SURVEY OF INDIA

GEODETIC REPORT

1937

PUBLISHED BY ORDER OF
BRIGADIER C. G. LEWIS, O.B.E.,
SURVEYOR GENERAL OF INDIA

PRINTED AT THE GEODETIC BRANCH OFFICE,
SURVEY OF INDIA, DEHRA DÛN, 1938.

Price Three Rupees, or Five Shillings and Three Pence

CONTENTS

CHAPTER IV

Magnetic Survey in Bihar

CHAPTER V

Computing Office and Tidal Section

COMPUTING OFFICE

TIDAL SECTION

CHAPTER VI

Observatories

Charts and Plates

INTRODUCTION

1. In 1936–37 triangulation, levelling, gravity and magnetic detachments have taken the field, and the usual routine work has been carried out at headquarters.

2. *Triangulation.*—(Chapter I). The primary triangulation through the Nāga Hills between Assam and Burma has been completed and satisfactory connection made with the Mandalay Meridional and Upper Irrawaddy series. Escorts were again necessary at the beginning of the season, although on a smaller scale than in the previous year, and detachments were provided by both the Assam Rifles and the Burma Military Police. No opposition was encountered in the Nāga Hills, and south of the Hukawng Valley no escorts were necessary.

3. *Levelling.*—(Chapter II). Two detachments worked on the high precision level net, in Central India, and added the equivalent of 463 miles of single levelling.

A third detachment carried double (precise) levelling from Sukkur on the Indus, through Sibi and Quetta to Chaman, relevelling a line observed 25 years before in order to detect changes of level resulting from the Mach and Quetta earthquakes of 1931 and 1935. Considerable changes were found, and an elevation of over one foot in about 10 miles at the lower end of the Bolān Pass appears to be real. At Mach and Quetta changes were small, but two rock-cut bench-marks near Quetta have undergone a relative movement of nearly one foot.

4. *Gravity.*—(Chapter III). Gravity was observed at 47 stations in or near Assam and Bengal, including stations in the Nāga and Lushai Hills. The pendulums showed a material change of length at the end of the season, but the resulting uncertainty has since been cleared up by repeating six of the stations at the beginning of the 1937–38 season.

5. *Magnetic.*—(Chapter IV). Magnetic observations were made in Bihār in continuation of work done in 1934–35. Force and dip were observed at 200 stations spaced along two north-south lines crossing the epicentral area of the 1934 earthquake. Very considerable changes occur in the intensity and direction of the magnetic force, but it has not been found possible to relate them to any probable irregularities in the shape of the alluvial trough.

6. *Computing Office.*—(Chapter V). The readjustment of the triangulation of India and Burma has been completed to the point at which revised co-ordinates of any astronomical station can be immediately obtained if required for scientific purposes. It is not at present intended to make the readjustment the basis of current surveys, and the calculation and publication of a fresh set of self-consistent latitudes, longitudes, sides and azimuths is not being undertaken.

The work on the Lambert grid which has occupied the computing office for many years, is now very nearly complete, and an effort is being made to overtake arrears in the computation of Hayford corrections at astronomical stations.

7. *Headquarters routine.*—(Chapters V & VI). The tidal predictions, and the time, magnetic, seismographical and meteorological observations at Dehra Dūn have been carried on as usual. The routine methods of tidal prediction have been overhauled and the strength of the section reduced. The standard bars and invar measuring wires have been compared and have retained their lengths satisfactorily. The hope of obtaining new seismographs at Dehra Dūn has been postponed for a year.

An observatory has been opened at Agra for latitude variation observations.

8. *Future programmes.* In 1937–38 primary triangulation is being undertaken near Gauhāti to improve the connection between the 1934–35 work and the old Assam Longitudinal series. In 1938–39 it is proposed to start a primary traverse running eastwards from near Calcutta to replace the old East Calcutta Longitudinal series. The later is considered unreliable, and the new traverse will constitute the main link between the triangulation of Assam and Burma and that of the rest of India.

Gravity is being observed in Baluchistān and the Punjab, and a line of astronomical latitudes and longitudes is being observed southwards from Mandalay to carry the geoidal section towards Malaya. Gravity observations in Burma have been postponed until 1938–39 and 1939–40. Three detachments are working on the high precision level net.

9. *Non-departmental publications.*—Brigadier Couchman made "The Progress of Geodesy in India" the subject of his Presidential address to the National Institute of Sciences at the 1937 meeting at Hyderābād.

Lt.-Colonel Glennie has continued his examination of the relation between gravity anomalies and geological structure in the United States,[1] and also in the Gangetic and Cuddapah areas in India.[2]

Mr. Gulatee has discussed the relation between gravity and deviations of the vertical in mountainous areas.[3]

DEHRA DŪN,
December 1937.

C. M. THOMPSON,
Colonel,
Director of the Geodetic Branch.

REFERENCES

[1] *Journal of Geology*, Vol. XLIV No. 7.
[2] *Beitrage zur angewandten Geophysik* Vol. 6, No. 3.
[3] *Proceedings of the Indian Academy of Sciences* Vol. V, No. 3.

PERSONNEL* OF THE GEODETIC BRANCH, 1936–37.

Director, Geodetic Branch

COLONEL C. M. THOMPSON.

OFFICE OF THE DIRECTOR, GEODETIC BRANCH

Ministerial Service

Head Assistant

Mr. Dalip Singh Bagdwal

Assistants

Mr. Krishna Lal Sharma

25 Clerks.

COMPUTING AND TIDAL PARTY

(RECORDS AND RESEARCH)

Class I Service

Major G. Bomford, R.E., in charge,

Mr. B. L. Gulatee, M.A. (Cantab.), Mathematical Adviser.

OBSERVATORY SECTION

Class II Service

Rai Sahib Raj Bahadur Mathur, B.A., to 4th June 1937.

Magnetic Observer

Mr. Shyam Narain, B.SC., to 31st October 1936 and from 1st May 1937.

Upper Subordinates Service

Mr. J. B. Mathur

Lower Subordinate Service

5 Computers.

TIDAL SECTION

Upper Subordinate Service

Mr. H. C. Banerjea, B.A. (Tidal Assistant)

TIDAL SECTION—(*concld*).

Upper Subordinate Service

Mr. A. N. Ramanathan, M.A. (on probation) from 10th August 1937.

Lower Subordinate Service

6 Computers.

COMPUTING SECTION

Upper Subordinate Service

Mr. M. Chatterji (Head Computer).

Mr. H. C. Deva, B.A.

Mr. C. B. Madan, B.A.

Lower Subordinate Service

11 Computers.

1 Librarian.

CHART SECTION

(ADMINISTERED BY O.C. 2 D.O.)

Lower Subordinate Service

5 Draftsmen.

No. 14 PARTY (GEOPHYSICAL)

Class I Service

Captain D. R. Crone, R.E., in charge, to 4th June 1937.

Class II Service

Rai Sahib Raj Bahadur Mathur, B.A., in charge from 5th June 1937.

Mr. M. N. A. Hashmie, B.A.

Mr. Shyam Narain B.SC., from 1st November 1936 to 30th April 1937.

Lower Subordinate Service

3 Computers.

---

* Excluding No. 1 Party, 20 Detachment, No. 2 Drawing and Forest Map Offices, Printing, Photo-Zinco, Stores and Workshop Sections, and Training School.

No. 15 PARTY (TRIANGULATION AND LEVELLING)

Class I Service

Capt. C. A. K. Wilson, R.E., in charge.

Class II Service

Mr. N. N. Chuckerbutty, L.C.E.,

Upper Subordinate Service

Mr. A. A. S. Matlub Ahmad.

Mr. Mohd. Faizul Hasan.

Mr. Mohd. Zafar Ali Qureshi.

Mr. G. S. Sidhu, from 29th August 1937.

Mr. Sheikh Alauddin, from 5th September 1937.

Lower Subordinate Service

1 Surveyor, 7 Computers, 1 Leveller and 2 Clerks.

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. 109 ... ... Mean Square M = ± 1·50

No.	Name of Series	Seasons	±*m*	±M
1	South Pārasnāth Mer. ...	1831-39	3·308	3·26
2	Budhon Meridional ...	1833-43	2·242	2·46
3	*Amūa Meridional* ...	1834-38	1·647	1·88
4	*Rangīr Meridional* ...	1834-64	1·643	1·79
5	*Calcutta Longitudinal* ...	1834-69	0·369	0·32
6	*Great Arc Meridional, Section 24°-30°* ...	1835-66	0·708	0·71
7	*Bombay Longitudinal* ...	1837-63	0·844	0·74
8	*Great Arc Meridional, Section 18°-24°* ...	1838-41	0·567	0·59
9	*Great Arc Meridional, Section 8°-18°* ...	1840-74	0·390	0·36
10	*Singi Meridional* ...	1842-62	1·187	1·14
11	*South Konkan Coast* ...	1842-67	2·176	1·93
12	*Karāra Meridional* ...	1843-45	1·507	1·81
13	*North Malūncha Mer.* ...	1844-46	1·266	1·42
14	*Chendwār Meridional* ...	1844-69	0·841	1·06
15	*Gora Meridional* ...	1845-47	0·973	1·21
16	*Calcutta Meridional* ...	1845-48	1·173	1·99
17	South Malūncha Mer. ...	1845-53	1·606	1·97
18	*Khānpisura Meridional* ...	1845-62	1·227	1·07
19	*Gurwāni Meridional* ...	1846-47	1·165	1·55
20	*North-East Lon.* ...	1846-55	0·446	0·65
21	*Hurīlāong Meridional* ...	1848-52	1·502	1·92
22	*North-West Himālaya* ...	1848-53	0·641	0·55
23	*Gurhāgarh Meridional* ...	1848-62	0·914	1·21
24	*East Coast* ...	1848-63	0·608	0·70
25	*Karāchi Longitudinal* ...	1849-53	0·558	0·60
26	*Abu Meridional* ...	1851-52	0·617	0·68
27	*North Pārasnāth Mer.* ...	1851-52	0·895	1·25
28	*Kāthiāwār Meridional* ...	1852-56	0·990	1·11
29	*Gujarāt Longitudinal* ...	1852-62	0·859	1·12
30	Kāthiāwār Lon. ...	1853	1·481	1·34
31	Sābarmati ...	1853-54	1·348	2·84
32	*Great Indus* ...	1853-61	0·359	0·43
33	*Rahūn Meridional* ...	1853-63	0·327	0·37
34	*Assam Longitudinal* ...	1854-60	0·579	0·71
35	*Cutch Coast* ...	1855-58	0·986	1·27
36	Kashmīr Principal ...	1855-60	0·884	0·86
37	*Jogi-Tila Meridional* ...	1855-63	0·481	0·59
38	Sambalpur Lon. ...	1856-57	0·806	0·87
39	(Cutch) Coast Line ...	1856-60	0·975	1·47
40	Kāthiāwār Meridional No. 1 ...	1858-59	0·930	1·51
41	Kāthiāwār Meridional No. 2 ...	1859-60	1·247	1·75
42	Kāthiāwār Meridional No. 3 ...	1859-60	0·969	1·48
43	*Bīdar Longitudinal* ...	1859-72	0·311	0·30
44	*Eastern Frontier or Shillong Meridional* ...	1860-64	0·409	0·49
45	*Sutlej* ...	1861-63	0·346	0·53
46	*Madras Mer. and Coast* ...	1861-68	0·426	0·40
47	Kāthiāwār Meridional No. 4 ...	1863-64	1·154	1·73
48	*East Calcutta Lon.* ...	1863 69	0·379	0·57
49	*Mangalore Meridional* ...	1863-73	0·440	0·45
50	Kumaun and Garhwāl ...	1864-65	1·742	1·50
51	Nāsik ...	1864-65	2·033	3·12
52	Burma Coast (*See* 106) ...	1864-82	0·380	0·39
53	*Jubbulpore Meridional* ...	1865-67	0·340	0·31
54	*Madras Longitudinal* ...	1865-80	0·384	0·37
55	Assam Valley Triangulation * ...	1867-78	1·690	2·65
56	*Brahmaputra Mer.* ...	1868-74	0·564	0·70
57	Coimbatore No. 1 ...	1869-71	1·547	2·07
58	*Bilāspur Meridional* ...	1869-73	0·302	0·38
59	Cuddapah ...	1871-72	0·826	0·96
60	Hyderābād ...	1871-72	1·405	1·56
61	Malabar Coast ...	1871,74,80	1·532	1·82
62	Jodhpur Meridional ...	1873-76	0·291	0·32
63	*South East Coast* ...	1875-79	0·522	0·66
64	Eastern Sind Mer. ...	1876-81	0·244	0·30
65	Siam Branch Triangulation ...	1878-81	3·711	4·34
66	Mandalay Meridional ...	1889-95	0·418	0·35
67	Mong Hsat † ...	1891-93	3·054	3·01
68	Manipur Longitudinal ...	1894-99	0·453	0·36
69	Makrān Longitudinal ...	1895-97	0·285	0·26
70	Mandalay Lon. ...	1899-1909	1·696	1·96
	...	1899-1902 / 1915-1916	0·750	0·81
71	Manipur Mer. ...			
72	Great Salween (*See* 105)	1900-11	0·404	0·32
73	Kidarkanta ...	1902-03	1·323	1·62
74	Kalāt Longitudinal ...	1904-08	0·365	0·25
75	Baluchistān Triangulation ...	1908-09	1·348	1·08
76	North Baluchistān ...	1908-10	0·221	0·17
77	Gilgit ...	1909-11	0·443	0·37
78	Khāsi Hills ...	1909-11	2·038	3·01
80	Upper Irrawaddy ...	1909-11	0·596	0·49
81	Jaintia Hills ...	1910-11	0·986	1·86
82	Bhir ...	1911-12	0·794	0·94
83	Rānchi ...	1911-12	1·840	2·34
84	Villupuram ...	1911-12	1·184	1·78
85	Sambalpur Meridional ...	1911-14	0·250	0·21
86	Indo-Russian Connection	1912-13	2·790	3·92
87	Khandwa ...	1912-13	0·999	1·24
88	Ashta ...	1913-15	1·048	1·33
89	Buldāna ...	1913-14	0·304	0·42
90	Naldrug ...	1913-14	1·465	1·85
91	Nāga Hills ...	1913-14	0·913	0·96
92	Middle Godāvari ...	1914-15	0·913	1·06
93	Kohima ...	1914-15	1·094	1·39
94	Cāchār ...	1914-15	1·077	1·66
95	Bombay Island ...	1911-14	...	...
96	Madura ...	1916-17	1·148	1·53
97	Bāgalkot ...	1916-17	0·701	0·83
99	Rangoon ...	1925-27	1·246	1·25
100	Kurram ...	1927-28	2·096	2·26
101	Peshāwar ...	1927-28	1·267	0·96
102	North Wazīristān ...	1927-28	1·895	2·47
103	Chittagong ...	1928-30	0·453	0·45
104	Mong Hsat ...	1929-31	0·441	0·38
105	Great Salween ...	1929-31	0·682	0·58
106	Burma Coast ...	1930-31	0·205	0·19
107	Dālbandin ...	1931-32	0·472	0·32
108	Assam Longitudinal	1934-36	0·426	0·47
109	Mandalay Meridional	1936-37	0·422	0·35

* Replaced by 108.

† Replaced by 104.

Mer. = Meridional

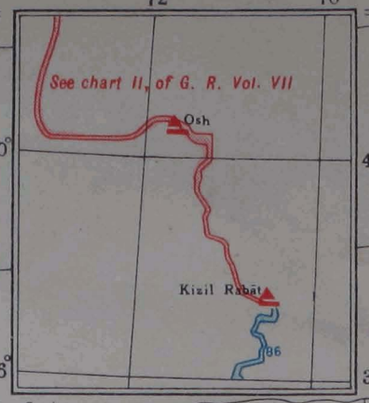
Lon. = Longitudinal.

INDIA

TRIANGULATION SERIES AND AZIMUTH STATIONS

Corrected to Sept. 1937.

(Work of Foreign Countries in red.)



Brahmaputra R.

REFERENCES

Series of Triangulation

Additions since 1936

Number of Series (Vide table opposite) 23

Base-Line

Astronomical Azimuths ▲

Where stations are close to each other, some are omitted.

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

Miles 100 0 100 200 300 400 Miles

Kābul · Peshawar · Chach Base · Srīnagar · Rāwalpindi · Indus R. · Kandahar · Dera Ismail Khān · LAHORE · Amritsar · Ludhiāna · Dehra Dūn · Dehra Dūn Base · Quetta · Multān · Sutlej R. · Meerut · DELHI · Jumna R. · Bīkaner · Sukkur · Agra · Lucknow · Fyzābad · Darjeeling · Brahmaputra R. · Dibrugarh · Sadiya · Jodhpur · Cawnpore · Sonakhoda Base · Shillong · Myitkyina · Karāchi Base · Karāchi · Hyderābād · Allahābād · Benares · Ganges R. · Deesa · Kalianpur · Shirōnj Base · Kalemyo Base · Nan-ning · Lao-hai · Ahmadābād · Jubbulpore · Calcutta Base · CALCUTTA · Chittagong · Mandalay · Hanoi · Haiphong · Kēngtūng Base · Mekong R. · Chindwin R. · GULF OF TONG-KING · Sambalpur · NĀGPUR · Akyab · Irrawaddy R. · Prome · Salween R. · Lampang · Mekong R. · Savannakhet · Tourane · BOMBAY · Poona · Bidar Base · Godāvari R. · Vizagapatam Base · Waltair · Secunderābād · Cocanāda · BAY OF BENGAL · RANGOON · Bassein · Moulmein · Amherst Base · Nagorn Sawarn · Sen Sab · Bangkok · Rajburi · Sisophone · Chandhaburi · Belgaum · Bellary · Bangalore Base · Bangalore · MADRAS · Mangalore · Mergui · Mergui Base · GULF OF SIAM · Saigon · Baria · ANDAMAN ISLANDS · Port Blair · Calicut · Trichinopoly · Nagorn Srīdharmrāj · Puket · Minicoy · Cape Comorin Base · Nagarkoil · Trincomalee · Batticaloa · Negombo · CEYLON · Colombo · NICOBAR ISLANDS · Kedah · Kelantan · SUMATRA

ARABIAN SEA

Published under the direction of Brigadier C. G. Lewis, O.B.E., *Surveyor General of India*.

Heliozincographed at the Survey of India Offices, Dehra Dūn.

S.I.-400-405-38,405.

CHAPTER I

TRIANGULATION

BY CAPTAIN C.A.K. WILSON, R.E.

1. Summary.—This season's programme consisted of a series running southwards from the point in the Nāga tribal territory reached last year in the observation of the Assam Longitudinal series, to make connection with the Upper Irrawaddy series and the Mandalay Meridional series.

This was successfully accomplished. Eleven stations were occupied and the average triangular error was 0·56 seconds. The values of m and M were $\pm 0 \cdot 422$ and $\pm 0 \cdot 35$ respectively. Abnormally cloudy weather hampered astronomical work, and latitudes were observed at only 3 stations.

2. Connection with other triangulation.—Satisfactory connection was made with the Upper Irrawaddy series and the Mandalay Meridional series. The new and old values of angles reobserved are given in the table below.

Triangle Bumdaw Bum–Loi Mye–Bumsai Bum, Upper Irrawaddy series.

Angle at		1936–37	1910–11	New *minus* old
Bumdaw Bum	H.S.	55° 21′ 26″·92	55° 21′ 27″·23	−0″·31
Loi Mye	H.S.	82 15 17·15	82 15 16·77	+0·38
Bumsai Bum	H.S.	42 23 20·23	42 23 20·47	−0·24

Triangle Taungthonlon–Loi Maw–Mawhun, Mandalay Meridional series.

Angle at		1937	1894–96	New *minus* old
Taungthonlon	H.S.	30 55′ 45″·22	30° 55′ 46″·67	−1″·45
Loi Maw	H.S.	76 56 25·93	76 56 25·60	+0·33

The following table shows the discrepancy in position, scale and azimuth between the new series and the published values of the closing sides.

		Value in terms of 1936-37 work = (a)	Value in terms of Upper Irrawaddy series = (b)	(a) − (b)
Latitude of Loi Mye	H.S.	25° 50′ 50″·935	25° 50′ 50″·959	−0″·024
Longitude of Loi Mye	H.S.	96 29 41·914	96 29 41·859	+0·055
Height in feet of Loi Mye	H.S.	5130	5126*	+4
Log side Loi Mye–Bumdaw Bum	H.S.	5·0708583	5·0708578	+0·0000005
Azimuth of Bumdaw Bum at Loi Mye	H.S.	75° 02′ 35″·52	75° 02′ 35″·52	0·00

		Value in terms of 1936-37 work = (a)	Value in terms of Mandalay Meridional series 1894-96 = (b)	(a) − (b)
Latitude of Taungthonlon	H.S.	24° 57′ 29″·360	24° 57′ 29″·427	−0″·067
Longitude of Taungthonlon	H.S.	95 48 23·092	95 48 23·049	+0·043
Height in feet of Taungthonlon	H.S.	5605	5603	+2
Log side Taungthonlon–Loi Maw	H.S.	5·1952805	5·1952805	Nil
Azimuth of Loi Maw at Taungthonlon	H.S.	279° 45′ 40″·27	279° 45′ 39″·21	+1·06

* As originally computed in 1911 and published in triangulation pamphlet 92 C in 1917. A revised value, 5111 feet, was obtained by an adjustment made in 1919, which has been accepted in other pamphlets published since that date.

3. **General.**—The initial connection with last year's work involved the posting of lamp squads on two stations on the Pātkai Range. These lamp squads had to reach their stations via Assam with an escort provided by the 4th Bn., Assam Rifles, Imphal, while the observing detachment went round via Rangoon, and marched from Kamaing via the Hukawng Valley with an escort of military police from Myitkyina. Early starts had to be made to ensure that both parties would arrive in time for observations to be commenced at the beginning of December. The observing detachment left Dehra Dūn on 23rd October and Lungwukaw Bum, the initial station of observation was reached on 3rd December.

4. **Organization.**—The triangulation detachment consisted of Captain C.A.K. Wilson, R.E., observer, with surveyor S.N. Sharma and computer S.C. Dhar performing reconnaissance duties. Computer Padam Singh was recorder.

61 inferior servants were employed, of whom 8 made up the lamp squads posted from Assam. Twelve lamp squads in all were used.

An escort of one platoon was provided by the Commandant, 4th Bn., Assam Rifles, under the command of Captain F.G.C. Macartney, I.A. to mount the two lamp squads for the Pātkai Range. No separate Political Officer was appointed this year, Captain Macartney performing all such duties, including the collection of coolies prior to the march. The observing detachment was provided with an escort of 1 Kachin officer and 30 Kachin other ranks by the Commandant, Western Bn., Burma Military Police, Myitkyina.

Detachment field headquarters and *khamāl* were located at Kamaing in the Myitkyina district.

5. **Supplies.**—This year the rice crop all over the Kachin country was meagre, and local supplies were not to be counted on. All lamp squads were therefore rationed from Kamaing.

6. **Transport.**—Chinese mules were used throughout the season, except in Nāga tribal territory where no mule tracks exist. A permanent coolie corps of 70 Rangpang Nāgas was employed by the Assam column, supplemented by local casually recruited Nāgas. Nāga coolies were used by the observing detachment for the ascent of Lungwukaw Bum H.S., but for all other stations Kachins were locally enlisted for the final climb.

For the initial march out from Kamaing five elephants were employed in addition to the mules, and marched as far as Taihpo Ga on the Tanai Hka (Chindwin River).

Some use was also made of the water-ways of the area. The escort and its kit was transported on rafts and country boats down the Chindwin from Taihpo Ga in the Hukawng Valley to Dalu, and the approach to Namalaw Taung H.S. was also made by boat down the Uyu River.

7. **Description of country.**—From the high and densely forested Sangpan Range in Nāga tribal territory the series was taken southwards over low lying swamps south of the Tanai Hka to the Kachin highlands of the Irrawaddy–Chindwin divide. These highlands form a wooded plateau between 3,000 and 6,000 feet high intersected by deep ravines carrying fast streams draining for the most part into the Uyu and Chindwin rivers. In them are located the famous Uyu Jade Mines, which were opened again this year and attracted numbers of Chinese prospectors from Yunnan.

Kachins of this area are cheerful and appear prosperous, comparing favourably with their sullen and backward relatives in the Hukawng Valley to the north-east.

South of the Jade Mines the tableland breaks up into wide valleys and ranges of hills. The valleys contain many Shan villages, especially around the great Indawgyi Lake. Elephants are numerous in this area, and this year large numbers were trapped and sent to Assam via the Hukawng Valley.

Namalaw Taung H.S., the lowest station of observation, was established in desolate and densely wooded country on the edge of the Laisai Tract and Singkaling Hkāmti State, in the Chindwin Valley.

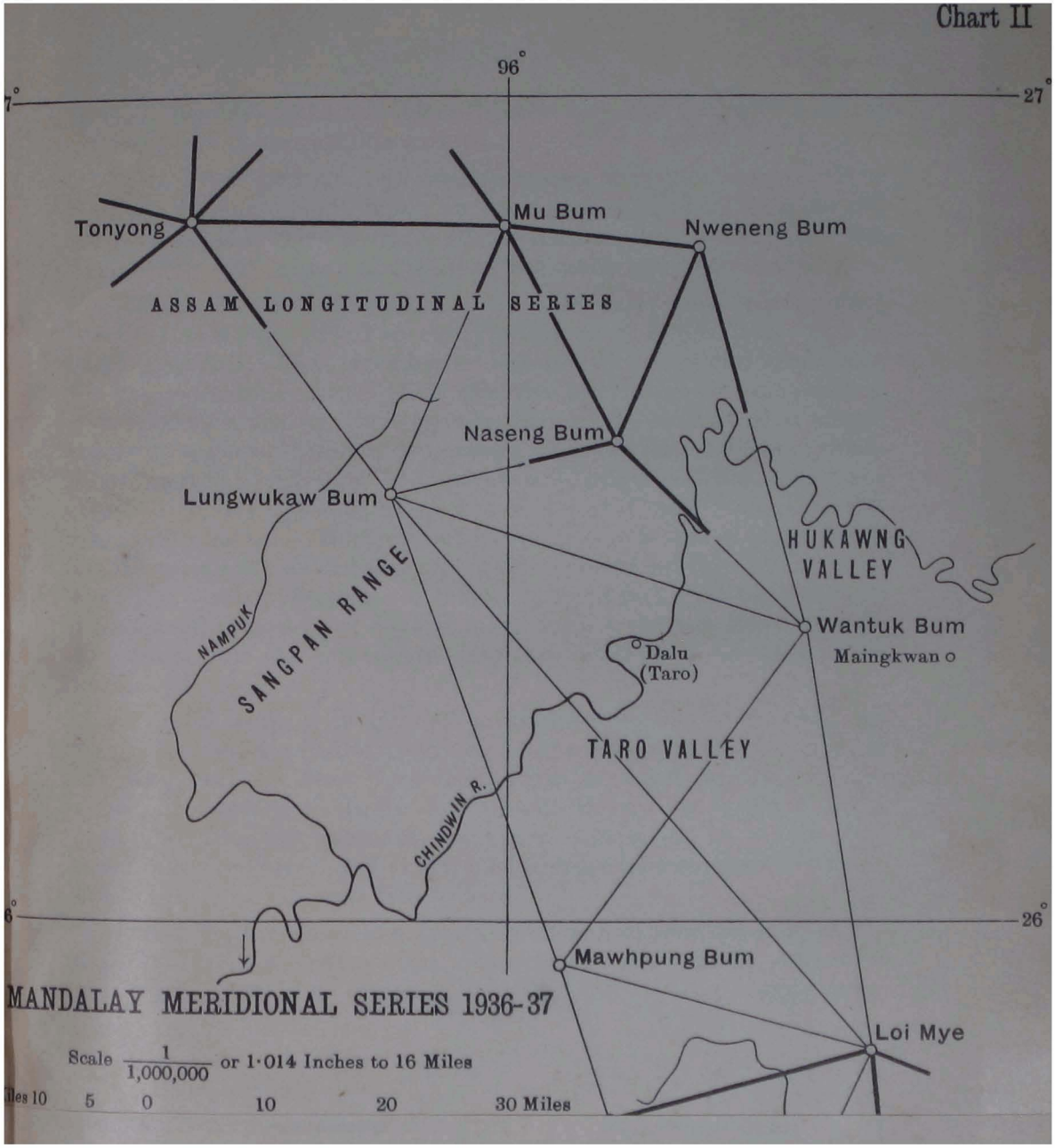
8. Narrative.—The observing detachment, with its escort and the three lamp squads required for stations in tribal territory, left Kamaing on foot on November 10th, reaching Maingkwan in the Hukawng Valley on the 16th and Sumbaw in Nāga tribal territory on the 24th. Several days were spent here collecting Nāga coolies, as it was found impossible to enlist Kachins, this being their harvest time. Eventually sufficient men were assembled on 30th and Lungwukaw Bum H.S. was reached on 3rd November. The Assam column under Captain Macartney had marched from Mārgherita on 4th November and had posted the two lamp squads for Tonyong H.S. and Mu Bum H.S. on the 18th and 29th respectively. Observations were much hindered at Lungwukaw Bum by cloud, and a 14 days' stay on this hill was necessary. From this hill the detachment were spectators at a distance of a head-hunting raid in the Namphuk Valley, in which 37 heads were reported to have been taken.

Low clouds and mist seem to remain in the Hukawng and Taro Valleys throughout the cold weather, and observations at Wantuk Bum H.S. and Mawhpung Bum H.S. had to be completed under difficult conditions. The march southwards through the uninhabited and densely forested Taro Valley was made along a path prepared a year or two previously for the Hopwood–Vernay expedition. This was the most exacting march of the season, and after this routes, though circuitous, were never difficult.

Once south of the cloudy area observations proceeded apace. Dense haze started in February but observations were made possible by the occasional rain that occurs at this time of year. A few storms were experienced in the neighbourhood of the Indawgyi Lake. The ruined pagodas reported in 1911 as obscuring the view from Taungthonlon H.S. to the north were removed by the special permission of the authorities. Local Budhists were spectators at the demolition, but raised no objection.

Observations were completed at Bumrawng Bum H.S. on 19th March, and the detachment reached Dehra Dūn on 4th April.

9. Health.—Apart from a few cases of malaria and scabies, which is rife among the Kachins, the health of the detachment was good. Much discomfort was caused throughout the season by


96°
27°
26°
Tonyong
Mu Bum
Nweneng Bum
ASSAM LONGITUDINAL SERIES
Naseng Bum
Lungwukaw Bum
HUKAWNG VALLEY
NAMPUK
SANGPAN RANGE
Wantuk Bum
Maingkwan o
Dalu (Taro)
TARO VALLEY
CHINDWIN R.
Mawhpung Bum
Loi Mye
MANDALAY MERIDIONAL SERIES 1936-37
Scale 1/1,000,000 or 1·014 Inches to 16 Miles
Miles 10 5 0 10 20 30 Miles

leeches, bamboo ticks and blood-blister flies, but the work was not impeded to any appreciable extent.

10. Observations.—Observations were taken on 20 zeros, three separate measures being made on each zero, a total of 60 measures for each angle. The position of the foot-screws on the stand was changed by 120° after each third of the zeros had been observed.

Wild precision Theodolite No. 59 was used throughout, mounted on a rigid stand specially prepared in Dehra Dūn. It was found that this stand, probably on account of the special iron straps holding it together, was slightly sensitive to changes of temperature. Twists of as much as two seconds during the course of a single round were very occasionally noticed. The twists, however, when they occurred at all were in general very much smaller, and only occurred during periods when the rise or fall of temperature was abnormally rapid. Evening and morning errors due to this cause tended to cancel, as did the errors on opposite swings. In view of the large number of measures taken, and the fact that observations were spread over several days at each station, the resultant error in any angle due to this cause may be considered to have been nugatory.

Argand lamps with 15-inch parabolic reflectors were used for night observation at all stations, and were observed on two rays of over sixty miles. They have been little modified in design since their introduction to India by Colonel Everest in 1836. Their bulk and fragility increase transport difficulties in rough and mountainous country, and it is hoped to introduce an electric beacon in the course of the next few seasons.

Six-inch, nine-inch and twelve-inch heliotropes were used for day observations. Afternoon observations were made whenever possible in addition to the usual morning and evening programme.

CHAPTER II

LEVELLING

BY CAPT. C.A.K. WILSON, R.E.

11. Summary.—The programme consisted of one double detachment levelling from Sukkur to Chaman and from Jacobābād to Garhi Khaira; one single detachment on high precision levelling from Katghora to Bilāspur; and another single detachment on high precision levelling from Bhopāl to Nāgpur.

The total out-turn of levelling was.—

High Precision levelling in fore direction	183 miles (201 gross)*
High Precision levelling in back direction	280 miles (305 gross)*
Equivalent total in one direction ...	463 miles (506 gross)*
Precise levelling	415 miles (451 gross)*

12. Sukkur to Chaman and Jacobabad to Garhi Khaira.—These lines were observed by No. 1 Detachment under Mr. A.A.S. Matlub Ahmad with 1st Class Leveller Hamidullah Khan as second leveller. The line Sukkur to Chaman was run in order to determine the disturbances in and around Quetta caused by the earthquakes of 1931 and 1935, and also to connect eight new primary protected bench-marks left for future investigation at four important geological faults between Quetta and Chaman. The route followed was along the old level lines 101 and 54 A to Quetta via Jacobābād, and thence along the motor road to Chaman.

The line Jacobābād–Garhi Khaira was undertaken, on payment, at the request of the Irrigation Department of the Government of Sind. The route followed was from the Jacobābād–Nasīrābād road as far as milestone 19 of the Nūr Wāh canal to its head on the Begāri Canal, and thence along the latter to Garhi Khaira.

13. Changes of level in Baluchistan.—Chart IV shows the difference between the heights above the standard bench-mark at Sukkur now obtained and those obtained in 1909–10 and 1913–14 when the line was levelled by two officers, simultaneously but independently levelling short sections in opposite directions.

Between Sukkur and Sibi there has been an apparent sinkage of up to about 8 inches, but this may not be real as levelling in this type of country (alluvial *pat*) has proved inaccurate in the past. See Geodetic Report Vol. V pages 94 and 95, Sukkur to Hyderābād. Shortly after Sibi there is a sudden rise of 1½ feet.

* The first of these figures represents the direct distance levelled between terminal bench-marks. The second includes additional check-levelling at ends, and branch-lines to G.T. stations etc.

INDIA

LINES OF
PRECISE LEVELLING
AND
TIDAL STATIONS
Corrected to Sept. 1937

Kābul
Peshāwar
Srīnagar
Rāwalpindi
Indus R.
Nasratābād
Kandahār
Chanuan
Dera Ismail Khān
LAHORE
Amritsar
Quetta
Multān
Sutlej R.
Ludhiāna
Dehra Dūn
Indus R.
Meerut
DELHI
Jumna R.
Ganges R.
Bīkaner
Sukkur
Āgra
Lucknow
Fyzābād
Jodhpur
Gwalior
Cawnpore
Benares
Karāchi
Hyderabād
Allahābād
Ganges R.
Deesa
Kalianpur
Navanar
Okha Point
Hāmtal
Ahmadābād
Jubbulpore
Bhavnagar
Narbada R.
Porbandar
Port Albert Victor
NĀGPUR
Sambalpur
Chāndbāli
Prince's Dock
BOMBAY
Apollo Bandar
Poona
Godāvari R.
Waltair
Vizagapatam
Secunderābad
Cocanāda
Raichūr
Bagalkot
Belgaum
Kistna R.
Marmagao
Kārwār
Bellary
Mangalore
Bangalore
MADRAS
Calicut
Beypore
Trichinopoly
Negapatam
Cochin
Pāmban Pass
Tuticorin
Trincomalee
Minicoy
Nagarkoil
Colombo
CEYLON
Galle
Brahmaputra R.
Dibrugarh
Salween R.
Shillong
Myitkyina
Brahmaputra R.
Chittagong
Chindwin R.
Mandalay
Mekong R.
Nan-ning
Lao-hai
Hanoi
Akyab
Salin
Irrawaddy R.
Prome
Salween R.
Mekong R.
GULF OF TONG-KING
RANGOON
Bassein
Elephant Point
Moulmein
Amherst
Diamond I.
Bangkok
Mergui
Koh Hlak
GULF OF SIAM
Saigon
ANDAMAN ISLANDS
Port Blair
NICOBAR ISLANDS
SUMATRA
George Town
BAY OF BENGAL
ARABIAN SEA

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

- Completed 1858–1934
- Completed this season

Levelling of Secondary Precision

- Completed 1921–36
- " this season

- Tidal Stations on which levelling has been adjusted — Madras
- Other Tidal Station — Tuticorin
- Foreign Geodetic Levelling

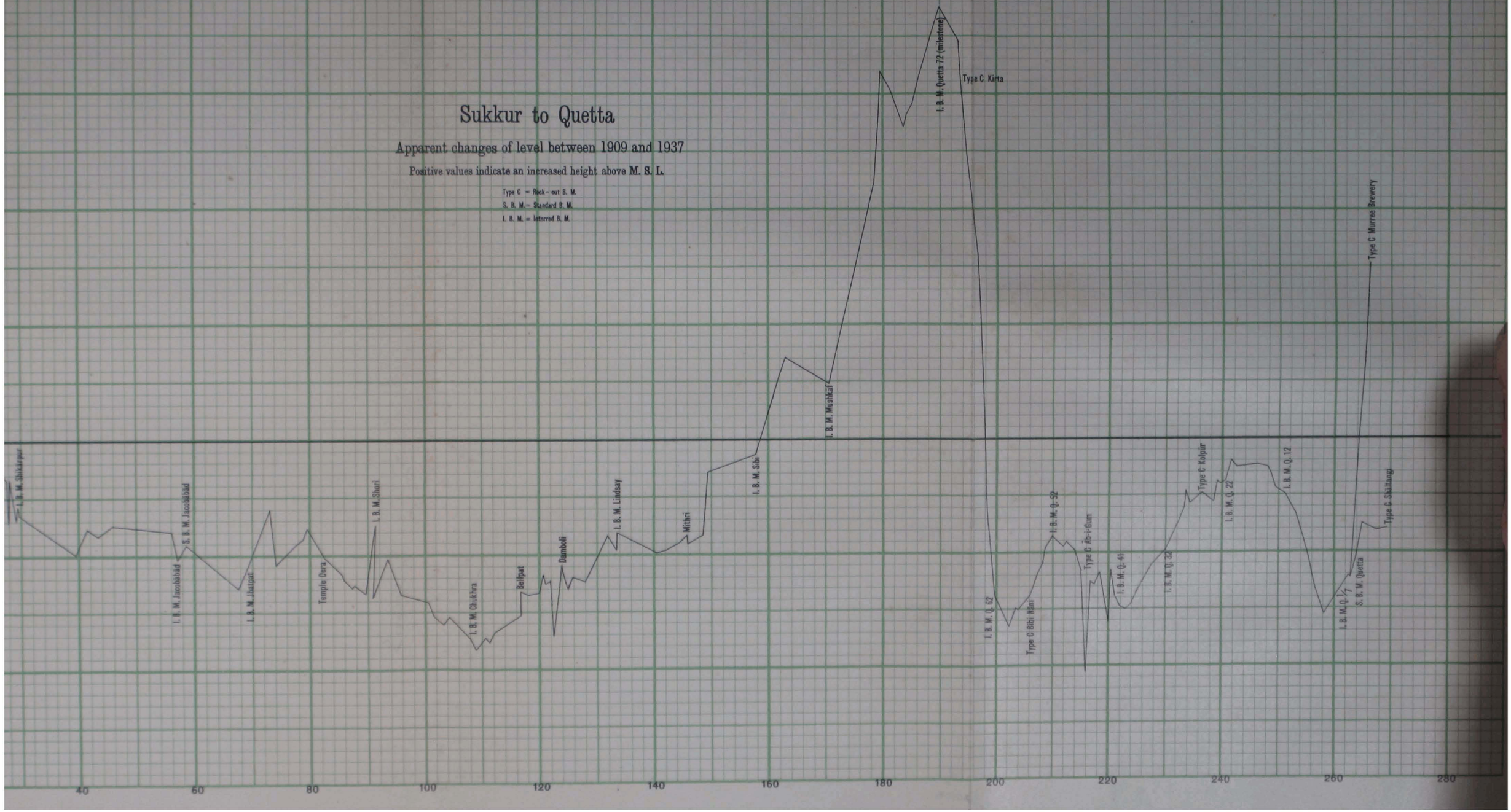
Scale 1 Inch = 60 Miles
Miles 100 0 100 200 300 400 Miles

Sukkur to Quetta

Apparent changes of level between 1909 and 1937

Positive values indicate an increased height above M. S. L.

Type C = Rock-cut B. M.
S. B. M.= Standard B. M.
I. B. M. = Interrod B. M.



This change was noticed by Mr. A.A.S. Matlub Ahmad and he at once relevelled the section in which most of the change occurred, so the change is either real or else common to the two 1913–14 levellers. The position of the change exactly at the outer edge of the hills suggests that it may be real.

A few miles further on, just before Bībi Nāni, this rise ceases and the old and new heights are again in agreement. The change of 2 feet occurs in about 7 miles and cannot be due to any ordinary levelling error: nor can it be due to a single blunder, as the change occurs progressively through several sections between bench-marks. The part of the line between Sibi and Bībi Nāni which thus appears to have been elevated between 1½ and 2 feet is exactly the prolongation of the Nāgau Range, which is the high (6000-7000 feet) outer range of the Baluchistān plateau on the south side of the Bolān pass.

From Bībi Nāni onwards there are smaller, though rather abrupt changes, but since these changes occur in a section where the line is rising steeply from 1500 to 5000 feet, where levelling is liable to fall below its usual standard, they may not be real. On the other hand they may be real, since earthquakes (Mach and Quetta) have occurred in this section, and the discrepancies are more abrupt than errors ought to be.

At Quetta itself bench-marks are fairly consistent *inter se*, except that the rock-cut bench-mark at Murree Brewery has apparently been raised about a foot relative to other Quetta bench-marks, including a rock-cut bench-mark at Shāltangi police *chauki*. The Murree Brewery bench-mark is on a branch-line, but the change of one foot in 3 miles is very large and is probably real.

In conclusion it may be said that a belt about 10 miles wide at the bottom end of the Bolān pass has very probably been raised 1½ feet since 1913–14; from Bībi Nāni onwards the general level is unchanged, but changes of 6 inches may have occurred; and at Quetta itself the Murree Brewery rock-cut bench-mark has probably risen 1 foot relative to other bench-marks.

For the purpose of publication, the new heights have been adjusted on to old heights between Sukkur and Jacobābād, to avoid disturbing existing circuits, while from Jacobābād onwards the new levelling has been accepted as correct.

14. **Katghora-Daltonganj and Katghora-Bilaspur.**—No. 2 Detachment under Mr. Mohammad Faizul Hasan carried out high precision levelling from Katghora to Daltonganj in the fore direction. The line follows the cart-track from Katghora to Pondi, and then runs by path and cart-track to Lakhanpur, thence along the unmetalled road to Nawādīh via Ambikāpur and Rāmānuj Ganj, and thence across country to the Garwa–Daltonganj road which it follows to Daltonganj.

On completion of the work the detachment proceeded to Katghora and took up the back levelling of the Katghora–Bilāspur line. The line runs along the metalled road to Ratanpur and thence along an unmetalled road to Bilāspur.

The progress of the detachment was much hampered by sickness and the uneven nature of the country.

15. New Howrah Bridge.—The observation of a line from the bench-mark in the Surveyor General's Office at Calcutta to the New Howrah Bridge was undertaken on payment at the request of the Engineer to the Commissioners of the New Howrah Bridge, and was carried out by Mr. Mohammad Faizul Hasan. He completed about 9 miles of single levelling, 4½ miles in the fore direction and 4½ in the back direction.

16. Bhopal-Nagpur.—This line was observed in the back direction by No. 3 Detachment under Mr. Z.A. Qureshi. The route follows the road from Bhopāl to Obaidulla Ganj, and thence runs along the line of the railway to Hoshangābād, whence it follows the road to Nāgpur. This detachment also was delayed by sickness, difficult country and much relevelment.

17. Probable errors.—The probable errors of the high precision and precise lines completed in 1936-37 are tabulated below :—

Line No.	Name of line	Probable systematic error	Probable accidental error
		feet/miles	*feet/miles*$^{\frac{1}{2}}$
115	Bhopāl-Nāgpur ...	0·000920	0·00302
101B	Sukkur-Chaman ...	...	0·00341
101C	Jacobābād-Garhi Khaira ...	...	0·00335

18. Progress of the new level net.—The following additions were made to the completed mileage of the new level net :—

Line No.	Name of line	Miles completed on main-line	Remarks
115	Bhopāl-Nāgpur ...	225	The whole line is complete.
118	Bilāspur-Katghora ...	55	Portion of line 118 (Raipur-Aurangābād) completed.
	Previously completed ...	9,150	
	Total completed to date	9,430	

In addition to the above, 597 miles have been completed in one direction only. The total mileage of the new level net when completed will be about 15,800 miles.

19. Protected bench-marks.—The following additions and corrections have been made to the list of Primary Protected bench-marks published in Geodetic Reports Vols. III & VIII and for 1934 to 1936.

Degree sheet	No. of bench-marks	Degree sheet	No. of bench-marks
34J	47, 53, 65, 69, 95, 103. 127, 155, 172, 183, 206.	55F	11, 36, 87, 105, 115.
		55G	8, 22.
34O	370 (*171*)	73L	80 to replace 84 of G.R. Vol. III reported destroyed.
39D	165 to replace 23 of G.R. Vol. III reported destroyed, 304.		

TABLE 1.—*Tabular statement of out-turn of work, season 1936–37.*

Detachments and lines levelled	Months	Distance levelled			Total		Number of stations at which the instruments were set up	Number of bench-marks connected		
		Main-line	Extras and branch-lines	Total	Rises	Falls		Protected Primary		Others
								Rock-cut	Others	
		Mls.	*Mls.*	*Mls.*	*feet*	*feet*				
No. 1 Detachment.										
Line 101 B Sukkur–Chaman.	Nov. to Dec. 36 & Jan. to May 37	343	26	369	13,839	6,569	6,590	9	38	537
Line 101 C Jacobābād–Garhi Khaira.	Dec. 36	68	5	73	374	422	808	...	2	75
No. 2 Detachment.										
Line 77 CC Surveyor General's office to New Howrah Bridge, Calcutta.	Oct. 36	9†	...	9†	124	124	216	...	1	15
Line 118 Portion Katghora–Daltonganj (Fore).	Nov. 36 to March 37	183	18	201	14,533	10,842	5,546	3	5	206
Line 118 Portion Katghora–Bilāspur (Back)*	April 37 to May 37	55	8	63	1,807	3,724	1,624	1	2	74
No. 3 Detachment.										
Line 115 Nāgpur–Bhopāl (Back)‡	Nov. 36 to May 37	225	17	242	11,703	12,176	5,216	2	8	311

* Relevelled 6 miles. † Total of fore and back directions.
‡ Relevelled 106 miles.

TABLE 2.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	Original levelling	Check-levelling 1936-37	
			miles		*feet*	*feet*	*feet*
		At Sukkur on line 101 B.					
98	40 A	Rock-cut (Type C)	0·00	1920-21,	0·000	0·000	0·000
100 PP	,,	Rock-cut (Type C)	0·81	,,	+ 50·310	+ 50·307	−0·003
249 (*49*)	,,	Flooring ...	1·06	1921-23	+ 35·455	+ 35·452	−0·003
250 (*48*)	,,	Step ...	1·13	,,	+ 29·647	+ 29·645	−0·002
50	,,	Bridge ...	1·51	1920-21	+ 31·886	+ 31·890	+0·004
53	,,	Step ...	1·61	,,	+ 22·188	+ 22·190	+0·002
251	,,	Step ...	1·98	1921-23	+ 13·201	+ 13·209	+0·008
101 PP	,,	S.B.M., Sukkur ...	2·11	1920-21	+ 49·074	+ 49·087	+0·013
		At Garhi Khaira on line 101 C.					
11	34 P	Bridge over Eden *wāh*	0·00	1921-22	0·000	0·000	0·000
12	,,	Rail No. 213 ...	0·94	,,	− 11·588	− 11·581	+0·007
14	,,	Rail No. 214 ...	3·14	,,	− 11·708	− 11·683	+0·025
138	39 D	Iron pipe ...	2·48	,,	− 8·858	− 8·851	+0·007
		At Quetta on line 101 B.					
16	34 J	Culvert ...	0·00	1913-14	0·000	0·000	0·000
17	,,	I.B.M. (Type B) ...	1·11	,,	− 44·374	− 44·357	+0·017
3	34 N	Bridge ...	2·38	,,	− 53·655	− 53·580	+0·075
19	34 J*	Step ...	2·58	,,	− 61·895	− 61·831	+0·064
21 PP	,,	Rock-cut (Type C)	5·99	,,	+ 87·312	+ 88·491	+1·179
5	34 N	Platform ...	2·98	,,	− 38·292	− 38·198	+0·094
8 PP	,,	S.B.M., Quetta ...	3·54	,,	− 43·409	− 43·275	+0·134
11	,,	Flooring ...	4·89	,,	+ 40·539	+ 40·800	+0·261
16	,,	Step ...	7·40	,,	+ 305·934	+ 306·172	+0·238
17	,,	Rock-cut (Type C)	9·31	,,	+ 516·334	+ 516·584	+0·250
		At Daltonganj on line 118.					
132	72 D	I.B.M., Daltonganj ...	0·00	1916-17	0·000	0·000	0·000
131	,,	Flooring ...	0·29	,,	+ 20·076	+ 20·083	+0·007
133	,,	Rock ...	0·71	,,	+ 36·098	+ 36·099	+0·001
134	,,	Rock ...	0·90	,,	+ 45·091	+ 45·089	−0·002
135	,,	Flooring ...	0·95	,,	+ 51·745	+ 51·734	−0·011
130	,,	Step ...	1·83	,,	+ 21·266	+ 21·268	+0·002

* Falls in degree sheet 34 N.

(*Continued*)

TABLE 2.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	Original levelling	Check-levelling 1935-36-37	
			miles		*feet*	*feet*	*feet*
		At Bhopāl on line 115.					
27	55 E	S.B.M., Bhopāl ...	0·00	1909-10	0·000	0·000	0·000
109	,,	Step ...	0·56	1928-29-30	+ 55·390	+ 55·388	−0·002
110	,,	Step ...	0·75	,,	+ 66·232	+ 66·232	−0·000
24	,,	Plinth ...	0·95	1909-10	+ 82·435	+ 82·435	−0·000
111	,,	Threshold ...	0·99	1928-29-30	+ 84·469	+ 84·466	−0·003
112	,,	Step ...	1·10	,,	+ 88·028	+ 88·024	−0·004
113	,,	Threshold ...	1·15	,,	+ 88·741	+ 88·741	−0·000
114	,,	Plinth ...	1·36	,,	+ 111·241	+ 111·238	−0·003
115	,,	Threshold ...	1·45	,,	+ 98·364	+ 98·367	+0·003
28	,,	Platform ...	0·83	1909-10	− 0·200	− 0·192	+0·008
105	,,	Flooring ...	0·90	1928-29-30	+ 0·472	+ 0·483	+0·011
		At Nāgpur on line 116.					
148	55 O	S.B.M., Nāgpur ...	0·00	1908-09	0·000	0·000	0·000
17	,,	Step ...	0·01	1890-92	− 0·793	− 0·760	+0·033
23	,,	Step ...	1·63	,,	− 0·912	− 0·892	+0·020
25	,,	Bridge ...	3·06	1875-78	− 37·212	− 37·185	+0·027
26	,,	Bridge ...	3·63	,,	− 41·321	− 41·221	+0·100
144	,,	E.B.M., Indora ...	4·93	1908-09	− 40·213	− 40·214	−0·001
18	,,	Base of pediment ...	0·20	1878-79	− 13·679	− 13·663	+0·016
147	,,	Step ...	0·65	1908-09	− 1·862	− 1·872	−0·010

TABLE 3.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1936-37	
			miles		*feet*	*feet*	*feet*
Revision of old lines 101 and 54A, Portion Sukkur–Quetta.							
101(PP)	40 A	S.B.M., Sukkur ...	0·00	1909-10	0·000	0·000	0·000
251	,,	Step ...	0·14	1921-23	− 35·873	− 35·878	−0·005
53	,,	Step ...	0·50	1909-10	− 26·886	− 26·897	−0·011
50	,,	Bridge ...	0·60	,,	− 17·188	− 17·197	−0·009
250(*48*)	,,	Step ...	0·99	1921-23	− 19·427	− 19·442	−0·015
249(*49*)	,,	Flooring ...	1·05	,,	− 13·619	− 13·635	−0·016
100(PP)	,,	Rock-cut (Type C) ...	1·30	1909-10	+ 1·236	+ 1·252	+0·016
98	,,	Rock-cut (Type C) ...	2·11	,,	− 49·074	− 49·087	−0·013
242	,,	Culvert ...	9·44	1921-23	− 56·401	− 56·466	−0·065
322(*60*)	,,	E.B.M., Bagarji ...	10·40	1909-10	− 55·558	− 55·787	−0·229
240(*61*)	,,	Culvert ...	11·78	1921-23	− 57·549	− 57·658	−0·109
62	,,	Culvert ...	13·66	1909-10	− 57·394	− 57·493	−0·099
328 (*239*) (*64*)	,,	Bridge ...	16·48	1921-23	− 56·445	− 56·579	−0·134
336(*236*) (*68*)	,,	Bridge ...	20·78	,,	− 59·598	− 59·780	−0·182
337(*69*)	,,	Bridge ...	22·05	1909-10	− 59·531	− 59·544	−0·013
338(*70*)	,,	Bridge ...	23·20	,,	− 59·711	− 59·784	−0·073
341(*72*)	,,	Bridge ...	26·44	,,	− 53·658	− 53·774	−0·116
342(*77*)	,,	Bridge ...	27·46	,,	− 57·387	− 57·514	−0·127
343(*233*) (*79*)	,,	Iron plug ...	27·76	1921-23	− 61·054	− 61·333	−0·279
344(*232*) (*81*)	,,	Step ...	27·89	,,	− 61·539	− 61·673	−0·134
345(*75*)	,,	Flooring ...	29·11	1909-10	− 61·960	− 62·235	−0·275
346 (PP) (*231*)(*78*)	,,	I.B.M., Shikārpur R.S.	29·46	1921-23	− 63·310	− 63·534	−0·224
347(*230*) (*76*)	,,	Step ...	29·53	,,	− 57·479	− 57·729	−0·250
149 (*7*)	39 D	Bridge ...	39·59	1909-10	− 60·501	− 60·894	−0·393
8	,,	Bridge ...	41·45	,,	− 61·299	− 61·601	−0·302
10	,,	I.B.M., (Type B), Humāyun R.S. ...	43·34	,,	− 70·184	− 70·508	−0·324
155(*12*)	,,	Bridge ...	46·04	,,	− 57·986	− 58·275	−0·289
162(*17*)	,,	Bridge ...	55·99	,,	− 68·367	− 68·679	−0·312
18	,,	I.B.M., (Type B), Jacobābād ...	57·00	,,	− 77·878	− 78·285	−0·407
125(*22*)	,,	Flooring ...	57·58	1921-23	− 72·622	− 73·014	−0·392
139(*21*)	,,	Plinth ...	57·96	,,	− 69·129	− 69·527	−0·398
175(*32*)	,,	Flooring ...	67·38	1913-14	− 74·946	− 75·453	−0·507
177(*33*)	,,	I.B.M., (Type A), Jhatpat R.S. ...	67·80	,,	− 81·284	− 81·734	−0·450

(*Continued*)

TABLE 3.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1936-37	
			miles		*feet*	*feet*	*feet*
Revision of old lines 101 and 54A, Portion Sukkur–Quetta—(contd.)							
182 (*39*)	39 D	Bridge ...	72·95	1913-14	− 64·942	− 65·181	−0·239
183 (*40*)	,,	Stone pillar ...	74·15	,,	− 63·858	− 64·285	−0·427
186 (*43*)	,,	Stone pillar ...	77·69	,,	− 56·175	− 56·535	−0·360
187 (*44*)	,,	Stone pillar ...	78·19	,,	− 55·613	− 55·962	−0·349
188 (*45*)	,,	Stone pillar ...	78·44	,,	− 55·173	− 55·516	−0·343
189 (*46*)	,,	Stone pillar ...	78·70	,,	− 54·165	− 54·508	−0·343
190 (*48*)	,,	Masonry tank ...	79·51	,,	− 52·006	− 52·307	−0·301
194 (PP) (*56*)	,,	I.B.M., (Type A), Temple Dera R.S.	82·69	,,	− 48·683	− 49·088	−0·405
195 (*57*)	,,	Flooring ...	82·73	,,	− 45·261	− 45·655	−0·394
197 (*63*)	,,	Stone pillar ...	85·33	,,	− 42·571	− 43·034	−0·463
198 (*64*)	,,	Stone pillar ...	85·80	,,	− 40·805	− 41·287	−0·482
200 (*67*)	,,	Stone pillar ...	87·31	,,	− 37·504	− 38·014	−0·510
201 (*69*)	,,	Stone pillar ...	87·81	,,	− 34·830	− 35·330	−0·500
203 (*73*)	,,	Stone pillar ...	89·83	,,	− 31·536	− 32·070	−0·534
205 (*76*)	,,	I.B.M., (Type A), Shori R.S. ...	91·29	,,	− 29·668	− 29·960	−0·292
206 (*77*)	,,	Stone pillar ...	91·66	,,	− 27·230	− 27·774	−0·544
208 (*79*)	,,	Bridge ...	93·43	,,	− 20·439	− 20·849	−0·410
210 (*83*)	,,	Stone pillar ...	95·66	,,	− 13·875	− 14·412	−0·537
211 (*84*)	,,	Stone pillar ...	95·91	,,	− 13·067	− 13·602	−0·535
212 (*85*)	,,	Stone pillar ...	96·41	,,	− 11·063	− 11·609	−0·546
213 (*86*)	,,	Stone pillar ...	96·66	,,	− 9·923	− 10·461	−0·538
215 (*87*)	,,	Stone pillar ...	98·41	,,	− 4·731	− 5·265	−0·534
216 (*89*)	,,	Flooring ...	99·39	,,	+ 0·958	+ 0·415	−0·543
217 (*91*)	,,	Stone pillar ...	100·48	,,	+ 1·335	+ 0·776	−0·559
218 (*93*)	,,	Stone pillar ...	101·73	,,	+ 6·936	+ 6·324	−0·612
219 (*94*)	,,	Stone pillar ...	101·98	,,	+ 8·381	+ 7·760	−0·621
220 (*95*)	,,	Stone pillar ...	102·48	,,	+ 11·451	+ 10·826	−0·625
221 (*96*)	,,	Stone pillar ...	102·98	,,	+ 15·532	+ 14·906	−0·626
222 (*97*)	,,	Flooring ...	103·49	,,	+ 21·624	+ 20·983	−0·641
223 (*98*)	,,	Stone pillar ...	104·49	,,	+ 17·524	+ 16·907	−0·617
224 (*99*)	,,	Stone pillar ...	104·74	,,	+ 20·011	+ 19·356	−0·655
225 (*100*)	,,	Stone pillar ...	104·99	,,	+ 20·469	+ 19·847	−0·622
226 (*104*)	,,	Stone pillar ...	106·49	,,	+ 26·731	+ 26·104	−0·627
227 (*105*)	,,	Stone pillar ...	106·99	,,	+ 29·063	+ 28·427	−0·636
228 (*108*)	,,	Flooring ...	108·05	,,	+ 39·387	+ 38·684	−0·703
229 (*107*)	,,	I.B.M., (Type A), Chukhra R.S. ...	108·08	,,	+ 31·409	+ 30·721	−0·688
230 (*109*)	,,	Stone pillar ...	109·04	,,	+ 36·667	+ 35·939	−0·728

(*Continued*)

TABLE 3.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1936-37	
			miles		*feet*	*feet*	*feet*
Revision of old lines 101 and 54A, Portion Sukkur–Quetta—(contd.)							
231(*110*)	39 D	Stone pillar ...	109·54	1913-14	+ 40·143	+ 39·458	−0·685
233(*112*)	,,	Stone pillar ...	110·80	,,	+ 43·581	+ 42·893	−0·688
234(*113*)	,,	Stone pillar ...	111·05	,,	+ 43·516	+ 42·812	−0·704
236(*116*)	,,	Flooring ...	112·31	,,	+ 51·147	+ 50·487	−0·660
241(*121*)	,,	Flooring ...	116·64	,,	+ 57·398	+ 56·787	−0·611
242(*122*)	,,	I.B.M., (Type A), Bellpat R.S. ...	116·73	,,	+ 48·701	+ 48·175	−0·526
3 (*1*)	39 C	Stone pillar ...	118·19	,,	+ 56·195	+ 55·657	−0·538
184 (*2*)	34 O	Stone pillar ...	119·95	,,	+ 61·705	+ 61·176	−0·529
185 (*3*)	,,	Stone pillar ...	120·70	,,	+ 61·652	+ 61·185	−0·467
186 (*4*)	,,	Stone pillar ...	121·20	,,	+ 62·124	+ 61·623	−0·501
188 (*6*)	,,	Stone pillar ...	121·95	,,	+ 61·870	+ 61·382	−0·488
189 (*7*)	,,	Bridge ...	122·69	,,	+ 66·772	+ 66·091	−0·681
191 (*10*)	,,	Flooring ...	124·04	,,	+ 70·017	+ 69·531	−0·486
192 (*9*)	,,	I.B.M., (Type A), Damboli ...	124·08	,,	+ 62·139	+ 61·703	−0·436
194 (*11*)	,,	Stone pillar ...	125·05	,,	+ 64·683	+ 64·163	−0·520
195 (*12*)	,,	Stone pillar ...	125·30	,,	+ 65·745	+ 65·261	−0·484
196 (*13*)	,,	Stone pillar ...	125·80	,,	+ 67·052	+ 66·577	−0·475
198 (*16*)	,,	Flooring ...	127·94	,,	+ 73·331	+ 72·841	−0·490
203 (*20*)	,,	Stone pillar ...	131·85	,,	+ 76·480	+ 76·147	−0·333
204 (*22*)	,,	Flooring ...	133·25	,,	+ 81·563	+ 81·182	−0·381
205 (PP) (*21*)	,,	I.B.M., (Type A), Lindsay ...	133·28	,,	+ 78·403	+ 78·081	−0·322
213 (*30*)	,,	Stone pillar ...	140·45	,,	+104·543	+104·154	−0·389
215 (*33*)	,,	Stone pillar ...	142·23	,,	+115·109	+114·730	−0·379
217 (*34*)	,,	Stone pillar ...	142·98	,,	+118·412	+118·040	−0·372
218 (*35*)	,,	Stone pillar ...	143·23	,,	+119·162	+118·788	−0·374
219 (*36*)	,,	Bridge ...	144·29	,,	+123·665	+123·302	−0·363
220 (*38*)	,,	Stone pillar ...	145·16	,,	+129·321	+128·961	−0·360
221 (*39*)	,,	I.B.M., (Type A), Mithri ...	145·78	,,	+126·386	+126·054	−0·332
222 (*40*)	,,	Flooring ...	145·89	,,	+134·534	+134·172	−0·362
225 (*44*)	,,	Stone pillar ...	148·29	,,	+138·355	+138·024	−0·331
228 (*47*)	,,	Stone pillar ...	149·55	,,	+144·186	+144·075	−0·111
238 (*56*)	,,	I.B.M., (Type B), Sibi	157·84	,,	+178·757	+178·704	−0·053
247 (*63*)	,,	Bridge ...	162·10	,,	+168·131	+168·358	+0·227
248 (*64*)	,,	Bridge ...	162·61	,,	+173·519	+173·774	+0·255
249 (*65*)	,,	Masonry tank ...	163·15	,,	+178·564	+178·854	+0·290
257 (*71*)	,,	I.B.M., (Type B) Mushkāf ...	171·50	,,	+210·484	+210·682	+0·198

(*Continued*)

TABLE 3.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1936-37	
			miles		*feet*	*feet*	*feet*
Revision of old lines 101 and 54A, Portion Sukkur–Quetta—(contd.)							
265 (*75*)	34 O	Boulder ...	178·44	1913-14	+ 338·854	+ 339·746	+ 0·892
266 (*76*)	,,	Bridge ...	179·19	,,	+ 378·493	+ 379·620	+ 1·127
267 (*77*)	,,	Bridge ...	179·81	,,	+ 380·490	+ 381·767	+ 1·277
269 (*79*)	,,	Bridge ...	181·51	,,	+ 422·084	+ 423·288	+ 1·204
272 (*81*)	,,	Bridge ...	183·59	,,	+ 460·163	+ 461·257	+ 1·094
273 (*82*)	,,	Bridge ...	184·19	,,	+ 469·531	+ 470·668	+ 1·137
275 (*83*)	,,	Bridge ...	185·14	,,	+ 497·478	+ 498·644	+ 1·166
276 (*84*)	,,	Culvert ...	185·45	,,	+ 504·592	+ 505·753	+ 1·161
278 (*85*)	,,	Boulder ...	186·38	,,	+ 533·109	+ 534·368	+ 1·259
279 (*86*)	,,	Rock in situ ...	186·76	,,	+ 541·923	+ 543·221	+ 1·298
280 (*87*)	,,	Bridge ...	187·30	,,	+ 559·330	+ 560·673	+ 1·343
282 (*88*)	,,	Culvert ...	188·18	,,	+ 583·548	+ 584·940	+ 1·392
285 (*91*)	,,	I.B.M., (Type B)	190·08	,,	+ 689·859	+ 691·358	+ 1·499
289 (*95*)	,,	Rock in situ ...	193·29	,,	+ 729·981	+ 731·358	+ 1·377
291(PP) (*96*)	,,	Rock-cut (Type C)	193·65	,,	+ 725·797	+ 727·049	+ 1·252
294 (*98*)	,,	Milestone ...	194·79	,,	+ 762·134	+ 763·130	+ 0·996
296 (*99*)	,,	Bed rock ...	195·85	,,	+ 837·781	+ 838·575	+ 0·794
297(*100*)	,,	Bridge ...	196·61	,,	+ 857·254	+ 857·896	+ 0·642
300(*101*)	,,	Milestone ...	197·79	,,	+ 901·602	+ 901·797	+ 0·195
301(*102*)	,,	Rock in situ ...	198·34	,,	+ 927·386	+ 927·176	− 0·210
303(*104*)	,,	I.B.M., (Type B)	199·81	,,	+ 986·459	+ 985·909	− 0·550
304(*105*)	,,	Rock in situ ...	200·85	,,	+ 1049·106	+ 1048·452	− 0·654
305(*106*)	,,	Bridge ...	201·36	,,	+ 1071·744	+ 1071·099	− 0·645
306(*107*)	,,	Bridge ...	202·00	,,	+ 1113·686	+ 1113·022	− 0·664
307(*108*)	,,	Bridge ...	202·31	,,	+ 1131·776	+ 1131·117	− 0·659
308(*110*)	,,	Rock in situ ...	203·65	,,	+ 1213·816	+ 1213·219	− 0·597
309(*111*)	,,	Bridge ...	204·00	,,	+ 1247·847	+ 1247·245	− 0·602
311(*112*)	,,	Bed rock ...	205·68	,,	+ 1406·125	+ 1405·553	− 0·572
313(*113*)	,,	Rock-cut (Type C)	206·11	,,	+ 1409·683	+ 1409·126	− 0·557
314(*114*)	,,	Bed rock ...	206·91	,,	+ 1477·824	+ 1477·305	− 0·519
315(*115*)	,,	Rock ...	207·28	,,	+ 1514·151	+ 1513·666	− 0·485
316(*116*)	,,	Rock in situ ...	207·98	,,	+ 1579·518	+ 1579·072	− 0·446
317(*117*)	,,	Boulder ...	208·31	,,	+ 1610·825	+ 1610·391	− 0·434
318(*118*)	,,	Rock in situ ...	208·88	,,	+ 1658·638	+ 1658·258	− 0·380
319(*119*)	,,	I.B.M., (Type B)	209·90	,,	+ 1748·322	+ 1747·983	− 0·339
321(*120*)	,,	Bridge ...	210·31	,,	+ 1783·999	+ 1783·661	− 0·338
322(*121*)	,,	Milestone ...	210·91	,,	+ 1842·484	+ 1842·131	− 0·353
323(*122*)	,,	Milestone ...	211·93	,,	+ 1953·885	+ 1953·507	− 0·378
324(*123*)	,,	Rock in situ ...	212·51	,,	+ 2033·225	+ 2032·860	− 0·365
326(*124*)	,,	Milestone ...	213·94	,,	+ 2256·136	+ 2255·742	− 0·394

(*Continued*)

TABLE 3.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1936-37	
			miles		*feet*	*feet*	*feet*
Revision of old lines 101 and 54A, Portion Sukkur–Quetta—(contd.)							
327(*125*)	34 O	Rock in situ ...	214·26	1913-14	+2312·399	+2311·999	−0·400
328(*126*)	,,	Rock-cut (Type C)	215·15	,,	+2485·760	+2485·296	−0·464
329(*127*)	,,	Bridge ...	215·93	,,	+2463·095	+2462·272	−0·823
330(*128*)	,,	Rock in situ ...	216·60	,,	+2603·389	+2602·886	−0·503
331(*129*)	,,	Rock in situ ...	217·18	,,	+2674·492	+2673·984	−0·508
332(*130*)	,,	Rock in situ ...	218·33	,,	+2815·101	+2814·629	−0·472
334(*132*)	,,	Boulder ...	219·86	,,	+3099·252	+3098·608	−0·644
335(*133*)	,,	Boulder ...	220·33	,,	+3114·148	+3113·690	−0·458
336(134)	,,	I.B.M., (Type B) Old Mach ...	221·05	,,	+3221·955	+3221·402	−0·553
338(*136*)	,,	Bridge ...	222·05	,,	+3361·091	+3360·503	−0·588
339(*137*)	,,	Milestone ...	223·06	,,	+3617·144	+3616·537	−0·607
340(*138*)	,,	Bed rock ...	223·94	,,	+3840·868	+3840·282	−0·586
341(*139*)	,,	Bridge ...	224·68	,,	+3779·586	+3779·042	−0·544
342(*140*)	,,	Bridge ...	225·18	,,	+3822·466	+3821·937	−0·529
343(*141*)	,,	Rock ...	226·01	,,	+3991·707	+3991·218	−0·489
345(*142*)	,,	Rock ...	226·30	,,	+4026·358	+4025·877	−0·481
346(*144*)	,,	Bed rock ...	227·24	,,	+4199·575	+4199·133	−0·442
347(*145*)	,,	Bed rock ...	227·80	,,	+4285·469	+4285·038	−0·431
348(*146*)	,,	Rock in situ ...	228·15	,,	+4339·704	+4339·275	−0·429
349(*147*)	,,	Rock in situ ...	228·39	,,	+4389·678	+4389·257	−0·421
351(*149*)	,,	Bed rock ...	229·40	,,	+4566·850	+4566·440	−0·410
352(*150*)	,,	Bed rock ...	229·55	,,	+4603·742	+4603·332	−0·410
353(*151*)	,,	Bed rock ...	229·84	,,	+4691·870	+4691·459	−0·411
354(*152*)	,,	Bed rock ...	230·04	,,	+4755·797	+4755·396	−0·401
355(*153*)	,,	I.B.M., (Type B) ...	230·19	,,	+4762·858	+4762·468	−0·390
356(*155*)	,,	Bridge ...	230·55	,,	+4805·317	+4804·938	−0·379
357(*156*)	,,	Rock in situ ...	230·86	,,	+4860·890	+4860·513	−0·377
358(*157*)	,,	Bridge ...	231·36	,,	+4948·551	+4948·214	−0·337
359(*158*)	,,	Rock in situ ...	231·56	,,	+4974·952	+4974·631	−0·321
360(*159*)	,,	Rock in situ ...	231·93	,,	+5024·423	+5024·103	−0·320
361(*160*)	,,	Rock in situ ...	232·20	,,	+5090·712	+5090·408	−0·304
362(*162*)	,,	Bed rock ...	233·19	,,	+5239·626	+5239·384	−0·242
363(*163*)	,,	Boulder ...	233·65	,,	+5303·839	+5303·655	−0·184
365(*165*)	,,	Bed rock ...	234·28	,,	+5417·825	+5417·599	−0·226
366(*166*)	,,	Bed rock ...	234·59	,,	+5426·455	+5426·234	−0·221
367(*167*)	,,	Bed rock ...	235·08	,,	+5457·930	+5457·716	−0·214
369(*170*)	,,	Rock in situ ...	236·21	,,	+5611·396	+5611·212	−0·184
370(PP) (*171*)	,,	Rock-cut (Type C) Kolpūr ...	236·43	,,	+5643·061	+5642·863	−0·198
371(*172*)	,,	Bed rock ...	236·93	,,	+5579·153	+5578·956	−0·197

(*Continued*)

TABLE 3.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1936-37	
			miles		*feet*	*feet*	*feet*
Revision of old lines 101 and 54A, Portion Sukkur–Quetta—(concld.)							
372(*173*)	34 O	Bridge ...	237·75	1913-14	+5551·837	+5551·632	−0·205
373(*174*)	„	Milestone ...	238·33	„	+5550·482	+5550·267	−0·215
374(*175*)	„	Bed rock ...	239·09	„	+5554·592	+5554·445	−0·147
375(*176*)	„	Bridge ...	239·61	„	+5568·907	+5568·750	−0·157
377(*177*)	„	I.B.M., (Type B) ...	240·40	„	+5589·229	+5589·084	−0·145
378(*178*)	„	Bridge ...	241·53	„	+5606·084	+5606·007	−0·077
379(*179*)	„	Bridge ...	242·66	„	+5613·235	+5613·131	−0·104
382(*181*)	„	Bridge ...	245·96	„	+5597·441	+5597·349	−0·092
3*	34 K	Platform ...	246·45	„	+5597·454	+5597·358	−0 096
4*	„	Bridge ...	246·71	„	+5596·709	+5596·617	−0·092
5 (*1*)	„	Bridge ...	247·35	„	+5596·422	+5596·309	−0·113
6 (*2*	„	Bridge ...	248·06	„	+5598·499	+5598·393	−0·106
22 (*1*)	34 J	Bridge ...	248·70	„	+5600·835	+5600·702	−0·133
23 (*2*)	„	Bridge ...	249·46	„	+5602·925	+5602·751	−0·174
24 (*3*)	„	Bridge ...	250·24	„	+5587·340	+5587·147	−0·193
25 (*4*)	„	I.B.M., (Type B) ...	251·13	„	+5663·842	+5663·640	−0·202
27 (*5*)	„	Bridge ...	253·14	„	+5502·493	+5502·230	−0·263
28 (*6*)	„	Bridge ...	253·63	„	+5481·373	+5481·083	−0·290
29 (*7*)	„	Bridge ...	254·08	„	+5461·271	+5460·938	−0·333
30 (*8*)	„	Bridge ...	254·48	„	+5443·526	+5443·163	−0·363
32 (*9*)	„	Bridge ...	255·15	„	+5428·202	+5427·783	−0·419
33 (*10*)	„	Bridge ...	255·60	„	+5415·836	+5415·381	−0·455
34 (*11*)	„	Bridge ...	256·43	„	+5404·468	+5403·940	−0·528
35 (*12*	„	Bridge ...	256·95	„	+5383·770	+5383·212	−0·558
36 (*13*)	„	Bridge ...	257·39	„	+5372·740	+5372·169	−0·571
37 (*14*)	„	Bridge ...	258·13	„	+5352·571	+5351·950	−0·621
39 (*16*)	„	Culvert ...	259·98	„	+5298·962	+5298·422	−0·540
40 (*17*)	34 J	I.B.M. (Type B) ...	261·09	„	+5254·588	+5254·059	−0·529
19 (*3*)	34 N	Bridge ...	262·35	„	+5245·307	+5244·830	−0·477
20†	„	Step ...	262·55	„	+5237·067	+5236·579	−0·488
46(PP) (*21*)	34 J	Rock-cut (Type C)	265·96	„	+5386·274	+5386·901	+0·627
23 (*5*)	34 N	Platform ...	262·95	„	+5260·670	+5260·212	−0·458
25(PP) (*8*	„	S.B.M., Quetta ...	263·51	„	+5255·553	+5255·130	−0·423
31 (*11*	„	Flooring ...	264·86	„	+5339 501	+5339·200	−0·301
38 (*16*)	„	Step ...	267·38	„	+5604 896	+5604·571	−0·325
40 (*17*)	„	Rock-cut (Type C)	269·29	„	+5815·296	+5814·977	−0·319

* These bench-marks have been shown wrongly in Degree Sheet 34 O and are numbered 182, 183/34 O.

† This bench-mark has been shown wrongly in Degree Sheet 34 J and is numbered 19/34 J.

TABLE 3.—*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 1936-37 than when originally levelled
No.	Degree sheet	Description		Date of original levelling	From published heights	From revision 1936-37	
			miles		*feet*	*feet*	*feet*
Revision of old lines 77,74 and 77 V.							
368	79 B	S.B.M., Calcutta ...	0·00	1882-83 1894-95 1899-1902	0·000	0·000	0·000
367	,,	Flooring ...	0·04	,,	− 0·496	− 0·502	−0·006
987 (*366*)	,,	Step ...	0·14	,,	− 1·650	− 1·641	+0·009
365	,,	Base of pillar ...	0·25	,,	− 0·324	− 0·348	−0·024
364	,,	Step ...	0·84	,,	+ 0·620	+ 0·596	−0·024
895 (*30*)	,,	Pavement ...	1·83	1926-27	− 0·071	− 0·086	−0·015
31	,,	Pavement ...	2·15	1862-63 1882-83	− 0·982	− 1·004	−0·022
990 (*896*), (*32*)	,,	Basement ...	3·53	1926-27	− 1·261	− 1·314	−0·053
897	,,	Stone ...	4·14	,,	+ 1·031	+ 1·025	−0·006
993 (*898*)	,,	Seat ...	4·21	,,	− 0·572	− 0·587	−0·015
353	,,	E.B.M., Calcutta ...	4·40	1882-83 1894-95 1899-1902	− 2·074	− 2·069	+0·005

TABLE 4.—*List of triangulation stations connected by spirit-levelling, season 1936–37.*

Name of station	Height above mean sea-level		Difference (Trian.—Lev.)	REMARKS
	Spirit-levelling	Trian-gulation		
	feet	*feet*	*feet*	
Baluchistān and Afghānistān Series.				
Mithri s. Lat. 29° 22′ 40″·93 Long. 67 49 3·75	396·609	400	+ 3	Top of pillar a few inches below ground level.
Dezgat h.s. Lat. 29° 31′ 44″·13 Long. 67 38 41·22	1037·062	1033	− 4	Mark-stone level with ground.
G. A. Knight 1901–02.				
Khojak h.s. Lat. 30° 51′ 24″·71 Long. 66 34 41·08	7860·526	7873	+12	Top of pillar about 1½ feet above ground level.
Chaman h.s. Lat. 30° 52′ 05″·79 Long. 66 31 28·91	5454·133	5467	+13	Mark-stone level with ground.
Great Arc Meridional Series, Section 18° to 24°.				
Bhimbat H.S. Lat. 22° 50′ 2″·06 Long. 77 37 15·53	2122	2120	− 2	Upper-mark.
Dhāba Deo H.S. Lat. 22° 5′ 19″·80 Long. 77 55 4·07	2702	2703	+ 1	Top of protecting pillar about 3 feet above upper-mark.
Jagdhar H.S. Lat. 21° 49′ 39″·40 Long. 77 58 31·22	2705	2704	− 1	Top of protecting pillar about 3 feet 6 inches above upper-mark.

CHAPTER III

GRAVITY

BY LT.-COLONEL E. A. GLENNIE, D.S.O., R.E.

20. Summary.—During the field season 1936–37 gravity observations were made at 47 stations, of which 26 were in Assam, 17 in Bengal, 3 in Bihār and one in the United Provinces. The detachment consisted of Mr. M. N. A. Hashmie, B.A., in charge (observer) and eight *khalāsis*. Apart from some malaria the health of the detachment was good.

Since the observations at Dehra Dūn in February 1937 indicated a considerable change in the times of vibration of the pendulums, repeat observations were made in October and November 1937 at six stations, and the opportunity was then taken to establish one additional gravity station in Bengal. For the sake of completeness these additional observations are included in this report. The method of observation was the same as in field season 1935–36.

21. Narrative.—Transport was mostly by rail, though occasionally local motor lorries were used. For the journey to Mokokchūng in the Nāga Hills relays of coolies were used, a march of 32 miles being accomplished in one day. To and from Aijal the transport consisted of small country boats, poled along the Dhaleswari River, which during the last 90 miles of the journey to Aijal, winds through dense jungle. Tigers, elephants and other wild animals were frequently seen. There were numerous rapids, past which the instruments had to be portaged.

Special thanks are due to the local district authorities, without whose help these two difficult journeys could not have been made.

22. Recess.—The recess work was carried out by Mr. Hashmie assisted by three computers. In addition to the computations the average height map of India was extended to Latitude 36° N., and Longitude 104° E.

Compilation of the topographic and isostatic correction data of all Survey of India gravity stations to date was also undertaken, and is published separately as a supplement to this report.

23. Results.—The times of vibration at Dehra Dūn are shown in Table 1 and 1A. In Table 2 are given the mean differences between the times of vibration for each pair of pendulums, and in Table 3 the times of vibration, the deduced value of g, and the probable error at each field station.

INDIA

PENDULUM STATIONS

Corrected to Oct. 1937

Kābul
Peshawar
Srinagar
Rāwalpindi
Nasratābād
Kandahār
Dera Ismail Khān
LAHORE
Amritsar
Quetta
Multān
Ludhiana
Dehra Dūn
DELHI
Meerut
Bīkaner
Sukkur
Jodhpur
Āgra
Lucknow
Fyzābād
Hyderābād
Karāchi
Cawnpore
Benares
Allahābād
Deesa
Kalianpur
Ahmadābād
Jubbulpore
Sambalpur
NĀGPUR
BOMBAY
Poona
Secunderābād
Waltair
Cocanāda
Belgaum
Bellary
Bangalore
MADRAS
Mangalore
Calicut
Trichinopoly
Trincomalee
Nagarkoil
Minicoy
Maldive Islands
Colombo
Laccadive Islands
Dibrugarh
Shillong
Myitkyina
Chittagong
CUTTA
Mandalay
Akyab
Prome
RANGOON
Bassein
Moulmein
Bangkok
Mergui
Port Blair
ANDAMAN ISLANDS
NICOBAR ISLANDS
SUMATRA
Lao-hai
Hanoi
Nan-ning
Saigon
GULF OF TONG-KING
GULF OF SIAM
BAY OF BENGAL
ARABIAN SEA
INDIAN OCEAN
Equator
Indus R.
Sutlej R.
Jumna R.
Ganges R.
Brahmaputra R.
Godāvari R.
Irrawaddy R.
Salween R.
Mekong R.

REFERENCE

Pendulum stations (Departmental) 104
Additions since 1936 421
Pendulum stations (Non Departmental) 35
Dr. Vening Meinesz's submarine stations (Departmental) 26

The work of Basevi and Harrison omitted from this chart which shows only the operations carried out with the half-seconds pendulums subsequently.

Scale 1 Inch=280 Miles 100 0 100 200 300 400 Miles
1,840,000

Table 4 gives the details of theoretical and observed gravity, and the Free Air, Bouguer, and Hayford or isostatic anomalies, with reference to Helmert's formula of 1901, and forms a sixth addendum to Table 2 of the Supplement to Geodetic Report Volume VI. Table 5 gives values of $g-\gamma_F$, the crustal warp anomaly, and Table 6 gives values of $g-\gamma_{CI}$, the isostatic anomaly with reference to the International gravity formula of 1930. This last table is the fourth addendum to Table 6 in Geodetic Report Volume VIII.

Probable errors computed by the method given in Geodetic Report 1934 are given in Table 3. These probable errors show the observations to be fully up to the standard of previous field seasons.

24. Changes in pendulum periods.—The times of vibration at Dehra Dūn are tabulated below:—

		A			B			C		
		s		Mean	s		Mean	s		Mean
October	1936	0·5079	242	220	0·5079	263	239	0·5079	238	218
February	1937		198			214			198	
October	1937		243	243		229	231		217	217
November	1937		243			233			216	

It will be seen that the mean values of the October 1936 and February 1937 results for pendulums B and C are not greatly different from those obtained in October and November 1937. If the difference Dehra Dūn value *minus* Field Station value of the times of vibration for individual pendulms are tabulated for the repeated stations, we get:—

Station No.	Pendulum A.				Pendulum B.				Pendulum C.			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
411	−364	−408	−386	...	...	...	...	−368	−371	−411	−391	−365
415	...	...	...	...	−368	−417	−392	−371	−380	−420	−400	−374
421	...	...	...	...	−346	−395	−370	−375	−360	−400	−380	−378
431	−173	−217	−195	...	−158	−207	−182	−185	...	...	...	−192
440	−430	−474	−452	...	−413	−462	−437	−440	...	...	...	−449
449	−513	−557	−535	...	−498	−547	−522	−515	...	...	...	−526

where the unit is seconds $\times 10^{-7}$, and

where I = Dehra Dūn October 1936 *minus* Field Station 1936–37.

II = „ February 1937 „ „ „ „

III = mean of I and II.

IV = Dehra Dūn October–November 1937 *minus* repeated value at Field Station.

Scrutiny of this table shows a change of length in all pendulums after station No. 415. The change is in the same direction

as, but smaller than, that indicated by the October 1936 and February 1937 values at Dehra Dūn.

To make this clear the differences I *minus* mean IV, II *minus* mean IV, III *minus* mean IV are tabulated below:—

Station No.	I − mean IV			II − mean IV			III − mean IV		
	A	B	C	A	B	C	A	B	C
411	**− 2**	...	**− 9**	−46	...	−49	−24	...	−29
415	...	**+ 5**	**− 7**	...	−44	−47	...	−19	−27
421	...	+31	+17	...	−18	−23	...	**+ 7**	**− 3**
431	+16	+31	...	−28	−18	...	**− 6**	**+ 7**	...
440	+15	+32	...	−29	−17	...	**− 7**	**+ 8**	...
449	+ 8	+23	...	−36	−26	...	**−14**	**− 1**	...

Those pairs which give the least difference at each station are in heavy type. Evidently after station 415 all pendulums changed length equivalent very closely to half the amount of change between the October 1936 and February 1937 swings at Dehra Dūn. Since the changes are all about the same it is not possible to detect without actual repeat observations exactly when the change occurred. There is therefore an uncertainty about stations Nos. 416, 417 418, 419 and 420. Applying half the change to these five stations, they are liable to an error of ± 4 mgals on this account.

Hence the adopted values at Dehra Dūn for the times of vibration are:—

For stations 411 to 417 inclusive, the October 1936 values.
„ „ 418 to 457 „ the mean of the October 1936 and Feb. 1937 values.
„ „ 458 „ the mean of the October and November 1937 values.

To adjust the stations between Nos. 415 and 421, a correction of −4 mgals has been applied to the value of g and to all anomalies at stations 416 and 417, and +4 mgals at stations 418, 419 and 420.

A further correction has been applied to the repeated stations so as to incorporate the October and November 1937 results. Giving double weight to the repeat observations the corrections on this account are:—

Station No.	Correction mgals.
411	+1
415	0
421	−1
431	0
440	0
449	+1

The values of g, $g-\gamma_A$, $g-\gamma_B$, $g-\gamma_{CH}$, $g-\gamma_{CI}$ and $g-\gamma_F$ in Tables 3, 4, 5, and 6 include these two corrections.

25. Consideration of results.—(*i*) The gravity results show extremely rapid variations of gravity in the Assam area. Both positive and negative anomalies are notably greater than those hitherto found in India. The value of $g-\gamma_{CH}$ at Station No. 435 is + 108 mgals and at Station No. 441 is − 120 mgals. These stations are about 160 miles apart. Between stations Nos. 435 and 447 the isostatic anomalies show a change of about 4·6 mgals per mile which is quite exceptional.

These results are perhaps not surprising in view of the obvious instability of this region.

As anticipated the Gangetic trough does not extend below the delta into the Bay of Bengal. Though locally closed in the Jalpaiguri area the trough recommences further east and then almost certainly bends south following the curve of the Arakan Yoma Range and of the Andaman and Nicobar Islands. The structure lines are shown accordingly in Chart IX.

The situation in this north-east corner of India is strikingly similar to that in the north-west corner, where the Indo-Gangetic trough is closed west of Dehra Dūn, recommences near Pathānkot and then curves south through Dera Ghāzi Khān to the Rann of Cutch. In each case the peninsular projection round which the trough bends shows high positive anomalies, but the greater stability of the north-west area is indicated by comparatively small negative anomalies in the trough there.

(*ii*) In the Madhupur jungle of Bengal a lateritic exposure occurs, unusual in an area which otherwise appears to be wholly alluvial. The Director of the Geological Survey of India drew attention to this, and observations were made over this exposure at Madhupur, Station No. 458. The local warp anomalies ($g-\gamma_F$) indicate a spur extending down under this area from the Gāro Hills. One would expect that the strike of the tertiary rocks where they emerge from the alluvium would be in conformity with this spur but this is not the case.*

(*iii*) On the return journey to Dehra Dūn in February 1937 three supplementary gravity stations were established to fix more definitely the southern margin of the Gangetic trough. It is now evident from Chart VIII that the Vindhyan downwarp south-east of the Arāvallis is quite separate from the Gangetic downwarp.

26. Local and normal warp anomalies.—The $g-\gamma_F$ anomalies are intended to indicate the local crustal warpings after eliminating the effect of the broad Hidden Range warpings. Chart XII represents the $g-\gamma_F$ anomalies with the Hidden Range effect re-introduced, and may be termed the chart of 'Normal warp anomalies'.

It is interesting to compare this chart with Chart X and with the Geoid charts given in Geodetic Report 1936, Chapter III.

* I am indebted to Mr. P. Evans, Chief Geologist, Burma Oil Company, Assam, for this information.

TABLE 1.—*Times of vibration at Dehra Dūn, season 1936–37.*

Date	A	Weight	B	Weight	C	Weight
1936	s		s		s	
October 9 ...	0·507 9259	10	0·507 9273	10		
,, 10 ...	9208	6	9225	6		
,, 10 ...	9281	8	9295	8		
,, 13 ...	9241	8	9257	8		
,, 10 ...			9266	8	0·507 9244	8
,, 11 ...			9268	6	9244	6
,, 11 ...			9249	8	9225	8
,, 11 ...	9230	8			9240	8
,, 11 ...	9233	6			9242	6
,, 11 ...	9229	8			9236	8
Weighted mean ...	0·507 9242	...	0·507 9263	...	0·507 9238	...

Date	A	Weight	B	Weight	C	Weight
1937	s		s		s	
February 25 ...	0·507 9198	10			0·507 9201	10
,, 26 ...	9191	6			9194	6
,, 26 ...	9197	8			9199	8
,, 26 ...			0·507 9216	8	9198	8
,, 27 ...			9219	6	9194	6
,, 27 ...			9216	8	9199	8
,, 27 ...	9206	8	9214	8		
,, 28 ...	9188	6	9205	6		
,, 28 ...	9204	8	9215	8		
Weighted mean ...	0·507 9198	...	0·507 9214	...	0·507 9198	...

Adopted mean times of vibration.

Stations	A	B	C
	s	s	s
411 to 417 inclusive ...	0·507 9242	0·507 9263	0·507 9238
418 to 457 inclusive ...	0·507 9220	0·507 9239	0·507 9218

TABLE 1A.—*Times of vibration at Dehra Dūn, season 1937–38.*

Date	A	Weight	B	Weight	C	Weight
1937	s		s		s	
October 2 ...	0·507 9255	8			0·507 9244	8
,, 2 ...	9238	14			9217	14
,, 3 ...			0·507 9229	8	9213	8
,, 3 ...			9211	6	9191	6
,, 4 ...			9222	8	9207	8
,, 4 ...	9258	8	9248	8		
,, 4 ...	9266	6	9248	6		
,, 5 ...	9241	8	9229	8		
,, 5 ...	9251	8			9240	8
,, 5 ...	9241	6			9217	6
,, 6 ...	9235	8			9221	8
,, 6 ...			9229	8	9217	8
,, 6 ...			9230	6	9215	6
,, 7 ...			9206	8	9194	8
,, 7 ...	9236	10	9238	10		
,, 8 ...	9224	8	9224	8		
Weighted mean ...	0·507 9243	...	0·507 9229	...	0·507 9217	...

Date	A	Weight	B	Weight	C	Weight
1937	s		s		s	
November 13 ...			0·507 9221	8	0·507 9214	8
,, 13 ...			9225	6	9212	6
,, 14 ...			9214	8	9205	8
,, 14 ...	0·507 9257	6	9250	6		
,, 15 ...	9242	8	9238	8		
,, 16 ...	9255	8	9252	8		
,, 15 ...	9231	8			9225	8
,, 15 ...	9234	6			9203	6
,, 16 ...	9243	8			9234	8
Weighted mean ...	0·507 9243	...	0·507 9233	...	0·507 9216	...

Adopted mean times of vibration.

	A	B	C
	s	s	s
General mean ...	0·507 9243	0·507 9231	0·507 9217

TABLE 2.—*Mean differences of pairs of pendulums, season 1936–37.*
(The unit is 10^{-7} sec.)

Station No.	A–C	v	Station No.	C–B	v	Station No.	B–A	v
411	− 3·0	+ 1·9	412	−14·9	− 4·6	413	+ 6·5	− 1·1
414	− 3·5	+ 1·4	415	−13·2	− 2·9	416	+15·1	+ 7·5
417	−11·1	− 6·2	418	−13·0	− 2·7	419	+13·0	+ 5·4
420	− 2·6	+ 2·3	421	−11·0	− 0·7	422	+10·4	+ 2·8
423	− 6·6	− 1·7	424	− 8·8	+ 1·5	425	+ 5·5	− 2·1
426	− 6·3	− 1·4	427	− 6·6	+ 3·7	428	+ 8·3	+ 0·7
429	− 4·9	0·0	430	− 4·9	+ 5·4	431	+ 5·3	− 2·3
432	− 5·7	− 0·8	433	−10·7	− 0·4	434	+ 4·9	− 2·7
435	− 5·5	− 0·6	436	− 7·4	+ 2·9	437	+ 2·7	− 4·9
438	− 3·4	+ 1·5	439	− 4·6	+ 5·7	440	+ 3·9	− 3·7
441	− 3·8	+ 1·1	442	− 9·5	+ 0·8	443	+ 2·2	− 5·4
444	− 2·1	+ 2·8	445	+ 1·3	+11·6	446	+ 3·0	− 4·6
447	− 5·3	− 0·4	448	− 7·3	+ 3·0	449	+ 6·0	− 1·6
450	− 3·9	+ 1·0	451	− 9·6	+ 0·7	452	+ 7·6	0·0
453	− 5·6	− 0·7	454	− 9·0	+ 1·3	455	+ 9·0	+ 1·4
456	− 3·5	+ 1·4				457	+ 7·3	− 0·3

Station No.	C–B	v	Station No.	C–B	v	Station No.	C–B	v
411*	− 6·6	+ 2·8	421*	−11·0	− 1·6	440*	− 5·2	+ 4·2
415*	−11·0	− 1·6	431*	− 7·0	+ 2·4	449*	− 2·4	+ 7·0
						458	−12·4	− 3·0

* Repeat stations.

TABLE 3.—*Mean times of vibration, deduced values of g and probable errors, season 1936–37.*

Station No.		Pendulums A	Pendulums B	Pendulums C	Mean	Probable error of Mean
						sec × 10^{-7}
411	*s*	0·507 9606	0·507 9589*	0·507 9609	0·507 9593	± 1·17
				0·507 9582*		
	g	978·923	978·925*	978·920	978·923	
				978·922*		
412	*s*		0·507 9508	0·507 9493	0·507 9501	1·71
	g		978·968	978·965	978·967	
413	*s*	0·507 9448	0·507 9454		0·507 9451	1·29
	g	978·984	978·989		978·987	
414	*s*	0·507 9626		0·507 9629	0·507 9628	1·29
	g	978·915		978·912	978·914	
415	*s*		0·507 9631	0·507 9618	0·507 9606	1·42
			0·507 9602*	0·507 9591*		
	g		978·921	978·917	978·919	
			978·920*	978·919*		
416	*s*	0·507 9681	0·507 9696		0·507 9689	2·51
	g	978·890	978·892		978·891	
417	*s*	0·507 9618		0·507 9629	0·507 9624	2·02
	g	978·914		978·908	978·911	
418	*s*		0·507 9723	0·507 9710	0·507 9717	1·56
	g		978·880	978·877	978·879	
419	*s*	0·507 9808	0·507 9821		0·507 9815	1·79
	g	978·840	978·843		978·842	
420	*s*	0·507 9763		0·507 9765	0·507 9764	1·12
	g	978·858		978·856	978·857	
421	*s*		0·507 9609	0·507 9598	0·507 9602	1·50
			0·507 9606*	0·507 9595*		
	g		978·920	978·917	978·918	
			978·918*	978·917*		
422	*s*	0·507 9584	0·507 9594		0·507 9589	1·43
	g	978·923	978·926		978·925	
423	*s*	0·507 9370		0·507 9376	0·507 9373	1·43
	g	979·005		979·002	979·004	
424	*s*		0·507 9614	0·507 9605	0·507 9610	1·50
	g		978·918	978·915	978·917	
425	*s*	0·507 9423	0·507 9428		0·507 9426	1·40
	g	978·985	978·990		978·988	
426	*s*	0·507 9433		0·507 9439	0·507 9436	1·08
	g	978·981		978·978	978·980	

* Values from 1937 repetition.

(*Continued*)

TABLE 3.—*Mean times of vibration, deduced values of g and probable errors, season 1936–37—(contd.)*

Station No.		Pendulums A	Pendulums B	Pendulums C	Mean	Probable error of Mean
						sec × 10^{-7}
427	*s*		0·507 9525	0·507 9518	0·507 9522	± 1·77
	g		978·953	978·947	978·950	
428	*s*	0·507 9455	0·507 9463		0·507 9459	1·45
	g	978·972	978·977		978·975	
429	*s*	0·507 9501		0·507 9506	0·507 9504	1·26
	g	978·955		978·952	978·954	
430	*s*		0·507 9415	0·507 9410	0·507 9413	1·77
	g		978·995	978·989	978·992	
431	*s*	0·507 9415	0·507 9421		0·507 9415	1·42
			0·507 9416*	0·507 9409*		
	g	978·988	978·993		978·991	
			978·992*	978·989*		
432	*s*	0·508 0183		0·508 0189	0·508 0186	1·25
	g	978·692		978·689	978·691	
433	*s*		0·507 9663	0·507 9652	0·507 9658	1·89
	g		978·900	978·896	978·898	
434	*s*	0·507 9745	0·507 9750		0·507 9748	1·42
	g	978·861	978·866		978·864	
435	*s*	0·507 9725		0·507 9731	0·507 9728	1·26
	g	978·868		978·865	978·867	
436	*s*		0·507 9581	0·507 9574	0·507 9578	1·14
	g		978·931	978·926	978·929	
437	*s*	0·508 0303	0·508 0306		0·508 0305	1·78
	g	978·646	978·652		978·649	
438	*s*	0·508 0195		0·508 0199	0·508 0197	1·29
	g	978·687		978·685	978·686	
439	*s*		0·507 9585	0·507 9581	0·507 9583	1·99
	g		978·930	978·923	978·927	
440	*s*	0·507 9672	0·507 9676		0·507 9670	1·56
			0·507 9671*	0·507 9666*		
	g	978·889	978·895		978·892	
			978·893*	978·890*		
441	*s*	0·507 9726		0·507 9730	0·507 9728	1·33
	g	978·868		978·866	978·867	
442	*s*		0·508 0345	0·508 0335	0·508 0340	1·46
	g		978·637	978·632	978·635	
443	*s*	0·507 9592	0·507 9594		0·507 9593	1·89
	g	978·920	978·926		978·923	

* Values from 1937 repetition.

(*Continued*)

TABLE 3.—*Mean times of vibration, deduced values of g and probable errors, season 1936–37—(concld.)*

Station No.		Pendulums A	Pendulums B	Pendulums C	Mean	Probable error of Mean
						sec × 10^{-7}
444	*s*	0·507 9566		0·507 9569	0·507 9568	± 1·41
	g	978·930		978·928	978·929	
445	*s*		0·507 9556	0·507 9557	0·507 9557	2·98
	g		978·941	978·932	978·937	
446	*s*	0·507 9648	0·507 9651		0·507 9650	1·72
	g	978·898	978·904		978·901	
447	*s*	0·507 9722		0·507 9727	0·507 9725	1·27
	g	978·869		978·867	978·868	
448	*s*		0·508 0417	0·508 0409	0·508 0413	1·42
	g		978·609	978·604	978·607	
449	*s*	0·507 9755	0·507 9761		0·507 9749	1·40
			0·507 9746*	0·507 9743*		
	g	978·857	978·862		978·861	
			978·864*	978·860*		
450	*s*	0·507 9964		0·507 9968	0·507 9966	1·32
	g	978·776		978·774	978·775	
451	*s*		0·507 9878	0·507 9868	0·507 9873	1·50
	g		978·817	978·812	978·815	
452	*s*	0·507 9865	0·507 9872		0·507 9869	1·54
	g	978·814	978·819		978·817	
453	*s*	0·507 9850		0·507 9856	0·507 9853	0·92
	g	978·820		978·817	978·819	
454	*s*		0·507 9884	0·507 9875	0·507 9880	1·29
	g		978·814	978·810	978·812	
455	*s*	0·507 9638	0·507 9647		0·507 9643	1·44
	g	978·902	978·906		978·904	
456	*s*	0·507 9529		0·507 9533	0·507 9531	1·30
	g	978·944		978·942	978·943	
457	*s*	0·507 9446	0·507 9454		0·507 9450	1·47
	g	978·976	978·980		978·978	
458	*s*		0·507 9582	0·507 9570	0·507 9576	1·89
	g		978·928	978·927	978·928	

* Values from 1937 repetition.

TABLE 4.—*Modern gravity observations in India.*
(Additions in field season 1936–37)

No.	Sheet No.	Station	Date	Height	Latitude N.	Longitude E.	g	$g-\gamma_A$	$g-\gamma_B$	$g-\gamma_C$
				feet	° ′ ″	° ′ ″	*cm/sec²*	*cm/sec²*	*cm/sec²*	*cm/sec²*
411	72 O	Katihār ...	20 10 36	104	25 32 35	87 34 20	978·923	−·057	−·061	−·023
412	78 G	Rangpur ...	23 10 36	110	25 45 14	89 15 23	978·967	−·028	−·032	+·015
413	78 F	Cooch Behār ...	26 10 36	155	26 19 08	89 27 24	978·987	−·043	−·048	+·026
414	78 F	Dalsingpāra ...	28 10 36	514	26 46 55	89 22 05	978·914	−·116	−·131	−·006
415	78 H	Bogra ...	30 10 36	62	24 50 50	89 22 30	978·919	−·017	−·019	+·007
416	78 D	Nator ...	1 11 36	48	24 24 30	88 57 56	978·891	−·016	−·018	+·001
417	78 H	Sirājganj ...	3 11 36	43	24 26 50	89 44 20	978·911	+·001	000	+·020
418	79 E	Kushtia ...	5 11 36	48	23 54 33	89 07 40	978·879	+·006	+·004	+·020
419	79 E	Farīdpur ...	7 11 36	22	23 35 25	89 50 40	978·842	−·013	−·014	−·001
420	79 I	Dacca ...	10 11 36	26	23 43 25	90 24 35	978·857	−·007	−·008	+·007
421	78 L	Mymensingh ...	13 11 36	49	24 46 02	90 24 02	978·918	−·013	−·015	+·013
422	78 G	Bahādurābād ...	15 11 36	69	25 09 40	89 45 53	978·925	−·032	−·034	−·004
423	78 F	Dhubri ...	18 11 36	106	26 01 16	89 55 55	979·004	−·010	−·014	+·043
424	78 K	Tura ...	20 11 36	1420	25 30 45	90 13 35	978·917	+·062	+·021	+·069
425	78 J	Bijni ...	23 11 36	153	26 29 10	90 43 15	978·988	−·055	−·060	+·020
426	78 N	Rangia ...	25 11 36	174	26 26 13	91 37 27	978·980	−·057	−·062	+·017
427	83 B	Rangapāra ...	27 11 36	387	26 48 50	92 41 10	978·950	−·095	−·107	−·003
428	83 B	Silghāt ...	29 11 36	234	26 36 24	92 55 57	978·975	−·069	−·077	+·007
429	83 B	Nowgong ...	1 12 36	203	26 20 53	92 41 13	978·954	−·074	−·081	−·010
430	83 B	Dharamtūl ...	3 12 36	186	26 10 00	92 21 28	978·992	−·025	−·031	+·037
431	78 N	Gauhāti ...	5 12 36	174	26 11 00	91 45 10	978·991	−·028	−·034	+·037
432	78 O	Shillong ...	7 12 36	5021	25 33 55	91 53 42	978·691	+·169	+·004	+·090
433	78 P	Sylhet ...	10 12 36	45	24 53 15	91 52 25	978·898	−·043	−·044	−·006
434	78 P	Shāistaganj ...	12 12 36	28	24 16 30	91 27 20	978·864	−·036	−·037	−·011
435	83 G	Hāflang ...	14 12 36	2240	25 10 53	93 01 20	978·867	+·112	+·039	+·108
436	83 G	Lumding ..	16 12 36	468	25 45 10	93 10 55	978·929	−·032	−·047	+·018
437	83 K	Kohima ...	19 12 36	4678	25 40 15	94 06 30	978·649	+·088	−·065	+·043
438	83 H	Imphal ...	21 12 36	2572	24 48 30	93 56 28	978·686	−·012	−·098	−·010
439	83 F	Golāghāt ...	24 12 36	323	26 30 45	93 58 08	978·927	−·102	−·113	−·034
440	83 J	Jorhāt ...	26 12 36	289	26 45 10	94 12 50	978·892	−·157	−·166	−·083
441	83 I	Lakhimpur N.	28 12 36	326	27 14 20	94 06 28	978·867	−·214	−·224	−·120
442	83 J	Mokokchūng ...	2 1 37	4400	26 19 20	94 31 18	978·635	+·002	−·133	−·027
443	83 M	Mārgherita ...	6 1 37	490	27 17 10	95 40 40	978·923	−·146	−·161	−·056
444	83 M	Saikhoa Ghāt ...	8 1 37	400	27 46 33	95 36 36	978·929	−·185	−·198	−·080
445	83 I	Dibrugarh ...	10 1 37	341	27 29 18	94 54 42	978·937	−·161	−·172	−·068
446	83 J	Nāzira ...	12 1 37	336	26 54 15	94 43 54	978·901	−·155	−·166	−·077
447	83 D	Silchar ...	15 1 37	72	24 49 40	92 48 00	978·868	−·065	−·067	−·018
448	84 A	Aijal ...	22 1 37	3768	23 43 00	92 43 22	978·607	+·095	−·020	+·042
449	79 M	Comilla ...	28 1 37	28	23 28 00	91 10 00	978·861	+·015	+·014	+·030
450	79 N	Chittagong ...	30 1 37	30	22 20 02	91 49 58	978·775	+·003	+·002	+·017
451	84 B	Rāngāmāti ...	1 2 37	300	22 38 25	92 12 50	978·815	+·048	+·040	+·070
452	79 N	Noākhāli ...	4 2 37	19	22 49 35	91 06 10	978·817	+·012	+·011	+·022

(*Continued*)

TABLE 4.—*Modern gravity observations in India.*
(Additions in field season 1936–37)—(*concld.*)

No.	Sheet No.	Station	Date	Height	Latitude N.	Longitude E.	g	$g-\gamma_A$	$g-\gamma_B$	$g-\gamma_C$
				feet	° ′ ″	° ′ ″	*cm/sec²*	*cm/sec²*	*cm/sec²*	*cm/sec²*
453	79 J	Barisāl ...	6 2 37	10	22 42 00	90 20 25	978·819	+·021	+·021	+·028
454	79 F	Khulna ...	9 2 37	12	22 48 48	89 34 22	978·812	+·007	+·007	+·014
455	72 K	Mansi ...	12 2 37	126	25 30 30	86 33 30	978·904	−·072	−·076	−·039
456	72 B	Rajāpatti ...	14 2 37	193	26 12 30	84 47 50	978·943	−·076	−·083	−·038
457	54 N	Jālaun ...	18 2 37	467	26 08 44	79 19 35	978·978	−·011	−·027	+·005
458	78 L	Madhupur ...	24 10 37	45	24 36 16	90 01 41	978·928	+·007	+·005	+·028

NOTE: – This table is the sixth addendum to Table 2 of the Supplement to Geodetic Report Vol. VI.

TABLE 5.—*Values of* $g-\gamma_F$.
(The unit is 1 mgal.)

Station No.	Corrections to $g-\gamma_{CH}$: Compensation	Hidden Range	Spheroid S. of I. II	$g-\gamma_F$	Station No.	Corrections to $g-\gamma_{CH}$: Compensation	Hidden Range	Spheroid S. of I. II	$g-\gamma_F$
411	− 1	+ 8	+29	+13	435	−18	+ 2	+29	+121
412	− 1	+12	+29	+55	436	− 7	+ 9	+29	+ 49
413	− 2	+18	+30	+72	437	−38	+ 7	+29	+ 41
414	−15	+22	+30	+31	438	−28	− 4	+28	+ 14
415	− 1	+ 2	+28	+36	439	− 5	+16	+30	+ 7
416	0	+ 4	+28	+33	440	− 4	+18	+30	− 39
417	0	+ 4	+28	+52	441	− 7	+23	+30	− 74
418	0	−10	+27	+37	442	−27	+14	+30	− 10
419	0	−14	+27	+12	443	−12	+20	+31	− 17
420	0	−12	+27	+22	444	− 5	+24	+31	− 30
421	− 1	+ 1	+28	+41	445	− 4	+22	+31	− 19
422	− 1	+ 5	+29	+29	446	− 6	+18	+30	− 35
423	− 1	+16	+30	+88	447	− 3	0	+28	+ 7
424	−10	+ 9	+29	+97	448	−21	−14	+27	+ 34
425	− 2	+20	+30	+68	449	− 1	−16	+27	+ 40
426	− 2	+19	+30	+64	450	0	−26	+26	+ 17
427	− 5	+20	+30	+42	451	− 5	−24	+26	+ 67
428	− 3	+18	+30	+52	452	0	−21	+27	+ 28
429	− 2	+16	+30	+34	453	0	−22	+26	+ 32
430	− 4	+14	+30	+77	454	0	−21	+27	+ 20
431	− 5	+15	+30	+77	455	− 1	+ 5	+29	− 6
432	−36	+10	+29	+93	456	− 2	+ 8	+30	− 2
433	− 1	+ 2	+28	+23	457	− 5	− 9	+30	+ 21
434	− 1	− 8	+28	+ 8	458	0	+ 3	+28	+ 59

TABLE 6.—*Values of* $g-\gamma_{CI}$.

(The unit is 1 mgal.)

Station No.	$g-\gamma_{CI}$	Station No.	$g-\gamma_{CI}$	Station No.	$g-\gamma_{CI}$
411	−40	429	− 27	447	−36
412	− 2	430	+ 19	448	+24
413	+ 9	431	+ 20	449	+13
414	−23	432	+ 73	450	− 1
415	−10	433	− 23	451	+52
416	−16	434	− 28	452	+ 4
417	+ 2	435	+ 91	453	+11
418	+ 2	436	+ 1	454	− 3
419	−18	437	+ 26	455	−56
420	−10	438	− 27	456	−55
421	− 5	439	− 51	457	−12
422	−22	440	−100	458	+11
423	+26	441	−137		
424	+52	442	− 44		
425	+ 3	443	− 73		
426	− 1	444	− 98		
427	−20	445	− 85		
428	−10	446	− 94		

NOTE:—This table is the fourth addendum to Table 6 of Chapter IV, Geodetic Report Vol. VIII.

INDIA

LATITUDE STATIONS

Corrected to Sept. 1937

Kābul
Peshāwar
Srīnagar
Rāwalpindi
Nasratābād
Kandahār
Dera Ismail Khān
LAHORE
Amritsar
Quetta
Multān
Ludhiāna
Dehra Dūn
Meerut
DELHI
Bikaner
Sukkur
Agra
Lucknow
Fyzābād
Jodhpur
Cawnpore
Hyderābād
Karāchi
Allahābād
Benares
Deesa
Kalianpur
Ahmadābād
Jubbulpore
Sambalpur
NĀGPUR
BOMBAY
Poona
Waltair
Secunderabad
Cocanāda
Belgaum
Bellary
Mangalore
Bangalore
MADRAS
Calicut
Trichinopoly
Trincomalee
Minicoy
Nagarkoil
CEYLON
Colombo
Dibrugarh
Shillong
Myitkyina
Chittagong
CALCUTTA
Mandalay
Akyab
Prome
Bassein
RANGOON
Moulmein
Bangkok
Mergui
Nan-ning
Lao-hai
Hanoi
Saigon
ANDAMAN ISLANDS
Port Blair
NICOBAR ISLANDS
SUMATRA
Brahmaputra R.
Indus R.
Sutlej R.
Jumna R.
Ganges R.
Irrawaddy R.
Salween R.
Mekong R.
Chindwin R.
Godavari R.
Kizil Rabāt
ARABIAN SEA
BAY OF BENGAL
GULF OF SIAM
GULF OF TONG-KING

Latitude stations (Departmental)
Additions since 1936
Latitude stations (Non Departmental & Foreign)

Where stations are close together some are omitted.

Scale 1 Inch = 5,840,000
Miles 100 0 100 300 400 Miles

INDIA

LONGITUDE STATIONS

Corrected to Sept. 1937

Kābul
Peshāwar
Srīnagar
Rāwalpindi
Indus R.
Nasratābād
Kandahār
Dera Ismail Khān
LAHORE
Amritsar
Ludhiāna
Sutlej R.
Quetta
Multān
Dehra Dūn
Brahmaputra R.
Meerut
DELHI
Jumna R.
Sukkur
Bikaner
Agra
Lucknow
Fyzābād
Jodhpur
Cawnpore
Benares
Ganges R.
Hyderābād
Karāchi
Allahābād
Deesa
Kalianpur
Ahmadābād
Jubbulpore
CALCUTTA
Chittagong
Sambalpur
NĀGPUR
Akyab
Irrawaddy R.
Prome
BOMBAY
Poona
Waltair
Sodāvari R.
Secunderabad
Cocanāda
Salween R.
Bassein
RANGOON
Moulmein
Belgaum
Bellary
Mangalore
Bangalore
MADRAS
Calicut
Trichinopoly
Minicoy
Nagarkoil
Trincomalee
CEYLON
Colombo
Dibrugarh
Shillong
Myitkyinā
Mandalay
Chindwin R.
Mekong R.
Lao-hai
Nan-ning
Hanoi
GULF OF TONG-KING
Bangkok
Mergui
Saigon
GULF OF SIAM
ANDAMAN ISLANDS
Port Blair
NICOBAR ISLANDS
SUMATRA
Osh
Kizil Rabat
from Aden
from Basra
from Jask

REFERENCE

Telegraphic Longitude stations
Longitude arcs
Wireless Longitude stations (Oriental)
Longitude stations (Non Oriental)
Chronometer Longitude stations (do)

Scale 1 Inch = 28,840,000
Miles 100 0 100 300 400 Miles

29 33 38 43 52 30 34 39 44 53 62 31 35 40 45 54 63 72 36 41 46 55 64 73 47 56 65 74 48 57 66 49 58 67 59 68 78 83 92 101 110 79 84 93 102 111 85 94 103 112 86 95 104 113 87 96 105 114 88 97 106

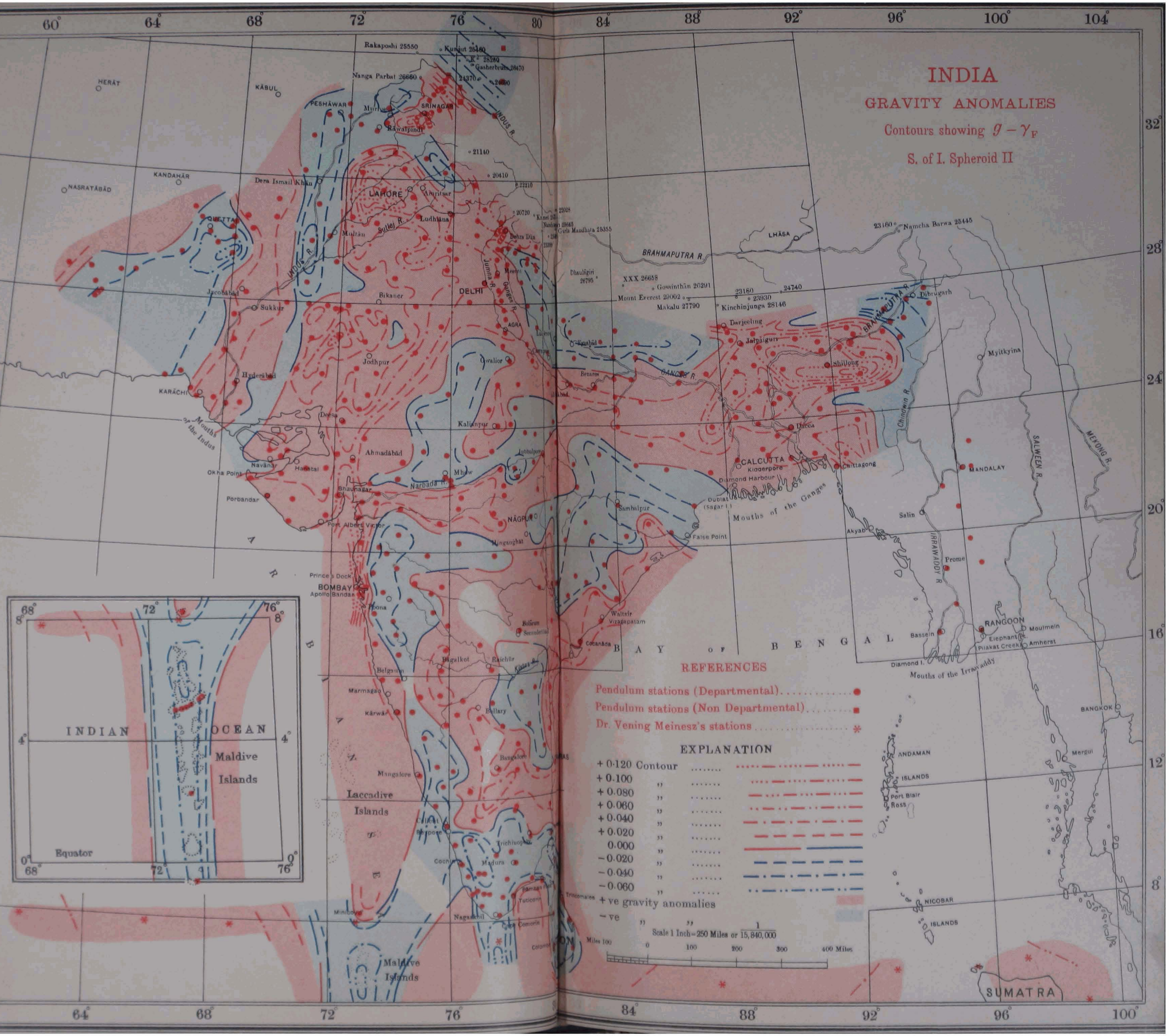
60° 64° 68° 72° 76° 80° 84° 92° 96° 100° 104° 108° 112° 40° 36° 32° 28° 24° 20° 16° 12° 8° 4°

INDIA

GRAVITY ANOMALIES

Contours showing $g - \gamma_F$

S. of I. Spheroid II



REFERENCES

Pendulum stations (Departmental).....

Pendulum stations (Non Departmental).....

Dr. Vening Meinesz's stations.....

EXPLANATION

+0·120 Contour	.....
+0·100	,, ...
+0·080	,, ...
+0·060	,, ...
+0·040	,, ...
+0·020	,, ...
0·000	,, ...
−0·020	,, ...
−0·040	,, ...
−0·060	,, ...

+ve gravity anomalies

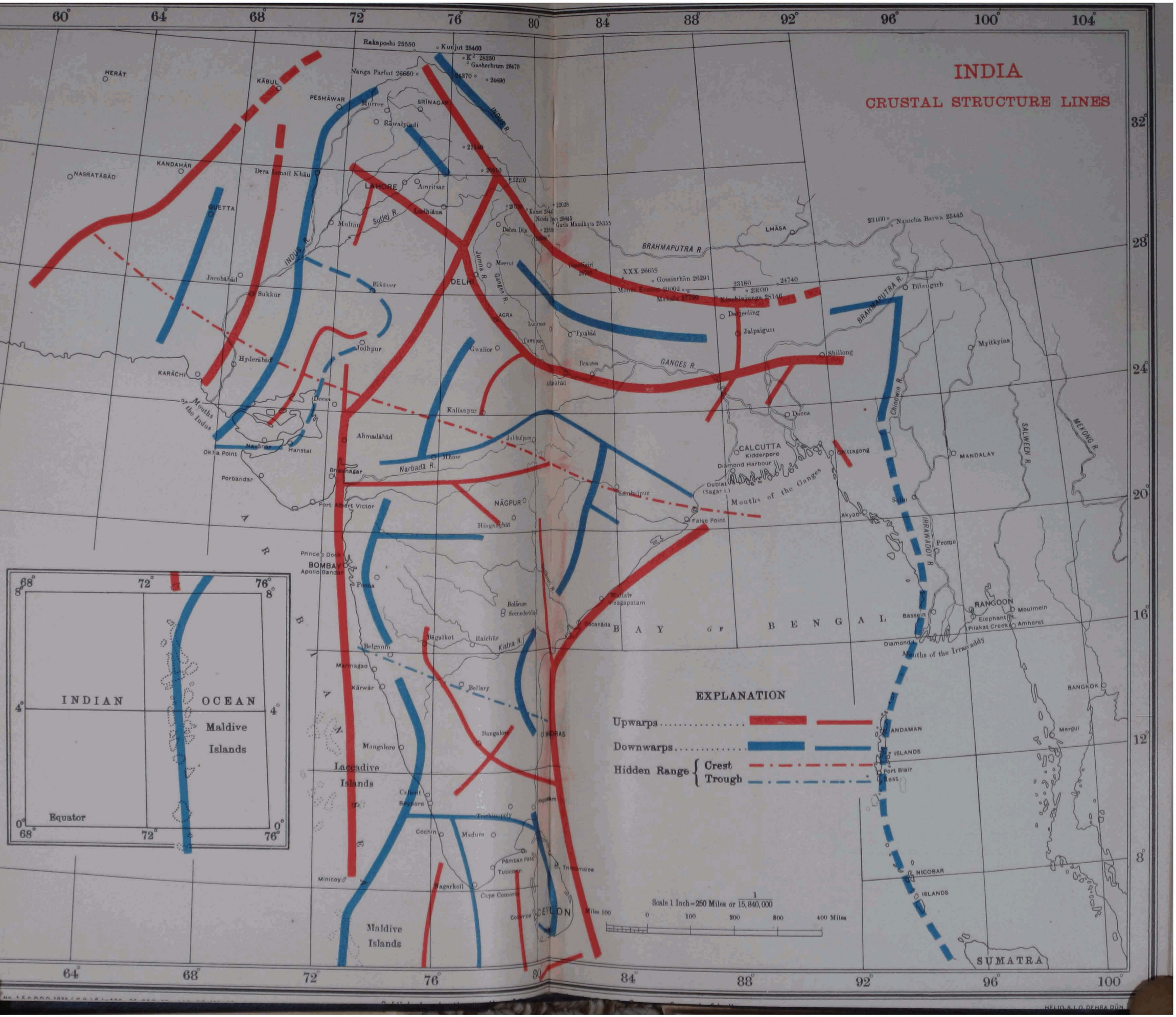
−ve ,, ,,

Scale 1 Inch = 250 Miles or $\frac{1}{15,840,000}$

Miles 100 0 100 200 300 400 Miles

INDIA

CRUSTAL STRUCTURE LINES



INDIA

GRAVITY ANOMALIES

(Hayford)

Contours showing $g - \gamma_{CH}$

from data up to Sept. 1937

(Helmert's formula of 1901)

Rakaposhi 25550 · Kunjut 25460 · 28250 · Gasherbrum 26470 · Nanga Parbat 26660 · 24370 · 24890 · 21110 · 20410 · 22210 · 20720 · 22028 · Kamet 25447 · Nanda Devi 25645 · Garla Mandhata 25355 · 22650 · 23899 · Dhaulāgiri 26795 · XXX 26858 · Gosainthān 26291 · Mount Everest 29002 · Makalu 27790 · 33180 · 24740 · 23030 · Kinchinjunga 28146 · 23160 · Namcha Barwa 25445

HERÁT · KÁBUL · PESHAWAR · Murree · SRINAGAR · Rawalpindi · INDUS R. · NASRATĀBĀD · KANDAHĀR · Dera Ismail Khān · LAHORE · Amritsar · QUETTA · Multān · Sutlej R. · Ludhiāna · Dehra Dūn · LHĀSA · BRAHMAPUTRA R. · Jacobābād · Sukkur · Bikaner · DELHI · Jumna R. · Ganges R. · Meerut · AGRA · Lucknow · Fyzabad · Cawnpore · Benares · Jodhpur · Gwalior · Hyderābād · KARĀCHI · Mouths of the Indus · Deesa · Kaliānpur · Allahābād · Jubbulpore · Ahmadābād · Navānar · Okha Point · Hansfal · Bhaunagar · Porbandar · Narbadā R. · Mhow · NAGPUR · Port Albert Victor · Hingaghat · Sambulpur · Dubiat (Sagar I.) · False Point · Mouths of the Ganges · CALCUTTA · Kidderpore · Diamond Harbour · Dacca · Chittagong · Akyab · Saiu · Prome · IRRAWADDY R. · Dibrugarh · BRAHMAPUTRA R. · Darjeeling · Jalpaiguri · Shillong · Myitkyina · Chindwin R. · MANDALAY · SALWEEN R. · MEKONG R.

Prince's Dock · BOMBAY · Apollo Bandar · Poona · Bolārum · Secunderābād · Waltair · Vizagapatam · Cocanāda · Belgaum · Bāgalkot · Raichūr · Kistna R. · Marmagao · Kārwār · Bellary · Bangalore · MADRAS · Mangalore · Calicut · Beypore · Trichinopoly · Cochin · Madura · Pamban Pass · Tuticorin · Trincomalee · Minicoy · Nagarkoil · Cape Comorin · Colombo · CEYLON · Laccadive Islands · Maldive Islands · B A Y O F B E N G A L · BASSEIN · RANGOON · Elephant Pt. · Moulmein · Pilakat Creek · Amherst · Diamond I. · Mouths of the Irrawaddy · BANGKOK · Mergui · ANDAMAN ISLANDS · Port Blair · Ross · NICOBAR ISLANDS · SUMATRA

INDIAN OCEAN · Maldive Islands · Equator

REFERENCES

Pendulum stations (Departmental) ●

Pendulum stations (Non Departmental) ■

Dr. Vening Meinesz's stations *

EXPLANATION

+0·100 Contour

+0·080 "

+0·060 "

+0·040 "

+0·020 "

0·000 "

−0·020 "

−0·040 "

−0·060 "

−0·080 "

−0·100 "

−0·120 "

\+ ve gravity anomalies

− ve " "

Scale 1 Inch = 250 Miles or $\frac{1}{15,840,000}$

Miles 100 0 100 200 300 400 Miles

INDIA

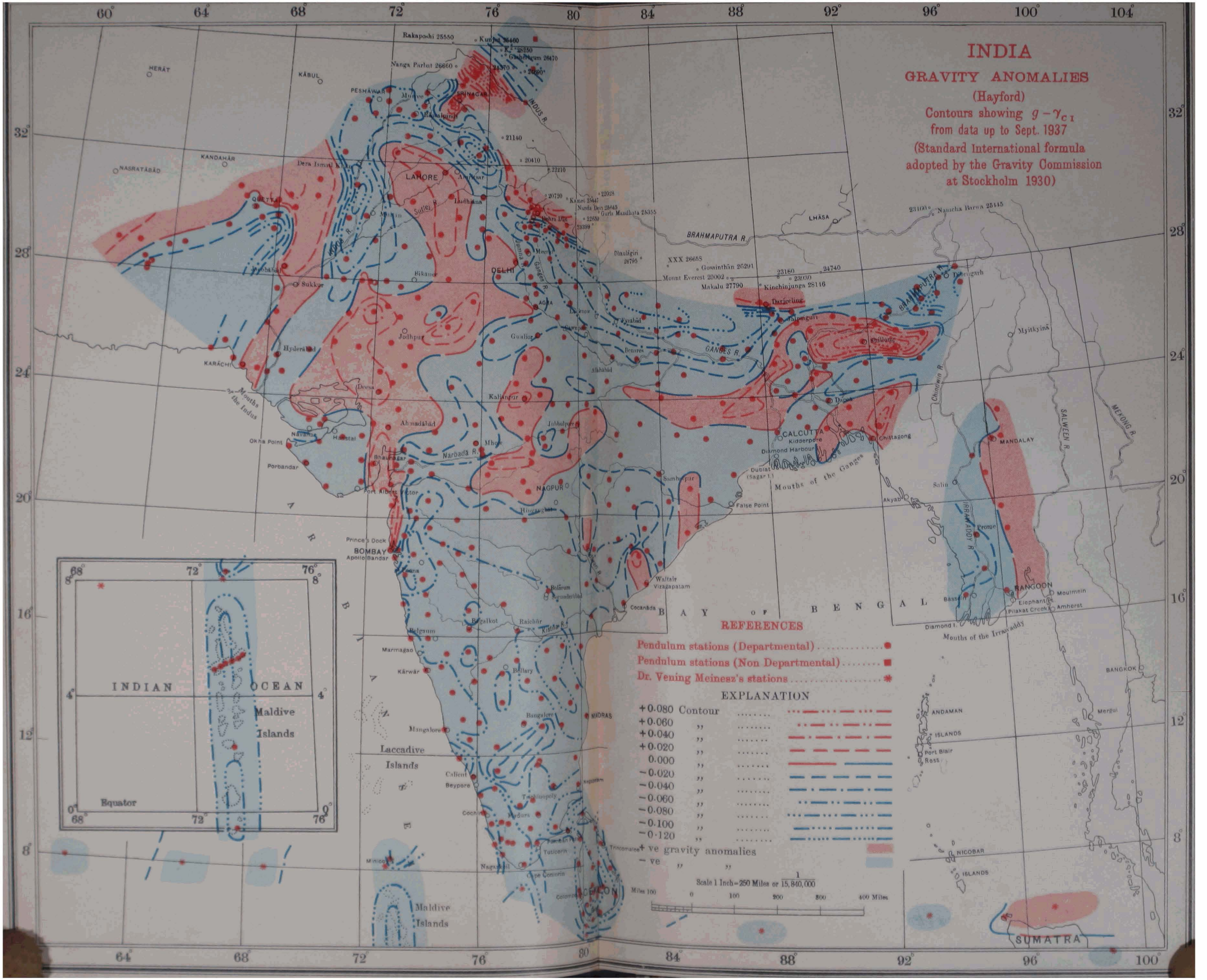
GRAVITY ANOMALIES

(Hayford)

Contours showing $g - \gamma_{c1}$

from data up to Sept. 1937

(Standard International formula adopted by the Gravity Commission at Stockholm 1930)



REFERENCES

Pendulum stations (Departmental) ●

Pendulum stations (Non Departmental) ■

Dr. Vening Meinesz's stations ✱

EXPLANATION

+0·080	Contour
+0·060	,,
+0·040	,,
+0·020	,,
0·000	,,
−0·020	,,
−0·040	,,
−0·060	,,
−0·080	,,
−0·100	,,
−0·120	,,

+ ve gravity anomalies

− ve ,, ,,

Scale 1 Inch = 250 Miles or $\frac{1}{15,840,000}$

Miles 100 0 100 200 300 400 Miles

INDIA

NORMAL WARP ANOMALIES

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

32° 28° 24° 20° 16° 12° 8°

HERÁT · KÁBUL · PESHÁWAR · KANDAHÁR · NASRATÁBÁD · QUETTA · Dera Ismail Khan · LAHORE · Amritsar · Multán · Sutlej R. · Ludhiana · Jacobábád · Sukkur · Bikaner · DELHI · Jumna R. · Meerut · Dehra Dún · AGRA · Lucknow · Cawnpore · Gwalior · Jodhpur · Hyderábád · KARÁCHI · Mouths of the Indus · Deesa · Kaliánpur · Ahmadábád · Okha Point · Navánar · Hansalat · Bhaunagar · Narbada R. · Mhow · Porbandar · Port Albert Victor · NÁGPUR · Hingunghat · Sambalpur · Dubiat (Sagar I.) · False Point · Mouths of the Ganges · CALCUTTA · Kidderpore · Diamond Harbour · Chittagong · Akyab · Salin · Prome · IRRAWADDY R. · Diamond I. · Mouths of the Irrawaddy · Bassein · RANGOON · Elephant Pt. · Pitakat Creek · Moulmein · Amherst · Prince's Dock · BOMBAY · Apollo Bandar · Poona · Waltair · Vizagapatam · Cocanáda · Bolárum · Secunderábád · Bágalkot · Raichúr · Kistna R. · Belgaum · Marmagao · Kárwár · Bellary · Bangalore · MADRAS · Mangalore · Laccadive Islands · Calicut · Beypore · Trichinopoly · Cochin · Madura · Pámban · Tuticorin · Trincomalee · Nagarkoil · Cape Comorin · Colombo · CEYLON · Minicoy · Maldive Islands · BAY OF BENGAL · LHÁSA · Namcha Barwa 25445 · BRAHMAPUTRA R. · Mount Everest 29002 · Makalu 27790 · Kinchinjunga 28146 · Gosainthán 26291 · Darjeeling · Jalpaiguri · Shillong · Dibrugarh · Myitkyinā · Chindwin R. · MANDALAY · SALWEEN R. · MEKONG R. · ANDAMAN ISLANDS · Port Blair · Ross · NICOBAR ISLANDS · BANGKOK · Mergui · SUMATRA

Rakaposhi 25550 · Kunjut 25460 · K² 28250 · Gasherbrum 26470 · Nanga Parbat 26660 · 24370 · 24690 · 21140 · 20410 · 22210 · 20720 · 23025 · Kamet 25446 · Nanda Devi 25645 · Gurla Mandhata 25355 · 23090 · XXX 26655 · Dhaulágiri 26795 · 23160 · 24740 · 23890 · 23140

INDIAN OCEAN · Maldive Islands · Equator

REFERENCES

Pendulum stations (Departmental) ●

Pendulum stations (Non Departmental) ■

Dr. Vening Meinesz's stations *

EXPLANATION

+0·120 Contour

+0·100 "

+0·080 "

+0·060 "

+0·040 "

+0·020 "

0·000 "

−0·020 "

−0·040 "

−0·060 "

−0·080 "

+ve gravity anomalies

−ve " "

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

Miles 100 0 100 200 300 400 Miles

REG. No. 373 D.D.D. 1938 (C.O.)-9. 1-405.

Published under the direction of Br… …is, O.B.E., Surveyor General of India.

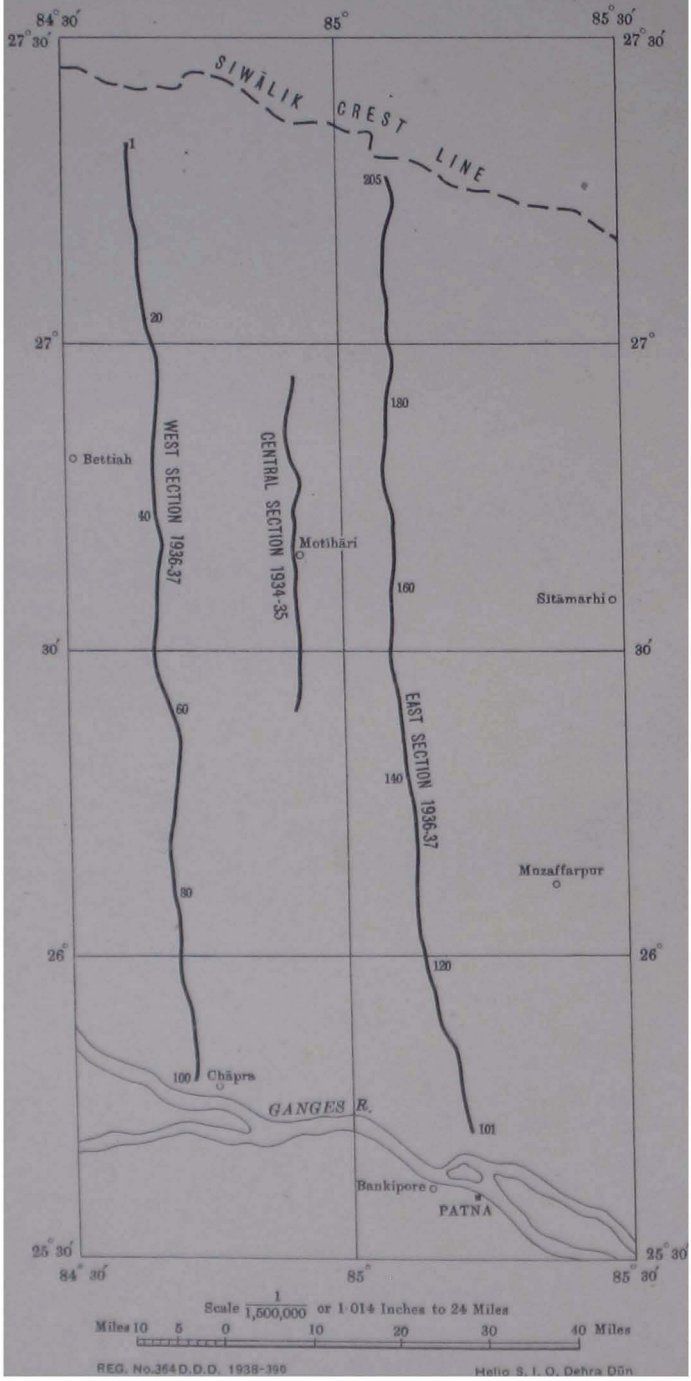
HELIO. S. I. O. DEHRA DÚN.

To accompany Geodetic Report 1937.

Chart XIII

Magnetic Sections in Bihār

Figures beside the section lines indicate station numbers



REG. No.364 D.D.O. 1938-39

Helio S. I. O. Dehra Dūn

CHAPTER IV

MAGNETIC SURVEY IN BIHAR

BY MAJOR G. BOMFORD, R.E.

27. Field observations.—Geodetic Report 1935, Chapter V, describes a line of magnetic stations observed across the epicentral tract of the 1934 Bihār earthquake, with the object of elucidating details of underground features which may have been responsible for the occurrence of the earthquake. During 1936–37 two longer lines of magnetic stations have been observed, running north and south parallel to the 1934–35 line, 10 or 15 miles on either side of it, in order to amplify the results previously obtained, and to see to what extent a single section can be typical of a larger area. These two lines run roughly along the meridians 84° 40′ and 85° 07′ east, and extend from the Ganges to just south of the crest of the Siwālik hills. Observations for horizontal force and dip have been made at intervals of roughly one mile along each section, at a total of 205 field stations. A programme of declination, dip and force was also observed at Bettiah, one of the repeat stations of the Indian magnetic survey.

The observations were made by Mr. Shyam Narain, with a squad of one computer and eight *khalāsis*. Two or three stations were occupied each working day, and camp was generally moved on carts every third day. Work started at the northern end of the western line on December 3rd, 1936 and closed at the northern end of the eastern line on April 20th, 1937. Permission to enter Nepāl for the last 30 stations was kindly given by the Government of Nepāl.

The observations were made with magnetometer No. 4 and earth inductor No. 45. The programme of observation of horizontal force at each station was two sets of deflection observations (at 22·5 cm) each of 4 readings, and two sets of vibration observations each of 217 vibrations lasting about 10 minutes. At every 6th station two sets of deflections were measured at all three distances (22·5, 30 and 40 cms) to determine the distribution factor. For dip the programme was two sets of eight readings each. The total programme at each station, including setting up the instruments, generally lasted about two hours.

For the vibration observations two box chronometers were carried, which were compared daily and rated by astronomical observations fortnightly or more frequently if necessary.

Comparative observations with the standard instruments at Dehra Dūn were made before and after the field season, 5 sets of H and 6 sets of dip on each occasion. The value of log $\pi^2 K$ was

also determined before the field season (3·37905), and the value which has been accepted is 3·37861. The value of the factor log $(1+P/r^2+Q/r^4)^{-1}$ obtained from the field observations was $\bar{1}\cdot99341$, and the value which has been accepted is $\bar{1}\cdot99274$. In both cases the accepted values are based on previous years' results. Any small change in them will have little effect on the computed anomalies of H and V, as the field observations and the comparative observations at Dehra Dūn will change by similar amounts.

28. Accuracy.—The two sets of H at each field station differed by an average amount of 11γ, with a maximum of 78γ. This suggests a probable error of 5γ for the mean of two sets. The two sets of dip differed on the average by $0'\cdot3$ with a maximum of $2'\cdot6$, which suggests a probable error of $0'\cdot15$ for the mean. Both these figures for the probable error are clearly much too low.

The comparative observations at Dehra Dūn gave the following figures (mean of two sets) for the necessary correction to the field magnetometer: +30, −3, −27, +56 and −9γ. This gives 17γ as the probable error of the mean of two sets with either instrument. Similarly, comparative observations for dip gave discrepancies of $+1'\cdot2$, $-0'\cdot5$, $-1'\cdot6$, $+0'\cdot6$, $+1'\cdot8$ and $-0'\cdot9$, giving a probable error of $0'\cdot7$ for the mean of two sets with either. These figures are reasonable. To them must be added something for the probable error of the correction for diurnal variation and disturbance obtained from the Dehra Dūn magnetographs. This may be estimated as 15γ and $1'\cdot0$, giving final total probable errors of 23γ in H and $1'\cdot2$ in dip. The resulting figure for V is 22γ.

29. Normal values.—In order to determine what may be described as anomalies, it is necessary to decide on "normal values" of the elements in the area. Table 1 gives the values of H and V in 1920·0 at various points along meridian 85° to the south of the area now under consideration, interpolated between stations of the magnetic survey (Records Volume XIX). For the changes between 1920·0 and 1937·0 the following data are available:—

(*a*) The 1937·0 observations at Bettiah.

(*b*) The data given in Geodetic Report Vol. VII, Chapter VI, from which a little extrapolation to the east gives the changes from 1920·0 to 1931·0.

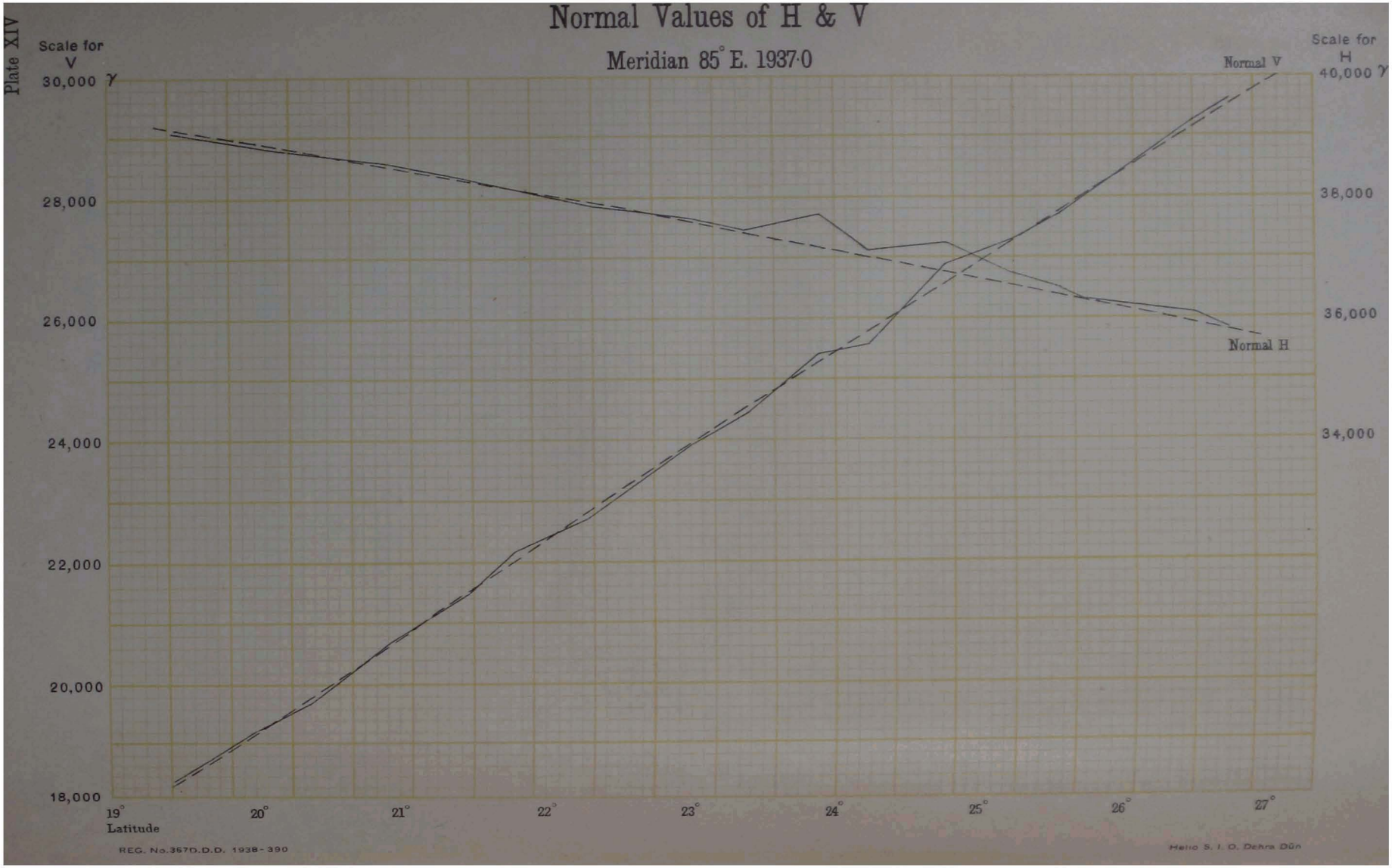
(*c*) Observations at Dehra Dūn and Alībāg (Bombay) show how the annual rate of change has varied between 1931 and 1937.

From these data it is possible to estimate the total changes between 1920·0 and 1937·0, which are entered in Table 1. Plate XIV shows the 1937·0 values and also the curves which can be drawn through them to represent the normal values. These curves are nearly straight lines, but consideration of the general rate of variation of H and V from equator to pole shows that in this area the

Plate XIV

Normal Values of H & V

Meridian 85° E. 1937·0



REG. No.367D.D.D. 1938-390

Helio S. I. O. Dehra Dün

centre of the curves, which are 8° in length, should be above the chord joining their ends by 140 γ in H and 200 γ in V. The curves which have been fitted to the plotted points have therefore been shaped accordingly. The H data show two maxima near latitudes 24° and 25°, which have been ignored when fitting the curve, since examination of 1920·0 data to the east and west shows that these variations are wholly excesses.

The curves show that in Bihār the normal 1937·0 values of H and V on meridian 85° are :—

$$H = 36200 - 8\,\delta\phi$$
$$V = 28400 + 25\,\delta\phi$$

where $\delta\phi$ is the excess of latitude over 26° expressed in minutes.

For the west section H is taken to be 20 γ less, and for the east section 20 γ greater than the above. Normal V is the same for all.

The above appear to be the most probable figures, but it would be quite possible to adopt formulae differing by 100 or 200 γ in the constant term and by 1 or 2 in the factor giving changes per minute of latitude.

30. Observed values.—The field values for H and dip were corrected for diurnal variation and disturbance by means of the Dehra Dūn magnetographs. They were reduced to the epoch 1937·0 by assuming an annual change of +65 γ in H and of −0′·7 in dip, obtained from the total change at Bettiah between 1920·0 and 1937·0 combined with a consideration of the variation in the rate of change at Dehra Dūn. The 1934–35 observations have been reduced to epoch 1937·0 with the same annual change*. Tables 2, 3 and 4 give the values finally reduced to 1937·0, the calculated normal values, and the anomalies observed *minus* normal. The anomalies are shown graphically in Plates XV and XVI.

Preliminary computations were carried out in the field, which were checked in the Observatory Section under Rai Sahib Raj Bahadur Mathur, who also supervised the observatory correction, reduction to epoch and final tabulation.

31. Calculation of magnetic anomalies.—If a body containing iron lies in the earth's magnetic field, magnetic poles are induced on its surface which modify the field and cause the local values of H and V to differ from the normal values in the neighbourhood†. The theory by which the anomalies δH and δV can be calculated is elementary, but difficulty has been found in finding an accurate and easily intelligible text-book, and the method used can advantageously be recorded.

---

* The results given in Geodetic Report 1935 have also received a correction of +92γ to H, zero to dip and +81γ to V, on account of 1934–35 comparative observations at Dehra Dūn which had not previously been included.

† This change in the field in turn modifies the induced poles, but since δH and δV are normally only small percentages of H and V, this complication can be ignored.

In Plate XVII, figure 1, A B C D is a body containing iron, LM is an element of the body of cross-sectional area s lying parallel to the earth's total magnetic force T.

Then at M there is induced a negative pole of strength sKT and at L there is induced a positive pole of strength sKT, where K is a number, known as the susceptibility of the material of which A B C D is composed.

Around M, therefore, there are induced negative poles with a concentration of $KT \sin a_1$, per unit area, and around L there are induced positive poles with a concentration of $KT \sin a_2$, where a_1, and a_2, are the angles (not necessarily in the plane of the paper) between T and the surface of the body at M and L respectively.

Positive and negative poles are similarly induced on the surfaces AD and AB.

The anomalous force at any point P is the attraction of all these poles on unit positive pole at P, so that unit area near M contributes,

$(KT \sin a_1)/PM^2$, along PM.

The total anomalies of H and V are then simply obtained by integration.

To take a concrete case, which is applicable to Bihār, suppose A B C D represents the cross section of a plane-sided body of infinite extent at right angles to the paper, with its axis lying (magnetic) east and west. If PQ is the normal at P let $QPC = \phi_C$, and let it be positive when C is south of P. Let β be the angle which T makes with any side (e.g., CD), θ the dip, and γ the inclination of CD to the horizontal. Then the component of the anomalous force acting in the direction from C to D is:—

$$R = 2\ KT \sin \beta \log_e PC/PD,$$

and the component acting at right angles (downwards positive) is:—

$S = -2KT\ (\phi_C - \phi_D) \sin \beta$, ϕ_C & ϕ_D being measured in radians,

The horizontal anomaly $\delta H = R \cos \gamma + S \sin \gamma$

and $\delta V = -R \sin \gamma + S \cos \gamma$.

Remembering that positive poles exercise a repulsion on a positive pole at P, the signs of R and S and the signs of the two terms in the formulae for δH and δV are best determined in every case by common-sense rather than by a necessarily elaborate rule of signs.

The attraction of other faces may be obtained in the same way, and the total effect of the body is the total of its faces.

As regards dimensions, it will be noticed that K, $\sin \beta$ $\log_e PC/PD$ and $(\phi_C - \phi_D)$ are pure numbers, so the anomalous forces are expressed as a fraction of the total force T, and distances may be measured in any convenient unit.

There are two practical difficulties in calculating the anomalous forces due to any body. The first is that it may be permanently magnetized quite independently of the induced magnetism. The amount and direction of this permanent magnetism can only be determined (and that with difficulty) if suitable specimens are available from throughout the bulk of the rock. The second difficulty is that the susceptibility K can only be very roughly guessed unless similar samples are available. A list of values which have been recorded is given in *Die magnetischen Verfahren der angewandten Geophysik* by H. Haalck, on which the following is based.

Values of susceptibility (K)

Limestone, sandstone, coal	...	0	to	·000100
Syenite, granite	...	·000040	to	·001350
Haematite	...	·000100	to	·003000
Dolerite, basalt	...	·000200	to	·005000
Magnetite	...	·004000	to	·097000

These figures show that the susceptibility of any large section of the earth's outer crust is unlikely to exceed ·005000, and that ·001500 may be taken as a typical high value, such as is probable for basaltic rocks, but unlikely to be recorded in sedimentary or granitic rocks except locally in beds of (magnetite) iron ore. In the lower crust (below 12 miles) the temperature is such that the susceptibility is likely to be zero. (*Dictionary of Applied Physics*, Vol. II, pages 546 and 550).

32. Effect of surface features.—The Gangetic alluvial trough runs roughly east and west and is long compared with its breadth. It is filled with alluvium of presumably zero susceptibility while its flanks and base may consist of susceptible igneous rocks. If assumptions be made regarding its cross section and the susceptibility of the underlying and flanking rocks, the anomalies in H and V can be calculated and compared with those actually observed.

Plate XVII, Fig. 2, shows the result of calculating on the assumption that the trough is 150 miles wide*: that its sides slope down at a slope of 2° from a depth of 0·02 miles to 1·07 miles: and that the susceptibility of the flanking rocks is ·001500. Apart from the fact that they are about 50 times too small, the calculated anomalies show considerable agreement with the observed west section (Plate XV). Starting from the south, δV rises to a maximum, falls to a minimum, rises again to nearly zero, and then starts to fall towards the Siwāliks: while δH falls to a minimum,

* From the Ganges to the north of the Siwāliks. The sedimentary rocks of the Siwāliks are probably of zero susceptibility like the alluvium. South of the Ganges the alluvium is probably shallow. The formulae of para 31 are applied to the two semi-infinite sections ABCD and A′B′C′D′. The effect of the uniformly magnetized rocks below DD′ is clearly zero.

rises again to low maximum, sinks to zero, and then starts to rise again*. There is much less resemblance to the east section.

Fig. 3 shows a deeper cross section for the south side of the trough, with a variable slope. This reproduces the form of the anomalies of the west section more closely, although it gives results which are still about 15 times too small.

Plate XVIII, Fig. 6, shows the result of assuming a trough 21 miles deep, with the result that even this depth gives anomalies equal to only one third of those observed. Plate XVII, Figs. 4 and 5 show the effects of two other forms of irregularity which have been calculated.

The calculated anomalies are directly proportional to the assumed susceptibility, so the section shown in Fig. 3 would reproduce the observed west section if the susceptibility was taken as ·022500, but this is an impossibly high figure. Fig. 4 would suffice if the susceptibility was ·004500, which is perhaps a possible value, but the figure hardly represents a possible section of the alluvial trough.

It is not possible to avoid the conclusion that variations in the depth of the alluvial trough cannot be responsible for any considerable part of the magnetic anomalies observed in Bihār.

33. Effect of changes of susceptibility.—Plate XVIII Figs. 7 and 8 show δH and δV for two semi-infinite blocks of susceptibility ·001000 whose upper surfaces are at depths of 0·02 and 1·00 miles respectively, and whose lower surfaces are at a depth of 10 miles. The effects of the two different blocks are very similar, except that the 0·02 depth gives a sharp and very local minimum both of δH and δV immediately over the vertical face. The smooth curve is a mean curve corresponding to a depth of about ½ mile, which (for the purpose outlined below) may be accepted as typical of any such block whose upper surface is at a depth of less than one mile.

The effect of a general decrease of susceptibility from south to north is obtained by superposing five such blocks as shown in Fig. 9. Here five blocks of susceptibility ·001000 are superposed, each displaced 4 miles relative to the preceding one. The curves for δH and δV are obtained by adding the anomalies due to each of the five blocks, and the general effect is that of a smooth change of susceptibility of ·000250 per mile for 20 miles or of a gradual change from ·005000 to zero. These curves will be quite accurate for any shallow depth of the top surface, since although a shallow depth produces the large local anomaly which has been rounded off in Figs. 7 and 8, the area rounded off is very small and if the five

* The calculated anomalies show sharp and very local peaks when an angle of the section lies near the surface. These peaks are of purely local significance and would disappear if the angle was rounded off. The dotted lines in the section show what would probably result from rounding off the angle.

curves corresponding to a depth of 0·02 miles had been superposed and rounded off, the result would have been very similar.

Fig. 10 gives the result of a change in the opposite direction, a decrease from north to south, and Fig. 11 combines Figs. 9 and 10 to give the effect of a band of susceptible rocks 40 miles wide of susceptibility ·005000 at the centre, decreasing to zero at the edges. The effect of a similar band of low susceptibility, with its centre ·005000 less than its edges is simply the opposite of Fig. 11, and is shown in Fig. 12. The values of δH and δV for other values of the change in susceptibility are in simple proportion. For bands of different widths Figs. 7 and 8 must be further superposed with lateral displacements, but the effect is roughly to widen or narrow the peaks in the curves of Figs. 9 to 12 in proportion to the width of the band.

Referring to the anomalies actually observed (Plates XV and XVI) it is seen that Fig. 11 bears a strong resemblance to the west section, while Fig. 10, with ordinates divided by three resembles the east section. These curves have been shown on Plates XV and XVI, plotted relative to a normal H 55 γ greater than that derived from Plate XIV, and a normal V 70 γ less. In the west section the agreement is very good and a band of high intensity centered on about latitude 25° 50′ is clearly indicated. The agreement between the observed and calculated anomalies could be improved by taking a band less intense and narrower than the 40 miles for which Fig. 11 is calculated*, but for reasons noted below there is no object in making detailed calculations. A band 25 miles wide† with a central K of ·003000 would probably give the best fit.

In the east section the fit of the curve is also good, but the variations are smaller and it cannot be said that the changes of susceptibility suggested necessarily have any real significance. For what they are worth the curves suggest that in the 20 miles south of latitude 26° 30′ susceptibility increases from south to north by a total amount‡ of ·001700.

In the most northerly 25 miles both the east and west sections show similar departures from the calculated curves: a depression of about 200 γ in V, and a fall of about 100 γ in H followed by a rise to normal. These variations suggest comparison with Fig. 12, indicating a decrease of susceptibility under the Siwāliks, but the variations are too small and too dependent on the accepted normal values to make any interpretation possible.

Plates XV and XVI show that the anomalies in the east and west sections bear little resemblance to each other, and this adds to the difficulty of interpretation in two ways. Firstly, the calculated curves are based on an infinite extension at right angles to the

* Shown in broken line at the bottom of Plate XV.
† Shown dotted at the bottom of Plate XV.
‡ Shown in broken line at the bottom of Plate XVI.

paper, which is clearly not the case if the two sections differ. And secondly, a difference between the two sections indicates changes of susceptibility from east to west, which must be responsible for part of the anomalies of H and V. It is not therefore correct to ascribe all the anomalies to changes from south to north.

The observed anomalies vary abruptly from one station to the next by sometimes as much as 100 γ. If the estimate of accuracy given in para 2 is at all correct, these variations are not due to error. It is not possible to trace any connection between these abrupt changes in the three different sections, and nothing can be said about their cause.

34. Conclusions.—The conclusions which may be drawn from the above paragraphs may be summarized as follows:—

(a) The effect of any probable form of the alluvial trough on H and V is far too small to account for the observed anomalies.

(b) A belt of rocks of high susceptibility underlies the south end of the west section, but does not extend as far as the east section.*

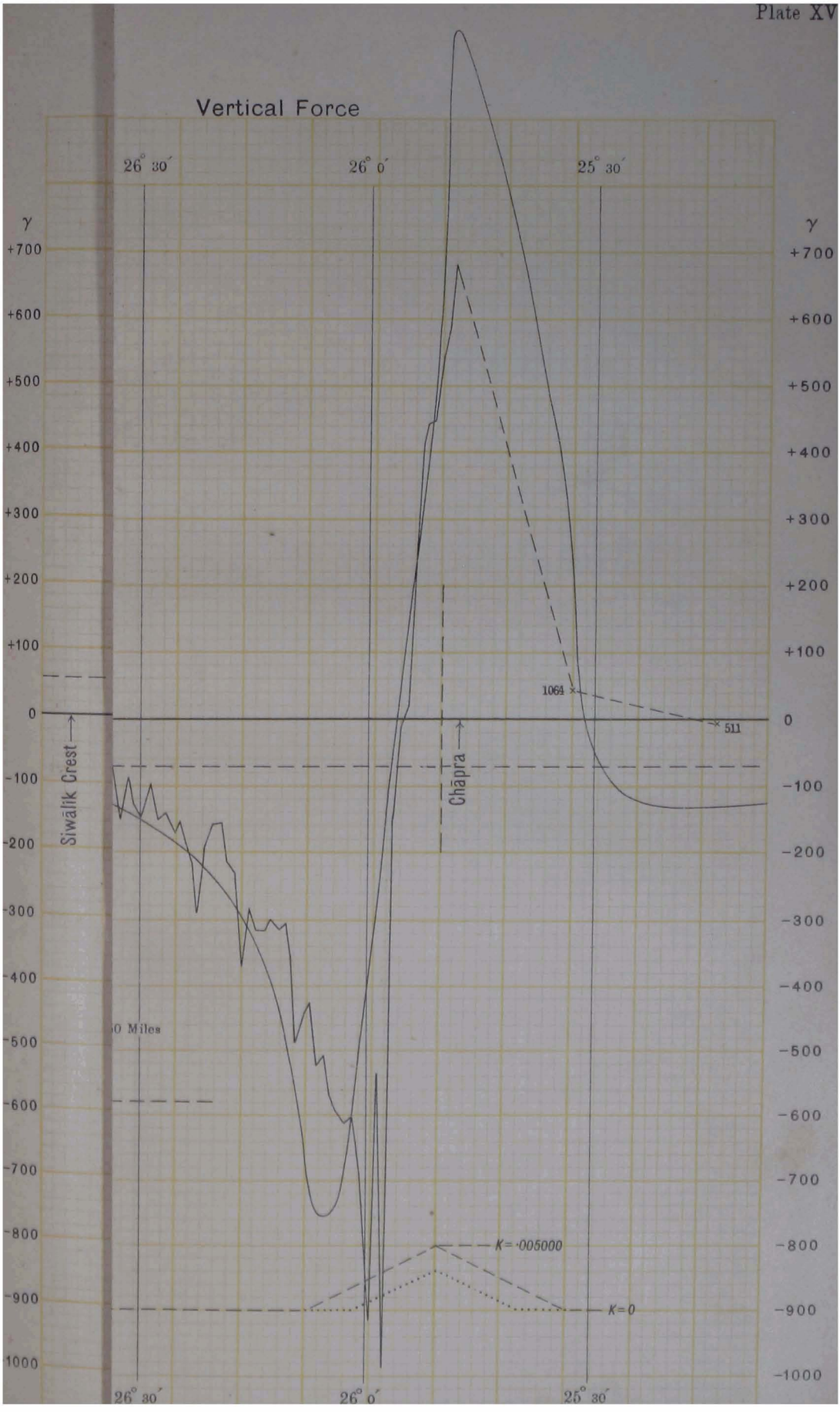
(c) Both the east and west sections indicate some disturbance at their north end.

TABLE 1.—*Values of H and V on meridian 85° E.*

Latitude	Interpolated between station Nos.†	Values in 1920·0		Change from 1920·0 to 1937·0		Values in 1937·0	
		H	V	H	V	H	V
° ′							
19 27	LX, 698	38288	17672	776	652	39064	18324
20 02	940, 697	38114	18564	754	671	38868	19235
20 23	941, 935	38026	19062	741	683	38767	19745
20 57	936, 1168	37872	20003	719	703	38591	20706
21 28	1165, 1167	37595	20741	700	721	38295	21462
21 48	1166, 1171	37452	21420	688	733	38140	22153
22 18	755, 754	37194	21937	667	748	37861	22685
23 02	1032, 1031	36996	23179	634	766	37630	23945
23 24	884, 1030	36812	23661	617	775	37429	24436
23 54	883, 879	37087	24614	595	788	37682	25402
24 15	882, 880	36509	24800	579	787	37088	25587
24 47	XIV	36680	26061	555	782	37235	26843
25 14	511	36167	26465	535	777	36702	27242
25 35	1064, 510	35962	26901	519	773	36481	27674
25 44	998	35835	27191	512	771	36347	27962
26 30	529	35583	28460	478	763	36061	29223
26 46	LIII, 531	35343	28848	466	760	35809	29608

* This is indicated in the final chart of Records Vol. XIX, where a disturbed area is shown in sheet 72C.

† The number refers to Record Volume XIX. The interpolation is not necessarily with equal weights.


Vertical Force
26° 30′
26° 0′
25° 30′
γ
+700
+600
+500
+400
+300
+200
+100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
Siwālik Crest
Chāpra
1064
511
K=·005000
K=0

Observed Magnetic Anomalies

West Section

Horizontal Force

Latitude 27° 0′ — 26° 30′ — 26° 0′ — 25° 30′

1064 — 511

Chāpra

Siwālik Crest

Scale 1 Inch = 25 Miles

Miles 10 — 0 — 10 — 20 — 30 — 40 — 50 Miles

The smooth curves are the anomalies due to changes of K shown – – – – –
The changes shown.....would secure a better fit.

Numbers 1064 and 511 refer to stations of the old Magnetic Survey.

Vertical Force

27° 0′ — 26° 30′ — 26° 0′ — 25° 30′

γ

+700 — +600 — +500 — +400 — +300 — +200 — +100 — 0 — −100 — −200 — −300 — −400 — −500 — −600 — −700 — −800 — −900 — −1000

1064 — 511

Chāpra

K = ·005000

K = 0 — K = 0

No.365D.D.D. 1938-390

Helio S. I. O. Dehra Dūn.

Observed Magnetic Anomalies

Plate XVI

East Section

Latitude 27° 0′ — 26° 30′ — 26° 0′ — 25° 30′

Horizontal Force

Siwālik Crest

R. Ganges

511

510

Vertical Force

Siwālik Crest

R. Ganges

511

510

K = 001700

K = 0

Latitude 27° 0′ — 26° 30′ — 26° 0′ — 25° 30′

Scale 1 Inch = 25 Miles

Miles 10 0 10 20 30 40 50 Miles

Central Section

27° 0′ — 26° 30′ — 26° 0′

γ

+400 +300 +200 +100 0 −100

H. F.

Motihāri

V. F.

Motihāri

+300 +200 +100 0 −100 −200 −300

27° 0′ — 26° 30′ — 26° 0′

REG. No. 365 D.D.D. 1938-390

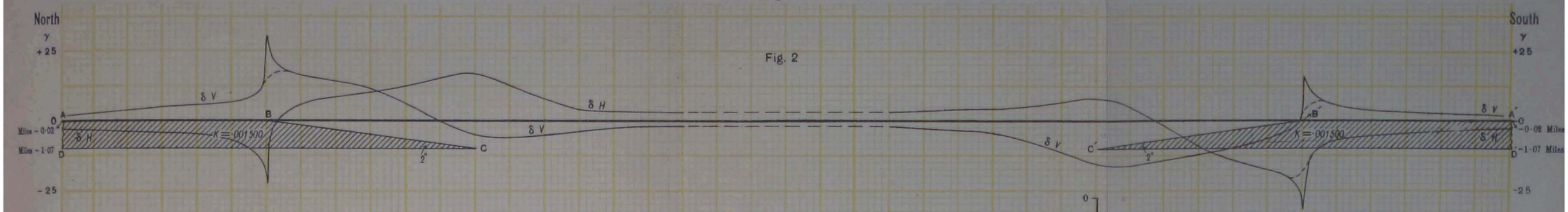
Helio S. I. O. Dehra Dun.

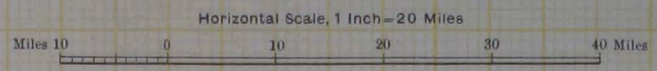
Calculated Magnetic Anomalies

Total Force = 47000 γ

Dip = 40° N.

Fig. 2





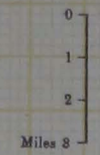


Fig. 1

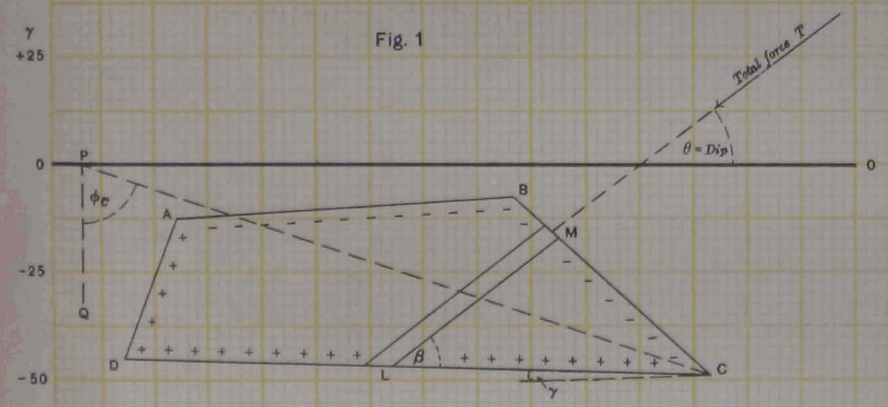


Fig. 3

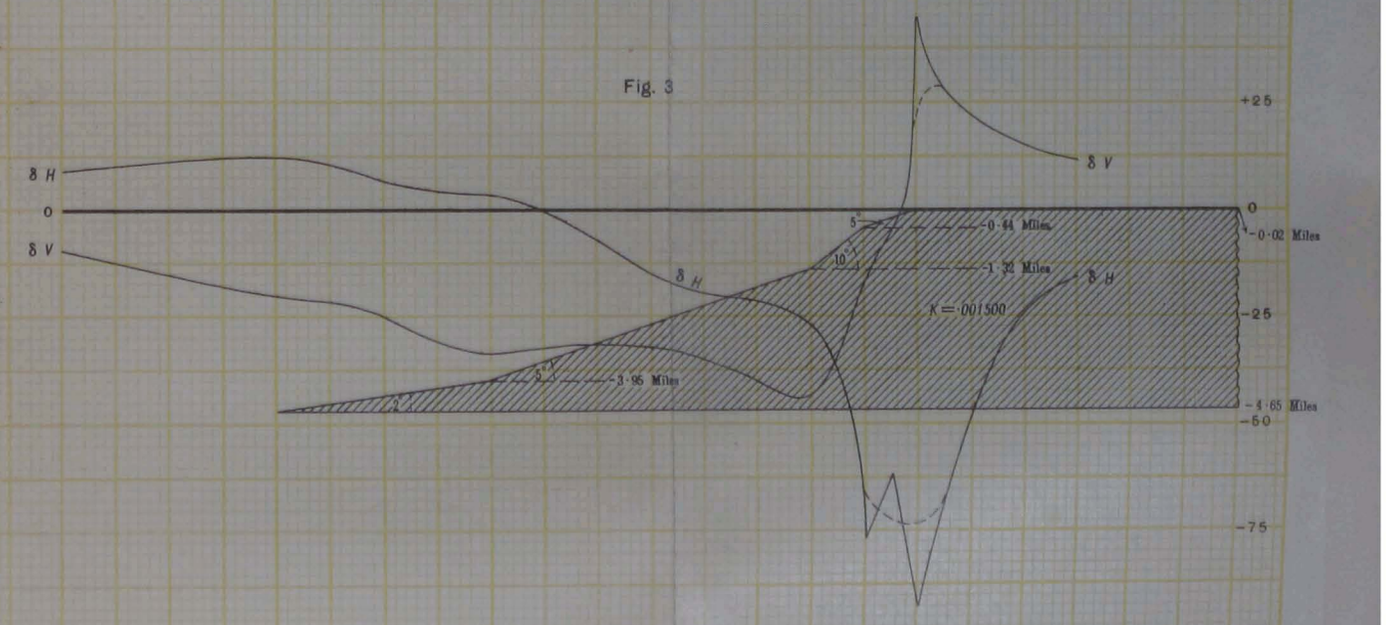


Fig. 4

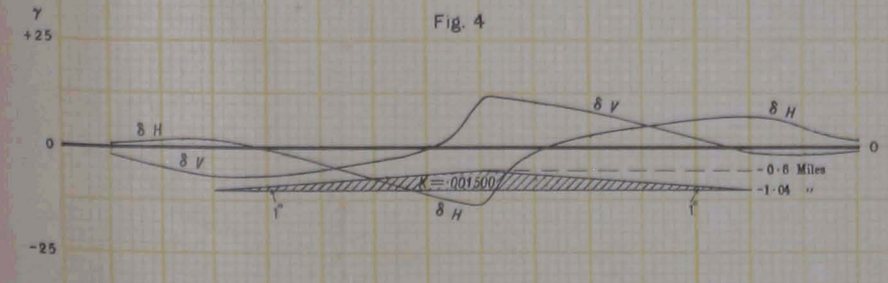
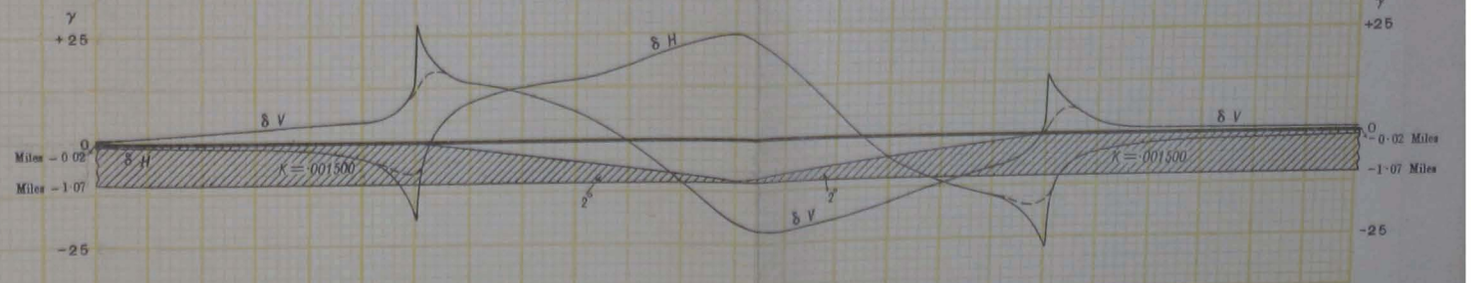


Fig. 5



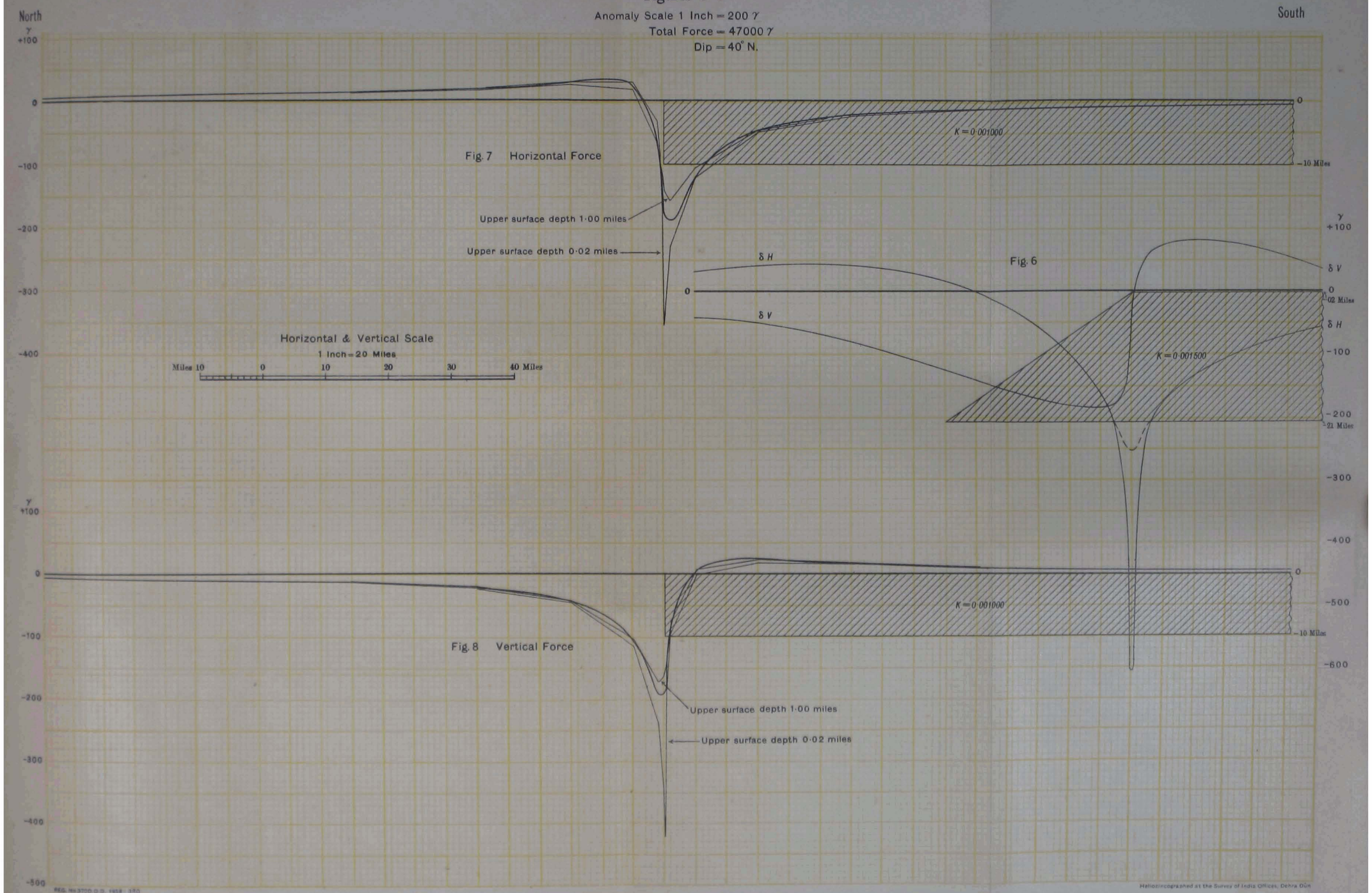
REG. No. 772D.O.D. 1938 - 330

Helioz reproduced at the Survey of India Offices, Dehra Dun

Calculated Magnetic Anomalies

Figures 6-8

Anomaly Scale 1 Inch = 200 γ
Total Force = 47000 γ
Dip = 40° N.



Heliozincographed at the Survey of India Offices, Dehra Dün

Calculated Magnetic Anomalies

Horizontal & Vertical Scale, 1 Inch = 40 Miles

Anomaly Scale 1 Inch = 1000 γ

Total Force = 47000 γ

Dip = 40° N.

Plate XIX

Fig. 9 Susceptibility decreasing to north

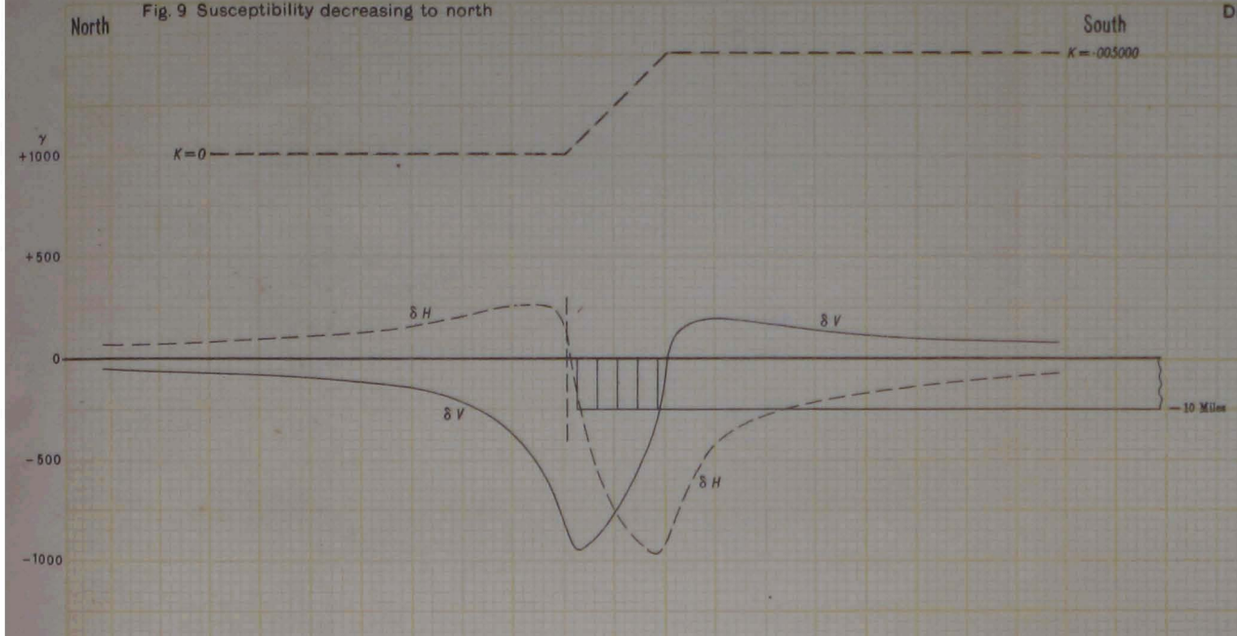


Fig. 10 Susceptibility increasing to north

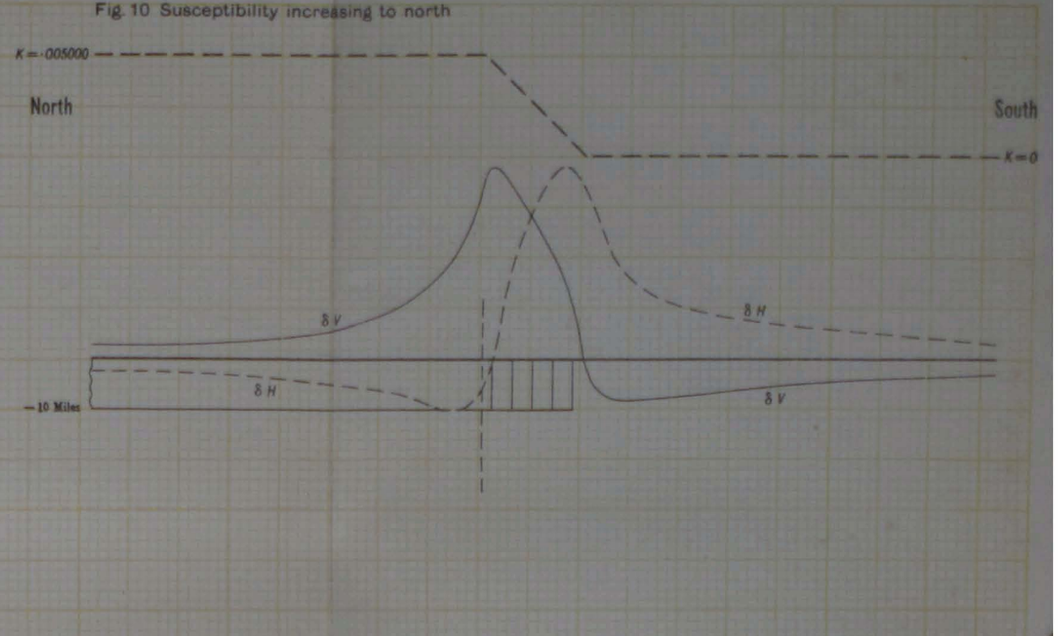


Fig. 11 Belt of high Susceptibility

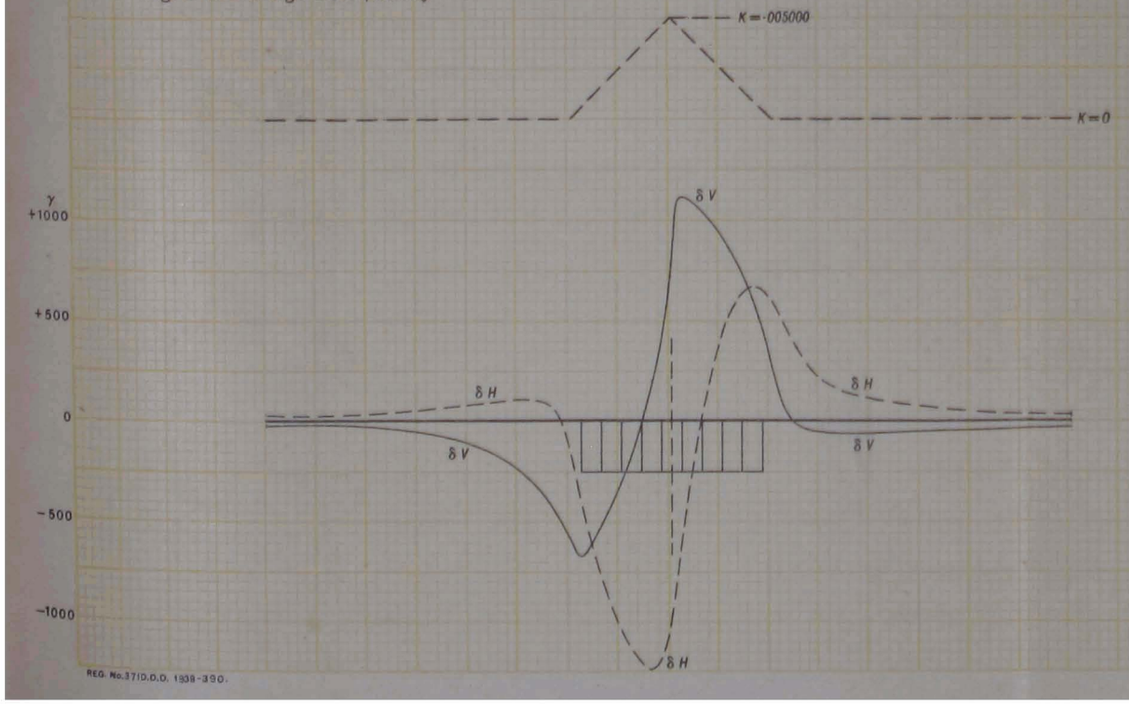
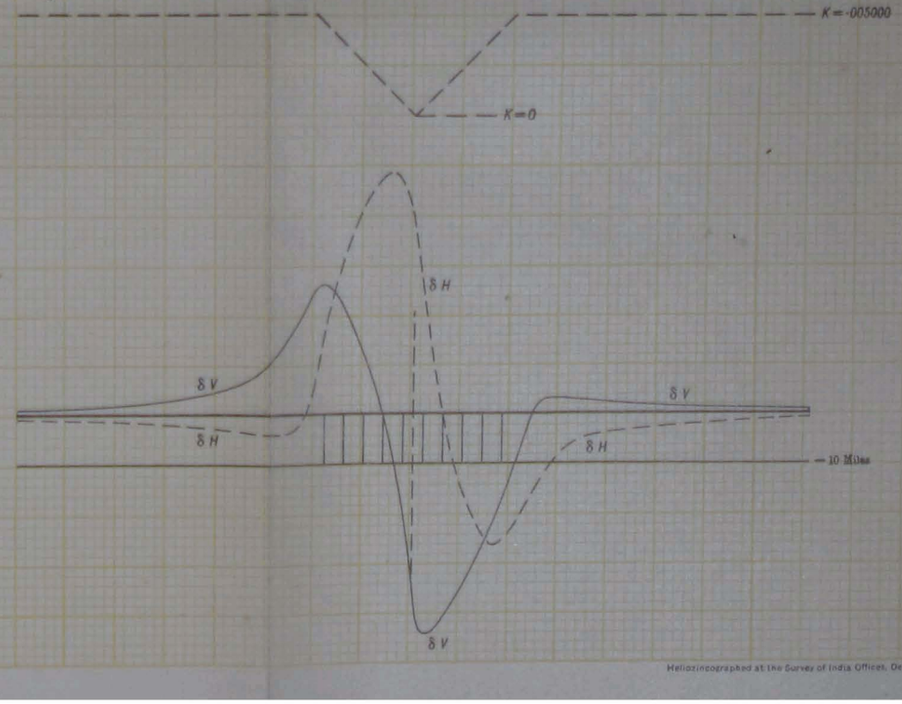


Fig. 12 Belt of low Susceptibility



REG. No. 3710.D.D. 1938-390.

Heliozincographed at the Survey of India Offices, Dehra Dún.

TABLE 2.—*Magnetic Stations 1936–37.*

WEST SECTION

Station No.	Latitude	Longitude	Observed (Reduced to 1937·0)			Normal 1937·0		Anomaly	
			H.F.	Dip	V.F.	H.F.	V.F.	H.F.	V.F.
	° ′ ″	° ′ ″	C.G.S.	° ′	C.G.S.	C.G.S.	C.G.S.	γ	γ
1	27 19 22	84 37 06	0·35575	40 16·1	0·30139	0·35545	0·30385	+30	−246
2	18 46	37 10	588	11·8	074	550	370	+38	−296
3	17 54	37 02	591	12·2	084	557	348	+34	−264
4	16 55	36 54	588	15·8	145	565	323	+23	−178
5	16 07	36 56	595	11·0	065	571	303	+24	−238
6	15 02	36 48	600	11·5	079	580	275	+20	−196
7	14 10	36 58	612	07·1	011	586	255	+26	−244
8	13 06	37 17	597	07·2	000	595	228	+ 2	−228
9	12 16	37 42	601	09·4	042	602	208	− 1	−166
10	11 21	38 00	601	07·9	0·30016	609	185	− 8	−169
11	10 31	37 53	612	05·8	0·29988	616	163	− 4	−175
12	09 41	37 52	618	06·0	997	622	143	− 4	−146
13	08 57	37 56	620	05·5	989	628	125	− 8	−136
14	08 07	37 49	614	04·4	965	635	103	−21	−138
15	07 10	38 07	631	04·5	981	642	080	−11	− 99
16	06 07	38 14	616	03·3	947	651	053	−35	−106
17	05 15	38 21	620	40 03·9	961	658	032	−38	− 71
18	04 13	38 29	624	39 58·3	866	666	0·30005	−42	−139
19	03 21	38 35	668	59·4	923	673	0·29985	− 5	− 62
20	02 14	38 51	629	55·4	819	682	955	−53	−136
21	01 14	39 17	638	53·6	795	690	930	−52	−135
22	27 00 24	39 28	642	...	...	697	910	−55	...
23	26 59 30	39 47	655	56·5	861	704	888	−49	− 27
24	58 37	39 38	630	54·7	807	711	865	−81	− 58
25	57 47	39 49	670	45·8	685	718	845	−48	−160
26	56 52	39 48	695	46·4	716	725	823	−30	−107
27	55 43	40 00	705	46·9	733	734	793	−29	− 60
28	53 37	39 35	755	41·0	671	751	740	+ 4	− 69
29	52 42	39 38	773	38·4	641	758	718	+15	− 77
30	51 48	39 23	773	38·4	641	766	695	+ 7	− 54
31	50 53	39 09	778	38·0	638	773	673	+ 5	− 35
32	50 02	38 57	800	34·7	598	780	650	+20	− 52
33	49 02	39 07	819	30·6	542	788	625	+31	− 83
34	48 07	39 18	821	26·9	480	795	603	+26	−123
35	47 07	39 21	851	26·1	490	803	578	+48	− 88
36	46 07	39 11	862	24·6	473	811	553	+51	− 80
37	45 12	39 20	866	23·4	456	818	530	+48	− 74
38	44 23	39 30	882	22·0	444	825	510	+57	− 66
39	26 43 32	84 39 39	0·35896	39 18·5	0·29394	0·35832	0·29488	+64	− 94

γ = 0·00001 C.G.S.

(*Continued*)

TABLE 2.—*Magnetic Stations 1936–37.*

WEST SECTION—(*contd.*)

Station No.	Latitude	Longitude	Observed (Reduced to 1937·0)			Normal 1937·0		Anomaly	
			H. F.	Dip	V. F.	H. F.	V. F.	H. F.	V. F.
	° ′ ″	° ′ ″	C. G. S.	° ′	C. G. S.	C. G. S.	C. G. S.	γ	γ
40	26 42 42	84 39 44	0·35912	39 15·2	0·29350	0·35838	0·29468	+ 74	−118
41	41 52	39 51	942	17·6	417	845	448	+ 97	− 31
42	41 01	40 03	933	18·4	424	852	425	+ 81	− 1
43	40 02	40 06	942	12·8	333	860	400	+ 82	− 67
44	39 12	40 02	946	10·6	299	866	380	+ 80	− 81
45	38 20	39 57	0·35986	07·7	281	874	358	+112	− 77
46	37 25	39 52	0·36003	05·4	254	881	335	+122	− 81
47	36 33	39 42	0·35982	08·1	284	887	315	+ 95	− 31
48	35 40	39 42	0·35989	07·8	285	894	293	+ 95	− 8
49	34 48	39 45	0·36013	39 03·6	232	902	270	+111	− 38
50	33 49	39 36	028	38 59·3	169	910	245	+118	− 76
51	32 55	39 29	038	53·2	071	917	223	+121	−152
52	31 53	39 21	074	53·9	112	925	198	+149	− 86
53	30 59	39 11	075	49·8	042	932	175	+143	−133
54	30 05	39 01	107	46·3	008	939	153	+168	−145
55	29 08	39 13	150	45·6	0·29031	947	128	+203	− 97
56	27 32	39 43	112	42·0	0·28938	960	088	+152	−150
57	26 40	39 51	137	40·3	928	966	068	+171	−140
58	25 48	40 03	129	37·7	878	974	045	+155	−167
59	25 00	40 23	187	34·6	870	980	025	+207	−155
60	24 10	40 47	163	32·6	817	986	0·29005	+177	−188
61	23 20	41 00	160	30·1	772	0·35994	0·28983	+166	−211
62	22 28	41 22	152	24·8	675	0·36000	963	+152	−288
63	21 36	41 34	188	27·0	742	007	940	+181	−198
64	20 36	41 44	192	27·8	757	015	915	+177	−158
65	19 31	41 42	214	25·3	733	024	888	+190	−155
66	18 24	41 38	216	20·0	643	033	860	+183	−217
67	17 32	41 27	207	18·3	607	040	838	+167	−231
68	16 39	41 22	205	08·9	446	046	817	+159	−371
69	15 43	41 22	233	11·4	511	054	793	+179	−282
70	14 50	41 04	232	08·2	454	062	770	+170	−316
71	13 57	40 50	232	06·8	431	068	750	+164	−319
72	13 04	40 42	234	06·5	428	075	728	+159	−300
73	12 11	40 35	240	03·9	388	082	705	+158	−317
74	11 15	40 39	216	38 04·4	378	090	682	+126	−304
75	10 23	40 43	223	37 59·7	304	097	660	+126	−356
76	09 33	40 52	192	52·3	154	103	640	+ 89	−486
77	08 37	40 48	187	53·6	172	111	615	+ 76	−443
78	26 07 45	84 40 39	0·36200	37 52·8	0·28169	0·36118	0·28595	+ 82	−426

γ=0·00001 C. G. S.

(*Continued*)

TABLE 2.—*Magnetic Stations 1936–37.*

WEST SECTION—(*concld.*)

Station No.	Latitude	Longitude	Observed (Reduced to 1937·0)			Normal 1937·0		Anomaly	
			H. F.	Dip	V. F.	H. F.	V. F.	H. F.	V. F.
	° ′ ″	° ′ ″	C. G. S.	° ′	C. G. S.	C. G. S.	C. G. S.	γ	γ
79	26 06 44	84 40 42	0·36153	37 47·5	0·28043	0·36126	0·28568	+ 27	−525
80	05 47	40 52	175	46·3	0·28040	134	545	+ 41	−505
81	04 52	41 08	124	43·4	0·27952	141	523	− 17	−571
82	04 02	41 18	086	42·1	901	148	500	− 62	−599
83	03 13	41 23	0·36030	42·4	863	154	480	−124	−617
84	02 20	41 32	0·35992	43·7	855	162	458	−170	−603
85	01 25	41 27	887	44·5	787	169	435	−282	−648
86	26 00 33	41 32	780	45·7	724	175	415	−395	−691
87	25 59 38	41 23	657	37 36·3	474	183	390	−526	−916
88	58 38	41 31	539	38 03·3	829	191	365	−652	−536
89	57 44	41 52	392	37 41·5	0·27355	198	342	−806	−987
90	56 53	41 54	386	38 31·3	0·28176	205	322	−819	−146
91	56 00	41 58	387	43·8	387	212	300	−825	+ 87
92	55 00	42 13	313	47·7	394	220	275	−907	+119
93	54 00	42 02	601	41·0	512	228	250	−627	+262
94	53 04	42 23	807	38·6	635	235	227	−428	+408
95	52 17	42 41	939	33·2	649	242	207	−303	+442
96	51 28	42 57	0·35956	32·0	642	248	187	−292	+455
97	50 31	43 00	0·36126	27·7	704	256	162	−130	+542
98	49 41	42 57	201	25·9	732	262	142	− 61	+590
99	48 55	42 40	221	29·0	802	269	122	− 48	+680
100	25 47 42	84 42 27	0·36457	38 13·8	0·28728	0·36278	0·28092	+179	+636

γ = 0·00001 C. G. S.

TABLE 3.—*Magnetic Stations 1936–37.*

EAST SECTION

Station No.	Latitude	Longitude	Observed (Reduced to 1937·0)			Normal 1937·0		Anomaly	
			H.F.	Dip	V·F.	H.F.	V.F.	H.F.	V.F.
	° ′ ″	° ′ ″	C.G.S.	° ′	C.G.S.	C.G.S.	C.G.S.	γ	γ
101	25 42 03	85 12 32	0·36491	37 24·6	0·27919	0·36363	0·27952	+128	− 33
102	43 06	12 25	474	24·9	911	355	0·27977	+119	− 66
103	44 00	12 15	455	25·2	901	348	0·28000	+107	− 99
104	44 53	12 01	447	26·5	917	341	022	+106	−105
105	45 43	11 46	416	28·0	919	334	042	+ 82	−123
106	46 31	11 37	408	30·6	956	328	062	+ 80	−106
107	47 31	11 28	423	30·8	971	320	087	+103	−116
108	48 28	11 15	289	31·1	874	312	112	− 23	−238
109	49 18	11 03	412	32·5	0·27991	306	132	+106	−141
110	50 17	10 58	390	35·2	0·28020	298	157	+ 92	−137
111	51 15	10 25	380	36·9	040	290	182	+ 90	−142
112	52 12	10 04	403	34·0	010	282	205	+121	−195
113	53 06	09 46	351	39·4	060	275	227	+ 76	−167
114	53 55	09 18	353	41·8	102	269	247	+ 84	−145
115	54 48	09 05	342	42·0	097	262	270	+ 80	−173
116	55 42	09 00	355	44·1	142	254	292	+101	−150
117	56 45	08 30	353	43·5	131	246	320	+107	−189
118	57 35	08 21	357	45·4	166	239	340	+118	−174
119	58 37	08 06	400	48·4	251	231	365	+169	−114
120	25 59 31	07 49	323	49·2	205	224	387	+ 99	−182
121	26 00 28	07 42	366	50·6	261	216	413	+150	−152
122	01 28	07 40	348	52·6	281	208	438	+140	−157
123	02 22	07 40	355	52·4	283	201	460	+154	−177
124	03 22	07 25	352	56·8	355	193	485	+159	−130
125	04 12	07 20	383	37 58·6	410	186	505	+197	− 95
126	05 07	07 21	440	38 05·1	566	179	528	+261	+ 38
127	06 03	07 26	424	01·0	483	171	552	+253	− 69
128	06 57	07 33	437	03·3	532	164	575	+273	− 43
129	07 53	07 26	424	06·7	580	157	598	+267	− 18
130	08 41	07 23	372	09·2	581	150	618	+222	− 37
131	09 34	07 26	443	11·2	672	143	640	+300	+ 32
132	10 29	07 15	421	15·5	728	136	663	+285	+ 65
133	11 28	07 08	422	13·7	698	128	688	+294	+ 10
134	12 17	07 11	371	19·8	763	122	708	+249	+ 55
135	13 06	07 04	402	22·3	830	115	728	+287	+102
136	14 01	07 04	344	28·6	892	108	750	+236	+142
137	15 00	06 57	424	23·7	871	100	775	+324	+ 96
138	15 52	06 51	377	32·2	981	093	798	+284	+ 83
139	26 16 40	85 06 38	0·36378	38 32·4	0·28985	0·36086	0·28818	+292	+167

γ = 0·00001 C.G.S.

(*Continued*)

TABLE 3.—*Magnetic Stations 1936–37.*

EAST SECTION—(*contd.*)

Station No.	Latitude	Longitude	Observed (Reduced to 1937·0)			Normal 1937·0		Anomaly	
			H. F.	Dip	V. F.	H. F.	V. F.	H. F.	V. F.
	° ′ ″	° ′ ″	C. G. S.	° ′	C. G. S.	C. G. S.	C. G. S.	γ	γ
140	26 17 35	85 06 30	0·36359	38 31·1	0·28948	0·36079	0·28840	+280	+108
141	18 26	06 17	342	38·0	0·29053	073	860	+269	+193
142	19 27	06 10	320	42·6	115	064	887	+256	+228
143	20 19	06 02	328	40·4	083	058	908	+270	+175
144	21 18	06 06	304	51·2 46·5	251 170	050	933	+254	+277
145	22 13	05 59	192	48·3	110	042	955	+150	+155
146	23 11	05 48	192	38 54·2	213	034	0·28980	+158	+233
147	24 01	05 40	175	39 00·4	307	028	0·29000	+147	+307
148	25 00	05 30	145	01·9	309	020	025	+125	+284
149	25 56	05 19	026	06·4	290	013	048	+ 13	+242
150	26 58	05 15	085	09·0	383	0·36004	075	+ 81	+308
151	27 45	05 06	021	07·7	309	0·35998	095	+ 23	+214
152	28 38	04 56	0·36007	08·7	315	991	115	+ 16	+200
153	29 33	04 36	0·35985	10·3	325	984	140	+ 1	+185
154	30 32	04 41	972	11·6	336	976	163	− 4	+173
155	31 23	04 50	948	15·9	392	969	185	− 21	+207
156	32 27	04 57	924	15·4	363	960	212	− 36	+151
157	33 22	05 00	905	16·2	362	953	235	− 48	+127
158	34 20	05 03	903	16·4	363	946	258	− 43	+105
159	35 14	04 56	906	14·6	335	938	280	− 32	+ 55
160	36 12	04 56	897	14·7	329	930	305	− 33	+ 24
161	37 03	05 03	871	16·2	334	924	327	− 53	+ 7
162	38 08	05 02	864	19·0	377	915	353	− 51	+ 24
163	39 11	05 12	920	16·2	374	906	380	+ 14	− 6
164	40 12	05 07	905	20·4	435	898	405	+ 7	+ 30
165	41 01	05 05	873	21·8	433	892	425	− 19	+ 8
166	41 57	04 58	878	24·7	488	884	450	− 6	+ 38
167	42 52	04 54	895	25·5	516	877	473	+ 18	+ 43
168	43 48	04 55	887	24·8	497	870	495	+ 17	+ 2
169	44 38	04 48	840	31·0	566	863	515	− 23	+ 51
170	45 27	04 40	838	31·2	569	856	537	− 18	+ 32
171	46 21	04 23	831	32·0	577	849	560	− 18	+ 17
172	47 03	04 17	811	30·7	537	844	577	− 33	− 40
173	48 04	04 07	758	33·6	544	835	603	− 77	− 59
174	49 01	04 08	810	32·6	570	828	625	− 18	− 55
175	49 54	04 16	809	34·1	595	821	648	− 12	− 53
176	50 57	04 22	785	33·5	565	812	675	− 27	−110
177	51 46	04 29	755	37·7	614	806	695	− 51	− 81
178	26 52 38	85 04 35	758 0·35844	37·5 39 35·2	612 0·29643	0·35799	0·29715	+ 2	−103 − 72

γ = 0·00001 C. G. S.

(*Continued*)

TABLE 3.—*Magnetic Stations 1936–37.*

EAST SECTION—(*concld.*)

Station No.	Latitude	Longitude	Observed (Reduced to 1937·0)			Normal 1937·0		Anomaly	
			H.F.	Dip	V.F.	H.F.	V.F.	H.F.	V.F.
	° ′ ″	° ′ ″	C.G.S.	° ′	C.G.S.	C.G.S.	C.G.S.	γ	γ
179	26 53 29	85 04 41	0·35729	39 40·2	0·29636	0·35792	0·29738	− 63	−102
180	54 21	04 47	703	39·7	605	785	760	− 82	−155
181	55 05	04 57	721	41·4	650	779	778	− 58	−128
182	55 57	05 04	697	45·0	693	772	800	− 75	−107
183	56 50	05 04	737	48·3	785	766	820	− 29	− 35
184	57 46	05 18	772	48·7	820	758	845	+ 14	− 25
185	58 38	05 32	708	49·7	785	751	865	− 43	− 80
186	26 59 30	05 48	732	51·3	833	744	888	− 12	− 55
187	27 00 05	05 00	693	54·1	850	739	903	− 46	− 53
188	00 50	04 50	673	54·2	835	734	920	− 61	− 85
189	01 43	04 45	586	55·5	785	726	943	− 40	−158
190	02 40	04 55	599	56·0	804	718	968	−119	−164
191	03 44	05 05	575	55·0	767	710	0·29993	−135	−226
192	04 32	05 16	637	56·3	841	704	0·30013	− 67	−172
193	05 25	04 36	589	57·9	829	697	035	−108	−206
194	06 04	04 28	579	58·6	833	691	053	−112	−220
195	07 00	04 35	568	58·3	819	684	075	−116	−256
196	07 54	04 44	617	56·5	828	677	098	− 60	−270
197	08 48	04 53	630	39 59·4	890	670	120	− 40	−230
198	09 40	04 47	622	40 01·6	922	662	143	− 40	−221
199	10 46	04 35	656	39 58·0	887	654	170	+ 2	−283
200	11 30	05 05	628	40 00·7	0·29911	648	188	− 20	−277
201	12 38	05 25	622	08·7	0·30047	639	215	− 17	−168
202	13 32	05 42	624	04·7	0·29979	632	238	− 8	−259
203	14 30	05 46	666	05·9	0·30035	624	263	+ 42	−228
204	15 26	05 32	607	07·4	012	617	285	− 10	−273
205	27 16 10	85 05 18	0·35645	40 06·9	0·30035	0·35610	0·30305	+ 35	−270

γ = 0·00001 C.G.S.

TABLE 4.— *Magnetic Stations 1934–35.*

CENTRE SECTION

Station No.	Latitude	Longitude	Observed (Reduced to 1937·0)			Normal 1937·0		Anomaly	
			H.F.	Dip	V.F.	H.F.	V.F.	H.F.	V.F.
	° ′ ″	° ′ ″	C.G.S.	° ′	C.G.S.	C.G.S.	C.G.S.	γ	γ
1*c*	26 58 09	84 54 53	0·35660	39 52·2	0·29789	0·35734	0·29855	− 74	− 66
1*b*	57 57	54 53	658	54·1	821	736	850	− 78	− 29
1*a*	57 45	54 39	664	53·1	808	738	845	− 74	− 37
2*c*	57 30	55 00	664	51·0	771	740	838	− 76	− 67
2*b*	57 17	55 00	672	51·9	794	742	833	− 70	− 39
2*a*	57 05	54 59	657	48·8	727	743	828	− 86	−101
2	56 52	55 00	667	51·0	773	745	823	− 78	− 50
3	56 06	55 04	731	47·1	759	751	803	− 20	− 44
4	55 20	54 55	709	46·8	735	758	783	− 49	− 48
5	53 05	55 11	696	43·8	671	775	728	− 79	− 57
6	50 02	54 48	740	38·7	619	800	650	− 60	− 31
7	48 19	55 05	763	37·0	609	814	608	− 51	+ 1
8	45 50	56 07	799	31·6	544	834	545	− 35	− 1
9	43 04	54 53	851	30·9	575	855	478	− 4	+ 97
10	42 00	55 07	851	31·3	582	864	450	− 13	+132
11	41 28	54 57	862	21·2	414	868	438	− 6	− 24
12	40 38	55 00	871	23·6	464	875	415	− 4	+ 49
13	39 53	55 03	841	20·2	379	881	398	− 40	− 19
14	38 58	54 54	906	16·1	361	888	375	+ 18	− 14
15	38 18	55 00	903	16·0	358	894	358	+ 9	0
16	37 21	55 00	911	12·4	301	901	335	+ 10	− 34
17	36 20	55 05	912	12·6	306	910	308	+ 2	− 2
18	35 30	54 50	939	09·1	267	916	288	+ 23	− 21
19	34 49	54 53	954	05·9	223	922	270	+ 32	− 47
20	32 11	55 03	0·35987	39 02·1	184	942	205	+ 45	− 21
21	29 20	55 00	0·36037	38 55·1	0·29104	966	133	+ 71	− 29
22	26 27	55 02	100	45·5	0·28989	0·35988	062	+112	− 73
23	26 24 01	84 54 58	0·36147	38 37·8	0·28895	0·36008	0·29000	+139	−105

γ = 0·00001 C.G.S.

CHAPTER V

COMPUTING OFFICE AND TIDAL SECTION

BY MAJOR G. BOMFORD, R.E.

COMPUTING OFFICE

35. Readjustment of the primary triangulation.—The readjustment of the primary triangulation of India and Burma has now been completed as far as it is at present expedient to take it. That is to say, revised values have been obtained for scale, azimuth and position at the junctions of all primary series. Revised geodetic values at astronomical stations can now be immediately obtained by interpolating between the changes at these junction points. If the new adjustment is ever made the basis of the survey and included in the triangulation pamphlets, each series will be independently adjusted on to the values of scale, azimuth and position now assigned at its two ends, by the method at present employed for adjusting a new series between its starting and closing stations. Some revision will be necessary in Assam and Burma in two or three years' time, on the completion of field work still in progress.

Chart XX shows the changes in position arising from the new adjustment. In India the only large changes are in longitude to the south of Bangalore where the inclusion of Laplace stations has caused changes amounting to 90 feet at Cape Comorin. Changes in Burma are rather larger (up to 120 feet at Moulmein), which are also mostly due to the inclusion of Laplace stations.

The blocks of triangulation usually known as the north-east and south-west quadrilaterals are wholly of secondary accuracy and have not yet been readjusted. The changes of position will not, however, be very large. The adjustment of the Burma Coast series south of Rangoon requires to be considered separately from India, with the Siamese triangulation which is not yet complete.

36. Lambert Grid.—The adjustment, classification and conversion to grid terms of all data in the frontier, trans-frontier and principal military training areas have now been completed, and the grid data pamphlets (57 in all) have now been compiled except two training area pamphlets.

Figures for the current year are:—3,000 points classified and converted, 25 pamphlets compiled, and 9 pamphlets published.

Triangulation of 'E' Company in 1935–37, lying inside the grid area, has been computed and adjusted and included in the pamphlets.

INDIA

TRIANGULATION SERIES AND AZIMUTH STATIONS

Corrected to Sept. 1937.

(Work of Foreign Countries in red.)

1937 adjustment *minus* previous adjustment

Latitude in seconds _____

Longitude „ „ _____

Base-Line .....

Astronomical Azimuths .....

Where stations are close to each other they are omitted.

Scale 1 Inch = 250 Miles

Secondary Series not yet adjusted

Pendent Series not yet adjusted

See chart II. of G. R. 99

Kābul · Peshāwar · Srīnagar · Rāwalpindi · Nasratābād · Kandahar · Dera Ismail Khan · Quetta · LAHORE · Amritsar · Ludhiāna · Dehra Dūn · Mīrān · Sutlej R. · Indus R. · Brahmaputra R. · Osh · Kisil R. · DELHI · Meerut · Bīkaner · Sukkur · Jodhpur · Agra · Cawnpore · Allahabad · Ganges R. · Jumna R. · Karachi Base · Karachi · Hyderābād · Deesa · Kalianpur · Jubbulpore · NĀGPUR · Sambalpur · BOMBAY · Poona · Bidar Base · Secunderābād · Godāvari R. · Vizagapatam Base · Waltair · Cocanāda · Belgaum · Bellary · Bangalore · MADRAS · Mangalore · Calicut · Trichinopoly · Minicoy · Cape Comorin Base · Pagarkoil · Trincomalee · Batticaloa · Negombo · CEYLON · Colombo · B A Y o f B E N G A L · A R A B I A N S E A · Dibrugarh · Brahmaputra R. · Salween R. · Shillong · Myitkyina · Kalemyo Base · Chittagong · Mandalay · Kyaukse Base · Akyab · Prome · Sittang R. · RANGOON · Bassein · Moulmein · Amherst Base · ANDAMAN ISLANDS · Port Blair · NICOBAR ISLANDS · SUMATRA · Lao-hai · Hanoi · Haiphong · Nan-ning · Mekong R. · Lampang · Nagorn Sawarn · Sen Sab · Bangkok · Haiburi · Sisophone · Chandhaburi · Mergui · Mergui Base · Nagorn Sridharmraj · Puket · Kelantan · Saigon · Bena · GULF OF TONG-KING · GULF OF SIAM

37. Mandalay Meridional series.—The computations of Mandalay Meridional series (1936–37), and of the astronomical observations made in connection with it, have been carried out. Details of the closure of the series on previous work are given in Chapter I.

38. Hayford computations.—Of the 1,000 stations at which the deviation of the vertical has been measured in India, the computed Hayford deflection has only been calculated at about 300. During the current year it has been computed at a further 90 stations, and it is hoped to continue the work and finish it during the next few years. Results will be published later.

39. Publications.—In addition to the grid triangulation pamphlets referred to above, the following publications have been prepared and seen through the press:—

(*i*) Geodetic Report 1936.

(*ii*) Levelling pamphlet No. 43, 2nd edition.

(*iii*) Auxiliary Tables Part III, 6th edition.

(*iv*) Geodetic Handbook Part VI (levelling), 3rd edition.

(*v*) Addenda to 4 Triangulation pamphlets.

40. Miscellaneous.—Triangulation and traverse carried out by No. 1 Party has been computed, especially a large number of resected stations and intersected points in the Gangotri glacier and Nanda Devi areas.

The heights of the Sambalpur Meridional series have been recomputed and adjusted in connection with discrepancies arising between the work of topographical parties in that area.

Sixty hypsometric heights observed by Mr. G. Sheriff in Bhutān in 1936 (sheet 78 M) have been computed.

A large number of requisitions for data, and other [illegible] of work, have been attended to, and assistance in their computations has been given to other parties.

41. Chart Section.—The Chart Section has completed:—

(*a*) Charts for 12 grid triangulation pamphlets.

(*b*) 18 charts and plates for Geodetic Report 1936.

(*c*) About 60 miscellaneous charts and diagrams.

TIDAL SECTION

42. Tidal observations.—Registrations with automatic gauges were continued by the Port authorities at Aden, Karāchi, Bombay, Vizagapatam, Dublat, Calcutta and Rangoon. Daylight observations on tide-poles were also continued at Bhāvnagar, Chittagong and Akyab. Reports are no longer received from Colombo.

The observatory at Aden was damaged by a storm on the 1st July 1937. It was put in order and restarted on the 9th July,

leaving a break of 8 days in the automatic registration, which was filled by quarter-hourly observations on a tide-pole. The zero of the gauge has been reset approximately to the same level as before the storm.

In connection with the re-building of the wharf at Brooking Street, Rangoon, the tidal observatory was removed from there to Sule Pagoda wharf No. 7 on the 24th February 1937 and the bench-mark of reference (Graham Smith's B.M.) was destroyed. It has been replaced by a new bench-mark, known as Scott's bench-mark, near the Flagstaff in Lewis Street. The observatory was first erected in Rangoon at the Latter Street wharf in 1880 (automatic registrations starting on 1st March 1880), whence it was removed to the Brooking Street wharf in June 1891, where it remained until February 1937.

The observatory at Bombay was dismantled on the 15th April for overhauling and zero measurements, and did not work from the 15th to the 22nd April 1937.

No breaks in tidal observations occurred at Karāchi or Calcutta during the year under report.

43. Corrections to predictions.—Empirical corrections based on the "actuals" of recent years, have as in previous years been applied to the 1938 predictions for Chāndbāli, Calcutta, Chittagong and Rangoon.

44. Tide-tables.—The Tide-tables of the Indian Ocean and the three pamphlets for Bombay, the Hooghly River and the Rangoon River have been prepared as usual and published in October 1936 for the year 1937 and in September 1937 for 1938. Advance predictions for 1938 for a number of ports were sent in October-December 1936, on the usual exchange basis, to the Hydrographic Departments in England, the United States and Japan for inclusion in their tide-tables.

A sum of Rs. 3,500/3/- has been realized from the sale of tide-tables during the year ending 30th September 1937, exclusive of agents' commission.

45. Accuracy of predictions.—Table 1 gives the greatest errors in the predicted height of low water during 1936 at the ports for which "actuals" are available. Tables 2 to 12 give detailed results for the comparison of the predicted and actual values. The quality of prediction is practically the same as in previous years.

46. Methods of prediction.—The routine methods of prediction have been overhauled, and a number of minor changes made which will make for quicker working without loss of accuracy, especially in the prediction of riverain ports. The strength of the Tidal Section has been reduced to a Tidal Assistant and 5 computers, and reduction to 4 computers is anticipated.

TABLE 1.—*Greatest differences between predicted and actual heights of low water during 1936.*

Port	Predicted *minus* Actual	Date	REMARKS
	feet		
Aden ...	+0·7	May 21 and June 19.	
Karāchi ...	−1·0	Feb. 29.	
Bhāvnagar ...	−4·9*	March 24.	
Bombay (Apollo Bandar)	−1·3	June 26.	
Vizagapatam ...	+0·8	Jan. 8.	
Shortt Island ...	−2·4	June 30.	Actual values are available up to 31st July 1936.
Dublat ...	−4·0	Oct. 4.	Riverain port.
Calcutta (Kidderpore) ...	−3·9	Oct. 4.	Do.
Chittagong ...	−3·3	Aug. 7.	Do.
Akyab ...	−1·4	Jan. 28.	
Rangoon ...	−2·1	May 30.	Riverain port.

* The mean range of the ordinary spring-tides at this port is 31½ feet.

TABLE 2.—*Mean errors E_1* and E_2* for 1936.*

ADEN

PERIOD 1936	MEAN ERRORS (Predicted – Actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes in time		0·7† feet in 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		17·1	0·1			16·5	0·0		17·6	0·1	17·4	0·1	4	3	0	0
16-31		4·1	0·2		3·2		0·0		8·0	0·2	10·4	0·1	0	2	0	0
Feb. 1-15		2·3		0·0	4·6			0·1	6·5	0·1	8·3	0·1	1	2	0	0
16-29	2·1		0·2		0·0		0·0		4·7	0·2	6·6	0·1	0	0	0	0
Mar. 1-15	8·2			0·0		0·9		0·1	9·9	0·1	7·7	0·2	2	0	0	0
16-31	2·8			0·1	5·9			0·1	12·1	0·2	12·4	0·1	2	2	0	0
April 1-15	2·1		0·0			3·7	0·0		10·6	0·2	12·1	0·2	2	2	0	0
16-30	0·3		0·1			0·6	0·1		6·3	0·2	7·0	0·2	0	0	0	0
May 1-15		1·6		0·1		8·7		0·0	7·4	0·1	9·8	0·1	0	0	0	0
16-31	2·5			0·1	1·3			0·1	6·0	0·1	5·5	0·2	0	0	0	0
June 1-15	3·6			0·1		0·5		0·1	7·0	0·1	4·6	0·2	0	0	0	0
16-30	2·2			0·1	1·3		0·0		3·7	0·1	6·4	0·2	0	1	0	0
July 1-15	5·0			0·0	0·2		0·0		6·1	0·1	5·7	0·1	0	0	0	0
16-31	1·3		0·0			1·8	0·0		3·3	0·2	6·0	0·2	0	0	0	0
Aug. 1-15	0·8		0·0			1·0	0·0		3·1	0·1	4·7	0·1	0	0	0	0
16-31		1·8		0·1	0·4			0·2	5·4	0·2	4·4	0·3	0	0	0	0
Sept. 1-15		2·3	0·0			2·0	0·0		4·5	0·1	5·7	0·1	0	0	0	0
16-30		5·2		0·0		0·7		0·1	7·5	0·1	6·1	0·1	0	0	0	0
Oct. 1-15	2·2		0·0			0·7	0·0		4·1	0·1	5·6	0·1	0	0	0	0
16-31		4·4	0·1		0·9			0·0	6·0	0·1	5·3	0·1	0	0	0	0
Nov. 1-15		5·3	0·1			5·9	0·0		7·7	0·1	7·3	0·1	0	0	0	0
16-30		0·8		0·1	0·2			0·2	3·9	0·1	4·4	0·2	0	0	0	0
Dec. 1-15		8·9		0·2		1·0		0·2	13·9	0·2	11·5	0·2	1	0	0	0
16-31		0·8		0·2	1·7			0·2	3·5	0·2	6·4	0·2	0	0	0	0
TOTALS ..	33·1	54·6	0·8	1·1	19·7	44·0	0·1	1·4	168·8	3·3	181·3	3·6	12	12	0	0
MEANS ...	− 0·9		0·0		− 1·0		− 0·1		7·0	0·1	7·6	0·2				

* E_1 is with regard to sign: E_2 is without regard to sign.
† One-tenth of the mean range of the ordinary spring-tides.

TABLE 3.—*Mean errors E_1* and E_2* for 1936.*

KARĀCHI

PERIOD 1936	MEAN ERRORS (Predicted − Actual)												Number of errors exceeding			
	E_1*								E_2*				*30 minutes* in time		*0·9*† *feet* in 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		0·5		0·2		2·7	0·1		10·3	0·2	13·0	0·1	0	0	0	0
16-31		1·5	0·0		4·7		0·3		6·7	0·1	11·8	0·3	0	2	0	0
Feb. 1-15		4·1		0·2	1·3		0·0		9·1	0·3	10·9	0·2	0	1	0	0
16-29		0·7		0·5	5·4			0·2	8·1	0·5	9·3	0·3	1	0	1	1
Mar. 1-15		1·6		0·1		0·5	0·1		10·6	0·2	8·8	0·2	0	1	0	0
16-31	3·7			0·3	8·3			0·1	7·8	0·3	12·0	0·2	0	1	0	0
April 1-15	2·6			0·3	6·7			0·0	6·6	0·4	8·4	0·3	0	0	0	0
16-30	1·8			0·1	4·8		0·1		6·2	0·2	9·3	0·2	0	0	0	0
May 1-15	0·3			0·2	3·3		0·2		6·5	0·2	8·0	0·3	0	0	0	0
16-31	0·0			0·3	2·7			0·0	4·5	0·3	9·6	0·2	0	1	0	0
June 1-15		4·8		0·5	3·0			0·3	8·0	0·5	10·2	0·3	0	0	0	0
16-30		4·9		0·8		1·4		0·6	9·2	0·8	8·4	0·6	0	0	9	0
July 1-15		2·3		0·3		0·5		0·1	8·2	0·4	8·6	0·2	0	1	0	0
16-31		4·9		0·2		1·0	0·0		8·4	0·2	9·6	0·3	1	0	0	0
Aug. 1-15		3·1		0·1		0·1	0·1		7·1	0·2	9·7	0·2	0	0	0	0
16-31		2·3		0·1	1·2		0·0		7·9	0·2	7·7	0·1	0	0	0	0
Sept. 1-15		4·7		0·3	0·1		0·1		8·2	0·3	6·7	0·2	0	0	0	0
16-30		1·8		0·3	8·6			0·1	5·4	0·3	11·4	0·2	0	1	0	0
Oct. 1-15		1·6		0·1	3·0		0·2		5·6	0·2	8·3	0·2	0	1	0	0
16-31		2·1		0·1	5·5		0·1		7·9	0·2	8·3	0·2	0	2	0	0
Nov. 1-15		0·9		0·4		2·7		0·2	6·4	0·4	9·1	0·2	0	0	0	0
16-30		0·9		0·4	5·6			0·2	6·7	0·4	10·8	0·3	0	3	0	0
Dec. 1-15		2·2		0·8	2·7			0·6	6·7	0·8	9·0	0·6	0	0	4	0
16-31	2·3			0·6	6·3			0·3	4·8	0·6	11·1	0·3	0	1	4	0
TOTALS...	10·7	44·9	0·0	7·2	73·2	8·9	1·3	2·7	176·9	8·2	230·0	6·2	2	15	18	1
MEANS ...	− 1·4		− 0·3		+ 2·7		− 0·1		7·4	0·3	9·6	0·3				

* E_1 is with regard to sign: E_2 is without regard to sign.
† One-tenth of the mean range of the ordinary spring-tides.

TABLE 4.—*Mean errors E_1* and E_2* for 1936.*

BHĀVNAGAR

PERIOD 1936	MEAN ERRORS (Predicted – Actual†)												Number of errors exceeding			
	E_1*								E_2*				30 minutes in time		1·0‡ feet in 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	14·2			0·3		26·7		0·7	16·7	0·6	30·3	1·0	0	9	3	5
16-31	15·6		0·6			27·6		0·7	18·1	0·6	37·7	1·3	0	8	1	8
Feb. 1-15	17·1			0·1		24·7		0·4	17·1	0·3	26·7	1·0	0	7	0	5
16-29	13·9		0·2			37·9		1·5	14·1	0·5	49·9	1·9	0	8	1	8
Mar. 1-15	22·5		0·2			18·1	0·0		22·5	0·4	21·0	0·9	0	5	1	5
16-31	16·4			0·3		25·9		1·3	19·9	0·6	35·8	1·8	0	7	4	8
April 1-15	17·5			0·2		10·8	0·0		17·5	0·4	15·3	0·6	0	0	0	3
16-30	11·1			0·1		38·7		0·9	17·8	0·6	40·5	1·8	0	8	2	9
May 1-15	17·3			0·3		8·4	0·5		17·3	0·7	8·9	0·7	0	0	1	3
16-31	12·8			0·3		25·1		0·2	17·6	0·7	26·4	1·0	0	8	4	6
June 1-15	16·5			0·4		9·5	0·4		16·5	0·6	11·3	0·5	1	0	3	1
16-30	8·9			0·8		16·7		0·4	16·7	0·9	20·4	0·5	0	5	6	2
July 1-15	19·0			0·4		15·5	0·5		19·1	0·4	18·7	0·6	0	5	1	4
16-31	15·9		0·1			13·7	0·7		16·4	0·5	21·4	0·8	0	5	0	5
Aug. 1-15	8·5			0·1		29·8	0·6		10·0	0·3	31·9	1·0	0	9	0	6
16-31	7·8		0·1			18·9	1·0		13·7	0·4	21·2	1·1	0	4	0	8
Sept. 1-15	8·3			0·4		30·9		0·3	8·7	0·7	32·4	0·8	0	8	5	6
16-30	22·6			0·4		11·6	0·3		22·6	0·7	22·1	0·8	0	4	2	4
Oct. 1-15	10·1		0·0			31·3		0·5	14·7	0·5	31·3	1·4	0	8	1	8
16-31	21·8			0·2		13·1	0·3		21·8	0·5	21·1	1·3	0	2	1	10
Nov. 1-15	10·6			0·7		23·9		0·7	15·8	0·9	24·1	0·8	0	5	6	3
16-30	20·1			0·8		10·5		0·1	20·1	0·8	11·7	1·0	2	2	6	5
Dec. 1-15	13·3			0·8		15·9		1·1	18·4	0·9	16·5	1·1	0	4	7	6
16-31	13·5			0·2		25·4		1·0	18·3	0·5	27·5	1·2	0	4	1	5
TOTALS	355·3		1·2	6·8		510·6	4·3	9·8	411·4	14·0	604·1	24·9	3	125	56	133
MEANS	+ 14·8		− 0·2		− 21·3		− 0·2		17·1	0·6	25·2	1·0				

* E_1 is with regard to sign: E_2 is without regard to sign.
† Actual values are tide-pole readings during daylight only.
‡ One-tenth of the mean range of the ordinary spring-tides is 3·1 feet.

TABLE 5.—*Mean errors E_1* and E_2* for 1936.*

BOMBAY (APOLLO BANDAR)

PERIOD 1936	MEAN ERRORS (Predicted − Actual)												Number of errors exceeding			
	E_1*								E_2*				*30 minutes* in time		*1·0*† *feet* in 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		3·9	0·1			12·4	0·3		10·7	0·2	14·3	0·3	0	1	0	1
16-31		7·3	0·3			7·0	0·3		12·4	0·4	10·8	0·3	3	2	0	0
Feb. 1-15		6·4	0·1			8·6	0·1		9·8	0·3	11·4	0·3	0	0	0	0
16-29	0·8			0·1		7·0		0·0	6·6	0·2	11·5	0·2	0	1	0	0
Mar. 1-15		3·3	0·0			4·7	0·0		9·4	0·4	10·5	0·2	1	0	0	0
16-31	6·0			0·3	3·7			0·4	10·7	0·4	7·6	0·5	1	0	0	1
April 1-15	4·7			0·3	4·1			0·2	7·4	0·3	6·4	0·4	0	0	0	0
16-30	2·3			0·0		5·5		0·1	10·2	0·4	8·0	0·2	2	0	0	0
May 1-15		6·3		0·2		3·9		0·0	8·3	0·3	7·1	0·2	0	1	0	0
16-31		1·0	0·0			4·1	0·2		6·1	0·2	6·6	0·3	0	0	0	0
June 1-15		16·2	0·1			14·8		0·3	17·1	0·3	14·8	0·3	5	0	0	0
16-30		10·1		0·7		4·6		0·7	12·8	0·8	9·4	0·7	2	1	7	5
July 1-15	1·6		0·1			2·8		0·3	8·4	0·4	12·0	0·4	0	1	0	1
16-31		9·2	0·2			11·9		0·1	16·4	0·4	14·6	0·2	3	3	3	0
Aug. 1-15		2·2	0·5			5·0		0·1	6·6	0·5	12·7	0·3	0	1	1	0
16-31		12·5	0·3			7·5		0·0	14·5	0·3	12·6	0·2	2	0	0	0
Sept. 1-15	3·4		0·3		6·8			0·0	6·6	0·3	12·2	0·2	0	1	0	0
16-30		0·0		0·1	4·3			0·0	6·4	0·2	7·8	0·2	0	4	0	0
Oct. 1-15	4·0		0·4		2·0		0·3		6·9	0·5	9·6	0·3	0	0	0	0
16-31		0·3	0·2			4·6	0·2		5·8	0·2	6·0	0·3	0	0	0	0
Nov. 1-15	3·8			0·4		2·1		0·6	5·2	0·5	10·1	0·6	0	1	0	1
16-30		2·2		0·1		6·1		0·3	6·5	0·2	7·3	0·3	1	0	0	0
Dec. 1-15	1·5			0·4		3·4		0·6	6·3	0·5	7·2	0·6	0	0	0	4
16-31		4·2	0·0			11·7		0·0	7·1	0·4	12·3	0·5	0	0	1	6
TOTALS...	28·1	85·1	2·6	2·6	20·9	127·7	1·4	3·7	218·2	8·6	242·8	8·0	20	17	12	19
MEANS ...	− 2·4		0·0		− 4·5		− 0·1		9·1	0·4	10·1	0·3				

* E_1 is with regard to sign: E_2 is without regard to sign.
† One-tenth of the mean range of the ordinary spring-tides is 1·4 feet.

TABLE 6.—*Mean errors E_1* and E_2* for 1936.*

VIZAGAPATAM

PERIOD 1936	MEAN ERRORS (Predicted − Actual†)												Number of errors exceeding			
	E_1*								E_2*				30 *minutes* in time		0·5‡ *feet* in 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			0·3				0·5			0·4		0·5	0	0	2	10
16-31			0·1				0·1			0·1		0·2	0	0	0	0
Feb. 1-15				0·4				0·2		0·4		0·3	0	0	2	2
16-29				0·1			0·0			0·2		0·1	1	1	0	0
Mar. 1-15			0·2				0·2			0·2		0·2	0	0	1	1
16-31			0·3				0·3			0·3		0·4	0	0	0	1
April 1-15				0·1			0·0			0·2		0·2	0	0	0	0
16-30			0·1				0·2			0·2		0·3	0	0	0	0
May 1-15				0·0			0·2			0·1		0·2	0	0	0	1
16-31				0·2				0·1		0·2		0·2	0	0	0	0
June 1-15	Tide-gauge out of order.															
16-30				0·0				0·0		0·2		0·1	0	0	1	0
July 1-15			0·2				0·3			0·2		0·3	0	0	0	0
16-31				0·0			0·1			0·1		0·2	0	0	0	1
Aug. 1-15			0·1				0·2			0·3		0·3	0	0	3	7
16-31				0·2				0·0		0·2		0·1	0	0	1	0
Sept. 1-15			0·3				0·3			0·3		0·3	0	0	9	9
16-30			0·3				0·6			0·3		0·6	0	0	1	18
Oct. 1-15			0·3				0·3			0·4		0·5	0	0	9	12
16-31				0·1			0·1			0·2		0·2	0	0	2	0
Nov. 1-15				0·1			0·0			0·1		0·1	0	0	0	0
16-30			0·0				0·3			0·1		0·3	0	0	0	2
Dec. 1-15			0·2				0·3			0·2		0·3	0	0	0	3
16-31			0·1				0·4			0·2		0·4	0	0	0	1
TOTALS ...			2·5	1·2			4·4	0·3		5·1		6·3	1	1	31	68
MEANS ...			+ 0·1				+ 0·2			0·2		0·3				

* E_1 is with regard to sign: E_2 is without regard to sign.
† Error small but not recorded.
‡ One-tenth of the mean range of the ordinary spring-tides.

TABLE 7.—*Mean errors E_1* and E_2* for 1936.*

SHORTT ISLAND

PERIOD 1936	MEAN ERRORS (Predicted − Actual†)												Number of errors exceeding			
	E_1*								E_2*				*30 minutes* in time		*1·0*‡ *feet* in 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		23·0		0·3		19·1		0·4	25·5	0·3	19·1	0·4	5	2	0	0
16-31		20·8		0·5		23·7		0·7	21·3	0·5	24·1	0·7	3	5	0	4
Feb. 1-15		20·1		0·7		18·5		0·9	22·3	0·7	18·5	0·9	2	4	0	1
16-29		13·3		0·4		20·7		0·8	22·7	0·5	22·6	0·8	3	4	0	3
Mar. 1-15		24·9		0·3		25·5		0·5	25·5	0·3	30·9	0·5	3	7	0	0
16-31		12·5		0·4		18·5		0·6	20·3	0·4	19·1	0·6	3	6	0	1
April 1-15		28·4		0·4		28·9		0·3	33·6	0·4	29·4	0·5	10	7	0	0
16-30		19·6		0·4		17·0		0·5	21·8	0·5	25·4	0·6	4	5	2	1
May 1-15		13·9		0·4		17·3		0·4	15·2	0·4	17·4	0·4	1	4	0	0
16-31		22·5		0·9		15·8		0·9	22·6	0·9	20·3	0·9	3	5	7	4
June 1-15		24·5		1·6		24·1		1·0	25·5	1·6	25·0	1·0	6	7	13	6
16-30		17·4		1·2		16·5		1·3	19·3	1·2	21·0	1·3	3	5	9	10
July 1-15		14·6		0·8		11·5		0·6	20·8	0·8	20·2	0·6	4	3	5	3
16-31		19·2		1·3		9·0		1·3	19·2	1·3	12·5	1·3	3	1	9	11
Aug. 1-15	Actual values are not available from 1st August 1936.															
16-31																
Sept. 1-15																
16-30																
Oct. 1-15																
16-31																
Nov. 1-15																
16-30																
Dec. 1-15																
16-31																
TOTALS ...		274·7		9·6		266·1		10·2	315·6	9·8	305·5	10·5	53	65	45	44
MEANS ...		− 19·6		− 0·7		− 19·0		− 0·7	22·5	0·7	21·8	0·8				

* E_1 is with regard to sign: E_2 is without regard to sign.
† Actual values are tide-pole readings during daylight only.
‡ One-tenth of the mean range of the ordinary spring-tides.

TABLE 8.—*Mean errors E_1* and E_2* for 1936.*

DUBLAT

PERIOD 1936	MEAN ERRORS (Predicted – Actual)												Number of errors exceeding			
	E_1*								E_2*				30 minutes in time		1·0† feet in 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	0·1			0·4		2·0		0·4	6·2	0·4	5·1	0·4	0	0	0	0
16-31	11·8			0·5	6·9			0·3	12·4	0·5	8·5	0·6	0	0	2	3
Feb. 1-15	10·7			0·7	8·9			0·5	11·9	0·7	10·6	0·5	0	0	2	0
16-29	13·0			0·5	10·3			0·2	15·1	0·6	11·5	0·4	2	1	3	0
Mar. 1-15	6·8			0·5	1·7		0·0		8·6	0·5	7·2	0·3	0	1	2	0
16-31	2·3			0·3		0·5		0·2	9·3	0·4	11·1	0·6	2	1	1	5
April 1-15		4·3		0·8		7·9		0·0	10·6	0·8	10·9	0·3	1	2	6	0
16-30		11·2		0·5		8·7		0·7	11·7	0·6	10·9	0·7	1	0	3	5
May 1-15		2·6		0·6		6·3	0·0		7·2	0·6	9·3	0·3	0	1	3	0
16-31		7·7		0·5		11·1		0·9	13·4	0·5	16·3	0·9	0	0	2	8
June 1-15		3·8		1·2	2·3			0·5	9·3	1·2	9·4	0·7	0	0	18	2
16-30		2·8		0·6		7·5		0·8	12·6	0·6	16·1	0·8	0	0	3	9
July 1-15		2·5		0·1		4·4	0·0		8·4	0·3	11·9	0·3	0	0	1	0
16-31	5·2			0·6	7·5			0·4	8·3	0·6	8·7	0·6	0	0	1	9
Aug. 1-15		3·0		0·3		0·4		0·3	7·9	0·7	7·0	0·4	0	0	6	0
16-31		0·5		0·8	11·0			0·7	6·9	0·8	13·5	0·8	0	1	12	9
Sept. 1-15		5·6		0·3		1·7		0·6	12·0	0·4	8·3	0·7	0	0	0	7
16-30		11·1		0·4		10·1		0·1	14·9	0·5	13·7	0·3	0	1	2	0
Oct. 1-15		14·2		0·6		10·7		1·0	15·1	0·6	14·2	1·0	1	2	4	10
16-31		11·4		0·8		17·7		0·6	12·5	0·8	17·7	0·6	0	1	5	3
Nov. 1-15		14·3		1·0		18·5		1·1	14·3	1·0	18·6	1·1	1	1	14	23
16-30		10·8		0·9		17·9		0·7	10·8	0·9	19·2	0·8	0	0	11	11
Dec. 1-15		4·8		0·7		12·1		0·8	7·4	0·7	12·1	0·8	0	0	0	10
16-31		0·8		0·4		9·8		0·6	6·5	0·4	9·8	0·6	0	0	2	3
TOTALS...	49·9	111·4		14·0	48·6	147·3	0·0	11·4	253·3	15·1	281·6	14·5	8	12	103	117
MEANS ...	− 2·6		− 0·6		− 4·1		− 0·5		10·6	0·6	11·7	0·6				

* E_1 is with regard to sign: E_2 is without regard to sign.
† One-tenth of the mean range of the ordinary spring-tides is 1·4 feet.

TABLE 9.—*Mean errors E_1* and E_2* for 1936.*

CALCUTTA (KIDDERPORE)

PERIOD 1936	MEAN ERRORS (Predicted − Actual)												Number of errors exceeding			
	E_1*								E_2*				*30 minutes* in time		*1·0* † *feet* in 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		8·1	0·2			15·3	0·1		12·1	0·3	16·3	0·4	1	3	0	0
16-31	4·3			0·3		5·9	0·2		9·9	0·4	11·7	0·4	0	0	0	0
Feb. 1-15		6·4	0·1			7·7	0·0		8·1	0·3	10·3	0·4	0	0	0	0
16-29		2·7		0·1		18·2	0·5		10·0	0·3	21·0	0·6	0	5	0	8
Mar. 1-15		9·3	0·1			8·0	0·3		11·2	0·3	11·9	0·4	1	2	0	2
16-31		2·2		0·2		13·9		0·1	10·8	0·3	17·3	0·2	1	2	0	0
April 1-15		9·3		0·1		8·3		0·0	10·0	0·3	9·3	0·3	0	0	0	0
16-30	1·0			0·2		4·0		0·3	8·6	0·4	13·2	0·4	0	1	2	4
May 1-15	2·2			0·4	5·0			0·4	8·0	0·4	8·0	0·5	0	1	0	4
16-31		0·1	0·2			6·6		0·3	10·4	0·4	12·8	0·5	1	0	2	2
June 1-15	0·5			0·6		3·7		0·3	6·6	0·6	10·6	0·6	0	0	2	6
16-30		4·1	0·2			5·8	0·1		12·6	0·5	14·8	0·4	2	2	0	0
July 1-15		6·3	0·1			11·4	0·2		8·5	0·3	15·9	0·5	0	5	0	2
16-31		4·0		0·5		4·3		0·6	8·0	0·5	9·7	0·7	0	0	0	5
Aug. 1-15		2·9		0·8		8·3		0·5	7·9	0·8	10·6	0·5	0	0	10	5
16-31	9·0			1·1	13·7			1·0	10·1	1·1	15·1	1·0	0	3	15	13
Sept. 1-15		0·5		0·6		5·9		1·0	6·9	0·6	9·3	1·0	1	0	2	14
16-30		6·7		0·9		9·2		1·6	8·8	0·9	11·4	1·6	0	0	12	29
Oct. 1-15		1·9		1·4		5·0		2·2	7·2	1·4	13·8	2·2	0	2	20	29
16-31		5·7		0·1		6·6		0·6	7·7	0·4	9·8	0·7	0	0	1	5
Nov. 1-15		6·8	0·2			4·5	0·0		8·5	0·2	7·2	0·2	0	0	0	0
16-30		7·3	0·1			6·9		0·0	8·0	0·4	9·9	0·3	0	0	0	0
Dec. 1-15		3·7	0·2			2·0	0·0		8·7	0·2	8·4	0·4	0	0	0	0
16-31		4·8	0·5			11·1	0·1		9·3	0·6	11·6	0·4	1	1	6	0
TOTALS...	17·0	92·8	1·9	7·3	18·7	172·6	1·5	8·9	217·9	11·9	289·9	14·6	8	27	72	128
MEANS ...	− 3·2		− 0·2		− 6·4		− 0·3		9·1	0·5	12·1	0·6				

* E_1 is with regard to sign: E_2 is without regard to sign.
† One-tenth of the mean range of the Ordinary Spring-tides is 1·2 feet.

TABLE 10.—*Mean errors E_1* and E_2* for 1936.*

CHITTAGONG

PERIOD 1936	MEAN ERRORS (Predicted − Actual†)												Number of errors exceeding			
	E_1*								E_2*				30 *minutes* in time		1·0‡ *feet* in height	
	H. W. Time		H. W. Height		L. W. Time		L. W. Height		H. W. Time	H. W. Ht.	L. W. Time	L. W. Ht.	H. W.	L. W.	H. W.	L. W.
	minutes		*feet*		*minutes*		*feet*		*minutes*	*feet*	*minutes*	*feet*				
	+	−	+	−	+	−	+	−								
Jan. 1-15	3·7		0·2		0·5			0·0	6·3	0·4	3·7	0·3	0	0	0	0
16-31		3·0		0·5		0·8	0·3		7·4	0·6	5·6	0·4	0	0	4	1
Feb. 1-15	2·3		0·0		0·5			0·2	4·5	0·3	4·6	0·3	0	0	0	0
16-29	4·0			0·5	3·8		0·3		8·9	0·7	7·9	0·5	0	0	4	0
Mar. 1-15	3·7		0·2		1·0			0·2	6·3	0·4	7·3	0·3	0	0	1	0
16-31	0·5			0·3		0·3		0·1	5·8	0·5	6·6	0·3	0	0	2	0
April 1-15		1·1		0·4		1·7		0·1	5·9	0·7	7·1	0·6	0	1	5	2
16-30	0·0			0·3		0·4		0·2	5·5	0·6	3·7	0·4	0	0	3	0
May 1-15		0·3		0·4		2·1	0·1		2·7	0·4	3·3	0·3	0	0	3	0
16-31	3·8			0·3	0·0			0·9	6·6	1·2	4·8	0·9	0	0	8	5
June 1-15	4·8			0·8	4·6			0·6	6·5	0·8	5·7	0·7	1	0	5	2
16-30	2·7		0·2		7·7			0·2	6·5	0·4	7·9	0·3	0	0	1	0
July 1-15	6·7		0·7		4·7			0·0	6·7	0·7	5·7	0·3	0	0	4	1
16-31	6·4		0·3		5·8			0·3	6·9	0·7	7·9	0·7	0	0	2	3
Aug. 1-15		1·5		0·4	1·1			1·1	8·5	0·5	5·0	1·1	0	0	1	6
16-31	5·3			0·8	1·3		0·2		6·1	0·8	6·1	0·4	0	0	5	1
Sept. 1-15	1·5			0·3	3·2		0·1		3·1	0·5	6·1	0·3	0	0	3	0
16-30	1·1		0·4		0·9		0·8		6·1	0·5	4·3	0·8	0	0	1	5
Oct. 1-15	3·1			0·4	4·4			0·4	7·7	0·7	5·3	0·4	0	0	5	1
16-31		3·1		0·1		0·0		0·0	5·3	0·3	4·6	0·2	0	0	0	0
Nov. 1-15	1·7		0·3		0·3		0·1		3·9	0·3	3·9	0·2	0	0	0	0
16-30		5·1		0·0	0·6		0·3		10·1	0·5	4·1	0·3	0	0	1	0
Dec. 1-15		1·5	0·3		1·0			0·0	6·5	0·4	6·0	0·1	0	0	1	0
16-31	2·3		0·5		0·8		0·2		5·8	0·5	6·6	0·2	0	0	3	0
TOTALS...	53·6	15·6	3·1	5·5	42·2	5·3	2·4	4·3	149·6	13·4	133·8	10·3	1	1	62	27
MEANS...	+ 1·6		− 0·1		+ 1·5		− 0·1		6·2	0·6	5·6	0·4				

* E_1 is with regard to sign: E_2 is without regard to sign.
† Actual values are tide-pole readings during daylight only.
‡ One-tenth of the mean range of the ordinary spring-tides is 1·3 feet.

TABLE 11.—*Mean errors E_1* and E_2* for 1936.*

AKYAB

PERIOD 1936	MEAN ERRORS (Predicted − Actual†)												Number of errors exceeding			
	E_1*								E_2*				*30 minutes* in time		*0·8*‡ *feet* in 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	4·5			0·0	4·7		0·1		4·5	0·2	4·7	0·2	0	0	0	0
16-31	4·9		0·0		4·3			0·3	4·9	0·2	4·3	0·6	0	0	0	4
Feb. 1-15	5·1			0·3	4·6			0·2	5·1	0·3	4·6	0·3	0	0	0	1
16-29	4·9			0·0	5·1			0·4	4·9	0·2	5·1	0·4	0	0	0	1
Mar. 1-15	4·4			0·1	4·9		0·0		4·4	0·2	4·9	0·1	0	0	0	0
16-31	4·3			0·0	4·8			0·3	4·3	0·1	4·8	0·3	0	0	0	1
April 1-15	4·7			0·4	4·8			0·1	4·7	0·4	4·8	0·2	0	0	0	0
16-30	4·7			0·3	4·8			0·3	4·7	0·3	4·8	0·3	0	0	2	0
May 1-15	4·9			0·3	5·3			0·0	4·9	0·3	5·3	0·1	0	0	0	0
16-31	4·8			0·0	5·5			0·1	4·8	0·4	5·5	0·1	0	0	0	0
June 1-15	4·3			0·4	4·4			0·1	4·3	0·4	4·4	0·1	0	0	1	0
16-30	4·7			0·1	5·1		0·2		4·7	0·2	5·1	0·2	0	0	0	0
July 1-15	4·9		0·3		3·9		0·2		4·9	0·3	3·9	0·2	0	0	1	0
16-31	5·4		0·0		5·3		0·0		5·4	0·1	5·3	0·1	0	0	0	0
Aug. 1-15	4·2			0·1	4·9		0·0		4·7	0·1	4·9	0·2	0	0	0	1
16-31	4·3			0·2	5·4			0·0	4·3	0·2	5·4	0·1	0	0	0	0
Sept. 1-15	4·4			0·3	4·1			0·1	4·4	0·3	4·1	0·1	0	0	0	0
16-30	4·6			0·1	4·3		0·0		4·6	0·1	4·3	0·1	0	0	0	0
Oct. 1-15	5·6			0·2	5·1			0·2	5·6	0·4	5·1	0·3	0	0	3	2
16-31	4·9			0·2	4·6			0·1	4·9	0·4	4·6	0·1	0	0	1	0
Nov. 1-15	4·6			0·2	4·7			0·2	4·6	0·3	4·7	0·3	0	0	0	0
16-30	4·4			0·3	5·3			0·1	4·4	0·3	5·3	0·2	0	0	0	0
Dec. 1-15	4·6			0·2	5·4			0·0	4·6	0·2	5·4	0·1	0	0	0	0
16-31	5·1		0·0		4·8		0·1		5·1	0·1	4·8	0·2	0	0	0	0
TOTALS...	113·2		0·3	3·7	116·1		0·6	2·5	113·7	6·0	116·1	4·9	0	0	8	10
MEANS ...	+ 4·7		− 0·1		+ 4·8		− 0·1		4·7	0·3	4·8	0·2				

* E_1 is with regard to sign: E_2 is without regard to sign.
† Actual values are tide-pole readings during daylight only.
‡ One-tenth of the mean range of the ordinary spring-tides.

TABLE 12.—*Mean errors E_1* and E_2* for 1936.*

RANGOON

PERIOD 1936	MEAN ERRORS (Predicted − Actual)												Number of errors exceeding			
	E_1*								E_2*				30 *minutes* in time		1·0† *feet* in 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		2·6	0·2		0·9		0·5		7·8	0·4	15·8	0·5	0	0	1	4
16-31	6·8		0·0		4·5			0·1	8·3	0·4	13·4	0·4	1	0	1	1
Feb. 1-15		4·2		0·0	1·3		0·3		9·1	0·3	12·1	0·4	1	0	0	0
16-29	2·9		0·3		0·7		0·2		8·8	0·5	12·1	0·4	1	2	3	0
Mar. 1-15		4·0	0·0		1·4		0·5		8·2	0·3	8·4	0·6	1	0	0	2
16-31	1·2		0·1			3·4		0·1	9·6	0·4	10·9	0·6	1	0	0	2
April 1-15		0·3		0·2	1·6		0·5		4·6	0·2	5·1	0·5	0	0	0	5
16-30	1·7			0·1		2·3		0·5	8·5	0·3	10·1	0·7	0	0	2	8
May 1-15		0·2		0·2	3·7		0·2		5·5	0·3	7·8	0·4	0	0	0	3
16-31		0·6		0·2		5·0		0·6	5·5	0·5	11·2	0·8	0	0	3	10
June 1-15	4·3			0·9	1·7			0·7	6·2	0·9	12·7	0·8	0	1	12	9
16-30	0·7		0·1			5·0		0·3	4·9	0·3	12·0	0·5	0	0	0	2
July 1-15		2·3	0·6			4·4	0·6		6·6	0·6	13·4	0·6	0	0	7	4
16-31		4·5		0·0	1·8			0·0	8·2	0·3	12·5	0·3	0	0	2	0
Aug. 1-15		1·5		0·3		8·4		0·4	10·1	0·4	11·6	0·5	0	0	0	0
16-31	6·6			0·5	1·9			0·1	8·2	0·6	11·0	0·3	0	0	6	0
Sept. 1-15	3·2		0·1			10·6		0·3	8·8	0·4	11·1	0·6	0	0	1	1
16-30		0·5	0·1			2·8	0·8		5·0	0·5	9·2	1·1	0	0	3	17
Oct. 1-15		1·0	0·3			5·2	0·1		9·2	0·3	7·1	0·6	0	0	0	4
16-31	2·6		0·3			4·2	0·5		5·1	0·4	11·3	0·6	0	0	2	6
Nov. 1-15		6·4	0·3			3·3	0·5		7·6	0·3	9·6	0·6	0	0	0	4
16-30		1·2	0·1			6·9	0·6		5·7	0·6	11·7	0·7	0	0	1	7
Dec. 1-15		3·0	0·3		2·4		0·7		6·3	0·5	13·4	0·7	0	0	2	6
16-31		4·6	0·4			9·2	0·7		5·5	0·5	13·3	0·8	0	0	0	10
TOTALS ...	30·0	36·9	3·2	2·4	21·9	70·7	6·7	3·1	173·3	10·2	266·8	14·0	5	3	46	105
MEANS ...	− 0·3		0·0		− 2·0		+ 0·2		7·2	0·4	11·1	0·6				

* E_1 is with regard to sign: E_2 is without regard to sign.
† One-tenth of the mean range of the ordinary spring-tides is 1·6 feet.

CHAPTER VI

OBSERVATORIES

BY MAJOR G. BOMFORD, R.E.

47. Standards of length.—The standard bars have been inter-compared, and seven invar wires have been standardized in preparation for primary traverse which it is intended to observe in Bengal. The bars and wires have maintained their previous lengths very satisfactorily. Details of the observations are given below. The observers were Major G. Bomford and Mr. B. L. Gulatee.

The N. P. L. certificates of the standard bars are given in Geodetic Report Volume VII, page 11, and the coefficients of expansion of the invar wires are given in Geodetic Report 1933, page 39. The coefficients of the two new wires 1037 and 1038, as given by the N. P. L. are +0·0000 and +0·0012 millimetres per 24 metres per °C respectively. In the paragraphs which follow, the "reputed length" of a bar is that given by its N. P. L. certificate at the temperature of comparison in the paragraph concerned. Details of previous comparisons are given in Geodetic Reports Volume VII, 1930–31, Chapter II: Vol. 1933, Chapter V: and Vol. 1934, Chapter VII.

(a) **Silica 1-m** *minus* **Nickel 1-m.**—

Date	Temperature	G.B.	B.L.G.
14-9-37 ..	T_S =24°·43	−0·3449mm	−0·3429mm
	T_N =24°·46	·3492	·3489
		·3436	·3448
		·3467	·3495
		·3484	·3477
		·3456	·3463
		·3431	·3430
		·3477	·3459
	Mean	−0·3462mm	−0·3461mm

Reputed length of nickel	= 1m	+0·3232mm
Reputed length of silica	= 1m	−0·0234mm
∴ Reputed silica *minus* nickel	=	−0·3466mm
Observed silica *minus* nickel	=	−0·3461mm
Discrepancy	=	−0·0005mm

The eight measures given above were made with the two bars in their eight possible different relative positions.

The discrepancy of 0·5 in 10^6 is satisfactory, and compares with 0·2 in 10^6 with the same sign in 1934.

(b) Invar 4-m (Baros plugs) *minus* **Nickel 1-m.—**

First metre (0 to 1) of invar bar.

Date	Temperature	G.B.	B.L.G.
7-9-37 ...	T_I = 25°·55	−0·2734mm	−0·2746mm
	T_N = 25°·49	·2760	·2763
		·2758	·2765
		·2760	·2751
		·2753	·2751
		·2765	·2757
		·2769	·2767
		·2734	·2751
	Mean	= −0·2754mm	−0·2756mm

Reputed length of nickel = 1m +0·3364mm
Observed invar *minus* nickel = −0·2755mm
∴ length of invar at 25°·55 = 1m +0·0609mm
and length of invar at 24°·3 = 1m +0·0591mm

24°·3C is the common temperature to which the four separate sections are reduced.

Second metre (1 to 2) of invar bar.

Date	Temperature	G.B.	B.L.G.
6-9-37 ...	T_I = 25°·00	−0·2844mm	−0·2844mm
	T_N = 24°·97	·2811	·2823
		·2834	·2824
		·2819	·2839
		·2858	·2842
		·2802	·2821
		·2809	·2820
		·2816	·2819
	Mean	−0·2824mm	−0·2829mm

Reputed length of nickel = 1m +0·3297mm
Observed invar *minus* nickel = −0·2827mm
∴ length of invar at 25°·00 = 1m +0·0470mm
and length of invar at 24°·3 = 1m +0·0460mm

Third metre (2 to 3) of invar bar.

Date	Temperature	G.B.	B.L.G.
3-9-37 ...	T_I = 25°·14 T_N = 25°·11	−0·2685mm ·2707 ·2696 ·2700 ·2714 ·2710 ·2710 ·2716	−0·2703mm ·2707 ·2700 ·2682 ·2716 ·2694 ·2706 ·2699
	Mean	−0·2705mm	−0·2701mm

Reputed length of nickel = 1m + 0·3315mm
Observed invar *minus* nickel = −0·2703mm
∴ length of invar at 25°·14 = 1m + 0·0612mm
and length of invar at 24°·3 = 1m + 0·0600mm

Fourth metre (3 to 4) of invar bar.

Date	Temperature	G.B.	B.L.G.
2-9-37 ...	T_I = 25°·00 T_N = 24°·95	−0·2722mm ·2749 ·2740 ·2735 ·2725 ·2736 ·2758 ·2754	−0·2734mm ·2768 ·2744 ·2750 ·2743 ·2754 ·2734 ·2754
	Mean	= −0·2740mm	−0·2748mm

Reputed length of nickel = 1m + 0·3295mm
Observed invar *minus* nickel = −0·2744mm
∴ length of invar at 25°·00 = 1m + 0·0551mm
and length of invar at 24°·3 = 1m + 0·0541mm

Combining the four sections of the invar bar gives the total length of the bar (baros plugs) as 4m + 0·2192mm at 24°·3 C according to comparison with the nickel bar.

(c) Invar 4-m (Baros plugs) *minus* Silica 1-m.—

First metre (0 to 1) of invar bar.

Date	Temperature	G.B.	B.L.G.
13-9-37 ...	T_I = 24°·27	+0·0799mm	+0·0813mm
	T_S = 24°·23	·0821	·0844
		·0800	·0796
		·0797	·0802
		·0825	·0813
		·0822	·0824
		·0814	·0813
		·0805	·0829
	Mean	+0·0810mm	+0·0817mm

Reputed length of silica = 1m −0·0235mm
Observed invar *minus* silica = +0·0814mm
∴ length of invar at 24°·27 = 1m +0·0579mm
and length of invar at 24°·3 = 1m +0·0579mm

Second metre (1 to 2) of invar bar.

Date	Temperature	G.B.	B.L.G.
10-9-37 ...	T_I = 24°·76	+0·0766mm	+0·0783mm
	T_S = 24°·70	·0769	·0790
		·0793	·0788
		·0781	·0790
		·0779	·0781
		·0789	·0784
		·0786	·0777
		·0807	·0792
	Mean	= +0·0784mm	+0·0786mm

Reputed length of silica = 1m −0·0233mm
Observed invar *minus* silica = +0·0785mm
∴ length of invar at 24°·76 = 1m +0·0552mm
and length of invar at 24°·3 = 1m +0·0545mm

Third metre (2 to 3) of invar bar.

Date	Temperature	G.B.	B.L.G.
9-9-37 ...	T_I = 25°·37	+0·0779mm	+0·0787mm
	T_S = 25°·41	·0786	·0793
		·0761	·0765
		·0768	·0757
		·0767	·0785
		·0791	·0815
		·0777	·0784
		·0759	·0776
	Mean	+0·0774mm	+0·0783mm

Reputed length of silica	= 1m −0·0230mm
Observed invar *minus* silica	= +0·0778mm
∴ length of invar at 25°·37	= 1m +0·0548mm
and length of invar at 24°·3	= 1m +0·0533mm

Fourth metre (3 to 4) of invar bar.

Date	Temperature	G.B.	B.L.G.
8-9-37 ...	T_I =25°·85	+0·0835mm	+0·0843mm
	T_S =25°·78	·0832	·0837
		·0825	·0815
		·0823	·0828
		·0828	·0843
		·0821	·0838
		·0842	·0840
		·0833	·0850
	Mean	= +0·0830mm	+0·0837mm

Reputed length of silica	= 1m −0·0228mm
Observed invar *minus* silica	= +0·0834mm
∴ length of invar at 25°·85	= 1m +0·0606mm
and length of invar at 24°·3	= 1m +0·0584mm

Combining the four sections of the invar bar gives the total length of the bar as 4m + 0·2241mm at 24°·3 C according to comparison with the silica bar.

This may be compared with 4m + 0·2192mm obtained from the nickel (sub-para b). The discrepancy is 1·2 in 10^6 which is satisfactory. The mean is accepted, and gives

4 m + 0·2217mm at 24°·3 C in 1937

for the length of the 4-m invar bar (baros plugs). The 1930 value was 4m + 0·2158mm and the 1934 value 4m + 0·2219mm.

In the above comparisons the invar bar was not moved during its comparison with the nickel bar. The nickel bar was reversed after the first four comparisons with each metre of the invar bar, but the latter was not reversed at all. Before comparison with the silica bar the invar bar was reversed and moved on to the other support of the comparator, where it was again left unmoved during comparison with the silica. The comparisons with the nickel and silica thus do not separately constitute full comparisons, although the mean of the two does, and the discrepancy of 1·2 in 10^6 between the two comparisons is not necessarily a measure of the inaccuracy of the final mean: the latter may be more accurate than this discrepancy suggests. The same procedure was followed in 1931 and 1934, when the discrepancies were 0·8 and 1·6 in 10^6 respectively.

(d) 4-m Invar. Edge B *minus* Baros plugs.—

Date	G.B.	B.L.G.
20-9-37 ...	+0·0007mm	+0·0011mm
	+ ·0026	+ ·0030
	− ·0068	− ·0048
	− ·0027	− ·0015
Mean	−0·0016mm	−0·0006mm
General mean	= −0·0011mm	

Length of 4-m invar (baros plugs)
at 24°·3 = 4m + 0·2217mm (1937)
∴ length of 4-m Edge B at 24°·3C = 4m + 0·2206mm
and at 28°·0C (required below) it is = 4m + 0·2417mm

In 1930, the difference Edge B *minus* baros plugs was +0·0008mm, and in 1934 it was −0·0035. The present figure of −0·0011 is intermediate between the two. The edge marks A and B are coarser than the marks on the centre line and these rather large changes are probably errors arising from that.

The bar was reversed after the first two sets. This was also done in the comparisons given in sub-para (e) and (f).

The length of Edge B is then accepted as

4 m + 0·2417mm at 28°·0 C in 1937

(e) 4-m Invar. Edge B *minus* Edge A.—

Date	G.B.	B.L.G.
20-9-37 ...	+0·0083mm	+0·0081mm
	+ ·0110	+ ·0113
	− ·0050	− ·0011
	+ ·0003	+ ·0008
Mean	+0·0037mm	+0·0048mm

General mean B *minus* A = + ·0042mm
Compare 1934 value of + ·0032mm
Compare 1930 value of + ·0038mm

(f) 4-m Invar. Marks on solid metal *minus* Baros plugs.—

Date	Temperature	G.B.	B.L.G.
20-9-37 ...	25°	+0·0001mm	+0·0006mm
		·0000	+ ·0019
		·0000	·0000
		− ·0010	− ·0001
	Mean	−0·0002mm	+0·0006mm
	General mean	= +0·0002mm	

N.P.L. certificate (1914) gives +0·002.

This comparison gives a satisfactory indication of the stability of the baros plugs. The discrepancy may well be error of comparison.

(g) 4-m Nickel-steel *minus* 4-m Invar Baros plugs.—

Date	Temperature	G.B.	B.L.G.
16-9-37 ...	T_I = 23°·81*	+0·4955mm	+0·4959mm
	T_{NS} = 23°·80	·4961	·4997
		·4974	·4981
		·4987	·5014
		·4983	·4976
		·4997	·4966
17-9-37 ...	T_I = 23°·07*	·4780†	·4786†
	T_{NS} = 23°·04	·4775†	·4745†
	Mean	+0·4927mm	+0·4928mm

Length of nickel-steel at 23°·61
(from 1934 comparison) = 4m +0·7118mm

Observed nickel-steel *minus* invar (baros plugs) = +0·4927mm

∴ length of invar at 23°·62C = 4m +0·2191mm

and length of invar at 24°·3 C = 4m +0·2230mm

The nickel-steel bar is of an alloy more stable than invar, but with a higher temperature coefficient. Between 1914 and 1934 its length increased by 2·5 in 10^6, which suggests that it may be considered as stable for a period of 3 years. Assuming its stability during 1934–37, it gives 4m+0·2230mm for the length of the invar bar (baros plugs) at 24°·3C.

There are thus three independent measures of the length of the invar bar (at 24·3°C):—

From the nickel metre	4m + 0·2192mm
From the silica metre	0·2241mm
From the nickel-steel 4-metre	0·2230mm

These are in satisfactory agreement. One millionth of the length of the bar is 0·0040mm. As stated in sub-para (c), the mean of the first two figures is accepted.

(h). Lengths of 24-m wires.—In September 1937 seven invar wires were hung on the comparator on two different days, and the 4-metre bar was stepped along the comparator before and after each comparison. Plate XXI shows the resulting lengths of the comparator. The lengths of the wires agree well with their 1934 values. Wire No. 249 has been discarded, and two new wires 1037

* Weighted mean of both days T_I = 23°·62 T_{NS} = 23°·61.

† These figures are equivalent to 0·4963, 0·4969, 0·4958 and 0·4928mm at 23°·80C.

and 1038 received in 1934 are being brought into use. Details are given below with 1934 values for comparison. One millionth of the length of a wire is 0·024mm.

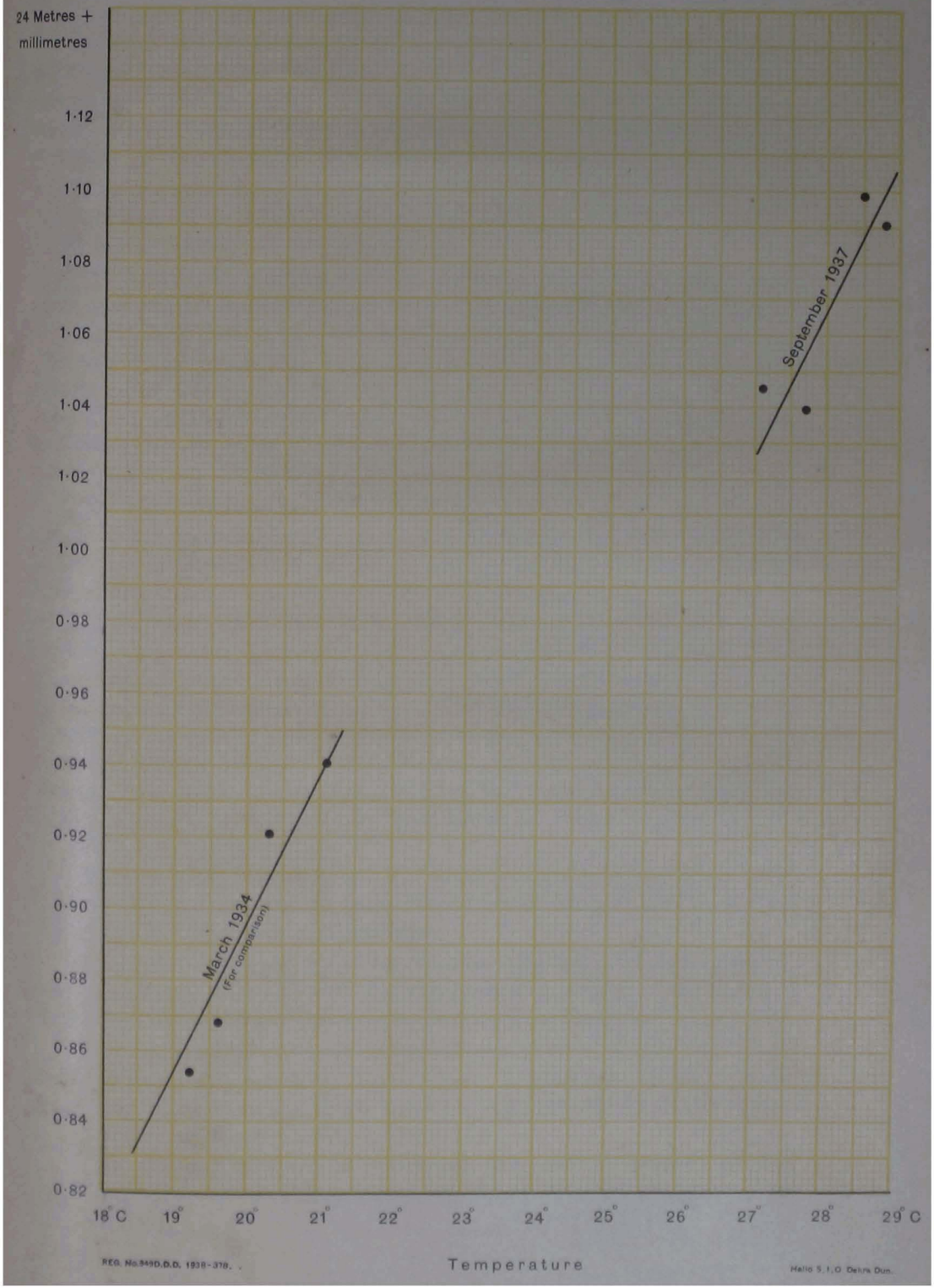
Millimetres in excess of 24 metres at 28°C.

Date	Wire Nos.						
	243	244	247	248	252	1037	1038
21-9-37 ...	−0·19	−2·37	+1·57	+1·73	+3·08	+0·82	+0·82
23-9-37 ...	−0·20	−2·41	+1·52	+1·71	+3·08	+0·79	+0·82
Mean ...	−0·20	−2·39	+1·54	+1·72	+3·08	+0·81	+0·82
March 1934...	−0·15	−2·38	+1·58	+1·74	+3·08	+0·80	+0·78

48. Longitude.—The usual bi-weekly time observations were made with the shutter and electric-driven transits. The observers were Rai Sahib R. B. Mathur, and Computer Prem Narain. The resulting values of the longitude are given in Table 1 and the monthly mean values, using the demi-definitive corrections to the Bordeaux and Rugby signals as given in the Bulletin Horaire and Admiralty Notices, are given below. The annual mean difference between the two instruments is 0ˢ·02 for Bordeax and 0ˢ·01 for Rugby.

	Motor Transit			Shutter Transit		
	No. of days	Bordeaux	Rugby	No. of days	Bordeaux	Rugby
		h m s	*h m s*		*h m s*	*h m s*
October 1936	4	...	5 12 11·85	3	5 12 11·82	5 12 11·82
November ,,	4	5 12 11·85	11·85	2	11·81	11·79
December ,,	2	11·88	11·82	3	...	11·83
January 1937	2	11·74	11·73	2	...	11·79
February ,,	3	11·76	11·75	2	...	11·79
March ,,	4	11·76	11·75	4	11·79	11·78
April ,,	3	11·83	11·83	4	11·81	11·79
May ,,	3	...	11·72	3	...	11·78
June ,,	2	...	11·97	1	...	...
July ,,	3	11·87	11·75	2	11·71	11·73
August ,,	1	...	11·72	1	...	11·74
September ,,	2	...	11·86	3	11·80	11·80
Mean ...		5 12 11·81	5 12 11·80		5 12 11·79	5 12 11·79

Length of 24-metre Comparator, 1937



REG. No.349D.D.D. 1938-378.

Hello S.I.O. Dehra Dun.

The Shortt clock has worked regularly, although the seconds dial has dropped seconds on two occasions. Riefler has run without interruption.

Two new relays have been received from Dr. de Graaff Hunter, for use with his shutter type of transit, to replace the pendulum apparatus which regulates the length of break and interval between breaks. With the new relays a shutter opening can be obtained of any desired length between $0^s \cdot 01$ and $0^s \cdot 26$ at intervals of 1 or 3 seconds. The new relays are robust, compact and very satisfactory.

The portable bent transit has been fitted with a shutter, and comparative observations between it and the transit previously fitted are in hand.

49. Latitude variation.—A latitude observatory has been built at Agra in the compound of the Meteorological Department's upper air observatory, and observations have been started from 1st January 1937 with the large Zenith telescope, using the same system as at Dehra Dūn in 1930–33. (See Geodetic Report 1933, page 44). Mr. J.B. Mathur has been in charge with one computer and two *khalāsis*. No results can yet be given as the first year is not complete.

50. Miscellaneous.—The levelling party's invar staves were standardized as usual, and repairs and adjustments were carried out to levels and theodolites used by parties in the field. A Hunter Short base and several barometers were standardized.

In October 1936 Rai Sahib R. B. Mathur made observations with a prismatic astrolabe on two nights to determine the astronomical longitude at Banog H.S. near Dehra Dūn, in order to complete a Laplace station there. The observations also furnished a value of latitude which differs from that previously obtained with a 24-inch theodolite by $0'' \cdot 92$. Results will be given in the usual form in the next Addendum Table to the Supplement to Geodetic Report Vol. VI, which will be published in the Geodetic Report for 1938.

Ranges and bearings for the army were measured in October 1936 at Dehra Dūn, and in May 1937 further ranges were measured at Dehra Dūn and also at Chakrāta.

The Omori seismograph has been in operation throughout the year, and Table 3 gives a list of earthquakes recorded. The installation of two Milne-Shaw seismographs has been postponed for a year.

The usual meteorological observations have been made at 8 a.m. and at 5 p.m. daily since 1st April 1937. A platform for the anemometer and wind-vane has been built on the roof of the observatory to carry the instruments above the dome.

The Observatory section carried out the reduction of the field magnetic observations made in Bihār during the year (see Chapter IV).

51. Magnetic Observations.—The usual programme of magnetic observations has been carried out at the Dehra Dūn observatory, consisting of a continuous magnetographic record of declination, horizontal force and vertical force, controlled by observations of dip daily and of declination and horizontal force three times a week.

The magnetographs have worked regularly and no interruptions of any consequence have occurred. There has been no serious flooding of the underground room during the year.

The mean values of the magnetic elements at Dehra Dūn in 1936 were:—

Declination	...	E. 0° 53′·8
Dip	...	N. 45° 40′·3
Horizontal force	...	0·33181 C.G.S.
Vertical force	...	0·33968 C.G.S.

The mean scale values of the magnetographs for an ordinate of 1/25 inch were:—

Declination	...	1·03 minutes.
Horizontal force	...	4·20 gammas.
Vertical force	...	10·27 to 12·84 gammas

Hitherto the vertical force has been computed using the value of the base-line obtained by taking the mean of all observations during a month, or by dividing the month in groups whenever abrupt changes were noticed. For the 1936 vertical force the base-line used for a selected quiet day is the one derived from observations of that day only.

The mean temperature of the observatory during the year was 26°·4. The maxima and minima were 27°·4 and 26°·0.

The moment of inertia of magnets Nos. 17 and 5 B was determined in April and May 1937, and log $\pi^2 K$ was found to be 3·41434 and 3·37739 respectively. The values accepted have been 3·41440 and 3·37738, as in the previous year.

The mean observed values of the factor log $(1+P/r^2+Q/r^4)^{-1}$ for magnets No. 17 and 5 B have been $\bar{1}\cdot99405$ and $\bar{1}\cdot99339$ respectively, and the values accepted have been $\bar{1}\cdot99415$ and $\bar{1}\cdot99340$, as in the previous year. The high observed value for magnet 5 B, namely $\bar{1}\cdot99339$ confirms the high values found since 1932.

Tables 4 and 5 give the values of the constants of the two magnets during the year, and Table 6 gives the base-line values of the magnetographs. As usual the values given by No. 17 have been accepted. Table 7 gives the monthly mean values of the elements for 1935 and 1936, and the annual changes during the period.

Tables 8 to 11 give the mean hourly deviations from the monthly means, and Table 12 gives the classification of the magnetic character of all days of 1936.

TABLE 1.—*Variation of Longitude of Dehra Dūn from accepted value, as determined by reception of wireless signals from Bordeaux and Rugby, 1936–37.*

Date (Greenwich)	Instrument used	Observer	No. of time stars		Observed value *minus* accepted* value			
					With demi-definitive corrections		With definitive corrections	
			North	South	Bordeaux	Rugby	Bordeaux	Rugby
1936					s	s	s	s
July 7	Motor	J.B.M.	4	4	...	+0·01	...	+0·01
15	Shutter	J.B.M.	3	4	...	−0·07	...	−0·06
29	Motor	J.B.M.	3	3	...	+0·06	...	+0·07
Aug. 7	Shutter	J.B.M.	5	4	...	−0·07	...	−0·10
Sept. 5	Shutter	J.B.M.	3	4	...	−0·10	...	−0·10
18	Shutter	R.B.M.	2	1	...	+0·10	...	+0·11
22	Motor	R.B.M.	4	3	...	+0·08	...	+0·08
28	Shutter	R.B.M.	4	3	...	−0·04	...	−0·03
Oct. 9	Motor	R.B.M.	4	4	...	+0·05	...	+0·04
12	Shutter	R.B.M.	4	4	...	+0·05	...	+0·05
16	Motor	R.B.M.	4	5	...	+0·03	...	+0·02
19	Shutter	R.B.M.	4	4	...	+0·08	...	+0·07
23	Motor	R.B.M.	4	4	...	+0·15	...	+0·13
27	Motor	R.B.M.	1	1	...	+0·08	...	+0·07
29	Shutter	R.B.M.	3	4	+0·05	+0·03	+0·04	+0·01
Nov. 3	Motor	R.B.M.	3	4	+0·13	+0·12	+0·14	+0·10
7	Shutter	R.B.M.	3	4	...	+0·01	...	+0·01
14	Motor	R.B.M.	3	4	...	+0·16	...	+0·17
18	Motor	P.N.	2	3	...	+0·06	...	+0·07
24	Shutter	P.N.	2	4	+0·04	+0·02	+0·04	+0·02
27	Motor	P.N.	2	4	+0·03	−0·03	+0·02	−0·03
Dec. 2	Shutter	P.N.	3	6	...	+0·07	...	+0·07
12	Motor	P.N.	4	4	...	+0·05	...	+0·03
21	Shutter	P.N.	3	5	...	+0·07	...	+0·06
27	Motor	R.B.M.	4	4	+0·11	+0·05	+0·10	+0·04
30	Shutter	R.B.M.	2	5	...	+0·03	...	+0·02
1937								
Jan. 6	Motor	P.N.	3	4	−0·04	−0·06	−0·04	−0·07
13	Shutter	P.N.	2	7	...	+0·05	...	+0·06
19	Motor	P.N.	2	5	−0·02	−0·02	−0·01	−0·04
25	Shutter	R.B.M.	3	5	...	−0·01	...	−0·02
Feb. 1	Motor	P.N.	2	4	−0·07	−0·04	−0·05	−0·07
7	Motor	P.N.	3	—	+0·06	...	+0·10	...
10	Shutter	P.N.	3	4	...	+0·01	...	−0·03
17	Shutter	P.N.	4	4	...	+0·03	...	+0·01
23	Motor	R.B.M.	4	3	...	+0·01	...	+0·01

* Accepted value of Longitude is $5^h\ 12^m\ 11^s{\cdot}77$.

(*Continued*)

TABLE 1.—*Variation of Longitude of Dehra Dūn from accepted value, as determined by reception of wireless signals from Bordeaux and Rugby, 1936–37*—(concld.)

Date (Greenwich)		Instrument used	Observer	No. of time stars		Observed value *minus* accepted* value			
						With demi-definitive corrections		With definitive corrections	
				North	South	Bordeaux	Rugby	Bordeaux	Rugby
1937									
						s	*s*	*s*	*s*
Mar.	1	Shutter	P.N.	4	4	+0·02	−0·02	+0·04	−0·02
	5	Motor	P.N.	4	4	−0·01	−0·08	0·00	−0·09
	9	Shutter	R.B.M.	2	5	...	−0·11	...	−0·08
	13	Motor	R.B.M.	3	3	...	−0·07	...	−0·06
	16	Shutter	P.N.	3	5	...	+0·06	...	+0·06
	20	Motor	P.N.	4	4	...	+0·01	...	−0·02
	25	Shutter	P.N.	4	4	...	+0·10	...	+0·06
	29	Motor	R.B.M.	4	3	...	+0·06	...	+0·02
April	5	Motor	R.B.M.	4	4	+0·06	+0·06	+0·07	+0·05
	10	Shutter	R.B.M.	4	3	...	+0·06	...	+0·04
	14	Shutter	R.B.M.	4	4	...	+0 03	...	+0·01
	19	Motor	R.B.M.	4	4	...	+0·12	...	+0·11
	24	Motor	R.B.M.	1	2	...	−0·01	...	−0·03
	27	Shutter	R.B.M.	3	3	+0·04	0·00	+0·04	0·00
	30	Shutter	R.B.M.	4	4	...	0·00	...	+0·01
May	4	Motor	R.B.M.	4	3	...	−0·04	...	−0·02
	10	Motor	R.B.M.	4	4	...	−0·10	...	−0·07
	17	Shutter	R.B.M.	2	2	...	−0·04	...	−0·01
	20	Motor	R.B.M.	4	3	...	−0·01	...	+0·02
	27	Shutter	R.B.M.	3	2	...	+0·06	...	+0·06
	31	Shutter	R.B.M.	4	4	...	+0·01	...	+0·02
June	4	Motor	R.B.M.	2	4	...	+0·23	...	+0·24
	15	Motor	R.B.M.	4	4	...	+0·18	...	+0·19
	24	Shutter	R.B.M.	3	5	...	...	...	...
July	5	Motor	R.B.M.	2	1	+0·10	+0·03		
	9	Motor	R.B.M.	3	4	...	−0·02		
	12	Shutter	R.B.M.	4	4	−0·06	−0·08		
	18	Motor	R.B.M.	3	4	...	−0·07		
	21	Shutter	R.B.M.	3	3	...	0·00		
Aug.	10	Shutter	R.B.M.	4	3	...	−0·03		
	19	Motor	R.B.M.	5	3	..	−0·05		
Sept.	2	Shutter	R.B.M.	4	4	+0·03	+0·01		
	6	Motor	R.B.M.	2	1	...	+0·07		
	12	Shutter	R.B.M.	3	4	...	+0·07		
	18	Motor	R.B.M.	4	4	...	+0·11		
	22	Shutter	R.B.M.	4	4	...	0·00		

* Accepted value of Longitude is $5^h\ 12^m\ 11^s{\cdot}77$.

TABLE 2.—*Error, rate, pressure and temperature of Shortt clock No. 34, by Rugby time signals during 1936–37.*

Date		Error at 15.30 hrs. I.S.T.	During preceding period				Remarks
			Rate * per day	Pressure	Oil gauge	Temperature	
1936		*m s*	*s*	*mm of mercury*	*mm*	*C*	
Oct.	9	+2 58·67	+0·01	31·7	41·8	25·8	
	12	58·66	0·00	31·7	41·2	25·0	
	16	58·69	+0·01	31·7	41·5	26·3	
	19	58·61	−0·02	31·7	41·3	26·5	
	23	58·63	+0·01	31·8	41·8	26·8	
	27	+2 54·52	...	31·8	41·9	26·3	Clock disturbed on the 26th.
	29	54·48	−0·02	31·7	41·6	26·7	
Nov.	3	54·40	−0·02	31·9	42·1	26·6	
	7	54·31	−0·02	32·1	42·7	26·5	
	14	54·27	−0·00	32·0	42·2	26·6	
	18	54·17	−0·03	32·0	42·0	26·9	
	24	54·27	+0·02	32·0	42·2	26·6	
	27	54·30	+0·01	32·0	42·6	26·6	
Dec.	2	54·34	+0·01	32·0	42·1	26·6	
	12	54·54	+0·02	32·0	42·1	26·6	
	21	54·64	+0·01	31·8	41·5	26·5	
	28	54·80	+0·02	31·7	41·5	26·6	
	30	54·87	+0·04	31·6	41·5	26·7	
1937							
Jan.	6	54·93	+0·01	31·6	41·7	26·3	
	13	55·03	+0·02	31·8	42·2	26·8	
	19	55·17	+0·02	31·8	41·9	26·5	
	25	55·27	+0·02	31·8	41·9	26·5	
Feb.	2	55·41	+0·02	31·9	42·0	26·6	
	7	55·53	+0·02	31·9	41·9	26·7	
	10	+2 55·48	−0·01	31·8	41·8	26·7	
	17	+2 38·60	+0·02	31·8	41·7	26·7	Seconds dial out of order.
	23	38·62	0·00	31·7	41·2	26·4	
Mar.	1	38·61	0·00	31·8	40·9	26·4	
	5	38·65	+0·01	31·7	41·3	26·3	
	9	38·64	0·00	31·8	41·4	26·4	
	13	38·68	+0·01	31·9	41·8	26·8	
	16	38·72	+0·01	31·9	41·9	26·8	
	20	38·71	0·00	31·8	41·9	26·7	
	25	38·70	0·00	31·8	41·8	26·5	
	29	38·72	0·00	31·8	41·9	26·5	
Apr.	6	38·60	−0·01	32·0	41·9	27·0	
	10	38·59	0·00	31·9	42·1	26·8	
	14	38·55	−0·01	31·8	41·8	26·5	
	19	+2 38·61	+0·01	31·9	41·8	26·8	

* +ve rate = gaining, −ve rate = losing.

(*Continued*)

TABLE 2.—*Error, rate, pressure and temperature of Shortt clock No. 34, by Rugby time signals during 1936–37*—(concld.)

Date		Error at 15.30 hrs. I.S.T.	During preceding period				Remarks
			Rate* per day	Pressure	Oil gauge	Temperature	
1937		*m* *s*	*s*	*mm of mercury*	*mm*	*C*	
Apr.	24	+2 38·38	−0·04	32·1	41·6	27·1°	
	27	38·29	−0·03	32·1	42·1	27·1	
	30	38·22	−0·02	32·0	41·9	26·4	
May	4	38·10	−0·03	32·0	41·7	26·8	
	10	38·01	−0·01	32·1	42·0	26·8	
	17	37·84	−0·02	31·8	41·9	27·1	
	20	37·80	−0·01	32·0	42·1	27·3	
	27	37·44	−0·05	32·2	43·2	28·0	
	31	37·25	−0·05	32·1	44·4	28·7	
June	4	+2 37·14	−0·03	31·8	43·9	27·9	
	16	+2 36·59	−0·05	32·0	44·2	28·8	
	25	−4 59·89	−0·05	31·8	44·3	29·1	Seconds dial out of order.
July	6	+0 02·02	−0·01	31·7	44·5	28·5	Seconds dial out of order.
	9	01·98	−0·01	31·7	44·0	27·9	
	13	01·98	0·00	31·7	43·8	27·9	
	19	02·00	−0·00	31·7	43·7	27·7	
	21	02·02	+0·02	31·7	43·6	27·9	
Aug.	10	02·02	0·00	31·7	43·6	27·8	
	20	02·17	+0·02	31·7	43·0	27·5	
Sept.	3	02·47	+0·02	31·6	42·6	27·3	
	7	02·58	+0·03	31·7	42·0	26·8	
	12	02·67	+0·02	31·7	41·8	26·8	
	17	02·80	+0·02	31·7	41·3	26·5	
	22	02·92	+0·02	31·8	41·0	26·4	

* $+^{ve}$ rate = gaining, $-^{ve}$ rate = losing.

TABLE 3.—*Earthquakes recorded at Dehra Dūn during 1936–37.*

No.	Date	Direction of 1st motion	Indian standard time				Intensity of record	Distance	Remarks
			1st P. T.	2nd P. T.	Long wave	Maximum	Finish			
	1936		*h m s*	*h m s*	*h m s*	*h m*	*h m*		*miles*	
1	Oct. 5	S.	15 24 20	15 31 40	15 41 00†	15 48	16 41	slight	3600	
2	„ 19	...	17 44 20	17 52 10	18 00 10†	18 10	18 45	slight	3900	
3	Nov. 2	...	20 37 50	20 46 00	20 56 40	21 05	...	slight	4200	
4	„ 3	S.	2 24 50	2 32 30	2 42 50	2 49	8 34	great	3900	
5	„ 11	...	22 43 40†	22 45 00†	22 46 00†	22 47	22 54	slight	800	
6	„ 13	...	18 13 10	18 22 10	18 33 20	18 42	...	moderate	4800	
	1937									
7	Jan. 7	...	12 07 10†	12 11 40†	...	12 15	12 26	slight	2000	
8	„ 11	...	18 54 10	18 57 40	...	19 00	23 03	very great	1400	
9	„ 11	...	23 25 00	...	...	23 25	23 30	slight	...	
10	„ 25	...	12 17 30†	12 28 00	12 43 00†	12 59	14 34	slight	5800	
11	Feb. 21	S.	12 42 30	12 50 20	13 02 10	13 08	14 58	great	4000	
12	„ 23	...	...	5 38 50†	5 46 50†	5 51	...	slight	3700	
13	„ 23	...	6 28 20†	6 35 30†	6 49 00	6 54	7 58	slight	4800	
14	Mar. 11	...	23 30 40†	23 31 10	...	23 31	23 32	slight	200	
15	„ 21	S.	21 45 30	21 47 50	21 49 40	...	22 20	slight	900	Felt at Bongra Sylhet and Dhubri (Assam).
16	Apr. 5	...	12 37 00	12 45 10	21 51 20†	12 53	13 56	slight	4200	
17	„ 16	S.	8 50 20	8 58 40	9 01 50†	9 06	...	slight	4300	
18	May 1	...	1 04 00	...	...	...	1 27	slight	Local	
19	„ 31	...	11 05 30	...	...	...	11 16	slight	Local	
20	June 21	...	21 03 00	...	...	22 10	23 36	slight	...	
21	July 22	...	23 01 20†	23 11 10†	23 19 30	23 29	1 46	great	4500	
22	„ 26	...	9 37 20†	9 50 10†	10 21 50†	10 35†	11 38	slight	8400	
23	„ 27	N.	1 37 00	1 43 10	1 54 40†	2 00	3 00	slight	2900	
24	Aug. 1	...	2 17 00	2 20 20†	2 23 40	2 24	3 50	moderate	1300	
25	„ 1	...	16 22 20†	16 25 30†	16 28 30	16 29	17 28	slight	1300	
26	„ 5	...	5 11 40	5 15 30	5 22 20	5 24	5 51	slight	2000	
27	„ 11	...	6 34 10	6 38 50	6 44 00	6 49	8 52	slight	2000	
28	„ 15	...	17 10 20†	17 11 50†	...	17 12	17 25	slight	600	
29	„ 20	...	12 25 20†	12 29 30†	12 35 20	12 39	13 08	slight	2200	
30	„ 20	N.	17 38 00	17 43 30	17 47 20	18 58	21 08†	great	2400	
31	„ 31	...	19 49 00	19 51 50	19 54 00	19 55	20 41	slight	1100	
32	Sept. 1	...	15 07 50†	...	...	15 20	15 42	slight	...	
33	„ 4	...	0 29 30	0 39 20	...	0 54	1 57	slight	5300	
34	„ 17	...	15 52 50†	15 59 30†	16 05 50†	16 07†	16 59	slight	3000	
35	„ 23	S.	18 48 30	18 58 20	19 10 10	19 21	21 54	slight	5500	
36	„ 27	...	14 34 00	14 41 20	14 48 30	14 55	16 14	moderate	3600	Felt in Central and Eastern Java.

† Recognized with difficulty. N. = North, S. = South.

TABLE 4.—*Mean values of the constants of Magnetometer No. 17 in 1936.*

Month	Declination constants	H. F. constants			
	Mean magnetic collimation	Distribution factors			Mean values of m
		$P_{1\cdot2}$	$P_{2\cdot3}$	$\log (1+P/r^2+Q/r^4)^{-1}$	
	′ ″	cm^3	cm^3		C.G.S.
January ...	− 6 06	5·99	7·10		798·65
February ...	− 6 03	5·86	6·92		·67
March ...	− 6 05	6·00	6·83		·70
April ...	− 5 54	5·77	7·34		·59
May ...	− 5 57	5·85	7·28		·55
June ...	− 6 00	5·82	7·33		·42
July ...	− 6 07	5·78	7·46		·59
August ...	− 6 05	5·85	7·19		·44
September	− 6 11	5·88	6·20		·43
October ...	− 6 07	6·14	6·67		·52
November	− 5 58	6·10	6·86		·59
December	− 6 10	5·97	8·14		·70

Observed $\bar{1}\cdot99405$ Accepted $\bar{1}\cdot99415$

TABLE 5.—*Mean values of the constants of Magnetometer No. 5 in 1936.*

Month	H. F. constants			
	Distribution factors			Mean values of m
	$P_{1\cdot2}$	$P_{2\cdot3}$	$\log (1+P/r^2+Q/r^4)^{-1}$	
	cm^3	cm^3		C.G.S.
January ...	6·68	6·83		936·07
February ...	6·78	6·83		935·82
March ...	6·88	7·53		·79
April ...	6·98	7·31		·55
May ...	7·09	8·51		·83
June ...	7·05	8·44		·67
July ...	7·03	7·93		·60
August ...	7·11	7·52		·50
September	7·17	7·97		·52
October ...	7·03	8·27		·46
November	7·29	7·99		·89
December	7·18	8·08		·67

Observed $\bar{1}\cdot99339$ Accepted $\bar{1}\cdot99340$

TABLE 6.—*Base-line values of Magnetographs at Dehra Dūn from Magnets No. 17 and No. 5.*

Month	1935		1936		
	H. F. by No. 17	H. F. by No. 5	Declination	H. F. by No. 17	H. F. by No. 5
	C.G.S.	C.G.S.	° ′	C.G.S.	C.G.S.
January	{0·327 57* {0·329 63	{0·327 55* {0·329 56	0 31·1	0·329 56	0·330 06
February	65	81	28·2	61	29 97
March	63	66	25·9	51	29 92
April	77	97	26·2	52	29 93
May	84	81	·8	66	30 00
June	70	56	27·4	64	30 01
July	62	69	26·8	58	29 99
August	68	72	27·1	65	29 93
September	73	71	{27·2† {15·5	59	29 99
October	68	79	15·3	63	29 99
November	71	70	14·8	54	30 03
December	0·327 63	0·329 74	0 15·1	0·329 49	0·329 86

* Up to 15th January. † Up to 18th September.

NOTE:—The values given by No. 17 have been accepted.

TABLE 7.—*Monthly mean values of Magnetic elements and their annual changes, Magnetometer No. 17, Dehra Dūn, 1935 and 1936.*

Month	Horizontal force			Declination			Dip			Vertical force		
	1935	1936	Annual change	1935	1936	Annual change	1935	1936	Annual change	1935	1936	Annual change
	C.G.S.	C.G.S.	γ							C.G.S.	C.G.S.	γ
January	0·33101	0·33151	+50	E. 0° 58′·0	E. 0° 55′·9	−2′·1	N. 45° 38′·3	N. 45° 40′·6	+2′·3	0·33846	0·33944	+ 98
February ...	101	167	+66	58·1	55·4	−2·7	39·4	41·6	+2·2	869	975	+107
March	114	167	+53	57·3	54·3	−3·0	39·5	40·9	+1·4	884	966	+ 82
April	128	170	+42	56·8	54·5	−2·3	38·7	41·4	+2·7	882	978	+ 96
May	145	189	+44	56·4	54·0	−2·4	39·3	40·3	+1·0	911	975	+ 64
June	137	177	+40	56·9	54·5	−2·4	39·0	39·4	+0·4	889	946	+ 57
July	165	180	+15	56·4	53·6	−2·8	38·9	40·9	+2·0	889	33982	+ 93
August	175	198	+23	56·3	53·5	−2·8	40·3	41·1	+0·8	928	34001	+ 73
September ...	168	186	+18	55·7	53·2	−2·5	39·0	40·7	+1·7	888	33981	+ 93
October	162	194	+32	56·1	52·7	−3·4	38·4	40·1	+1·7	877	977	+100
November ...	146	188	+42	56·6	51·8	−4·8	40·4	38·9	−1·5	934	948	+ 14
December ...	0·33136	0·33199	+63	E. 0 55·2	E. 0 52·2	−3·0	N. 45 40·7	N. 45 37·9	−2·8	0·33929	0·33939	+ 10
Mean ...	0·33140	0·33181	+41	E. 0° 56′·7	E. 0° 53′·8	−2′·9	N. 45° 39′·3	N. 45° 40′·3	+1′·0	0·33894	0·33968	+ 74

γ = 0·00001 C.G.S.

TABLE 8.—*Declination at Dehra Dūn in 1936* (determined from five selected quiet days in each month).

Month	Monthly mean values *	Hourly deviation from the mean																							
		Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.
	E. 0° + ′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January ...	55·9	+0·1	0·0	0·0	+0·1	−0·1	−0·1	0·0	+0·2	+0·4	**+0·5**	+0·4	−0·1	−0·9	**−1·0**	−0·4	−0·3	−0·1	+0·1	+0·2	+0·1	+0·1	+0·1	+0·1	0·0	0·0
February ...	55·4	+0·4	0·0	0·0	+0·1	+0·2	+0·1	+0·1	+0·2	**+0·7**	+0·6	+0·3	−0·3	−1·0	**−1·5**	−1·2	−0·1	+0·1	+0·2	+0·2	+0·4	0·0	−0·1	0·0	+0·3	+0·2
March ...	54·3	+0·2	+0·2	+0·1	+0·1	+0·3	+0·1	−0·4	+0·4	+1·6	+2·5	**+2·7**	+1·6	−0·6	−2·3	**−2·4**	−1·6	−0·9	−0·3	−0·4	−0·5	−0·5	−0·2	0·0	0·0	0·0
October ...	52·7	+0·2	+0·3	+0·3	+0·4	−0·1	−0·1	+0·1	+1·6	+2·9	**+3·2**	+2·5	+0·2	−1·9	**−2·8**	−2·3	−1·2	−0·6	−0·5	−0·4	−0·3	−0·3	−0·2	+0·2	+0·1	+0·3
November ...	51·8	+0·1	+0·1	−0·1	+0·2	−0·1	−0·3	−0·2	+0·4	+1·1	**+1·5**	+1·2	+0·1	−1·0	−1·2	−0·6	−0·6	−0·5	**−1·6**	+0·1	−0·1	−0·5	−0·2	+0·2	+0·3	+0·2
December ...	52·2	+0·1	+0·3	+0·3	+0·3	0·0	−0·2	−0·3	−0·2	−0·1	+0·6	**+1·0**	+0·7	−0·3	−0·3	−0·1	−0·3	**−0·5**	−0·5	−0·2	−0·2	−0·2	−0·2	+0·1	0·0	+0·2
Winter Means ...	53·7	+0·2	+0·2	+0·1	+0·2	0·0	−0·1	−0·1	+0·4	+1·1	**+1·5**	+1·4	+0·4	−1·0	**−1·5**	−1·2	−0·7	−0·4	−0·4	−0·1	−0·1	−0·2	−0·1	+0·1	+0·1	+0·2
April ...	54·5	+0·1	+0·1	0·0	+0·2	+0·1	0·0	+0·3	+1·8	+3·2	**+3·7**	+2·6	+0·6	−1·3	−2·5	**−2·6**	−2·1	−1·3	−0·6	−0·3	−0·4	−0·1	−0·5	−0·3	0·0	+0·1
May ...	54·0	+0·5	+0·3	+0·4	+0·5	+0·5	+0·7	+2·4	+4·0	+4·5	+3·3	+1·5	−1·1	−3·3	**−3·9**	−3·9	−3·1	−1·9	−0·6	+0·2	+0·2	−0·4	−0·1	+0·2	+0·3	+0·3
June ...	54·5	+0·7	+0·5	+0·5	+0·6	+0·5	+0·7	+2·4	+3·9	+4·4	+3·7	+1·7	−0·8	−2·8	−3·9	**−4·0**	−3·4	−2·5	−1·3	+0·1	+0·3	−0·1	−0·2	+0·2	+0·4	+0·3
July ...	53·6	0·0	0·0	+0·1	+0·2	+0·4	+0·6	+1·6	+4·0	+4·0	+2·8	+0·9	−1·0	−2·2	**−3·3**	−3·3	−0·8	−2·0	−1·2	+0·1	+0·1	−0·6	−0·6	−0·1	−0·2	−0·5
August ...	53·5	+0·1	0·0	+0·3	+0·3	+0·6	+0·7	+2·4	+3·6	+4·1	+3·1	+1·3	−0·9	−2·5	−1·9	**−3·4**	−2·6	−1·7	−1·0	−0·1	−0·3	−0·5	−0·5	−0·4	−0·2	−0·2
September ...	53·2	+0·3	+0·2	+0·4	+0·5	+0·4	+0·5	+1·4	+3·3	+4·0	+3·0	+1·1	−0·9	−2·9	**−3·6**	−3·3	−2·2	−1·1	−0·3	−0·2	−0·4	−0·4	−0·3	−0·1	−0·1	−0·1
Summer Means ...	53·9	+0·3	+0·2	+0·3	+0·3	+0·4	+0·5	+1·8	+3·4	+4·0	+3·3	+1·5	−0·7	−2·5	−3·2	**−3·4**	−2·4	−1·8	−0·8	0·0	−0·1	−0·4	−0·4	−0·1	0·0	0·0

* Obtained from the mean of all hours for the five selected quiet days in each month.

NOTE:—The mean declination for any hour in a month may be obtained by applying the hourly deviation for that hour with the sign given, to the monthly mean. Figures in thick type indicate the maximum and minimum values of the hourly deviation.

TABLE 9.—*Horizontal force at Dehra Dūn in 1936* (determined from five selected quiet days in each month).

Month	Monthly mean values *	Hourly deviation from the mean																							
		Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January ...	33151	0	− 2	− 1	0	− 1	− 1	− 1	0	− 3	− 5	**− 8**	− 5	+ 2	**+ 8**	+ 8	+ 6	+ 4	+ 1	+ 1	+ 1	0	0	− 1	− 2	+ 1
February ...	167	− 9	− 8	− 6	− 7	− 7	− 7	− 5	− 4	0	0	+ 6	+14	+19	**+23**	+19	+11	+ 3	− 2	− 5	− 5	− 7	**−10**	− 8	− 4	− 2
March ...	167	− 7	− 9	− 9	− 7	− 6	− 4	− 3	− 1	− 4	+ 1	+ 7	+15	+ 9	+10	+10	+12	+ 5	− 5	− 8	− 6	− 9	**−11**	− 9	− 5	− 4
October ...	194	− 3	− 3	− 3	**− 4**	− 2	− 2	− 3	− 3	− 4	− 4	+ 1	+ 8	+13	**+14**	+ 9	+ 5	− 3	− 4	− 2	− 1	− 3	− 2	0	0	**0**
November ...	188	− 4	− 2	− 3	− 2	− 2	− 1	+ 3	+ 4	+ 6	+ 8	+10	+11	+14	+14	+ 5	− 2	− 3	− 4	− 3	− 2	− 3	− 3	+ 1	− 2	+ 2
December ...	199	− 4	− 5	− 4	− 5	− 3	− 2	0	− 6	+ 9	+11	+11	+14	+12	+ 5	0	− 4	− 4	− 5	− 6	− 7	− 7	− 5	− 4	− 3	− 3
Winter Means ...	33178	− 5	− 5	− 4	− 4	− 4	− 3	− 2	0	+ 1	+ 2	+ 5	+10	+12	+12	+ 9	+ 5	0	− 3	− 4	− 3	− 5	− 5	− 4	− 3	− 1
April ...	33170	− 9	− 8	− 5	− 6	− 7	− 6	− 5	− 7	− 7	− 2	− 1	+21	**+24**	+24	+20	+10	+ 3	− 4	− 6	− 8	− 7	− 6	− 5	− 3	− 6
May ...	189	− 7	−10	−11	− 8	− 6	− 6	− 5	− 9	**−14**	−11	− 2	+17	+25	**+27**	+22	+19	+ 9	0	− 5	− 6	− 6	− 7	− 7	− 7	− 3
June ...	177	− 9	− 6	− 8	− 7	− 5	− 5	− 1	− 2	− 4	− 4	+ 1	+ 4	+ 8	**+13**	+10	+10	+10	+ 7	− 1	− 4	− 1	0	+ 1	+ 3	+ 3
July ...	180	− 9	− 9	− 7	− 6	− 6	− 5	− 4	− 4	− 1	+ 3	+ 7	+11	**+12**	+11	+11	+ 8	+ 7	+ 3	− 5	− 7	− 5	− 1	− 1	+ 1	+ 1
August ...	198	− 4	− 7	− 9	− 6	− 7	− 4	− 3	− 7	− 9	− 8	− 5	+ 5	+12	+15	**+16**	+13	+ 9	+ 3	− 1	− 2	− 2	− 4	0	0	+ 1
September ...	186	− 6	− 5	− 7	− 5	− 4	− 4	− 4	− 8	−15	**−16**	−12	− 1	+ 9	+17	**+19**	+16	+11	+ 5	+ 5	+ 4	+ 2	+ 2	+ 2	+ 1	+ 3
Summer Means ...	33183	− 7	− 8	− 8	− 6	− 6	− 5	− 4	− 6	− 8	− 6	− 2	+10	+15	**+18**	+16	+13	+ 8	+ 2	− 2	− 4	− 3	− 3	− 2	− 1	0

γ = 0·00001 C. G. S.

* Obtained from the mean of all hours for the five selected quiet days in each month.

NOTE:—The mean horizontal force for any hour in a month may be obtained by applying the hourly deviation for that hour with the sign given, to the monthly mean. Figures in thick type indicate the maximum and minimum values of the hourly deviation.

TABLE 10.—*Vertical force at Dehra Dūn in 1936* (determined from five selected quiet days in each month).

Month	Monthly mean values *	Hourly deviation from the mean																								
		Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January ...	33944	0	0	0	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 3	0	− 1	0	+ 1	0	− 3	− 2	− 2	− 2	− 1	− 1	0	0	+ 1	+ 1
February ...	76	− 2	− 2	− 2	− 3	− 3	− 3	− 3	− 1	0	+ 1	− 4	+ 4	+ 3	0	− 1	+ 2	0	− 1	0	+ 2	+ 1	+ 2	+ 2	+ 4	+ 4
March ...	66	+ 2	+ 2	+ 2	+ 2	+ 2	+ 3	+ 2	+ 7	+ 7	+ 6	− 1	−14	−15	−16	−12	− 5	− 2	− 2	0	+ 2	+ 6	+ 7	+ 8	+ 9	+12
October ...	77	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2	+ 6	+ 5	− 1	−10	−13	−14	−12	− 7	− 3	+ 1	+ 2	+ 2	+ 5	+ 6	+ 6	+ 6	+ 7	+ 7
November ...	48	+ 3	+ 3	+ 2	+ 2	+ 1	+ 1	+ 2	+ 2	+ 3	+ 1	− 4	− 7	− 9	− 7	− 6	− 4	− 1	+ 1	+ 3	+ 3	+ 3	+ 4	+ 4	+ 4	+ 3
December ...	39	+ 9	+ 6	+ 6	+ 7	+ 7	+ 6	+ 6	+ 9	+10	+ 8	+ 8	− 9	− 9	− 9	− 9	− 8	− 7	− 4	− 6	− 6	− 5	− 5	− 5	− 4	− 5
Winter Means ...	58	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 4	+ 4	+ 3	− 2	− 7	− 7	− 7	− 6	− 4	− 2	− 1	− 1	+ 1	+ 2	+ 2	+ 3	+ 4	+ 4
April ...	78	+ 6	+ 6	+ 6	+ 5	+ 5	+ 5	+ 9	+13	+11	+ 5	− 5	−18	−19	−13	− 8	− 3	− 1	0	0	− 1	0	+ 1	+ 2	+ 2	+ 2
May ...	75	+ 9	+ 9	+10	+ 9	+ 9	+11	+16	+14	+ 8	− 2	−11	−21	−24	−21	−14	− 9	− 5	+ 1	+ 3	+ 1	+ 3	+ 3	+ 3	+ 3	+ 3
June ...	46	+ 1	+ 1	+ 3	+ 2	+ 3	+ 5	+11	+ 9	+ 4	− 2	−13	−16	−16	−17	−16	−10	− 1	+ 5	+ 6	+ 5	+ 6	+ 7	+ 8	+ 9	+ 8
July ...	33982	+ 5	+ 4	+ 5	+ 5	+ 5	+ 6	+12	+11	+ 4	− 2	− 9	−16	−19	−18	−15	−11	− 4	−17	−15	−15	−15	+ 6	+ 7	+ 6	+ 6
August ...	34001	+ 1	+ 1	+ 1	+ 2	+ 2	− 2	− 2	− 1	− 1	− 1	− 5	−14	−13	−11	− 6	− 2	− 1	+ 1	+ 3	+ 3	+ 5	+ 6	+ 7	+ 6	+ 5
September ...	33981	+ 1	+ 2	+ 2	+ 3	+ 3	+ 4	+ 6	+ 9	+ 7	− 2	−11	−12	−13	−11	− 5	− 2	+ 2	+ 2	+ 1	+ 1	+ 2	+ 3	+ 3	+ 4	+ 4
Summer Means ...	977	+ 4	+ 4	+ 5	+ 4	+ 5	+ 5	+ 9	+ 9	+ 6	− 1	− 9	−16	−17	−15	−11	− 6	− 2	− 1	0	− 1	0	+ 4	+ 5	+ 5	+ 5

γ = 0·00001 C.G.S.

* Obtained from the mean of all hours for the five selected quiet days in each month.

NOTE:—The mean vertical force for any hour in a month may be obtained by applying the hourly deviation for that hour with the sign given, to the monthly mean. Figures in thick type indicate the maximum and minimum values of the hourly deviation.

TABLE 11.—*Dip at Dehra Dūn in 1936* (determined from five selected quiet days in each month).

Month	Monthly mean values *	Hourly deviation from the mean																							
		Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.
	N. 45° + ′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January ...	40·6	0·0	+0·1	+0·1	0·0	+0·2	+0·2	+0·2	+0·1	+0·2	**+0·4**	+0·4	+0·2	−0·1	−0·3	−0·4	**−0·5**	−0·3	−0·1	−0·1	−0·1	0·0	0·0	+0·1	+0·2	+0·1
February ...	41·6	+ 0·2	0·0	0·0	0·0	0·0	0·0	−0·1	0·0	0·0	−0·1	−0·7	−1·1	−1·0	**−1·4**	−1·2	−0·6	−0·4	−0·1	+0·1	+0·2	+0·3	**+0·4**	+0·4	+0·2	+0·1
March ...	40·9	+ 0·5	+0·6	+0·6	+0·5	+0·4	+0·4	+0·3	+0·4	+0·6	+0·3	−0·4	−1·4	−1·7	**−1·8**	−1·6	−0·8	−0·3	+0·2	+0·4	+0·4	+0·8	**+0·9**	+0·9	+0·7	+0·9
October ...	40·1	+ 0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	**+0·4**	+0·4	+0·1	−0·6	−1·1	−1·4	−1·3	−0·8	−0·4	+0·2	+0·3	+0·2	+0·3	+0·4	+0·4	+0·3	+0·3	+0·3
November ...	38·9	+ **0·4**	+0·3	+0·3	+0·2	+0·2	+0·1	0·0	−0·1	−0·1	−0·3	+0·3	−0·9	−1·1	−1·1	−0·5	−0·1	+0·1	+0·3	+0·3	+0·3	+0·3	+0·4	+0·2	+0·4	+0·1
December ...	37·9	+ **0·7**	+0·6	+0·5	+0·6	+0·5	+0·4	+0·3	+0·1	+0·1	−0·2	−0·2	−1·2	−1·1	−0·7	−0·5	−0·2	−0·1	+0·1	0·0	+0·1	+0·1	0·0	0·0	−0·1	−0·1
Winter Means ...	40·0	+ **0·4**	+0·3	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2	0·0	−0·2	−0·9	−1·1	−1·1	−0·8	−0·4	−0·1	+0·1	+0·2	+0·2	+0·3	+0·4	+0·3	+0·3	+0·2
April ...	41·4	+ 0·7	+0·7	+0·5	+0·5	+0·6	+0·5	+0·7	**+1·0**	+0·9	+0·3	−0·7	−2·0	**−2·3**	−1·9	−1·5	−0·7	−0·2	+0·2	+0·3	+0·4	+0·4	+0·3	+0·3	+0·2	+0·4
May ...	40·3	+ 0·7	+0·9	+1·0	+0·8	+0·7	+0·8	+1·0	**+1·1**	+1·1	+0·4	−0·5	−2·0	**−2·6**	−2·5	−1·9	−1·5	−0·8	0·0	+0·4	+0·3	+0·4	+0·5	+0·5	+0·5	+0·3
June ...	39·4	+ 0·5	+0·3	**+0·6**	+0·4	+0·4	+0·5	+0·6	+0·5	+0·4	+0·1	−0·7	−1·0	−1·2	**−1·6**	−1·4	−1·0	−0·6	−0·1	+0·4	+0·5	+0·4	+0·3	+0·3	+0·3	+0·2
July ...	40·9	+ 0·9	+0·8	+0·8	+0·7	+0·7	+0·7	**+1·0**	+0·9	+0·4	−0·1	−0·7	−1·2	**−1·4**	−1·3	−1·2	−0·8	−0·4	−0·9	−0·3	−0·2	−0·3	+0·5	+0·6	+0·4	+0·4
August ...	41·1	+ 0·2	+0·4	**+0·5**	+0·4	+0·5	+0·1	+0·1	+0·3	+0·4	+0·3	0·0	−1·0	−1·3	**−1·4**	−1·1	−0·8	−0·5	−0·1	+0·2	+0·2	+0·3	+0·5	+0·3	+0·3	+0·2
September ...	40·7	+ 0·3	+0·3	+0·5	+0·4	+0·3	+0·4	+0·5	+0·9	**+1·1**	+0·7	+0·1	−0·6	−1·1	**−1·4**	−1·2	−0·9	−0·5	−0·2	−0·2	−0·2	0·0	0·0	0·0	+0·1	+0·1
Summer Means ...	40·6	+ 0·6	+0·6	+0·7	+0·5	+0·5	+0·5	+0·7	**+0·8**	+0·7	+0·3	−0·4	−1·3	−1·7	−1·7	−1·4	−1·0	−0·5	−0·2	+0·1	+0·2	+0·2	+0·4	+0·3	+0·3	+0·3

* Obtained from the mean of all hours for the five selected quiet days in each month.

NOTE:—The mean dip for any hour in a month may be obtained by applying the hourly deviation for that hour with the sign given, to the monthly mean. Figures in thick type indicate the maximum and minimum values of the hourly deviation.

Dehra Dūn { Lat. 30° 19′ 19″ N. / Long. 78 3 19 E. **TABLE 12.—*Classification and dates of Magnetic disturbances at Dehra Dūn in 1936.***

Dates	January	February	March	April	May	June	July	August	September	October	November	December
1936												
1	C	C	C	S	C	S	C.	C	C	(C)	T.L.	C
2	C	S	(C)	C	C	M	V.G.	C	C	C	C	C
3	(C)	C	(C)	S	(C)	C	C	(C)	(C)	C	S	C
4	(C)	C	C	C	C	C	(C)	C	C	(C)	C	S
5	C	C	C	C	C	(C)	S	C	C	C	C	C
6	C	C	C	C	C	(C)	M	C	(C)	C	(C)	C
7	C	(C)	C	C	C	C	C	(C)	C	C	C	C
8	M	C	(C)	C	C	C	C	C	C	C	C	C
9	C	C	S	C	(C)	G	C	C	C	C	S	(C)
10	M	M	C	(C)	M	S	C	C	C	C	S	(C)
11	S	M	C	(C)	M	C	M	C	S	C	M	C
12	S	(C)	C	C	C	C	C	C	C	(C)	C	S
13	S	(C)	C	C	C	C	C	C	(C)	C	C	M
14	C	M	C	C	(C)	C	C	C	C	C	(C)	C
15	C	C	C	S	C	C	(C)	C	C	C	S	C
16	(C)	M	C	C	C	C	C	C	(C)	M	C	C
17	(C)	S	(C)	(C)	S	C	S	(C)	C	S	C	C
18	M	C	C	S	C	C	S	(C)	C	S	C	C
19	C	M	C	M	S	G	C	C	C	C	C	(C)
20	C	C	C	M	C	M	C	C	C	C	C	(C)
21	S	M	S	M	C	(C)	(C)	C	C	C	(C)	C
22	C	S	C	M	C	C	C	C	S	(C)	(C)	C
23	C	C	S	S	C	(C)	C	(C)	C	C	C	C
24	G	C	S	C	(C)	C	(C)	C	C	M	(C)	(C)
25	M	S	C	C	(C)	C	C	C	(C)	C	C	C
26	S	S	C	(C)	C	C	C	C	C	C	S	C
27	C	C	C	(C)	C	C	C	C	C	C	C	M
28	C	(C)	C	C	C	(C)	C	C	C	(C)	M	G
29	(C)	(C)	(C)	C	M	C	M	C	C	C	G	C
30	C	...	C	C	M	C	C	S	C	C	C	C
31	C	...	C	...	C	...	(C)	C	...	V.G.	...	C
C	21	18	27	21	25	24	24	30	28	26	20	26
S	5	5	4	5	2	2	3	1	2	2	6	2
M	4	6	...	4	4	2	3	...	...	2	2	2
G	1	...	...	...	...	2	...	...	...	...	1	1
V.G.	...	...	...	...	...	...	1	...	...	1	...	...
T.L.	...	...	...	...	...	...	...	...	...	...	1	...

C=Calm. S=Slight. M=Moderate. G=Great. V.G.=Very great. T.L.=Trace lost. (C)=Selected quiet day.

PUBLICATIONS

OF THE

SURVEY OF INDIA

(Corrected up to 31st December 1937)

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

PART I. NUMERICAL DATA

Triangulation Pamphlets. Each covering one square degree, giving descriptions, positions, (latitude and longitude) and heights

Triangulation Pamphlets.—(*Concluded*).

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 published up till 1932, a coloured map 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.

Charts Nos. XXII&XXIII at the end of the Geodetic Report shew what triangulation pamphlets have been published.

Price Re. 1 per pamphlet. Published at Dehra Dūn.

Levelling Pamphlets.

(i) Levelling of Precision. Giving heights and descriptions of all Bench-marks fixed by Levelling of Precision and of certain selected secondary lines. Each pamphlet embraces an area of $4^\circ \times 4^\circ$ 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.

(a) Levelling of Precision in India and Burma.

Pamphlet		Latitude N.	Longitude E.	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	1934	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

Levelling Pamphlets.—(*Continued*).

Pamphlet		Latitude N.	Longitude E.	Published in	Price
Sheet	Distinctive name of Sheet				
		° °	° °		
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	1929	Rs. 3-0-0
	Addendum to 53 ...	...	...	1934	Rs. 2-0-0
54	(Āgra) ...	24–28	76–80	1930	Rs. 3-0-0
55	(Nāgpur) ...	20–24	76–80	1912	Rs. 2-0-0
56	(Hyderābād, Deccan)	16–20	76–80	1931	Rs. 2-0-0
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	1930	Rs. 2-0-0
73	(Cuttack) ...	20–24	84–88	1913	Rs. 2-0-0
	Addendum to 73 ...	...	...	1927	Rs. 2-0-0
74	(Puri) ...	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		

(b) Levelling of Precision in Mesopotamia.

Descriptions and heights of bench-marks in Mesopotamia in one pamphlet, published at Dehra Dūn, 1923. *Price Rs. 3.*

Levelling Pamphlets.—(*Continued*).

ii) Levelling of Secondary Precision.

Descriptions and heights of bench-marks, printed by Gestetner at Dehra Dūn.

Serial No.	Line number	Situated in degree sheets	Published in	Price
1	52A (Ruk to Sehwān) ...	35 M & N and 40 A	1928	As. 6
2	52B (Daur to Lundo) ...	40 B & C	,,	,,
3	52C (Shāhpur to Mahrābpur)	35 N and 40 A, B, C, F & G	,,	,,
4	52D (Tando Alāhyār to Hyderābād)	40 C & D	,,	,,
5	52E (Rohri to Jām Sahib)	40 A, B & E	,,	,,
6	52F (Shāhpur to Mīrpur Purāna)	40 B, C & G	,,	,,
7	52G [Lāndhi canal bungalow (39th mile) to Khipro]	40 C & G	,,	,,
8	52H (Khipro to Ghulām Bhurgari)	40 G	,,	,,
9	52I (Mīrpur Khās to Tando Ghulām Ali via Umarkot and Dādāh) ...	40 C, D, G & H	,,	,,
10	52J (Mīrpur Khās to Tando Ghulām Ali via Dīgri)	40 G	,,	,,
11	52K (Dīgri to Dādāh) ...	40 G & H	,,	,,
12	70J (Barākar to Hazāribāgh Road)	73 I and 72 H & L	,,	As. 12
13	74C (Howrah to Uttarpāra) 74D (Baidyabāti to Seorāphuli) 74E (Bāndel Church to Bāndel Ry. Stn.) 74F [B.M. 251 (*118*)/79A to Pandua Ry. Stn.]	79 A & B	,,	As. 8

Levelling Pamphlets.—(*Continued*).

Serial No.	Line number	Situated in degree sheets	Published in	Price
14	74G (B.M. 126/73M to Saktigarh Ry. Stn.) 74H (B.M. 116/73M to Burdwān Ry. Stn.) 70E (B.M. 85/73M to Mānkar Ry. Stn.) 70F (B.M. 76/73M to Pānagar Ry. Stn.) 70G (B.M. 58/73M to Durgāpur Ry. Stn.) 70H (B.M. 28/73M to Rānīganj Ry. Stn.) 70I (B.M. 15/73M to Asansol, Kālipahāri and Churulia) 70M (Khāna Ry. Stn. to Galsi Ry. Stn.)	73 I & M	1928	As. 12
15	77Q (Calcutta to Nārāyanpur) 77R (Nārāyanpur to Nārāyanpur)	79 B	,,	Re. 1
16	87A (Moulmein to Paan) 87B (Moulmein to Wekali) 87C (Babukon to Kawmyatkyi) 87D (Nyaungbinzeik to Natchaung)	94 H & L and 95 E & I	,,	As. 12
17	88B (Kyauktaga to Myitkyo) 88C (Dalanun to Pazunmyaung) 88D (Pegu to Zenyaungbin) 88E (Myitkyo to Okpo) 88F (E.B.M. at R.D. 25 of the Yenwe Embankment to Uaw) 90A (Nyaungzaye to Kandin) 90B (Ma-ubin to Bassein) 90C (Sagamya to Pantanaw) 90E (Thonze to Rangoon)	85 L, N, O & P and 94 B, C & D	,,	Rs. 2

Levelling Pamphlets.—(*Continued*).

Serial No.	Line number	Situated in degree sheets	Published in	Price
18	89A (Kyaukse to Minzu) 89B (Ywakainggyi to Amarapura) 89C (Kyaukse to Mandalay) 89D (Tangôn to Shwebo) 89E (Kabo to Myittaw) 89F (Okshitkan to Paukkan) 90D (Meiktila to Yewe)	93 B & C and 84 M, N, O & P	1928	Rs. 1-8
19	29C (Nīra to Batgarh) ...	47 F & J	1929	As. 6
20	53A (Madad Chāndia to Mehar)	35 M	,,	,,
21	54B (Shikārpur to Kambar)	40 A	,,	,,
22	54C (Wāriāso to Rato-dero)	34 P, 35 M, 39 D and 40 A	,,	,,
23	55I (Garh Mahārāja to Damāmia)	39 N, 44 A & B	,,	,,
24	55K (Ahar Bela to Multān) 55L (Rangpur to Muzaffargarh) 55M (Muzaffargarh to Basti Maluk)	39 N & O	,,	As. 10
25	55O (Sujābād to Sabuwāli)	39 O	,,	As. 6
26	55P (Jabboāna to Kot Māldeo)	44 A	,,	,,
27	56H (Kasūr to Basirpur)	44 F, I & J	,,	,,
28	57D (Lodhrān to Bahāwalpur)	39 O	,,	,,
29	57H (Basirpur to Lodhrān)	39 O, 44 B, C & F	,,	,,
30	57J (Kutabpur to Adamwāhān)	39 O	,,	,,
31	57L (Dīngarh to Khānpur)	39 L, O & P	,,	,,
32	57M (Mithra to Khānpur)	39 H & L and 40 E & I	,,	,,
33	57N (Chachran to Khānbela)	39 K, L & O	,,	,,
34	74B (Kidderpore to Dublat)	79 B	,,	,,
35	77V (Hastings Bridge to Dakhineswar)	79 B	,,	,,

Levelling Pamphlets.— (*Continued*).

Serial No.	Line number	Situated in degree sheets	Published in	Price
36	70K (Allahābād to Barākar)	63 G, K & O, 72 C, G, K & L and 73 I	1929	As. 14
37	70L (Mughal Sarāi to Hazāribāgh Road) ...	63 O & P and 72 D & H	„	As. 10
38	55N (Basti Maluk to Kabīrwāla)	39 N & O	1930	As. 6
39	55H (Abdul Hakīm to Garh Mahārāja) 55 J (Damāmia to Ahar Bela)	39 N & 44 B	„	As. 6
40	29D (Gotūr to Kalādgi) ...	47 L & P	1931	As. 8
41	29B (Nīra to Jhālki) ...	47 J, K & O	1930	As. 6
42	64 I (Ghāziābād to Cawnpore) 64 J (Cawnpore to Allahābād)	53 H, 54 I, J & N and 63 B, C & G	1930	Rs. 1-2
43	77 S (Khulna to Mādārīpur) 77 T (Mollāhāt to Barisāl) 77 U (Kachua to Alaipur)	79 E, F, I & J	1933	As. 10
44	88G (Thanatpin to Tongyi) 88H (Ohne to Thongwa and Ohne)	94 C & D	1933	As. 10
45	57 I (Khudiān to Lodhrān) 57K (Bahāwalpur to Fāzilka)	39 N & O and 44 B, C, F, G & J	1932	As. 14
46	3 Branch-Lines between Hazāribāgh and Gomoh	72 H & L and 73 I	1933	As. 6
47	55Q (Rohilānwāli to Leiah)	39 J, K & O	1933	As. 14

Levelling Pamphlets.—(*Continued*).

Serial No.	Line number	Situated in degree sheets	Published in	Price
48	88 I (Bridge No. 74 to Myitkyo) 88 J (Panut to Penwegon)	94 B & C	1933	As. 6
49	70 S (Mānpur to Luckeesarai) 70T (Patna to Gaya)	72 C, D, G, H & K	,,	As. 6
50	121B (Toposi to Ondal) 121C (Toposi to Gaurāngdih) 151A (Pāndaveswar to Palāsthāli) 70R (Ikrah to Sītārāmpur) 70U (Pradhānkhunta to Pāthardih) 70V (Dhānbād to Jamuniātānr) 70Q Toposi to Bārābani	73 I & M	,,	As. 10
51	56I (Ferozepore to Jagraon) 61I (Mahna to Head of Bhadaur distributary) 61J (Badhni Kalān to Alamwāla)	44 I, J, M & N	,,	As. 14
52	57O (Bhatinda to Dorāha) 57P (Islāmwāla to Lambi)	44 J, K & N and 53 B	,,	As. 10
53	57Q (Hanumāngarh to Hissār) 57R (Hissār to Bālsamand)	44 K, O & P and 53 D	,,	As. 10
54	75C (Muhammadnagar Patna to Bhadrakh) 75D (Bhadrakh to Cuttack) 75E (Cuttack to Pīr Hāt)	73H, K, L & O	,,	As. 14

Levelling Pamphlets.—(*Continued*).

Serial No.	Line number	Situated in degree sheets	Published in	Price
55	74J (Saktigarh to Bally) 74K (Seoraphuli to Tarakeswar) 74L (Bandel to Barharwa)	72 P, 73 M, 78 D and 79 A & B	1933	As. 10
56	74M (Khana to Kiul: portion Tinpahar to Pirpainti) 74N (Nalhati to Azimganj) 74O (Tinpahar to Rajmahal)	72 K, O & P, 73 M and 78 D	,,	As. 14
57	70O (Jasidih to Baidyanath Dham) 70P (Madhupur to Giridih) 72A (Bhagalpur to Mandar hill)	72 K, L & P	,,	As. 6
58	74I (Uttarpara to Kalna)	79 A & B	,,	As. 6
59	52M (S.B.M. Sukkur to Barrage Road Bridge, Sukkur) ...	40 A	,,	As. 6
60	57S (Bhiwani to Bahadurgarh) 57T (Hansi to Bhatinda) 57U (Mansa to Sohuwala)	44 J, K, N & O and 53 C, D & H	,,	As. 14
61	57V (Badopal to Narwana) 57W (Narwana to Rajpura)	44 O and 53 B & C	,,	As. 10
62	61K (Chandigarh to Doraha) 57X (Doraha to Patiala)	53 B	,,	As. 10

Levelling Pamphlets.—(*Concluded*).

Serial No.	Line number	Situated in degree sheets	Published in	Price
63	75 F (Chāribātia to Kendrāpāra) 75 G (Kiarbank to Puri) 39 B (Puri to Puri)	73 H, K & L and 74 E & I	1933	As. 10
64	57 Z (Jākhal to Rohti) 57AA (Bhūrthala to Kotli Maurān)	44 N & O and 53 B	1934	As. 10
65	61 L (Chandigarh to Jagādhri) 61 M (Jagādhri to Karnāl) 61 N (Butāna to Chandāna) 61 O (Karnāl to Jīnd) 57 Y (Rohtak to Pānīpat)	53 B, C, D, F & G	1934	Rs. 1-2
66	87 (Pegu to Amherst: portion Pegu to Myitkyo revised in 1933–34) 88 (Elephant Point to Thazi: portion Rangoon to Pyinbongyi revised in 1933–34) 88 G (Thanatpin to Tongyi revised in 1933–34) 88 H (Ohne to Thongwa and Ohne revised in 1933–34)	94 C & D	1934	As. 14
67	52 L (Daur to Bāndhi) ...	35 N & 40 B	1937	As. 6

NOTE:—See also pamphlets of 'Levelling of Precision in India and Burma' pages iii and iv, for certain selected lines of Secondary Precision.

Tide-Tables.

From 1880 to 1922 tidal predictions based on the observations of the Survey of India were published annually by the India Office, London. From 1923 the prediction and publication have been undertaken at Dehra Dūn by the Survey of India, and until 1930 were published as follows:—

(1) A single volume styled **"The Major Series"** *priced Rs. 8.*

(2) **Combined Pamphlets** varying in *price from Rs. 1-2 to Rs. 1-8 per copy.*

(3) **Separate Pamphlets** for individual ports *priced As. 12 per copy.* (For names of these ports see Geodetic Report Volume V, pages 31–33).

Commencing from 1931, a new form of publication styled **"Tide-Tables of the Indian Ocean"** has been introduced *priced Rs. 3 per copy.* This comprises full tide-tables for the 41 Indian ports predicted by the Survey of India, and 22 other standard ports in the Indian Ocean and Far East, also for 6 English and Mediterranean ports. In addition, it contains the non-harmonic tidal constants and tidal differences for about 470 ports and anchorages, and the harmonic tidal constants of about 170 important tidal stations, mainly in the Indian Ocean and Far East.

Separate Pamphlets of tide-tables have also been published for the following ports:—

Bombay	... *price As.*	*12 per copy*
Hooghly River	... „ *Rs.*	*1-8* „
Rangoon River	... „ *Rs.*	*1-2* „

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. *Price Rs. 10-8.*

G.T.S. Volumes.—(*Continued*).

Vol. II **History and General Description of the Reduction of the Principal Triangulation.** Dehra Dūn, 1879. *Price Rs. 10-8.*

Vol. III **North-West Quadrilateral.** The Principal Triangulation, the Base-Line Figures, the Karāchi Longitudinal, NW. Himālaya, and the Great Indus Series. Dehra Dūn, 1873. *Price Rs. 10-8.*

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.*

Vol. IV A **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 Captain J. P. Basevi and W. J. Heaviside, and of their Reduction. Dehra Dūn and Calcutta, 1879. *Price Rs. 10-8.*

Vol. VI **South-East Quadrilateral.** The Principal Triangulation and Simultaneous Reduction of the following series:—Great Arc-Section 18°-24°, the East Coast, the Calcutta and the Bīdar Longitudinal, the Jubbulpore and the Bilāspur Meridionals. Dehra Dūn, 1880. *Price Rs. 10-8.*

Vol. VII **North-East Quadrilateral.** General Description and Simultaneous Reduction. Also details of the following five series:—North-East Longitudinal, the Budhon Meridional, the Rangīr Meridional, the Amua Meridional, and the Karāra Meridional. Dehra Dūn, 1882. *Price Rs. 10-8.*

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.*

Vol. IX **Telegraphic Longitudes.** During the years 1875–77 and 1880–81. Dehra Dūn, 1883. *Price Rs. 10-8.*

Vol. X **Telegraphic Longitudes.** During the years 1881–82, 1882–83, and 1883–84. Dehra Dūn, 1887. *Price Rs. 10-8.*

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.*

G. T. S. Volumes.—(*Concluded*).

Vol. XIII **Southern Trigon.** Details of the following five series:—South Konkan Coast, and 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.*

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.*

Vol. XVIII **Astronomical Latitudes.** From 1885 to 1905 and the deduced values of Plumb-line Deflections. Dehra Dūn, 1906. *Price Rs. 10-8.*

Vol. XIX **Levelling of Precision in India.** From 1858 to 1909. Dehra Dūn, 1910. *Price Rs. 10-8.*

Vol. XIXA **Bench-Marks on the Southern Lines of Levelling.** Dehra Dūn, 1910. *Price Rs. 5.*

Vol. XIXB **Bench-Marks on the Northern Lines of Levelling.** Dehra Dūn, 1910. *Price Rs. 5.*

PART III. HISTORICAL AND GENERAL REPORTS

Memoirs.

1. A Memoir on the Indian Surveys, by C. R. Markham, India Office, London, 1871. *Price Rs. 5.*
2. A Memoir on the Indian Surveys. (Second Edition), by C. R. Markham, C.B., F.R.S., India Office, London, 1878. *Price Rs. 5-8.*
3. Abstract of the Reports of the Surveys and of other Geographical operations in India, 1869–78, by C. R. Markham and C. E. D. Black, India Office, London. Published annually between 1871 and 1879. (Out of print).
4. A Memoir on the Indian Surveys, 1875–1890, by C. E. D. Black, India Office, London, 1891. *Price Rs. 5-8.*

"Notes of the Survey of India" are issued monthly. *Price As. 2.*

Annual and Special Reports.

Annual Reports of the **Revenue Branch.** 1851 to 1877. (1851 to 1870, out of print).

Ditto **Topographical Branch.** 1860 to 1877. (1863 to 1877, out of print).

Ditto **Trigonometrical Branch.** 1861 to 1878. (1861 to 1863, 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 to 1900. *Price Rs. 3 per volume.*
from 1900 to 1922. *Price Rs. 2 per volume.*
from 1923 onwards prices as given below.

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 then (*c*) **"Records of the Survey of India"** until 1921.

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, and Map Publication and Office work. Published annually. *From 1922 to 1924 Price 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, Publication Office, and topographical parties.

From 1933 inclusive, the General and Map Publication and Office work Reports have been combined into one report under the title of General Report. *Price Rs. 1-8, or 2s. 6d.*

The following fuller reports are available:—

(*b*) **Extracts from Narrative Reports.**

1900-01. Recent Improvements in Photo-Zincography. G.T. Triangulation in Upper Burma. Experimental Base Measurement with Jäderin Apparatus. Topography in Upper Burma. Calcutta, 1903. (Out of print).

1901-02. G.T. Triangulation in Upper Burma. Topography in Upper Burma. Sind, Punjab. Calcutta, 1904. (Out of print).

1902-03. Principal Triangulation in Upper Burma. Topography in Upper Burma, Shan States. Survey of Sāmbhar Lake. 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.*

Annual Reports &c.—(*Continued*).

1903-04. 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. Triangulation in Baluchistān. Survey Operations with the Somāliland Field Force. Calcutta, 1907. *Price Rs. 1-8.*

1905-06. Topography in Shan States. Calcutta, 1908. *Price Rs. 1-8.*

1906-07. Triangulation in Baluchistān. Topography in Shan States. Calcutta, 1909. *Price Rs. 1-8.*

1907-08. Topography in Shan States. Calcutta, 1910. *Price Rs. 1-8.*

1908-09. Calcutta, 1911. *Price Rs. 1-8.*

(*c*) **Records of the Survey of India.**

Vol. I **1909-10.** Calcutta, 1912. *Price Rs. 4.*

Vol. II **1910-11.** Calcutta, 1912. *Price Rs. 4.*

Vol. III **1911-12.** 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.** Note on the relationship of the Himālayas to the Indo-Gangetic Plain. Calcutta, 1914. *Price Rs. 4.*

Vol. VI **1912-13.** Link connecting the Triangulations of India and Russia. Dehra Dūn, 1914. *Price Rs. 4.*

Vol. VII **1913-14.** 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.** 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.** Mechanical Integrator for calculating Attractions (illustrated). Traverse Survey of the boundary of Imperial Delhi. Dehra Dūn, 1917. *Price Rs. 4.*

Annual Reports &c.—(*Continued*).

Vol. XI **1916-17.** Triangulation; use of high trestle for stations and 100-foot mast signals. 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.** 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.** Levelling in Mesopotamia. Dehra Dūn, 1920. *Price Rs. 4.*

Vol. XV **1919-20.** Levelling; proposed new level net. 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.** High Climbs in the Himālaya prior to the Everest Expedition. Mt. Everest Survey Detachment, 1921. Traverse Survey of Allahābād city. Settlement of Boundary between Mysore and South Kanara. Dehra Dūn, 1922. *Price Rs. 4.*

Vol. XVII **1923.** Memoir on Maps of Chinese Turkistān and Kansu from the Surveys made during Sir A. Stein's Explorations, 1900–01, 1906–08, 1913–15. Dehra Dūn, 1923. *Price Rs. 12.*

Vol. XVIII **1921-22.** 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 Bhutān and South Tibet 1922, by Captain H. R. C. Meade, I.A. Dehra Dūn, 1925. *Price Rs. 1-8.*

Vol. XXII **1926.** Exploration of the Shaksgam Valley and Aghil Ranges, 1926, by Major K. Mason, M.C., R.E. Dehra Dūn, 1928. *Price Rs. 3.*

Annual Reports &c.—(*Continued*).

Vol. XXIII **1926-30.** Report on Sind Rectangulation, 1926–30, by Lt.-Colonel A. H. Gwyn, I.A. Dehra Dūn, 1932. *Price Rs. 1-8.*

Vol. XXIV **1901-29.** Riverain Surveys in the Punjab, 1901 to 1929. Dehra Dūn, 1934. *Price Rs. 1-8.*

Vol. XXV **1925-31.** Surveys in Swāt, Chitrāl & Gilgit and neighbouring territories, carried out by 'A' Survey Company from 1925 to 1931, by Lt.-Colonel C. G. Lewis, O.B.E., R.E. Dehra Dūn, 1934. *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.*

Vol. III **1926-27.** The International Longitude Project. Computations and Publication of data. Observatories. Tides. Gravity and Deviation of the Vertical. Triangulation. Levelling. Research and Technical Notes regarding Personal Equation Apparatus and the height of Mount Everest. Dehra Dūn, 1929. *Price Rs. 3.*

Vol. IV **1927-28.** Computations and Publication of data. Observatories. Tides. Gravity and Deviation of the Vertical. Triangulation. Levelling. Dehra Dūn, 1929. *Price Rs. 3.*

Vol. V **1928-29.** Computations and Publication of data. Observatories. Tides. Gravity and Deviation of the Vertical. Triangulation. Levelling. Research and Technical Notes. Dehra Dūn, 1930. *Price Rs. 3.*

Vol. VI **1929-30.** Computations and Publication of data. Observatories. Tides. Gravity. Triangulation. Levelling. Research and Technical Notes. Dehra Dūn, 1931. *Price Rs. 3.*

Vol. VII **1930-31.** Computations and Publication of data. Observatories. Tides. Deviation of the Vertical. Gravity. Triangulation and Base Measurement. Levelling. The Magnetic Survey. Dehra Dūn, 1932. *Price Rs. 3.*

Annual Reports &c.—(*Concluded*).

Vol. VIII **1931-32.** Computations and Publication of data. Observatories. Tides. Gravity. Triangulation. Levelling. Research and Technical Notes. Dehra Dūn, 1933. *Price Rs. 3.*

1933. Triangulation and Base Measurement. Levelling. Deviation of the Vertical. Computations and Publication of data. Observatories. Tides. Research and Technical Notes. Dehra Dūn, 1934. *Price Rs. 3.*

1934. Triangulation and Base Measurement. Levelling. Gravity. Deviation of the Vertical. Computing Office and Tidal Section. The International Longitude Project. Observatories. Research and Technical Notes. Dehra Dūn, 1935. *Price Rs. 3.*

1935. Triangulation. Levelling. Deviation of the Vertical. Gravity. Geophysical Survey in Bihār. Computing Office and Tidal Section. Observatories. Research and Technical Notes. Dehra Dūn, 1936. *Price Rs. 3.*

1936. Triangulation. Levelling. Deviation of the Vertical. Gravity. Computing Office and Tidal Section. Observatories. Subsoil Water Levels. Levelling in Bengal and Bihār. Dehra Dūn, 1937. *Price Rs. 3.*

Index to Annual Reports of the Survey of India 1904–05 to 1926–27, by Lt.-Col. A. H. Gwyn, R.A. Calcutta, 1935.

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.**	872
2.	**Circular Orders (Administrative).**	432
3.	**Circular Orders (Professional).**	196
4.	**Departmental Orders** (appointments, promotions, transfers etc.)	

Departmental Orders.—(*Concluded*).

These are numbered serially and had reached the above numbers by November 1936. *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 Handbooks. 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, 1905.
   ,, ,, 1904-1908. Calcutta, 1909. (Out of print).
   ,, ,, 1909-1913. Calcutta, 1915.
   ,, ,, 1914-1918. Calcutta, 1920.
   ,, ,, 1919-1924. Dehra Dūn, 1929.
   ,, ,, 1925-1935. Calcutta, 1936.
2. *Circular Orders (Administrative) 1878-1903. Calcutta, 1904.
   ,, ,, 1904-1908. Calcutta, 1909.
   ,, ,, 1909-1913. Calcutta, 1915.
   ,, ,, 1914-1918. Calcutta, 1920.
   ,, ,, 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.

Catalogues and Lists.

1. **Catalogue** of Maps published by the Survey of India. Calcutta, 1931. *Price Re. 1.*

List 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 Books in the headquarters Library, Calcutta, 1901. (Out of print).

3. **Catalogue** of Scientific Books and Subjects in the Library of the Trigonometrical Survey Office. Dehra Dūn, 1908. *Price Re. 1.*

4. **Catalogue** of books in the Library of the Great Trigonometrical Survey. Dehra Dūn, 1911.

* For Departmental use only.

Catalogues and Lists.—(*Concluded*).

5. Classified **Catalogue** of the Trigonometrical Survey Library. Dehra Dūn, 1921. *Gratis.*

6. Author **Catalogue** of the Trigonometrical Survey Library. Dehra Dūn, 1923.

7. **Green Lists.** Part I List of Officers in the Survey of India (annually to date 1st January. Special Supplementary Edition dated 1st July 1932). Calcutta. *Price Rs. 1-14, or 3s. 3d.*

Part II History of Services of Officers in the Survey of India (annually up to 1st July 1931. 1932 Edition not published. Biennially to date 1st July, from 1933 inclusive). Calcutta. *Price Rs. 1-6, or 2 s. 3 d.*

8. **Blue Lists.** Ministerial and Lower Subordinate Establishments of the Survey of India.

Part I Headquarters and Dehra Dūn offices (annually to date 1st April. Special 1932 Edition published on 1st July). Calcutta. *Price Rs. 3-10.*

Part II Circles and parties (annually to date 1st January. Special 1932 Edition published on 1st July). Calcutta. *Price Rs. 8-10.*

From 1935 inclusive onwards Parts I and II have been published on 1st April in a single volume.

1935 edition ... ... *Price Rs. 9-2, or 15 s.*

1936 and 1937 editions ... *Unpriced.*

9. **List of the Publications of the Survey of India** (published annually), Dehra Dūn. *Gratis.*

10. **Price List of Mathematical Instrument Office.** Corrected up to 1st July 1935. Calcutta, 1936. *Gratis.*

Tables and Star Charts.

1. **Auxiliary Tables.** To facilitate the computations of a Trigonometrical Survey, and the projection of maps for India, by Radhanath Sickdhar. Calcutta, 1851.

2. **Auxiliary Tables.** To facilitate the calculations of the Survey Department of India, by J. B. N. Hennessey, F.R.A.S. Dehra Dūn, 1868. (Out of print).

3. **Auxiliary Tables.** To facilitate the calculations of the Survey of India. Third Edition, by Colonel C. T. Haig, R.E. Dehra Dūn, 1887. *Price Rs. 2.*

4. **Auxiliary Tables.** To facilitate the calculations of the Survey of India. Fourth Edition, by Lt.-Colonel S. G. Burrard, R.E., F.R.S. Dehra Dūn, 1906. *Price Rs. 2.*

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

5. **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, 1936. *Price Re. 1.*

Part II Mathematical Tables, (reprinted with additions). Dehra Dūn, 1931. *Price Rs. 2.*

Part III Topographical Survey Tables, (reprinted with additions). Dehra Dūn, 1937. *Price Rs. 3.*

Part IV Geodetic Tables, (A) Triangulation Tables. Dehra Dūn, 1931. *Price Re. 1.*

6. Tables for Graticules of Maps. Extracts for the use of Explorers. Dehra Dūn, 1918. *Price As. 4.*

7. *Metric Weights and Measures and other tables. Photo-Litho Office. Calcutta, 1889.

8. Logarithmic Sines and Cosines to 5 places of decimals. Dehra Dūn, 1886. *Price As. 4.*

9. Logarithmic Sines, Cosines, Tangents and Cotangents to 5 places of decimals. Dehra Dūn, 1915. (Out of print).

10. Common Logarithms to 5 places of decimals, 1885. (Out of print).

11. Table for determining Heights in Traversing. Dehra Dūn, 1898. *Price As. 8.*

12. Tables of distances in Chains and Links corresponding to a subtense of 20 feet. Dehra Dūn, 1889. *Price As. 4.*

13. * ,, ,, 10 feet. Calcutta, 1915.

14. * ,, ,, 8 feet. ,,

15. Field Traverse Tables. First Edition. Calcutta, 1927. *Price As. 8.*

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

17. Star Charts for latitude 30° N., by Lt.-Colonel S. G. Burrard, R.E., F.R.S. Dehra Dūn, 1906. *Price Rs. 1-8.*

18. Star Charts for latitude 15° N. Dehra Dūn, 1928. *Price Rs. 2.*

19. Star Charts for latitude 30° N. Dehra Dūn, 1928. *Price Rs. 2.*

20. Catalogue of 249 Stars for epoch 1st Jan. 1892, from observations by the Survey, Dehra Dūn, 1893. *Price Rs. 2.*

21. *Rainfall, maximum and minimum temperatures, from 1868 to 1927, recorded at the Survey Office Observatory, Dehra Dūn, 1928.

22. *Instructions to Plane-Tablers. Third Edition, 1935.

* For Departmental use only.

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.

2. Ditto. Second Edition. London, 1855.

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.-Col. R. Smyth. Third Edition, revised and enlarged. Calcutta, 1875.

4. Handbook, Revenue Branch. Calcutta, 1893.

Price Rs. 2-8.

Survey of India Handbooks.

1. ***Handbook of General Instructions.** Sixth Edition, 1937.

2. **Handbook, Trigonometrical Branch.** Second Edition. Calcutta, 1902. (Out of print).

3. **Handbook of Trigonometrical Instructions.** Third Edition. Parts in pamphlet forms.

Part I Geodetic Triangulation. First Edition. Dehra Dūn, 1931. *Price Rs. 2-8.*

Part V The Tides. First Edition, revised, Dehra Dūn, 1926. *Price Rs. 2.*

Part VI Levelling. Third Edition, revised, Dehra Dūn, 1937. *Price Re. 1.*

4. **Handbook, Topographical Branch.** Third Edition. Calcutta, 1905. (Out of print).

5. **Handbook of Topography.** Fourth Edition. Calcutta, 1911. Chapters, in pamphlet form—

Chapter I Introductory. Fifth Edition, 1932. *Price As. 8.*

" II Constitution and Duties of a Survey Party. Third Edition, 1936. *Price Re. 1.*

" III Triangulation and its Computation, revised, 1930. *Price Re. 1.*

" IV Theodolite Traversing. Third Edition, 1927. *Price Re. 1.*

" V Plane-tabling. Fourth Edition, 1935. *Price Re. 1.*

" VI Fair Mapping. Seventh Edition, 1935. *Price Re. 1.*

* For Departmental use only.

Survey of India Handbooks.—(*Concluded*).

Chapter VII Trans-Frontier Reconnaissance. Fourth Edition, 1934. *Price Re. 1.*

„ VIII Surveys in War. Second Edition, 1930. *Price Re. 1.*

„ IX Forest Surveys and Maps. 1925. *Price As. 8.*

„ X Map Reproduction. Third Edition, 1928. *Price As. 8.*

„ XI Geographical Maps. (at Press).

„ XII Air Surveys. Provisional Edition, 1933. *Price Re. 1.*

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.*

9. **Survey of India Copy Book of Hand Printing.** Calcutta.

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. *Notes of some of the Methods of Map Reproduction suitable for the Field with appendix—Suggested Equipment Tables for the Light Field Litho Press (experimental), by Lieut. A. A. Chase, R.E. Calcutta, 1911.

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).

* For Departmental use only.

Notes and Instructions.—(*Concluded*).

Base Lines and Magnetic.

6. *Notes on use of the Jäderin Base line Apparatus. Dehra Dūn, 1904. (Out of print).

7. *Miscellaneous Papers relating to the Measurement of Geodetic Bases by Jäderin Invar Apparatus. Dehra Dūn, 1912.

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

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. Instructions for Topographical Surveying, by Lt.-Colonel Sir A. Scott Waugh, F.R.S., F.R.G.S. &c. Roorkee, 1861.

12. Notes on the Aneroid barometer for the use of travellers in determining heights of peaks in Southern India by Major Branfill, R.E. 1871.

13. Curriculum of the course of instruction for Probationers of the Provincial Service of the Survey of India. Dehra Dūn, 1913.

14. Notes on the spelling of Turki, Tibetan and Chinese place names, by Colonel R. A. Wauhope, C.B., C.M.G., C.I.E., R.E. Dehra Dūn, 1919. *Price As. 8.*

15. *Amended Instructions for the Survey and Mapping of Town Guide Maps. August 1919.

16. *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.

17. **Accounts Pamphlet.** Notes on accounts for field units. Dehra Dūn, 1928. *Price Re. 1.*

18. Specimens of papers set at Examinations for the Class II Service. Dehra Dūn, 1927, 1929 & 1933. *Price Re. 1 per year.*

19. Specimens of drawing on blue prints etc.

20. Specimens of hand printing.

21. How to correct proofs.

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., (later Sir Henry Hayden, Kt., C.S.I., C.I.E.,) Supdt.,

* For Departmental use only.

Unclassified Papers.—(*Continued*).

Geological Survey of India. Revised by Colonel Sir Sidney Burrard, K.C.S.I., F.R.S., and A. M. Heron, D.SC., F.G.S., F.R.G.S., F.R.S.E., Supdt., Geological Survey of India. (Second Edition). Delhi, 1933.

Part I The High Peaks of Asia. *Price Rs. 3-6*, or *5s. 9d.*

" II The Principal Mountain Ranges of Asia. *Price Rs. 3*, or *5s. 3d.*

" III The Glaciers and Rivers of the Himālaya and Tibet. *Price Rs. 9-2*, or *15s.*

" IV The Geology of the Himālaya. *Price Rs. 12-8*, or *20s. 3d.*

All four parts bound in one volume. *Price Rs. 28*, or *£2. 3s. 6d.*

2. *Report on the Identification and Nomenclature of the Himālayan Peaks as seen from Kātmāndu, Nepāl, by Captain H. Wood, R.E., Calcutta, 1904. *Price Rs. 2.*

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).

Exploration.

1. *Account of Survey operations in connections, 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).

5. Report on the Trans-Himālayan Explorations in Eastern Tibet during 1878, and in South-Eastern Tibet during 1875-76, by Major-General J. T. Walker, C.B., R.E., F.R.S. Dehra Dūn, 1879. *Price Re. 1.*

6. Report on Explorations in Nepāl and Tibet, by Explorer M–H. season 1885-86, prepared by Mr. C. Wood, Dehra Dūn, 1887. *Price Re. 1.*

7. Report on the Explorations in Sikkim, Bhutān and Tibet, 1856-86, by Lt.-Colonel G. Strahan, R.E. Dehra Dūn, 1889. *Price Rs. 1-8.*

8. Report on the Explorations in Great Tibet and Mongolia made by A-K in 1879-82: prepared by J. B. N. Hennessey, M.A., F.R.S. Dehra Dūn, 1891. *Price Rs. 3*

9. Reports on an Exploration on the North-East Frontier, 1913 by Captain F. M. Bailey, I.A., Political Department and Captain H. T. Morshead, R.E., Survey of India. Simla, 1914.

---

* For Departmental use only.

Unclassified Papers.—(*Continued*).

10. Alphabetical index showing the Geographical positions of all names appearing on Sheet No. 72. Dehra Dūn, 1914. *Price As. 6.*

11. The "Where Is It". Reference index showing geographical position of all important localities in INDIA and adjacent countries, in four parts. Calcutta, 1928.

Part	I	Place names. Cities, towns, and other sites.	*Price As. 12.*
,,	II	Railway stations. Complete list, 1928.	
,,	III	Localities. Districts, States, Tribes etc.	
,,	IV	Physical. Ranges, passes, peaks, glaciers, rivers, canals, lakes, bays, capes, islands etc.	

12. Glossary of Vernacular Terms used in Survey of India Maps. Calcutta, 1931. *Price As. 5.*

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.

6. *Report on the Trigonometrical Results of the Earthquake in Assam, by Captain S. G. Burrard, R.E. Calcutta, 1898. (Out of print).

7. *Notes on the Topographical Survey of the 1/50,000 Sheets of Algeria by the Topographical Section of the "Service Geographique de l'Armēe" by Captain W. M. Coldstream, R.E. Calcutta, 1906.

8. *The Simla Estates Boundary Survey on the scale of 50 feet to 1 inch by Captain E. A. Tandy, R.E. Calcutta, 1906.

9. *A note on the stage reached by the Geodetic Operations of the Survey of India in 1920, by Lt.-Colonel H. McC. Cowie, R.E. The Magnetic Survey of India, by Major R. H. Thomas, D.S.O., R.E., and a note on the present levelling policy, by Major K. Mason, M.C., R.E. Dehra Dūn, 1922. (Out of print).

* For Departmental use only.

Unclassified Papers.—(*Concluded*).

10. Report on the Levelling operations in connection with the selection of the site of the new Capital at Delhi, 1911-12. Simla, 1912.

11. The International Longitude Project, Oct.-Nov., 1926. Dehra Dūn, 1928.

Geodesy.

1. Notes on the Theory of Errors of Observation, by J. Eccles, M.A. Dehra Dūn, 1903. *Price As. 8.*

2. *Note on a Change of the Axes of the Terrestrial Spheroid in relation to the Triangulation of the G.T. Survey of India, by J. de Graaff Hunter, M.A. Dehra Dūn. (Out of print), now incorporated in Professional Paper No. 16.

3. Report on the Treatment, and use of Invar in measuring Geodetic Bases, by Captain H. H. Turner, R.E. London, 1907. *Price As. 8.*

Projections.

1. On the projection used for the General Maps of India. Dehra Dūn, 1903.

2. *On the deformation resulting from the method of constructing the International Atlas of the World on the scale of one to one million, by Ch. Lallemand. Translated by J. Eccles, M.A., together with tables for the projection of 1/M Maps on the International system. Dehra Dūn, 1912.

Mapping.

1. Memorandum on the compilation of map of a portion of Tibet explored by Captain H. H. P. Deasy in 1896. Dehra Dūn, 1897.

2. The reproduction of Maps and drawings by Mr. T. A. Pope. Calcutta, 1905.

3. *A Note on the different methods by which hills can be represented upon maps, by Colonel S. G. Burrard, C.S.I., R.E., F.R.S., Surveyor General of India, Simla, 1912.

4. *A note on the representation of hills, by Major C. L. Robertson, C.M.G., R.E. Dehra Dūn, 1912.

5. *A note on the representation of hills on the Maps of India, by Major F. W. Pirrie, I.A. Dehra Dūn, 1912. (Out of print).

6. *A consideration of the Contour intervals, and Colour Scales best suited to Indian 1/M maps, by Captain M. O'C. Tandy, R.E. Calcutta, 1913. (Out of print).

Professional Papers.

No. 1. **Projection.** On the Projection for a Map of India, and adjacent Countries, on the scale of 1: 1,000,000, by Colonel St. G. C. Gore, R.E. Second Edition. Dehra Dūn, 1903. *Price Re. 1.*

No. 2. ***Base Lines.** Method of measuring Geodetic Bases by means of Metallic Wires, by M. Jäderin. (Translated from

* For Departmental use only.

Professional Papers.—(*Continued*).

Memoires Prēsentēs par Divers. Savants ā l' Acadēmie des Sciences de l' Institute de France). Dehra Dūn, 1899. (Out of print).

No. 3. **Base Lines.** Method of measuring Geodetic Bases by means of Colby's Compensated Bars, compiled by Lieut. H. McC. Cowie, R.E. Dehra Dūn, 1900. (Out of print).

No. 4. **Spirit levels.** Notes on the Calibration of Levels, by Lieut. E. A. Tandy, R.E. Dehra Dūn, 1900. (Out of print).

No. 5. **Geodesy.** The Attraction of the Himālaya Mountains upon the Plumb-Line in India, considerations of recent data, by Major S. G. Burrard, R.E. Second Edition, Dehra Dūn, 1901. *Price Rs. 2.*

No. 6. **Base Lines.** Account of a Determination of the Coefficients of Expansion of the Wires of the Jäderin Base Line Apparatus, by Captain G. P. Lenox-Conyngham, R.E. Dehra Dūn, 1902. *Price Re. 1.*

No. 7. ***Miscellaneous.** Calcutta, 1903. *Price Re. 1.*

(1) On the values of Longitude employed in maps of the Survey of India.
(2) Levelling across the Ganges at Dāmukdia.
(3) Experiment to test the increase in the length of a levelling staff due to moisture and temperature.
(4) Description of a Sun-dial designed for use with tide-gauges.
(5) Nickel-steel alloys and their application to Geodesy. (Translated from the French).
(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.*

No. 9. **Geodesy.** An Account of the Scientific work of the Survey of India; and a Comparison of its progress with that of Foreign Surveys. Prepared for the use of the Survey Committee assembled in 1905, by Lt.-Colonel S. G. Burrard, R.E., F.R.S. Calcutta, 1905. *Price Re. 1.*

No. 10. **Pendulums.** The Pendulum Operations in India, 1903-1907, by Major G. P. Lenox-Conyngham, R.E. Dehra Dūn, 1908. *Price Rs. 2-8.*

No. 11. **Refraction.** Observations of Atmospheric Refraction, 1905-09, by H. G. Shaw, Survey of India. Dehra Dūn, 1911. *Price Re. 1.*

No. 12. **Geodesy.** On the Origin of the Himālaya Mountains, by Colonel S. G. Burrard, C.S.I., R.E., F.R.S. Calcutta, 1912. *Price Re. 1.*

* For Departmental use only.

Professional Papers.—(*Concluded*).

No. 13. **Isostasy.** Investigation of the Theory of Isostasy in India, by Major H. L. Crosthwait, R.E. Dehra Dūn, 1912. (Out of print).

No. 14. **Refraction.** Formulæ for Atmospheric Refraction, and their application to Terrestrial Refraction and Geodesy, by J. de Graaff Hunter, M.A. Dehra Dūn, 1913. *Price Rs. 2.*

No. 15. **Pendulums.** The Pendulum Operations in India and Burma, 1908–13, by Captain H. J. Couchman R.E., Dehra Dūn, 1915. *Price Rs. 2-8.*

No. 16. **Geodesy.** The Earth's Axes and Triangulation, by J. de Graaff Hunter, M.A. Dehra Dūn, 1918. *Price Rs. 4.*

No. 17. **Isostasy.** Investigations of Isostasy in Himālayan and Neighbouring regions by Colonel Sir S. G. Burrard, K.C.S.I., R.E., F.R.S. Dehra Dūn, 1918. *Price Re. 1.*

No. 18. **Isostasy.** A criticism of Mr. R. D. Oldham's memoir "The structure of the Himālayas and of the Gangetic Plain", by Lt.-Colonel H. McC. Cowie, R.E. Dehra Dūn, 1921. *Price Rs. 1-8.*

No. 19. **Aerial Photography.** Experiments in Aeroplane Photo Surveying by Major C. G. Lewis, R.E., and Captain H. G. Salmond, (Late R.A.F.). Dehra Dūn, 1920. *Price Rs. 1-8.*

No. 20. **Air Survey.** Reconnaissance Survey from Aircraft, by Lt.-Colonel G. A. Beazeley, D.S.O., R.E. Dehra Dūn 1927. *Price Rs. 1-8.*

No. 21. **Rectangulation.** Irrigation and Settlement Surveys 1926, by Major J. D. Campbell, D.S.O., R.E. Dehra Dūn. 1927. *Price Rs. 1-8.*

No. 22. **Levelling.** Three Sources of error in Precise Levelling, Captain G. Bomford, R.E. Dehra Dūn. 1929. *Price Rs. 1-8.*

No. 24. **Air Survey.** Notes on Air Survey in India, by Major W. J. Norman, M.C., R.E. Dehra Dūn, 1929. *Price Rs. 1-8.*

No. 25. **Glaciers.** The representation of Glaciated Regions on maps of the Survey of India, by Major Kenneth Mason, M.C., R.E. Dehra Dūn, 1929. *Price As. 8.*

No. 26. **Geography.** Mount Everest and its Tibetan Names, by Colonel Sir S. G. Burrard, K.C.S.I., F.R.S. Dehra Dūn, 1931. *Price As. 8.*

No. 27. **Gravity.** Gravity Anomalies and the Structure of the Earth's Crust, by Major E. A. Glennie, D.S.O., R.E. Dehra Dūn 1932. *Price Rs. 1-8.*

Departmental Papers*.

No. 1. **Type.** A consideration of the most suitable forms of type for use on maps, by Captain M. O'C. Tandy, R.E. Dehra Dūn, 1913.

No. 2. **Symbols.** A review of the Boundary Symbols used on the maps of various countries, by Captain M. O'C. Tandy, R.E. Dehra Dūn, 1913.

* For Departmental use only.

Departmental Papers*.—(*Concluded*).

No. 3. **Maps.** Extract from "The New map of Italy, Scale 1: 100,000", by Luigi Giannitrapani. Translated from the Italian by Major W. M. Coldstream, R.E. Dehra Dūn, 1913.

No. 4. **Town Surveys.** A report on the practice of Town Surveys in the United Kingdom and its application to India, by Major C. L. Robertson, C.M.G., R.E. Dehra Dūn, 1913.

No. 5. **Stereo-Plotter.** Thompson Stereo-plotter and its use, with notes on the field work, by Lieut. K. Mason, R.E. Dehra Dūn, 1913.

No. 6. **Levelling.** Levelling of High Precision, by Ch. Lallemand. Translated from the French by J. de Graaff Hunter, M.A. Dehra Dūn, 1914.

No. 7. **Standard Bars.** Bar Comparisons of 1907–08, by Major H. McC. Cowie, R.E. Dehra Dūn, 1915.

No. 8. **Helio-Zincography.** Report on Rubber Off-set Flat bed Machine Printing, by Captain S. W. Sackville Hamilton, R.E. Calcutta, 1915.

No. 9. **Stereo-Auto-Plotting.** A translation of Paul Corbin's French Stéréo Autogrammétrie, by Lt.-Colonel H. McC. Cowie, R.E. Dehra Dūn, 1922.

No. 10. **Base Lines.** A Booklet of Instructions with full descriptions and tables for the Hunter Short Base, First Edition compiled by Major C. M. Thompson, I.A. Dehra Dūn, 1928. Second Edition compiled by H. C. Banerji, B.A. Dehra Dūn, 1931.

No. 11. **Gravity and Isostasy.** Investigations regarding Gravity and Isostasy by W. Heiskanen (Translated by V. Pelts, Esq. Revised and completed by Major C. M. Thompson, I.A.). Dehra Dūn, 1928.

No. 12. **Geodesy.** Geodesy, by J. de Graaff Hunter, M.A. SC.D., F. INST. P. Dehra Dūn, 1929. *Price Rs. 4.*

No. 13. **Spherical Trigonometry and Astronomy.** Notes on Spherical Trigonometry, and Astronomy etc., by Lt.-Colonel C. M. Thompson, I.A. Dehra Dūn, 1929. *Price Rs. 2.*

No. 14. **Wild Theodolite.** Instructions for the use of the Wild Universal Theodolite by Captain D. R. Crone, R.E, and the Wild Photo-Theodolite, by Lt.-Colonel C. G. Lewis, O.B.E., R.E. Dehra Dūn, 1932.

No. 15. **Air Survey.** Notes on Air Survey and Map Publication in England, 1931, by Major H. R. C. Meade, I.A., with a foreword by Captain D. R. Crone, R.E. Calcutta, 1932.

No. 16. **Map Policy.** By Colonel J. D. Campbell, D.S.O. Calcutta, 1937.

Professional Forms.

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

* For Departmental use only.

G.B.—P.O.—J.S. 426—29-11-37—350 bks.

INDEX
TO
THE TRIANGULATION PAMPHLETS
(INDIA & BURMA)

CORRECTED TO 30th. Sept. 1937.

56° 60° 64° 68° 72° 76° 80° 84° 88° 92° 96° 100° 104°

36° 32° 28° 24° 20° 16° 12° 8°

AFGHANISTAN
BALUCHISTAN
N.W. FRONTIER PROVINCE
KABUL
HERAT
PESHAWAR
KANDAHAR
QUETTA
KALAT
KASHMIR
SRINAGAR
Indus R.
Jhelum R.
Chenab R.
Ravi R.
Sutlej R.
LAHORE
Beas R.
SIMLA
TIBET
LHASA
Brahmaputra R.
NEPAL
KATMANDU
SIKKIM
BHUTAN
DARJEELING
Sadiya
ASSAM
DELHI
BIKANER
RAJPUTANA
Jumna R.
Agra
LUCKNOW
Gogra R.
AJMER
UNITED PROVINCES
BANKIPORE
SHILLONG
Brahmaputra R.
Chindwin R.
Bhamo
Hyderabad
KARACHI
ALLAHABAD
Sone R.
BIHAR
Ganges R.
DACCA
Sironj
Jubbulpore
RANCHI
CALCUTTA
MANDALAY
Mekong R.
INDO CHINA
Narbada R.
NAGPUR
CENTRAL PROVINCES
ORISSA
Tapti R.
Mahanadi R.
Cuttack
Irrawaddy R.
Salween R.
BOMBAY
Godavari R.
HYDERABAD
Cocanada
RANGOON
Kistna R.
BAY OF BENGAL
BANGKOK
Mergui
GULF OF SIAM
MYSORE
BANGALORE
MADRAS
CEYLON

Key to Degree Sheets.

A	E	I	M
B	F	J	N
C	G	K	O
D	H	L	P

55

The numbers of the sheets of the 1:1,000,000 series are shown thus 55

REFERENCES

	Completed
Triangulation Charts in old style	⊠
Do Pamphlets (G.T. data only)	□
Do Do (Complete data)	▨
Do Do Addendum or Supplementary Data	S
Areas containing no triangulation	●

Grid lines have been omitted between Degree Sheets published in one pamphlet

Reg. No. 97 D.D.D. 1935 (C.O.) S.I.—500-'38-360.

Scale 1/20,000,000 or 1·013 Inches to 320 Miles

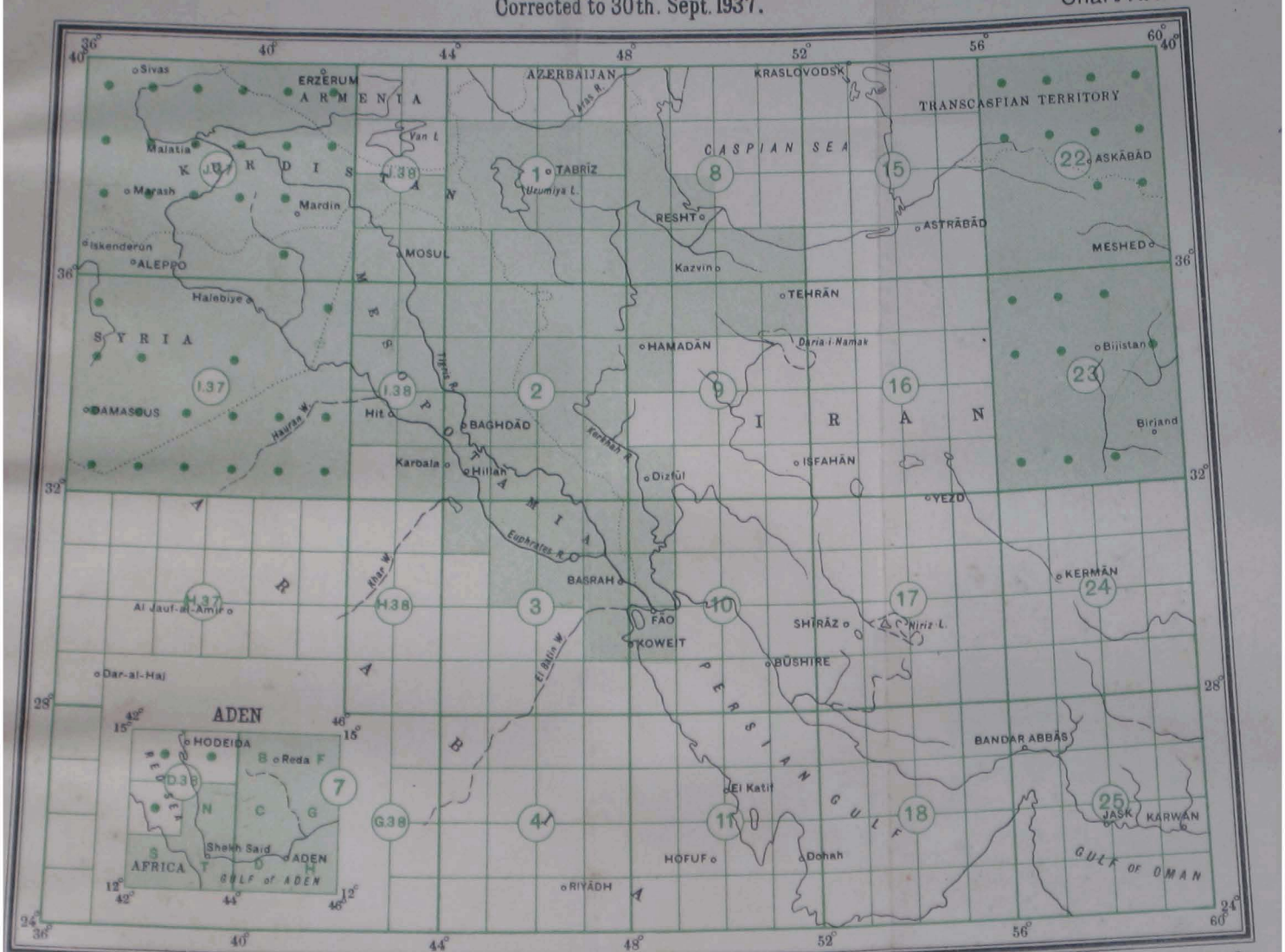
Miles 100 50 0 100 200 300 400 500 Miles

Heliozincographed at the Survey of India Offices, Dehra Dūn.

To accompany Geodetic Report 1937.

INDEX TO THE TRIANGULATION PAMPHLETS
IRĀQ, IRĀN & ADEN
Corrected to 30th. Sept. 1937.

Chart XXIII



Key to Sheet lettering International Sheet.

A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R
S	T	U	V	W	X

J-37

In this system each numbered sheet (e.g. J-37) covers an area of 4° in latitude by 6° in longitude.
The degree sheets are designated thus. North J-37 S

Scale $\frac{1}{15,000,000}$ or 1·013 inches to 240 Miles.

Miles 100 50 0 100 200 300 400 Miles

REFERENCES.

1. Sheet published . . . . . □
2. Area containing no data . . . . . ●

Note:- Grid lines have been omitted between Degree sheets published in one pamphlet

Key to Sheet lettering Indian Sheet.

A	E	I	M
B	F	J	N
C	G	K	O
D	H	L	P

2

In this system each numbered sheet (e.g. 2) covers an area of 4° in latitude by 4° in longitude.
The degree sheets are designated thus. 2-A

HELIO.S.I.O. DEHRA DŪN.
Reg. No. 98.D.D.D. 1938-350
To accompany Geodetic Report 1937