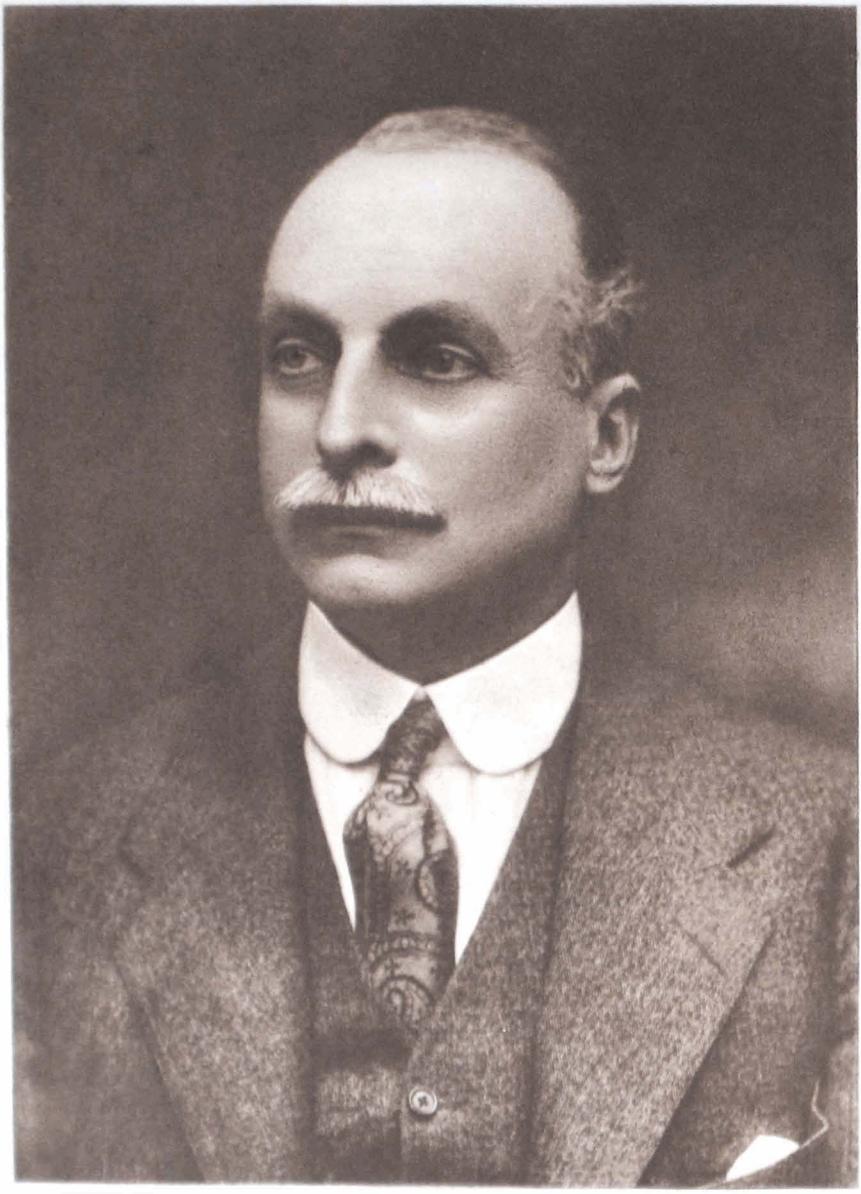


COLONEL H. L. CROSTHWAIT, C.I.E., R.E.,
SUPERINTENDENT OF THE TRIGONOMETRICAL SURVEY 1921-1923.

Colonel Herbert Leland Crosthwait, C.I.E., R.E.

Colonel Crosthwait, whose photograph appears as the frontispiece of this volume, joined the Survey of India in November 1897. From 1897 to 1902 he was in charge of the Tidal and Levelling party, and from December 1902 to June 1903 was employed with the Chili-Argentine Boundary Commission as Assistant Commissioner. His services there were highly appreciated in the Report of the Commission.

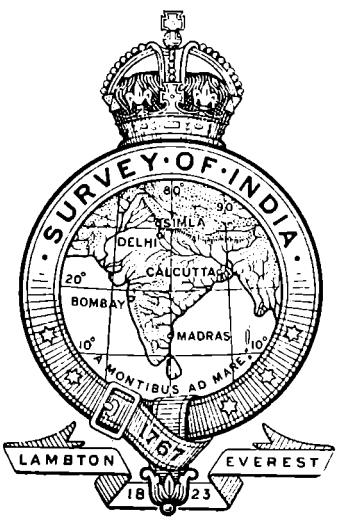
He was then employed on topographical surveys in the United Provinces, on the North West Frontier, and on forest surveys in Bombay until 1910. Subsequently he held charge of the Pendulum and Astronomical parties, and, in 1912, published a paper on Isostasy in India as Professional Paper No. 13.

During the war his services were retained in India until 1918, when he was placed in charge of the East Persia Survey party for a year, and later of the Waziristān Survey party in 1919. For his services in Waziristān he was made a C.I.E.

He was Superintendent of the Trigonometrical Survey from 1921 until his retirement in 1923.

Since retirement he has become a Director of the Aircraft Operating Company Ltd. of 8 New Square, Lincoln's Inn, London W.C. 2.

GEODETIC REPORT
VOL. II



From 1st October 1925
To 30th September 1926

PUBLISHED BY ORDER OF
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INTRODUCTION AND SUMMARY

The Geodetic Branch has not yet returned to the full normal scientific activities of pre-war days. Happily it is making progress in that direction. In the present year No. 13 (Latitude) and No. 14 (Pendulum) parties, having done a long summer field season in the Kashmīr valley and Deosai plains, remained at head-quarters during the winter and No. 15 party (Triangulation) resumed operations with a single detachment. No. 17 party was actively employed on both geodetic and commercial levelling.

At the Cambridge meeting of the International Union of Astronomy, the important International longitude scheme had been fixed to begin on 1st October 1926; and it was then decided that preliminary practice observations should commence a fortnight earlier. At Dehra Dūn preparations were in hand throughout the year and every effort was necessary to get all the instrumental arrangements into first class order. Apart from new apparatus obtained from England, a considerable amount of equipment was designed and made locally, which will be described in due course when the account of the longitude work is published; some mention is made of this equipment in Chap. 1 §§ 19-23. The personnel of Computing and Tidal party, Nos. 13, 14 and 15 parties, as well as officers under instruction, were involved in the longitude work in varying degrees. Six officers were trained in transit or astrolabe observations, and, in the course of this work, certain possible improvements in instruments and procedure came to light.

Rectangular co-ordinates, as usually employed in the Survey of India for traverse purposes, have been based on what is practically Cassini's projection. This projection is suited to a strip of country running north and south, and its distortions are mainly in the elongation of the outer meridians. They amount to about 1 in 1,000 at a distance of 200 miles from the central meridian. The projection is not orthomorphic. As a result of a decision of an Artillery Survey Conference another projection has been introduced for rectangular co-ordinates. This is the Lambert orthomorphic projection. It has been adapted to the Everest spheroid and retains its truly orthomorphic character. Tables and forms for use on this projection have been prepared (*vide* Chap. 1 § 5). It is necessary to issue a warning that the old forms (8,9,10 Trav.) for computation of rectangular co-ordinates cannot be used with this projection.

An enquiry into differences between spirit-levelled and triangulated heights is in progress (*vide* Chap. 1 § 7).

Tidal work has gone on much as usual. Attention is drawn to

the corrections found desirable in the case of three riverain ports (*vide* Chap. I § 13). In the case of Rangoon it appears that the need for the corrections is due to very considerable changes in the river channel since the prediction tables were prepared.

Comparative test observations for time were made in the Walker and Hunter observatories and just outside the former. The results suggested refraction uncertainty in the case of the former observatory, the use of which has since been discontinued (*vide* Chap. 1 § 18).

Moving-wire micrometers were fitted for the first time to the two transit instruments (*vide* Chap. 1 § 19).

A three-valve wireless set was installed. (*vide* Chap. 1 § 22).

Work has been continued steadily at the Dehra Dūn magnetic observatory (*vide* Chap. 1 §§ 24-32).

The computation of Kodaikānal and Toungoo magnetic observatory results had fallen largely into arrears, when publication was suspended. This was brought up to date this year, and the results published in Geodetic Report Vol. I.

Geodetic triangulation has been resumed after an interval of eight years (*vide* Chapter II).

Three detachments have been employed on levelling of high precision. In addition, secondary and tertiary levelling for the Sutlej Valley Irrigation Project was completed (*vide* Chapter III).

The method used for levelling across Karāchi harbour for high precision purposes is given in Chap. III § 11.

Some difficulties which have arisen in the adjustment of the high precision line from Rānīganj to Dināpur are discussed in Chap. III § 12.

High precision levelling was carried across two considerable rivers in Bengal—the Mahānandā and the Padmā, the latter being 37 chains wide (*vide* Chap. III § 13).

Bench-marks made on living trees have been under observations at Dehra Dūn for some 12 years. Colonel Cotter discusses their possibilities in Chapter IV.

The Trigonometrical Handbook, printed in 1902, is out of print; and also needs revision. It is to be gradually replaced by a Geodetic Handbook, published in separate chapters. The chapter on Levelling of precision written by Mr. H. G. Shaw, was published in 1920. A second edition of this, comprising considerable modifications, is now at press. The chapter on the Tides, by Major C. M. Thompson, R.A., was under publication during 1925-26, and has since been published.

The personnel of the Geodetic Branch is given on the next page.

DEHRA DŪN,
July 1928.

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

PERSONNEL* OF THE GEODETIC BRANCH, 1925-26

Director, Geodetic Branch

LT.-COLONEL. R. H. THOMAS, D.S.O., R.E., from 1st October 1925 to 27th November 1925.

LT.-COLONEL. M.O'C. TANDY. D.S.O., O.B.E., R.E., from 28th Nov. 1925 to 30th Sept. 1926.

COMPUTING AND TIDAL PARTY

(RECORDS AND RESEARCH)

Class I Officers.

Major C. M. Thompson, I.A., in charge from 1st October to 12th October 1925.

Lt.-Colonel R. H. Thomas, D.S.O., R.E., in charge from 13th October to 18th November 1925.

Dr. J. de Graaff Hunter, M.A., Sc.D., F. Inst. P., in charge from 19th November 1925 to 30th September 1926.

Mr. B. L. Gulatee, B.A. (Cantab), from 3rd July 1926.

COMPUTING SECTION.

Mr. Mukundananda Acharya, Head Computer and 10 Geodetic Computers.

TIDAL SECTION.

Class II Officers.

Mr. D. H. Luxa, Tidal assistant, from 26th October 1925 to 30th September 1926.

Mr. R. B. Mathur, B.A., from 1st to 25th October 1925

10 Computers.

OBSERVATORY SECTION.

Class II Officers.

Mr. R. B. Mathur, B.A., from 26th October 1925 to 30th September 1926.

Upper Subordinate Service.

Mr K. K. Das, B.A., from 7th June to 28th August 1926.

Mr. H. C. Banerjea, B.A., from 24th August 1926.

Magnetic Observatory.

Mr. K. N. Mukerji, M.A.

1 Computer.

OFFICE SECTION.

Mr. Baldeo Bihari Lal from 12th January 1926.

1 Clerk.

13 PARTY (ASTRONOMICAL)

Class I Officers.

Captain E. A. Glennie, D.S.O., R.E., in charge from 1st to 26th October 1925.

Class II Officers.

Mr. S. S. McA'F. Fielding, in charge from 27th October 1925 to 30th September 1926.

Lower Subordinate Service.

3 Computers, etc.

14 PARTY (PENDULUMS)

Class I Officers.

Captain E. A. Glennie, D.S.O., R.E., in charge from 27th October 1925 to 3rd March 1926.

Lieut. G. Bomford, R.E., in charge from 4th March to 30th September 1926.

Lower Subordinate Service.

4 Computers, etc.

15 PARTY (TRIANGULATION)

Class I Officers.

Captain G. H. Osmaston, M.C., R.E.

Lower Subordinate Service.

3 Computers, etc.

17 PARTY (LEVELLING)

Class I Officers.

Major A. H. Gwyn, I.A., in charge up to 31st March 1926.

Lt.-Colonel V. R. Cotter, I.A., in charge from 1st April 1926 to 30th September 1926.

Class II Officers.

Mr. N. R. Mazumdar.

Mr. J. L. Sahgal.

Upper Subordinate Service.

Mr. S. C. Mukerjee, from 7-5-26.
Mr. L. D. Joshi.
Mr. P. B. Roy.
Mr. A. A. S. Matlub Ahmad
Mr. H. C. Banerjea, B.A., till 23-8-26
Mr. I. K. Ponappa.
Mr. H. K. Kar.

Lower Subordinate Service.

22 Computers, etc.

64 Purely temporary levellers, etc.

TRAINING

Class I Officers under instruction.

Lieut. H.W. Wright, R.E., from 13th January 1926 to 8th December 1926.

Lieut I. M. Cadell, R.E., from 8th February 1926 to 6th December 1926.

TRAINING SCHOOL

Mr. S. F. Norman, Instructor.

* Excluding No. 2 D.O., Publication and Stores, F.M.O. and 20 Party.

CHAPTER I

COMPUTING AND TIDAL PARTY

BY

J. DE GRAAFF HUNTER, M.A., SC.D., F. INST. P.

AND

CAPTAIN G. BOMFORD, R.E.

(i) Computing Section

1. *Indian triangulation pamphlets.*—Triangulation data of 23 Indian degree sheets have been compiled. Four pamphlets have been printed, and 5 pamphlets are in the press. Shortage of stock of triangulation pamphlets, which number about 1000, is being steadily made up by reproduction by photozincography. The opportunity is being utilised to make such minor additions as will not interfere with reproduction. Proofs of 126 pamphlets have been examined, and 40 pamphlets have been photozincographed.

2. *'Irāq triangulation pamphlets.*—The compilation of the 'Irāq triangulation pamphlets has been continued. These pamphlets contain the work of the Turco-Persian boundary commission of 1913-14, and active service surveys of 1914-1920. There will be about 27 pamphlets in all, of which 12 have so far been compiled. Many parts of the work started from isolated bases with assumed heights and longitudes, and approximate latitudes. Connection has since been made, and all have been reduced to terms of the astronomical latitude and longitude of Fāo, observed in 1913. Where possible, heights have been reduced to terms of spirit-levelling based on the Fāo tidal observations by the Royal Navy in 1916; but connections have not been frequent, and the lines of levelling are less extensive than the triangulation. Whenever 'Irāq triangulation has been connected with that of the Turco-Persian boundary commission, the results of the former have been accepted. The discrepancies found amounted at the worst place to 1 second in latitude, 20 seconds in longitude and 200 feet in height. It is to be remembered that the Turco-Persian boundary work was in numerous sections, based on independent latitude observations at a variety of places: some of these were in mountainous country, where considerable deviation of the vertical is probable.

3. *Professional forms.*—Traverse forms 12, 13, 14, 17, 22, and Topo form 1 have been reduced to foolscap size. Astrolabe forms 3, 4 & 5 have been modified. The following new forms have been constructed and printed:—

3A Topo.—An angle book for use with the Wild theodolite.

27 Topo.—Theodolite resection, for use with spherical co-ordinates.

6 Ast.—Combination of the results obtained graphically from sets of 4 stars each.

7 Ast.—Final deduction of latitude and its probable error.

8 Ast.—Deduction of clock rate and probable error of a time observation.

1 & 2 Art.—Described in (§ 5).

4. *Auxiliary Tables.*—Part I (1921) of the Auxiliary Tables, (5th edition) has been reprinted. In part II, Table 15 Math. has been amplified.

5. *Lambert's orthomorphic projection.*—As the result of a decision arrived at by the artillery survey conference, held at Akora on 12th January 1926, two forms and a set of tables were prepared for the conversion of the spherical co-ordinates to rectangular, and *vice versa*, on Lambert's conical orthomorphic projection. This projection is also known as Lambert's second projection with two standard parallels. It is truly orthomorphic; that is to say, the scale at any point is the same in all directions. On the standard parallels (in this case 30° 42′N. and 36° 18′N.), the scale is correct. At the extreme latitudes for which the projection is intended to be used (29° 30′ N. and 37° 30′ N.), the scale error is 1·25 per 1000. Between the standard parallels, the scale error does not exceed 1·2 per 1000. The tables will be incorporated in part III of the Auxiliary Tables, 5th edition, as 43 Sur. and 44 Sur. The forms have been named 1 Art. and 2 Art. Co-ordinates are given to the nearest yard. 7-figure logarithms are required.

6. *Topographical Handbook.*—The Handbook of Topography, Chapter IV, "Theodolite Traversing" 1924, has been revised. The principal changes are the omission of the six appendices. Appendices I and II, dealing with theodolite resection, are being transferred to Chapter VII, "Transfrontier reconnaissance", and the tables, constituting appendices III to VI, are being published separately in a pamphlet entitled "Field Traverse Tables".

7. *Differences between spirit-levelled and triangulated heights.*—At the time of the reduction of the Indian triangulation, the trigonometrical heights were, as far as possible, brought into agreement with spirit-levelled heights, by adjustments at about 240 stations at which connection had been made. Since that time a further 180 stations have been connected with the spirit-levelling. A summary has been prepared of the discrepancies brought to light, with the intention of making it possible to apply further corrections when necessary. The average error found was about five feet; errors up to 10 feet were not uncommon, and in two places errors of over 20 feet occurred. These large differences were found in very old series (Calcutta Meridional and Rangīr Meridional), which were observed before it was the custom to confine the measurement of vertical angles to the time of minimum refraction.

The paucity of the data and the lack of apparent system among the discrepancies, have made it impossible to apply a generalised correction to different areas, as was hoped. Instead, it is intended to assess the reliability of the trigonometrical heights in different areas and to estimate the amounts by which they may be doubtful, without at present expressing any opinion regarding the actual amount or direction of their errors. This work is now in hand, and a further statement will be included in a future Geodetic Report.

8. *Miscellaneous.*—Times of sunrise and sunset were computed for the port of Calcutta for inclusion in the tide-tables for 1927. They were also computed for other latitudes in compliance with extra-departmental requests.

The following data were compiled, and supplied to Professor A. Crichton Mitchell, Rapporteur to the International Geodetic and Geophysical Union :—

(*a*) Daily and monthly values of declination, horizontal force, and vertical force for Dehra Dūn, Toungoo, and Kodaikānal for 1920.

(*b*) Difference between the daily maximum and minimum values of the above elements at the three observatories for the same period.

A further set of aneroid barometer observations, made by Sir A. Stein in Central Asia and the Pāmirs in 1915, were reduced. These consisted of 82 stations, including the Russian meteorological station of Kharuk, where a check was obtained on his observations.

Three hundred requisitions for data were received from departmental and extra-departmental officials. 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. In a few cases computations were made to meet the requirements.

670 trigonometrical stations were repaired by district officers at a cost of Rs. 3,457. Out of 365 districts, from which reports are due, 50 failed to make returns.

(ii) Tidal Section

9. *Tidal observatories.*—Registrations by automatic tide-gauges were continued at the following stations:—

Aden, Karāchi, Bombay (Apollo Bandar), Madras, Kidderpore, Rangoon, Bassein and Basrah. These operations were conducted under the direction of this department, the immediate control of each observatory being entrusted to the local officials of the ports concerned. In addition to the above, the actual times and heights of high- and low-water were observed on tide-poles (during daylight only) at the following stations:—Bhāvnagar, Chittagong and Akyab. These actual observations were compared with the predicted values, with a view to seeing whether the predictions still maintained a sufficient degree of accuracy.

Table 1 gives a complete list of the stations at which registrations have been carried out since 1874, the year in which regular tidal observations were commenced in India. The stations at which automatic tide-gauges are still working are shown in italics. Minor stations were closed after a few years on the completion of requisite registrations.

TABLE 1.—*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	47	
4	Maskat ...	,,	1893	1898	5	
5	Bushire ...	,,	1892	1901	8	
6	*Karāchi* ...	,,	1868	1880	*13	* Small tide-gauge working
			1881	still working	45 } 58	
7	Hanstal ...	,,	1874	1875	1	Tide-tables not published
8	Navānar ...	,,	1874	1875	1	
9	Okha Point ...	,,	1874 re-started	1875	1	Year 1904-05 is excluded
			1904	1906	1 } 2	
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	48	
14	Bombay (Prince's Dock)	,,	1888	1924	37	
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	
21	Galle ...	,,	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	1890	10	
			1895	still working	31 } 41	

TABLE 1.—*List of tidal stations—(concld.)*

Serial No.	Station	Automatic or personal observations	Date of commencement of observations	Date of closing of observations	Number of years of observations	Remarks
27	Cocanāda ...	auto-matic	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	45	
33	Chittagong ...	,,	1886	1891	5	
34	Akyab ...	,,	1887	1892	5	
35	Diamond Island ...	,,	1895	1899	5	
36	*Bassein* (Burma) ...	,,	1902 re-started 1923	1903 still working	2 3 } 5	Re-started in November 1923
37	Elephant Point ...	,,	1880 re-started 1884	1881 1888	5	Year 1880-81 is excluded
38	*Rangoon* ...	,,	1880	still working	46	
39	Amherst ...	,,	1880	1886	6	
40	Moulmein ...	,,	1880 re-started 1909	1886 1924	6 16 } 22	Dismantled in November 1924
41	Mergui ...	,,	1889	1894	5	
42	Port Blair ...	,,	1880	1925	45	Dismantled in April 1925
43	Basrah ...	personal	1916	1922	7 } 11	Observations taken on a tide-pole until 31-3-22: Automatic tide-gauge installed on 1-4-22
43A	*Basrah* ...	auto-matic	1922	still working	4	

10. *Inspections.*—The tidal observatories at Bassein, Rangoon and Kidderpore were inspected by Mr. D. H. Luxa, the tidal assistant, between February and March 1926. With a view to economy, no inspection of the tidal observatories at Aden, Karāchi, Bombay and Madras was carried out. Further, it was arranged with the port authorities at these places, and also with those at Kidderpore, that they should in future inspect and maintain their observatories themselves, except for the supply of certain stores and the cost of periodically overhauling the tide-gauge driving clocks.

At the request of the Deputy Conservator to the Commissioners of the port of Calcutta, their automatic tide-gauge at Phuldobi was also inspected, with the object of seeing whether these registrations could be utilised for the preparations of tide-tables. It had been in use for the past nine years. It was found to be in a satisfactory condition and its

results are suitable for harmonic analysis. The port Commissioners were not, however, prepared to allot the necessary funds.

11. *Tidal operations at Basrah.*—The tidal registrations obtained from the automatic tide-recorder which was originally set up at Ma'qil on the 1st April 1922, and which was subsequently removed and re-erected at Tanūmah (Basrah) on the 2nd November 1922, have been regularly received from the Port Director, Basrah, except, for the period from 1st to 29th June 1925, when registration failed. The tidal registrations at Basrah for the year 1925 have, however, not been utilised for any further harmonic reduction, as the values of the diurnal tidal constants deduced from the computations of the past years were considered to be sufficient.

12. *Reduction of Bassein tidal observations.*—Tidal observations were resumed at Bassein in November 1923. The tidal registrations for the year commencing 1st January 1924, have been reduced by harmonic analysis and the new values of the constants will be of use in the computation of data for future years. The constants are given in Table 2.

TABLE 2.—*Values of the tidal constants for Bassein*

Tide symbol	1924 $A_0 = 8{\cdot}330$				Tide symbol	1924 $A_0 = 8{\cdot}330$			
	R	ζ	H	κ		R	ζ	H	κ
Short period	*feet*		*feet*		Short period	*feet*		*feet*	
S_1	0·078	149°·29	0·078	149°·29	L_2	0·212	109°·99	0·187	38°·57
S_2	0·696	92·29	0·696	92·29	N_2	0·384	256·35	0·372	51·46
S_4	0·009	93·86	0·009	93·86	ν_2	0·143	107·36	0·139	359·96
S_6	0·002	242·10	0·002	242·10	μ_2	0·254	261·40	0·239	172·39
S_8	0·040	92·03	0·040	92·03	T_2	0·065	46·01	0·065	48·03
M_1	0·030	244·65	0·028	267·11	$(MS)_4$	0·183	240·97	0·178	16·47
M_2	2·242	274·61	2·175	50·14	$(2SM)_2$	0·086	83·75	0·084	308·25
M_3	0·022	213·76	0·021	57·01	$2N_2$	0·138	143·87	0·134	318·50
M_4	0·252	61·04	0·237	332·03	$(M_2N)_4$	0·093	32·35	0·088	322·95
M_6	0·092	198·15	0·084	244·65	$(M_2K_1)_3$	0·052	317·38	0·056	276·74
M_8	0·022	340·87	0·020	162·87	$(2M_2K_1)_3$	0·057	187·38	0·059	274·52
O_1	0·142	90·81	0·167	45·52					
K_1	0·335	222·95	0·360	46·81	Long period Mm	0·191	53·38	0·172	33·77
K_2	0·147	279·05	0·185	107·62	Mf	0·091	351·41	0·130	37·40
P_1	0·120	252·03	0·120	62·42	MSf	0·226	196·00	0·219	60·51
J_1	0·022	292·24	0·025	93·42	Sa	2·304	233·48	2·304	153·10
Q_1	0·021	106·83	0·024	81·15	SSa	0·426	89·12	0·426	287·34

13. *Corrections to predictions.*—Comparison of the predictions for Chittagong, Basrah and Rangoon with the actual times and heights of the tides has shown that the predictions published in the tables require the following corrections. They have accordingly been applied in the 1927 tide-tables. Comparison in future years will show whether they are permanently desirable or not.

Chittagong.—Based on comparisons in 1925. A correction of +10 minutes to all times of high- and low-water and a correction of +0·6 feet to all low-water heights only.

Basrah.—Based on comparisons in 1924 and 1925. A correction of +44 minutes to all times of high- and low-water.

Rangoon.—Based on comparisons in 1923-25. The corrections are given in Table 3.

TABLE 3.—*Monthly corrections at Rangoon*

Month	Times of high-water	Times of low-water	Height
	minutes	*minutes*	*feet*
January ...	−22	−14	Nil
February ...	−28	−19	,,
March ...	−23	−13	,,
April ...	−15	− 4	,,
May ...	− 9	− 4	,,
June ...	−14	− 8	,,
July ..	−20	−13	,,
August ...	−28	−11	,,
September ...	−11	0	,,
October ...	+ 2	+ 7	,,
November ...	+ 6	+ 8	,,
December ...	− 3	+ 2	,,

14. *Tide-tables.*—The tide-tables for 1927 for Basrah and the Indian ports were prepared and published. Distribution was completed by October 1926. Advance copies of the 1927 tide-tables for Suez, Aden, Bushire, Karāchi, Bombay, Madras, Chittagong, Mergui, Dublat (Sāgar Island), Elephant Point, Bhāvnagar, Colombo, Marmagao and Trincomalee, were prepared and despatched by the end of March 1926 to the Hydrographer to the Admiralty for incorporation in the admiralty tide-tables for 1927.

The money realised by the sale of tide-tables during the year ending 30th September 1926, amounted to Rs. 4,040/1/-, excluding commission charged by agents, and the cost of copies issued gratis.

15. *Comparison between actual and predicted values.*—From comparisons made between the actual and predicted times and heights of high- and low-waters for the year 1925, the predictions for 1925 were found to be as accurate as those for the preceding year, except in the case of Basrah, where a great deterioration had taken place both with regard to times and heights. The average errors, predicted *minus* actual, for the year were as follows:—

Time of high-water	−68·2	minutes
Time of low-water	−45·6	,,
Height of high-water	+ 1·0	feet
Height of low-water	+ 1·6	,,

The greatest difference between the predicted and actual heights of low-water for 1925 at the riverain ports was as follows:—

Kidderpore	Predicted *minus* actual	+2·8 ft.	on 9th October 1925.
Bassein	,,	−3·7 ,,	on 5th September 1925.
Basrah	,,	+5·1 ,,	on 29th & 30th May ,,

Tables 4 to 15 give the fortnightly mean errors of the predictions for all stations at which comparisons were made.

TABLE 4.—*Mean errors E_1 and E_2 for 1925*

ADEN

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes of time		0·7 feet 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.				
	minutes		feet		minutes		feet		minutes	feet	minutes	feet	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15		3·5	0·1			4·5		0·0	6·2	0·1	7·6	0·1	1	0	0	0
16-31		3·2	0·2			7·9	0·1		6·9	0·2	11·0	0·1	0	1	0	0
Feb. 1-15		5·9	0·3			9·3	0·2		10·0	0·3	11·1	0·2	0	0	0	0
16-28		2·4	0·1			3·8		0·0	4·6	0·1	9·7	0·1	0	1	0	0
Mar. 1-15		0·0	0·0			4·5		0·0	7·2	0·1	11·3	0·1	0	1	0	0
16-31		2·9	0·1			5·3	0·0		5·5	0·1	10·6	0·1	0	1	0	0
April 1-15	1·9		0·1			4·9	0·1		8·5	0·1	7·8	0·1	1	1	0	0
16-30	1·0		0·1			0·0	0·1		6·8	0·1	6·4	0·1	0	0	0	0
May 1-15		4·4		0·0		3·7		0·1	6·9	0·1	6·7	0·1	0	0	0	0
16-31		6·3		0·1		4·7		0·1	7·2	0·1	6·0	0·1	0	0	0	0
June 1-15	1·0		0·0		0·4			0·0	6·2	0·1	4·1	0·1	0	0	0	0
16-30	1·4		0·1		3·8		0·1		5·5	0·1	7·5	0·1	0	0	0	0
July 1-15	0·6		0·1			0·1	0·0		7·0	0·1	5·6	0·1	0	0	0	0
16-31	2·8		0·1		3·9		0·1		7·0	0·1	6·5	0·1	0	0	0	0
Aug. 1-15		0·7	0·2			1·6	0·1		6·6	0·2	6·1	0·2	0	0	0	0
16-31		4·1	0·1			0·7		0·0	7·9	0·1	8·4	0·1	1	0	0	0
Sept. 1-15		5·4		0·1		10·7		0·2	7·5	0·2	11·3	0·2	1	2	0	0
16-30		2·5		0·2		0·0		0·2	7·5	0·2	8·3	0·2	1	1	0	0
Oct. 1-15		4·4	0·0			4·5		0·0	9·4	0·1	9·1	0·1	2	1	0	1
16-31	2·3			0·0	2·4			0·1	5·5	0·1	7·7	0·1	0	0	0	0
Nov. 1-15	1·1			0·1	2·9			0·2	6·6	0·1	5·7	0·2	0	0	0	0
16-30		1·6	0·1			2·0	0·0		5·8	0·1	7·4	0·1	0	0	0	0
Dec. 1-15		5·0		0·1	5·2			0·1	7·7	0·1	9·9	0·2	0	0	0	0
16-31	0·8		0·1			1·5		0·0	7·5	0·1	8·3	0·1	0	0	0	0
TOTALS ...	12·9	52·3	1·8	0·6	18·6	69·7	0·8	1·0	167·7	3··	194·1	3·0	7	9	0	1
MEANS ...	− 1·6		+ 0·1		− 2·1		0·0		7·0	0·1	8·1	0·1				

* E_1 is with regard to sign ; E_2 is without regard to sign.

TABLE 5.—*Mean errors E_1 and E_2 for 1925*

BASRAH

PERIOD 1925	MEAN ERRORS (Predicted — actual)												Number of errors exceeding			
	E_1 *								E_2 *				30 minutes of time		One foot of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time Ht.		L. W. Time Ht.					
	minutes		feet		minutes		feet		minutes	feet	minutes	feet	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15		29·6		0·1		41·5		0·3	43·8	0·4	67·3	0·5	15	23	7	12
16-31		4·9	1·1			22·9	0·7		34·5	1·1	47·6	0 8	17	19	22	18
Feb. 1-15		37·0	1·1			39·6	1·1		39·1	1·1	64·7	1·2	13	18	22	21
16-28		24·4	0·9			7·2	1·0		32·0	1·0	35·8	1·1	9	14	22	20
Mar. 1-15		60 6	1·0			44·3	1·7		72·4	1·0	50·5	1·7	21	18	22	27
16-31		44·6	0·8			24 8	1·7		56·2	1·0	39·9	1·7	20	15	23	29
April 1-15		56·0	1·3			24·8	2·3		67·2	1·4	47·4	2·3	17	12	18	20
16-30		68 8	1·7			49 0	3·1		59·5	1·7	50·5	3·1	15	19	24	27
May 1-15		74·8	1·7			51·9	3·0		74·8	1·7	61·7	3·0	19	20	28	27
16-31		86 0	2·3			78·9	3·7		98·2	2·3	78·9	3·7	24	25	29	29
June 1-15		147·0	1·3			66·0	4·5		147·0	1·3	66·0	4·5	1	1	1	1
16-30		65·0	2·2			32·7	3·5		65·0	2·2	32·7	3·5	3	1	3	3
July 1-15		89·7	2·0			77·8	3·6		89·7	2·0	78·8	3·6	11	13	12	14
16-31		71·1	1·5			37·6	2·8		75·4	1·5	64·8	2·8	25	27	30	31
Aug. 1-15		68·9	0·7			35·5	1·4		74·2	0·7	64 0	1·4	19	22	17	28
16-31		68·6	0·6			52·2	1·2		73·4	0·6	60·3	1·2	24	20	17	29
Sept. 1-15		67·7	0·6			51·7	1·0		71·9	0·6	61·8	1·0	19	21	18	26
16-30		50·7	0·6			35·4	0·7		56·3	0·6	42·3	0·7	21	16	14	18
Oct. 1-15		90·4	0 3			73·9	0·4		90·4	0·5	73·9	0·5	21	20	10	9
16-31		97 6	0·5			68·7	0·5		97·6	0·5	72·7	0·5	12	11	6	5
Nov. 1-15		64·3	0·4			54·0	0·7		65·7	0·6	54·7	1·0	18	20	12	19
16-30		48·3	0·1			32·7	0·2		55·5	0·4	43·5	0·4	18	15	8	6
Dec. 1-15		52 5	0 3			44·4	0·4		57·6	0·6	56·6	0·7	17	20	11	17
16-31		48·1	0·6			46·2	0·6		55·8	0·6	74·7	0·7	16	26	14	13
TOTALS ...	0 0	1515·9	23·6	0·1	0·0	1093·7	39·8	0·3	1653·2	25·4	1391·1	41·6	395	416	390	449
MEANS ...		− 63·2	+ 1·0			− 45·6	+ 1·6		68·9	1·1	58 0	1·7				

* E_1 is with regard to sign : E_2 is without regard to sign.

TABLE 6.—*Mean errors E_1 and E_2 for 1925*

KARACHI

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Numbers of errors exceeding			
	E_1								E_2*				*30 minutes* of time		*0·9 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		1·2		0·3	4·5			0·1	9·7	0·3	12·0	0·3	0	0	0	0
16-31		6·9	0·2		9·6		0·4		11·5	0·2	13·3	0·4	0	2	0	0
Feb. 1-15		1·0		0·1		0·3	0·0		10·1	0·2	8·8	0·2	1	0	0	0
16-28	4·9			0·1	11·2		0·1		7·3	0·2	16·8	0·2	0	3	0	0
Mar. 1-15	1·4			0·4	12·5			0·2	7·2	0·4	13·6	0·2	0	2	0	1
16-31		3·0		0·4	12·0			0·2	11·5	0·4	13·3	0 3	1	3	0	0
April 1-15		5·1		0·3	10·9			0·1	8·7	0·3	11·9	0·2	1	1	0	0
16-30		3·9		0·3	9·9			0·1	7·5	0·3	10·9	0·2	0	3	0	0
May 1-15		3·1		0·2	11·3			0·1	6·5	0·2	11·3	0·2	1	0	0	0
16-31		1·1		0·1	12·3		0·1		9·5	0·2	15·2	0·3	1	5	0	0
June 1-15	2·3			0·2	14·1			0·0	7·5	0·3	14·6	0·3	0	1	0	0
16-30		8·8		0·5	6·6			0·3	9·4	0·5	15·0	0·3	1	3	1	0
July 1-15	4·2		0·1		15·2		0·1		8·7	0·2	16·7	0·2	1	2	0	0
16-31	0·6			0·2	12·3		0·0		7·7	0·2	17·0	0·2	0	4	0	0
Aug 1-15		4·7		0·2	5·8			0·1	10·3	0·2	12·7	0·2	1	1	0	0
16-31		1·5		0·3	10·2			0·2	6·2	0·3	14·8	0·2	0	1	0	0
Sept. 1-15		9·4		0·2		0·4		0·1	16·4	0·2	9·3	0·1	1	2	0	0
16-30		3·8		0·3	11·0			0·0	6·8	0·3	11·3	0·2	0	1	0	0
Oct. 1-15		1·6		0·4	7·3			0·3	8·6	0·4	11·8	0·3	0	3	0	0
16-31		6·4		0·2	4·5		0·1		8·3	0·2	9·6	0·2	0	0	0	0
Nov. 1-15		1·1		0·3	5·7			0·3	7·5	0·3	10·6	0·3	0	2	0	0
16-30		0·5		0·2	9·7			0·1	4·6	0·2	10·2	0·2	0	0	0	0
Dec. 1-15		8·9		0·1	17·2			0·0	8 9	0·1	17·4	0·2	0	5	0	0
16-31		1·3	0·0		11·6		0·1		7 8	0·1	11·8	0 2	0	2	0	0
TOTALS ..	13·4	73·3	0·3	5·3	225·4	0 7	0 9	2·2	208·2	6·2	309 9	5·6	9	46	1	1
MEANS ...	− 2·5		− 0·2		+ 9·4		− 0·1		8·7	0·3	12 9	0·2				

* E_1 is with regard to sign : E_2 is without regard to sign.

TABLE 7.—*Mean errors E_1 and E_2 for 1925*

BHAVNAGAR

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes of time		1·1 feet of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time Ht.		L. W. Time Ht.					
	minutes		feet		minutes		feet		minutes	feet	minutes	feet	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15		0·6		0·3		1·6		0·0	4·6	0·4	3·6	0·4	0	0	0	0
16-31	0·3			0·0		1·4	0·0		3·8	0·4	5·3	0·3	0	0	0	0
Feb. 1-15		0·9	0·0			1·1	0·1		5·5	0·4	4·7	0·4	0	0	0	0
16-28		1·2	0·0		1·8		0·1		4·8	0·5	4·2	0·5	0	0	0	0
Mar. 1-15	2·7		0·0			0·2		0·2	5·6	0·4	3·8	0·5	0	0	0	0
16-31	0·9		0·1		2·2		0·1		4·4	0·4	4·7	0·4	0	0	0	0
April 1-15	1·5		0·0		0·7			0·0	3·5	0·5	4·5	0·5	0	0	0	0
16-30	1·6		0 0		0·9		0·2		3·6	0·5	3·5	0·4	0	0	0	0
May 1-15		2·5		0·1		0·5		0·1	4·9	0·3	3·8	0·4	0	0	0	0
16-31	0·2			0 0		1·8	0·0		4·6	0·3	3·9	0·2	0	0	0	0
June 1-15		0·7	0·1			0·7	0·1		3·9	0·3	4·9	0·4	0	0	0	0
16-30	2·1		0·2		0·9		0·2		4·2	0·4	3·5	0·4	0	0	0	0
July 1-15		0·8		0·1		1·0	0·1		3·9	0·4	3·8	0·4	0	0	0	0
16-31		3·1		0·1		1·3	0·0		4·3	0·3	4·0	0·4	0	0	0	0
Aug. 1-15		0·1		0·1		0·5	0·0		3·7	0·4	3·1	0·3	0	0	0	0
16-31		1·9	0·1			0·9	0·3		4·5	0·4	3·0	0·4	0	0	0	0
Sept. 1-15		1·3	0·1			3·0	0·2		3·7	0·4	3·8	0·4	0	0	0	0
16-30		2·7	0·2			0·2	0·0		7·7	0·6	6·2	0·5	0	0	0	0
Oct. 1-15		1·9	0·2			1·6		0·1	6·0	0·4	4·1	0·3	0	0	0	0
16-31		1·8	0·1			2·9		0·0	5·6	0·4	4·6	0·4	0	0	0	0
Nov. 1-15		2·2	0·1			1·4	0·1		5·0	0·3	4·1	0·4	0	0	0	0
16-30	0·7		0·0			2·7		0·0	4·2	0·3	4·0	0·3	0	0	0	0
Dec. 1-15	0·1		0·0			1·9	0·0		3·2	0·3	3·7	0·4	0	0	0	0
16-31		1·9		0·2		1·8		0·1	3·1	0·3	3·3	0·2	0	0	0	0
TOTALS ...	10·1	23·6	1·2	0·9	6·5	26·5	1·5	0·5	108·3	9·3	98·1	9·2	0	0	0	0
MEANS ...	− 0·6		0·0		− 0·8		0·0		4·5	0·4	4·1	0·4				

* E_1 is with regard to sign ; E_2 is without regard to sign.

TABLE 8.—*Mean errors E_1 and E_2 for 1925*

BOMBAY

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Numbers of errors exceeding			
	E_1*								E_2*				30 *minutes* of time		1·0 *feet* 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	5·9		0·2			8·4	0·2		10·6	0·3	8·6	0·4	3	0	0	1
16-31		1·5	0·6			8·9	0·8		6·5	0·6	10·0	0·8	0	0	2	10
Feb. 1-15	5·2		0·2			6·4	0·4		10·1	0·3	9·9	0·4	1	0	0	2
16-28		1·6	0·1			7·6	0·3		3·9	0·2	8·8	0·3	0	0	0	0
Mar. 1-15	6·3			0·0		5·2		0·0	8·4	0·2	7·6	0·2	1	0	0	0
16-31	4·7			0·3		0·9		0·0	6·9	0·3	8·9	0 2	1	0	0	0
April 1-15	6·2			0·1		4·2		0·0	7·4	0·1	6·2	0·3	2	0	0	0
16-30	3·6			0·2		3·0	0·2		5·5	0·3	8·7	0·3	0	0	0	0
May 1-15	1·9		0·0			6·1	0·0		4·7	0·2	8·1	0·3	0	0	0	0
16-31	1·8		0·2			4·8	0·3		3·5	0·3	11·1	0·3	0	2	0	0
June 1-15	0·1			0·1		4·1	0·0		5·7	0·2	7·4	0·2	0	0	0	0
16-30		0·2		0·2		0·7		0·1	7·1	0·5	4·9	0·3	0	0	2	0
July 1-15		0·3	0·4			2·3	0·3		4·4	0·4	5·0	0·3	0	0	2	0
16-31	2·6		0·1			2·8	0·2		7·5	0·2	5·5	0·2	0	0	0	0
Aug. 1-15	7·1		0·3		2·6		0·3		10·0	0·3	8·5	0·3	2	1	0	0
16-31	6·2		0·3			4·6	0·1		7·7	0·4	9·8	0·3	1	3	0	0
Sept. 1-15	4·2		0·4			4·8	0·3		8·2	0·4	7·9	0·4	1	0	0	0
16-30	0·7		0·3		2·2		0·2		2·2	0·3	4·6	0·3	0	0	0	0
Oct. 1-15	5·4			0·0		0·8	0·0		7·7	0·1	4·7	0·2	1	0	0	0
16-31	1·3		0·3			3·9	0·2		2·7	0·3	5·9	0·4	0	0	0	0
Nov. 1-15	0·4			0·2		7·1		0·0	6·0	0·2	10·6	0·2	1	2	0	0
16-30	0·1		0·2			5·4	0·1		3·7	0·2	9·1	0·3	0	1	0	0
Dec. 1-15		5·1	0·1			11·7	0·1		9·5	0·2	12·7	0·2	1	4	0	0
16-31	9·2		0·4			5·8	0·4		12·3	0·4	8·8	0 4	2	1		0
TOTALS ...	72·9	8·7	4·1	1·1	4·8	109·5	4·4	0·1	162·2	6·9	193·3	7·5	17	14	7	13
MEANS ...	+ 2·7		+ 0·1		− 4·4		+ 0·2		6·8	0·3	8·1	0·3				

* E_1 is with regard to sign ; E_2 is without regard to sign.

TABLE 9.—*Mean errors E_1 and E_2 for 1925*

MADRAS

PERIOD 1925	MEAN ERRORS (Predicted—actual) 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* 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 L.W.	0·4 feet of height H.W.	0·4 feet L.W.
Jan. 1-15	5·8			0·0	6·4		0·0		8·9	0·2	8·3	0·2	0	0	0	0
16-31	10·1			0·0	10·0		0·0		10·1	0·1	11·5	0·1	0	1	0	0
Feb. 1-15	6·6			0·3	7·1			0·2	6·6	0·3	8·7	0·2	0	1	4	0
16-28	11·3			0·2	10·0			0·1	11·7	0·2	10·0	0·1	0	0	2	0
Mar. 1-15	7·6			0·2	8·9			0·1	8·0	0·2	8·9	0·1	0	1	1	0
16-31	10·6			0·2	9·4			0·1	11·0	0·2	9·4	0·2	0	1	1	0
April 1-15	6·5		0·1		8·3		0·3		6·8	0·2	9·1	0·3	0	1	0	5
16-30	5·7			0·1	6·6		0·1		8·0	0·1	8·1	0·2	0	0	0	2
May 1-15	4·8		0·0		6·6		0·2		5·7	0·1	7·2	0·2	0	0	0	0
16-31	6·8		0·3		5·9		0·4		7·8	0·4	6·1	0·5	0	0	16	18
June 1-15	3·2		0·3		3·0		0·3		3·9	0·3	6·3	0·3	0	0	2	4
16-30	8·8		0·0		8·0		0·2		9 2	0·1	8·0	0·2	0	0	0	1
July 1-15	6·3		0·2		5·1		0·4		6·5	0·2	5·4	0·4	0	0	3	12
16-31	5·8		0·3		4·1		0·5		6·6	0·3	5·3	0·5	0	0	1	23
Aug. 1-15	7·7			0·2	7·2			0·0	8·0	0·2	7·2	0·2	0	1	3	1
16-31	8·1		0·1		3·5		0·3		8·2	0·1	5·2	0·3	0	0	0	4
Sept. 1-15	9·9		0·2		9·1		0·3		10·8	0·2	9·7	0 3	0	1	5	7
16-30	2·1		0·4		1·8		0·5		4·6	0·4	4·4	0·5	0	0	14	20
Oct. 1-15	2·8		0·3		8·2		0·4		5·5	0·3	8·8	0·4	0	1	0	9
16-31	4·5		0·3		1·9		0·5		7·3	0·3	6·8	0·5	0	0	11	17
Nov. 1-15	3 1		0·0		6·8		0·1		4·2	0·1	7·4	0·1	0	1	0	0
16-30	4·5			0·1	2·8		0·2		6·1	0·2	4·9	0·2	0	0	3	0
Dec. 1-15	1·0			0·1	4·2		0·0		4·6	0·1	4·8	0·1	0	0	0	0
16-31	5·9		0·0		5·1		0·1		6·6	0·1	6·9	0·2	0	0	0	1
TOTALS...	149·5	0·0	2·5	1·4	150·0	0·0	4·8	0·5	176·7	4·9	178·4	6·3	0	9	66	124
MEANS...	+ 6·2		0·0		+ 6·3		+ 0·2		7·4	0·2	7·4	0·3				

* E_1 is with regard to sign: E_2 is without regard to sign.

TABLE 10.—*Mean errors E_1 and E_2 for 1925*

KIDDERPORE

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes of time		1·0 feet 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	13·9			0·1	17·4		0·0		14·1	0·3	17·8	0·3	0	0	0	0
16-31	18·7		0·2		8·0		0·1		18·7	0·3	10·5	0·3	3	0	0	0
Feb. 1-15	21·0			0·4	28·1			0·4	21·2	0·6	28·1	0·4	4	16	8	4
16-28	15·6		0·3		7·4		0·0		15·8	0·4	11·7	0·4	1	0	0	0
Mar. 1-15	20·5		0·0		24·7			0·1	20·5	0·4	24·7	0·3	5	8	0	0
16-31	9·1		0·2		6·3			0·2	13·0	0·4	12·9	0·3	1	1	0	0
April 1-15	14·8			0·3	14·8			0·3	17·0	0·4	16·3	0·3	4	5	2	0
16-30	5·5			0·3	3·9			0·3	10·3	0·4	12·8	0·4	2	1	3	0
May 1-15	4·0		0·3			3·8	0·0		7·5	0·6	15·5	0·5	1	2	2	4
16-31	10·6		0·2		11·3		0·1		12·4	0·3	14·6	0·3	1	2	2	0
June 1-15	5·2		0·7			6·3	0·4		8·0	0·7	10·9	0·4	0	0	2	1
16-30	1·5		1·0		16·0		0·3		8·7	1·1	18·7	0·7	0	2	16	6
July 1-15	8·8		1·2			0·6	1·4		10·0	1·2	7·0	1·4	0	0	19	21
16-31	8·2		0·6		13·3		0·6		10·7	0·9	15·3	0·7	0	0	10	8
Aug. 1-15	3·0		0·9		1·4		1·1		8·1	1·0	7·4	1·1	0	0	13	16
16-31	0·8		0·5		9·6		1·1		6·1	0·6	13·6	1·1	0	2	6	16
Sept. 1-15	0·2		0·9		6·7		1·2		6·9	0·9	11·3	1·2	0	3	9	19
16-30		14·9	1·2			14·1	1·5		14·9	1·2	14·9	1·5	0	1	16	17
Oct. 1-15		11·9	1·7			3·6	2·3		13·9	1·7	14·9	2·3	0	1	26	28
16-31		16·0	0·8			18·0	1·6		16·1	0·8	18·8	1·6	3	4	9	31
Nov. 1-15		13·4	0·9			4·7	1·3		14·9	0·9	12·0	1·3	1	1	14	26
16-30		18·2	0·9			21·7	1·0		19·1	0·9	21·7	1·0	6	4	7	11
Dec. 1-15		2·5	0·2		1·7		0·4		10·5	0·3	9·9	0·4	0	2	1	1
16-31	9·5			0·3	0·6		0·1		12·8	0·4	11·9	0·4	0	0	0	0
TOTALS ...	170·9	76·9	12·7	1·4	171·2	72·8	14·5	1·3	311·2	16·7	353·2	18·6	32	55	165	209
MEANS ...	+ 3·9		+ 0·5		+ 4·1		+ 0·6		13·0	0·7	14·7	0·8				

* E_1 is with regard to sign : E_2 is without regard to sign.

TABLE 11.—*Mean errors E_1 and E_2 for 1925*

CHITTAGONG

PERIOD 1925	MEAN ERRORS (Predicted — actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes of time		1·0 feet of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time	Ht.	L. W. Time	Ht.				
	minutes		feet		minutes		feet		minutes	feet	minutes	feet	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15		12·5		0·6		3·5		0·8	15·3	0·6	9·9	0·8	1	0	3	2
16-31		4·3		0·1		1·1		0·7	14·1	0·2	8·7	0·7	2	0	0	6
Feb. 1-15		1·5		0·7	3·5			1·0	10·8	0·7	7·1	1·0	3	0	5	7
16-28	3·3			0·2	0·7			0·8	8·7	0·4	6·2	0·8	0	0	1	4
Mar. 1-15		2·5		0·1		0·7		0·6	8·0	0·4	7·7	0·6	1	0	0	2
16-31	3·5		0·0			4·8		0·6	8·4	0·5	7·1	0·6	0	0	1	2
April 1-15		2·7		0·2		5·6		0·6	5·4	0·5	7·9	0·6	0	0	2	0
16-30		4·5		0·3		5·8		0·3	4·8	0·5	6·7	0·6	0	0	2	1
May 1-15		9·6	0·4			13·1		0·3	10·1	0·9	13·6	0·6	1	0	7	3
16-31		11·5		0·5		17·5		0·8	11·9	0·5	17·5	0·8	2	3	2	4
June 1-15		7·3	0·1			15·4		0·4	9·3	0·5	17·9	0·4	1	2	1	0
16-30		11·8	0·3			5·8		0·5	13·8	0·7	6·2	0·6	0	0	3	3
July 1-15		2·1		0·3		12·7		0·7	8·2	0·7	13·9	0·8	0	1	1	5
16-31		16·4		0·1	7·1			0·5	16·4	0·3	9·8	0·6	0	0	0	2
Aug. 1-15		5·9	0·2			8·5		0·2	9·4	0·7	9·5	0·4	1	0	4	1
16-31		6·9		0·5		8·6		0·9	7·8	0·6	15·1	0·9	1	3	4	5
Sept. 1-15		4·0		0·6		8·6		1·6	7·3	0·6	18·2	1·6	0	2	2	11
16-30		20·7	0·6			25·8		0·0	20·9	0·6	25·8	0·4	3	8	2	0
Oct. 1-15		31·9	0·6			29·1		0·1	31·9	0·6	29·1	0·2	8	6	4	0
16-31		28·5		0·1		27·8		1·0	28·5	0·4	27·8	1·0	7	5	0	6
Nov. 1-15		28·3	0·6			27·0	0·0		28·3	0·6	27·0	0·3	5	3	2	0
16-30		20·0	0·6			34·9		0·1	20·0	0·6	34·9	0·3	1	12	3	0
Dec. 1-15		16·9		0·3		21·6		0·5	16·9	0·3	21·6	0·6	2	1	0	1
16-31		12·1		0·4		13·8		0·8	12·1	0·4	15·4	0·8	0	1	0	1
TOTALS	6·8	61·9	3·4	5·0	11·3	291·7	0·0	13·8	328·3	12·8	364·6	1·0	38	47	49	66
MEANS		−10·6		−0·1		−11·7		−0·6	13·7	0·5	15·2	0·7				

* E_1 is with regard to sign; E_2 is without regard to sign.

TABLE 12.—*Mean errors E_1, and E_2 for 1925*

AKYAB

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes of time		0·3 feet 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	7·7			0·2	6·3			0·2	7·7	0·2	6·3	0·2	0	0	0	0
16-31	7·0			0·1	6·5			0·0	7·0	0·2	6·5	0 1	0	0	0	0
Feb. 1-15	7·5			0·6	6·5			0·5	7·5	0·6	6·5	0·6	0	0	4	2
16-28	6·8			0·2	5·9			0·2	6·8	0·2	6·8	0·3	0	0	0	1
Mar. 1-15	6·9			0·4	6·7			0·4	6·9	0·4	6·7	0·4	0	0	0	1
16-31	7·0			0·4	6·8			0·2	7·0	0·4	6·8	0·3	0	0	0	1
April 1-15	7·1			0·3	6·7			0·4	7·1	0·3	6·7	0·5	0	0	0	1
16-30	7·4			0·3	6·7			0·8	7·4	0·5	6·7	0·4	0	0	2	0
May 1-15	8·6			0·0	7·3		0·0		8·6	0·4	7·3	0·4	0	0	3	1
16-31	6·9			0·2	6·8		0·0		6·9	0·2	6·8	0·2	0	0	0	1
June 1-15	6·8		0·1		7·0		0·1		6·8	0·2	7·0	0·2	0	0	0	0
16-30	8·1			0·0	6·7		0·2		8·1	0·3	6·7	0·3	0	0	0	1
July 1-15	7·2		0·2		6·6		0·2		7·2	0·3	6·6	0·2	0	0	0	0
16-31	6·8			0·0	6·6			0·1	6·8	0·2	6·6	0·2	0	0	0	0
Aug. 1-15	7·2		0·1		6·4		0·2		7·2	0·2	6 4	0·3	0	0	0	0
16-31	6·1			0·1	6·1			0 1	6·1	0·2	6·1	0·1	0	0	0	0
Sept. 1-15	5·8		0·2		5·4			0·1	5·8	0·3	5·4	0·2	0	0	1	0
16-30	5·9		0·4		5·5		0·6		5 9	0·4	5·5	0 6	0	0	1	2
Oct. 1-15	5·5		0·4		5·5		0·4		5·5	0·4	5·5	0·4	0	0	0	0
16-31	6·0			0·1	5·4			0·0	6·0	0·1	5·4	0·2	0	0	0	0
Nov. 1-15	6·5		0·2		6·8		0·4		6·5	0·4	6·8	0·4	0	0	0	0
16-30	7·2			0·1	6·5		0·6		7·2	0·3	6·5	0·6	0	0	1	3
Dec. 1-15	7·0		0·0		6·9		0·1		7·0	0·2	6·9	0·3	0	0	0	0
16-31	7·4		0·1		6·8		0·0		7·4	0·1	6·8	0·1	0	0	0	0
TOTALS...	166 4	0·0	1·7	3·0	154·4	0·0	2·8	2·5	166·4	7·0	155·3	7·5	0	0	12	14
MEANS ...	+ 6·9		− 0·1		+ 6·4		0·0		6·9	0·3	6 5	0·3				

* E_1 is with regard to sign : E_2 is without regard to sign.

TABLE 13.—*Mean errors E_1, and E_2 for 1925*

RANGOON

PERIOD 1925	MEAN ERRORS (Predicted — actual)												Number of errors exceeding			
	E_1*								E_2*				30 *minutes* of time		1·0 *feet* of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time Ht.		L. W. Time Ht.		H. W.	L. W.	H. W.	L. W.
	minutes		*feet*		*minutes*		*feet*		*minutes*	*feet*	*minutes*	*feet*				
	+	−	+	−	+	−	+	−								
Jan. 1-15	13·1		0·3		13·0		0·6		13·2	0·4	15·1	0·7	0	8	2	6
16-31	24·0		0·1		13·3			0·0	24·0	0·3	14·6	0·6	4	0	0	4
Feb. 1-15	23·6			0·1	24·2		0·1		23·6	0·3	24·2	0·4	4	12	0	3
16-28	28·9		0·1		15·3		0·1		28·9	0·4	16·7	0·5	6	0	0	2
Mar. 1-15	25·7			0·0	23·8		0·1		26·0	0·3	23·8	0·3	7	10	0	0
16-31	21·1			0·2	11·3		0·1		21·1	0·3	14·7	0·4	1	2	0	0
April 1-15	16·6		0·0		12·2			0·1	19·0	0·2	14·9	0·5	2	3	0	2
16-30	10·6		0·2		3·1		0·4		11·2	0·3	10·1	0·5	1	2	0	2
May 1-15	7·1		0·4		0·9		0·1		11·4	0·5	9·7	0·5	1	2	0	0
16-31	7·1		0·2		9·2		0·1		10·4	0·3	12·0	0·4	1	2	1	0
June 1-15	10·2		0·5		0·0			0·1	10·8	0·5	8·1	0·5	0	0	0	3
16-30	14·8		0·2		9·6		0·6		14·8	0·3	12·4	0·6	1	2	0	6
July 1-15	18·0		0·3		6·9			0·1	18·2	0·4	11·6	0·4	1	1	1	2
16-31	19·6		0·1		19·1		0·6		19·7	0·3	19·1	0·6	3	10	0	5
Aug. 1-15	21·2		0·4		8·3		0·1		21·7	0·5	11·7	0·4	6	2	1	2
16-31	23·0			0·4	16·3		0·3		23·0	0·5	17·5	0·5	5	7	4	3
Sept. 1-15	16·5		0·4		5·7			0·3	19·4	0·5	10·4	0·5	5	2	2	1
16-30	4·1		0·6			4·2	1·1		6·9	0·6	8·0	1·1	0	0	1	16
Oct. 1-15	0·4		0·5			1·0	0·4		8·4	0·6	9·7	0·5	1	1	2	4
16-31		7·2	0·2			13·9	0·5		9·6	0·4	14·1	0·7	1	0	1	6
Nov. 1-15		5·4	0·8			3·0	0·9		7·6	0·8	11·3	1·0	0	0	8	13
16-30		10·0	0·6			15·9	1·1		10·1	0·6	16·2	1·1	0	3	1	14
Dec. 1-15	0·9		0·3			0·2	0·8		6·5	0·4	12·1	0·8	0	0	0	9
16-31	4·0		0·4			1·1	0·4		5·4	0·4	12·4	0·5	0	2	0	4
TOTALS ...	319·5	22·6	6·6	0·7	192·2	39·3	8·4	0·6	370·9	10·2	330·4	11·6	50	71	24	107
MEANS ...	+ 12·0		+ 0·2		+ 6·4		+ 0·3		15·5	0·4	13·8	0·6				

* E_1 is with regard to sign; E_2 is without regard to sign.

TABLE 14.—*Mean errors E_1, and E_2 for 1925*

BASSEIN

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes of time		0·6 feet of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time Ht.		L. W. Time Ht.					
	minutes		feet		minutes		feet		minutes	feet	minutes	feet	H. W.	L. W.	H. W.	L. W.
	+	−	+	−	+	−	+	−								
Jan. 1-15	2·7			0·6		17·6	0·2		13·3	0·6	18 7	0·2	1	5	9	0
16-31	9·6			0·9		9·1		0·0	18·4	0·9	16 4	0·3	6	6	26	0
Feb. 1-15	3·7			0·6		7·1	0·2		16·5	0·6	15·0	0·2	6	3	11	0
16-28	15·6			0 6		1·3	0·5		16·3	0·6	20·3	·5	5	3	11	8
Mar. 1-15	6·0			0·2		5·8	0·5		20·3	0·5	19·3	0·5	5	7	10	6
16-31	7·5			0·6		6·9	0·4		9·2	0·6	18·2	0·4	2	3	13	9
April 1-15	3·6			0·4		15·3	0·3		17·4	0·7	21·8	0·5	3	9	15	8
16-30	2·2			0·7		19·3	0·3		10·6	0·7	21·8	0·4	1	9	15	2
May 1-15	5·8			0·5		19·4	0·2		20·7	0 5	19·8	0·4	4	1	11	5
16-31		1·6		0 7		32·5		0·1	16·0	0·7	34·3	0·3	5	18	30	0
June 1-15	9·2			0·7		21·3		0·3	23·3	0·7	22·8	0·7	9	8	14	15
16-30		5·4		0·3		22·6	0·2		14·8	0·3	23·8	0·3	6	8	4	1
July 1-15	18·3			0·1		13·3		0·4	25·9	0·2	15·8	0·7	13	3	0	14
16-31	4·3		0·2			6·7		0·4	16·1	0 3	15·7	0·5	5	1	1	9
Aug. 1-15	7·2		0·4			3·8		1·1	18·4	0·4	11·9	1·1	7	0	3	23
16-31		24·3	0·2			9·4		1·8	24·3	0·3	14·6	1·8	7	4	0	31
Sept. 1-15		20·4	0·1			21·2		2·4	25·9	0·2	22·9	2·4	9	9	0	29
16-30		6·8	0·6			10·7		0·8	14·8	0·6	15·6	0 9	1	4	9	16
Oct. 1-15		4·7	0·3			25·7		1·1	10·3	0·3	26·8	1·1	1	12	3	31
16-31		7·4		0·2		23·6		0·7	18·1	0·2	23·8	0·8	6	10	0	15
Nov. 1-15		3·3		0·2		26·3		0·0	13·9	0·4	26·3	0·4	1	9	7	8
16-30		11·6		0 4		25·4	0·0		19·2	0·4	25·4	0·3	6	8	3	2
Dec. 1-15	0·7			0·6		24·2		0·0	20·6	0·6	24·2	0·2	7	6	13	0
16-31		4·1		0·8		29·0		0·2	19·6	0·8	29·0	0·3	6	15	21	2
TOTALS ...	96·4	89·6	1·8	9·1	0·0	397·5	2·8	9·3	423·9	12·1	504·2	15·2	122	161	319	224
MEANS ...	+ 0·3		− 0·3		− 16·5		− 0·3		17·7	0·5	21·0	0·6				

* E_1 is with regard to sign: E_2 is without regard to sign.

TABLE 15.—*Mean errors E_1, and E_2 for 1925*

PORT BLAIR

PERIOD 1925	MEAN ERRORS (Predicted—actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes of time		0·7 feet of height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time Ht.		L. W. Time Ht.		H. W.	L. W.	H. W.	L. W.
	minutes		feet		minutes		feet		minutes	feet	minutes	feet				
	+	−	+	−	+	−	+	−								
Jan. 1-15		1·2		0·3		0·6		0·3	4·2	0·3	3·6	0·3	0	0	0	0
16-31		6·4		0·2		1·7		0·2	7·3	0·2	7·5	0·2	0	0	0	0
Feb. 1-15		7·4		0·1		3·3		0·2	8·0	0·1	7·2	0·2	0	1	0	0
16-28		0·8		0·2	3·4			0·3	4·0	0·2	6·0	0·3	0	0	0	0
TOTALS ...	0·0	15·8	0·0	0·8	3·4	5·6	0·0	1·0	23·5	0·8	24·3	1·0	0	1	0	0
MEANS ...	− 4·0		− 0·2		− 0·6		− 0·3		5·9	0·2	6·1	0·3				

* E_1 is with regard to sign; E_2 is without regard to sign.

NOTE—The observations were discontinued from 1st March 1925.

(iii) Observatory Section

16. *Summary.*—The regular work of this section consists of:—

(*a*) Time observations,

(*b*) Magnetic observatory and absolute observations,

(*c*) Seismograph and meteorological observations.

In addition to the above, extensive preparations were made for the International Longitude project in October and November 1926.

17. *Transit instruments.*—The observatory possesses 2 transit instruments of 36″ focal length, known as Transits Nos. 1 and 2, and also a smaller bent transit. By January 1926, Transit No. 2 had been installed in the new Hunter observatory, and fitted with one of the two moving-wire micrometers recently received. The regular time observations, which had been in progress with Transit No. 1 in the Walker observatory, were then continued with Transit No. 2.

18. *Simultaneous observations in Walker and Hunter Observatories.*—Before dismantling the Walker observatory, the transit instrument there was fitted with the other moving-wire micrometer, and a series of nights' observations, using identical stars, was made with both instruments with a view to testing their accuracy. The results are given in Table 16. It will be noticed that, when Transit No. 1 was inside the Walker observatory, the deduced difference between the longitudes of the two observatories was badly in error. Better results were obtained, when the transit instrument was moved to an old pillar a few yards outside the building. It is believed that the first group was affected by lateral refraction, caused by the dome, situated a few feet to the east of the Walker observatory transit room, and that, when the instrument was used outside, this effect was avoided. The Hunter observatory has been specially designed and sited to avoid lateral refraction.

19. *Moving-wire micrometers.*—The moving micrometer eye-pieces are intended to minimise the personal equation of the observer. They have been used very successfully in America and elsewhere. The whole eye-piece, including a single vertical wire, can be traversed from side to side by means of two milled wheels, one on either side of the eye-piece, which the observer operates with both hands. Instead of recording the passage of a star across a fixed wire, the eye-piece is so traversed that the wire remains in apparent coincidence with the star. The movement of the wire is automatically recorded on the chronograph by a number of electrical contacts, which rotate with the milled wheels. This device is often referred to as an impersonal or self-registering micrometer.

TABLE 16.—*Simultaneous time-observations made at the Walker and the Hunter observatories*

Date of observation	Hunter observatory		Walker observatory		Pillar N. of Walker observatory		Difference in Longitude Hunter—Walker observatory	Means
	Observer	Clock Error	Observer	Clock Error	Observer	Clock Error		
		seconds +		*seconds* +		*seconds* +	*seconds*	*seconds*
15-5-1926	B	23·06	M	22·95			−0·11	
16-5-1926	M	22·92	B	23·20			+0·28	
18-5-1926	M	22·78	B	22·96			+0·18	0·00
22-5-1926	B	22·56	M	22·26			−0·30	
25-5-1926	B	22·31	M	22·25			−0·06	
7-6-1926	H	20·28			O	20·67	+0·39	
9-6-1926	H	19·98			O	20·23	+0·25	
10-6-1926	O	19·90			H	20·22	+0·32	+0·46
14-6-1926	O	19·31			H	20·15	+0·84	
15-6-1926	H	19·29			O	19·80	+0·51	

H = Dr. J. de Graaff Hunter. O = Captain G. H. Osmaston. B = Captain G. Bomford. M = Mr. R. B. Mathur.

N.B.—The difference of longitude found by measurement on the ground is +0ˢ·49.

Originally three fixed wires were left in the field of view to indicate the position at which the observations should be begun and ended, but loss of accuracy was experienced as the star passed over the fixed wires. They have now been replaced by pointers which do not cross the stars' path.

The computation forms have been remodelled to suit the impersonal micrometer and named 1 to 10 Long. and a chart, designed by Mr. R. B. Mathur, has been constructed to facilitate the reduction of the times of the several contacts to a single mean value.

20. *Riefler clock.*—Efforts have been made to improve the temperature conditions in the clock cell. A double ceiling has been made with saw-dust insulation and the surrounding verandah has been bricked in. The temperature control switchboard has been overhauled and the temperature is now satisfactorily regulated. During part of the hot weather it was found impossible to keep the temperature as low as the usual 80° F., as this figure was but little above or even below the daily minimum temperature outside. The effect of this rise of temperature on the rate of the clock may be seen in Table 17.

21. *Clocks A & B.*—The two clocks A & B hitherto used in the Walker observatory have been moved to the Hennessey observatory. These two clocks were made by Frodsham about 50 years ago. They have mercury pendulums and no pressure control. Clock A has been installed in the same cell as the Riefler clock, and B in the annular space surrounding the pillar of the solar telescope. The latter has been rated to mean time.

22. *Wireless reception.*—A three-valve wireless receiving set by Siemens was installed in June 1926, and rhythmic time signals were received from Bordeaux and Saigon. Until the end of August reception was found difficult during the day.

23. *International Longitude Project.*—A large amount of work was done in preparation for the International Longitude Project, in part of which the observatory section was assisted by the personnel of Nos. 13 and 14 parties. The moving-wire micrometer was removed from Transit No. 1 and fitted to the bent transit instrument, which was installed with Transit No. 2 in the Hunter observatory. The arrangements for illuminating the field of both transits were altered and improved, small electric bulbs being used instead of oil lamps. Permanent fixtures were provided for the nadir mercury baths, which were carefully levelled lest a dislevelled margin might cause a general displacement of the mercury surface by surface tension. A new bubble was permanently attached to Transit No. 2 in place of the striding level previously used. As it was intended to record the level before and after each star, the use of the striding level would have been very inconvenient. Two horizontal collimators were mounted in the meridian and housed in extensions from existing buildings.

The value of one division of the eye-piece micrometers was determined and found to be—

Transit No. 2 (North transit), 1 division $= 0^s \cdot 0768$.
Bent transit (South transit), 1 ,, $= 0^s \cdot 0781$.

TABLE 17.—*Rate of Riefler clock, 1925-26*

Date	Cell temperature	Clock			Remarks
		Rate	Pressure	Temperature	
1925	F	*s*	mm	C	
	°			°	
Sept. 28	...	...	...	...	
Oct. 5	80·4	+0·24	597	26·8	
" 12	83·2	+0·16	599	28·2	
" 20	83·6	+0·22	601	28·6	
" 28	83·0	+0·19	599	28·1	
Nov. 7	83·3	+0·24	600	28·4	
" 14	83·6	+0·19	600	28·8	
" 20	83·2	+0·26	600	28·3	
" 28	83·8	+0·16	602	29·1	
Dec. 5	84·0	+0·22	602	29·2	
" 13	83·7	+0·28	602	28·9	
" 19	82·2	+0·29	601	28·2	
" 26	80·6	+0·28	597	27·4	
1926					
Jan. 3	80·2	+0·21	596	27·0	
" 13	78·9	+0·24	595	26·3	
" 21	78·9	+0·24	595	26·4	
Feb. 4	79·4	+0·20	595	26·7	
" 13	79·9	+0·26	596	27·0	
" 20	79·3	+0·26	595	26·6	
" 26	80·8	+0·27	596	27·5	
March 8	79·9	+0·26	596	26·8	
" 15	79·3	+0·25	595	26·4	
" 25	79·8	+0·25	595	26·7	
" 31	79·9	+0·29	595	26·8	
April 10	79·9	+0·23	595	26·7	
" 17	80·1	+0·19	596	26·8	
" 25	81·4	+0·20	597	27·4	
May 2	80·5	+0·19	596	26·8	
" 18	79·7	+0·13	595	26·3	Roof over cell put up between 15th & 22nd May.
June 2	80·3	−0·12	595	26·6	
" 7	82·8	−0·13	597	28·0	
" 15	84·7	−0·12	601	29·0	
" 24	86·3	−0·07	603	29·8	
July 1	86·5	−0·05	604	30·1	
" 20	86·4	+0·01	604	30·1	
Aug. 3	82·5	+0·05	600	28·9	
" 18	81·1	+0·04	596	27·1	
Sept. 6	80·9	...	597	27·0	Clock stopped on 2nd Sept. It was restarted the same day.
" 25	80·4	+0·69	598	26·8	High rate probably due to the clock not settling down after restarting on 2nd Sept.
" 28	80·2	...	598	26·7	Clock set back about 15 seconds on 28th Sept. and pressure increased to 642 mm.
" 30	80·1	+0·02	642	26·6	

The electric circuits necessary for the clocks, relays, chronographs, transit instruments, astrolabe and wireless reception were somewhat complex. Arrangements to vary them several times during a night's observations were necessary in order to determine the relative lags of chronograph pens and relays and for clock comparisons. A switchboard was made up and placed in the Hennessey observatory outside the clock cell, by means of which any of the clocks could be put in circuit with any of the three principal relays, which were in turn connected with a plug board in the observatory. On this board pairs of plug holes were connected to each relay, and to each instrument and chronograph, and the circuits required for the various operations could be made up at will by plugging in short lengths of connecting wire.

One of the drum chronographs was converted to run at double its previous speed, to provide a more open scale for the measurement of the clock comparisons and small relay lags.

A new break circuit device, giving a break of great regularity and of adjustable length, as is required for the reception of rhythmic time signals, was made in the workshops and fitted to the pendulums of A and B clocks. It is described in Bulletin Géodésique No. 14 of 1927.

An apparatus for the direct measurement of personal equation with the prismatic astrolabe was also made and put into use. It will be described in the Geodetic Report Vol. III, 1926-27.

A complete programme of star observations for both transit instruments and the astrolabe was prepared, and a considerable amount of advance computations for the astrolabe was also carried out.

At the end of September preliminary work was carried out for a few nights with both transit instruments and the astrolabe. An account of the work done in connection with the longitude project will be given in the Geodetic Report Vol. III, 1926-27.

24. *Dehra Dūn Magnetic Observatory.*—The observations at the Dehra Dūn magnetic observatory are the only magnetic work now done by the Survey of India. They comprise a continuous magnetographic record of declination, horizontal and vertical force, daily observation of dip and bi-weekly observation of declination and horizontal force. The observations made during 1925 are summarised in Tables 18 to 26.

The compilation of the observations at Toungoo and Kodaikānal in 1922-23, and at Dehra Dūn in 1922-25 had fallen into arrears as a result of the closing of the magnetic party in 1923. It was completed during the year and published in the Geodetic Report Vol. I.

25. *Stoppages.*— With a few exceptions the magnetographs have worked satisfactorily during the year. The clock, working the drums of the declination and horizontal force magnetographs, stopped for a few hours on five occasions. Some trouble was caused by the light of the declination magnetograph leaking on to the trace, through a small crack in the frame which carries the condensing lens.

26. *Subsoil water.*—Water began to percolate into the observatory passage on 13th August 1926. Pumping was resorted to and the water disappeared gradually in about a fortnight.

27. *Mean values of the declination and horizontal force constants.*—Table 18 gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1\cdot2}$ and $P_{2\cdot3}$ and the accepted value of $\log\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\right)^{-1}$ for Magnet No. 17.

TABLE 18.—*Mean values of the constants of Magnet No. 17 at Dehra Dūn in 1925*

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′ 56″	6·00	5·85		806·56	
February ...	− 6 57	5·79	6·31		·66	
March ...	− 6 54	5·76	6·43		·57	
April ...	− 6 48	5·84	6·04		·51	
May ...	− 6 53	5·79	6·44		·37	
June ...	− 6 56	5·82	6·23		·25	
July ...	− 6 57	5·59	6·35		·33	
August ...	− 6 55	5·78	6·48		·39	
September ...	− 6 59	5·78	6·35		·44	
October ...	− 6 53	5·68	6·43		·43	
November ...	− 6 55	5·88	6·28		·52	
December ...	− 6 57) − 6 17)	5·98	6·50		·64	
				$\bar{1}\cdot99385$ throughout		806·18 throughout

28. *Mean base line values.*—Table 19 gives the mean monthly observed values of the declination and horizontal force base lines: these monthly observed values have been accepted and used to compute the values of these elements for 1925, and the moment of inertia of the magnet was assumed to be the same as determined in 1919.

TABLE 19.—*Base line values of magnetographs at Dehra Dūn in 1925*

Months	Declination		Horizontal force
	Mean value of base line		Mean value of base line
	°	′	C.G.S.
January ...	0	45·4	·32637
February ...	0	45·4	·32638
March ...	0	45·6	·32641
April ...	0	45·6	·32643
May ...	0	45·4	·32645
June ...	0	45·4	·32645
July ...	0	45·2	·32648
August ...	0	45·2	·32651
September ...	0	45·4	·32646
October ...	0	45·3	·32647
November ...	0	45·7	·32641
December ...	0	45·4	·32631

29. *Mean scale values and temperature range.*—The mean scale values for 1925 for an ordinate of 1/25 inch are :—

Horizontal force	4·32 gammas.
Declination	1·03 minutes.
Vertical force	9·69 to 10·95 gammas.

The mean temperature for the year was 26°·9 C., with maximum and minimum monthly values of 27°·3 C. and 26°·3 C. The temperature of reduction is 27°·0 C.

30. *Mean monthly values and annual changes.*—Table 20 shows the monthly mean values of the magnetic elements for 1924 and 1925 and the annual changes for that period.

TABLE 20.—*Annual changes at Dehra Dūn in 1924-25*

Months	Horizontal force ·32000 C.G.S. +			Declination E. 1° +			Dip N. 45° +			Vertical force ·33000 C.G.S. +		
	1924	1925	Annual change	1924	1925	Annual change	1924	1925	Annual change	1924	1925	Annual change
	γ *	γ *	γ *	′	′	′	′	′	′	γ *	γ *	γ *
January ...	923	945	+22	36·4	32·7	−3·7	15·4	18·8	+3·4	219	308	+89
February ...	927	945	+18	36·2	32·4	−3·8	15·9	19·2	+3·3	232	315	+83
March ...	941	951	+10	35·7	32·1	−3·6	15·6	19·3	+3·7	241	322	+81
April ...	946	959	+13	35·4	31·7	−3·7	16·2	20·1	+3·9	259	346	+87
May ...	946	961	+15	35·2	30·8	−4·4	16·4	20·5	+4·1	262	357	+95
June ...	944	953	+09	34·7	30·6	−4·1	17·0	20·7	+3·7	271	351	+80
July ...	950	950	00	34·8	30·0	−4·8	17·0	21·3	+4·3	277	361	+84
August ...	950	949	−01	33·9	29·6	−4·3	17·5	21·8	+4·3	288	370	+82
September ...	932	939	+07	33·5	29·4	−4·1	18·4	22·7	+4·3	286	377	+91
October ...	942	941	−01	33·5	29·3	−4·2	18·3	21·9	+3·6	295	364	+69
November ...	939	940	+01	33·2	29·1	−4·1	18·4	22·9	+4·5	294	382	+88
December ...	972	940	−32	32·8	28·7	−4·1	17·5	23·0	+5·5	310	384	+74
Means ...	943	948	+05	34·6	30·5	−4·1	17·0	21·0	+4·0	270	353	+84

* γ = ·00001 C. G. S.

31. *Mean values of the magnetic elements.*—Table 21 shows the mean values of the magnetic elements at Dehra Dūn in 1925 :—

TABLE 21.—*Annual means 1925*

Latitude	Longitude	Dip	Declination	Horizontal force	Vertical force
° ′ ″	° ′ ″	° ′	° ′	C. G. S.	C. G. S.
30 19 19 N.	78 3 19 E.	N. 15 21·0	E. 1 30·5	·32948	·33353

32. *Hourly values of the magnetic elements.*—Tables 22 to 26 show the classification and dates of magnetic disturbances, the monthly means of the magnetic elements, and their diurnal inequalities at Dehra Dūn in 1925.

TABLE 22.—*Classification and dates of magnetic disturbances at Dehra Dūn observatory in 1925*

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

(C) = Selected quiet days. C = Calm. S = Slight. M = Moderate. G = Great. — = Trace lost.

TABLE 23.—*Declination at Dehra Dūn in 1925*, (determined from 5 selected quiet days in each month)

Months	Mean hourly value	Hourly deviation from the mean																							
		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
	E 1°+ ′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	32·7	+0·3	+0·1	+0·1	0	−0·1	−0·4	−0·6	−0·5	+0·1	+1·2	**+1·4**	+0·4	−0·4	**−0·7**	−0·7	−0·2	+0·1	+0·2	+0·1	+0·1	+0·2	+0·1	+0·1	+0·1	+0·1
Feb.	32·4	+0·2	+0·2	−0·2	0	−0·1	−0·3	−0·4	**−0·5**	+0·1	+1·0	**+1·2**	+0·5	−0·2	−0·5	**−0·2**	0	−0·1	0	0	0	0	+0·1	+0·1	+0·2	+0·2
Mar.	32·1	+0·1	0	0	−0·2	−0·3	−0·2	−0·1	+0·3	+1·4	**+2·0**	+1·9	+0·8	−0·7	**−1·8**	−1·6	−0·9	−0·3	+0·1	0	−0·1	−0·1	**0**	−0·1	−0·1	0
Oct.	29·3	+0·1	+0·2	+0·2	+0·3	+0·1	+0·1	+0·3	+1·4	+2·5	**+2·6**	+1·7	+0·1	−2·0	**−3·0**	−2·1	−0·8	+0·2	−0·2	−0·5	−0·5	−0·4	−0·3	−0·1	+0·1	+0·2
Nov.	29·1	+0·4	+0·4	+0·4	+0·3	+0·1	0	−0·1	+0·2	+0·9	**+1·2**	+0·8	−0·3	−1·4	**−1·7**	−1·2	−0·7	−0·3	−0·2	+0·8	0	0	0	+0·2	+0·2	+0·4
Dec.	28·7	+0·1	+0·2	−0·1	+0·1	−0·1	−0·3	−0·5	**−0·8**	−0·3	+0·4	**+0·9**	+0·8	+0·2	−0·2	−0·2	−0·3	−0·1	−0·1	−0·2	0	0	0	−0·1	+0·1	+0·2
Winter Means*	30·7	+0·2	+0·2	+0·1	+0·1	0	−0·2	−0·2	0	+0·8	**+1·4**	+1·3	+0·4	−0·7	**−1·3**	−1·0	−0·5	−0·1	0	+0·1	−0·1	0	0	0	+0·1	+0·2
April	31·7	+0·8	+0·6	−0·2	+0·3	+0·3	+1·2	+0·6	+1·8	**+2·6**	+2·5	+1·1	−1·1	−2·3	**−2·9**	−2·6	−1·7	−0·6	+0·1	0	−0·3	−0·3	−0·3	−0·1	0	+0·1
May	30·8	+0·6	+0·5	+0·5	+0·6	+0·6	+0·9	+2·0	+2·7	**+2·8**	+2·7	0	−1·3	−2·7	**−2·9**	−2·0	−1·4	−0·7	−0·2	0	−0·2	−0·3	−0·3	−0·1	0	+0·2
June	30·6	+0·2	+0·3	+0·3	+0·3	+0·3	+0·6	+2·4	+3·7	**+4·1**	+3·3	+1·1	−1·3	−3·0	**−3·8**	−3·4	−2·5	−1·6	−0·6	0	0	−0·1	0	+0·1	+0·2	+0·3
July	30·0	+0·3	+0·3	+0·5	+0·4	+0·5	+0·8	+2·3	**+3·2**	+3·1	+2·1	+0·5	**−1·4**	−2·5	**−2·9**	−2·6	−2·0	−1·4	−0·6	−0·2	−0·3	−0·4	−0·3	−0·2	−0·1	+0·2
Aug.	29·6	0	+0·2	+0·4	+0·4	+0·5	+0·8	+2·2	+3·6	**+4·0**	+3·1	+0·9	−1·8	−3·3	**−3·8**	−3·3	−1·9	−0·8	+0·1	+0·3	−0·1	−0·3	−0·2	−0·2	−0·1	+0·1
Sept.	29·4	+0·3	+0·3	+0·3	+0·4	+0·5	+0·8	+1·5	+2·9	**+3·4**	+2·2	−0·1	−2·2	−3·5	**−3·5**	−2·8	−1·6	−0·3	+0·3	+0·3	+0·1	+0·2	0	+0·2	+0·3	+0·4
Summer Means*	30·4	+0·3	+0·3	+0·3	+0·4	+0·4	+0·8	+1·8	+2·9	**+3·3**	+2·6	+0·5	−1·6	**−2·9**	**−3·3**	−2·8	−1·9	−0·9	−0·2	0	−0·2	−0·2	−0·2	−0·1	0	+0·2

* Derived from the actual difference between the value for any hour and the general mean for all hours for the six months.

NOTE—The mean declination for any hour may be obtained by applying the hourly deviation for that hour with the sign given, to the mean hourly value for the month.

TABLE 24.—*Horizontal force at Dehra Dūn in 1925*, (determined from 5 selected quiet days in each month)

Months	Mean hourly value	Hourly deviation from the mean																							
		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	γ
Jan.	32945	− 3	− **4**	− 3	− 3	− 1	0	+ 2	+ 3	+ **4**	+ 3	+ 2	0	0	0	+ 1	− 1	− 1	− 1	− 1	− 1	− 2	− 2	− 1	− 1	− 1
Feb.	945	− **9**	− 7	− 3	− 5	− 3	− 1	− 1	+ 1	+ 5	+ 9	+10	+12	**+12**	+10	+ 5	− 1	− 3	− 3	− 4	− 4	− 4	− 4	− 4	− 4	− 3
Mar.	951	− 9	− **9**	− 7	− 5	− 6	− 5	− 5	− 1	+ 1	+ 4	+ 7	+10	+14	**+17**	+11	+ 6	0	− 2	− 5	− 5	− 4	− **2**	− 3	− 3	− 4
Oct.	941	− 3	− 2	− 2	− 2	− 2	+ 1	0	− 2	− 6	**−11**	− 5	− 1	+ 5	**+14**	+11	+ 2	− 1	− 2	0	+ 3	+ 1	0	+ 1	− 1	− 2
Nov.	946	− 4	− 5	− 3	− 4	− 4	− 4	− 1	+ 2	+ 5	+ 6	+ 6	+ 8	**+13**	+11	+ 6	− 1	− 4	− 7	**−10**	− 7	− 6	− 5	− 2	− 4	− 3
Dec.	940	− **6**	− 5	− 4	− 5	− 5	− 4	− 1	+ 4	+ 8	+11	+11	**+13**	+11	+ 7	+ 1	− 2	− 3	− 6	− 3	− 1	− 3	− 5	0	− 6	− 5
Winter Means*	944	− **6**	− 6	− 4	− 4	− 4	− 2	− 1	+ 1	+ 3	+ 3	+ 5	+ 7	+ 9	**+10**	+ 6	0	− 2	− 4	− 4	− 3	− 3	− 3	− 2	− 3	− 3
April	32959	− 6	**−10**	− 8	− 8	− 8	− 9	− 7	− 9	− 6	− 1	+ 9	+17	+21	**+21**	+17	+12	+ 6	0	− 3	− 4	− 4	− 4	− 4	− 3	− 2
May	961	− 9	− 9	−10	− 9	− 7	− 7	− 8	**−10**	−10	− 4	+ 5	+13	+19	**+23**	+21	+17	+16	+ 3	− 4	− 6	− 6	− 5	− 4	− 4	− 4
June	953	− 4	− 4	− 3	− **5**	− 6	− 3	− 1	− 2	− 5	− **6**	− 4	+ 3	+ 8	+13	**+13**	+11	+ 7	+ 2	− 3	− 5	− 4	− 3	− 2	− 1	− 1
July	950	− 3	− 3	− 4	− 4	− 4	− 4	− 4	− 7	− **8**	− 4	+ **3**	+ 9	+12	**+13**	+12	+ 8	+ 2	− 4	− 2	− 3	− 2	− 1	− 1	0	0
Aug.	949	0	+ 1	− 2	− 4	− 3	− 5	− 2	− 5	−10	−11	**−12**	− 4	+ 9	+15	**+16**	+12	+10	+ 2	0	− 1	− 1	0	+ 1	+ 2	+ 2
Sept.	939	0	− 1	0	− 2	0	0	0	− 8	**−18**	−17	−10	− 4	+ 5	+15	**+16**	+13	+ 9	+ 3	− 1	− 2	− 3	− 1	+ 1	− 1	0
Summer Means*	952	− 4	− **4**	− 5	− 5	− 5	− 5	− 4	− 7	**−10**	− 7	− 2	+ 6	+12	**+17**	+16	+12	+ 8	+ 1	− 2	− 4	− 3	− 2	− 2	− 1	− 1

* Derived from the actual difference between the value for any hour and the general mean for all hours for the six months.

NOTE—The mean horizontal force for any hour may be obtained by applying the hourly deviation for that hour with the sign given, to the mean hourly value for the month.

Figures in thick type indicate the maximum and minimum values of the hourly deviation.

$\gamma = 0$ 00001 C. G. S.

TABLE 25.—*Vertical force at Dehra Dūn in 1925,* (determined from 5 selected quiet days in each month)

Months	Mean hourly value	Hourly deviation from the mean																							
		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.	33308	+ 4	+ 3	+ 4	+ 4	+ 4	+ 4	+ 3	+ 3	**+ 6**	+ 5	+ 4	−10	**−12**	− 9	− 8	− 4	− 2	− 1	− 1	− 2	− 1	0	+ 1	+ 1	0
Feb.	315	0	+ 1	+ 1	0	0	0	0	+ 1	+ 3	+ 2	− 1	− 3	− 6	− 4	**−13**	− 3	− 2	0	0	+ 1	+ 2	+ 3	+ 3	+ 3	+ 4
Mar.	322	0	+ 1	+ 2	+ 2	+ 2	+ 2	+ 2	+ 4	**+ 6**	+ 6	+ 1	− 5	− 9	− 7	− 4	− 2	0	+ 1	0	+ 1	+ 2	+ 2	+ 3	+ 3	+ 3
Oct.	364	− 2	− 2	− 2	− 2	− 2	− 2	− 1	+ 1	+ 1	− 3	− 8	− 8	**−12**	− 8	− 2	0	+ 6	+ 5	+ 3	+ 6	+ 6	+ 7	+ 6	+ 7	+ 7
Nov.	282	+ 5	+ 6	+ 7	+ 7	+ 6	+ 6	+ 6	+ 7	+ 7	+ 6	+ 2	−14	**−15**	−12	− 8	− 6	− 4	− 4	− 4	− 2	− 2	− 1	− 1	− 1	− 2
Dec.	384	**+ 3**	+ 3	+ 3	+ 2	+ 1	+ 1	+ 2	0	+ 1	+ 2	+ 1	0	− 1	− 4	− 4	**− 4**	− 2	0	0	+ 1	+ 1	+ 1	+ 1	0	+ 1
Winter Means*	346	+ 2	+ 2	+ 2	+ 2	+ 2	**+ 2**	+ 2	+ 3	**+ 4**	+ 3	0	− 7	− 9	− 7	− 7	− 3	− 1	0	0	+ 1	+ 1	+ 2	+ 2	+ 2	+ 2
April	33346	+ 3	+ 2	+ 3	+ 3	+ 3	+ 3	+ 4	+ 6	**+ 6**	+ 3	− 2	**−10**	−10	− 8	− 5	− 1	0	0	0	0	0	0	+ 1	+ 1	+ 1
May	357	+ 2	+ 2	+ 2	+ 2	+ 3	+ 4	+ 5	+ 4	− 1	− 6	−11	**−13**	−11	− 5	− 1	− 1	+ 2	+ 2	+ 2	+ 2	+ 3	+ 4	+ 5	+ 5	+ 5
June	351	+ 4	+ 4	+ 4	+ 4	+ 4	+ 6	**+11**	+ 8	+ 2	− 4	−11	**−22**	−19	−11	−10	− 4	+ 3	+ 5	+ 6	+ 5	− 4	+ 8	+ 8	+ 8	+ 8
July	361	+ 4	+ 3	+ 5	+ 3	+ 5	+ 7	**+10**	+ 8	+ 4	0	− 5	**−11**	−11	−11	− 9	− 6	− 3	0	+ 1	+ 1	+ 2	+ 3	+ 4	+ 5	+ 5
Aug.	370	+ 5	+ 4	+ 4	+ 4	+ 4	+ 5	+ 8	+ 7	+ 3	− 3	−12	**−21**	−16	−13	− 4	+ 1	+ 2	+ 2	+ 3	+ 2	+ 2	+ 4	+ 5	+ 7	+ 7
Sept.	377	+ 6	+ 6	+ 7	+ 6	+ 6	+ 7	+ 9	**+ 9**	+ 7	0	− 4	−13	**−15**	−11	− 7	− 4	− 1	− 1	− 2	− 1	0	0	0	+ 1	+ 1
Summer Means*	361	+ 3	+ 3	+ 4	+ 3	+ 4	+ 5	+ 7	+ 6	+ 3	− 2	− 8	**−16**	−14	−10	− 7	− 3	0	+ 1	+ 1	+ 1	+ 2	+ 3	+ 3	+ 4	+ 4

* Derived from the actual difference between the value for any hour and the general mean for all hours for the six months.

NOTE—The mean vertical force for any hour may be obtained by applying the hourly deviation for that hour with the sign given, to the mean hourly value for the month.

Figures in thick type indicate the maximum and minimum values of the hourly deviation.

TABLE 26.—*Dip at Dehra Dūn in 1925,* (determined from 5 selected quiet days in each month)

Months	Mean hourly value	Hourly deviation from the mean																							
		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
	N45°+	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan.	18·8	+0·4	**+0·4**	+0·4	+0·4	+0·3	+0·3	+0·1	0	+0·1	+0·1	+0·1	−0·5	**−0·6**	−0·4	−0·4	−0·1	0	0	0	0	+0·1	+0·1	+0·1	+0·1	+0·1
Feb.	19·2	**+0·5**	+0·4	+0·2	+0·3	**+0·2**	+0·1	+0·1	0	−0·1	−0·4	−0·6	−0·8	**−0·9**	−0·7	−0·9	−0·1	+0·1	+0·2	+0·2	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4
Mar.	19·3	+0·4	**+0·5**	+0·4	+0·3	+0·4	+0·3	+0·3	+0·2	+0·2	+0·1	−0·4	−0·8	−1·2	**−1·3**	−0·8	−0·5	0	+0·1	+0·2	+0·3	+0·3	+0·2	+0·3	+0·3	+0·3
Oct.	21·9	+0·1	0	0	0	0	−0·1	0	+0·2	+0·4	**+0·5**	−0·1	−0·3	−0·8	**−1·1**	−0·6	−0·1	+0·4	+0·4	+0·2	+0·2	+0·3	+0·4	+0·3	+0·5	+0·5
Nov.	22·9	**+0·5**	**+0·6**	+0·5	+0·6	+0·5	+0·5	+0·4	+0·3	+0·1	0	−0·2	−1·1	**−1·4**	−1·2	−0·7	−0·2	0	+0·2	+0·3	+0·3	+0·2	+0·2	+0·1	+0·2	+0·1
Dec.	23·0	**+0·5**	+0·4	+0·4	+0·4	+0·3	+0·3	+0·2	−0·2	−0·3	−0·4	−0·5	**−0·7**	−0·6	−0·5	−0·2	−0·1	+0·1	+0·3	+0·2	+0·1	+0·2	+0·3	+0·1	+0·3	+0·3
Winter * Means	20·9	**+0·4**	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1	0	0	−0·1	−0·3	−0·7	**−1·0**	−0·9	−0·6	−0·2	+0·1	+0·2	+0·1	+0·2	+0·2	+0·2	+0·2	+0·3	+0·2
April	20·1	+0·4	+0·6	+0·5	+0·5	+0·5	+0·6	+0·5	**+0·8**	+0·6	+0·2	−0·6	−1·4	**−1·6**	−1·5	−1·2	−0·7	−0·3	0	+0·1	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1
May	20·5	+0·6	+0·6	+0·7	+0·6	+0·6	+0·6	+0·7	**+0·8**	+0·5	−0·1	−0·8	−1·3	**−1·5**	−1·4	−1·1	−0·8	−0·7	0	+0·3	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5
June	20·7	+0·4	+0·4	+0·3	+0·4	+0·5	+0·4	**+0·6**	+0·5	+0·3	+0·1	−0·4	−1·3	**−1·5**	−1·3	−1·2	−0·8	−0·3	+0·1	+0·4	+0·5	+0·5	+0·5	+0·5	+0·4	+0·4
July	21·3	+0·4	+0·3	+0·5	+0·4	+0·5	+0·6	+0·7	**+0·8**	+0·6	+0·2	−0·4	−1·0	−1·2	**−1·2**	−1·1	−0·7	−0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·3	+0·3
Aug.	21·8	+0·3	+0·2	+0·3	+0·4	+0·4	−0·5	+0·5	+0·7	**+0·7**	+0·5	0	−0·8	−1·3	**−1·4**	−1·0	−0·5	−0·4	0	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·3
Sept.	22·7	+0·3	+0·4	+0·4	+0·4	+0·3	+0·4	+0·3	+0·9	**+1·3**	+0·9	+0·3	−0·4	−1·0	**−1·3**	−1·2	−0·9	−0·5	−0·2	0	+0·1	+0·2	+0·1	0	+0·1	+0·1
Summer * Means	21·2	+0·4	+0·4	+0·4	+0·4	+0·5	+0·5	+0·6	**+0·7**	+0·7	+0·3	−0·3	−1·0	**−1·4**	−1·4	−1·1	−0·7	−0·4	0	+0·2	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3

* Derived from the actual difference between the value for any hour and the general mean for all hours for the six months.

NOTE—The mean dip for any hour may be obtained by applying the hourly deviation for that hour with the sign given, to the mean hourly value for the month.

Figures in thick type indicate the maximum and minimum values of the hourly deviation.

33. *Seismograph and meteorological observations.*—The Omori seismograph was in operation throughout the year except during the latter half of September 1926, when frequent stoppages of the clock necessitated its being dismantled for repairs. Table 27 shows the earthquakes recorded at Dehra Dūn during 1925-26.

The usual daily meteorological observations were made throughout the year.

TABLE 27.—*Earthquakes recorded at Dehra Dūn during 1925-26*

Date	Time of beginning Indian Standard Time		Duration	Distance of epicentre		Intensity	Remarks
	Dehra Dūn	Simla*		Dehra Dūn	Simla*		
	hr m	*hr m*	*minutes*	*miles*	*miles*		
12 - 10 - 1925	11 - 35	11 - 35	47	3,000	3,000	Slight	
13 - 10 - 1925	23 - 31	23 - 30	103	11,000	4,500	,,	
15 - 10 - 1925	18 - 6	...	46	2,000	...	,,	
22 - 10 - 1925	22 - 39	22 - 40	35	2,500	3,000	,,	
7 - 11 - 1925	0 - 54	0 - 54	12	200	Local	V. ,,	
10 - 11 - 1925	19 - 31	19 - 31	183	3,000	4,000	Moderate	
13 - 11 - 1925	17 - 53	17 - 53	120	3,000	3,300	,,	
7 - 12 - 1925	14 - 5	14 - 7	40	500	250	,,	
10 - 12 - 1925	20 - 8	20 - 8	70	6,000	10,000	,,	
18 - 12 - 1925	23 - 47	...	15	500	...	Slight	
29 - 12 - 1925	21 - 54	...	24	2,300	...	,,	
19 - 1 - 1926	2 - 45	2 - 44	60	2,100	2,500	Moderate	
25 - 1 - 1926	6 - 18	6 - 19	151	2,500	5,500	,,	
8 - 2 - 1926	21 - 52	21 - 11	45	1,600	8,000	,,	
22 - 2 - 1926	4 - 30	...	¼	50	...	Slight	Felt at Dehra Dūn
18 - 3 - 1926	19 - 50	19 - 44	30	3,000	2,600	Moderate	
4 - 6 - 1926	12 - 24	12 - 24	15	750	800	Slight	
27 - 6 - 1926	1 - 24	1 - 24	25	2,450	2,600	Moderate	Malta Italy
29 - 6 - 1926	20 - 7	20 - 5	31	3,000	2,600	Slight	
1 - 7 - 1926	4 - 27	...	21	300	...	V. ,,	
1 - 7 - 1926	19 - 53	19 - 47	39	4,000	2,700	Moderate	Pedang (Sumatra)
27 - 7 - 1926	12 - 56	12 - 55	2	Local	200	Slight	Felt at Dehra Dūn
2 - 9 - 1926	7 - 5	7 - 3	90	5,000	4,700	Great	
7 - 9 - 1926	18 - 4	18 - 5	42	4,600	5,000	Slight	300 miles S. of Cocos Island
10 - 9 - 1926	16 - 13	16 - 13	84	3,400	...	Great	
12 - 9 - 1926	21 - 22	21 - 21	34	3,000	3,000	Slight	
16 - 9 - 1926	23 - 43	23 - 42	68	2,000	6,000	,,	

* From Daily Weather Report.

N.B.—The instrument was not in working order from 17th to 30th September 1926.

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 = ±1·81

No	Name of Series	Seasons	±m	±M	No	Name of Series	Seasons	±m	±M
1	South Pārasnāth Mer.	1831-39	3·308	3·26	49	*Mangalore Meridional*	1863-73	0·440	0·45
2	Budhon Meridional ...	1833-43	2·242	2·46	50	Kumaun and Garhwāl	1864-65	1·742	1·50
3	*Amāa Meridional* ...	1834-38	1·647	1·88	51	Nāsik ...	1864-65	2·033	3·12
4	*Rangīr Meridional* ...	1834-64	1·643	1·79	52	Burma Coast ...	1864-82	0·380	0·39
5	*Calcutta Longitudinal*	1834-69	0·369	0·32	53	*Jubbulpore Meridional*	1865-67	0·340	0·31
6	*Great Arc Meridional, Section 24°-30°* ...	1835-66	0·706	0·71	54	*Madras Longitudinal*	1865-80	0·384	0·37
					55	Assam Valley Triangulation ...	1867-78	1·690	2·65
7	*Bombay Longitudinal*	1837-63	0·844	0·74	56	*Brahmaputra Mer.* ...	1868-74	0·564	0·70
8	*Great Arc Meridional, Section 18°-24°* ...	1838-41	0·567	0·59	57	Coimbatore No. 1 ...	1869-71	1·547	2·07
9	*Great Arc Meridional, Section 8°-15°* ...	1840-74	0·390	0·36	58	*Bilāspur Meridional*...	1869-73	0·302	0·33
					59	Cuddapah ...	1871-72	0·826	0·96
10	*Singi Meridional* ...	1842-62	1·187	1·14	60	Hyderābād ...	1871-72	1·405	1·56
11	*South Konkan Coast*	1842-67	2·176	1·93					
12	*Karāra Meridional* ...	1843-45	1·507	1·81	61	Malabar Coast ...	1871, 74, 80	1·532	1·82
					62	Jodhpore Meridional	1873-76	0·291	0·32
13	*North Malūncha Mer.*	1844-46	1·266	1·42	63	*South East Coast* ...	1875-79	0·522	0·65
14	*Chendwār Meridional*	1844-69	0·841	1·06					
15	*Gora Meridional* ...	1845-47	0·973	1·21	64	Eastern Sindh Mer. ...	1876-81	0·244	0·30
					65	Siam Branch Triangulation ...	1878-81	3·711	4·34
16	*Calcutta Meridional*...	1845-48	1·173	1·99					
17	South Malūncha Mer.	1845-53	1·606	1·97	66	Mandalay Meridional	1889-95	0·418	0·35
18	*Khānpisura Meridional*	1845-62	1·227	1·07					
					67	Mong Hsat ...	1891-93	3·054	3·01
19	*Gurwāni Meridional*...	1846-47	1·165	1·55	68	Manipur Longitudinal	1894-99	0·453	0·36
20	*North-East Lon.* ...	1846-55	0·446	0·65	69	Makrān Longitudinal	1895-97	0·285	0·26
21	*Hurilāong Meridional*	1848-52	1·502	1·92					
					70	Mandalay Lon. ...	1899-1909	1·696	1·98
22	*North-West Himālaya*	1848-53	0·641	0·55	71	Manipur Mer. ...	1899-1909 / 1915-16	0·750	0·81
23	*Gurkāgarh Meridional*	1848-62	0·914	1·21	72	Great Salween ...	1900-11	0·404	0·32
24	*East Coast* ...	1848-63	0·608	0·70					
					73	Kidarkanta ...	1902-03	1·323	1·62
25	*Karāchi Longitudinal*	1849-53	0·558	0·60	74	Kalāt Longitudinal ...	1904-08	0·365	0·25
26	*Abu Meridional* ...	1851-52	0·617	0·68	75	Baluchistān Triangulation ...	1908-09	1·348	1·08
27	*North Pārasnāth Mer.*	1851-52	0·895	1·25					
28	*Kāthiāwār Meridional*	1852-56	0·990	1·11	76	North Baluchistān ...	1908-10	0·221	0·17
29	*Gujarāt Longitudinal*	1852-62	0·859	1·12	77	Gilgit ...	1909-11	0·443	0·37
30	Kāthiāwār Lon. ...	1853	1·481	1·34	78	Khāsi Hills ...	1909-11	2·038	3·01
31	Sābarmati ...	1853-54	1·348	2·84	79	Mawkmai ...	1909-11	1·575	2·35
32	*Great Indus* ...	1853-61	0·359	0·43	80	Upper Irrawaddy ...	1909-11	0·596	0·49
33	*Rāhon Meridional* ...	1853-63	0·327	0·37	81	Jaintia Hills ...	1910-11	0·986	1·86
34	*Assam Longitudinal*...	1854-60	0·579	0·71	82	Bhīr ...	1911-12	0·794	0·94
35	*Cutch Coast* ...	1855-58	0·986	1·27	83	Rānchi ...	1911-12	1·840	2·34
36	Kashmīr Principal ...	1855-60	0·884	0·86	84	Villupuram ...	1911-12	1·184	1·78
37	*Jogi-Tila Meridional*	1855-63	0·481	0·59	85	Sambalpur Meridional	1911-14	0·250	0·21
38	Sambalpur Lon. ...	1856-57	0·806	0·87	86	Indo-Russian Connection ...	1912-13	2·790	3·92
39	(Cutch) Coast Line ...	1856-60	0·975	1·47	87	Khandwa ...	1912-13	0·999	1·27
40	Kāthiāwār Meridional No. 1 ...	1858-59	0·930	1·51	88	Ashta ...	1913-15	1·048	1·33
41	Kāthiāwār Meridional No. 2 ...	1859-60	1·247	1·75	89	Buldāna ...	1913-14	0·304	0·43
42	Kāthiāwār Meridional No. 3 ...	1859-60	0·969	1·48	90	Naldrug ...	1913-14	1·465	1·85
					91	Nāga Hills ...	1913-14	0·918	0·96
43	*Bidar Longitudinal* ...	1859-72	0·311	0·30	92	Middle Godāvari	1914-15	0·918	1·08
44	*Eastern Frontier or Shillong Meridional*	1860-64	0·409	0·49	93	Kohima ...	1914-15	1·094	1·39
45	*Sutlej* ...	1861-63	0·346	0·53	94	Cāchār ...	1914-15	1·077	1·65
					95	Bombay Island ...	1911-14		
46	*Madras Mer. and Coast*	1861-68	0·426	0·40	96	Madura ...	1916-17	1·148	1·53
47	Kāthiāwār Meridional No. 4 ...	1863-64	1·154	1·73	97	Bāgalkot ...	1916-17	0·701	0·88
48	*East Calcutta Lon.* ...	1863-69	0·379	0·57	98	Sind Sagar Triangulation ...	1917-18	1·875	3·24

Mer. = Meridional. Lon. = Longitudinal.

INDIA

TRIANGULATION SERIES AND AZIMUTH STATIONS

Corrected to Sept. 1926

Rakaposhi 25550 · Kunjut 25460 · K 2 28250 · Gasherbrum 20470 · Nanga Parbat 26620 · 24370 · 24090 · 21140 · 20410 · 22210 · 20720 · 22028 · Kamet 25447 · Nanda Devī 25645 · Gūrla Mandhata 25355 · 22650 · 23399 · Dhaulāgiri 26795 · XXX 26658 · Gosainthān 26291 · Mount Everest 29002 · Makalu 27790 · 23180 · 24740 · 23930 · Kinchinjunga 28146 · 23460 · Namcha Barwa 25445

HERÁT · KÁBUL · KANDAHÁR · NASRATÁBÁD · QUETTA · PESHÁWAR · Murree · Chach Base · Rāwalpindi · SRINAGAR · Dera Ismail Khān · Multān · LAHORE · Amritsar · Ludhiāna · Sutlej R. · INDUS R. · Jacobābād · Sukkur · Bīkaner · DELHI · Meerut · Jomna R. · Ganges R. · AGRA · Lucknow · Cawnpore · Fyzābād · Gwalior · Jodhpur · Benares · Allahābād · Hyderābād · Karāchi Base · KARĀCHI · Mouths of the Indus · Deesa · Kanpur · Sironj Base · Ahmadābād · Jubbulpore · Navānar · Okha Point · Hanstal · Bhaunagar · Porbandar · Narbada R. · Mhow · Port Albert Victor · NĀGPUR · Bānganghāt · Prince's Dock · BOMBAY · Apollo Bandar · Poona · Bider Base · Bolārum · Secunderābād · Godāvari R. · Vizagapatam Base · Vizagapatam · Cocanada · Bāgalkot · Raichūr · Kistna R. · Belgaum · Marmagao · Kārwār · Bellary · Bangalore · Bangalore Base · Mangalore · MADRAS · Calicut · Beypore · Trichinopoly · Negapatam · Cochin · Madura · Pamban Pass · Tuticorin · Trincomalee · Minicoy · Cape Comorin Base · Cape Comorin · Colombo · CEYLON · Galle · Saugor Island · Mouths of the Ganges · Calcutta Base · CALCUTTA · Kidderpore · Diamond Harbour · Dubiatta (Sagar I.) · Sarisalpur · False Point · LHĀSA · BRAHMAPUTRA R. · Darjeeling · Jalpaiguri · Sonakhoda Base · Dibrugarh · Shillong · Myitkyinā · Dacca · Chittagong · Chindwin R. · MANDALAY · SALWEEN R. · MEKONG R. · Akyab · Salih · IRRAWADDY R. · Prome · RANGOON · Bassein · Moulmein · Elephant Pt. · Pilakat Creek · Amherst · Diamond I. · Mouths of the Irrawaddy · BANGKOK · Mergui · Mergui Base · ANDAMAN ISLANDS · Port Blair · NICOBAR ISLANDS · BAY OF BENGAL · ARABIAN SEA

REFERENCES

Series of Triangulation

Addition Since 1925

Number of Series (vide table opposite) — 23

Base Line

Astronomical Azimuths

By reason of the small scale of this chart Azimuth 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

60° 64° 68° 72° 76° 80° 84° 88° 92° 96° 100° 104°

32° 28° 24° 20° 16° 12° 8°

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HELIO. S. I. O. DEHRA DUN

Chapter II

TRIANGULATION

(No. 15 Party)

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

1. *General.*—The party had not been employed on triangulation work since 1917-18, and was re-formed as one detachment in October 1925, and employed on principal triangulation in Lower Burma. This was required, firstly, to supply well fixed points for the topographical programme to be carried out in the season 1927-28 and, secondly, for the local governments who proposed to make a large-scale map of Rangoon by means of air-photographs. The available G. T. data had been found insufficient for satisfactory ground control.

Previous triangulation in this area consisted of minor work of 1875, which was based on G. T. intersected points, fixed from rays about 60 miles long. Many of the stations, so fixed, were on pagodas and had since disappeared.

The party left Dehra Dūn on 24th October 1925, and established head-quarters at Tharrawaddy by 1st November. The field season closed on 18th March 1926, when the party returned to recess at Dehra Dūn.

2. *Reconnaissance.*—The proposed scheme of triangulation was to break off southwards from the Burma Coast Series on meridian 96° E., from the old stations Kyaingbyingyi and Sanwingantaung. It was soon found to be impossible to extend southwards from the former, owing to forest obstruction.

Mr. S. S. Mc A' Fee. Fielding joined the party in the middle of November and a fresh attempt was made further east. The base Sanwingantaung-Kanyindaung was found to be suitable. From here the series consists of eight triangles, the western flank lying on the main ridge of the Pegu Yoma hills, and the eastern on low hills at the edge of the forest, or in the cultivated plains beyond.

The reconnaissance and building of stations were carried out as far as Rangoon, and the observations commenced in February 1926. Observations were taken from two stations during the month, but further work proved impossible owing to the thick haze.

Low masonry pillars of the hill station type were always constructed, even at the stations of Chanakpho and Siriam near Rangoon, where a trestle or mast would have to be erected for observational purposes. Such

pillars have the advantage of being cheap, and at the same time more permanent than tower stations, which are difficult and costly to maintain.

3. *Description of the country.*—The Pegu Yoma district consists of a series of low sandstone ridges running north and south, thickly covered with bamboo, teak and evergreen forest. The main watershed rises steeply on both sides, and good sites for stations were obtained on it; but the summits of the lower hills were not well defined and extensive clearing was necessary before stations could be chosen, making the reconnaissances long and laborious. The remainder of the country, outside the forest, was a flat alluvial plain with rice cultivation and thickly studded with trees and villages, the only elevations being mounds forming the bases of old pagodas. These mounds were avoided, as far as possible, as stations on them would be liable to be built over or destroyed by the local inhabitants.

Communication in the Pegu Yomas is difficult. Footpaths exist only as far as the Karen villages, situated in small clearings in the jungle. The Karens seldom move far from their villages and consequently they make poor guides; neither can they be depended upon for any supplies, as they only grow sufficient rice and vegetables for their own use. Water is generally plentiful in all the main jungle streams up to the end of February.

Coolies and elephants were used for transport; the former were difficult to obtain between November and January, being employed in the rice fields during these months. Work was held up on one occasion for several days, while coolies were collected from surrounding villages. The Forest Department could only lend their elephants on exceptional occasions, as they were all working at this time of year. Five contractor's elephants were engaged during most of the season. They were small and carried only 3 to 4 maunds each; even so, they proved very useful in carrying cement, rice and other heavy stores.

4. *Health of the party.*—The health of the party as a whole was only fair. All the personnel from Dehra Dūn, including 22 khalasies, suffered from malaria during the season, and there were two cases of dysentery. On the other hand, the health of the specially enlisted Hazāribāgh khalasies was good throughout.

5. *Summary of work*:—

Length of triangulation reconnoitred	80 miles
No. of new stations built	7
No. of stations observed at	2
Theodolite used	T. & S. 12-inch No. 5

INDIA

LINES OF
PRECISE LEVELLING
AND
TIDAL STATIONS
Corrected to Sept. 1926

REFERENCES

Levelling of High Precision since 1914

- Projected
- One direction only completed this season
- One direction only completed in previous seasons
- Both directions completed this season
- Both directions completed, one this season and one previously
- Both directions completed previously
- Levelling of precision 1858-1921

Levelling of Secondary Precision (selected lines only)

- Completed 1921-25
- do. this season
- Standard Bench-marks
- Tidal observatory (working) — Madras
- do. do. (closed) — Cochin

Scale 1 Inch = 250 Miles or 1/15,840,000

Miles 100 0 100 200 300 400 Miles

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HELIO. S.I.O. DEHRA DÚN

CHAPTER III

LEVELLING

(No. 17 Party)

BY LT.-COLONEL V.R. COTTER, I.A.

1. *Classes of levelling.*—Three classes of levelling are now carried out:—

(*a*) *Levelling of high precision*—sometimes called *primary*, conforms to the standard laid down by the International Geodetic Conference of 1912. It is laid out in the form of a geodetic net covering the whole of India: this net is separate from the first net of 1858 to 1909 the results of which were published in G.T.S. Vols. XIX, XIX A and XIX B, in 1910.

Each line is levelled twice in opposite directions with an interval of several months.

(*b*) *Secondary levelling*—is precise levelling, not intended for the new geodetic net. Its quality is similar to that employed on the first net of 1858 to 1909. Its main purpose is to supplement the primary levelling in providing bench-marks for public utility, and to form a basis for tertiary levelling.

Two levellers work separately, one closely following the other.

(*c*) *Tertiary levelling*—is all other levelling, required for the provision of bench-marks; it is specially valuable for irrigation and other engineering projects.

Methods vary according to lengths of line, and standard of accuracy required.

2. *Organization.*—The field office opened at Rahīmyār Khān on 1st November 1925, and the recess office at Mussoorie on 9th April 1926.

No. 1 detachment (*Sutlej Valley levelling group*) under Mr. N. R. Mazumdar with field head-quarters at Rahīmyār Khān, completed the levelling for the Sutlej Valley irrigation project, comprising 1,371 linear miles of secondary levelling and 29,776 linear miles (3,819 square miles) of tertiary levelling. In addition the following secondary levelling lines were run:—

(i) For the Haveli irrigation project, 121 miles.
(ii) Near the Panjnad weir, 68 miles.

No. 2 detachment, under Mr. A. A. S. Matlub Ahmad, executed levelling of high precision as below:—

(i) In the back direction from Barmer to Hyderābād along line 150, 217 miles.

(ii) In the back direction from Hyderābād to Manora along line 101, 145 miles.

No. 3 detachment, under Mr. J. L. Sahgal, executed levelling of high precision as below :—

(i) In the back direction from Dinājpur to Rānīganj along line 151, 261 miles.

(ii) In the back direction from Rānīganj to Midnapore along line 121 A, 114 miles.

(iii) The connection of 13 new standard bench-marks both in the fore and back direction.

No. 4 detachment, under Mr. L. D. Joshi, executed levelling of high precision as below :—

(i) In the fore direction from Muttra to Cawnpore along line 108, 223 miles.

(ii) In the fore direction from Cawnpore to Benares along line 119, 218 miles.

No. 5 detachment, under Mr. P. B. Roy, executed simultaneous double levelling of secondary precision in Bengal, Bihār and Orissa, and the United Provinces :—

(i) From Barākar to Allahābād, 472 miles.
(ii) From Mughal Sarai to Hazāribāgh Road, 214 miles.
(iii) Branch lines, 27 miles.

3. *Summary*.—The levelling comprised :—

441 miles of primary levelling in the fore direction.
737 miles of primary levelling in the back direction.
902 miles of secondary levelling.
29,776 miles (3,849 square miles) of tertiary levelling.

The secondary and the tertiary work was done for local Governments etc. The calculated probable errors for the completed portions of the primary levelling net satisfy high precision requirements.

4. *Sutlej Valley levelling group*.—Levelling was commenced with 5 sections. Table 1 gives the details of each section. During the latter half of the season, 3 computers from No. 5 section were formed into a computing section at head-quarters, in order that sufficient data should be available for a continuous supply of work to recess sections from the start.

5. *Sutlej Valley secondary levelling*.—On completion of No. 5 section's programme, a secondary section was formed with Mr. I. K. Ponappa in charge and Babu Indra Singh as second leveller. This section did 112 miles of secondary levelling in Sind for the Bombay Irrigation Department. They then connected some riverain pillars on the west bank of the Panjnad, and a number of rectangulation pillars recently laid down by No. 23 Party on the banks of the Sutlej and the Panjnad, near their confluence. Accurate heights of these pillars were wanted by the Executive Engineer, Panjnad Weir Division, for selection of weir and discharge sites. 59 miles of simultaneous double levelling was done for this work.

TABLE 1.—*Organization of Sutlej Valley levelling group*

Section	Head-quarters staff	No. of levellers	Date of commencement	Date of completion	Block Nos.	Area square miles	Locality
1	Mr. H.K. Kar 1 camp assistant ...	14, reduced to 12 in December	16th October	April	W″, X″, F″, G‴, B‴, C‴, V‴, D‴, S′, & T′.	1145	Ahmadpur and Allahābād tahsīls of Bahāwalpur and Ferozepore districts of the Punjab.
2	B. Faizul Hasan 1 camp assistant .	14	20th ,,	10th March	V‴, K‴, J‴, I‴, & H‴	801	Khānpur tahsīl of Rahīmyār Khān district of Bahāwalpur State.
3	B. Mohd. Ishak Khan 1 camp assistant ...	10	21st ,,	17th ,,	L‴, P‴, U‴, & W‴.	747	Rahīmyār Khān and Ahmadpur Lamma tahsīl of Bahāwalpur State.
4	B. Syed Nayar Hasan 1 camp assistant ...	14	18th ,,	15th ,,	K‴, J‴, I‴, O‴, N‴, & M‴.	775	Khānpur, Rahīmyār Khān and Ahmadpur Lamma tahsīl of Bahāwalpur State.
5	Mr. I.K. Ponappa 1 camp assistant ...	12, reduced to 10 in the middle of December	20th ,,	31st Dec.	T‴, P‴, R‴, S‴, O‴, Z‴, & N‴.	381	Ahmadpur Lamma tahsīl of Bahāwalpur State.

The secondary section connected the new standard bench-mark at Bahāwalpur Irrigation Office by high precision levelling with a number of inscribed bench-marks in the city, to obtain the height of the newly constructed standard bench-mark. On completion of the above, the section did 121 miles of secondary levelling from Abdul Hakīm Railway Station to Garhmahārāja, for the Haveli project.

During the Panjnad weir levelling, the Panjnad was crossed with 6-chain, and the Sutlej with 4-chain, shots. In the Haveli levelling work the Chenāb was crossed with 8-chain shots. All the crossings were done in the ordinary way, no target being necessary.

6. *Sutlej Valley tertiary levelling.*—The areas allotted to Nos. 1 and 3 sections, and part of that allotted to No. 2, were in the desert; water in these parts was very scarce; there were no *tobās* (small ponds) as in the last year's areas, and water had sometimes to be fetched from wells 16 miles away, for which extra transport had to be arranged. A great part of the area of section 3 was full of sand-hills, sometimes over a hundred feet high, and the areas bordering the rivers were intersected by numbers of overflow channels of the Panjnad. Levelling in these areas was necessarily very slow. In many detached areas, especially where there were high sand-hills or thick jungle, no sub-rectangulation had been done; levellers lost much time in such areas, as aligning had to be done by pacing from pillars of adjacent lines.

The total length of secondary levelling was 1,371 miles and of tertiary levelling 29,776 miles. The cost rates are given in Table 2. They include 14% for supervision and instruments.

TABLE 2.—*Cost rate of tertiary levelling*

	Cost per Sq. mile	Cost per mile
Field	Rs. 34·3	Rs. 4·4
Recess (probable)	4·97	0·64
Totals	39·27	5·08

7. *East Indian Railway secondary levelling.*—This levelling was carried out by No. 5 detachment (Mr. P. B. Roy) on the system of simultaneous double levelling. The programme of the detachment consisted of the following lines totalling 713 miles.

(i) Barākar to Allahābād.
(ii) Mughal Sarai to Hazāribāgh Road, and
(iii) Three branch lines between Hazāribāgh Road and Gomoh.

The country was partly flat and open, and partly hilly and undulating. The rivers Ajai, Kiul, Son, Karamnāsā, Tons and Phalgu were crossed by direct levelling over the railway bridges.

The probable errors of mean results derived from the formula p.e. $= \frac{1}{3}\sqrt{\frac{\Sigma d^2}{M}}$ feet (where "d" is the discrepancy between the levellers in the values of two consecutive bench-marks and "M" the total length of line in miles) are as follows:—

Branch line 70 K Barākar to Allahābād	$\pm$ ·0031 feet (miles)$^{-\frac{1}{2}}$
Branch line 70 L Mughal Sarai to Hazāribāgh Road.	$\pm$ ·0032 feet (miles)$^{-\frac{1}{2}}$

In addition to the usual types of standard, type A embedded, type B embedded and inscribed bench-marks, there were connected "pillar type" and "vertical type" railway bench-marks. The "pillar type" railway bench-mark consists of a stone block of about 2 feet by 2 feet by 9 inches, fixed on top of a *pakka* masonry pillar, about 3 feet high and 2 feet square. The "vertical type" railway bench-marks are stones fixed in the walls of railway stations, buildings etc.

American binocular level No. 6724, Cooke's level No. 3, staves Nos. 01 and 03, 23 A and 23 B and standard steel tape No. 10 were used by the detachment.

8. *Branch line 70 K (secondary) Barākar to Allahābād.*—The branch line 70 K from Barākar to Allahābād *via* Sitārāmpur, Patna, and Mughal Sarai follows the East Indian Railway Grand Chord and main-lines. The out-turn amounted to 472 miles, during the course of which heights of 465 bench-marks were determined.

Discrepancies with old work were found as shown below and were distributed in proportion to distance.

Discrepancy in	2·1	miles	from	B.Ms.	54/73 I	to 231/73 I = + 0·017 ft.
,,	215·7	,,	,,	,,	231/73 I	,, 20/72 G = − 1·184 ft.
,,	3·3	,,	,,	,,	86/72 G	,, 22/72 G = + 0·006 ft.
,,	2·1	,,	,,	,,	22/72 G	,, 23/72 G = + 0·021 ft.
,,	129·1	,,	,,	,,	23/72 G	,, 82/63 O = − 0·352 ft.
,,	40·6	,,	,,	,,	82/63 O	,, 52/63 K = − 0·043 ft.
,,	1·7	,,	,,	,,	52/63 K	,, 58/63 K = + 0·030 ft.
,,	1·2	,,	,,	,,	53/63 K	,, 55/63 K = + 0·007 ft.
,,	58·3	,,	,,	,,	52/63 K	,, 58/63 G = − 0·325 ft.

The following old bench-marks were allotted new numbers and heights:—9/72 G, 57/63 K, 51/63 K, 54/63 K, 41/63 G and 43/63 G, as the difference between the old and new heights showed that their heights had changed.

The following bench-marks were allowed to retain their old heights, as they will be connected by a primary line in 1926-27:—B.Ms. 51, 160, 158, 159, 162, 163, 45, 57, all of sheet 63 G.

9. *Branch line 70 L (secondary) Mughal Sarai to Hazāribāgh Road.*—The branch line 70 L from Mughal Sarai to Hazāribāgh Road, *via* Gaya, follows the East Indian Railway Grand Chord line.

The out-turn amounted to 214 miles, during the course of which heights of 218 secondary bench-marks were determined.

Discrepancies with old work were found as follows and were distributed in proportion to distance.

Discrepancy in	9·6	miles	from	B.Ms.	82/63 O	to 89/63 O	= −0·007 ft.
,,	5·3	,,	,,	,,	89/63 O	,, 100/63 O	= +0·070 ft.
,,	4·3	,,	,,	,,	100/63 O	,, 102/63 O	= +0·030 ft.
,,	29·8	,,	,,	,,	102/63 O	,, 122/63 O	= +0·247 ft.
,,	20·6	,,	,,	,,	122/63 O	,, 8/72 D	= +0·140 ft.
,,	144·2	,,	,,	,,	146/72 D	,, 109/72 H	= +0·900 ft.
,,	1·0	,,	,,	,,	107/72 H	,, 106/72 H	= −0·007 ft.
,,	1·1	,,	,,	,,	105/72 H	,, 104/72 H	= +0·004 ft.

The following old bench-marks were allotted new numbers and heights:—B.Ms. 83, 101, 118, all of Sheet 63 O, their heights having changed.

10. *Minor branch lines.*—Three short branch lines were levelled between Hazāribāgh Road and Gomoh, along the East Indian Railway Grand Chord line. The out-turn amounted to 27 miles, during the course of which heights of 50 secondary bench-marks were determined. The new bench-marks have been adjusted between the nearest old ones.

11. *Line 150 (primary) Kotri to Barmer and Line 101 (primary) Karāchi to Kotri.*—The back levelling of these lines was completed by No. 2 detachment under Mr. A. A. S. Matlub Ahmad. The instruments used by No. 2 detachment were large pattern Zeiss level No. 3342 by Carl Zeiss of Jena, staves Nos. 20A and 20B, and standard steel tape No. 3. For probable errors *vide* Table 3.

The Indus river near Gidu Bandar was crossed by direct levelling over the railway bridge. During the levelling operations both wheeled and pedestrian traffic were altogether stopped. The level was placed on the railway structure just above the piers, and the staves were placed on the sideway girders. The bubble of the level was steady throughout.

The following method was adopted for crossing Karāchi Harbour. At the extreme SE. end of Kiamāri groyne, a *pakka* platform was built for the instrument. An inscribed bench-mark was cut on the stone pavement adjoining, and west of the east embankment of Manora Island, facing Kiamāri groyne, 1½ furlongs SE. of the Military Pier. On this mark, back staff No. 20A with a target was erected. A right angled isosceles triangle was formed with the aid of a prismatic compass, having a right angle at the instrument site, thus obtaining a point on the groyne for the forward staff No. 20B. Fortunately at this point there was a *pakka* stone pillar on the groyne, and an inscribed bench-mark was cut on this pillar, on which staff No. 20B with target was erected. Having thus selected the best firm position for the instrument and staves, the observations were started, the level being equidistant from the staves.

Great pains were taken to cross the harbour at its narrowest part which, by measuring along the groyne from the instrument to staff

No. 20B, was found to be 33·55 chains, this distance being about 2·5 chains less than that obtained for the crossing in 1893-94.

As both the staves were on the edge of the water, the rays to the staves were free from radiation, and the atmosphere was steady throughout.

12. *Line 151 (primary) Rānīganj to Dinājpur.*—The observations lasted four days, work being done both in the mornings and evenings. 90 sets of readings were recorded. The mean value accepted for the crossing is −2·559 feet.

The back levelling of this line was carried out by No 3 detachment under Mr. J. L. Sahgal. The line emanated near Rānīganj from B.M. 39/73M of branch line 70A (Benares to Burdwān), and, after crossing the two secondary lines, 77M (Berhampore to Tinpāhār) and 77N (Porādaha to Rautara), finished on B.M. 78/78C of branch line 77B (Pārbatipur to Manihārī), which is a line of single levelling.

Discrepancies with old work were found as shown below and were distributed in proportion to distance.

Discrepancy in 3·1 miles from B.Ms. 39/73 M to 33/73 M = +0·005 ft.
" 91·6 " " " 39/73 M " 30/78 D = +0·497 "
" 29·4 " " " 30/78 D " 57/78 D = −0·070 "
" 99·9 " " " 57/78 D " 127/78D = −0·592 "
" 98·4 " " " 127/78 D " 78/78 C = −0·534 "

B.Ms. 30/73 M, 29/73 M and 28/73 M have received the same correction as B.M. 31/73 M. Branch lines, which closed on old bench-marks have been adjusted between the starting and the closing points, and B.Ms. 43/78 C, 44/78 C, and 46/78 C have received the same corrections as B.M. 42/78 C.

The adjustment of this line presented some difficulties. A reference to the Record Volume XV will show that there is at present a discrepancy of nearly 2 feet in the old net line between Howrah and Benares, as compared with the new net line. It is almost certain that the old levelling is in error, but despite this it was decided to adhere to the policy of temporarily adjusting the new net to the old. The published height of Rānīganj though at variance with its true value, has been accepted as the initial value for levelling and the line starts with one terminal point in error. The other terminal point, Dinājpur, is none too reliable, having been fixed by single levelling for the old net. The circuit, in which it is, has a closing error of about a foot. In addition two modern lines of double levelling of precision cross line 151. These two lines, when combined with other modern levelling, show themselves to be of high accuracy.

Unless all level values in this part of Bengal are to be upset, the published values of modern work as well as the old net values of the terminal point must be accepted. In consequence there are some corrections in line 151, which are too large from the point of view of levelling of high precision.

An investigation of the concordance of unadjusted values shows that all modern work in this locality is of excellent quality, and it is

regrettable that the method of adjustment of the new net to the old, results in the new heights being affected by the errors of the older observations, but there the matter must rest pending the completion of the new level net.

The total distance levelled including the branch line was 261 miles, in course of which heights of 21 primary and 279 secondary bench-marks were determined. Out of these secondary bench-marks, 8 had to be rejected, as they were found to have either risen or sunk. About 28 per cent of this line had to be relevelled, mostly in the fore direction. For probable errors *vide* Table 3.

13. *Line 121.1 (primary) Mohanpur (Midnapore) to Rānīganj.*— The back levelling of this line was carried out by No. 3 detachment under Mr. J. L. Sahgal. The total distance levelled, including branch lines, was 114 miles, in course of which heights of 9 primary and 146 secondary bench-marks were determined. About 22 per cent had to be relevelled, mostly in the fore direction. This line could not be adjusted, as the line Howrah to Jaleswar from which it emanates, has been levelled in the fore direction only.

The country was fairly flat at the beginning and end, and undulating in the middle. In addition to several minor rivers and water courses, the following important rivers were crossed :—

(i) The Mahānandā near Godāgāri, in two parts : first shot about 11¼ chains and the second 6 chains. For the first, 20 direct observations and 8 with the target were taken. Seven sets of direct observations were taken for the second shot. There was an island in the middle of river. For the 11¼ chain-shot, one staff and the instrument were placed on the island, while the other staff was on the Godāgāri bank of the river. For the second shot, one staff was on the island, and the instrument and the second staff on the bank opposite to Godāgāri. The soil was firm. Pegs 5 feet long were driven on both banks, the levels of which were checked daily. Cooke's 6-inch vernier theodolite and a 10-foot subtense bar were used for determining the width of the river.

(ii) The Padmā near Lālgolā, crossed with the targets, was about 37 chains wide. 104 sets of observations were taken, of which one set was rejected.

The site selected was about half a furlong north of the railway station cabin at Lālgolā Ghāt. One staff was kept on the west bank on a *pakka* pillar, and the other on a 5-foot peg on the island opposite. The instrument was set up on a brick platform on the island, to raise it high enough to read the back staff. Both the shots were mostly over water, so as to eliminate the effects of unequal refraction. One difficulty to be surmounted in this crossing was that the instrument and back staff being on an island, were very low, and the forward staff on the opposite bank was on high ground. The west bank at this place was about 20 feet high in two steps, and precipitous. The ground was hard on the surface, with mud underneath, and water oozed out at about 12 feet above

water level. A pillar was therefore erected for the staff. Three subsidiary pegs were fixed on either bank for check purposes. The width of the river was determined by subtense bar.

The successful crossing of these two rivers was largely due to the use of the improved pattern targets, fitted with gears easy of manipulation, and allowing of gentle movements, devised by Mr. N. R. Mazumdar.

In addition to the usual types of bench-marks a new type of standard bench-mark (type M) was connected this season at Howrah, Midnapore, Bānkurā, Rānīganj and Berhampore.

The instruments used by No. 3 detachment were Zeiss level No. 3488, staves Nos. 16A and 16B and standard steel tape No. 7. For probable errors *vide* Table 3.

14. *Lines 108 and 119 (primary) Muttra-Cawnpore-Benares.*—The fore levelling of these two lines between Muttra and Cawnpore, and Cawnpore and Benares respectively was done by No. 4 detachment under Mr. L. D. Joshi. The back levelling will be done next field season.

The instruments used were Zeiss level No. 16310, staves Nos. 19A and 19B, and the standard steel tape No. 4.

15. *Probable errors of primary lines.*—Table 3 shows the probable errors of the lines of high precision levelling completed in 1925-26. The probable error after M miles of levelling is $\sqrt{e_a^2 M + e_s^2 M^2}$ feet. e_a is the probable accidental error in feet after 1 mile of levelling and e_s is the corresponding systematic error. The permissible values of e_a and e_s are ·00416 and ·00106 feet respectively.

TABLE 3.—*Probable errors of primary lines*

Line	e_a	e_s
	feet	*feet*
150 (Kotri to Barmer) ...	0·0032	0·00055
101 (Karāchi to Kotri) ...	0·0032	0·00092
151 (Rānīganj to Dinājpur) ...	0.0033	0·00028
121A (Mohanpur (Midnapore) to Rānīganj)	0·0036	0·00075

TABLE 4.—*Tabular statement of out-turn of work, season 1925-26*

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	Rock-cut Protected old	new	Standard old	new	Primary stations of triangulation old	new	Secondary: Embedded old	new	Rock-cut old	new	Inscribed old	new	Tertiary: Irrigation and P. W. D. old	new	Railway old	new
No. 2 Detachment.																															
Net-line 150 Barmer to Kotri (1)	Oct. 25 to Feb. 26	209	50	38	11	41	14	221	11	52	1474·754	2079·549	2834	1	19	2	1	1	4*	...	2	...	...	...	...	38	192	6	1	...	...
Net-line 101 Kotri to Karāchi (2)	Jan. 26 to Mar. 26	120	13	90	21	03	02	141	16	92	1249·750	1276·204	1667	1	...	2	4	2	3*	1†	1	1	...	...	22	20	93‡	1	...	1	...
No. 3 Detachment.																															
Net-line 151 Dināj pur to Rānīganj (3)	Oct. 25 to Mar. 26	239	03	00	22	10	30	261	13	30	2900·5	2658·2	2962	7	...	...	...	1	9*	...	4	1	...	2	1	34	235	...	1	...	5
Net-line 121A Rānīganj to Mohanpur (Midnapore) (4)	Mar. 26 to May. 26	105	37	50	8	57	20	114	14	70	2252·7	2257·8	1128	...	4	...	1	...	4*	...	1	1	...	1	16	6	119	...	1	...	1

(1) Relevelled 36 mls. 06 chs. 12 lks. (2) Relevelled 7 mls. 69 chs. 22 lks. (3) Relevelled 72 mls. 60 chs. 30 lks. (4) Relevelled 25 mls. 23 chs. 60 lks.

* Standard (Type M). † Secondary station of triangulation. ‡ Includes 7 tree bench-marks and 1 T. O. bed plate.

TABLE 4.—*Tabular statement of out-turn of work, season 1925-26—(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 old	new	Rock-cut Protected old	new	Standard old	new	Primary stations of triangulation old	new	Secondary: Embedded old	new	Rock-cut old	new	Inscribed old	new	Tertiary: Irrigation and P. W. D. old	new	Railway old	new
No. 4 Detachment																															
Net-line 108 Muttra to Cawnpore	Oct. 25 to Jan. 26	210	46	40	12	35	50	223	01	90	1660·694	1813·863	2574	...	...	...	...	3	...	2	...	12	...	...	...	32	132	2	103	...	1
Net-line 119 Cawnpore to Benares	Jan. 26 to May 26	204	55	50	13	35	40	218	10	90	1074·412	1224·807	2370	1	...	...	...	2	...	3	...	11	...	...	...	18	200*	...	...	...	...
No. 5 Detachment.																															
Line 70 K Barākar to Allahābād	Nov. 25 to Mar. 26	449	68	00	21	76	00	471	64	00	2868·454	2942·695	3988	...	.	...	1	3	...	1	1	1	..	.	...	26	227	...	...	1	210
Line 70 L Mughal Sarai to Hazāribāgh Road	Mar. 26 to Apr. 26	217	07	00	0	60	00	217	67	00	2443·899	1630·506	2058	...	...	1	...	..	...	...	...	4	...	...	...	11	68	...	...	4	132
Line 70 J 3 Branch-lines between Hazāribāgh Road and Gomoh	April 26	0	00	00	23	04	00	23	04	00	415·499	683·769	272	...	...	..	...	...	...	...	...	...	.	...	...	3	1	...	...	24	22

* Includes 3 tree bench-marks.

TABLE 5.—*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 in 1924-25-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1924-25-26	
			miles	*feet*		*feet*	*feet*
		Line 150 (Barmer-Kotri) at Barmer					
23	40 O	(Type C) at Barmer ...	0·0	0 000	1921-25	0·000	0·000
8	,,	Railway rest house ,, ...	1·3	− 41·068	,,	− 41·067	+ 0·001
9	,,	Railway station ,, ...	1·5	− 40·000	,,	− 40·004	− 0·004
10	,,	Sub post office ,, ...	1·6	− 41·370	,,	− 41·374	− 0·004
11	,,	Water tank of Hem *sarāi*	1·9	− 20·463	,,	− 20·486	− 0·023
12	,,	Verandah of ,, ...	1·9	− 18·273	,,	− 18·302	− 0·029
13	,,	Seth Kammi Rām's house	2·0	− 13·790	,,	− 13·799	− 0·009
14	,,	Police station ...	2·0	− 13·029	,,	− 13 041	− 0·012
15	,,	Civil dispensary ...	2·1	− 9·294	,,	− 9·312	− 0·018
16	,,	Step of court house ...	2·1	− 6·350	,,	− 6·345	+ 0·005
17	,,	Vestibule of ,, ...	2·1	− 6·452	,,	− 6·441	+ 0·005
18	,,	A. V. School ...	2·2	− 5·591	,,	− 5·580	+ 0·011
19	,,	Seth Rām Lāl's house ...	2·2	+ 0·367	,,	+ 0·378	+ 0·011
20	,,	Ganesh Mal's house ...	2·3	+ 4·703	,,	+ 4·702	− 0·001
21	,,	Seth Brij Lāl's house ...	2·3	+ 1·444	,,	+ 1·439	− 0·005
22	,,	Bāl kishan's *sarāi* ...	2·4	− 2·912	,,	− 2·912	0·000
		Line 150 (Barmer-Kotri) at Hyderābād and Kotri					
210	40 C	(Type B) at Kotri ...	0 0	0·000	1920-21	0·000	0·000
211	,,	Railway station ,, ...	0·3	+ 6·542	,,	+ 6·537	− 0·005
34	,,	N.E. end of Indus bridge	1·6	+ 27·447	(1904-06 / 1920-21)	+ 27·449	+ 0·002
413 (216)	,,	Thakur Dās' bungalow Gidu Bandar ...	2·4	+ 3·508	(1920-21 / 1924-26)	+ 3 477	− 0·031
33	,,	Bridge No. 7 ...	3 1	+ 19·585	1904-06	+ 19·563	− 0·022
217	,,	Tapedār's training school	3·6	+ 4·483	(1904-06 / 1920-21)	+ 4·460	− 0·023
161	,,	S. B. M. Hyderābād ...	4·7	+ 33·718	1904-06	+ 33·696	− 0·022
414 (155)	,,	Civil hospital ,, ,,	6·1	+ 52·895	(1904-06 / 1924-26)	+ 52·890	− 0·005
156	,,	Metha Rām hall ,, ...	6·2	+ 53·278	1924-26	+ 53·253	− 0·025
154	,,	Training college ,, ...	6·3	+ 54 989	,,	+ 54 968	− 0·021
153	,,	(Type C) at Ganjo Takkar hill ...	7·6	+ 65·882	,,	+ 65·914	+ 0·032
210	,,	(Type B) at Kotri ...	0·0	0·000	1920-21	0·000	0·000
215 (35)	,,	Flotilla office ,, ...	0·8	+ 2·714	,,	+ 2·683	− 0·031
214 (38)	,,	Zero of Kotri gauge ...	1·1	+ 4·095	,,	+ 4·063	− 0·032
39	,,	Wooden water gauge ...	1·2	+ 3·505	(1904-06 / 1920-21)	+ 3·488	− 0·017
213	,,	District bungalow, Kotri ,,	1·3	+ 3·763	1920-21	+ 3·728	− 0·035

TABLE 5.— *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 in 1924-25-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1924-25-26	
			miles	*feet*		*feet*	*feet*
		Line 101 (Karāchi-Khānpur) at Karāchi					
109	35 P	S.B.M. at Napier barracks	0·0	0·000*	1909-10	0·000	0·000
108	,,	Monument at Trinity church	0·4	— 9·782*	(1859-60 1893-94)	— 9·789	— 0·007
3	,,	S. B. M. at ,, ,, ...	0·6	— 8·174	,,	— 8·168	+ 0·006
5	,,	E. entrance of Frère hall	0·9	— 8·399	,,	— 8·381	+ 0·018
99	,,	W. ,, ,, ...	1·0	— 10·446*	,,	— 10·443	+ 0·003
100	,,	Queen's statue ...	1·0	— 10·539*	,,	— 10·579	— 0·040
101	,,	Step to Queen's statue ...	1·1	— 12·785*	,,	— 12·786	— 0·003
103	,,	10 feet NE. of Clifton h.s.	3·6	+ 59·124*	,,	+ 59·129	+ 0·005
104	,,	Clifton h.s ...	3·6	+ 60·935*	,,	+ 60·939	+ 0·004
1	35 L	Reference B.M. of Manora T.O. ...	9·3	— 26·773	,,	— 26·789	— 0·016
109	35 P	S.B.M. at Napier barracks	0·0	0·000*	1909-10	0·000	0·000
110	,,	Roman Catholic church ...	0·5	+ 3·577*	(1859-60 1893-94)	+ 3·575	— 0·002
111	,,	(Type C) near Municipal reservoirs ...	1·7	+ 57·521*	,,	+ 57·578	+ 0·057
115	,,	,, at Towers of silence	3·9	+ 39·819*	,,	+ 39·823	+ 0·004
8	,,	Railway bridge No. 17 ..	8·5	+ 14·718	,,	+ 14·748	+ 0·030
		Line 101 (Karāchi-Khānpur) at Tatta					
72	35 P	Step of Travellers' Bw. ...	0·0	0·000	1889-90	0·000	0·000
68	,,	Verandah ,, ,, ...	0·0	+ 1·719	,,	+ 1·678	— 0·041
70	,,	Municipal office .	1·8	— 23·788	,,	— 23·743	+ 0·045
78	,,	Bridge over Kalriwāh .	5·4	— 21·743	,,	— 21·604	+ 0·139
80	,,	,, Khatianwāh...	7·2	— 28·584	,,	— 28·454	+ 0·130
81	,,	Bridge near Chilia ..	8·1	— 31·918	,,	— 31·759	+ 0·159
82	,,	Khuiwāro *dharmsāla* ...	9·0	— 22·431	,,	— 22·253	+ 0·178
92	,,	M.S. Tatta 8 ...	9·5	+ 9·825	1858-60	+ 9·955	+ 0·130
78	40 D	,, ,, 9 ...	10·5	+ 7·519	,,	+ 7·644	+ 0·125
77	,,	,, ,, 10 ...	11·4	— 3·458	,,	— 3·351	+ 0·107
		Line 151 (Rānīganj-Dinājpur) at Rānīganj†					
39	73 M	Rock ...	0·0	0·000	1914-17	0·000	0·000
38	,,	Wheel guard stone ...	0·6	+ 5·845	,,	+ 5·793	— 0·052
34	,,	Well ...	2·8	— 2·141	,,	— 2·119	+ 0·022
33	,,	Platform ...	3·1	+ 12·962	,,	+ 12·967	+ 0·005

* Determined from the levelling of 1909-10.

† This work was done in 1925-26.

TABLE 5.—*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 in 1925-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1925-26	
			miles	*feet*		*feet*	*feet*
Line 151 (Rānīganj-Dināj pur) at Rānīganj—(contd.)							
32	73 M	Bridge ...	3·5	+ 7·088	1914-17	+ 7·097	+ 0·009
31	,,	,, ...	3·8	+ 19·775	,,	+ 19·775	0·000
30	,,	,, ...	4·6	+ 21·138	,,	+ 21·057	− 0·081
29	,,	,, ...	4·9	+ 6·618	,,	+ 6·570	− 0·048
28	,,	Rock	5·5	+ 30·078	,,	+ 30·040	− 0·038
40	,,	Parapet	0·7	− 42·071	,,	− 42·059	+ 0·012
42	,,	Pier	1·8	− 58·862	,,	− 58·858	+ 0·004
Line 151 (Rānīganj-Dināj pur) at Godāgāri							
127	78 D	Interred ...	0·0	0·000	1920-21	0·000	0·000
126	,,	Verandah ...	0·3	+ 4·960	,,	+ 4·944	− 0·016
125	,,	Bridge ...	0·9	+ 4·727	,,	+ 4·717	− 0·010
128	,,	Culvert ...	1·0	+ 2·747	,,	+ 2·706	− 0·041
129	,,	Step ...	1·5	+ 5·321	,,	+ 5·334	+ 0·013
Line 151 (Rānīganj-Dināj pur) at Dināj pur							
78	78 C	Memorial ste ...	0·0	0·000	1899 1900	0·000	0·000
77	,,	Standard ...	0·2	− 2·884	,,	− 2·893	− 0·009
76	,,	Verandah ...	0·4	+ 2·331	,,	+ 2·335	+ 0·004
41	,,	Bridge ...	0·7	− 2·438	,,	− 2·413	+ 0·025
42	,,	Embedded ...	0·7	− 1·312	,,	− 1·310	+ 0·002
43	,,	Bridge ...	1·4	+ 8·294	,,	+ 8·324	+ 0·030
44	,,	,, ...	1·6	+ 8 203	,,	+ 8·223	+ 0·030
46	,,	Pier ...	3·7	− 9·234	,,	− 9·189	+ 0·045
Line 108 (Muttra-Cawnpore) at Muttra							
25	54 E	S.B.M. at Muttra ...	0·00	0·000	1905-06	0·000	0·000
40	,,	Sessions judge's court ...	0·03	+ 2·035	1912-13	+ 2·033	− 0·002
21	,,	At culvert ...	0·85	+ 5·680	,,	+ 5·682	+ 0·002
20	,,	At platform ...	1·43	+ 13·527	,,	+ 13·528	+ 0·001
19	,,	E.B M. at Ry. Stn. Cantt.	1·52	+ 13·735	,,	+ 13·692	− 0·043
42	,,	Water trough ...	2·14	+ 13·520	,,	+ 13·507	− 0·013
24	,,	Platform Jn. Ry. Stn. ...	2·88	+ 21·583	,,	+ 21·563	− 0·020

TABLE 5.—*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 in 1925-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1925-26	
			miles	*feet*		*feet*	*feet*
		Line 108 (Muttra-Cawnpore) at Agra					
124	54 I	S.B.M. at Agra ...	0·00	0·000	1915-16	0·000	0·000
125	,,	Culvert No. ½ ...	0·59	− 6·536	,,	− 6·439	+0·097
126	,,	Drain ...	1·07	+19·601	,,	+19·683	+0·082
127	,,	Post office ...	1·44	+26·015	,,	+26·100	+0·085
128	,,	Church ...	2·04	+27·130	,,	+27·213	+0·083
33	,,	Stone Bir ...	2·09	+24·973	,,	+25·057	+0·084
123	,,	Fort R.S. ...	0·10	+ 2·904	,,	+ 3·007	+0·103
122	,,	Jumna bridge ...	0·59	−11·671	,,	−11·535	+0·136
121	,,	,, ,, ...	0·78	−11·789	,,	−11·688	+0·101
120	,,	Culvert ...	0·94	− 9·557	,,	− 9·469	+0·088
119	,,	Jumna bridge ...	1·28	− 9·970	,,	− 9·866	+0·104
		Line 119 (Cawnpore-Aurangābād) at Cawnpore					
28	63 B	E.B.M. at Cawnpore ...	0·00	0·000	1915-16	0·000	0·000
162	,,	Edward memorial hall ...	0·27	+ 7·108	,,	+ 7·104	−0.004
163	,,	Queen Victoria statue ...	0·39	+ 7·655	,,	+ 7·657	+0·002
164	,,	Currency office ...	0·81	− 1·143	,,	− 1·140	+0·003
165	,,	Christ church ...	1·05	− 1·435	,,	− 1·431	+0·004
167	,,	Ex. Engineer's office ...	1·55	− 0·680	,,	− 0·667	+0·013
168	,,	S.B.M. Cawnpore ...	1·59	− 0·023	,,	− 0·010	+0·013
		Line 119 (Cawnpore-Aurangābād) at Allahābād					
51	63 G	S.B.M. at Allahābād ...	0·00	0·000	1920-21	0·000	0·000
160	,,	Culvert ...	3·14	− 7·660	,,	− 7·569	+0·091
159	,,	Kachahri ...	3·65	− 4·328	,,	− 4·278	+0·050
158	,,	,, ...	4·00	− 2·672	,,	− 2·625	+0·047
162	,,	Water trough ...	2·48	−28·136	,,	−28·076	+0·060
163	,,	Bridge ...	3·10	−37·897	,,	−37·833	+0·064
45	,,	Well ...	4·24	−32·566	,,	−32·484	+0·082
58	,,	Fort ...	4·42	−19·284	,,	−19·230	+0·054
57	,,	,, ...	4·47	−19·631	,,	−19·500	+0·131
56	,,	,, ...	4·52	−28·973	,,	−28·877	+0·096

TABLE 5.—*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 in 1925-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1925-26	
			miles	*feet*		*feet*	*feet*
		Line 119 (Cawnpore-Aurangābād) at Benares					
89	63 K	At well ...	0·00	0·000	1863-65	0·000	0·000
73	63 O	At Jn. of roads ...	0·26	−10·227	1914-15	−10·255	−0·028
74	,,	E.B.M. at Benares ...	1·13	−15·521	1916-17	−15·516	+0·005
94	63 K	At bridge ...	0·19	− 0·779	1863-64	− 0·788	−0·009
95	,,	At well ...	0·19	+ 3·184	,,	+ 3·205	+0·021
96	,,	S.B.M. at Benares ..	1·22	+ 3·032	,,	+ 3·025	−0·007
		Line 70 A (Benares-Burdwān) at Barākar					
49	73 I	G.T.S. ○ on bridge B.M. ...	0·0	0·000	1914-15 1916-17	0·000	0·000
50	,,	,, ,, ...	0·4	− 4·513	,,	− 4·515	−0·002
52	,,	+ on stone pillar ..	0·6	− 1·529	,,	− 1·535	−0·006
51	,,	E.B.M. at Barākar ...	0·7	− 7·546	,,	− 7·548	−0·002
54	,,	G.T.S. ○ on bridge B.M. ...	1·0	− 0·419	,,	− 0·427	−0·008
55	,,	G.T.S. ○ on rock B.M. ...	1·7	+35·261	,,	+35·192	−0·069
		Line 72 (Dildārnagar-Pīrpainti) at Patna					
20	72 G	S.B.M. at Bankipore ..	0·0	0·000	1914-15	0·000	0·000
22	,,	G.T.S. ○ on culvert B.M. ...	4·6	+6·980	,,	+6·968	−0·012
23	,,	G.T.S. ○ on bridge B.M. ...	6·7	+6·564	,,	+6·530	−0·034
		Line 70 A (Benares-Burdwān) at Mughal Sarai					
82	63 O	G.T.S. ○ on platform B.M. ..	0·0	0·000	1914-15 1916-17	0·000	0·000
81	,,	G.T.S. ○ on bridge B.M. ...	0·8	− 2·071	,,	− 2·070	+0·001
83	,,	E.B.M. at Alīnagar ...	1·8	− 5·513	,,	− 5·486	+0·027
84	,,	G.T.S. ○ on well B.M. ...	3·1	− 0·065	,,	− 0·073	−0·008

TABLE 5.—*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 in 1925-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1925-26	
			miles	*feet*		*feet*	*feet*
Line 70 (Allahābād-Dildārnagar) at Mirzāpur							
52	63 K	G.T.S. ⊙ B.M. on goods platform ...	0·0	0·000	1863-65 1905-06	0·000	0·000
57	„	S.T.C. ○ M.B. on culvert ...	1·7	+13·767	„	+14·620	+0·853
58	„	S.B.M. at Mirzāpur ...	1·7	+13·879	„	+13·848	−0·031
51	„	G.T.S. ⊕ B.M. on platform ...	0·1	− 0·571	„	− 0·552	+0·019
53	„	S.T.C. ○ M.B. „ culvert ...	0·8	− 4·297	„	− 4·297	0·000
54	„	„ „ „ ...	1·4	− 5·954	„	− 6·014	−0·060
55	„	G.T.S. ○ B.M. at *kachahri* ...	2·0	− 6·927	„	− 6·934	−0·007
Line 67A (Sultānpur-Allahābād) at Allahābād							
58	63 G	G.T. ● B.M. at Allahābād Fort ...	0·0	0·000	1920-21	0·000	0·000
57	„	G.T.S. ○ B.M. at Fort ...	0·0	− 0·347	1898-99	− 0·273	+0·074
45	„	G.T.S. ○ B.M. on well ...	0·2	−13·282	1920-21	−13·256	+0·026
163 (46)	„	1886 July + 18th „ bridge ...	1·3	−18·613	„	−18·594	+0·019
162 (47)	„	⊕ „ cattle trough ...	1·9	− 8·852	„	− 8·829	+0·023
158	„	G.T.S. ○ B.M. „ verandah ...	5·0	+16·612	„	+16·619	+0·007
159 (54)	„	G.T.S. ○ B.M. at *kachahri* ...	4·9	+14·956	„	+14·968	+0·012

TABLE 5.—*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 in 1925-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1925-26	
			miles	*feet*		*feet*	*feet*
		Line 67 A (Sultānpur-Allahābād) at Allahābād—(contd.)					
160 (53)	63 G	⊛ at Muir College ...	4·4	+11·624	1920-21	+11·673	+0·049
51	,,	S.B.M. at Scotch kirk ...	5·0	+19·284	,,	+19·261	−0·023
43	,,	G.T.S. ○ B.M. on plinth ...	4·7	+ 3·118	1898-99	+ 3·160	+0·042
41	,,	G.T.S. ○ B.M. on retaining wall ...	5·5	+ 0·589	,,	+ 0·485	−0·104
		Line 70 J (Barākar-Hazāribāgh Road) at Hazāribāgh Road					
109	72 H	Railway pillar at Hazāribāgh Road ...	0·0	0·000	1924-25	0·000	0·000
108	,,	G.T.S. ○ B.M. at S.M. office	0·1	0·018	,,	− 0·021	−0·003
107	,,	Ry. B.M. on bridge 155 ...	1·1	−36·438	,,	−36·470	−0·032
106	,,	G.T.S. ○ B.M. on bridge 154 ...	2·0	−21·771	,,	−21·796	−0·025
105	,,	Ry. B.M. on bridge 152 ...	2·7	−35·611	,,	−35·639	−0·028
104	,,	Ry. B.M. ,, ,, 150 ...	3·8	−61·177	,,	−61·210	−0·033
		Between Hazāribāgh Road and Gomoh ***Line 70 J (Barākar-Hazāribāgh Road) at Chichaki Railway Station***					
103	72 H	Ry. B.M. on bridge 146 ...	0·0	0·000	1924-25	0·000	0·000
102	,,	,, ,, ,, 145 ...	1·1	+17·055	,,	+17·060	+0·005
101	,,	,, ,, at Chichaki R.S.	1·6	+39·490	,,	+39·488	−0·002
100	,,	,, ,, on bridge 141 ...	1·7	+35·142	,,	+35·144	+0·002
99	,,	,, ,, ,, 138 ...	3·0	+58·824	,,	+58·803	−0·021
98	,,	,, ,, ,, 134 ...	4·2	+41·963	,,	+41·915	−0·048
97	,,	,, ,, ,, 132 ...	5·1	+15·826	,,	+15·795	−0·031
96	,,	,, ,, ,, 130 ...	6·1	− 9·267	,,	− 9·287	−0·020

TABLE 5.—*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 in 1925-26 than when originally levelled
No.	Degree sheet	Description		Original levelling	Date	Check levelling 1925-26	
			miles	*feet*		*feet*	*feet*
Line 70 J (Barākar-Hazāribāgh Road) at Chowdhriband and Isri Railway Stations							
94	72 H	Ry. B.M. at Chowdhriband R.S. ...	0·0	0·000	1924-25	0·000	0·000
5	72 L	,, ,, on bridge 123 ...	1·3	− 29·790	,,	− 29·790	0·000
4	,,	,, ,, ,, ,, 121 .	2·3	− 51·383	,,	− 51·390	−0·007
3	,,	,, ,, ,, ,, 117 ...	3·9	−108·136	,,	−108·156	−0·020
2	,,	G.T.S. ○ on bridge 114 .. B.M.	4·6	−101·314	,,	−101·341	−0·027
1	,,	Ry. B.M. ,, ,, 113 ...	5·3	−146·473	,,	−146·498	−0·025
308	73 I	G.T.S. B.○M. at Isri R.S.	6·3	−136·660	,,	−136·699	−0·039
309	,,	Ry. pillar ,, ,, .	6·4	−143·395	,,	−143·435	−0·040
307	,,	G.T.S. ○ on platform ... B.M.	7·5	−156·633	,,	−156·656	−0·023
306	,,	Ry. B.M. on bridge 105 ...	8·6	−173·484	,,	−173·510	−0·026
305	,,	,, ,, ,, 101 ...	10·0	−184·450	,,	−184·469	−0·019
Line 70 J (Barākar-Hazāribāgh Road) at Nimia Ghāt and Gomoh Railway Stations							
303	73 I	Ry. B.M. at Nimia Ghāt R.S. ...	0·0	0·000	1924-25	0·000	0·000
302	,,	,, on bridge 93 ..	0·1	− 2·692	,,	− 2·692	0·000
301	.	B.○M. ,, ,, 90 ...	0·6	−10·959	,,	−10·960	−0·001
300	.	Ry. B.M. ,, ,, 86 ...	1·6	−41·824	,,	−41·813	+0·011
299	,,	,, ,, ,, 82 ...	3·2	−81·266	,,	−81·249	+0·017
298	,,	,, ,, ,, 76 ...	4·3	−90·731	,,	−90·712	+0·019
297	,,	,, ,, ,, 71 ...	5·9	−99·098	,,	−99·055	+0·043
296	,,	,, at Gomoh ...	7·0	−74·439	,,	−74·380	+0·059

TABLE 6.—*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 1924-26 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1924-26 (unadjusted)	
			miles		*feet*	*feet*	*feet*
		Part of Line 101 (Karāchi-Kotri)					
109	35 P	S.B.M. at Napier barracks, Karāchi ...	0·0	1859-60	0·000	0·000	0·000
108	,,	Monument at Trinity church ..	0·4	1893-94 ,,	− 9·782	− 9·788	−0·006
3	,,	S. B. M. at ,, ...	0·6	,,	− 8·174	− 8·167	+0·007
5	,,	E. entrance of Frère hall	0·9	,,	− 8·399	− 8·380	+0·019
99	,,	W. entrance of ,, ,,	1·0	,,	−10·446	−10·442	+0·004
116 (100)	,,	Queen's statue ...	1·0	,,	−10·539	−10·578	−0·039
101	,,	Step to Queen's statue ...	1·1	,,	−12·783	−12·785	−0·002
103	,,	10 feet NE. of Clifton h.s.	3·6	,,	+59·124	+59·132	+0·008
104	,,	Clifton h.s. ...	3·6	,,	+60·935	+60·942	+0·007
1	35 L	Reference B.M. of Manora T.O. ..	9·3	,,	−26·773	−26·786	−0·013
110	35 P	Roman Catholic church	0·5	,,	+ 3·577	+ 3·575	−0·002
122 (111)	,,	(Type C) near Municipal reservoirs ...	1·7	,,	+57·521	+57·581	+0·060
115	,,	(Type C) at Towers of silence ...	3·9	,,	+39·819	+39·824	+0·005
8	,,	Railway bridge No. 17 ...	8·5	,,	+14·718	+14·748	+0·030
181 (72)	,,	Step of Makli hills, Travellers' bungalow, Tatta	62·2	1889-90	+28·487	+27·923	−0·564
186 (68)	,,	Makli hills T. bungalow	62·2	,,	+30·206	+29·601	−0·605
189 (70)	,,	Municipal office, Tatta ...	64·0	,,	+ 4·699	+ 4·178	−0·521
78	,,	Bridge over Kalriwāh ...	67·6	,,	+ 6·744	+ 6·318	−0·426
80	,,	,, ,, Khatianwāh	69·4	,,	− 0·097	− 0·531	−0·434
194 (81)	,,	Bridge near Chilia V. ...	70·3	,,	− 3·431	− 3·836	−0·405
195 (82)	,,	Khuiwāro *dharmsāla* ...	71·2	,,	+ 6·056	+ 5·669	−0·387
91 40 D ($\frac{92}{35P}$)	40 D	M. S. Tatta 8, Jerruck 24	71·7	1858-60	+38·312	+37·879	−0·433
78	,,	,, 9 ,, 23	72·7	,,	+36·006	+35·568	−0·438

TABLE 6.—*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 1924-26 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1924-26 (unadjusted)	
			miles		*feet*	*feet*	*feet*
		Part of Line 101 (Karāchi-Kotri)—(contd.)					
92 (77)	40 D	M.S. Tatta 10, Jerruck 22	73·6	1858-60	+ 25·029	+ 24·572	−0·457
494 (213)	40 C	District. Bungalow, Kotri	119·2	1920-21	+ 30·620	+ 30·338	−0·282
39 495 (214)	,,	Wooden water gauge, Kotri ...	119·4	1904-06 1920-21	+ 30·362	+ 30·098	−0·264
(38)	,,	Zero of Kotri gauge, Kotri (P.W.D. B.M.) ...	119·4	1920-21	+ 30·952	+ 30·673	−0·279
496 (215) (35)	,,	Stone near Flotilla office, Kotri (Ry. B.M.) ...	119·7	,,	+ 29·571	+ 29·293	−0·278
210	,,	(Type B) at Kotri ...	120·5	,,	+ 26·857	+ 26·610	−0·247
		Line 150 (Kotri-Barmer)					
210	40 C	(Type B) at Kotri ...	0·0	1920-21	0·000	0·000	0·000
211	,,	Ry. station ,, ...	0·3	,,	+ 6·542	+ 6·538	−0·004
34	,,	N.E. end of Indus bridge	1·6	1904-06	+ 27·447	+ 27·452	+0·005
413 (216)	,,	Thakur Dās' bungalow ...	2·4	(1924-26 / 1920-21)	+ 3·508	+ 3·478	−0·030
33	,,	Bridge No. 7	3·1	1904-06	+ 19·585	+ 19·566	−0·019
217	,,	Tapedār's training school, Hyderābād ...	3·6	1920-21	+ 4·483	+ 4·462	−0·021
161	,,	S.B.M. at ,, ...	4·7	1904-06	+ 33·718	+ 33·701	−0·017
414 (155)	,,	Civil hospital ,, ...	6·1	(1904-06 / 1924-26)	+ 52·895	+ 52·897	+0·002
156	,,	Metha Rām hall ,, .	6·2	1904-06	+ 53·278	+ 53·260	−0·018
154	,,	Clock tower of training college ..	6·3	,,	+ 54·989	+ 54·975	−0·014
152	,,	(Type C) at Ganjo Takkar hill	7·6	,,	+ 65·882	+ 65·922	+0·040
420 (27)	,,	Bridge No. 3 ...	8·2	(1924-26 / 1904-06)	+ 2·480	+ 2·825	+0·345
234	,,	Stone, P. W. D., S. D.O's office, Tando Alāhyār ...	31·8	1921-22	+ 0·200	+ 0·263	+0·063
233	,,	Plinth of do. ... (Irrigation B.M.)	31·8	,,	+ 0·165	+ 0·227	+0·062
417 (231)	,,	Bridge, over Ghalluwāh ... (Irrigation B.M.)	35·8	,,	+ 6·271	+ 6·251	−0·020
450 (230)	,,	,, near Goth Faiz Mohd.	38·4	,,	+ 1·376	+ 1·387	+0·011

TABLE 6.—*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 1924-26 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1924-26 (unadjusted)	
			miles		*feet*	*feet*	*feet*
		Line 150 (Kotri-Barmer)—(contd.)					
451 (229)	40 C	Bridge No. 29 ..	39·8	1921-22	+ 0·437	+ 0·447	+0·010
455 (228)	,,	Iron pipe at Bulghai R.S. (Irrigation B.M.)	43·0	,,	− 1·035	− 0·757	+0·278
459 (227)	,,	Bridge over Jāmrao canal at its 17th mile ...	44·4	,,	+ 5·279	+ 5·231	−0·048
463 (226)	,,	Iron pipe near M. S. 428 (Irrigation B.M.)	48·3	,,	− 8·015	− 7·702	+0·313
144 (28)	40 G	Executive Engineer's office, Mirpur Khās ...	51·0	,,	− 10·690	− 10·778	−0·088
145 (27)	,,	Civil hospital ,, ...	51·7	,,	− 10·579	− 10·669	−0·090
146 (26)	,,	Iron pipe at .. R.S. .. (Irrigation B.M.)	52·0	,,	− 9·396	− 9·498	−0·102
176 (57)	,,	P.W.D., I. Bw., Pithoro ..	74·9	1922-23	− 26·845	− 26·864	−0·019
23	40 O	(Type C) at Barmer ...	209·3	1921-25	+613·179	+613·698	+0·519
8	,,	Ry. rest house, ,, ...	210·6	,,	+572·111	+572·626	+0·515
9	,,	Ry. station, ...	210·8	,,	+573·179	+573·689	+0·510
10	,,	Sub Post office, ,, ...	210·9	,,	+571·809	+571·319	−0·490
11	,,	Water tank of Hem *sarāi*	211·2	,,	+592·716	+593·210	+0·494
12	,,	Verandah ,, ,,	211·2	,,	+594·906	+595·394	+0·488
13	,,	Seth Khanni Rām, Cham in Rām's house at Barmer	211·3	,,	+599·389	+599·898	+0·509
14	,,	Police station ,, ...	211·3	,,	+600·150	+600·656	+0·506
15	,,	Civil dispensary ,,	211·4	,,	+603·885	+604·385	+0·500
16	,,	Step of Court house	211·4	,,	+606·829	+607·352	+0·523
17	,,	Vestibule of ,, ,,	211·5	,,	+606·727	+607·251	+0·524
18	,,	A.V. School ,, ...	211·5	,,	+607·588	+608·117	+0·529
19	,,	Seth Rām Lāl's house	211·5	,,	+613·546	+614·076	+0·530
20	,,	Ganesh Mal's house	211·6	,,	+617·882	+618·401	+0·519
21	,,	Seth Brij Lāl's	211·6	,,	+614·623	+615·138	+0·515
22	,,	Bālkishan's *sarāi*	211·7	,,	+610·267	+610·786	+0·519
		Parts of branch lines 77M (Berhampore-Tinpāhār) and 77L (Chākdāha-Jayrāmpur).					
30	78 D	Interred ...	0·0	1920-21	0·000	0·000	0·000
29	,,	Step ...	0·0	,,	+ 3·482	+ 3·481	−0·001
41	,,	Verandah ...	0·1	,,	+ 5·222	+ 5·188	−0·034
43	,,	Step ...	0·5	,,	+ 2·867	+ 2·875	+0·008
42	,,	..	0·7	,,	+ 3·750	+ 3·702	−0·048

TABLE 6.—*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 1924-26 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1924-26 (unadjusted)	
			miles		*feet*	*feet*	*feet*
		Parts of branch lines 77 M (Berhampore-Tinpāhār) and 77 L (Chākdāha-Jayrāmpur)—(contd.)					
44	78 D	Bridge ...	0·7	1920-21	− 2·718	− 2·716	+0·002
46	,,	Kerb ...	7·0	,,	+ 8·271	+ 8·311	+0·040
47	,,	Stairs ...	8·1	,,	+ 8·544	+ 8·584	+0·040
48	,,	Steps ..	8·5	,,	+ 9·497	+ 9·546	+0·049
49	,,	Interred ...	9·4	,,	+ 4·873	+ 4·919	+0·046
50	,,	Step ...	9·5	,,	+11·151	+11·185	+0·034
51	,,	,,	9·6	,,	+ 9·460	+ 9·505	+0·045
60	,,	Pillar ...	14·2	,,	+12·004	+12·023	+0·019
59	,,	Interred ...	14·3	,,	+ 7·259	+ 7·290	+0·031
53	,,	Step ...	15·3	,,	+ 6·359	+ 6·387	+0·028
52	,,	,, ...	15·7	,,	+ 8·489	+ 8·496	+0·007
54	,,	Interred ...	21·8	,,	+ 8·423	+ 8·475	+0·052
55	,,	Verandah ...	22·4	,,	+18·861	+18·911	+0·050
56	,,	Culvert ...	24·4	,,	+ 6·292	+ 6·371	+0·079
57	,,	Verandah ...	29·4	,,	+15·668	+15·740	+0·072
58	,,	Interred ...	29·5	,,	+11·001	+11·097	+0·096
		Line 108 (Muttra-Cawnpore)*					
25	54 E	S.B.M. at Muttra ...	0 0	1905-06 1912-13	0·000	0·000	0·000
42	54 I	○ at Firozābād T.S. ...	63·1	1915-16	− 3·318	− 3·531	−0·213
60	,,	At Ghiror ...	90·6	,,	− 33·505	− 33·824	−0·319
59	,,	do. bridge ...	90·7	,,	− 26·562	− 26·761	−0·199
17	54 M	At Singhpur ...	103·6	,,	− 42·975	− 43·246	−0·271
16	,,	At Mainpuri ...	109·0	,,	− 49·811	− 50·079	−0·268
9	54 N	At Kalsān T.S. ...	150·3	,,	− 59·629	− 59·845	−0·216
11	,,	At Bahosi ...	148·1	,,	− 86·764	− 87·099	−0·335
19	,,	At Aimah ...	161 6	,,	−102·776	−102·899	−0·123
32	,,	At Kakwan ...	174·7	,,	−111·073	−111·165	−0·092
40	63 B	At Jagatpur ...	186·8	,,	−126·042	−126·157	−0·115
51	,,	At Barasirohi ...	198·5	,,	−136·796	−136·835	−0·039
161	,,	At M.S. 130 ...	201·9	,,	−141·741	−141·801	−0·060
174	,,	At bridge ...	202·4	,,	−144·915	−144·959	−0·044
160	,,	do. ...	202·7	,,	−139·135	−139·172	−0·037
158	,,	At culvert ...	207·3	,,	−145·022	−145·035	−0·013
169	,,	At parapet ..	207·8	,,	−144·263	−144·268	−0·005

* This work was done in 1925-26.

TABLE 6.—*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 1925-26 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1925-26 (unadjusted)	
			miles		*feet*	*feet*	*feet*
		Part of line 119 (Cawnpore-Benares)					
168	63 B	S.B.M. Cawnpore ...	0·0	1917-18	0·000	0·000	0·000
150	,,	At Naronha's exchange ...	1·7	,,	+ 5·291	+ 5·259	−0·032
151	,,	At well ...	3·6	,,	+ 6·260	+ 6·244	−0·016
152	,,	At culvert ...	4·2	,,	+ 9·041	+ 9·030	−0·011
157	,,	do. ...	12·1	,,	− 4·457	− 4·397	+0·060
70	,,	At Mahārājpur ...	13·0	,,	− 7·321	− 7·254	+0·067
83	,,	At Anng ...	27·2	,,	− 15·298	− 15·162	+0·136
93	,,	At Malwa ...	41·6	,,	− 22·055	− 21·947	+0·108
3	63 C	At Fatehpur ...	51·1	1915-16	− 42·469	− 42·304	+0·165
62	63 G	At Arrahpur ...	66·2	,,	− 55·490	− 55·279	+0·211
70	,,	At Katohun ...	76·2	,,	− 61·037	− 60·844	+0·193
71	,,	At Majilgāon T.S. ...	76·8	,,	− 12·154	− 11·969	+0·185
80	,,	At Saini ...	87·5	,,	− 62·311	− 62·163	+0·148
81	,,	At Karra T.S. ...	91·3	,,	− 24·872	− 24·729	+0·143
92	,,	At Kokhraj ...	100·7	,,	− 79·331	− 79·189	+0·142
102	,,	At Muktipurwa ...	113·7	,,	− 91·778	− 91·682	+0·096
124	,,	At Jhūsī ...	121·0	,,	−107·080	−107·080	0·000
23	63 K	At Bāripur T.S. ...	162·6	1863-65	− 86·823	− 87·868	−1·045
		Branch line 70 A (Benares-Burdwān)					
82	63 O	G.T.S. ○ on waiting shed B.M. ...	0·0	1914-15 1916-17	0·000	0·000	0·000
83	,,	E.B.M. at Alīnagar ...	1·8	,,	− 5·513	− 5·486	+0·027
89	,,	,, ,, Chandauli ...	9·6	,,	−15·756	−15·749	+0·007
99	,,	G.T.S ○ on well B.M. ...	14·4	,,	−10·272	−10·329	−0·057
100	,,	E.B.M. at Said Rāja ...	14·9	,,	−15·813	−15·878	−0·065
101	,,	G.T.S. ○ on culvert B.M. ...	18·3	,,	−17·414	−17·544	−0·130
102	,,	G.T.S. ○ ,, bridge B.M. ...	19·2	,,	−10·600	−10·694	−0·094
118	,,	G.T.S. ○ ,, culvert B.M. ...	42·7	,,	+ 7·380	+ 7·141	−0·239

TABLE 6.—*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 1925-26 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1925-26 (unadjusted)	
			miles		*feet*	*feet*	*feet*
Branch line 70 A (Benares-Burdwān)—(contd.)							
121	63 O	G.T.S. ○ on well B M. ...	48·3	1914-15 1916-17	+ 26·863	+ 26·522	−0·341
122	,,	E.B.M. at Kudra ...	49·0	,,	+ 22·005	+ 21·659	−0·346
9	72 D	G.T.S. ○ on bridge B.M. ...	69·2	,,	+103·465	+102·975	−0·490
8	,,	Type C at Karwāndia ...	69·6	,,	+218·390	+217·905	−0·485
Branch line 70 K (Barākar-Allahābād)							
54	73 I	G.T.S. ○ at bridge B.M. ...	0·00	1914-15 1916-17	0·000	0·000	0·000
97 (9)	72 G	Top mark stone of Phulwaria T.S. ...	198·63	1863 64	−186·796	−184·924	+1·872

TABLE 7.—*List of triangulation stations connected by spirit-levelling, season 1925-26*

Name of station	Height above mean sea level			Difference	Remarks
	New spirit-levelling	Old spirit-levelling	Triangu-lation	Trian-Lev.	
	feet	*feet*	*feet*	*feet*	
Eastern Sind Meridional Series					
Hatodan H.S. Lat. 25° 29′ 34″·72 Long. 69 49 45·34	297·250	...	299	+2	Upper mark stone
Bhitala H.S. Lat. 25° 38′ 47″·02 Long. 70 8 44·81	360·303	...	362	+2	Upper mark stone
Great Indus Series					
Karāchi Observatory S. Lat. 24° 49′ 50″·25 Long. 67 1 35·13	35·422	...	35	0	Top surface mark stone
Calcutta Meridional Series					
Madhabpur (Madabpur) T.S. Lat. 24° 29′ 46″·39 Long. 88 19 36·06	113·523	...	116	+2	Ground level mark stone
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	...	149	+21	Upper mark stone
Kisnāpur T.S. Lat. 25° 2′ 34″·83 Long. 88 28 27·64	101·879	...	117	+15	Ground level mark stone

TABLE 7.—*List of triangulation stations connected by spirit-levelling, season 1925-26—(concld.)*

Name of station	Height above mean sea level			Difference	Remarks
	New spirit-levelling	Old spirit-levelling	Triangu-lation	Trian-Lev.	
	feet	*feet*	*feet*	*feet*	
Gurwāni Meridional Series					
Meja H.S. Lat. 25° 7′ 10″·16 Long. 82 6 53·38	497·959	...	498·00	0	Upper mark stone

TABLE 8.—*Results of comparison of staves with standard steel tape No. 3, Lines 150 & 101, season 1925-26*

Date of comparison	Length of staff—10 feet		Remarks
	No. of staff		
	20A	20B	
	feet	*feet*	
20-10-25 ...	−0·0035	−0·0032	Clear
26-10-25 ...	−0·0031	−0·0026	,,
1-11-25 ...	−0·0034	−0·0028	,,
12-11-25 ...	−0·0034	−0·0029	,,
21-11-25 ...	−0·0043	−0·0036	,,
27-11-25 ...	−0·0050	−0·0046	,,
4-12-25 ...	−0·0056	−0·0050	,,
10-12-25 ...	−0·0056	−0·0048	,,
17-12-25 ...	−0·0047	−0·0039	,,
26-12-25 ...	−0·0053	−0·0048	,,
3- 1-26 ...	−0·0054	−0·0047	,,
11- 1-26 ...	−0·0055	−0·0048	,,
18- 1-26 ...	−0·0049	−0·0041	,,
23- 1-26 ...	−0·0038	−0·0036	,,
3- 2-26 ...	−0·0033	−0·0030	,,
13- 2-26 ...	−0·0036	−0·0027	Clear & cool breeze
23- 2-26 ...	−0·0031	−0·0021	Clear
27- 2-26 ...	−0·0013	−0·0008	,,
9- 3-26 ...	−0·0016	−0·0011	Cloudy
18- 3-26 ...	−0·0008	−0·0004	Clear
30- 3-26 ...	−0·0018	−0·0008	,,

TABLE 8.—*Results of comparison of staves with standard steel tape No. 7, Lines 151 and 121A, season 1925-26—(contd.)*

Date of comparison	Length of staff—10 feet		Remarks
	No. of staff		
	16A	16B	
	feet	*feet*	
21-10-25 ...	−0·0027	+0·0014	Light scattered clouds
28-10-25 ...	−0·0021	+0·0016	Clear
4-11-25 ..	−0·0028	+0·0018	Light scattered clouds
12-11-25 ..	−0·0027	+0·0018	Scattered clouds
19-11-25 ...	−0·0032	+0·0014	Clear
27-11-25 ...	−0·0027	+0·0013	Light scattered clouds and cool breeze
5-12-25 ...	−0·0033	+0·0014	do.
14-12-25 ...	−0·0039	+0·0009	Clear
23-12-25 ...	−0·0030	+0·0012	Scattered clouds
1-1-26 ...	−0·0033	+0·0007	Clear
9-1-26 ...	−0·0031	+0·0011	Scattered clouds and cool breeze
18-1-26 ...	−0·0037	+0·0010	Clear
28-1-26 ...	−0·0052	−0·0004	do.
6-2-26 ...	−0·0045	+0·0003	Light scattered clouds
14-2-26 ...	−0·0054	−0·0002	Clear
22-2-26 ...	−0·0073	−0·0012	Clear and cool breeze
3-3-26 ...	−0·0069	−0·0017	Light scattered clouds and cool breeze
12-3-26 ...	−0·0052	−0·0003	do.
21-3-26 ...	−0·0047	+0·0002	Clear and cool breeze
27-3-26 ...	−0·0060	+0·0003	do.
5-4-26 ...	−0·0069	−0·0015	Light scattered clouds
10-4-26 ...	−0·0070	−0·0011	do. & cool breeze
18-4-26 ...	−0·0079	−0·0014	Clear and cool breeze
25-4-26 ...	−0·0067	−0·0013	do.
2-5-26 ...	−0·0073	−0·0008	Light scattered clouds and cool breeze
10-5-26 ...	−0·0066	−0·0006	do.

TABLE 8.—*Results of comparison of staves with standard steel tape No. 4, Lines 108 & 119, season 1925-26—(contd.)*

Date of comparison	Length of staff—10 feet		Remarks
	No. of staff		
	19A	19B	
	feet	*feet*	
17-10-25 ...	−0·0000	−0·0003	Clear & high breeze
25-10-25 ...	−0·0012	−0·0009	Light clouds and cool breeze
6-11-25 ..	−0·0011	−0·0010	Light scattered clouds & cool breeze
16-11-25 ...	−0·0011	−0·0010	Clear
26-11-25 ...	−0·0014	−0·0009	Clear & breeze
6-12-25 ...	−0·0019	−0·0014	Clear
17-12-25 ...	−0·0008	−0·0010	Light scattered clouds & cool breeze
26-12-25 ...	−0·0010	−0·0004	Clear & cool breeze
7- 1-26 ...	−0·0024	−0·0013	Scattered clouds & cool breeze
17- 1-26 ...	−0·0020	−0·0012	Clear & very high wind
27- 1-26 ...	−0·0013	−0·0010	Light clouds & breeze
7- 2-26 ...	−0·0011	−0·0009	Clear & high breeze
17- 2-26 ...	−0·0017	−0·0014	Clear & breeze
26- 2-26 ...	−0·0015	−0·0011	Clear
9- 3-26 ...	−0·0017	−0·0011	Clear & high breeze
21- 3-26 ...	−0·0008	−0·0001	do.
31- 3-26 ...	−0·0026	−0·0024	Clear & breeze
10- 4-26 ...	−0·0021	−0·0022	Light scattered clouds & breeze
21- 4-26 ...	−0·0038	−0·0030	Light scattered clouds
2- 5-26 ...	−0·0042	−0·0033	do.

TABLE 8.—*Results of comparison of staves with 10-foot standard steel tape No. 10 in Bengal and Bihār & Orissa, season 1925-26—(concld.)*

Date of comparison	Length of staff—10 feet				Remarks
	No. of staff				
	01	03	23A	23B	
	feet	*feet*	*feet*	*feet*	
2-11-25 ...	+0·0001	+0·0016	−0·0008	−0·0008	Clear
9-11-25 ...	+0·0007	+0·0016	−0·0008	−0·0006	do.
17-11-25 ...	−0·0003	−0·0013	−0·0012	−0·0004	Clear & cool breeze
24-11-25	−0·0001	−0·0013	−0·0011	−0·0011	Clear
2-12-25 ...	−0·0007	+0·0001	−0·0020	−0·0013	do.
11-12-25 ..	−0·0012	+0·0002	−0·0025	−0·0021	Scattered clouds
18-12-25 ..	−0·0003	+0·0013	−0·0001	−0·0004	Light scattered clouds
28-12-25 ..	−0·0013	+0·0008	−0·0023	−0·0016	Clear
8- 1-26 ..	−0·0008	+0·0016	−0·0008	−0·0009	do.
19- 1-26 ...	−0·0007	+0·0011	−0·0013	−0·0008	Clear & cool breeze
31- 1-26 ...	−0·0014	+0·0009	−0·0028	−0·0017	Light clouds
9- 2-26 ...	−0·0013	+0·0005	−0·0020	−0·0019	Clear
18- 2-26	−0·0021	−0·0012	−0·0035	−0·0026	Clear & cool breeze
2- 3-26 ...	−0·0007	−0·0012	−0·0038	−0·0030	Clear
11- 3-26 ..	−·0015	−0·0005	−0·0025	−0·0025	Scattered clouds
20- 3-26 ..	−0·0025	−0·0009	−0·0035	−0·0030	Clear
30- 3-26 .	−0·0026	−0·0012	−0·0035	−0·0033	do.
9- 4-26 ...	−0·0025	−0·0012	−0·0034	−0·0030	do.
20- 4-26 .	−0·0022	−0·0021	−0·0046	−0·0038	Scattered clouds
26- 4-26 ..	−0·0055	−0·0038	−0·0061	−0·0058	Clear

Chapter IV

TREE BENCH-MARKS

BY LT.-COLONEL V. R. COTTER, I.A.

1. *Origin of the investigation.*—The success attending the use of tree bench-marks in Canada led to an investigation of the behaviour of such bench-marks in India. It is not often that levelling is carried through wild or forest areas and, generally speaking, there are numerous permanent structures on which bench-marks can be inscribed, as well as suitable sites for the erection and preservation of specially constructed marks. There are occasions, however, when levelling has to be carried through a forest area, in order to connect up two settled areas of land. Such a condition will possibly be encountered when the Indian levelling net is connected with the Burma levelling of precision, should this projected work be undertaken.

Apart, however, from the above special case, it is desirable to know what reliance can be placed on a tree bench-mark. The life of a tree bench-mark is limited by the life of the tree, but it is open to question whether the permanence of an inscribed bench-mark, on (say) a culvert, is as great as that of a tree bench-mark. This investigation will also help us to arrive at some conclusion on the question of including tree bench-marks among the category of the regular bench-marks picked up in primary or other levelling operations.

In Canada lines of levels are very frequently run through forest areas, and the conclusions arrived at by the Canadian Survey Department are outlined in the appendix to this chapter. No figures are given in support of their contention that heights of the bench-marks do not alter, but it may be taken that they are satisfied that such is the case.

2. *Experiments at Dehra Dūn.*—The following is an outline of the experiments carried out at Dehra Dūn.

(i) Three types of the bench-marks were made:—

Class A. Zinc plate fixed on heart wood of tree.
„ B. „ „ „ on wood below bark of tree.
„ C. „ „ „ on bark of tree.

(ii) 11 such bench-marks have survived the 12 years (one tree having been cut down), and these 11 bench-marks have been connected at intervals with the standard bench-mark in the Geodetic Branch Office grounds.

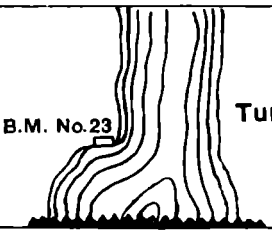
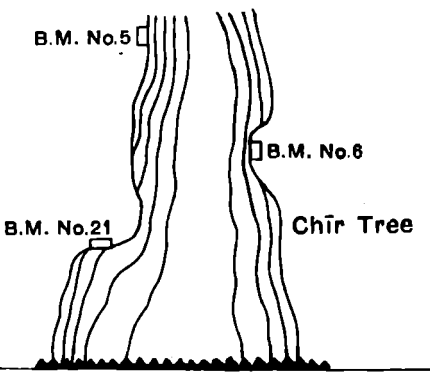
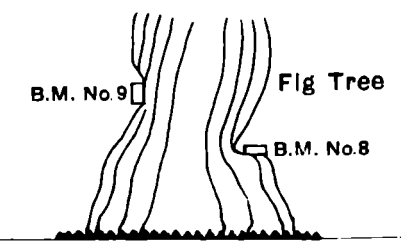
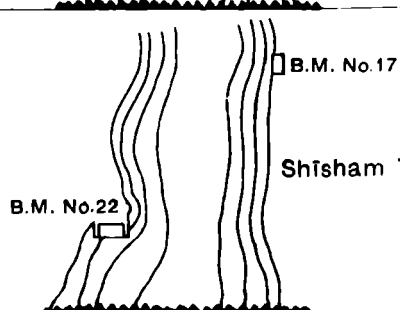
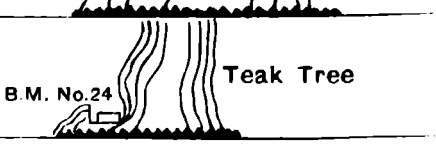
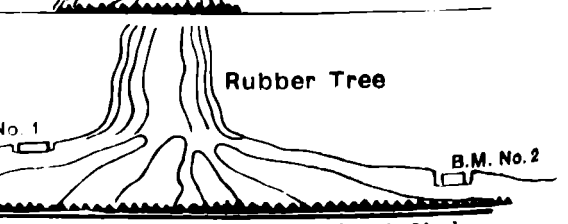
(iii) Heights were determined both before and after the monsoon as shown in Table 1.

TABLE 1.—*Probable error of a single observation at any time*

B.M. No.	Class *	δL = Height of each individual determination − Mean height										P. e. of a height taken at any time $\doteqdot \cdot 6745 \sqrt{\frac{\Sigma(\delta L)^2}{(N-1)}}$
		April 1914	October 1914	April 1915	October 1915	May 1916	October 1916	April 1917	November 1917	May 1923	May 1926	
		feet	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
23	A	+·004	·000	·000	+·002	·000	+·003	+·001	+·001	−·005	−·007	±·002
21	A	−·008	+·001	−·003	−·004	+·002	+·006	+·001	−·002	+·007	−·004	±·003
8	A	−·008	−·001	−·006	−·006	·000	+·003	+·001	−·001	+·014	+·002	±·004
2	B	−·014	+·013	+·006	·000	−·005	+·006	−·002	+·003	−·002	−·010	±·005
24	A	+·004	+·010	+·012	·000	−·001	+·005	·000	−·007	−·002	−·021	±·006
22	A	−·014	−·005	−·003	−·007	−·003	+·004	−·002	−·006	+·022	+·009	±·007
6	B	+·010	−·013	+·001	−·007	−·008	+·011	+·017	+·007	−·011	−·005	±·007
1	B	−·014	+·009	+·001	+·001	+·007	+·025	−·001	−·003	−·003	−·018	±·008
9	B	+·026	−·011	+·017	−·005	+·007	+·003	+·001	−·007	−·016	−·015	±·009
17	C	+·002	+·014	−·032	−·005	+·003	+·002	+·012	+·015	+·002	−·009	±·009
5	C	+·005	−·004	+·063	−·013	−·017	−·009	−·017	−·003	+·005	−·008	±·016

*A. Bench-mark on heart wood of tree.
B. Bark removed—Bench-mark on wood below bark of tree.
C. Bench-mark on bark of tree.

TREE BENCH-MARKS

B.M. No.	Class	Condition after 12 years	Rough Sketch of position
23	A	The bark had to be cut considerably to allow the staff to be put up.	
5	C	On bark of a *Chīr* tree.	
6	B	The bark had grown over and had to be removed while connecting.	
21	A	The bark had not grown over the bench-mark.	
9	B	The wood was covered up to some extent.	
8	A	The bark had not grown over.	
17	C	On bark of a *Shīsham* tree.	
22	A	The bark had to be cut partially to erect the staff. The heart of the wood on which the plate rests, appears to have dried up and is being eaten up.	
24	A	The B.M. was largely covered with bark, which had to be removed when connecting	
2	B	The bark had not grown over the bench-mark.	
1	B	The bark had not grown over the bench-mark.	

Classification :—A. On heart wood of tree. B. Bark removed—Bench-Mark on wood below bark. C. On bark of tree.

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3. *Results.*—Plate III shows the class of each bench-mark and its position on the tree.

Table 1 shows the difference between the mean height over the whole period, and each individual determination. This table also shows the probable error of any one height value, derived from the discordances between the several measures made during the epoch. The bench-marks are here shown in order of value of these probable errors, and it at once becomes evident that class A, cut on heart wood, is the most reliable. Of the first 6 in order of reliability, 5 are of this class. We can thus at once discard classes B and C as inferior, and confine ourselves to a discussion of class A.

From Table 1 we get the information in Table 2 column 4. We have allowed ± ·002 ft. as the probable error of observation, and by combining this with the probable error in column 3, we obtain a figure showing us the probable accidental error due to movements of the tree itself. The average accidental error due to tree movements of bench-marks of class A appears to be ± ·004 ft.

TABLE 2.—*Probable accidental error due to movements of tree bench-marks*

1	2	3	4
B.M. No.	Class *	Probable error of a height taken at any time = M	Probable accidental error due to movements of tree B.M. = $\sqrt{M^2-(\cdot 002)^2}$
		feet	*feet*
23	A	± ·002	·000
21	A	± ·003	± ·002
8	A	± ·004	± ·003
24	A	± ·006	± ·006
22	A	± ·007	± ·007
		Average p. e. = ± 0·005	Average = ± ·004

* A. Bench-mark on heart wood of tree.

4. *Utilisation in primary levelling.*—It is evident that, having added such a large accidental error to the result of our determination of height, we shall have to reject the values given by a single tree bench-mark for high precision purposes. The average probable error of determination of height of the 5 bench-marks of class A, noted in Table 2 column 3, is ± ·005 ft. This is practically all accidental error. Presuming we wish

to fix the level of one reference point from the group of these 5 bench-marks in Table 2, the probable error of the resulting height of the reference point would be approximately $\pm \frac{\cdot 005}{\sqrt{5}}$ *i.e.* $\pm \cdot 002$ ft. This would meet the requirements of high precision levelling, but any less number than 5 would not suffice.

It is difficult to see, therefore, how tree bench-marks can be included in high precision lines in the ordinary way. Mathematically perhaps, the fore and back levelling of lines containing tree bench-marks could be adjusted by assigning a lower weight to each tree bench-mark, which would amount practically to neglecting its value in the matter of discordances between fore and back levelling. But this is not a practical solution. The only practical solution would be to have groups of 5 or 6 tree bench-marks connected as small branch lines to the main line, so that the error would not come into the main line of levelling. The latter method might quite possibly be of use in crossing a jungle area. Suppose there were rest houses or clearings of sorts every 10 or 15 miles, and that the leveller could not find any kind of permanent mark in the intervals, then a series of branch lines, with groups of 5 or 6 tree bench-marks on each, might be the only method of retaining good values for canal or road engineers for the future. A group of 5 or 6 in good condition would also suffice for high precision levelling operations, as having a value equivalent to that of one ordinary bench-mark.

5. *Utilisation in secondary and tertiary levelling.*—For double levelling of precision, now termed secondary levelling, we would expect a single determination of height to have a probable error of $\pm \cdot 004$ ft. We can, therefore, say that a group of two tree bench-marks would have the same weight as one ordinary permanent bench-mark.

For irrigation purposes, where a discrepancy between levellers of ·007 feet per shot is allowed, we could treat the value of a tree bench-mark as having the same weight as one ordinary permanent bench-mark.

6. *Summary.*—The conclusions are :—

(*i*) Tree bench-marks should always be placed on heart wood.

(*ii*) Tree bench-marks should not be included in lines of levelling of high precision, but groups of 5 or more may be included in branch lines.

(*iii*) For levelling of secondary precision a tree bench-mark is sufficiently good, when the levelling is for irrigation purposes.

APPENDIX

Copy of a letter from the Surveyor General of Canada on the subject of tree bench-marks

Department of the Interior,
Topographical Surveys Branch,
Ottawa, Canada, *May 8th 1914.*

Sir,

With reference to your letter of March 23rd, File No. 423/83 Gen., inquiring about our experience of tree bench-marks in levelling operations, I have the honour to inform you that many thousands of such bench-marks have been established in the course of our levelling in the unsettled or partly settled parts of the country, but our experience of them does not extend back over many years.

Tree bench-marks are not used on lines of precise levels unless for purposes of temporary reference. They are used during the survey of the initial meridians and base lines, which run through the outlying portions of the country in advance of all other surveys. During the survey of these lines, transportation is very difficult. On such surveys it is practically out of the question to establish really permanent bench-marks, except on the rare occasions when they can be established on rock.

The objections to tree bench-marks are not based on questions of constancy of elevation, but on the want of permanence of the tree itself. The mark cannot last longer than the tree. Conditions governing the life of a tree are so entirely different, not only in different countries but in different parts of the same country, that this matter can only be decided locally. A tree's life is bounded, not only by its natural span, but by the tree's local liability to catastrophy from wind, lightning or forest fire and, further, by the chance of its being cut down for any of many possible reasons.

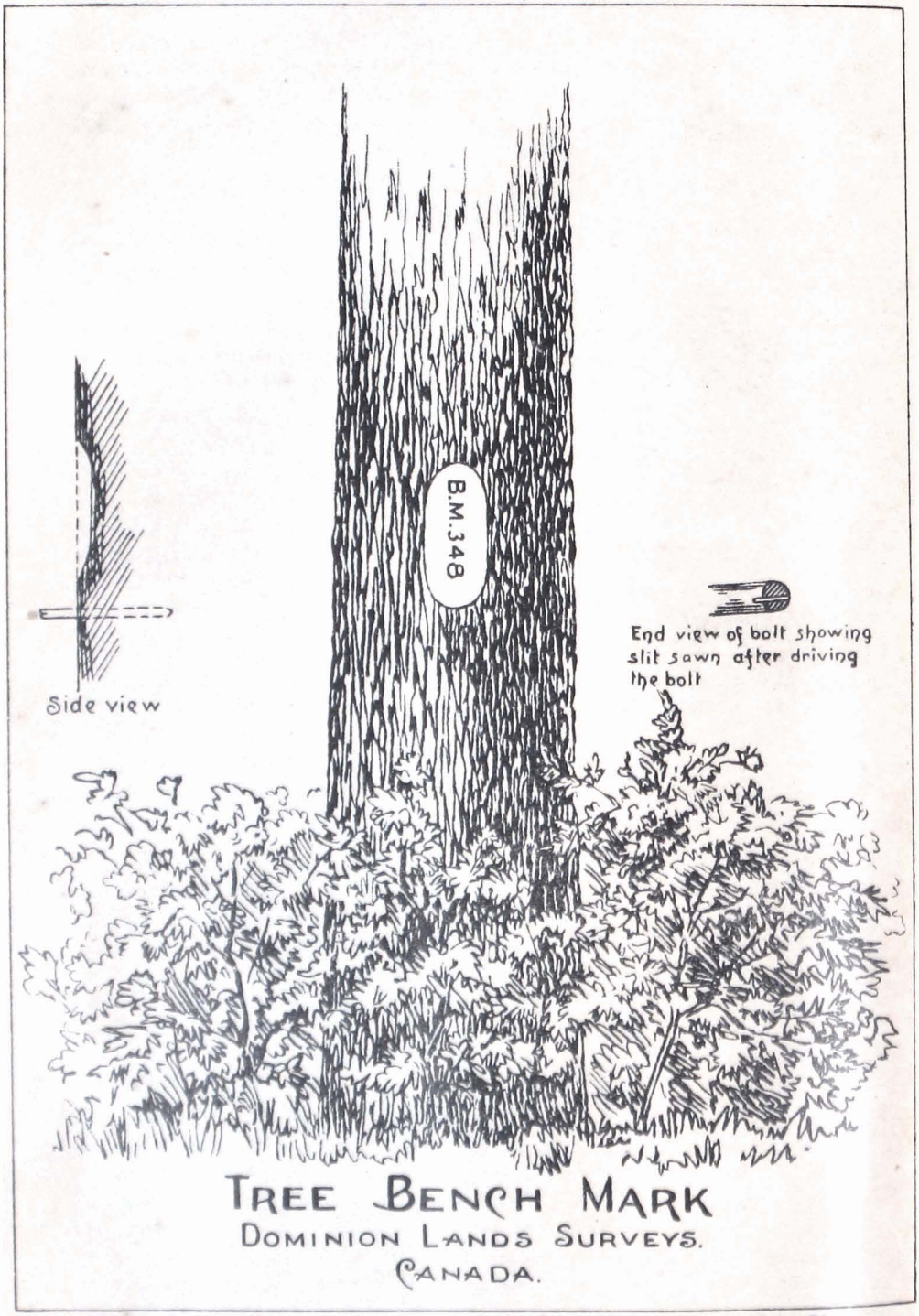
There are no serious objections in the way of constancy of elevation, in so far as regards trees in Canada, in all of which the annual addition of wood takes place on the outside, while the inner bulk of the tree does not change from year to year. Conditions may be different with such trees as palms, whose method of growth is different. As regards trees in Canada, the following opinion was obtained from the Chief of the Tree Planting Division, Forestry Branch, some time ago:—"In reply to the enquiry as to whether a nail driven horizontally into a tree about 3 feet from the ground would remain at the same elevation, the answer is that there would be no change, no matter how long the tree lived. The spot would not become any farther away from the ground. The only chance of a slight difference of elevation would, perhaps, be in the case of a very small tree becoming slightly heaved up by frost; or if soil might be washed in and cause a very slight rise".

In regard to the actual mark placed on the tree, probably this would be governed by different conditions in India and in Canada. In north-western Canada, where tree bench-marks are being established, the

trees are not large, seldom over 18 inches in diameter, and the trunk does not expand as it nears the ground, but goes almost straight down. In order to hold a levelling staff on the mark, either a large piece must be cut out of the side of the tree, seriously handicapping its life and its ability to resist wind, or else a bolt or spike must be driven into the side of the trunk. Where questions of transportation allow its use, the best bolt is one sufficiently long to be driven in firmly and to project enough to hold the staff, and sufficiently strong to withstand wilful disturbance. A bolt nine inches long, of circular section, half an inch diameter, driven so as to leave 3 inches projecting, has been used here. The cutting edge is chisel-shaped as it drives more easily than a point, and the bolt is of a round section, as it is difficult to drive a square section and keep one side horizontal. There is no difficulty in driving the bolt, so that its length keeps horizontal. The bolt is generally placed about 3 feet above the ground, but this is chiefly to facilitate finding it if there should be snow on the ground. So far iron bolts have been used, but some form of bronze would have advantages. No hole is made for an iron bolt, it is simply driven in, but in the case of a bronze bolt, a hole of slightly smaller diameter could first be drilled in the tree and the bolt be then driven in firmly. There is no head on the bolt, the place where the rod is to be held is marked with a file on top of the bolt, after it has been driven, or better, a horizontal slit is sawn across the head of the bolt and the staff is held on a chisel inserted in the slit and levelled by a hand level. The tree is identified by having a "blaze" cut out of its bark immediately above the spike. The letters "B.M." and the No. are cut on the wood, where the tree is blazed, and its position is recorded with reference to the nearest survey post, in addition to recording the kind of tree and its diameter. The reference to a survey mark is easy, as the survey line is one long straight line across country with an iron post established every half mile. The reference consists of the exact distance measured along the line from the nearest post, together with the rectangular offset to the tree.

Where transportation is more serious, the size of the spike has to be diminished, but the smallest used is a six-inch nail, projecting one inch. Tree bench-marks are established every half mile or one mile according to the trees available. There are generally plenty of trees, but rock is always used in preference, if it occurs, forest fires being a serious danger to trees in Canada. Even if the tree is only scorched, it soon blows over.

In regard to any mark left on a tree, it is, of course, to be recollected that, no matter what its nature may be, it is liable, to be covered up by the tree's growth. In Canada a tree will expand radially on every side about one inch in twelve years between twenty and a hundred years of age, and there are few trees which have escaped fire so long as to have passed the stage of their rapid growth before they are used as bench-marks. A "blaze" cut on the tree down to the wood below will remain indefinitely but in the case of some kinds of trees here it becomes entirely covered up by overgrowth from the edges in about twenty-five years. After this occurs, the wood forming over the blaze



TREE BENCH MARK

DOMINION LANDS SURVEYS.

CANADA.

Reg. 285. M.D.D. 1927.

Helio. S.I.O. Dehra Dün.
To accompany Geodetic Report Vol. II.

will expand outwardly, and only a slight discolouration of the bark will show that the tree was ever marked. A spike will similarly gradually become embedded in the tree, so that it may happen that a staff can no longer be held on it. This, however, is of small consequence, so long as the tree can be identified. Even if the spike is entirely covered, it can be found by cutting and its elevation taken by using a steel rule and a hand level in conjunction with the staff. Of course conditions of growth are different in different countries, and with different ages of the same tree.

Where a tree's trunk expands greatly, as it nears the ground, a mark could be made by driving a large copper nail vertically into a root, after cutting away the bark, but this does not appear to have any advantage over a mark in the trunk, except that it may be less liable to wilful disturbance. There is more chance of movement in a root, either from wind or if the root is forced to expand, as a whole, upwards. This would almost certainly occur with a root some distance from the base of the tree.

Tree bench-marks should be placed on healthy growing trees and the less interference with the tree the better. If it can be identified without any cutting of the bark, it is better to make no mark. An iron bolt should do no harm, though possibly other metal might be injurious to a small tree. Bench-marks should not be placed on stumps, no matter how firm they may appear. They quickly become unstable. Provided the tree is healthy and a little on the youthful side of its prime, the larger the tree the better.

In Canada, owing to the great depth to which frost penetrates, with the result that no artificial mark with its foundation less than six feet below the surface is really safe from slow upheaval, the question of an artificial mark, more permanent than a tree, for use on the outlying surveys is probably a more difficult one than in India. It is this trouble from frost which makes recourse to trees, even though small ones, necessary in these surveys.

While our tree bench-marks are so situated that there has been no opportunity to test their constancy with any permanent bench-mark of the class established on our precise levels, yet there seems no reason to consider that their constancy is limited, except by the question of the existence of the trees themselves. If conditions are such that the tree will last a long time, there should be no objection to such bench-marks. The difficulty here is that the average life of a tree is comparatively short.

A sketch of a tree bench-mark is enclosed.

I have the honour to be,
Sir,
Your most obedient servant,
Sd/ E.
Surveyor General.

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

*** Publications detailed in Parts III, IV and V are also obtainable from the Officer in charge, Map Record and Issue Office, 13, Wood Street, Calcutta.**

Sterling Prices of Publications.—The prices to be charged for Survey of India publications in sterling equivalents in English money have been worked out under the rules given in letter No. A-401 dated the 17th January 1924 from the Under Secretary to the Government of India, Department of Industries and Labour, Delhi, to the Secretary to the High Commissioner for India, General Department, 42 Grosvenor Gardens, London, S.W. 1. These sterling prices are subject to fluctuation with the exchange rate and will be revised from time to time. The prices at the current rate of exchange are:—

Price in Indian money		English equivalent	
Rupees	Annas	Shilling	Pence
0	2	0	3
0	4	0	5
0	8	0	10
0	12	1	3
1	0	1	9
1	2	1	11
1	8	2	6
1	12	3	0
2	0	3	6
2	8	4	6
3	0	5	3
3	8	6	0
4	0	6	9
4	4	7	3
4	8	7	6
5	0	8	3
5	8	9	0
6	0	9	9
6	8	10	6
7	0	11	6
7	8	12	0
8	0	13	6
8	8	14	6
9	0	15	0
9	8	16	0
10	0	16	6
10	8	17	6
12	0	19	6

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 100.

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 in	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	Re. 1-0-0
48	(Goa) ...	12–16	72–76	1912	Rs. 2-0-0
49	(Calicut) ...	8–12	72–76	1911	Re. 1-0-0
52	(Leh) ..	32–36	76–80	1912	Re. 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 in	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	Re. 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	Re. 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:—

(i) A single volume styled "**The Major Series**" comprising **Tide-Tables** for the following ports:—

Tide-Tables—(*Continued*).

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 Rāmeswaram) *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, F.R.S. &c, 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. and his assistants, 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.

Vol. I—**The Standards of Measure and the Base-Lines,** also an Introductory Account of the early operations of the Survey, during the period of 1800-1830. Dehra Dūn, 1870. (Out of print).

G.T.S. Volumes—(*Continued*).

Appendix No. 1. Description of the method of comparing, and the apparatus employed.

Appendix No. 2. Comparisons of the Lengths of the 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 **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—**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).

Vol. IV—**North-West Quadrilateral**—The Principal Triangulation, the Great Arc—Section 24°-30°, Rahūn, Gurhāgarh and Jogi-Tīla Meridional Series, and the Sutlej Series. Dehra Dūn, 1876. *Price Rs. 10-8.*

G.T.S. Volumes—*(Continued).*

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**, details of, by Captains J. P. Basevi and W. J. Heaviside, and of 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 Bīdar 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, Hurīlāong Meridional, Chendwār Meridional, North Parasnāth Meridional, North Malūncha Meridional, Calcutta Meridional, East Calcutta Longitudinal, Brahmaputra Meridional, Eastern Frontier—Section 23°-26°, and Assam Longitudinal. Dehra Dūn, 1882. *Price Rs. 10-8.*

G.T.S. Volumes—(*Continued*).

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.*

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.

G.T.S. Volumes—(*Concluded*).

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, Bahak, 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.*

Memoirs.—(*Continued*).

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 1922-25 Rs. 2, from 1925 Re. 1.* (*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.

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).

Annual Reports &c.—(*Continued*).

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.*

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.*

Annual Reports &c.—(*Continued*).

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. 3.*

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.*

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.*

Annual Reports &c.—(*Concluded*)

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 Research. 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 Dūn, 1928. *Price Rs. 6.*

Vol. II—**1925-26**—Computations and Research. Tidal work. Time and Magnetic observations. Preparations for the International Longitude Project. Triangulation. Levelling. Investigation of the behaviour of tree bench-marks in India.
Dehra Dūn, 1928. *Price Rs. 3.*

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).**

In 1904 the various orders issued since 1878 were reclassified as follows :—

	Number to date.
1.—**Government of India Orders.**—	834
2.—**Circular Orders (Administrative).**—	420
3.—**Circular Orders (Professional).**—	196

4.—**Departmental Orders.** (appointments, promotions, transfers, etc.)

Departmental Orders.—(*Continued*).

These are numbered serially and had reached the above numbers by September 1928. *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 31st March 1928, Calcutta, 1928. *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. **Catalogue** of Maps of Cantonments and Military stations. Dehra Dūn, 1927. *Price As. 8.*
5. **Catalogue** of Books in the headquarters Library, Calcutta, 1901. (Out of print).
6. **Catalogue** of Scientific Books and Subjects in the Library of the Trigonometrical Survey Office. Dehra Dūn, 1908. *Price Re. 1.*
7. Classified **Catalogue** of the Trigonometrical Survey Library. Dehra Dūn, 1921. *Gratis.*

* For Departmental use only.

Catologues and Lists.—(*Continued*).

8. **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.*

9. **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.*

10. **List of the publications of the Survey of India** (published annually) Dehra Dūn. *Gratis.*

11. **Price List of Mathematical Instrument Office.** Corrected up to 1st September 1927, Calcutta, 1928. *Gratis.*

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, 1928. *Price Rs. 3.*

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. Calcutta, 1928. *Price As. 8.*

13. Star Charts for latitude 20° N., by Colonel J.R. Hobday, I.S.C. Calcutta, 1904. *Price Rs. 1-8.*

* For Departmental use only.

Tables and Star Charts.—(*Continued*).

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 1927, recorded at the Survey Office Observatory, Dehra Dūn, 1928.

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, Dehra Dūn, 1928. *Price Re. 1.*

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.*

„ VI—Fair Mapping.—reprinted with additions and revised, 1922. *Price Re. 1.*

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Survey of India Hand-Books.—(*Continued*).

Chapter VII—Trans-frontier Reconnaissance. Third Edition, 1924. *Price As. 8.*

„ „ —Addendum, 1928. *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.

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Notes and Instructions.—(*Continued*).

8. *Instructions for taking Magnetic Observations, by J. Eccles, M.A. Dehra Dūn, 1896. (Out of print).

9. **Rectangular Co-ordinates.**—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).

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* For Departmental use only.

Unclassified Papers.—(*Continued*).

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).

3. *Report on the Observations of the Total Solar Eclipse of 6th April, 1875 at Camorta, Nicobar Islands, by Captain 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, R.E. Calcutta, 1898. (Out of print).

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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).

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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.

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(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.

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(6) Theory of electric projectors. (Translated from the French).

No. 8—**Magnetic**—Experiments made to determine the temperature coefficients of Watson's Magnetographs, by Captain H. A. Denholm Fraser, R. E. Calcutta, 1905. *Price Re. 1.*

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A large number of forms for the record and reduction of Survey Operations are stocked at Dehra Dūn.

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§ Obtainable from Charles Robert Johnson at the offices of "Engineering", 35 and 36, Bedford Street Strand, London, W. C.

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46. †The Stereographic Survey of the Shaksgam, by Major K. Mason, M.C., R.E. (Geographical Journal, October 1927).

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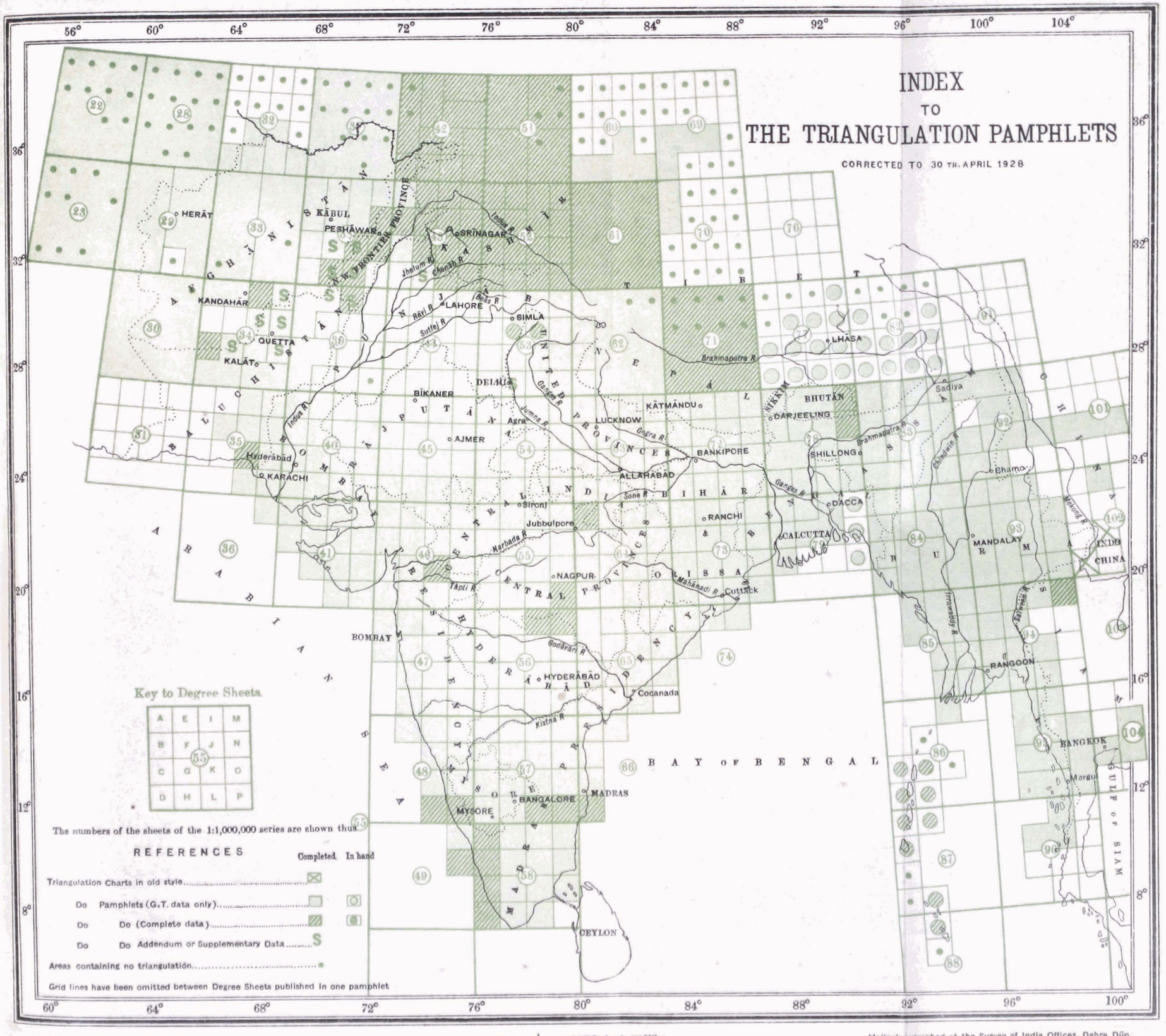

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To accompany Geodetic Report Vol. II

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60° 64° 68° 72° 76° 80° 84° 88° 92° 96° 100° 104°

32° 28° 24° 20° 16° 12° 8°

Rakaposhi 25550 · Kunjut 25460 · K 2 28250 · Gasherbrum 26470 · Nanga Parbat 26620 · 24370 · 24490 · 21140 · 20410 · 22210 · 20720 · Kamet 25447 · 22028 · Nanda Devī 25645 · Gurla Mandhata 25355 · 22650 · 23399 · Dhaulāgiri 26795 · XXX 26658 · Gosainthān 26291 · Mount Everest 29002 · Makalu 27790 · 23180 · 24740 · 23930 · Kinchinjunga 28146 · 23460 · Namcha Barwa 25445

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REFERENCES

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Miles 100 0 100 200 300 400 Miles

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REFERENCES

- Longitude stations
- Longitude arcs
- Wireless Longitude station (Departmental)
- Wireless Longitude stations (Non Departmental)
- Chronometer Longitude stations (do)

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Miles 100 0 100 200 300 400 Miles

60° 64° 68° 72° 76° 80° 84° 88° 92° 96° 100° 104°

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32° 28° 24° 20° 16° 12° 8°

Rakaposhi 25560 · Kunjut 25460 · K 2 28250 · Gasherbrum 26470 · Nanga Parbat 26620 · 24370 · 24690

HERÁT · KÁBUL · PESHÁWAR · Murree · SRINAGAR · Rāwalpindi · INDUS R. · 21140 · 20410 · 22210

NASRATĀBĀD · KANDAHĀR · Dera Ismail Khān · LAHORE · Amritsar · QUETTA · Multān · Sutlej R. · Ludhiāna · 20720 · Kamet 25447 · 22028 · Nanda Devī 25645 · Gurla Mandhata 25355 · Dehra Dūn · 22650 · 23399 · INDUS R.

Jacobābād · Sukkur · Bikaner · DELHI · Jumna R. · Ganges R. · Meerut · Dhaulāgiri 26795 · XXX 26658 · Gosainthān 26291 · Mount Everest 29002 · Makalu 27790 · BRAHMAPUTRA R. · LHĀSA · 23160 · Namcha Barwa 25445 · 23180 · 24740 · 23930 · Kinchinjunga 28146

Darjeeling · Jalpaiguri · Dibrugarh · BRAHMAPUTRA R.

Hyderābād · KARĀCHI · Jodhpur · AGRA · Lucknow · Fyzābād · Cawnpore · Gwalior · Benares · GANGES R. · Allahābād · Shillong · Myitkyinā

Mouths of the Indus · Deesa · Kalianpur · Dacca · Chindwin R.

Navānar · Hanstal · Okha Point · Ahmadābād · Jubbulpore · CALCUTTA · Kidderpore · Diamond Harbour · Chittagong · MANDALAY · SALWEEN R. · MEKONG R.

Porbandar · Bhaunagar · Narbadā R. · Mhow · Dublat (Sagar I.) · Mouths of the Ganges · Salin

Port Albert Victor · NĀGPUR · Hinganghāt · Sambalpur · False Point · Akyab · IRRAWADDY R. · Prome

Prince's Dock · BOMBAY · Apollo Bandar · Poona · Godāvari R. · Bolārum · Secunderābād · Waltair · Vizagapatam · RANGOON · Moulmein · Elephant Pt. · Pilakat Creek · Amherst · Bassein · Diamond I. · Mouths of the Irrawaddy

B A Y O F B E N G A L

Belgaum · Bāgalkot · Raichūr · Kistna R. · Cocanāda · BANGKOK

Marmagao · Kārwār · Bellary · Bangalore · MADRAS · Mangalore · ANDAMAN ISLANDS · Port Blair · Mergui

Calicut · Beypore · Negapatam · Trichinopoly · Cochin · Madura · NICOBAR ISLANDS

Pāmban Pass · Tuticorin · Trincomalee · Minicoy · Nagarkoil · Cape Comorin · Colombo · CEYLON · Galle

A R A B I A N S E A

REFERENCES

Pendulum stations (Departmental) ..... ●

Additions since 1925 ..... Nil

Pendulum stations (Non Departmental) ..... ■

Dr. Vening Meinesz submarine stations (Non Departmental) ..... *

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