft. and $\pm 0{\cdot}00039$ ft. per mile.

225. *Fore levelling of line 101 A* Line 101A.—The fore levelling was done by No. 2 detachment (Mr. A. A. S. Matlub Ahmad). Work commenced at Sukkur on 29th October 1924 and the line was closed at Hyderābād on 3rd January 1925. The detachment then began work on line 150. The back levelling (No. 4 detachment Mr. Jiya Lal Sahgal), began at Hyderābād on 24th January 1925 and closed at Sukkur on 11th April 1925.

It had been intended to base this line on Rohri, but there was a lack of suitable bench marks there. The route lay along that of old line 52, but the old bench marks were found to have nearly all been destroyed or disturbed. However there were enough undisturbed to justify the new work being adjusted to them. The closing on the old net discloses that there is an error in the new levelling of over one foot. 225. (Contd.)

"Where the new work disagrees with the published difference between bench marks, the new bench marks have been given provisional values only; elsewhere the new levelling is good revision work."

The difference of heights between the ends of the line is computed at $-160 \cdot 925$ feet; the difference arrived at in the adjustment of the old net was $-159 \cdot 702$ feet, a discrepancy of $+1 \cdot 223$ feet. The probable accidental and systematic errors of the new line, from Lallemand's internal evidence formulæ are $\pm 0 \cdot 00371$ ft. and $\pm 0 \cdot 00062$ feet per mile which satisfy the requirements of high precision levelling $\pm 0 \cdot 00416$ ft. and $\pm 0 \cdot 00106$ ft. respectively.

226. *Instruments used.*

The instruments used were:—fore level Zeiss No. 3342, staves Nos. 20A and 20 B, standard steel tape No. 3, back level Zeiss No. 3488 staves Nos. 19 A and 19 B and standard steel tape No. 4.

227. *Back levelling of line 102.*

Line No. 102:—The back levelling of this line was left incomplete (*vide* § 189) and the remaining portion was levelled by No. 4 detachment (Mr. Jiya Lal Sahgal). Work commenced at Govardhanla on 31st October and closed on 30th November 1924. The detachment next proceeded to Karāchi to take up line 101. The mark at Mithra on which it was hoped to close, was found to be disturbed, so work had to be carried on to Bhutta Sheikh,—a total distance of 86 miles.

The probable accidental and systematic errors for line 102, from Lallemand's formulæ, are $\pm 0 \cdot 00413$ ft., and $\pm 0 \cdot 00018$ ft. per mile (satisfying the requirements of high precision work $\pm 0 \cdot 00416$ ft. $\pm 0 \cdot 00106$ ft. respectively).

228. *Instruments used*

The instruments used were:—level Zeiss No. 3488; staves Nos. 19 A and 19 B and standard steel tape No. 4.

Line 105—As indicated in § 189, No. 4 detachment carried out the relevelment of short lengths, which completes the line 105.

229. *Probable accidental and systematic errors.*

The table showing the probable accidental and systematic errors for the whole line is given below:—

Line	Probable accidental error	Probable systematic error
	feet	*feet*
Portion Khānpur to Bahawālpur ...	$\pm 0 \cdot 00343$	$\pm 0 \cdot 00008$
" Multān to Jhang-Maghiana ...	$\pm 0 \cdot 00416$	$\pm 0 \cdot 00042$

229. (*Contd.*) which satisfy the requirements for high precision levelling ±0·00416 ft. and ±0·00106 ft. respectively.

230. *Line 121.* Line No. 121.—The fore levelling of the portion from Howrah to Jaleswar was carried out by No. 3 detachment (Mr. H. C. Banerjea, B.A.). Work commenced at Howrah on 6th November 1924, and closed at Jaleswar on 1st January 1925, when the detachment returned to Midnapore to take up line 121 A.

231. *Instruments used.* The instruments used were:—level Zeiss No. 16215; staves Nos. 16 A, and 16 B and standard steel tape No. 7.

The fore levelling to new standard bench marks under construction was left for 1925-26.

232. *Fore levelling of lines 121 A and 150.* Line 121 A.—The fore levelling of the line from Mohanpur (Midnapore) to Rānīganj was done by No. 3 detachment. Work commenced at Midnapore on 7th January 1925, and closed at Rānīganj on 13th February 1925, the detachment then proceeded along line 151. The new standard bench marks under construction were left for 1925-26.

The fore levelling of line 150 was all done this season. From Kotri to Hyderābād, by No. 4 detachment (Mr. Jiya Lal Sahgal), and from Hyderābād to Barmer by No. 2 detachment (Mr. A. A. S. Matlub Ahmad). This detachment commenced work at Hyderābād on 4th January 1925, and closed at Barmer on 3rd April 1925.

Instruments used were the same as those for lines 101 A and 102.

233. *Fore levelling of line 151.* Line 151.—All the fore levelling of this line from Rānīganj to Dinājpur was done this season by No. 3 detachment except for the connection of new standard bench marks under construction, and for the Ganges crossing at Lālgolā Ghāt, which was reconnoitred for 1925-26. The detachment closed work for the season at Dinājpur on 15th May 1925.

234. *Check levelling at Rangoon and Pegu.* Check levelling at Rangoon and Pegu.—This was carried out by No. 1 detachment, by means of simultaneous double levelling of precision, during the course of the secondary levelling on the Insein and Pegu lines. Some of the Rangoon bench marks were suspected by the Port authorities to have been altered in height, an earthquake in 1919 being thought to have affected them. This present season's levelling indicates that some of the heights have altered with reference to those of standard bench mark in cantonment gardens, Rangoon (B.M. 32/94 D), of the Shwedagon Pagoda mark (B.M. 31/94 D), and 9 others which agree *inter se*, as is shown in the following table.

Check levelling at Rangoon

Bench mark No. falling in degree sheet 94 D	Brief description of bench mark	New height above (+) or below (−) Shwedagon	Height as previously determined	Risen (+) or sunk (−) since last levelling
		feet	*feet*	*feet*
31	↑ BOM. 108 on slab on E. side of Shwedagon Pagoda steps, Rangoon ...	0·000	0·000	0·000
32	Standard bench mark on high knoll in Cantonment Gardens, Rangoon ...	+ 0·393	+ 0·393	0·000
28	G.T.S. □ at NE. angle of Railway Audit Offices, Rangoon. A few inches below ground level ...	−78·746	−78·746	0·000
29	O B.M. at NE. corner of plinth of Railway Audit Offices, Rangoon ...	−77·523	−77·523	0·000
27	G.T.S. O B.M. at S. end of step of E. entrance to basement of Sule Pagoda, Rangoon ..	−89·150	−89·150	0·000
26	↑ B.M. 31 on stone block under portico of S. entrance of Town Hall, Rangoon ..	−90·641	−90·641	0·000
17	Standard bench mark in Customs House flagstaff enclosure, Rangoon ...	−88·994	−88·994	0·000
16	G.T.S. O B.M. at W. end of step of E. entrance of General Post Office, Rangoon ..	−92·040	−92·040	0·000
21	Zero end of bed plate of tide gauge at Rangoon Tidal Observatory ...	−88·433	−88·433	0·000
7	G.T.S. O B.M. at N.E corner of northernmost of 3 pagodas at Dala village ...	−92·574	−92·574	0·000
53	G.T.S. □ B.M. at P.W.D. Inspection bungalow, Seikgyi, 1½ feet below ground level ...	−97·612	−97·612	0·000
70 (54)	↑ B.M. 111 on N. parapet of drain at junction of Simpson and Shwedagon Pagoda roads, Rangoon ...	−50·973	−50·881	−0·092
71 (30)	↑ B.M. 66 on W. parapet of drain 230 feet S. of entrance gate of Presbyterian Church, Rangoon ...	−67·216	−67·253	+0·037
72 (22)	↑ B.M. 169 at base of palisade fence E. of gateway of Crisp Street Jetty, Rangoon ...	−91·978	−91·847	−0·131
73 (24)	↑ B.M. 168 at base of palisade fence, at its W. end. N. of S. and T. Corps Wharf on Strand road, Rangoon ...	−91·582	−91 525	−0·057

Check levelling at Rangoon.—(Concld.)

Bench mark No. falling in degree sheet 94 D	Brief description of bench mark	New height above (+) or below (−) Shwedagon	Height as previously determined	Risen (+) or sunk (−) since last levelling
		feet	*feet*	*feet*
74	B.M. on W. end of N. entrance of Examination ○ Hall at Port Health Station, at Brooking Street Wharf, Rangoon ..	−93·043	new bench mark	
75 (18)	Graham Smith's bench mark outside SE. corner of enclosure of Mayo Marine Institute, Rangoon ...	−92·590	−92·608	+0·018
76 (20)	B○M. at SW. corner of shed of Brooking Street Wharf waiting room for Indians, Rangoon ...	−91·461	−91·449	−0·012
77 (19)	B○M. at NW. corner of shed of Brooking Street Wharf waiting room for Europeans, Rangoon ...	−91·490	−91·508	+0·018
78 (8)	G.T.S. at SE. corner of northernmost of 3 ○ Pagodas at Dala village ... B.M.	−92·914	−92·851	−0·063
79 (9)	B.M. on iron pillar 77 feet of Leigangyaung ↓ Pagoda at Dala village	−96·149	−96·170	+0·021

234. *(Contd.)* At Pegu the check was desired on account of a report from the local P.W.D. Officer in 1924, that the standard bench mark appeared to have changed its height. The new levelling indicates that of 13 bench marks checked, the standard and two other marks have kept their relative heights; one has risen 0·143 ft., and nine have sunk. Of these, five are at the railway station, and the sinking varies from 0·280 ft. to 0·067 ft. (average 0·177); one on a railway bridge over a mile away has sunk 0·053 feet. The remaining three have sunk comparatively little; they are not near the railway:

Interred at Thanatpin	0·020 ft.
On a massive building	0·016 ,,
On a road culvert	0·005 ,,

235. *Triangulation stations.* The triangulation stations connected by all detachments are shewn in Table No. XIII.

236. *Relevelments.* Relevelments.—The back levelling run this season was only 284 miles; the percentage of relevelment was about 15%. This betterment may be due to the interval of time between fore and back being short (about 6 months).

Standard bench marks have been built or are under construction, at Howrah (two), Midnapore, Bānkurā, Rānīganj and Berhampore (Bengal). 237. *Proposed sites of standard bench marks*

Standard bench marks of the new type referred to in § 205, have been built or are under construction at the following places:—

Gharo, Tatta, Jerruck, on line 101 between Karāchi and Kotri.

Mīrpur Khās, Chhor, Gadra road, Barmer, on line 150.

Ulūbāria, Panskura, Belda, Jaleswar, on line 121.

Bishnupur, on line 121A.

Sainthia, Kāndi, Lālgolā Ghāt, Godāgāri Ghāt, Nachoul, Sapahar, Bālurghāt, Kumārganj, on line 151.

Chānditala, Arāmbāgh in Hoogly district for future connection.

This new type consists of a Chunār sand stone dressed monolith 1 foot square at base and 3 feet high, the upper 3 inches being dressed to the form of a frustum of a pyramid terminating in a smooth square of about 3-inch side. The stone rests on a bed of concrete 5 feet square and 3 feet deep, the upper surface of stone being 1 foot above ground level. It is surrounded by a masonry wall 5 feet square (outside), 1 foot thick and 2½ feet high. It includes two subsidiary marks on either side of the monolith consisting of hard stone prisms 8 inches long and 3 inches square, their smooth tops flush with the surface, near the edges of the concrete bed protected by bricks or stone slabs, and a stout iron bolt 1 inch square and 8 inches long built horizontally into the masonry wall and projecting about 2 inches out of it. The inner enclosure is filled in with rubble to a height of about 6 inches above the top surface of the monolith, and the rest with earth. 238. *New type of bench marks described*

At Gharo, Tatta, Jerruck, Mīrpur khās, Chhor, Gadra road and Barmer, there has been substituted for the sand stone monolith a fine cement concrete pillar, with a large flat headed copper bolt sunk in the top. All the standards listed above will be connected in 1925-26. The standard bench mark at Bahāwalpur has been moved to a more accessible place, and will be connected in 1925-26.

The monoliths of the standard bench marks at Khānpur and Burdwān not having been originally built of the best stone, have weathered badly. Only Chunār sand stone or good white Jhelum stone, as used for the Bahāwalpur standard, should be used in future unless the expense is prohibitive. The subsidiary marks should also be of the hardest stone. The interred bench marks connected during the last few years have been called embedded. The original distinction as in G.T.S. Vol. XIX has now been reverted to.

An examination of the records of primary levelling from 1910-11

238. (Contd) to 1923-24 inclusive, shows that 684 new bench marks classed as secondary were called "embedded" in error; they are "interred", types A and B. Also 46 old bench marks of these types have been called secondary.

239. Publications. The following manuscripts were sent to the press:—

Levelling Pamphlet for sheet No. 44.

Line	In degree sheet	Line	In degree sheet
Gooty to Ongole ...	57 E. I. M. and 66 A.	Branch line to Asansol & Churūlia railway stn. ..	73 I & M.
Nandyāl to Atmākūr ...	57 I.	Barākar to Hazāribāgh road railway stn. ...	72 H. & 73 I.
Ahmadnagar to Dhond ...	47 I. and J.	BURMA	
Viramgām to Nakhtrāna Mota ...	41 E. F. I. J. M. N. and 46 A.		
Khānpur to Mārwār Pāli	39 L. 40 I. J. M N. & O., and 45 C. & G.	Nyaungzaye to Kandin ...	85 N., O. & P.
		Mau-bin to Bassein .	85 L. & P.
		Sagamya to Pantanaw ...	85 P.
Jacobābād to Khānpur	39 D. H. & L., and 40 A. & E.	Moulmein to Pa-an ...	94 H.
		Moulmein to Wekali ...	94 H.
Khānpur to Bahāwalpur	39 L. & O	Ba-Bu kow to Kaw myat-kyi ..	94 H. & L.
Multān to Jhang (part)...	39 N.		
Sukkur to Hyderābād ...	40 A. B. & C.	Nyaungbinzeik to Natchaung ...	94 H. & L. and 95 I.
Dehra to Mājra ...	53 J.		
Calcutta to Nārāyanpur	79 B.	Kyauktaga to Myitkyo ...	94 B. & C.
Nārāyanpur to Nārāyanpur ...	79 B.	Dalanun to Pazun mavaung ...	94 C.
Howrah to Uttarpāra ...	79 B.	Kyaukse to Minzu ..	93 C.
Baidyabāti to Sheorāphūli ...	79 B.	Ywakainggyi to Amarapura ...	93 C. & 84 O.
Branch line to Bāndel railway station	79 B.	Kyaukse to Mandalay ...	93 B. & C.
" " Pandua " ...	79 A.	Meiktila to Yewe ...	84 O. & P. and 93 C.
" " Saktigarh " ..	73 M.		
" " Burdwān " .	73 M.	Tangôn to Shwebo ...	84 M. & N
" " Khāna & Galsi	73 M.	Kabo to Myittaw ...	84 N.
" " Mānkar " ...	73 M.	Okshitkan to Paukkan .	84 N.
" " Pāngar " ..	73 M.	Thonze to Rangoon ..	85 O. & 94 C. & D.
" " Durgapur " ...	73 M.		
" " Rānīganj " ..	73 M.	Pegu to Zenyaungbin ...	94 C.
" " Kālipāhāri railway stn. ...	73 M.	Myitkyo to Okpo ...	94 C.
		R.D. 25 of Yenwe embankment to Uaw ...	94 C.

The arrears of publication are:—

Manmād to Ahmadnagar, 1921-22 (requires check levelling near Nāndgaon, which is in the programme for 1926-27).

Surat-Dhūlia - awaits back levelling which is in the programme for 1926-27.

Branch line at Anjār (Cutch), awaits relevelling in 1926-27.

Sind secondary levelling, 1922-23; awaits completion of line 150 next season.

Bāgalkot-Bijāpur 1914-15; requires revision of line Belgaum-Bāgalkot (1910-11).

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Chs.	Lks.	Extras and branch-lines Mls.	Chs.	Lks.	Total Mls.	Chs.	Lks.	Total number of feet: Rises feet	Falls feet	Mean number of stations at which the instruments were set up	Number of bench marks connected: Primary: Interred old	new	Standard old	new	Primary stations of triangulation old	new	Secondary: Embedded old	new	Temporary points new	Oil wells new	Inscribed old	new	P. W. D. old	new	Railway old	new	Permanent points new	Masonry pillar new
No. 1 Detachment.																															
Tangôn to Shwebo	Nov. 24	46	14	80	18	66	10	65	00	90	154·431	245·763	498	...	...	1	...	...	...	3	8	...	...	7	7	1	6	...	...	...	...
Kabo to Myittaw	Dec. 24 Jan. 25	64 5	32 38	30 20	17 4	63 00	80 00	82 9	16 38	10 20	294·292 29·661	325·619 15·609	562 76	...	...	...	...	...	...	...	13	...	...	...	41	...	13	...	...	...	...
Okshitkan to Paukkan	Nov. 24 Dec. 24	35 22	70 10	20 00	5 14	23 43	70 60	41 36	13 53	90 60	140·314 341·554	199·122 248·315	292 350	...	...	...	...	...	2	2	7	...	...	5	17	...	5	1	...	...	...
Yenangyaung oil fields	Jan. 25 Feb. 25 Mar. 25 April 25	40 10 76 10 116 71	79 29 29 64 41 63	45 20* 50 70* 90 85	... ...	... ...	.. ..	51 87 116 71	28 14 41 63	65 20 90 85	... ...	... ...	977 1512 1502 615	...	...	...	...	...	...	1	...	3039	1048	1	3	...	...	...	...	270	...
Thonze to Rangoon	April 25 May 25	46 30	38 03	40 50	3 30	32 28	70 30	49 60	71 31	10 80	249·832 635·367	236·387 589·720	346 486	...	...	...	...	...	...	1	...	...	...	5	50	...	1	...	1	...	17
Pegu to Zenyaungbin	May 25	5	28	00	...	...	...	5	28	00	16·265	17·714	34	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	..	...	...
Myitkyo to Okpo	May 25	6	31	80	...	...	..	6	31	80	16·697	24·396	42	1	...	...	...	...	...	...	2	..	...	1	...	...	...	...	...	...	...
R. D. 25 of Yenwe embankment to Uaw	May 25	9	69	70	...	..	...	9	69	70	54·229	35·816	66	...	...	...	...	...	...	1	3	...	...	..	...	...	...	...	...	...	1

* Secondary.

TABLE X.—Tabular statement of outturn of work, season 1924-25—(Contd.)

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Main-Line Chs.	Main-Line Lks.	Extras and branch-lines Mls.	Extras and branch-lines Chs.	Extras and branch-lines Lks.	Total Mls.	Total Chs.	Total Lks.	Total number of feet: Rises (feet)	Falls (feet)	Mean number of stations at which the instruments were set up	Primary: Interred (Type B) old	Interred (Type B) new	Rock-cut Protected old	Rock-cut Protected new	Standard old	Standard new	Primary stations of triangulation old	Primary stations of triangulation new	Secondary: Embedded old	Embedded new	Rock-cut or Irrigation old	Rock-cut or Irrigation new	Inscribed old	Inscribed new	P. W. D. old	P. W. D. new	Railway old	Railway new	Permanent points new	Masonry pillar new
No. 1 Detachment.—(contd.) Check Levelling at Pegu	May 25	...	...	...	9	30	90	9	30	90	...	...	94	...	...	...	...	1	...	...	...	2	...	...	...	8	...	1	...	1	...	...	..
Check Levelling at Rangoon	May 25	...	...	...	7	37	80	7	37	80	...	...	98	2	...	...	...	2	..	...	..	1	...	...	...	15	1	...	...	...	...	...	...
No. 2 Detachment.																																	
Sukkur to Hyderābād	Oct. 24	4	22	62	1	08	28	5	30	90	135·072	166·288	102	...	...	1	...	1	...	...	...	1	...	...	...	13	1	...	...	...	...	..	...
	Nov. 24	94	17	40	0	77	00	95	14	40	303·668	410·159	938	...	.	...	...	...	...	...	...	...	4	.	...	28	65	...	...	...	...	...	...
	Dec. 24	93	34	20	0	36	40	93	70	60	290·914	342·383	916	...	...	...	...	...	..	...	...	5	3	...	...	9	81	...	...	...	2	...	...
	Jan. 25	1	43	90	1	56	10	3	20	00	108·191	58·373	58	...	...	..	...	1	...	...	...	...	...	...	...	8	1	1	...	...	...	...	...
Hyderābād to Barmer	Jan. 25	71	46	50	1	52	40	73	18	90	443·460	479·412	780	..	9	1	..	1	...	...	..	...	..	...	...	7	65	7	1	...	...	...	...
	Feb. 25	61	68	80	4	47	36	66	36	16	1115·558	484·513	714	..	5	...	...	..	...	...	2	...	...	...	..	...	57	...	..	...	...	...	...
	Mar. 25	68	28	70	0	00	00	68	28	70	967·759	395·919	746	...	5	...	...	..	...	...	..	...	.	...	1	...	64	...	..	...	...	...	...
	April 25	2	44	40	2	28	40	4	72	80	153·776	149·343	70	...	...	1	.	...	...	.	...	...	...	...	...	15	...	..	...	..	...	...	...

Detachments and Lines levelled	Months	Distance levelled: Main-Line			Extras and branch-lines			Total			Total number of feet: Rises	Falls	Mean number of stations at which the instruments were set up	Number of bench marks connected: Primary: Interred		Rock-cut Protected		Standard		Primary stations of triangulation		Secondary: Embedded		Rock-cut or Irrigation		Inscribed		P. W. D.		Railway		Zinc plate on tree	Reconnected
		Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	feet	feet		old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	new	new
No. 3 Detachment.																																	
Line No. 121 Howrah to Mohanpur (Midnapore) and Jaleswar	Nov. 24	47	69	90	7	76	60	55	66	50	333·178	316·478	794																				
	Dec. 24	87	02	00	0	21	40	87	23	40	613·472	629·572	1052	...	...	..	...	...	...	1	2	2	...	...	1	13	142	1	7	...	3	8	...
	Jan. 25	...	...	...	0	27	00	0	27	00	...	...	8																				
Line No. 121 A Mohanpur (Midnapore) to Rānīganj	Jan. 25	71	44	50	2	73	10	74	37	60	1383·761	1208·455	1072	1	3	...	1	...	...	...	1	...	...	1	16	6	118	...	1	...	1	...	...
	Feb. 25	31	14	40	2	32	60	33	47	00	728·306	624·760	484																				
Line No. 151	Feb. 25	38	76	40	...	...	...	38	76	40	884·772	1023·132	592																				
Rāniganj to Dinājpur: Rāniganj to Lālgolā Ghāt Section	Mar. 25	81	72	80	0	29	60	82	22	40	757·223	914·005	1096	5	...	...	...	...	...	..	...	...	...	1	1	19	108	...	1	...	5	8	7
	April 25	5	02	20	...	...	...	5	02	20	80·677	71·305	76																				
Godāgāri to Dinājpur	May 25	63	38	70	10	52	10	74	10	80	815·487	795·988	950	1	...	...	...	1	...	...	3	1	...	...	...	10	92	...	...	...	.	18	...
	April 25	34	00	10	4	02	00	38	62	10	306·816	275·038	514																				

TABLE X.—Tabular statement of outturn of work, season 1924-25—(Contd.)

Detachments and Lines levelled	Months	Distance levelled: Main-Line Mls.	Chs.	Lks.	Extras and branch-lines Mls.	Chs.	Lks.	Total Mls.	Chs.	Lks.	Total number of feet: Rises feet	Falls feet	Mean number of stations at which the instruments were set up	Number of bench marks connected: Primary: Interred (Type B) old	new	Rock-cut Protected old	new	Standard old	new	Primary stations of triangulation old	new	Secondary: Embedded old	new	Rock-cut or Irrigation old	new	Inscribed old	new	P. W. D. old	new	Railway old	new	Musto's type old	new
No. 4 Detachment.																																
Govardhanla to Bhutta Sheikh	Nov. 24	66	23	10	20	11	34	86	34	44	1847·8	2048·8	1026	5	...	...	...	...	...	..	...	...	...	...	...	8	...	...	...	...	...	...	...
Karāchi to Kotri	Dec. 24	58	50	90	11	14	40	69	65	30	651·7	737·2	700	1	...	2	...	2	...	1	...	...	...	...	...	18	52	...	...	1	...	...	...
	Jan. 25	59	71	70	0	00	00	59	71	70	700·6	251·7	636	...	...	...	...	...	...	...	...	..	..	...	27	16	22	..	...	...	...	...	...
Kotri to Hyderābād	Jan. 25	4	53	60	...	...	...	4	53	60	96·5	62·8	58	1	...	...	...	1	...	...	...	...	...	...	...	5	1	...	...	...	...	..	...
Hyderābād to Sukkur	Jan. 25	22	23	42	1	45	00	23	68	42	154·3	191·7	258	...	...	...	...	1	...	...	...	...	...	...	...	10	20	1	...	...	..	...	2
	Feb. 25	49	53	40	0	34	83	50	08	23	158·3	139·9	690	...	...	...	...	...	...	...	...	4	...	...	...	6	41	...	...	...	.	...	...
	Mar. 25	86	28	50	0	71	35	87	19	85	352·6	287·7	974	...	...	...	...	...	...	...	...	1	7	...	...	22	68	...	...	...	...	...	...
	April 25	35	12	80	1	26	60	36	39	40	295·7	213·2	374	...	..	1	...	1	...	...	...	1	...	...	...	20	19	...	...	...	...	...	...
Relevelments only { Jacobābād to Khānpur	April 25	...	...	...	...	...	...	...	...	...	70·323	55·944	92	2	...	...	...	...	...	...	...	...	...	...	...	12	...	...	...	...	...	...	...
and Khānpur to Darkhāna	April 25	...	...	...	...	...	...	...	...	...	88·897	80·010	262	1	...	...	...	...	...	...	.	...	...	...	...	23	...	...	...	2	...	...	...

TABLE X.—*Tabular statement of outturn of work, season 1924-25*—(*Contd.*)

Detachments and Lines levelled	Months	Distance levelled									Total number of feet		Mean number of stations at which the instruments were set up	Number of bench marks connected																Marine sockets
		Main-Line			Check levelling branch lines			Total			Rises	Falls		Primary						Secondary										
														Rock-cut Protected		Standard		Primary stations of triangulation		Embedded		Rock-cut		Inscribed		P. W. D.		Railway		
		Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	feet	feet		old	new	old	new	old	new	old	new	new	new	old	new	old	new	old	new	
No. 5 Detachment.																														
Calcutta to	Jan. 25	6	57	00	...	...	...	6	57	00	83·301	83·594	127	...	...	1	...	...	...	1	...	...	...	6	2	...	...	...	...	...
Nārāyanpur	Feb. 25	37	02	00	15	59	50	52	61	50	254·746	265·261	429	...	...	...	...	...	...	...	1	...	...	...	39	...	...	...	...	43
Nārāyanpur to	Feb. 25	29	19	00	14	32	50	43	51	50	206·461	211·344	442	...	...	...	...	...	..	...	3	...	..	...	35	...	1	...	...	51
Nārāyanpur	Mar. 25	43	21	00	3	77	00	47	18	00	326·833	321·994	344	...	...	...	...	..	...	...	5	...	...	...	60	...	3	...	1	24
Howrah to Uttarpara	Mar. 25	11	67	50	0	74	00	12	61	50	126·340	125·237	198	...	...	...	...	...	...	1	...	...	...	10	15	...	...	...	10	...
Baidyabati to Sheorāphūli	Mar. 25				2	67	00	2	67	00	...	...	40	...	...	...	...	...	...	1	...	...	...	3	4	...	..	...	1	...
Bāndel ...	Mar. 25				3	39	00	3	39	00	...	...	60	...	...	...	...	...	...	1	...	...	...	4	7	...	...	...	3	...
Pandua ...	Mar. 25				2	57	00	2	57	00	...	...	38	...	...	...	...	...	...	...	...	...	...	3	1	...	...	..	1	...
Saktigarh ...	April 25				1	13	00	1	13	00	...	...	18	...	...	...	...	...	...	...	...	...	...	3	3	...	...	...	1	...
Burdwān ...	April 25				2	64	50	2	64	50	...	...	28	...	...	1	...	...	...	1	...	...	...	1	2	2	...	...	1	...
Khāna ...	April 25				3	54	00	3	54	00	...	...	40	...	...	...	...	...	...	1	...	...	...	2	2	...	...	...	1	...
Galsi ...	April 25				5	61	00	5	61	00	...	...	52	...	...	...	...	...	...	...	...	...	...	5	3	...	...	...	1	...
Mānkar ...	April 25				4	09	00	4	09	00	...	...	36	...	.	...	...	...	...	1	...	...	...	3	2	...	...	...	1	...

TABLE X.—Tabular statement of outturn of work, season 1924-25—(Concld.)

Detachments and Lines levelled	Months	Distance levelled									Total number of feet		Mean number of stations at which the instruments were set up	Number of bench marks connected																Marine Sockets
		Main-Line			Check levelling branch lines			Total			Rises	Falls		Primary								Secondary								
														Rock-cut Protected		Standard		Primary stations of triangulation		Embedded		Rock-cut		Inscribed		P. W. D.		Railway		
		Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	feet	feet		old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	
No. 5 *Detachment.*—(Contd.)																														
Pānagar ...	April 25	...	...	...	1	51	00	1	51	00	...	...	22	...	...	...	...	...	...	1	...	...	...	1	3	...	...	...	1	...
Durgapur ...	April 25	...	...	...	3	58	00	3	58	00	...	...	56	...	...	...	...	..	..	...	...	1	...	2	4	...	...	...	1	...
Rāniganj ...	April 25	...	...	...	3	08	00	3	08	00	...	...	54	...	...	...	1	...	...	1	...	1	...	6	4	..	...	...	1	...
Asansol and Kālipāhāri ...	April 25	...	...	...	3	45	50	3	45	50	...	...	60	...	.	...	...	...	...	...	...	2	...	4	6	...	...	...	2	...
Barabani and Churūlia ...	April 25	...	...	...	11	01	00	11	01	00	...	..	148	...	...	...	...	...	...	...	...	...	...	..	9	...	...	...	3	...
Barākar to Hazāribāgh Road ...	April 25	29	37	00	6	42	00	36	59	00	751·819	406·721	346	...	...	..	...	..	...	1	...	...	...	4	10	...	...	...	43	...
	May 25	60	11	50	5	76	00	68	48	50	1417·497	839·680	747	...	...	...	...	...	...	2	..	...	...	4	18	...	...	...	52	...

TABLE XI.—CHECK LEVELLING

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check—original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Tangôn					
			miles	*feet*	date	*feet*	*feet*
2	84 M	Bridge No. 171 ...	0·0	0·000	1902-03-04	0·000	0.000
3	,,	E.B.M. at Tangôn ..	2·9	+ 7·601	,,	+ 7·508	− 0·093
1	,,	Bridge No. 166 ...	2·2	−15·157	,,	−15·211	− 0·054
56	84 N	,, ,, 162 ...	4·0	− 16·583	,,	− 16·578	+ 0·005
55	,,	,, ,, 159 ...	5·0	− 17·564	,,	− 17·545	+ 0·019
54	,,	Culvert No. 157 ...	6·0	− 20·021	,,	− 20·022	− 0·001
49	,,	E.B.M. at Tantabin ...	8·4	− 20·695	,,	− 20·879	− 0·184
62	,,	Culvert ...	12·2	− 58·965	,,	− 58·907	+ 0·058
		At Shwebo					
39	84 N	□330·80 on canal B.M. 110	0·0	0·000	1902-03-04	0·000	0·000
33	,,	E.B.M. at Shwebo R.S. ...	9·8	+ 13·505	,,	+ 13·533	+ 0·028
30	,,	Culvert ...	10·9	+ 3·675	,,	+ 3·674	− 0·001
31	,,	S.B.M. at Shwebo ...	11·0	+ 3·176	,,	+ 3·174	− 0·002
		At Padu					
4	84 N	E.B.M. at Padu ...	0·0	0·000	1902-03-04	0·000	0·000
6	,,	Wooden peg ...	2·2	− 21·113	,,	− 21·024	+ 0·089
7	,,	Bridge No. 41 ...	3·2	− 15·041	,,	− 14·888	+ 0·153
8	,,	,, ,, 42 ...	5·1	− 13·162	,,	− 13·462	− 0·300
9	,,	,, ,, 45 ...	7·3	+ 18·091	,,	+ 17·836	− 0·255
10	,,	,, ,, 47 ...	9·0	+ 56·221	,,	+ 56·022	− 0·199
11	,,	E.B.M. at Paukkan ...	10·7	+ 82·637	,,	+ 82·357	− 0·280
16	,,	Culvert ...	11·1	+ 73·683	,,	+ 73·383	− 0·300
		At Thonze					
302	85 O	Culvert ...	0·0	0·000	1922-23	0·000	0·000
303	,,	Bridge ...	0·9	− 2·422	,,	− 2·437	− 0·015
304	,,	Culvert ...	3·3	− 1·463	,,	− 1·538	− 0·075
305	,,	Bridge ...	5·6	− 2·748	,,	− 2·799	− 0·051

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check−original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Rangoon					
			miles	*feet*	date	*feet*	*feet*
31	94 D	Shwedagon Pagoda ...	0·0	0·000	1892-93, 1909-10	0·000	0·000
32	„	S.B.M. at Cantonment ...	0·2	+ 0·393	„	+ 0·383	−0·010
54	„	↑ B.M. at drain . 11	0·7	−50·881	„	−50·975	−0·094
30	„	↑ B.M. on stone block ... 66	1·3	−67·253	„	−67·221	+0·032
28	„	E.B.M. at Ry. offices ...	1·4	−78·746	„	−78·751	−0·005
29	„	O B.M. „ „ „ ...	1·4	−77·523	„	−77·537	−0·014
27	„	Sule Pagoda ...	1·9	−89·150	„	−89·151	−0·001
26	„	Town hall ...	1·9	−90·641	„	−90·643	−0·002
17	„	S.B.M. at Rangoon ..	2·3	−88·994	„	−89·015	−0·021
16	„	G.P.O. Rangoon ...	2·4	−92·040	„	−92·066	−0·026
22	„	↑ B.M. on stone block ... 169	3·0	−91·847	„	−91·999	−0·152
24	„	↑ B.M. on stone block ... 168	3·1	−91·525	„	−91·603	−0·078
18	„	Graham Smith's B.M. ...	2·7	−92·608	„	−92·606	+0·002
20	„	B.O M. on pillar ...	2·7	−91·449	„	−91·478	−0·029
19	„	„ „ ...	2·8	−91·508	„	−91·507	+0·001
21	„	Bed plate tidal B.M. ...	2·9	−88·433	„	−88·448	−0·015
		At Pegu					
32	94 C	S.B.M. at Pegu ...	0·0	0·000	1909-10	0·000	0·000
38	„	G.T.S. O at Pegu R.S. ...	0·9	+ 1·912	„	+ 1·785	−0·127
31	„	B.M. □ on pillar „ ...	1·0	+ 0·659	„	+ 0·473	−0·186
30	„	G.T.S. O on platform ...	1·0	+ 1·789	„	+ 1·509	−0·280
28	„	B.M. „ „ ...	1·1	+ 1·856	„	+ 1·789	−0·067
27	„	„ „ ...	1·1	+ 1·720	„	+ 1·496	−0·224

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Pegu					
			miles	*feet*	date	*feet*	*feet*
40	94 C	B ○ M. on bridge No. 1 ...	2·4	+ 9·952	1909-10	+ 9·898	−0·054
33	,,	,, ,, culvert ...	0·0	+ 1·073	,,	+ 1·068	−0·005
100	,,	Zinc plate at pagoda ...	0·9	+15·712	1912-13	+15·686	−0·026
34	,,	Rail embedded ...	1·4	+24·001	1909-10	+24·132	+0·031
36	,,	Culvert at Thanatpin ...	6·8	− 8·569	,,	− 8·614	−0·045
37	,,	E.B.M. at P.W.D office ...	6·8	−10·535	,,	−10·595	−0·060
101	,,	,, ,, 1·13 ...	7·0	−13·422	1912-13	−13·463	−0·041
		At Myitkyo					
111	94 C	E.B.M. at Myitkyo lock ...	0·0	0·000	1912-13 -14	0·000	0·000
112	,,	G.T.S. ○ B.M. , ,, ...	0·1	− 1·709	,,	− 1·678	+0·031
		At R. D. 25 of Yenwe embankment					
170	94 C	E.B.M. at R. D. 25	0·0	0·000	1923-24	0·000	0·000
169	,,	Iron plug ...	0·0	+ 3·109	,,	+ 3·107	−0·002
		Between Dala and Seikgyi					
7	94 D	G.T.S. ○ B.M. 2 on N. pagoda ...	0·0	0·000	1892-93	0·000	0·000
8	,,	G.T.S. ○ B M. 1 ,, ...	0·0	− 0·277	,,	− 0·339	−0·162
9	,,						
3	,,	B.M. on iron pillar ..	0·2	− 3·596	,,	− 3·574	+0·022
		↓ E.B.M. at Seikgyi	3·7	− 5·038	,,	− 5·031	+0·007
		At Sukkur					
101	40 A	S.B.M. at Sukkur	0·00	0·000	1904-06	0·000	0·000
251	,,	Step of Municipal reservoir ,, ...	0·13	−35·873	1921-24	−35·875	−0·032
53	,,	Church of England ,, ...	0·52	−26·886	1904-06	−26·887	−0·001

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling: No.	Degree sheet	Description	Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by: Original levelling		Check levelling 1924-25	Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
		At Sukkur					
			miles	*feet*	date	miles	*feet*
50 (48)	40 A	Bridge near Municipal office, Sukkur	0·64	−17·188	1904-06	−17·187	+0·001
250 (49)	,,	Railway Institute ,,	1·02	−19·427	1921-24	−19·439	−0·012
249	,,	Traveller's Bungalow ,,	1·10	−13·619	,,	−13·630	−0·011
100	,,	Rock cut B.M. (Type C) ,,	1·35	+ 1·236	1904-06	+ 1·235	−0·001
		At Hyderābād					
161	40 C	S.B.M. at Hyderābād ...	0·00	0·000	1904-06	0·000	0·000
155	,,	Civil Hospital, Hyderābād	1·35	+19·177	,,	+19·200	+0·023
156	,,	Metho Rām's Hall ,, ...	1·35	+19·560	,,	+19·561	+0·001
154	,,	Training College ,, ...	1·35	+21·271	,,	+21·280	+0·009
160	,,	St. Thomas' Church ,, ...	0·03	+ 0·625	,,	+ 0·624	−0·001
159	,,	Travellers bungalow ,, ...	0·42	− 0·542	,,	− 0·548	−0·006
31	,,	*Kachahri* ,, ...	0·57	+ 7·864	,,	+ 7·852	−0·012
158	,,	Subordinate Judge's ,, Court ,, ...	0·72	−10·272	,,	−10·280	−0·008
157	,,	N. V. High School ,, ...	0·78	− 5·347	,,	− 5·361	−0·014
		At Barmer					
23	40 O	Rock cut B. M. (type C) Barmer ...	0·00	0·000	1921-25	0·000	0·000
8	,,	Ry. Rest house Barmer	1·29	−41·068	,,	−41·078	−0·010
9	,,	Ry. station ,,	1·50	−40·000	,,	−40·012	−0·012
10	,,	Sub post office ,,	1·54	−41·370	,,	−41·382	−0·012
11	,,	Hem *Sarai* ,,	1·86	−20·464	,,	−20·475	−0·011
12	,,	,, ,,	1·90	−18·274	,,	−18·291	−0·017
13	,,	Seth Kanni Rām house ,,	1·94	−13·791	,,	−13·796	−0·005
14	,,	Police station ,,	2·00	−13·030	,,	−13·039	−0·009
15	,,	Civil Dispensary ,,	2·05	− 9·295	,,	− 9·306	−0·011
16	,,	Court house ,,	2·10	− 6·350	,,	− 6·340	+0·010
17	,,	Entrance ,,	2·12	− 6·452	,,	− 6·440	+0·012
18	,,	A.V. School ,,	2·16	− 5·591	,,	− 5·575	+0·016
19	,,	Seth Rām lāl's house ,,	2·21	+ 0·367	,,	+ 0·384	+0·017
20	,,	Ganesh Mal's ,, ,,	2·25	+ 4·702	,,	+ 4·710	+0·008
21	,,	Seth Brijlāl's ,, ,,	2·30	+ 1·443	,,	+ 1·447	+0·004
22	,,	Bālkishan's *Sarai* ,,	2·36	− 2·913	,,	− 2·903	+0·010

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (—) starting bench mark as determined by			Difference (check—original). The sign + denotes that the height was greater and the sign — less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Howrah					
			miles	*feet*	date	*feet*	*feet*
455	79 B	At Civil court ...	0·0	0·000	1913-14	0·000	0·000
267	,,	At Pump S. of Burn & Co's Work shop ...	0·4	— 3·792	,,	— 3·815	—0·023
456	,,	On platform ...	0·9	— 4·160	,,	— 4·180	—0·020
457	,,	On pavement ..	3·2	— 1·097	,,	— 1·337	—0·240
458	,,	On bridge ...	3·8	— 2·560	,,	— 2·602	—0·042
264	,,	Botanical gardens ...	5·2	— 5·024	,,	— 5·060	—0·036
454	,,	At lamp post ...	0·1	— 0·712	,,	— 0·693	+0·019
453	,,	At P. T. O. ...	0·3	— 0·821	,,	— 0·830	—0·009
246	,,	At canal lock, Ulubāria ...	20·4	— 3·488	1881-82-83	— 3·529	—0·041
245	,,	At I.B. Ulubāria ...	20·5	— 7·910	,,	— 8·149	—0·239
		At Jaleswar					
29	73 O	Embedded, Jaleswar ...	0·0	0·000	1881-82-83	0·000	0·000
28	,,	On culvert ...	1·1	— 0·234	,,	+ 0·208	+0·442
27	,,	On bridge No. 142 ...	2·0	+ 2·821	,,	+ 3·295	+0·474
26	,,	Patna T.S. ...	3·0	+37·869	,,	+38·273	+0·404
25	,,	On bridge No. 141 ...	4·0	+ 0·815	,,	+ 1·499	+0·684
17	,,	,, No. 131 ...	12·5	—12·888	,,	—12·183	+0·705
14	,,	Embedded, Basta ...	14·9	—21·258	,,	—21·134	+0·124
		At Rānīganj					
28	73 M	On rock ...	0·0	0·000	1916-17	0·000	0·000
29	,,	On bridge No. 131 ...	0·6	—23·460	,,	—23·489	—0·029
30	,,	On bridge on feeder road	0·9	— 8·940	,,	— 8·945	—0·005
31	,,	,, No. 5 ...	1·7	—10·303	,,	—10·294	+0·009
32	,,	,, No. 1 ...	2·0	—22·990	,,	—22·973	+0·017
33	,,	At garden ...	2·4	—17·116	,,	—17·103	+0·013
34	,,	At well ...	2·7	—32·219	,,	—32·189	+0·030
35	,,	Type A ...	2·9	—41·581	,,	—41·689	—0·108
38	,,	On wheel guard-stone ...	4·9	—24·233	,,	—24·282	—0·049
39	,,	On rock ...	5·4	—30·078	,,	—30·074	+0·004
40	,,	On Ry. drain No. 9 ...	6·1	—72·149	,,	—72·133	+0·016
42	,,	On bridge ...	7·2	—88·940	,,	—88·938	+0·002

TABLE XI.—CHECK LEVELLING—*(Contd.)*

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling: No.	Degree sheet	Description	Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by: Original levelling		Check levelling 1924-25	Difference (check−original). The sign + denotes that the height was greater and the sign − less than when originally levelled
		At Berhampur					
			miles	*feet*	date	*feet*	*feet*
30	78 D	Type B ...	0·0	0·000	1920-21	0·000	0·000
29	,,	At E. E's office verandah	0·0	+ 3·482	,,	+ 3·480	−0·002
41	,,	At Collector's Court ...	0·1	+ 5·222	,,	+ 5·195	−0·027
43	,,	At club ...	0·5	+ 2·867	,,	+ 2·868	+0·001
42	,,	At church ...	0·6	+ 3·750	,,	+ 3·697	−0·053
		At Godāgāri					
127	78 D	Type B ...	0·0	0·000	1920-21	0·000	0·000
126	,,	At Railway station ...	0·3	+ 4·960	,,	+ 4·940	−0·020
125	,,	On bridge No. 2 ...	0·9	+ 4·727	,,	+ 4·717	−0·010
128	,,	On culvert ...	1·0	+ 2·747	,,	+ 2·712	−0·035
129	,,	At I. B. ...	1·6	+ 5·321	,,	+ 5·344	+0·023
		At Dinājpur					
78	78 C	On Memorial pillar ...	0·0	0·000	1899-1900 & 1909	0·000	0·000
77	,,	Standard bench mark ...	0·2	− 2·884	,,	− 2·894	−0·010
76	,,	At *Kachahri* ...	0·4	+ 2·331	,,	+ 2·335	+0·004
41	,,	Railway bridge No. 28 ...	0·7	− 2·438	,,	− 2·416	+0·022
42	,,	Embedded ...	0·7	− 1·312	,,	− 1·310	+0·002
43	,,	Railway bridge No. 30 E. abutment ...	1·4	+ 8·294	,,	+ 8·317	+0·023
44	,,	Railway bridge No. 30 W.C.	1·5	+ 8·203	,,	+ 8·226	+0·023
46	,,	Railway bridge No. 35 ...	3·7	− 9·234	,,	− 9·206	+0·028
		At Kotri					
213	40 C	District bungalow Kotri ...	0·0	0·000	1920-21	0·000	0·000
39	,,	Water gauge Indus ,, ...	0·1	− 0·258	1904-06	− 0·241	−0·017
214 (38)	,,	Zero of Kotri gauge ,, ...	0·2	+ 0·332	1920-21	+ 0·334	+0·002
215 (35)	,,	Near Flotilla office ,, ...	0·5	− 1·049	,,	− 1·046	−0·003
210	,,	(Type B) bench mark ,, ...	1·3	− 3·763	,,	− 3·729	−0·034

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Kotri					
			miles	*feet*	date	*feet*	*feet*
210	40 C	(Type B) at Kotri	0·0	0·000	1920-21	0·000	0·000
211	,,	Railway station ,, ...	0·1	+ 6·542	,,	+ 6·534	−0·008
34	,,	Gidu Bander ,, ...	1·2	+27·447	1904-06	+27·430	−0·017
216	,,	Thakur Dās bungalow ,, ...	2·0	+ 3·508	1920-21	+ 3·462	−0·046
33	,,	Bridge No. 7 ,, ...	2·9	+19·585	1904-06	+19·547	−0·038
217	,,	Tapedars Training School ,, ...	3·0	+ 4·483	1920-21	+ 4·446	−0·037
161	,,	S.B.M. at Hyderābād ,, ...	3·6	+33·718	1904-06	+33·676	−0·042
		At Hyderābād					
161	40 C	S.B.M. at Hyderābād	0·00	0·000	1904-06	0·000	0·000
155	,,	Civil Hospital ,, ...	1·35	+19·177	,,	+19·200	+0·023
156	,,	Metha Ram's Hall ,, ...	1·35	+19·560	,,	+19·561	+0·001
154	,,	Training College ,, ...	1·35	+21·271	,,	+21·280	+0·009
160	,,	St. Thomas' Church ,, ...	0·03	+ 0·625	,,	+ 0·624	−0·001
159	,,	Traveller's bungalow ,, ...	0·42	− 0·542	,,	− 0·548	−0·006
31	,,	*Kachahri* ,, ...	0·57	+ 7·864	,,	+ 7·852	−0·012
158	,,	Subordinate Judge's Court ,, ...	0·72	−10·272	,,	−10·280	−0·008
157	,,	N. V. High School ,, ...	0·78	− 5·347	,,	− 5·361	−0·014
		At Sukkur					
101	40 A	S.B.M. at Sukkur	0·00	0·000	1904-06	0·000	0·000
251	,,	Step of reservoir ,,	0·13	−35·873	1921-24	−35·875	−0·002
53	,,	Church of England ,,	0·52	−26·886	1904-06	−26·887	−0·001
50	,,	Bridge, Municipal office ,,	0·64	−17·188	,,	−17·187	+0·001
250 (48)	,,	Railway institute ,,	1·02	−19·427	1921-24	−19·439	−0·012
249 (49)	,,	Travellers bungalow ,,	1·10	−13·619	,,	−13·630	−0·011
100	,,	Rock cut B.M. (Type C) ,,	1·35	+ 1·236	1904-06	+ 1·235	+0·001

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
			miles	*feet*	date	*feet*	*feet*
		At Govardhanla					
5	40 I	Stone pillar at Mawkeri Govardhanla ...	0·0	0·000	1923-24	0.000	...
4	"	Zinc plate 4 miles S. of Govardhanla ...	3·0	−38·943	"	−38·942	−0·001
3	"	Zinc plate 5½ miles S. of Govardhanla ...	8·5	−32·788	"	−32·792	+0·004
2	"	(Type B) at Govardhanla well	14·3	−32·081	"	−32·071	−0·010
		At Bhutta Sheikh*					
75	39 L	Zinc plate at Bhutta Sheikh	0·0	0·000	1922-23	0·000	0·000
76	"	(Type B) at Punnu Kutia	0·9	− 5·394	"	5·376	−0·018
78	"	Zinc plate at Lamana ...	2·7	− 0·943	"	− 0·930	−0·013
79	"	" at Munshi ...	4·5	+ 0·254	"	+ 0·294	+0·040
80	"	" at Jatki ...	5·9	+ 4·978	"	+ 4·988	+0·010
		At Karāchi					
109	35 P	S.B.M. at Karāchi ...	0·0	0·000	1893-94	0·000	0·000
5	"	Frere Hall " ...	0·7	− 8·399	1909-10	− 8·380	−0·019
6	35 L	Clock Tower " ...	3·5	− 23·697	1893-94	−23·712	+0·015
2	35 P	Telegraph Office, Karāchi	4·6	−26·457	"	−26·459	+0·002
108	"	Stone Monument " ...	5·7	− 9·782	"	− 9·789	+0·007
3	"	Trinity Church " ...	5·8	− 8·174	"	− 8·168	−0·006
100	"	Queen's statue " ...	6·1	−10·539	"	−10·582	+0·043
99	"	Step of Frere Hall " ...	6·2	−10·446	"	−10·446	0·000
100	35 P	Queen's statue, Karāchi ...	0·0	0·000	1893-94	0·000	0·000
104	"	Clifton G.T.S. h.s.	2·6	+71·474	"	+71·508	+0·034
103	"	Rock near Karāchi "	2·6	+69·663	"	+69·696	+0·033
101	"	Step to Queen's Statue "	5·1	− 2·244	"	− 2·205	−0·039

* Branch line No. 57L Dingarh to Khānpur.

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
At Calcutta							
			miles	*feet*	date	miles	*feet*
368	79 B	S.B M. Calcutta ...	0·00	0·000	1921-22	0·000	0·000
367	,,	G.T.S. O S.G's. office, Calcutta B.M.	0·00	− 0·496	,,	− 0·500	−0·004
366	,,	G.T.S. O Photo litho office ,, B.M.	0·20	− 1·650	,,	− 1·644	+0·006
365	,,	G.T.S. O M.I.O. ,, B.M.	0·30	− 0·324	,,	− 0·337	−0·013
459	,,	G.T.S. O St. James' church ,, B.M.	1·40	− 4·290	,,	− 4·297	−0·007
460	,,	G.T.S. O Campbel hospital ,, B.M.	2·10	− 1·102	,,	− 1·125	−0·023
462	,,	G.T.S. O Monument, Sealdah B.M.	2·40	+ 1·195	,,	+ 1·151	−0·044
461	,,	E.B.M., Sealdah ...	2·60	+ 1·520	,,	+ 1·525	+0·005
At Howrah							
453	79 B	G.T.S. O P. & T.O. Howrah ... B.M.	0·00	0·000	1913-14	0·000	0·000
454	,,	G.T.S. O lamp post ,, ... B.M.	0·10	+ 0·109	,,	+ 0·140	+0·031†
455	,,	G.T.S. O Civil court ,, ... B.M.	0·20	+ 0·821	,,	+ 0·832	+0·011
267	,,	G.T.S. O *Goal dighi* ... B.M.	0·56	− 2·971	,,	− 2·980	−0·009

† Revised height by levelling of 1924-25.

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Uttarpāra					
			miles	*feet*	date	*feet*	*feet*
447	79 B	E.B.M. dispensary, Uttarpāra ...	0·00	0·000	1913-14	0·000	0·000
326	,,	○ bridge, Bally creek B.M.	0·45	+ 4·938	,,	+ 4·869	−0·069†
327	,,	G.T.S. ○ Library, Uttarpāra B.M.	0·15	+ 1·787	,,	+ 1·818	+0·031†
446	,,	G.T.S. ○ platform ,, ... B.M.	0·65	+ 2·206	,,	+ 2·235	+0·029†
328	,,	G.T.S. ⊙ ,, ,, ... B.M.	1·01	+ 4·301	,,	+ 4·308	+0·007
445	,,	G.T.S. ○ at bridge ... B.M.	1·72	+ 1·754	,,	+ 1·710	−0·044†
		At Baidyabāti					
433	79 B	E.B.M. at Baidyabāti ...	0·00	0·000	1916-17	0·000	0·000
435	,,	G.T.S. ○ at bridge ... B.M.	1·30	−9·805	1913-14	−9·793	+0·012
436	,,	B.○M. on M.S. 17 ...	1·91	−1·426	,,	−1·463	−0·037†
334	,,	G.T.S. ○ at bridge ... B.M.	2·56	−1·184	,,	−1·169	+0·015
		At Bāndel					
405	79 B	E.B.M. at Bāndel ...	0·00	0·000	1916-17	0·000	0·000†
406	,,	G.T.S. ○ on culvert ... B.M.	0·39	+ 4·934	,,	+ 4·889	−0·045
348	,,	G.T.S. ○ at Normal School, Hooghly ... B.M.	0·74	+10·873	,,	+10·798	−0·075†
347	,,	G.T.S. ○ at Imāmbara, Hooghly ... B.M.	1·11	+ 7·945	,,	+ 7·907	−0·038
407	,,	B.⊙M. at bridge ...	1·34	+ 5·469	,,	+ 5·433	−0·046

† Revised height by levelling of 1924-25.

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Pandua					
			miles	*feet*	date	*feet*	*feet*
118	79 A	B.O M. on R. B. pillar ..	0·00	0·000	1916-17	0·000	0·000†
119	,,	B.O M. ,, ,, ...	0·51	− 1·730	,,	− 1·799	−0·069
121	,,	G.T.S. O on Culvert B.M. ...	1·71	− 4·016	,,	− 4·074	−0·058
		At Saktigarh					
126	73 M	G.T.S. O at bridge B.M. ...	0·00	0 000	1916-17	0·000	0·000
127	,,	G.T.S. O ,, ,, B.M. ...	0·23	+ 4·262	,,	+ 4·280	+0·018†
129	,,	B.O M. at pillar ...	0·86	− 4·551	,,	− 4·549	+0·002
		At Burdwān					
116	73 M	E.B.M. at Burdwān ...	0·00	0·000	1916-17	0·000	0·000
115	,,	S.B.M. ,, ...	0·03	+ 5·117	,,	+ 5·079	−0·038†
114	,,	B.D.B.M. O at pillar 100·90 ...	0·16	+ 5·335	,,	+ 5·332	−0·003
113	,,	B.D.B.M. O ,, 100·18 ...	0·70	+ 3·953	,,	+ 3·915	−0·038†
112	,,	G.T.S. O at bridge B.M. ...	1·08	+ 3·865	,,	+ 3·870	+0·005

† Revised height by levelling of 1924-25.

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Khāna					
			miles	*feet*	date	*feet*	*feet*
104	73 M	G.T.S. ○ on R.B. pillar B M ...	0·00	0·000	1916-17	0·000	0·000
103	,,	G.T.S ○ ,, B.M. ...	0·79	+ 3·264	,,	+ 3·257	−0·007
102	,,	E.B.M. at Kulgaria ...	1·29	+ 2·272	,,	+ 2·146	−0·126†
101	,,	G.T.S. ○ at R.B. pillar B.M. ...	1·84	+ 5·921	,,	+ 6·041	+0·120†
100	,,	G.T.S. ○ ,, B.M. ...	2·85	+ 9·222	,,	+ 9·207	+0·015
99	,,	G.T.S. ○ at bridge B.M. ...	3·48	+13·286	,,	+13·352	+0·066†
98	,,	G.T.S. ⊙ at well B.M. ...	4·28	+16·106	,,	+16·111	+0·005
97	,,	G.T.S. ○ at R.B. pillar B M. ...	5·36	+14·147	,,	+14·304	+0·157†
96	,,	B ○ M. ,, ...	6·14	+19·625	,,	+19·685	+0·060†
		At Mānkar					
85	73 M	G.T.S. ○ at bridge B.M. ...	0·00	0·000	1916-17	0·000	0·000
84	,,	(No inscription) at R.B. pillar ...	0·81	− 3·444	,,	− 3·461	−0·017
83	,,	G.T.S. ○ at R.B. pillar B M. ...	1·56	+ 3·596	,,	+ 3·658	+0·062
82	,,	E.B.M. at Būd Būd ...	2·10	+ 4·992	,,	+ 5·020	+0·028
		At Pānagar					
76	73 M	E.B.M. at Pānagar ...	0·00	0·000	1916-17	0·000	0·000
73	,,	G.T.S. ○ at tank B M. ..	1·19	−22·896	,,	−22·884	+0·012

† Revised height by levelling of 1924-25.

TABLE XI.—CHECK LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree Sheet	Description		Original levelling		Check levelling 1924-25	
		At Durgapur					
			miles	*feet*	date	*feet*	*feet*
58	73 M	G.T.S. ○ B.M. at rock ...	0·00	0·000	1916-17	0·000	0·000
60	"	B.○M. at bridge ...	1·01	+ 7·945	..	+ 7·960	+0·015
61	"	G.T.S. ○ B M. at M.S. No. 112 ...	1·59	− 2·136	"	− 2·190	−0·054*
		At Rāniganj					
28	73 M	G.T.S. ○ B.M. at rock ...	0 00	0·000	1916-17	0·000	0·000
29	"	G.T S. ○ B.M. at bridge ..	0·59	−23·460	"	−23·477	−0·017†
30	"	B.○M. " " ...	0 89	− 8·940	"	− 8·935	+0·005†
31	"	B.○M. " " ...	1·65	−10·303	"	−10·256	+0·047†
32	"	B.○M. " " ...	2·00	−22·990	"	−22·932	+0·058†
33	"	B.○M. at platform ..	2·35	−17·116	"	−17·057	+0·059†
34	"	G.T.S. ○ B.M. " " ..	2·73	−32·219	"	−32·144	+0·075†
35	"	E.B.M. at Rāniganj ...	2 93	−41·581	"	−41·684	−0·067†
		At Asansol					
15	73 M	G.T.S. ○ B.M. at gate lodge ..	0·00	0·000	1914-15 & 1916-17	0·000	0·000
14	"	G.T.S. ○ B.M. on rock ..	0·28	+ 4·267	"	+ 4·277	+0·010
13	"	G.T S. ○ B.M. " " ...	0·80	+29·001	..	+29·020	+0·019

* Revised height by levelling of 1924-25

† The old bench marks are not adjusted as they will receive values from net levelling of 1924-25 and 1925-26.

TABLE XI.—CHECK LEVELLING—(*Concld.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected for check levelling			Distance from starting bench mark	Observed height above (+) or below (−) starting bench mark as determined by			Difference (check − original). The sign + denotes that the height was greater and the sign − less than when originally levelled
No.	Degree sheet	Description		Original levelling		Check levelling 1924-25	
		At Asansol					
			miles	*feet*	date	*feet*	*feet*
77	73 I	G.T.S. O on culvert B.M.	1·38	+ 9·582	1914-15 & 1916-17	+ 9·560	−0·022
76	,,	B.O M. on well ...	1·76	+30·741	,,	+30·789	+0·048†
75	,,	G.T.S O at lamp post .. B.M.	2·23	+33·498	,,	+33·526	+0·028
		At Barākar					
49	73 I	G.T.S. O at Barākar bridge B.M.	0·00	0·000	1914-15 & 1916-17	0·000	0·000
50	,,	G.T.S. O ,, ,, B.M.	0·45	− 4·513	,,	− 4·523	−0·010
51	,,	E.B.M. at Barākar ..	0·58	− 7·546	,,	− 7·551	−0·005†
52	,,	+ on pillar ...	0·60	− 1·529	,,	− 1·556	−0·027†
54	,,	G.T.S. O on bridge ... B.M.	0·88	− 0·419	,,	− 0·425	−0·006
		At Hazāribāgh Road					
66	72 H	G.T.S. O on rock *in sitū* .. B.M.	0·00	0·000	1914-15 & 1916-17	0·000	0·000
65	,,	G.T.S. O on bridge ... B.M.	0·01	−24·360	,,	−24·359	+0·001
64	,,	G.T.S. O on rock *in sitū* ... B.M.	0·01	+18·911	,,	+18·910	0·001
63	,,	E.B.M. at M.S. 220 ...	0·02	+37·255	,,	+37·252	−0·003

† Revised value by levelling of 1924-25.
E. B. M. = Embedded bench mark. **S. B. M.** = Standard bench mark.
I. B. M. = Interred bench mark.

TABLE XII.—REVISION LEVELLING

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected during the revisionary operations			Distance from starting bench mark	Difference between orthometric heights above (+) or below (−) the starting bench mark			Difference (revision − original). The sign + denotes that the height was greater and the sign − less in 1924-25 than when originally levelled
No.	Degree sheet	Description		From published heights	Date of original levelling	From Revision 1924-25 (Unadjusted)	
Revision of part of Main line 52 (Sujāwal to Shikārpur							
			miles	*feet*		*feet*	*feet*
100	40 A	(Type C) B.M. Sukkur ...	0·00	0 000	1904-06	0·000	0·000
52	,,	Railway Pay clerk's office Sukkur ..	0·40	− 56·453	,,	− 56·470	+ 0·017*
99	,,	Railway station Sukkur ...	0·44	− 56·729	,,	− 56·740	+ 0·011
47	,,	Platform R. S. ,, ...	0·47	− 50·352	,,	− 50·375	+ 0·023
46	,,	Bridge No. 349 ,, ...	1·39	− 34·962	,,	− 34·987	+ 0·025*
44	,,	E.B.M. at Rohri Jn. R. S.	3·23	− 32·368	,,	− 32·457	+ 0·089*
43	,,	Bridge No. 180 ...	4·66	− 54·789	,,	− 54·840	+ 0·051*
41	,,	,, ,, 166 ...	8·72	− 64·106	,,	− 64·193	+ 0·087*
40	,,	Pillar near M. P. 291 ...	10·68	− 63·831	,,	− 64·156	+ 0·325*
36	,,	,, ,, 287 ...	14·68	− 63·896	,,	− 64·233	+ 0·337*
34	,,	Bridge No. 143 ..	18·82	− 70·468	,,	− 70·581	+ 0·113*
30	,,	,, ,, 127 ...	22·87	− 78·185	,,	− 78·297	+ 0·112*
29	,,	Pillar near M. P. No. 277	24·74	− 74·996	,,	− 75·236	+ 0·24[illegible]*
28	,,	,, ,, ,, 275	26·75	− 76·076	,,	− 76·236	+ 0·160*
23	,,	Culvert No. 113 ..	33·61	− 83·440	,,	− 83·561	+ 0·121*
22	,,	Bridge ,, 111 ...	34·84	− 80·142	,,	− 80·210	+ 0·068*
14	,,	Culvert ,, 97 ...	43·18	− 92·527	,,	− 92·757	+ 0·230*
10	,,	,, ,, 82 ..	47·34	− 95·280	,,	− 95·515	+ 0·235*
9 (219)	,,	Bridge ,, 75 ...	49·16	− 95·788	,,	− 96·054	+ 0·266*
8 (7)	,,	Culvert ,, 68 ...	51·29	− 99·260	,,	− 99·459	+ 0·199*
218	,,	,, ,, 62 ..	53·41	− 100·768	,,	− 101·066	+ 0·298*
4	,,	,, ,, 60 ...	55·20	− 101·829	,,	− 102·028	+ 0·199*
2	,,	,, ,, 47 ...	59·05	− 101·210	,,	− 101·411	+ 0·201*
1	,,	,, ,, 41 ...	61·42	− 105·157	,,	− 105·360	+ 0·203*
50	,,	Bridge ,, 33 ...	66·51	− 105·494	,,	− 105·747	+ 0·253*
49	40 B	Pillar near T. P. 234/18 ..	68·20	− 110·567	,,	110·891	+ 0·324*
45	,,	Culvert No. 7 ..	76·32	− 118·828	,,	− 119·333	+ 0·505*
44	,,	Bridge ,, 11 ..	78·56	− 114·299	,,	− 114·227	− 0·072*
43	,,	Bridge No. 7 ...	80·57	− 115·712	,,	− 116·000	+ 0·288*
39	,,	Culvert No. 219 ...	86·76	− 122·360	,,	− 122·700	+ 0·340*
36	,,	,, ,, 209 ...	92·38	− 127·089	,,	− 127·502	+ 0·413*
35	,,	,, ,, 206 ...	93·34	− 128·225	,,	− 128·668	+ 0·443*
34	,,	,, ,, 204	95·07	− 130·880	,,	131·292	+ 0·412*
23	,,	Pillar near M. P. 194 ..	111·62	− 146·734	,,	− 147·350	+ 0·616*
20	,,	,, ,, 192 ...	113·64	− 148·082	,,	− 148·741	+ 0·659*

* New value and number given others are unaltered.

TABLE XII.—REVISION LEVELLING—(*Contd.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected during the revisionary operations			Distance from starting bench mark	Difference between orthometric heights, above (+) or below (−) the starting bench mark			Difference (revision − original). The sign + denotes that the height was greater and the sign − less in 1924-25 than when originally levelled
No.	Degree sheet	Description		From published heights	Date of original levelling	From Revision 1924-25 (Unadjusted)	
Revision of part of Main line 52 (Sujāwal to Shikārpur)							
			miles	*feet*		*feet*	*feet*
16	40 B	E.B.M. at Nawāb Shāh R.S.	121·55	−154·937	1904-06	−156·058	+1·121*
8	,,	Culvert No. 185 ...	132·38	−165·944	,,	−166·621	+0·677*
7	,,	E.B.M. at Sarhari R.S. ...	132·58	−162·268	,,	−163·231	+0·963*
5	,,	Culvert No 180 ...	134·46	−168·198	,,	−169·074	+0·876*
2	,,	E.B.M. at Lundo R.S. ...	138·94	−164·906	,,	−165·793	+0·887*
86/223	40 C	,, Shāhdādpur R.S.	147·72	−170·236	,,	−171·113	+0·877*
78	,,	,, Tando Adam ,,	159·64	−178·562	,,	−179·593	+1·031*
71	,,	Bridge No. 95 ,,	167·70	−182·660	,,	−183·810	+1·150*
54	,,	Fuleli canal Bridge ...	192·27	−177·920	,,	−179·212	+1·292
157	,,	N. V. High school Hyderābād ...	194·21	−164·989	,,	−166·287	+1·298
158	,,	Subordinate Judge's Court Hyderābād ...	194·27	−169·914	,,	−171·206	+1·292
31	,,	*Kachahri* Hyderābād ...	194·42	−151·778	1909-10	−153·072	+1·294
159	,,	Traveller's bungalow Hyderābād ...	194·57	−160·184	1904-06	−161·473	+1·289
160	,,	St. Thoma's church Hyderābād ...	194·96	−159·017	,,	−160·301	+1·284
161	,,	S.B.M. Hyderābād ...	194·99	−159·642	,,	−160·925	+1·283
155	,,	Civil hospital Hyderābād	196·35	−140·465	,,	−141·723	+1·258
156	,,	Metha Rām's Hall Hyderābād ...	196·43	−140·082	,,	−141·362	+1·280
154	,,	Training college Hyderābād ...	196·60	−138·371	,,	−139·643	+0·272
101	40 A	S.B.M. at Sukkur ...	0·00	0·000	1904-06	0·000	0·000
251	,,	Step of Municipal reservior at Sukkur ...	0·13	− 35·873†	,,	− 35·886	−0·013*
53	,,	Church of England at Sukkur ...	0·52	− 26·886	,,	− 26·896	+0·010
50	,,	Bridge near Municipal office at Sukkur ...	0·64	− 17·188	,,	− 17·193	+0·005
48	,,	Railway Institute at Sukkur ...	1·02	− 19·436	,,	− 19·443	+0·007*
49	,,	Traveller's bungalow at Sukkur ...	1·10	− 13·631	,,	− 13·633	+0·002*
100	,,	(Type C) B. M. at Sukkur	1·35	+ 1·236	,,	+ 1·232	−0·004

* New value and number given, others are unaltered.
† Value from line 101 (Jacobābād to Khānpur).

TABLE XII.—REVISION LEVELLING—(*Concld.*)

Discrepancies between the old and new heights of bench marks

Bench marks of the original levelling that were connected during the revisionary operations			Distance from starting bench mark	Difference between orthometric heights, above (+) or below (−) the starting bench mark			Difference (revision − original). The sign + denotes that the height was greater and the sign − less in 1924-25 than when originally levelled
No.	Degree sheet	Description		From published heights	Date of original levelling	From Revision 1924-25 (Unadjusted)	
Revision of part of branch line 77 M (Berhampore to Tinpāhār)							
			miles	*feet*		*feet*	*feet*
30	78 D	Type B. at Berhampore ...	0·0	0·000	1920-21	0·000	0·000
44	,,	At bridge ...	0·7	− 2·718	,,	− 2·720	−0·002
46	,,	At well ...	7·0	+ 8·271	,,	+ 8·268	−0·003
47	,,	At R S. Murshidābād ...	8·2	+ 8·544	,,	+ 8·557	+0·013
48	,,	At Jail ,, ...	8·6	+ 9·497	,,	+ 9·520	+0·023
49	,,	Type B ,, ...	9·4	+ 4·873	,,	+ 4·901	+0·028
50	,,	At boarding house Murshidābād ..	9·6	+11·151	,,	+11·170	+0·019
51	,,	At Govt. school Murshidābād ..	9·7	+ 9·460	,,	+ 9·487	+0·027
60	,,	At well, P.W.D. I. B., Jiāganj ...	14·3	+12·004	,,	+11·981	−0·023
59	,,	Type B. at Jiāganj ...	14·3	+ 7·259	,,	+ 7·248	−0·011
53	,,	At D.B. I.B., ,, ...	15·4	+ 6·359	,,	+ 6·338	−0·021
52	,,	At R.S. ,, ...	15·7	+ 8·489	,,	+ 8·443	−0·046
54	,,	Type B. at Bhagwāngolā	21·9	+ 8·423	,,	+ 8·408	−0·015
55	,,	At R.S. ,, ...	22·4	+18·861	,,	+18·839	−0·022
56	,,	At Ry. culvert ...	24·4	+ 6·292	,,	+ 6·309	+0·017
57	,,	At R.S. Lālgolā ...	29·5	+15·668	,,	+15·676	+0·008
58	,,	Type B ,, ...	29·5	+11·001	,,	+11·032	+0·031

TABLE XIII.—*List of Great Trigonometrical Survey stations connected by spirit levelling, season 1924-25*

Name of station	Height above mean sea level			Difference	Remarks
	New spirit-levelling	Old spirit-levelling	Triangulation	Trian-Lev	
		Mandalay Longitudinal Series			
	feet	*feet*	*feet*	*feet*	
Sadaung East S. Lat. 22° 10′ 16″·582 Long. 95 48 36·223	474·801	...	477	+ 2	Top of pillar
Lindalu S. Lat. 22° 3′ 27″·466 Long. 95 44 23·614	633·751	...	635	+ 1	Upper mark stone
		Eastern Sind Meridional Series			
Hatudan H.S. Lat. 25° 29′ 34″·72 Long. 69 49 45·34	297·733	...	299	+ 1	Upper mark stone
Bhitāla H.S. Lat. 25° 38′ 47″·02 Long. 70 8 44·81	360·921	...	362	1	do
		Calcutta Longitudinal Series			
Nibria T.S. Lat. 22° 35′ 33″·92 Long. 88 14 42·43	12·195*	...	14	+ 2	Ground level mark stone
		East Coast Series			
Dāntūn T.S. Lat. 21° 56′ 10″·27 Long. 87 16 42·89	115·819*	...	116	0	Top mark stone
Patna T.S. Lat. 21° 47′ 20″·83 Long. 87 11 45·53	80·531*	80·491	80	– 1	do.

* Unadjusted single levelling height.

TABLE XIII.—*List of Great Trigonometrical Survey stations connected by spirit levelling, season 1924-25—(Concld.)*

Name of station	Height above mean sea level			Difference	Remarks
	New spirit-levelling	Old spirit-levelling	Triangulation	Trian-Lev.	
South Malūncha Meridional Series					
	feet	*feet*	*feet*	*feet*	
Gop T.S. Lat. 22° 25′ 10″·77 Long. 87 16 28·02	192·993*	...	211	+18	Mark stone at 4 feet from base of plinth of Tower
Calcutta Meridional Series					
Khetia T.S. Lat. 24° 36′ 51″·25 Long. 88 23 3·19	127·424	...	132	+5	Ground level mark stone
Charaldānga T.S. Lat. 24° 52′ 43″·95 Long. 88 23 4·21	128·188	...	131	+3	Top mark stone
Kisnapur T.S. Lat. 25° 23′ 31″·83 Long. 88 28 27·64	101·879	...	117	+15	Ground level mark stone
Great Indus Series					
Karāchi Obsy. G.T.S. Stn. Lat. 24° 49′ 50″·25 Long. 67 01 35·13	35·420	31·829 +3·7	35	0	
Clifton G.T.S. h.s. Lat. 24° 49′ 10″·10 Long. 67 03 07·67	96·689	96·657	96	−1	Ground level mark stone

* Unadjusted single levelling height.

TABLE XIV.—*Results of comparison of staves with standard steel tape No. 2, season 1924-25*

Place and date	Difference of length of staves from 10 feet				Remarks
	No. of staff				
	23B	22B	13A	13B	
Tangôn 3-11-24	+0·001171	+0·001397	+0·002480	+0·001998	Clear.
Myittaw 14-11-24	+0·002216	+0·002081	+0·002106	+0·002296	Scattered clouds.
Maukkyo 24-11-24	+0·002473	+0·001998	+0·001838	+0·002075	„
Sadaung 6-12-24	+0·002484	+0·002602	+0·001787	+0·001916	Clear
Sathe 16-12-24	+0·001704	+0·001653	+0·001611	+0·001490	Light scattered clouds and cool breeze.
Nyaunghla 26-12-24	+0·001553	+0·001337	+0·001574	+0·001373	Scattered clouds.
Kinu 4-1-25	+0·001865	+0·001486	+0·001371	+0·001436	Clear.
Okhan 20-4-25	−0·000831	−0·002381	−0·004363	−0·003327	Scattered clouds.
Taukkyan 1-5-25	−0·000329	−0·001243	−0·002405	−0·002623	Clear.
Ahlone (Rangoon) 14-5-25	+0·000781	−0·000320	−0·002543	−0·002874	Scattered clouds.
Pegu 26-5-25	+0·001717	+0·002163	−0·000870	−0·000589	Drizzling.

TABLE XIV—*Results of comparison of staves with standard steel tape No. 3, season 1924-25*—(*Contd.*)

Place and date		Difference of length of staves from 10 feet		Remarks
		No. of staff		
		20A	20B	
Sukkur	28-10-24	−0·002494	−0·001485	Clear
Khairpur Mīrs	5-11-24	−0·002606	−0·001746	,,
Setharja	15-11-24	−0·003478	−0·002829	,,
Kandiāro Road	19-11-24	−0·003506	−0·002537	,,
Daur	1-12-24	−0·003518	−0·003334	,,
Nawāb Shāh	8-12-24	−0·003867	−0·003264	,,
Shāhdādpur	17-12-24	−0·003297	−0·002752	,,
Oderolāl	23-12-24	−0·003540	−0·002927	,,
Hyderābād	3-1-25	−0·003336	−0·002129	,,
Khesano	13-1-25	−0·004021	−0·002598	Clear
Mīrpur khās	21-1-25	−0·003995	−0·003180	,,
Pithoro	31-1-25	−0·003366	−0·002892	Dusty
Chhor	8-2-25	−0·003852	−0·003608	Clear
Jalu-jo-chaunro	18-2-25	−0·004287	−0·003836	,,
Munabao	27-2-25	−0·005223	−0·004846	,,
Gudra Road	8-3-25	−0·005257	−0·004483	,,
Rāmsar	15-3-25	−0·004807	−0·004043	,,
Bhachbhar	20-3-25	−0·005026	−0·003926	,,
Jasai	25-3-25	−0·005660	−0·004850	,,
Atimalani	30-3-25	−0·005783	−0·004645	,,
Barmer	2-4-25	−0·006070	−0·005288	,,

TABLE XIV.—*Results of comparison of staves with standard steel tape No. 7, season 1924-25*—(*Contd.*)

Place and date		Difference of length of staves from 10 feet — No. of staff — 16A	16B	Remarks
Santragachi	5-11-24	−0·003872	+0·000939	Clear
do.	2-11-24	−0·003526	+0·000929	do.
Ulubāria	20-11-24	−0·001626	+0·001595	Drizzling
Kola	28-11-24	−0·002043	+0·001913	Light clouds and cool breeze
Debra	5-12-24	−0·003205	+0·000917	Clear and cool breeze
Nārāyangarh	16-12-24	−0·003573	+0·000485	Clear
Jaleswar	27-12-24	−0·004187	+0·000718	do.
Midnapore	7-1-25	−0·003155	+0·000616	Scattered clouds and cool breeze
Debra	5-12-24	−0·003205	+0·000917	Clear and cool breeze
Nārāyangarh	16-12-24	−0·003573	+0·000485	Clear
Jaleswar	27-12-24	−0·004187	+0·000718	do.
Midnapore	7-1-25	−0·003155	+0·000616	Scattered clouds and cool breeze
Garhbeta	17-1-25	−0·001635	−0·000320	
Onda	26-1-25	−0·004695	+0·000201	Clear and high cool breeze
Shali	5-2-25	−0·005749	−0·000305	Clear
Ukhra	16-2-25	−0·005762	−0·000254	do.
Shali	5-2-25	−0·005749	−0·000305	Clear
Ukhra	16-2-25	−0·005762	−0·000254	do.
Chinpai R.S.	25-2-25	−0·008010	−0·001913	Clear and high wind
Sainthia	5-3-25	−0·008441	−0·002539	Clear and breeze
Kandi	15-3-25	−0·006982	−0·001113	...
Jiāganj	27-3-25	−0·007103	−0·001172	Clear and breeze
Godāgāri	5-4-25	−0·008405	−0·001161	,, ,, high breeze
Parbatipur *adda*	17-4-25	−0·006009	−0·000312	Light clouds and high wind
Sapahar	28-4-25	−0·003057	+0·001787	Clear and high wind
Pabirām	6-5-25	−0·003714	+0·001074	Clear
Dinājpur	15-5-25	−0·001607	+0·002296	Clear and breeze

TABLE XIV.—*Results of comparison of staves with standard steel tape No. 4, season 1924-25*—(*Contd.*)

Place and date		Difference of length of staves from 10 feet		Remarks
		No. of staff		
		19A	19B	
Rāmlāl-ka-kawa	30-10-24	−0·002141	−0·002537	Clear and cool breeze
Gareebwāla kawa	17-11-24	−0·002962	−0·003619	,,
Pathānwāla ,,	6-11-24	0·003816	−0·003741	,,
Goru	22-11-24	−0·003731	−0·004028	,,
Khānpur	30-11-24	−0·003312	−0·003391	Clear
Karāchi	7-12-24	−0·003024	−0·003731	Scattered clouds
Drigh Road R.s	15-12-24	−0·002936	−0·003803	,,
Pipri	20-12-24	−0·004018	−0·003658	,,
Guja	28-12-24	−0·003670	−0·003614	,,
Hilaya	6- 1-25	−0·003010	−0·002843	Clear
Jerruck	12- 1-25	−0·003091	−0·003297	,,
Kotri	19- 1-25	−0·003805	−0·003539	,,
Dethā	26- 1-25	−0·002870	−0·002475	,,
Oderolāl	4- 2-25	−0·003372	−0·003396	,,
Shāhdādpur	13- 2-25	−0·003883	−0·004292	,,
Sarhari	20- 2-25	−0·004221	−0·004406	Cloudy
Nawāb Shāh	3- 3-25	−0·003833	−0·003820	Clear
Daur	10- 3-25	−0·004096	−0·003827	,,
Bhiria Road	19- 3-25	−0·004980	−0·004702	Dusty
Mahrābpur	27- 3-25	−0·005389	−0·005378	Clear
Khairpur Mīrs	4- 4-25	−0·005300	−0·005009	Cloudy
Rohri	12- 4-25	−0·005257	−0·005148	Clear

TABLE XIV.—*Results of comparison of staves with standard steel tape No. 10, season 1924-25—(Concld.)*

Place and date	Difference of length of staves from 10 feet				Remarks
	No. of staff				
	E_1	O_1	23A	17B	
Calcutta 27-1-25	−0·001707	−0·000024	−0·003445	−0·001972	Clear
Dhapa 6-2-25	−0·000899	−0·000131	−0·003369	−0·001876	Clear & high wind
Bānsra 15-2-25	0·000725	0·000000	−0·003240	−0·001544	Clear
Hatkhola 25-2-25	−0·002837	−0·001443	−0·005188	−0·003029	"
Uttarbhāg 9-3-25	−0·001895	−0·002514	−0·004870	−0·002709	"
Calcutta 19-3-25	−0·002235	−0·001710	−0·005412	−0·002723	"
Lillooah 31-3-25	−0·001303	−0·001134	−0·005013	−0·002844	Light clouds
Asansol 11-4-25	−0·002544	−0·001856	−0·001019	−0·002921	Clear
Sitārāmpur 19-4-25	−0·002513	−0·001420	−0·005552	−0·002522	"
Pradhānkhanta 29-4-25	−0·001417	−0·000476	−0·004170	−0·002341	"
Gomoh 8-5-25	−0·003789	−0·002443	−0·006131	−0·004229	"
Hazāribāgh Road 19-5-25	−0·003519	−0·002569	−0·007344	−0·004164	Cloudy
Bagodar 24-5-25	−0·002184	−0·001165	−0·004640	−0·002652	"
Sitārāmpur 3-6-25	−0·002011	−0·000926	−0·005046	−0·004315	Cloudy & raining

Chapter VI

THE HEIGHT OF MOUNT EVEREST AND OTHER PEAKS

A lecture delivered by Dr. J. de Graaff Hunter, M.A., Sc. D., F. Inst. P. at the meeting o the Indian Science Congress at Madras, February 1922.

The problem of determining the heights of great peaks, not readily accessible and in some cases only possible to observe from considerable distances, has a good many difficulties. This certainly holds for Everest, situated as it is at the north boundary of Nepal. Owing to the fact that it is the highest point of the earth, it is of especial interest to fix its height with as much precision as possible. Public interest in the mountain has been enhanced lately by the despatch of an expedition which has made a reconnaissance of the mountain in 1921; and an attempt to reach the summit is to be made in the current year 1922. 240. *General.*

Old values of the height of Everest are :— 241. *Old values of the height of Everest.*

(a) 29,002 feet. Although the height of the mountain is nearly 1000 feet greater than that of any other known peak, and there is no doubt at all about its pre-eminence in this respect, questions have been raised as to whether 29,002 represents the facts of the case. This value has been given wide publicity, and is the one generally known. The terminal 2 of this figure has often been discussed. Some people imagine that the result is a perfectly accurate one; while others, quite rightly, have conjectured that the 2 might as well be left out, so far as our knowledge can tell. There has been the practical inconvenience that, were the 2 omitted, the height would become a round number of 1000 feet; and to some minds this would convey the idea that the precision of the determination was good only to the nearest 1000 feet. This would err more than the view that the height is exactly 29,002 feet as determined in 1852.

(b) In 1907 Colonel Sir Sidney Burrard published the revised value of 29,141 feet. As he did not consider that finality had been reached, he did not advocate the changing of the height on Survey of India maps.

The difference of these two results is due to a modified treatment of the observations. It is still impossible to be quite definite to the last 10 feet in height. Here I may correct a popular misconception. Some people imagine that if a climber could reach the summit, then all doubt as to the height would disappear. This is not so. Even if he were able to take with him accurate observing instruments, he would not be able to improve our height value appreciably.

The several practical methods of determining height in use are :— 242. *Methods of determining height.*

(1) Observations of barometric pressure, which includes observations with mercury, aneroid barometers or with hypsometers.

242. (*Contd.*)

(2) Spirit levelling right up to the point.

(3) Observation of the angle of elevation of a point from a station of known height and at a known distance.

243. *Barometric observations.*

As regards barometer observations it may be noted that the transport of a mercury barometer, and its subsequent setting up have special difficulties. If a portable barometer of the Fortin type is used, in which the mercury is never removed from the glass tube, there is grave danger of the glass breaking in the course of transit, as the result of the jolting of the heavy mercury in the glass. With the class of barometer, typified by the George barometer, the mercury is removed for transit. It is difficult to ensure entire absence of air in the tube, or in the mercury itself. Meteorologists may say that this can be overcome, and no doubt this is the case in some circumstances. These circumstances are not existent at the end of a very strenuous climb.

The aneroid barometer avoids these difficulties. But unfortunately no aneroid has yet been made that has any pretence to accuracy when subjected to the variations entailed by a climbing expedition Mountaineers frequently forget this.

The hypsometer is an instrument by which measurements of the temperature of steam are made. This temperature depends on the atmospheric pressure, and gives a good determination of the pressure. In my opinion it is by far the best of the instruments for pressure determination, which are available to the mountaineer.

Having obtained the air pressure at the point, as well as a simultaneous value of the pressure at some station of known height; and further the air temperature at both places, the formula of Laplace serves to find the height difference. This formula, however, is based on the assumption that the mean temperature of the air column between the two points is the mean of the two terminal temperatures. The accuracy of this assumption is likely to be the better when the two points are not very distant from one another. Even if there is a clear line between the two points, it will not always be very precise, as I shall show later. Errors of height are accordingly introduced, which I estimate may amount to several hundred feet, even when a reliable value of the pressure has been obtained.

244. *Spirit levelling.*

I need only say of spirit levelling that it is entirely out of the question to run a line of spirit levelling to the summit of a great peak. A tolerably decent track is essential.

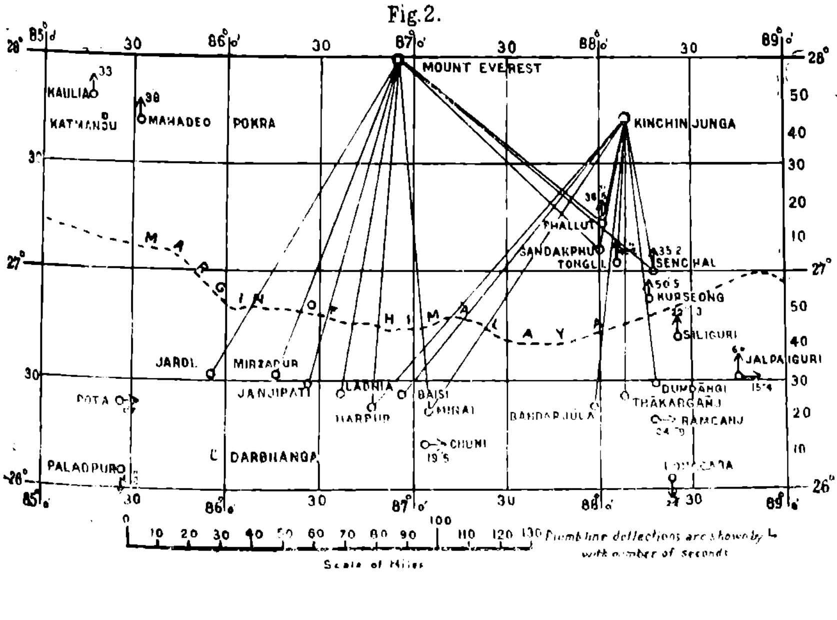
245. *Vertical angles.*

We have cut out barometric observations on account of lack of accuracy; and spirit levelling is impracticable. Both depend on a visit to the point. There remains the method of observing the angle of elevation. It is from such observations that the height of Everest is deduced.

The discovery that Mount Everest, or as it was then designated "peak xv" was the highest mountain on earth, was made in the Computing Office of the Survey of India in 1852. Those who had observed it were not aware of its pre-eminence, and it was the calculation of its height which brought this to light. Sir Andrew Waugh, who was the Superintendent of the Trigonometrical Survey at that time, decided to name this, the highest of peaks, Mont Everest, after his distinguished predecessor and former chief. This name, with Mont changed into Mount, has since then been adhered to by most. A few have tried to substitute names, claimed to be those in use by the local inhabitants; but up to date, all these have proved to be truly applicable to other peaks; and no local name for Mount Everest has been substantiated. 246. *The name Mount Everest.*

The observations on which the height 29,002 was based in 1852, were those made in the season 1849-50 from 6 stations in the plains of Bengal (figure 2), situated at distances ranging between 108 and 119 miles from Everest. Later observations were made in 1880, 81, 83 and 1902, from several stations in the neighbourhood of Darjeeling. These stations lie at distances between 85 and 109 miles. It is only in 1921 that it has been permitted to trigonometrical surveyors to get closer up for observations, and it is expected that advantage will be taken of this in 1922. 247. *The observations of vertical angles to Everest.*

Fig. 2.



248. *What is meant by the height of a mountain.*

When we speak of the height of a mountain, it is understood, in a general way, that the height above sea level is meant. By sea level the mean level of the sea, freed from the effect of tides, is implied. The actual sea is distant 450 miles from Mount Everest, at its nearest. But we may extend sea level in imagination inland, by constructing imaginary canals along which the water of the sea could find its way. A practical way of getting to very nearly the same result is afforded by spirit levelling. The spirit level is set up parallel or very nearly so, to the water surface of the imaginary canals; and by successive steps the elevation of any point of the line above sea level is determined. This method is applicable in fairly flat country, and so the depth of sea level below the earth's surface may be determined up to the fringe of the Himalaya.

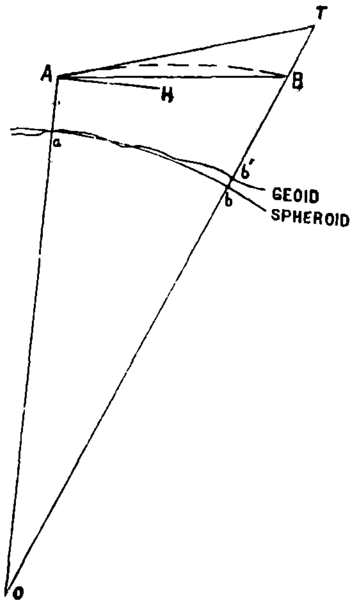
But when we proceed into the hills this method fails. It is then necessary to arrive in some way or other, more or less precise, at the shape of the sea level surface right up to the mountain with whose height we are concerned.

Now geodetic operations, of which the earliest were executed more than 2000 years ago, have accumulated information which permits us to draw the conclusion that the form of the sea level surface is not very different from that generated by the revolution of an ellipse about its minor axis. This figure is generally referred to as an oblate spheroid, or briefly as "the spheroid". We shall for the present accept this as being the correct form of the sea level surface, and at a later stage discuss briefly the divergences which are found to occur.

249. *Height above the spheroid.*

Let us now consider the height above the spheroid. This is indicated by Bb in figure 3, where A is an observing station of known height Aa, and B is the point whose height Bb is sought. A a O and B b O are verticals meeting (approximately) in O. The angle AOB is known from triangulation, and aO = bO is the radius of curvature of the spheroid in the plane of the paper. If the true angle of elevation BAH were known, it would be a matter of simple trigonometry to find the length OB and thence Bb.

Fig. 3.



250. *Refraction.*

But we must take things as they are, and consider the effect of refraction of the atmosphere. The path of a ray of light from A to B is not straight. It is bent into a curve, indicated by the dotted line. An observer at A sees B in the direction of the tangent to this curve, namely AT. If we do not take account of this fact, we shall find Tb for the height of B, a height in error by amount TB. To fix ideas, I may say that in the case of the Everest observations, this error would be about 800 feet or more. It clearly can not be neglected.

251. *The observed Phenomena of terrestrial refraction.*

As soon as surveyors found that refraction of light had a serious effect on their observations, the assumption was made that the path of the light, instead of being a straight line, was a circle of small curvature. A little consideration will show then that the angle of refraction TAB increases directly as the distance AB. A rough idea of its magnitude is given by saying that it is about 3 seconds of arc per mile, or 5 minutes per hundred miles.

252. *Diurnal change.*

But it was noticed soon that refraction was by no means a constant quantity throughout the day. Refraction is at its smallest value during the early afternoon hours. Moreover its value at this time is nearly the same from day to day. Hence about 1850 the practice arose of making observations of angular elevations of terrestrial objects between the hours of 1 and 4 p.m., a practice still rightly continued where possible.

253. *Reciprocal observations.* On the assumption that the dotted line AB is circular, it is clear that the angle of refraction at B is the same as that at A. If both these angles are observed, it is possible by considering the angles of Δ AOB to determine the magnitude of the angle of refraction, a process sufficiently accurate for some purposes.

254. *Later developments.* It was first stated about 1910 that the diurnal change in refraction observed at hill stations was small compared with that found at plain stations. In 1913, while considering the question, I noticed that the diurnal change in refraction varied as the temperature, minimum refraction occurring at the time of maximum temperature. This is well shown in the figures Nos. 4 and 5 where ordinates represent the apparent elevations of two points, and abscissae represent the temperature. Actual observations are shown by small circles, which are joined up by straight lines in the order 8, 10, 12 and 14 hours. Attention is drawn to the approximate straightness of the lines.

Fig. 4

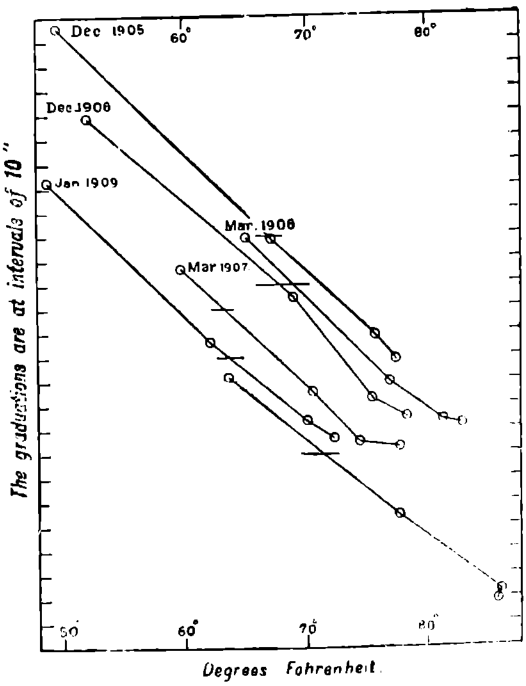
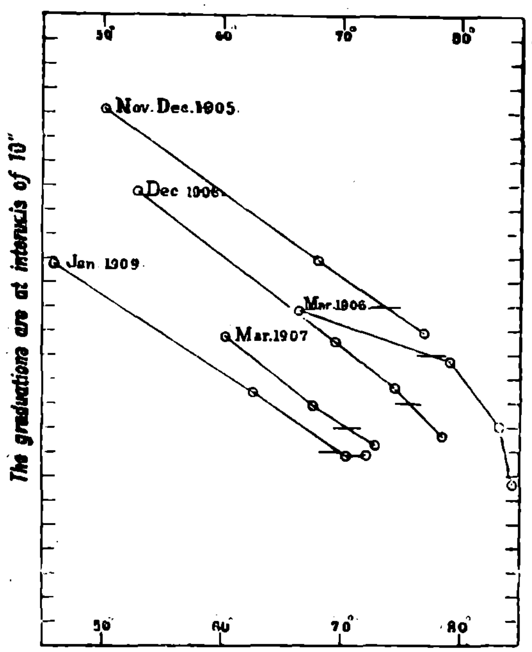


Fig. 5.



I further noticed with surprise that the change was smaller on the longer ray of two from one station, which were examined, indicated by the greater slope of the lines in fig. 4. The lengths of the rays in figures 4, 5 are 46 and 93 miles respectively. One had come to think of refraction as varying with the length of ray, and so expected its changes to be greater on a long ray. 254. *(Contd.)*

These then are the main experimental facts. Let us see how far we can explain them, and predict them.

To find the path of a ray of light through the atmosphere, it is necessary to know the physical laws of the air, and the conditions which obtain. *Then* the rest can be done by mathematics. In general, over a limited area, the atmosphere may be considered to be arranged in horizontal spherical layers of equal density. Only small local deviations from this state can exist. It remains to be known how the density of the air changes with the height above a datum surface. For other reasons it is more convenient to consider how the temperature changes with height. From this the changes of pressure and density may be 255. *Refraction considered theoretically.*

255. (Contd) found by the help of Boyle's law $p = C\tau\rho$, and the mechanical equation of equilibrium $dp = -\rho g dh$. Finally it is necessary to know how the refractive index of air changes under the varying conditions met with. This is given by the law of Gladstone and Dale $\mu - 1 = K\rho$. From these three equations it follows that the curvature of the ray at a point is $\frac{1}{\sigma} = -\frac{K d\rho}{\mu\, dh} \cot a$. Everything is known, save the law of change of density with height, which we proceed to consider.

256. *Thermal equilibrium of the atmosphere.* If we consider the thermal equilibrium of the air, neglecting the diurnal heating to which it is subjected, the law of decrease of temperature and thence of density with height can be found. In the case of air, which is not saturated with water vapour, the decrease of temperature with height is nearly uniform, and follows the adiabatic gradient. This gradient is such that, if a given mass of air is taken from one height, and conveyed to another height, in adjusting itself to the new pressure it will also arrive at a temperature and density the same as that of the surrounding air, without receiving or giving up heat. This gradient is about 5°·4 F. per 1000 feet.

If the air is saturated with moisture, owing to the latent heat of water vapour, the gradient becomes 3°·3 F. per 1000 feet.

We must not, however, ignore the cycle of heat changes which occur during the day, which by radiation communicate heat to the air.

257. *Radiation.* In the course of the day, the air undergoes a cycle of heat effects. The sun rises, and heat traverses the atmosphere.

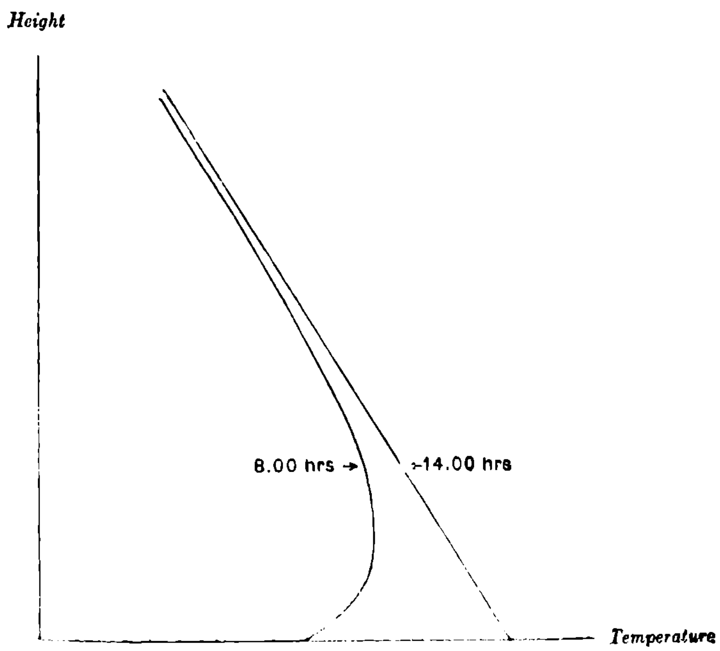
Some of this heat is absorbed by the air, and the remainder reaches the earth. Here, part is reflected. The reflected portion again traverses the air, and is partially absorbed by it. The portion absorbed by the earth gives rise to earth radiation, which in due course traverses the air. In addition the air in close contact with the earth receives heat by direct conduction. Now air is a bad conductor of heat, and this conduction effect is only appreciable in the lower layers.

First consider the radiation effects. The absorption of dry air is almost negligible. But when moisture is present,—and it always is,—the case is considerably different. The air then takes up heat from the several types of radiant heat which occur, to an extent proportional to the absolute humidity. On the whole, except where there are considerable changes with height of humidity, it seems a fair deduction to say that the air at different heights is changed by much the same number of degrees of temperature. As far as I can make out, the change of temperature on account of radiation is less than 5° F., and so I conclude that the gradient of temperature is very little affected by the radiation. Up to date I have not been able to consult practical meteorologists on this point, and what I have to say depends on the interpretation of refraction, and barometric observations, combined with mathematical theory.

Now I turn to the conduction effect of the earth on the air in contact with it. I find, on working out the conduction of heat in air that a periodic change of period 24 hours, and of given range at the surface, will cause at the height of 100 metres an effect of about 1°/₀ of the surface value. This is a purely mathematical result. 258. *Conduction effect.*

My interpretation of this reasoning is illustrated in figure 6. It appears that there is a fairly uniform gradient, within certain limits of height, at all hours. This gradient can be less rapid than the adiabatic gradient, but can not be more rapid; for then there would be a convective adjustment. It appears that at midday, this uniform gradient extends practically down to the earth's surface; while, at the earlier hours of the day, the curve of temperature deviates considerably, as shown. In the afternoon, it may be that the gradient near the surface exceeds the general gradient above; but it can not exceed the adiabatic gradient.

Fig. 6.



Lapse of Temperature with height

To assist in the deduction of the temperature at various heights, some ten years ago I had simultaneous readings of barometers made at Dehra Dūn and at Mussoorie. Mussoorie is about 10 miles distant from 259. *Barometric height results.*

259. *(Contd.)* Dehra Dūn, and some 4400 feet higher. The readings were made at various hours of the day, and continued for a month. From these readings, the difference of height was computed by the ordinary formula. The mean values for each hour were worked out, and compared with a value found by spirit levelling. The discrepancies are shown in figure 6. These may be attributed to faulty values of the mean air temperature employed. In general the heights were too small, except near midday. This is equivalent to too small an evaluation of the mean temperature of the intervening air column. It is what would be expected with the temperature law I have exhibited on the figure. And I may add that the explanation agrees well in amount.

260. *Application to the case of refraction.* For the time of minimum refraction, or maximum temperature, I find that a constant gradient of temperature explains very well observed results at all heights. The difficulty formerly was to compute the diurnal change in refraction. From the diagram it is clear that the effect is due to the low lying layers of air. It is easy to deduce its amount, which is found to be proportional to the deviation of the temperature, dependant on conduction, and also proportional to the cotangent of the angle of elevation. This explanation based on the temperature law illustrated, explains 90°/$_{o}$ of the effect.

We now have something to work on to determine the refraction at all hours, provided certain data as regards surface temperature, are available. It is undoubtedly best to make observations of vertical angles in the afternoon hours. But, on account of clouds, which very often obscure peaks at these hours, one must perforce have some observations at other hours. It is for these that the correction for diurnal change in refraction is necessary. Unfortunately in many of our height observations, surface temperatures are not available, and one can only make estimations of their probable values. Before actually applying this to the case in hand, I must give a short statement of the part played by the irregular form of the sea level surface.

261. *The form of the sea level surface or geoid.* The sea level surface is designated for brevity "the geoid". If a line is drawn at right angles to the geoid, this will represent the vertical at the place. It is the direction of the force of gravity there, and it is with reference to this vertical that any observing instrument, levelled in the ordinary way, is set up. Now this line is not in general at right angles to the spheroid at the corresponding point. The angle between the two verticals is called the deflection of the plumb-line.

The way in which deflections of the plumb-line are measured, may be briefly explained. First of all a series of triangulation is executed between two points, and, assuming that these lie on the spheroid, it is possible to compute their latitudes and longitudes. These quantities are also observed astronomically, and slightly different values are found. The differences are the components of plumb-line deflection in the two directions at right angles.

In figure 3, I have shown diagrammatically the geoid. It is clear that before any calculation can be made of height above the geoid, its form must be known. It is however easier to compute the height above the spheroid, and then, if possible, apply a correction for the difference. In this way all the several observations from surrounding stations should give the same result.

262. *Effect of plumb-line deflection in height determination.*

To do this, it is first necessary to modify observed angles of elevation, which are with reference to the geoidal vertical, and so express them with reference to the spheroidal vertical. It will be seen then, that it is necessary to know the deflection of the plumb-line at all observing stations.

This brings in another uncertainty. Although we know the deflections at some 500 stations in India, this is not nearly enough. In the case of the observations to Mount Everest, plumb-line deflection is only known at a few of the stations, and then only in one component. Until these deflections have been observed, we must estimate them as best we can.

From experience elsewhere, it is probable that the deflections are small at most of the plains stations involved.

I have done the best I can with incomplete data, and the results are exhibited in table on page 299. The results show a considerable improvement on what has formerly been obtained. The outstanding difficulties arise:

263. *Results of the investigation.*

(1) when the time of observation has not been in the early afternoon hours, in the case of observations from plains stations.

(2) when the plumb-line deflections are unknown.

Even so, the agreement reached is good.

We arrive at the height of Mount Everest above the spheroid as 29,149, with a probable error of 4·6 feet. This is unlikely to be in error by more than 15 feet. For Kinchinjunga the case is more favourable. The deduced height is 28,287 with probable error of 2·2, not likely to be wrong by more than 7 feet.

264. *Probable error of the results.*

These heights are above that spheroid which agrees with the geoid in the Bengal plains. We can only estimate the rise of the geoid at Everest and Kinchinjunga above this spheroid. The heights above the geoid arrived at will be less than the spheroidal heights by some (37 feet at Phallut) 70 and 60 feet. I estimate that these quantities are liable to be wrong by 15 and 5 feet respectively.

Our final results are:—

Everest 29,080, with a possible error of 30 feet.
Kinchinjunga 28,227, ,, ,, ,, ,, 12 ,,

265. *Reason for using geoidal heights.* It may seem fanciful to some to worry about the geoidal height. I must say then that this is the only height which is liable to be the same, when deduced from observations from different sides. It is the height which counts in all practical engineering projects involving levels. It is also the measure of effort required by the mountaineer who climbs the height.

266. *Previous great climbs* In view of this year's assault on Everest it may be of interest to give a short statement of previous great climbs. The heights reputed to have been reached must be accepted with proper regard to their liability to error. When the top of a peak has been reached, if this peak has been fixed by trigonometrical observations, it may be 100 feet wrong. Points fixed by barometers may be as much as 500 feet wrong.

(*a*) *About 1860, possibly a few years earlier, a *khalasi* fixed a pole on Shilla in Spiti. Its great height was unknown till the computations were worked out; and when it was found to be 23,050 feet, it aroused no interest. The record was lost for about 50 years. It lasted for 45 years.

(*b*) During surveys of Kāngra, Kumaun, Kashmīr and Ladākh, 1855-65, no less than 37 ascents were made to over 20,000 feet. These were all fixed trigonometrically.

(*c*) Amongst these may be mentioned Johnson's claim on E. 61, on the K'un-lun, in 1865, height 23,890; now proved to have been fallacious, for he plotted the point wrongly on his plane-table.

(*d*) The next claim is W. W. Graham's on Kabru, in Sikkim, 24,002. The latest authorities, including Raeburn and Collie, believe that he mistook the Peak and climbed a much lower one known as "The Forked Peak".

(*e*) The next claim is that of Hunter Workman on Pyramid Peak in the Kara-koram region in 1903. The Peak has not been triangulated and the height attributed by the climber is open to grave doubts.

(*f*) Mrs. Bullock Workman's claim to have reached the summit of Pinnacle Peak in Suru district of Kashmīr is not doubted, but her estimated height 23,300 has been proved by trigonometrical operations some 500 feet too high.

(*g*) In 1905, Longstaff with two Swiss guides attempted the ascent of Gurla Mandhata in Garhwāl; authorities agree in estimating the altitude reached to be approximately 24,000 feet.

(*h*) But the first certain altitude record in India to beat the Shilla *khalasi* is Dr. Longstaff's ascent of Trisul, in Garhwāl, 23,360. This height has been triangulated and rests on evidence absolutely independent of the climber's estimate.

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* This table of records was furnished by Bt. Major K. Mason, M.C., R.E.

(*i*) Two Norwegians, Rubenson and Monrad have beaten Longstaff's Trisul climb by reaching the summit of Kabru in the same year. The triangulated height is 24,002. **266.** (*Contd.*)

(*j*) The generally accepted altitude record was reached by the Duke of the Abruzzi in 1909 on the Bride Peak, in the Kara-koram. The altitude reached, 24,583 by Fortin barometer has not been checked by trigonometrical operations.

(*k*) The highest camp at which humans have passed a night is that of Mr. C. F. Meade on the north arête of Kamet, Garhwāl. Trigonometrical readings have shown this to be at 23,500.

(*l*) The highest point reached during the reconnaissance of Everest (1921) was approximately 23,300 (?); roughly there is another 6,000 feet to go.

Height of Mount Everest and Kinchinjunga

Observing station		Mount Everest				Kinchinjunga			
Name	Height	Time	Diurnal change in refraction *	Plumb-line	Height	Time	Diurnal change in refraction *	Plumb-line	Height
	feet	*hours*	*seconds*	*seconds*	*feet*	*hours*	*seconds*	*seconds*	*feet*
Jarol ...	220	15·7			29171				
Mirzapur ...	245	16·0			29158				
Janjipati ...	255	17·4	8		29119				
Ladnia ...	235	14·9			29160				
Harpur C ...	219	16·0			29143	15·0			28281
Baisi ...	214					16·0			28282
Minai ...	228	15·3			29170	17·4	8	(10)†	28312
Bandarjūla	238					9·3	26		28296
Thakurganj	264					8·9	15	(15)†	28287
Dumdāngi ...	307					15·6	0	(20)‡	28282
HILL STATIONS									
Senchal ...	8623	9·6	0	23·0	29136	10·4	0	34·6	28285
Tonglu ...	10098					10·4	0	42·1	28287
Sandakphu	11960					10·1	0	42·1	28287
Phallut ...	11853	9·5	0	22·5	29131	10·0	0	35·6	28280
Mean ...					29149				28287
Probable error ...					±1·6				±2·2

* Estimation based on height of observer above ground level and hour of day. No temperature readings available.

† Interpolated value.

‡ Estimated.

PUBLICATIONS

OF THE

SURVEY OF INDIA

Obtainable from the Director, Geodetic Branch, Survey of India, Dehra Dūn, U.P.

SYNOPSIS

Part I—Numerical Data

Part II—Geodetic Works of Reference

Part III—Historical and General Reports

Part IV—Catalogues and Instructions

Part V—Miscellaneous Papers

PART I.—NUMERICAL DATA

Triangulation Pamphlets—each covering one square degree, giving descriptions, positions, (latitude and longitude) and heights of triangulated points and other data with chart. The chart shows the plan of triangulation with the position of stations and points. Triangulation data falling in 1/M sheet are printed in a series of sixteen pamphlets A to P In the last pamphlet of every series, a coloured map on scale 1 inch = 16 miles approximately is given in addition to the chart, to illustrate the topographical features of the area covered by the 1/M sheet. Pamphlets having this map are charged Rs. 1-8 extra. An Index chart of the published triangulation pamphlets is given at page 324.

Price Re. 1 per pamphlet. Published at Dehra Dūn.

Levelling Pamphlets—giving heights and descriptions of all *Bench marks,* fixed by Levelling of Precision. Each pamphlet embraces an area of 4° × 4° and the numbering is the same as that of the corresponding sheets of the 1/M map of India. Each is illustrated by a map of the area. Published at Dehra Dūn.

(i) Levelling of Precision in India and Burma—

Pamphlet		Latitude	Longitude	Published	Price
Sheet	Distinctive name of sheet				
34	(Quetta) ...	28°–32°	64°–68°	1916	Rs. 2-0-0
35	(Karāchi) ..	24–28	64–68	1911	Rs 2-0-0
38	(Kābul) ..	32–36	68–72	1912	Rs. 2-0-0
39	(Multān) ...	28–32	68–72	1913	Rs. 2-0-0
	Addendum to 39 ...	...	...	1916	Rs. 2-0-0
40	(Hyderābād, Sind) ...	24–28	68–72	1911	Rs. 2-0-0
41	(Rājkot) ...	20–24	68–72	1913	Rs. 2-0-0
43	(Srīnagar) ...	32–36	72–76	1913	Rs. 2-0-0
	Addendum to 43 ...	...	...	1915	Rs. 2-0-0
44	(Lahore) ...	28–32	72–76	1926	Rs. 3-0-0
45	(Ajmer) ...	24–28	72–76	1911	Rs. 2-0-0
46	(Baroda) ...	20–24	72–76	1912	Rs. 2-0-0
47	(Bombay) ...	16–20	72–76	1912	Rs. 2-0-0
	Addendum to 47 Island of Bombay ...	...	...	1915	Rs. 1-0-0
48	(Goa) ...	12–16	72–76	1912	Rs. 2-0-0
49	(Calicut) ...	8–12	72–76	1911	Rs. 1-0-0
52	(Leh) ..	32–36	76–80	1912	Rs. 1-0-0
53	(Delhi) ...	28–32	76–80	1920	Rs. 3-0-0
54	(Agra) ...	24–28	76–80	1921	Rs. 2-0-0

Levelling Pamphlets—(*Continued*).

Sheet	Pamphlet — Distinctive name of sheet		Latitude	Longitude	Published	Price
			° °	° °		
55	(Nāgpur)	...	20-24	76-80	1912	Rs. 2-0-0
56	(Hyderābād, Deccan)	...	16-20	76-80	1912	Rs. 2-0-0
	Addendum to 56	...	...	.	1919	Rs 1-0-0
57	(Mysore)	...	12-16	76-80	1919	Rs. 2-0-0
58	(Ootacamund)	..	8-12	76-80	1914	Rs. 2-0-0
62	(Mānasarowar)	...	28-32	80-84	1922	Rs. 1-0-0
63	(Allahābād)	...	24-28	80-84	1923	Rs. 2-0-0
64	(Raipur)	...	20-24	80-84	1912	Rs. 2-0-0
65	(Vizagapatam)	...	16-20	80-84	1913	Rs. 2-0-0
66	(Madras)	..	12-16	80-84	1912	Rs. 2-0-0
72	(Kātmāndu)	...	24-28	84-88	1912	Rs. 2-0-0
	Addendum to 72	...			1919	Rs. 2-0-0
73	(Cuttack)	...	20-24	84-88	1913	Rs. 2-0-0
	Addendum to 73	...	..	...	1920	Rs. 2-0-0
74	(Purī)	..	16-20	84-88	1913	Rs 2-0-0
78	(Darjeeling)	...	24-28	88-92	1923	Rs. 2-0-0
79	(Calcutta)	...	20-24	88-92	1924	Rs. 2-0-0
83	(Dibrugarh)	...	24-28	92-96	1912	Rs. 2-0-0
84	(Akyab)	...	20-24	92-96	1918	Rs. 2-0-0
85	(Prome)	...	16-20	92-96	1917	Rs. 2-0-0
92	(Bhamo)	...	24-28	96-100	1918	Rs. 2-0-0
93	(Mandalay)	.	20-24	96-100	1917	Rs. 2-0-0
94	(Rangoon) }	...	16-20	96-100	1916	Rs. 2-0-0
95	(Mergui) }		12-16	96-100		

(ii) **Levelling of Precision in Mesopotamia**—

Descriptions and heights of bench marks in Mesopotamia in one pamphlet, published at Dehra Dūn, 1923. *Price Rs. 3.*

Tide-Tables—

Since 1881 Tidal predictions based on the observations of the Survey of India have been published annually by the India Office, London, up till the year 1922. From 1923 onwards the prediction and publication have been undertaken at Dehra Dūn by the Survey of India. The tables give the times and heights of high and low water for every day in the year for 37 ports, and are published early in the previous year. They are published as follows :—

Tide-Tables—(*Continued*).

(i) A single volume styled "**The Major Series**" comprising Tide-Tables for the following ports:—

Suez, Aden, Bushire Karāchi, Okha Point & Bet Harbour, Bhāvnagar, Bombay, Cochin, Tuticorin, Pāmban Pass, Colombo, Madras, Vizagapatam, Dublat, Diamond Harbour, Kidderpore, Chittagong, Elephant Point and Rangoon. *Price Rs. 8/-*

(ii) **Combined Pamphlets** as below:—

(*a*) Okha Point and Bet Harbour (Mouth of the Gulf of Cutch); Porbandar; Port Albert Victor (Kāthiāwār); Bhāvnagar *Price Rs. 1-8.*

(*b*) Marmagao; Kārwār *Price Rs. 1-2*

(*c*) Dublat (Sāgar Island); Diamond Harbour; Kidderpore (Calcutta) — Hooghly River *Price Rs. 1-8.*

(*d*) Amherst; Moulmein — Moulmein River *Price Rs 1-2.*

(*e*) Tuticorin; Pāmban Pass (Island of Rāmesvaram) *Price Rs. 1-2.*

(*f*) Colombo; Galle; Trincomalee — Ceylon *Price Rs. 1-8.*

(*g*) Diamond Island; Bassein — Bassein River *Price Rs. 1-2.*

(*h*) Elephant Point; Rangoon — Rangoon River *Price Rs. 1-2.*

(iii) **Separate pamphlets** for each of the following ports:—

Suez, Aden, Basrah, Bushire, Karāchi, Bombay, Beypore, Cochin, Negapatam, Madras, Cocanāda, Vizagapatam, False Point, Chittagong, Akyab, Mergui, and Port Blair. *Price of each pamphlet is As. 12.*

PART II.—GEODETIC WORKS OF REFERENCE

Everest's Great Arc Book.

1. An account of the Measurement of an Arc of the Meridian between the parallels of 18° 3′ and 24° 7′, by Captain George Everest East India Company, London, 1830. (Out of print)

2. An account of the Measurement of two Sections of the Meridional Arc of India, bounded by the parallels of 18° 3′ 15″, 24° 7′ 11″ and 29° 30′ 48″, by Lt.-Colonel G. Everest, F.R.S. East India Company, London, 1847 (Out of print).

3. Engravings to illustrate the above. London, 1847. (Out of print).

G.T.S. Volumes—describing the operations of the Great Trigonometrical Survey.

G.T.S. Volumes—(*Continued*).

Vol. I—**Standards of Measure and Base Lines,** also an Introductory Account of the early operations of the Survey, during the period of 1800-1830. Dehra Dūn, 1870. (Out of print).

Appendix No. **1**. Description of the method of comparing, and the apparatus employed.

Appendix No. **2**. Comparisons of the Lengths of 10-feet Standards **A** and **B**, and determinations of the Difference of their Expansions.

Appendix No. **3**. Comparisons between the 10-feet Standards I_B I_S and **A**.

Appendix No. **4**. Comparisons of the 6-inch Brass Scales of the Compensated Microscopes.

Appendix No **5**. Determination of the Length of the Inch [7.8] on Cary's 3-foot Brass Scale.

Appendix No. **6**. Comparisons between the 10-feet Standard Bars I_S and **A** for determining the Expansion of bar **A**.

Appendix No. **7**. Final determination of the Differences in Length between the 10-feet Standards I_B I_S and **A**.

Appendix No. **8**. On the Thermometers employed with the Standards of Length.

Appendix No. **9**. Determination of the Lengths of the Sub-divisions of the Inch [*a.b*].

Appendix No. **10**. Report on the Practical Errors of the Measurement of the Cape Comorin Base.

Vol. II—**A History and General Description of the Reduction of the Principal Triangulation**. Dehra Dūn, 1879. (Out of print).

Appendix No. **1**. Investigations applying to the Indian Geodesy.

Appendix No **2**. The Micrometer Microscope Theodolites.

Appendix No. **3**. On Observations of Terrestrial Refraction at certain stations situated on the plains of the Punjab.

Appendix No. **4**. On the Periodic Errors of Graduated Circles, &c.

Appendix No. **5**. On certain Modifications of Colonel Everest's system of observing introduced to meet the specialities of particular instruments.

Appendix No **6**. On Tidal Observations at Karāchi in 1855.

Appendix No. **7**. An alternative Method of obtaining the Formulæ in Chapters VIII and XV employed in the Reduction of Triangulation.—Additional Formulæ and Demonstrations.

Appendix No. **8**. On the Dispersion of Circuit Errors of Triangulation after the Angles have been corrected for Figural conditions.

Appendix No. **9**. Corrections to azimuthal observations for imperfect Instrumental Adjustments.

Appendix No. **10**. Reduction of the N.W. Quadrilateral—the Non-Circuit Triangles and their Final Figural Adjustments.

Appendix No. **11**. The Theoretical Errors of the Triangulation of the North-West Quadrilateral.

Appendix No. **12**. Simultaneous Reduction of the N.W Quadrilateral —the Computations.

Vol. III—**North-West Quadrilateral**—The Principal Triangulation, the Base-Line Figures, the Karāchi Longitudinal, N.W. Himālaya, and the Great Indus Series. Dehra Dūn, 1873. (Out of print).

G.T.S. Volumes—(*Continued*).

Vol. IV—**North-West Quadrilateral**—The Principal Triangulation, the Great Arc—Section 24°-30°, Rahūn, Gurhāgarh and Jogi-Tila Meridional Series and the Sutlej Series. Dehra Dūn, 1876. *Price Rs. 10-8.*

Vol. IVA—**North-West Quadrilateral**—The Principal Triangulation, the Jodhpur and the Eastern Sind Meridional Series with the details of their Reduction and the Final Results. Dehra Dūn, 1886. *Price Rs. 10-8.*

Vol. V—**Pendulum Operations** of Captains J. P. Basevi and W. J. Heaviside, and their Reduction. Dehra Dūn and Calcutta, 1879. *Price Rs. 10-8.*

Appendix No. 1. Account of the Remeasurement of the Length of Kater's Pendulum at the Ordnance Survey Office, Southampton.

Appendix No. 2. On the Relation between the Indian Pendulum Operations, and those which have been conducted elsewhere.

Appendix No. 3. On the Theory, Use and History of the Convertible Pendulum.

Appendix No. 4. On the Length of the Seconds Pendulum determinable from Materials now existing.

Appendix No. 5. A Bibliographical List of Works relating to Pendulum Operations in connection with the Problem of the Figure of the Earth.

Vol. VI—**South-East Quadrilateral**—The Principal Triangulation and Simultaneous Reduction of the following Series:—Great Arc—Section 18° to 24°, the East Coast, the Calcutta and the Bidar Longitudinal, the Jubbulpore and the Bilāspur Meridionals. Dehra Dūn, 1880. (Out of print.)

Vol. VII—**North-East Quadrilateral**—General Description and Simultaneous Reduction. Also details of the following five series:—North-East Longitudinal, the Budhon Meridional, the Rangir Meridional, the Amua Meridional, and the Karāra Meridional. Dehra Dūn, 1882. *Price Rs. 10-8.*

Appendix No. 1. The Details of the Separate Reduction of the Budhon Meridional Series or Series J of the North-East Quadrilateral.

Appendix No. 2. Reduction of the North-East Quadrilateral. The Non-circuit Triangles and their Final Figural Adjustments.

Appendix No. 3. On the Theoretical Errors generated respectively in Side, Azimuth, Latitude and Longitude in a Chain of Triangles.

Appendix No. 4. On the Dispersion of the Residual Errors of a Simultaneous Reduction of several Chains of Triangles.

Vol. VIII—**North-East Quadrilateral**—Details of the following eleven series:—

Gurwāni Meridional, Gora Meridional, Hurilāong Meridional, Chendwār Meridional, North Parasnāth Meridional, North Malūncha Meridional, Calcutta Meridional, East Calcutta

G.T.S. Volumes—*(Continued)*.

Longitudinal, Brahmaputra Meridional, Eastern Frontier—Section 23°-26°, and Assam Longitudinal. Dehra Dūn, 1882. *Price Rs. 10-8.*

Vol. IX—**Telegraphic Longitudes**—during the years 1875-77 and 1880-81. Dehra Dūn, 1883. *Price Rs. 10-8.*

Appendices to Part I.
1. Determination of the Geodetic Elements of Longitude Stations.
2. Descriptions of Points used for Longitude Stations.
3. Comparison of Geodetic with Electro-Telegraphic Arcs of Longitude.
4. Circuit Errors of Observed Arcs of Longitude.
5. Results of Idiometer Observations made during Season 1880-81.

Appendices to Part II.
1. Situations of the Longitude Stations at Bombay, Aden and Suez.
2. Survey Operations at Aden.
3. Results of the Triangulation.
4. Right Ascensions of Clock Stars.

Vol. X—**Telegraphic Longitudes**—during the years 1881-82, 1882-83, and 1883-84. Dehra Dūn, 1887. *Price Rs. 10-8.*

Appendices to Part I.
1. Determination of the Geodetic Elements of the Longitude Stations.
2. Descriptions of Stations of the Connecting Triangulation and of those at which the Longitude Observations were taken.
3. On the Errors in ΔL caused by Armature-time and the Retardation of the Electric Current.
4. On the Rejection of some doubtful Arcs of Season 1881-82.
5. On the probable causes of the Errors of Arc-measurements, and on the Nature of the Defects in the Transit Instruments which might produce them.

Vol. XI—**Astronomical Latitudes**—during the period 1805-1885. Dehra Dūn, 1890. *Price Rs. 10-8.*

Vol XII—**Southern Trigon**—General Description and Simultaneous Reduction. Also details of the following two series:—Great Arc—Section 8°-18°, and Bombay Longitudinal. Dehra Dūn, 1890. *Price Rs. 10-8.*

Vol. XIII—**Southern Trigon**—Details of the following five series:—South Konkan Coast, Mangalore Meridional, Madras Meridional and Coast, South-East Coast, and Madras Longitudinal. Dehra Dūn, 1890. *Price Rs. 10-8.*

Vol XIV—**South-West Quadrilateral**—Details of Principal Triangulation and Simultaneous Reduction of its component series. Dehra Dūn, 1890. *Price Rs. 10-8.*

Vol. XV—**Telegraphic Longitudes**—from 1885 to 1892 and the Revised Results of Volumes IX and X: also the Simultaneous Reduction and Final Results of the whole Operations. Dehra Dūn, 1893. *Price Rs. 10-8.*

Appendix No. 1. Determination of the Geodetic Elements of the Longitude Stations.

Appendix No. 2. On Retardation. (A numerical mistake was made in this appendix in the conversion of a formula from kilometres to miles: the conclusions drawn cannot therefore be upheld).

Vol. XVI—**Tidal Observations**—from 1873 to 1892, and the Methods of Reduction. Dehra Dūn, 1901. *Price Rs. 10-8.*

G.T.S. Volumes—(*Continued*).

Vol. XVII—**Telegraphic Longitudes**—during the years 1894-95-96. The Indo-European Arcs from Karāchi to Greenwich. Dehra Dūn, 1901. *Price Rs. 10-8.*

Appendix No. 1. Descriptions of Points used for Longitude Stations.
Appendix No. 2. The Longitude of Madras.

Vol. XVIII—**Astronomical Latitudes**—from 1885 to 1905 and the deduced values of Plumb-line Deflections. Dehra Dūn, 1906. *Price Rs. 10-8.*

Appendix No. 1. On Deflections of the Plumb-line in India

Appendix No. 2. Determination of the Geodetic Elements of the Latitude Stations of Bajamara, Bahuk, Lambatach and Kidarkanta.

Appendix No. 3. On the (N-S) Difference exhibited by Zenith Sector No. 1.

Appendix No. 4. On the Value of the Micrometer of the Zenith Telescope.

Appendix No. 5. On the Azimuth Observations of the Great Trigonometrical Survey of India.

Appendix No. 6 A Catalogue of the Publications of the Great Trigonometrical Survey of India.

Appendix No. 7. On the combination weights employed.

Vol. XIX—**Levelling of Precision in India**— from 1858 to 1909. Dehra Dūn, 1910. *Price Rs. 10-8.*

Appendix No. 1. Experiment to test the changes, due to Moisture and Temperature, in the Length of a Levelling Staff.

Appendix No. 2. On the erection of standard bench marks in India during the years 1904-1910.

Appendix No. 3. Memorandum on the steps taken in 1905-1910 to enable movements of the Earth's crust to be detected.

Appendix No. 4. Dynamic and Orthometric corrections to the Himālayan levelling lines and circuit; and a consideration of the order of magnitude of possible refraction errors.

Appendix No. 5. The passage of rivers by the Levelling Operations.

Appendix No. 6. The Errors of the Trigonometrical values of Heights of stations of the principal triangulation.

Appendix No. 7. The effect on the spheroidal correction of employing Theoretical instead of Observed values of Gravity and a discussion of different formulæ giving variation of Gravity with Latitude and Height.

Appendix No. 8. On the discrepancy between the Trigonometrical and spirit level values of the difference of height between Dehra Dūn and Mussoorie.

Vol. XIXA—**Bench Marks** on the **Southern** Lines of Levelling. Dehra Dūn, 1910. *Price Rs. 5.*

Vol. XIXB—**Bench Marks** on the **Northern** Lines of Levelling. Dehra Dūn, 1910. *Price Rs. 5.*

PART III.—HISTORICAL AND GENERAL REPORTS

Memoirs.

1. A Memoir on the Indian Surveys, by C. R. Markham, India Office, London, 1871. *Price Rs. 5*
2. A Memoir on the Indian Surveys. (Second Edition), by C.R Markham, C.B., F.R.S., India Office, London, 1878. *Price Rs. 5-8.*
3. Abstract of the Reports of the Surveys and of other Geographical operations in India, 1869-78, by C. R. Markham and C. E. D. Black, India Office, London. Published annually between 1871 and 1879. (Out of print).
4. A Memoir on the Indian Surveys, 1875-1890, by C. E. D. Black, India Office, London, 1891. *Price Rs. 5-8.*

"Notes of the Survey of India" are issued monthly. *Price As. 2.*

Annual and Special Reports.

Reports of the **Revenue Branch**—1851-1877. (1851-67 and 1869-70, out of print). *Price Rs. 3.*

Ditto **Topographical Branch**—1860-1877. (Out of print)

Ditto **Trigonometrical Branch**—1861-1878.—(1861-71, out of print). *Price Rs. 2.*

In 1878 the three branches were amalgamated, and from that date onwards annual reports in single volumes for the whole department, were published as follows:—

General Reports { from 1877-1900 (1877-79, 1887-88, 1895-96 and 1897-98, out of print). *Price Rs. 3 per volume.* from 1900-1922 (1902-04 and 1906-08, out of print). *Price Rs 2 per volume.*

From 1900 onwards the Report was issued annually in the form of a condensed statement known as (*a*) the "**General Report**" supplemented by fuller reports, which were called (*b*) "**Extracts from Narrative Reports**" up to 1909, and since then until 1921 have been styled (*c*) "**Records of the Survey of India**".

From 1922 the annual reports are published in three separate volumes of octavo size, *viz.*, (*a*) **General Report** which is confined to reporting the Survey operations of the ordinary field parties and detachments with only brief abstracts of geodetic operations, Map Publication and Office work. Published annually *Price Rs. 2.* (*d*) **Map Publication and Office Work** report which contains all the Index Maps showing the Progress of Map Publication on all scales, with reports on publication and issue. Published annually beginning with year 1924. *Price Re. 1.* (*e*) **Geodetic Report** which includes full details of all scientific work of the Geodetic Branch, Survey of India excluding the work of the Dehra Drawing Office and Publication Office. Vol. I of this series covers a period of three years 1922-25. *Price Rs. 6.* Subsequent volumes will be published annually. There will be in addition occasional Records volumes.

Annual Reports.—(*Continued*).

These fuller reports are available as follows:—

(*b*) **Extracts Volumes.**

1900-01—Recent Improvements in Photo-Zincography. G. T. Triangulation in Upper Burma. Latitude Operations. Experimental Base Measurement with Jäderin Apparatus. Magnetic Survey. Tidal and Levelling. Topography in Upper Burma. Calcutta, 1903 (Out of print).

1901-02—G.T. Triangulation in Upper Burma. Latitude Operations. Magnetic Survey. Tidal and Levelling. Topography in Upper Burma. Topography in Sind. Topography in the Punjab. Calcutta, 1904. (Out of print).

1902-03—Principal Triangulation in Upper Burma. Topography in Upper Burma. Topography in Shan States. Survey of Sāmbhar Lake. Latitude Operations. Tidal and Levelling. Magnetic Survey. Introduction of the Contract System of Payment in Traverse Surveys. Traversing with the Subtense Bar. Compilation and Reproduction of Thāna Maps. Calcutta, 1905. *Price Rs. 1-8.*

1903-04—Magnetic Survey. Pendulum. Tidal and Levelling. Astronomical Azimuths. Utilization of old Traverse Data for Modern Surveys in the United Provinces. Identification of Snow Peaks in Nepāl. Topographical Surveys in Sind. Notes on town and Municipal Surveys. Notes on Riverain Surveys in the Punjab. Calcutta, 1906. *Price Rs. 1-8.*

1904-05—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Triangulation in Baluchistān. Survey Operations with the Somāliland Field Force. Calcutta, 1907. *Price Rs. 1-8.*

1905-06—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Topography in Shan States. Calcutta, 1908. *Price Rs. 1-8.*

1906-07—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Triangulation in Baluchistān. Astronomical Latitudes. Topography in Shan States. Calcutta, 1909. *Price Rs. 1-8.*

1907-08—Magnetic Survey. Tidal and Levelling. Astronomical Latitudes. Pendulum Operations. Topography in Shan States. Calcutta, 1910. *Price Rs. 1-8.*

1908-09—Magnetic Survey. Tidal and Levelling. Pendulum Operations. Triangulation. Calcutta, 1911. *Price Rs. 1-8.*

(*c*) **Records of the Survey of India.**

Vol. I—**1909-10**—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey (Astronomical latitudes and pendulum observations). Magnetic Survey. Calcutta, 1912. *Price Rs. 4.*

Vol. II—**1910-11**—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey. Magnetic Survey. Calcutta, 1912. *Price Rs. 4.*

Vol. III—**1911-12**—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey. Magnetic Survey. Calcutta, 1913. *Price Rs. 4.*

Annual Reports.—(*Continued*).

Vol. IV—**1911-13**—*Explorations on the North-East Frontier—North Burma, Mishmi, Abor and Mīri Surveys.* Calcutta, 1914. *Price Rs. 4.*

Vol. V—**1912-13**—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey. Magnetic Survey. Note on the relationship of the Himālayas to the Indo-Gangetic Plain. Calcutta, 1914. *Price Rs. 4.*

Vol. VI—**1912-13**—*Link connecting the Triangulations of India and Russia.* Dehra Dūn, 1914. *Price Rs. 4.*

Vol. VII—**1913-14**—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey. Magnetic Survey (Annual report and Government Committee's report). Note on Scales and cost rates of Town plans. Calcutta, 1915. *Price Rs. 4.*

Vol. VIII—{ **1865-79 Part I** / **1879-92 Part II** } *Explorations in Tibet and neighbouring regions.* Dehra Dūn, 1915. *Price of each part Rs. 4*

Vol. VIII (A)—**1914**—*Explorations in the Eastern Kara-koram and the upper Yārkand Valley,* by Lt.-Colonel H. Wood R.E., Dehra Dūn 1922. *Price Rs. 3.*

Vol. IX—**1914-15**—Topographical Survey. Triangulation. Tidal and Levelling Operations. Magnetic Survey. Criterion of strength of Indian Geodetic Triangulation. A traverse signal for City Surveys. "The plains of Northern India and their relationship to the Himālaya Mountains" an address by Colonel S. G. Burrard, F.R.S. Report on Turco-Persian Frontier Commission. Calcutta, 1916. *Price Rs. 4.*

Vol X—**1915-16**—Topographical Survey. Tidal and Levelling Operations. Magnetic Survey. Mechanical Integrator for calculating Attractions (illustrated). Traverse Survey of the boundary of Imperial Delhi. Dehra Dūn, 1917. *Price Rs. 4.*

Vol. XI—**1916-17**—Topographical Survey. Triangulation—use of high trestle for stations and 100-feet mast signals. Tidal and Levelling Operations. Magnetic Survey. Note on Basevi's Pendulum Operations at Morê. Photo-Litho Office—New method of preparing Layer plates—Developments and Improvements in preparing Tint-plates. Dehra Dūn, 1918. *Price Rs. 4.*

Vol. XII—***Notes on Survey of India Maps and the modern development of Indian Cartography,*** by Lt.-Colonel W. M. Coldstream, R.E., Superintendent, Map Publication. Calcutta, 1919. *Price Rs. 2.*

Vol. XIII—**1917-18**—Topographical Survey. Tidal and Levelling Operations. Magnetic Survey. Photo-Litho office—the Powder Process. Problem of the Himālayan and Gangetic Trough—Review by Dr. A. Morley Davies. Dehra Dūn, 1919. *Price Rs. 4.*

Vol. XIV—**1918-19**—Topographical Survey. Tidal and Levelling Operations. Levelling in Mesopotamia. Magnetic Survey. Dehra Dūn, 1920. *Price Rs. 4.*

Annual Reports.—(*Continued*).

Vol. XV—**1919-20**—Topographical Survey. Tidal work. Levelling—proposed new level net. Magnetic Survey. The Earth's Axes and Figure, by J. de Graaff Hunter (a paper read at the R. A. S. Geophysical Meeting). Report on the expedition to Kamet. Note on the Topography of the Nun Kun Massif in Ladākh. Dehra Dūn, 1921. *Price Rs. 4.*

Vol. XVI—**1920-21**—Topographical Survey. Tidal work. Levelling and Magnetic Survey. High Climbs in the Himālaya prior to the Everest Expedition. Mt. Everest Survey Detachment Report, 1921. Traverse Survey of Allahābād city. Settlement of Boundary between Mysore and South Kanara. Dehra Dūn, 1922. *Price Rs. 4.*

Vol. XVII—**1923**—*Memoir on Maps of Chinese Turkistān and Kansu* from the Surveys made during Sir A. Stein's Exploratoins, 1900-01, 1906-08, 1913-15. Dehra Dūn 1923. *Price Rs. 12.*

Vol. XVIII—**1921-22**—Topographical Survey. Tidal work. Levelling and Magnetic Survey. Traverse Survey of Allahābād city. Settlement of Boundary between Mysore and South Kanara. Notes on Revision Survey in the neighbourhood of Poona Dehra Dūn, 1923. *Price Rs. 4.*

Vol. XIX—**1901-20**—The Magnetic Survey, by Lt.-Colonel R. H. Thomas, D.S.O., R.E., and E. C. J. Bond, V.D. Dehra Dūn 1925. *Price Rs. 4.*

Vol. XX—**1914-20**—The War Record. Dehra Dūn 1925 *Price Rs 3.*

Vol. XXI—**1922-23-24**—I. *Air Survey in the Irrawaddy Delta* 1923-24, *by* Major C. G. Lewis, R.E., and

II. *Reconnaissance Survey in Bhutan and South Tibet 1922*, by Captain H. R. C. Meade, I.A. Dehra Dūn 1925. *Price Rs. 1-8.*

(*e*) **Geodetic Reports.**

Vol. I—**1922-25**—Computations and Researches. Tidal work. Time and Magnetic observations. Latitude and Pendulum observations in Bihār, Assam and Kashmīr. Levelling. Lecture on "The height of Mount Everest and other Peaks". Dehra Dun 1928. *Price Rs. 6.*

PART IV.—CATALOGUES AND INSTRUCTIONS

Departmental Orders.

From 1878 to 1885 the Surveyor General's orders were all issued as "*Circular Orders*". Since then they have been classified as follows:—

From 1885 to 1904 as:
- 1—**Government of India Orders** (called "*Circular Orders*" up to 1898).
- 2—**Departmental Orders** (**Administrative**).
- 3—**Departmental Orders** (**Professional**).

Departmental Orders.—(*Continued*).

In 1904 the various orders issued since 1878 were reclassified as follows :—

	Number to date.
1.—**Government of India Orders.**—	829
2.—**Circular Orders (Administrative).**—	419
3.—**Circular Orders (Professional).**—	196
4.—**Departmental Orders.** (appointments, promotions, transfers, etc.)	

These are numbered serially and had reached the above numbers by December 1927. *Government of India Orders and Circular Orders* (*Administrative*) are bound up in volumes from time to time, as shown below, while *Circular Orders* (*Professional*) are gradually incorporated in the Survey Hand-books. Besides the above, temporary orders have been issued since 1910 in the form of "**Circular Memos**". These either lapse or become incorporated in some more permanent form, and are therefore only numbered serially for each year. Bound volumes of orders are available as follows :—

1. *Government of India Orders (Departmental) 1878-1903.—Calcutta, 1904.
   Ditto ditto 1904-1908.—Calcutta, 1909. (Out of print).
   Ditto ditto 1909-1913.—Calcutta, 1915.
   Ditto ditto 1914-1918.—Calcutta, 1920.
2. *Circular Orders (Administrative) 1878-1903. —Calcutta, 1904.
   Ditto ditto 1904-1908.—Calcutta, 1909.
   Ditto ditto 1909-1913.—Calcutta, 1915.
   Ditto ditto 1914-1918.—Calcutta, 1920.
   Ditto ditto 1919-1924.—Dehra Dūn, 1926.
3. * Regulations on the subject of Language Examinations for Officers of the Survey of India. Calcutta, 1914.
4. * Map Publication Orders 1908-1914 (Superintendent, Map Publication's Orders.)—Calcutta, 1914.
5. Specimens of papers set at Examinations for the Provincial Service.—Dehra Dūn, 1927. *Price Re. 1.*

Catalogues and Lists.

1. **Catalogue of Maps** published by the Survey of India. Corrected to 1st July 1924, Calcutta, 1924. *Price Re. 1.*

Lists of new maps published during each month appear in the monthly NOTES OF THE SURVEY OF INDIA. These monthly lists are also issued separately.

2. **Catalogue of Maps** of the Bombay Presidency, Calcutta, 1913. *Price As. 4.*
3. **Catalogue of Maps of Burma.** Calcutta 1925. *Price As. 8.*
4. **List of the publications of the Survey of India** (published annually) Dehra Dūn. *Gratis.*
5. **Price List of Mathematical Instrument Office.** Calcutta, 1921. *Gratis.*
6. Catalogue of Books in the headquarters Library, Calcutta, 1901. (Out of print).

* **For Departmental use only.**

Catalogues and Lists—(*Continued*).

7. Catalogue of Scientific Books and Subjects in the Library of the Trigonometrical Survey Office. Dehra Dūn, 1908. *Price Re. 1.*

8. Classified Catalogue of the Trigonometrical Survey Library. Dehra Dūn, 1921. *Gratis.*

9. **Green Lists**—Part I—List of officers in the Survey of India (annually to date 1st January), Calcutta. *Price As. 12.*

Part II—History of Services of Officers in the Survey of India (annually to date 1st July), Calcutta. *Price Rs. 1-12.*

10. **Blue Lists**—Ministerial and Lower Subordinate Establishments of the Survey of India.

Part I—Headquarters and Dehra Dūn offices (published annually to date 1st April), Calcutta. *Price Rs. 3-8.*

Part II—Circles and parties (published annually to date 1st January), Calcutta. *Price Rs. 4-4.*

Tables And Star Charts.

1. **Auxiliary Tables**—to facilitate the calculations of the Survey of India. Fourth Edition, Dehra Dūn, 1906. (Out of print).

2. **Auxiliary Tables**—of the Survey of India. Fifth Edition, (revised and extended), by J. de Graaff Hunter, M.A., Sc.D., F. INST. P. **In parts**—

Part I—Graticules of Maps, (reprinted). Dehra Dūn, 1926. *Price Re. 1.*

Part II—Mathematical Tables, (reprinted with additions). Dehra Dūn, 1924. *Price Rs. 2.*

Part III—Topographical Survey Tables, (reprinted with additions). Dehra Dūn, 1923. *Price Rs. 1-8.*

3. Tables for Graticules of Maps. Extracts for the use of **Explorers.** Dehra Dūn, 1918. *Price As. 4.*

4. * Metric Weights and Measures and other tables. Photo-Litho Office. Calcutta, 1889. (Out of print.)

5. Logarithmic Sines and Cosines to 5 places of decimals. Dehra Dūn, 1886. (Out of print).

6. Logarithmic Sines, Cosines, Tangents and Cotangents to 5 places of decimals. Dehra Dūn. 1915. (Out of print)

7. Common Logarithms to 5 places of decimals, 1885. (Out of print).

8. Table for determining Heights in Traversing. Dehra Dūn, 1898. *Price As. 8.*

9. Tables of distances in Chains and Links corresponding to a subtense of 20 feet. Dehra Dūn, 1889. *Price As. 4.*

10. * Ditto ditto 10 feet. Calcutta, 1915.

11. * Ditto ditto 8 feet. Ditto.

12. Field traverse tables. First Edition. (in the press).

* For Departmental use only.

Tables and Star Charts.—(*Continued*).

13. Star Charts for latitude 20° N., by Colonel J.R. Hobday, I.S.C. Calcutta, 1904. *Price Rs. 1-8.*

14. Star Charts for latitude 30° N., by Lt.-Colonel S. G. Burrard, R.E., F.R.S. Dehra Dūn, 1906. *Price Rs. 1-8.*

15. Catalogue of 249 Stars for epoch 1st Jan. 1892, from observations by the Survey, Dehra Dūn, 1893. *Price Rs. 2.*

16. * Rainfall, maximum and minimum temperatures, from 1868 to 1926, recorded at the Survey Office Observatory, Dehra Dūn. (in the press).

Old Manuals.

1. A Manual of Surveying for India, detailing the mode of operations on the Revenue Surveys in Bengal, and the North-Western Provinces. Compiled by Captains R. Smyth, and H.L. Thuillier. Calcutta 1851. (Out of print.)

2. Ditto Second Edition. London, 1855. (Out of print).

3. A Manual of Surveying for India, detailing the mode of operations on the Trigonometrical, Topographical and Revenue Surveys of India. Compiled by Colonel H. L. Thuillier, C.S.I., F.R.S., and Lt.-Colonel R. Smyth. Third Edition, revised and enlarged. Calcutta, 1875. (Out of print.)

4. Hand-Book, Revenue Branch. Calcutta, 1893. *Price Rs. 2-8.*

Survey of India Hand-Books.

1. **Hand-Book of General Instructions,** (in 2 vols.) Fifth Edition. 1927.

2. **Hand-Book, Trigonometrical Branch,** Second Edition. Calcutta 1902. (Out of print).

3. **Hand-Book of Trigonometrical Instructions**.—Third Edition. Parts in pamphlet forms—

   Part V—The Tides. Third Edition, revised, Dehra Dūn 1926. *Price Rs. 2.*

   Part VI—Levelling. Third Edition, revised, 1927. (in the press).

4. **Hand-Book Topographical Branch,**—Third Edition. Calcutta, 1905. (Out of print.)

5. **Hand-Book of Topography.**—Fourth Edition. Calcutta, 1911. Chapters, in pamphlet forms—

   Chapter I—Introductory.—reprinted with additions, 1921. *Price As. 8*

   " II—Constitution and Organization of a Survey Party.—reprinted with additions, 1923. *Price As 8*

   " III—Triangulation and its Computation.—revised 1923. *Price Re. 1.*

   " IV—Theodolite Traversing—Third Edition 1927. *Price Re. 1.*

   " V—Plane-tabling.—Third Edition 1926. *Price Re 1.*

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Survey of India Hand-Books.—(*Continued*).

Chapter VI—Fair Mapping.—reprinted with additions and revised 1922. *Price Re. 1.*

" VII—Trans-frontier Reconnaissance. Third Edition, 1924. *Price As. 8.*

" VIII—Surveys in time of war, 1926 *Price As. 8.*

" IX—Forest Surveys and Maps.—revised, 1925. *Price As. 8.*

" X—Map Reproduction. Second Edition, 1919. *Price As. 8.*

" XI—Geographical maps. Second Edition, 1926. *Price As. 8.*

6. ***Photo-Litho Office.** Notes on Organization, Methods and Processes, by Major W. C. Hedley, R.E. Third Edition Calcutta, 1924.

7. **The Reproduction (for the guidance of other Departments), of Maps, Plans, Photographs, Diagrams, and Line Illustrations.** Calcutta, 1914. *Price Rs. 3.*

8. Survey of India Copy Book of Lettering. Calcutta. *Price Rs. 3-8.*

Notes and Instructions.

Drawing and paper.

1. *Notes on Printing Papers suitable for Maps, and on Whatman Drawing Paper, by Major W. M. Coldstream, R.E. Calcutta, 1911. (Out of print).

Printing and Field Litho processes.

2. *Report on Rubber Offset Printing for Maps, by Major W. M. Coldstream, R.E. Calcutta, 1911.

3. *Notes on the "Vandyke" or Direct Zinc Printing Process, with details of Apparatus and Chemicals required for a small section. Compiled in the Photo and Litho Office, Survey of India. Calcutta, 1913. (Out of print).

4. *Report on the Working of the Light Field Litho Press (experimental) in November, and December 1910, with Appendices, by Lieut. A.A. Chase, R.E. Calcutta, 1911.

(i) Notes on some of the Methods of Reproduction suitable for the Field.

(ii) Suggested Equipment Tables for the Light Field Litho Press, (experimental.)

5. *Report on a trial of the equipment of the 1st (Prince of Wales' Own) Sappers and Miners, for reproducing maps in the field, by Lieut. A. A. Chase, R.E. Calcutta, 1912. (Out of print).

Base Lines and Magnetic.

6. *Notes on use of the Jäderin Base line Apparatus. Dehra Dūn. 1904. (Out of print).

7. *Miscellaneous Papers relating to the Measurement of Geodetic Bases by Jäderin Invar Apparatus. Dehra Dūn, 1912.

8. *Instructions for taking Magnetic Observations, by J. Eccles, M.A. Dehra Dūn, 1896. (Out of print).

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* For Departmental use only.

Notes and Instructions—(*Continued*).

9. **Rectangular Coordinates.**—On a Simplification of the Computations relating to, by J. Eccles, M. A. Dehra Dūn, 1911. *Price Re. 1.*

10. ***For Explorers.**—Notes on the use of Thermometers, Barometers and Hypsometers with Tables for the Computation of Heights, by J. de Graaff Hunter, M.A. Dehra Dūn, 1911. (Out of print).

11. *Amended Instructions for the Survey and Mapping of Town Guide Maps. August 1919.

12 *Notes on boundary ribands on maps of the Survey of India, by Major F. Fraser Hunter, D.S.O., I.A. Calcutta, 1922.

13 *Notes on the map of Arabia and the Persian Gulf, with a general index of place names on the map, 1905-08, by Captain F. Fraser Hunter, I.A. Calcutta, 1910.

PART V.—MISCELLANEOUS PAPERS

Unclassified Papers.

Geography.

1. A Sketch of the Geography and Geology of the Himālaya Mountains and Tibet (in four parts), by Colonel S.G. Burrard, R.E., F.R.S., Supdt., Trigonometrical Surveys, and H.H. Hayden, B.A., F.G.S., Supdt., Geological Survey of India. Calcutta, 1907-08.

Part I.—The High Peaks of Asia.
" II.—The Principal Mountain Ranges of Asia.
" III.—The Rivers of the Himālaya and Tibet.
" IV.—The Geology of the Himālaya.
} *Price Rs. 2.* per part

2 *Report on the Identification and Nomenclature of the Himālayan Peaks as seen from Kātmāndu, Nepāl, by Captain H. Wood, R.E. Calcutta, 1904.

3. Routes in the Western-Himālaya, Kashmīr, etc., by Lt.-Colonel T. G. Montgomerie, R.E., F.R.S., F.R.G.S. Dehra Dūn, 1909. (Out of print).

4. Routes in the Western-Himālaya, Kashmīr, etc. with which are included Montgomerie's Routes. Volume I. Pūnch, Kashmīr and Ladākh, by Major Mason, M.C., R.E., First Edition, Dehra Dūn, 1923. *Price Rs. 6.*

Exploration.

1. *Account of the Survey Operations in connection with the Mission to Yārkand and Kashgar in 1873-74, by Captain Henry Trotter, R.E. Calcutta, 1875. (Out of print).

2. Report on the Trans-Himālayan Explorations during 1869. (Out of print).

3. Report on the Trans-Himālayan Explorations during 1870. Dehra Dūn, 1871. (Out of print).

4. Report on the Trans-Himālayan Explorations during 1878. Calcutta, 1880. (Out of print).

Special Reports.

1. *Report on the Mussoorie and Landour, Kumaun and Garhwāl, Rānīkhet and Kosi Valley Surveys, extended to Peshāwar and Kāghān Triangulation during 1869-70, by Major T.G. Montgomerie, R.E. (Out of print).

2. Report on the Recent Determination of the Longitude of Madras, by Captain S. G. Burrard, R.E. Calcutta, 1897. (Out of print).

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Unclassified Papers.—(*Continued*).

3. *Report on the Observations of the Total Solar Eclipse of 6th April, 1875 at Camorta Nicobar Islands, by Colonel J. Waterhouse. Calcutta, 1875. (Out of print).

4. *The Total Solar Eclipse, 22nd January, 1898. Dehra Dūn, 1898.

(1) Report on the observations at Dumraon.
(2) Report on the observations at Pulgaon.
(3) Report on the observations at Sahdol.

5. *Report on Local Attraction in India, 1893-94, by Captain S.G. Burrard, R.E. Calcutta, 1895. (Out of print).

6. *Report on the Trigonometrical Results of the Earthquake in Assam, by Captain S.G. Burrard. Calcutta, 1898. (Out of print).

7. *Notes on the Topographical Survey of the 1/50,000 Sheets of Algeria by the Topographical Section of the "Service Geographique de l'Armée", by Captain W.M. Coldstream, R.E. Calcutta, 1906.

8. *The Simla Estates Boundary Survey on the scale of 50 feet to 1 inch, by Captain E.A. Tandy, R.E. Calcutta, 1906.

9. *A note on the stage reached by the Geodetic Operations of the Survey of India in 1920, by Lt.-Colonel H.McC. Cowie, R.E. The Magnetic Survey of India, by Major R. H. Thomas, D.S.O., R.E. and a note on the present levelling policy, by Major K. Mason, M.C., R.E. Dehra Dūn, 1922. (Out of Print).

Geodesy.

1. Notes on the Theory of Errors of Observation, by J. Eccles, M.A. Dehra Dūn, 1903. *Price As. 8.*

2. *Note on a Change of the Axes of the Terrestrial Spheroid in relation to the Triangulation of the G.T. Survey of India, by J. de Graaff Hunter, M.A. Dehra Dūn. (Out of print), now incorporated in Professional Paper No. 16.

3. Report on the Treatment, and use of Invar in measuring Geodetic Bases, by Captain H.H. Turner, R.E. London, 1907. *Price As. 8.*

Projections.

1. On the projection used for the General Maps of India. Dehra Dūn, 1903. (Out of print).

2. *On the deformation resulting from the method of constructing the International Atlas of the World on the scale of one to one million, by Ch. Lallemand. Translated by J. Eccles, M.A., together with tables for the projection of 1/M Maps on the International system. Dehra Dūn, 1912. (Out of print).

Mapping.

1. *A Note on the different methods by which hills can be represented upon maps, by Colonel S. G. Burrard, C.S.I., R.E., F.R.S., Surveyor General of India. Simla, 1912.

2. *A Note on the representation of hills, by Major C. L. Robertson, C.M.G., R.E. Dehra Dūn, 1912.

3. *A Note on the representation of hills on the Maps of India, by Major F. W. Pirrie, I.A. Dehra Dūn, 1912.

* For Departmental use only.

Unclassified Papers.—(*Continued*).

4. *A consideration of the Contour intervals, and Colour Scales, best suited to Indian 1/M maps, by Captain M.O'C. Tandy, R.E. Calcutta, 1913. (Out of print).

Professional Papers.

No. 1—**Projection**—On the Projection for a Map of India, and adjacent Countries, on the scale of 1: 1,000,000, by Colonel St. G. C. Gore, R.E. Second Edition. Dehra Dūn, 1903. *Price Re. 1.*

No. 2 ***Base Lines**—Method of measuring Geodetic Bases by means of Metallic Wires, by M. Jäderin. (Translated from Memoires Prēsentēs par Divers. Savants ā l' Acadēmie des Sciences de l' Institute de France). Dehra Dūn, 1899. (Out of print).

No. 3—**Base Lines**—Method of measuring Geodetic Bases by means of Colby's Compensated Bars, compiled by Lieut. H. McC. Cowie, R. E. Dehra Dūn, 1900. (Out of print).

No. 4—**Spirit levels**—Notes on the Calibration of Levels, by Lieut. E. A. Tandy, R. E. Dehra Dūn, 1900. (Out of print).

No. 5—**Geodesy**—The Attraction of the Himālaya Mountains upon the Plumb-Line in India, considerations of recent data, by Major S. G. Burrard, R.E. Second Edition. Dehra Dūn, 1901. *Price Rs. 2.*

No. 6—**Base Lines**—Account of a Determination of the Coefficients of Expansion of the Wires of the Jäderin Base Line Apparatus, by Captain G. P. Lenox-Conyngham, R.E. Dehra Dūn, 1902. (Out of print).

No. 7—***Miscellaneous.** Calcutta, 1903.

(1) On the values of Longitude employed in maps of the Survey of India.

(2) Levelling across the Ganges at Dāmukdia.

(3) Experiment to test the increase in the length of a levelling staff due to moisture and temperature.

(4) Description of a Sun-dial designed for use with tide gauges.

(5) Nickel-steel alloys and their application to Geodesy. (Translated from the French).

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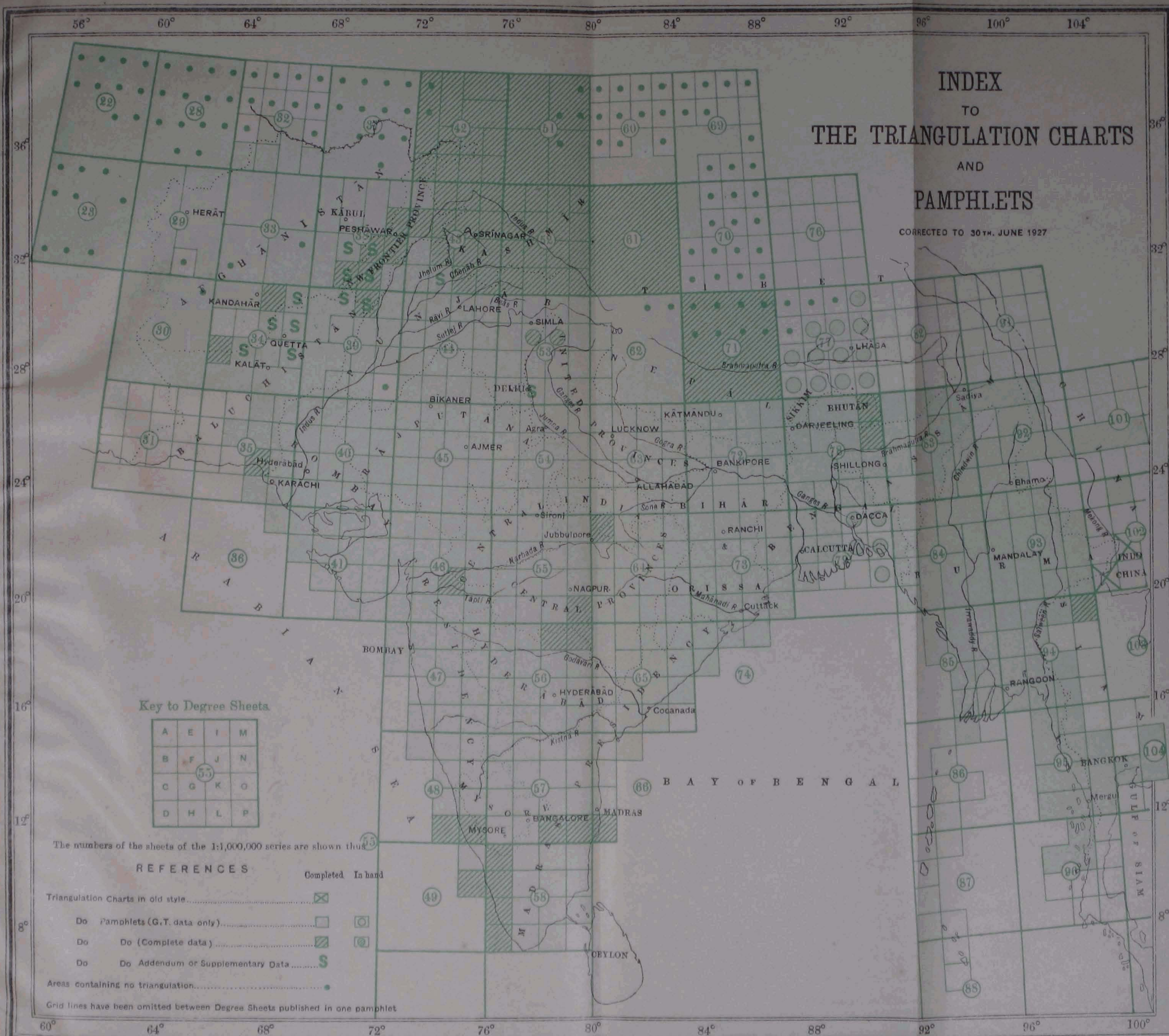
Chart XVI



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Scale $\frac{1}{20,000,000}$ or 1·013 Inches to 320 Miles

Miles 100 50 0 100 200 300 400 500 Miles

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