Survey of India.

EXTRACTS

FROM

NARRATIVE REPORTS

FOR THE SEASON

1904-05.

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CONTENTS.

I

THE MAGNETIC SURVEY OF INDIA.

Extracted from the Narrative Report of Captain R. H. Thomas, R.E., in charge No. 26 Party (Magnetic) for Season, 1904-05.

1. The field season commenced on 20th October 1904 and closed early in May.

Outturn of field work.

2. The following table shows the outturn of work by the field detachments during the season under review.

TABLE A (I).

Statement showing the outturn of field detachments in the season 1904-05.

Observer.	1 Date of commencement of field work.	2 Date of finishing field work.	3 Total days of field work.	4 New stations visited.	5 Old stations revisited.	6 Duplicate stations occupied.	7 Total stations.	8 Average outturn per week.	9 REMARKS.
Mr. P. Morton .	7th November 1904.	15th April 1905	160	44	...	...	44	1·93	
„ R. P. Ray .	6th November 1904.	29th April 1905	175	55	...	1	56	2·24	Partly on railways.
„ A. M. Talati	6th November 1904.	26th April 1905	172	45	1	...	46	1·87	
„ E. A. Meyer	8th November 1904.	5th May 1905	179	62	...	...	62	2·42	Partly on railways.
TOTAL .	...	...	686	206	1	1	208	2·12	

Note.—Columns 1 and 2 do not include the time spent on journeys before commencing and after finishing field work. At all stations complete observations of dip, declination and intensity were made.

During the previous three seasons 602 stations were visited so that the total number now amounts to 808.

It is estimated that, with the present establishment, three more working seasons will be required to complete the preliminary survey, allowing for an extension into the more accessible hill districts and partial revision where such is found to be necessary.

Accuracy of the work.

3. The magnetometers behaved uniformly well in the season under report and the results from them are fully up to the standard laid down: the dip circles however in some instances gave considerable trouble in spite of their having been put in thorough adjustment at the beginning of the field season.

The work of the field detachments.

4. The first detachment under Mr. Morton commenced work at Manchar in the Poona District on the 7th November 1904 and thence marched southwards, observing mainly in the Nizam's Dominions. He also worked from Mangalore along the west coast to Kathiawar by steamer and boat. Owing to difficulties of transport this detachment was unable to complete its programme: forty-four new stations were however completed before the detachment returned to Dehra Dun on the 20th April 1905.

B

The second detachment under Babu R. P. Ray commenced work at Goilkera on the Bengal Nagpur Railway on November 6th and after two months' work along railways, made a series of marches in the Central Provinces, completing 56 new stations. This detachment closed field work on the 29th April 1905.

The third detachment under Mr. Talati worked throughout the field season in Rajputana and Central India; with a few exceptions the stations of observation were all within Native States. Forty-six new stations were established.

This observer having been transferred from this party was withdrawn from field work on the 26th April 1905: his programme was, however, practically completed by this date.

The fourth and last detachment under Mr. Meyer commenced work on the 4th November and completed 62 stations partly on railways, but mainly in Hyderabad State, closing field work on the 5th May 1905. At the beginning and end of the season each observer made a set of comparative observations at Dehra Dun.

Work done by Imperial officers.

5. The two Imperial officers erected the self-recording instruments at Toungoo in December 1904, observed at five new and four old repeat stations and in addition made comparative observations at the base stations. Major Fraser was, however, deputed to Chatham in March 1905, while his assistant proceeded on two months' examination leave in January: their work was thus necessarily curtailed: for this reason observations at 13 old repeat stations had to be omitted.

During the recess season the officer in charge erected the V. F. instrument at Dehra Dun; experiments are now in progress with regard to the elimination, as far as possible, of the temperature co-efficient.

Values of P, p and q in the distribution co-efficient.

6. The following table shows the value of the distribution constant P during the past year.

TABLE A (II).

Numbers of Magnet.	P. from 22·5 and 30 cms.					P. from 30 and 40 cms.					Remarks.
	Mean from all observations.	Adopted mean value.	Total number of observations.	Number of rejected observations.	Number of observations used in finding means.	Mean from all observations.	Adopted mean value.	Total number of observations.	Number of rejected observations.	Number of observations used in finding mean.	
1 A	7·55	7·55	109	4	105	7·78	7·82	107	14	93	
3 A	6·09	6·10	83	6	77	7·10	7·06	103	31	72	
4 A	7·33	7·33	70	1	69	8·31	8·29	74	7	67	
5 A	7·20	7·21	87	4	83	8·13	8·10	83	6	77	
6 A	7·95	7·96	60	0	60	7·86	7·96	67	14	53	
10	5·68	5·72	25	2	23	6·96	7·01	25	5	20	as used with suspended magnet of ordinary pattern.
10	−4·62	−4·62	5	0	5	−2·71	−2·71	5	2	3	as used with special suspended magnet 10K.

TABLE A (II)—*continued.*

Numbers of Magnet.	P. from 22·5 and 20 cms.					P. from 30 and 40 cms.					Remarks.
	Mean from all observations.	Adopted mean value.	Total number of observations.	Number of rejected observations.	Number of observations used in finding mean.	Mean from all observations.	Adopted mean value.	Total number of observations.	Number of rejected observations.	Number of observations used in finding mean.	
16 .	6·82	6·83	100	7	93	8·93	8·88	103	17	85	January to October 1904.
	7·07	7·06	24	1	23	8·53	8·99	25	9	16	November and December 1904.
17 .	7·53	7·54	96	2	94	8·04	8·01	94	7	87	January to October 1904.
	7·35	7·35	19	0	19	8·59	8·78	20	2	18	November and December 1904.
20 .	6·75	6·76	111	3	108	7·50	7·49	116	14	102	1904.

NOTE.—(1) Though the values of P in the Kodaikanal instrument (No. 16) show a sudden rise at the beginning of November, there was no appreciable change in moment.

(2) In no. 17 at Dehra Dun a new mirror was fixed to the deflected magnet on 30th October 1904. From this date a change of P.s occurred, without any apparent change in moment.

(3) In all the magnetometers of this survey the ratio $\frac{\text{short}}{\text{long}}$ magnet $= \frac{1}{1\cdot46}$, the dimensions of the long or deflecting magnet being length 3·65 inches, external diameter 0·4 inch, internal 0·3 inch. No. 10 magnetometer is also provided with a special short magnet 10K in which the ratio $\frac{\text{short}}{\text{long}}$ magnet $= \frac{1}{1\cdot23}$.

TABLE B.

Table showing the values of $P_{1\cdot2}$, $P_{2\cdot3}$ and of p and q for different magnets.

Magnet.	$P_{1\cdot2}$	$P_{2\cdot3}$	p	q	Remarks.
1 A . . .	7·55	72·8	8·17	—200	
3 A . . .	6·10	7·06	8·29	—710	
4 A . . .	7·33	8·29	9·52	—710	
5 A . . .	7·21	8·10	9·24	—659	
6 A . . .	7·96	7·96	7·96	0	
10 . . .	5·72	7·01	8·67	—955	using the ordinary suspended magnet.
10 . . .	—4·62	—2·71	—0·26	—1413	using suspended magnet 10K.
16 . . .	6·83	8·88	11·51	—1517	January to October 1904.
16 . . .	7·06	8·99	11·47	—1428	November and December 1904.
17 . . .	7·54	8·01	8·61	—348	January to October 1904.
17 . . .	7·35	8·78	9·33	—318	November and December 1904.
20 . . .	6·76	7·49	8·43	—543	1904.

The next table shows the correction which would have to be applied to the computed values of $\frac{m}{H}$ if the above values of p and q were used in computation instead of the value of P.

The correction tabulated is therefore—

$$\text{Log}\left(1-\frac{p}{r^2}-\frac{q}{r^4}\right)-\log\left(1-\frac{P}{r^2}\right)$$

TABLE C.

Instrument.	1 $\text{Log}\left(1-\frac{p}{r^2}-\frac{q}{r^4}\right)$ y=22·5 cms.	2 $\text{Log}\left(1-\frac{P}{r^2}\right)$ r=22·5 cms.	3 Correction $10^5 \times$	REMARKS.
1	$\bar{1}$·99328	$\bar{1}$·99348	—20	
3	$\bar{1}$·99405	$\bar{1}$·99474	—69	
4	$\bar{1}$·99298	$\bar{1}$·99367	—69	
5	$\bar{1}$·99314	$\bar{1}$·99377	—63	
6	$\bar{1}$·99312	$\bar{1}$·99312	0	
10	$\bar{1}$·99414	$\bar{1}$·99506	—92	As used with suspended magnet of ordinary pattern.
10	$\bar{1}$·00261	$\bar{1}$·00395	—134	As used with deflected magnet 10K.
16	$\bar{1}$·99263	$\bar{1}$·99410	—147	Jany. to Oct. 1904.
16	$\bar{1}$·99251	$\bar{1}$·99389	—138	Nov. & Dec. 1904.
17	$\bar{1}$·99315	$\bar{1}$·99348	—35	Jany. to Oct. 1904.
17	$\bar{1}$·99247	$\bar{1}$·99365	—118	Nov. & Dec. 1904.
20	$\bar{1}$·99364	$\bar{1}$·99416	—52	1904.

Taking the value of H at Dehra Dun=·334 C.G.S., the table annexed shows the changes in absolute value which would result from taking the q terms into account.

TABLE D.

The change in the values of H (due to taking the q term into account) at Dehra Dun in 1904-05.

H at Dehra Dun=·334 C.G.S.

Instrument.	Change in H at Dehra Dun using the q term.	REMARKS.
1	$+87\gamma$	
3	$+277\gamma$	
4	$+277\gamma$	
5	$+247\gamma$	
6	0	

TABLE D—*continued.*

The change in the values to H (due of taking the q term into account) at Dehra Dun in 1904-05.

H at Dehra Dun=·334 C.G.S.

Instrument.	Change in H at Dehra Dun using the q term.	REMARKS.
10	+35γ	
10K	+52γ	
16	+57γ	January to October 1904.
16	+53γ	November and December 1904.
17	+13γ	January to October 1904.
17	+45γ	November and December 1904.
20	+20γ	

7. It was noted in last year's report that the comparison of houses in declination at the beginning of the field season 1903-04 gave a difference

Comparison of N and S. houses in declination at the end of the field season, 1903-04.

$$S\,H - N\,H = +0'{\cdot}68.$$

At the end of the same season the difference was again measured by simultaneous observations with two pairs of magnetometers.

The results obtained are given below:—

TABLE E.

Comparison of houses—end of field season, 1903-04.

Instruments.	Date.	No. 10 in S H or $\frac{S\,H}{10}$	No. 4 in N H or $\frac{N\,H}{4}$	$\frac{S\,H}{10} - \frac{N\,H}{4}$ or X	Observers.
Magnetometers 4 and 10.		° ′ ″	° ′ ″	″	
	29-4-04	2—44—20	2—45—48	—88	A. M. T. and K. K. D.
	29-4-04	2—44—29	2—45—55	—86	
	30-4-04	2—44—32	2—45—37	—65	
	30-4-04	2—44—38	2—45—44	—56	
				Mean X = —74″	
	Date.	No. 4 in S H or $\frac{S\,H}{4}$	No. 10 in N H or $\frac{N\,H}{10}$	$\frac{S\,H}{4} - \frac{N\,H}{10}$ or X	
		° ′ ″	° ′ ″	″	
	29-4-04	2—45—29	2—44—54	+35	
	29-4-04	2—45—27	2—44—41	+46	
	30-4-04	2—45—33	2—44—39	+54	
	30-4-04	2—45—24	2—44—44	+40	
				Mean X = +44	

Hence 10—4 = —59″

S H—N H = —15″ = —0′·2

TABLE E—*continued.*

Comparison of houses—end of field season 1903-04.

Instruments.	Date.	No. 6 in S H or $\frac{SH}{6}$	No. 3 in N H or $\frac{NH}{3}$	X or $\frac{SH}{6} - \frac{NH}{3}$	Observers.
Magnetometers 6 and 3.	17-5-04	2—43—45	2—43—3	+42	H. P. M. and R. P. R.
	17-5-04	43—50	43—10	+40	
	19-5-04	44—9	43—30	+39	
	19-5-04	44—18	43—30	+48	
				Mean X = +42″	
	Date.	No. 3 in S H or $\frac{SH}{3}$	No. 6 in N H or $\frac{NH}{6}$	X or $\frac{SH}{3} - \frac{NH}{6}$	
	18-5-05	2—43—49	2—43—11	+38	
	18-5-05	43—29	42—40	+49	
				Mean X = +44″	

Hence 6—3 = —1″
S H—N H = +43″ = 0′·72

The fact that the instrumental differences are in accord with those deduced rom the curves seems to show that these differences (S H—N H) are real, the second agrees with the value found at the beginning of the season. The difference between houses at the beginning of the next field season however was found to be negligible, and this is most probably the correct value. The value S H—N H = +0′·68 was probably due to some magnetic substance which remained permanently in the neighbourhood of the houses during a considerable period, and was removed some time during the recess season of last year.

The value —0′·25 found at the end of April 1904 seems to indicate that during these two days sufficient care was not taken to remove other magnets to a safe distance.

In the comparisons of instruments at the end of field season 1903-04 with the Standard (No. 17) such observations as were taken in the N. house with magnetometers 10 and 4 have been corrected by —0·25′, and similarly those with 6 and 3 by +0′·68.

Comparison of N. and S. houses in declination at the beginning of the field season, 1904-05.

8. At the beginning of the field season 1903-04 simultaneous observations were made in the two absolute houses to determine the difference in declination; four pairs of instruments were used, and the results obtained are given below:—

TABLE F.

Magnetometers.	Differences obtained. S. H. – N. H.	Instrumental differences.
1 and 10	+6″	10 — 1 = — 1″
3 and 4	—6	4 — 3 = + 60
5 and 6	—0·5	6 — 5 = — 14
17 and 19	—7	17 — 19 = + 13

Hence mean difference S H —N H = —2″
or the difference between houses is negligible.

Comparison of instruments in Declination.

9. Six magnetometers were compared with the Survey standard (No. 177) in declination at the beginning and end of the field season under review. The results obtained are tabulated below :—

TABLE G.

Comparison of magnetometers in declination at the end of field season 1903-04 and beginning of season 1904-05.

Date.	No. of Instruments.	Site N H or S H	S (Instrument under comparison).	D D Dehra Dun Standard No. 17.	D D−S = β.	D D−β = D.	S−D.	Observer.
			° ′	° ′	′	° ′	′	
25-3-04 . .	I	S H	2—39·42	2—39·62	+0·20	2 - 39·60	—0·18	R. H. T.
" . . .		"	2—39·49	39·10	—0·39	39·08	+0·41	
" . . .	Mag-	"	2—39·39	39·52	+0·13	39·50	—0·11	
" . . .	net	"	2 - 39·27	39·82	+0·55	39·80	- 0·53	
26-3-04 . .	I A	"	2—93·95	39·93	—0·02	39·91	+0·04	
" . . .		"	2—93·87	39·93	+0·06	39·91	- 0·04	
27-3-04 . .		"	2—41·00	41·17	+0·17	41·15	—0·15	
" . . .		"	2—41·03	41·27	+0·24	41·25	—0·22	
29-3-04 . .		"	2—38·98	39·22	+0·24	39·20	- 0·22	
" . . .		"	2 38·85	39·10	+0·25	39·08	—0·23	
" . . .		"	2 - 38·60	39·00	+0·40	38·98	—0·38	
" . . .		"	2—38·22	38·07	· 0·15	38·05	+0·17	
" . . .		"	2—37·8	37·97	+0·09	37·95	—0·07	
30-3-04 . .		"	2--37·92	37·67	- 0·25	37·65	+0·27	
" . . .		"	2—37·72	37·77	+0·05	37·75	—0·03	
2-4-04 . .		"	2—43·97	43·68	- 0·19	43·66	+0·21	
" . . .		"	2—43·98	43·78	-- 0·20	43·76	+ 0·22	
30-4-04 . .		"	2—37·78	37·52	—0·26	37·50	+0·28	
" . . .		"	2—37·77	37·30	—0·47	37·28	+0·49	
3-5-04 . .		"	2—40·72	40·72	0	40·70	+0·02	
" . . .		"	2—40·92	40·92	0	40·90	+0·02	
					β = +0·02		±0·20	
1-11-04 . .	I	N H	2—41·72	2—41·98	+0·26	2—41·91	—0·19	R. H. T.
" . . .		"	40·63	41·07	+0·44	41·00	—0·37	
2-11-04 . .		"	40·82	41·17	+0·35	41·10	—0·28	
" . . .	Mag-net.	S H	40·92	40·55	—0·37	40·48	+0·44	
" . . .		"	40·68	40·43	—0·25	40·36	+0·29	
3-11-04 . .	I A	"	40·07	40·43	+0·36	40·36	—0·29	
" . . .		"	40·05	40·33	+0·28	40·26	—0·21	
" . . .		N H	39·60	39·93	+0·33	39·86	—0·26	
" . . .	I	"	2 - 39·73	2—40·23	+0·50	2—40·16	—0·43	R. H. T.
" . . .		"	39·68	39·62	—0·06	39·55	+0·13	
" . . .		"	39·47	39·52	+ 0·05	39·45	+0·02	

TABLE G—*continued.*

Comparison of magnetometers in declination—end of field season 1903-04 and beginning of season 1904-05.

Date.	No. of Instruments.	Site S H or N. H.	S (Instrument under comparison.)	D D Dehra Dun Standard No. 17.	D D—S =β	D D—β =D	S—D.	Observer.
			° ′	° ′	′	° ′	′	
4-11-04 . . .	Magnet.	S H	39·37	39·10	—0·27	39·03	+0·34	
,, . . .	1A	,,	40·03	39·52	—0·51	39·45	+0·58	
,, . . .		,,	41·45	41·37	—0·08	41·30	+0·05	
					′ β = +0·07		′ ±0·28	
17-5-04 . . .		N. H.	2—43·77	2—44·12	+0·35	2—43·92	—0·15	R. P. R.
,, . . .	3	,,	43·80	44·22	+0·32	44·02	—0·12	
18-5-04 . .		S. H.	43·82	44·22	+0·40	44·02	—0·20	
,, . . .		,,	43·48	43·60	+0·12	43·40	+0·08	
19-5-04 . .	Magnet.	N. H.	44·22	44·22	...	44·02	+0·20	
,, . . .	3A	,,	44·22	44·22	...	44·02	+0·20	
					′ β = +0·20		′ ±0·16	
22-10-04 . .		N H	2—39·03	2—39·03	0	2—39·09	—0·06	R. P. R.
,, . . .		S H	38·30	38·32	+0·02	38·38	—0·08	
24-10-04 . .		N H	42·28	42·02	—0·26	42·08	+0·20	
,, . . .		S H	42·07	42·33	+0·26	42·39	—0·32	
25-10-04 . .		N H	40·20	40·17	—0·03	40·23	—0·03	
,, . . .		S H	39·25	39·23	—0·02	39·29	—0·04	
,, . . .		,,	39·07	39·03	—0·04	39·09	—0·02	
,, . . .		N H	38·48	38·22	—0·26	38·26	+0·20	
26-10-04 . .		,,	40·57	40·38	—0·19	40·44	+0·13	
,, . . .		S H	40·35	40·17	—0·18	40·23	+0·12	
27-10-04 . .		N H	41·60	41·62	+0·02	41·68	—0·08	
,, . . .		S H	40·77	40·78	+0·01	40·84	—0·07	
28-10-04 . .		N H	38·90	38·93	+0·03	38·99	—0·09	
,, . . .		S H	39·35	39·13	—0·22	39·19	+0·16	
					′ β = —0·06		′ ±0·11	
28-4-04 . .		N H	2—40·45	2—39·77	—0·68	2—40·49	—0·04	K. K. D.
,, . . .	4	,,	39·85	38·95	—0·90	39·67	+0·18	
29-4-04 . .		,,	45·55	45·03	—0·52	45·75	—0·20	
,, . . .		,,	45·67	45·13	—0·54	45·85	—0·18	
,, . . .		S H	45·48	44·72	—0·76	45·44	+0·04	
,, . . .	Magnet.	,,	45·45	44·52	—0·93	45·24	+0·21	
30-4-04 . .		N H	2—45·37	2—44·72	—0·65	2—45·44	—0·07	
,, . . .		,,	45·48	44·92	—0·56	45·64	—0·16	

Table G—*contd.*

Comparison of magnetometers in declination—end of field season 1903-04 and beginning of season 1904-05.

Date.	No. of Instrument.	Site N or S H.	S (Instrument under comparison).	D D Dehra Dun Standard No. 17.	D D—S =β	D D—β =D.	S—D.	Observer.
			° ′	° ′	′	° ′	′	
2-5-04 . .	Mag-net.	S H	45·55	44·63	—0·92	45·35	+0·20	K. K. D.
„ . .	4A	„	45·43	44·73	—0·70	45·45	—0·02	
					′ β=—0·72		′ ±0·13	
24-10-04 . .		S H	2—43·07	2—42·02	—1·05	2—43·04	+0·03	A. M. T.
„ . .		N H	43·52	42·33	—1·19	43·35	+0·17	
25-10-04 . .		S H	41·05	40·17	—0·88	41·19	—0·14	
„ . .		N H	40·32	39·23	—1·09	40·25	+0·07	
„ . .		„	39·83	39·03	—0·80	40·05	—0·22	
„ . .		S H	39·15	38·22	—0·93	39·24	—0·09	
26-10-04 . .		„	41·62	40·38	—1·24	41·40	+0·20	
„ . .		N H	41·32	40·17	—1·15	41·19	+0·13	
27-10-04 . .		S H	42·72	41·62	—1·10	42·64	+0·08	
„ . .		N H	42·17	41·33	—0·84	42·35	—0·18	
„ . .		„	41·72	40·78	—0·94	41·80	—0·08	
28-10-04 . .		S H	39·87	38·93	—0·94	39·95	—0·08	
„ . .		N H	40·27	39·13	—1·14	40·15	+0·12	
					′ β=—1·02		′ ±0·13	
19-4-04 . .	5	N H	2—40·05	2—39·77	—0·28	2—40·05	0	E. A. M.
20-4-04 . .		„	40·66	40·08	—0·58	40·36	+0·30	
„ . .	Mag-net.	„	40·15	39·77	—0·38	40·05	—0·10	
22-4-04 . .		S H	45·17	44·92	—0·25	45·20	—0·03	
„ . .	5A	„	44·57	44·20	—0·37	44·48	+0·09	
29-4-04 . .		„	40·75	40·70	—0·05	40·98	—0·23	
„ . .		„	39·20	39·17	—0·03	39·45	—0·25	
					β=0·82		±0·14	
22-10-04 . .		N H	2—42·15	2—41·30	—0·85	2—41·63	+0·52	E. A. M.
„ . .		S H	41·97	41·42	—0·55	41·75	+0·22	
24-10-04 . .		N H	39·72	39·35	—0·37	39·68	+0·04	
„ . .		S H	38·72	38·42	—0·30	38·75	—0·03	
25-10-04 . .		N H	42·50	41·92	—0·58	42·25	+0·25	
„ . .		S H	42·15	41·92	—0·23	42·25	—0·10	
26-10-04 . .		N H	2—39·25	2—39·03	—0·22	2—39·36	—0·11	
„ . .		S H	39·53	39·13	—0·40	39·46	+0·07	

TABLE G—*contd.*

Comparison of magnetometers in declination—end of field season 1903-04 and beginning of season 1904-05.

Date.	No. of Instrument.	Site S H or N H.	S (Instrument under comparison).	D D Dehra Dun Standard No. 17.	D—S β	D D—β = D.	S—D.	Observer.
27-10-04 . . .		N H	° ' 40·43	° ' 40·27	—0·16	° ' 40·60	' —0·17	F. A. M.
,, . .		S H	41·32	41·20	—0·12	41·53	—0·21	
28-10-04 . .		N H	42·05	42·13	+0·08	42·46	—0·41	
,, . .		S H	41·62	41·42	—0·20	41·75	—0·13	
					' β=—0·33		' ±0·19	
17-5-04 . .		S H	2—43·30	2—43·40	+0·10	2—43·21	+0·09	
,, . .	6	,,	43·75	44·12	+0·37	43·93	—0·18	H. P. M.
,, . .	Magnet.	,,	43·83	44·22	+0·37	44·03	—0·18	
18-5-04 . .		N H	43·90	44·22	+0·32	44·03	—0·13	
,, . .	6A	,,	43·39	43·60	+0·21	43·41	—0·02	
19-5-04 . .		S H	44·15	44·22	+0·07	44·03	+0·12	
,, . .		,,	44·30	44·22	—0·08	44·03	+0·27	
					' β=+0·19		' ±0·14	
22-10-04 . .		S H	2—41·48	2—41·30	—0·18	2—41·37	+0·11	H. P. M.
,, . .		N H	41·85	41·42	—0·43	41·49	+0·36	
24-10-04 . .		S H	39·75	39·67	—0·08	39·74	+0·01	
,, . .		N H	38·33	38·42	+0·09	38·49	—0·16	
25-10-04 . .		S H	42·07	41·92	—0·15	41·99	+0·08	
,, . .		N H	41·87	41·92	+0·05	41·99	—0·12	
26-10-04 . .		S H	39·02	39·03	+0·01	39·10	—0·08	
,, . .		N H	39·27	39·13	—0·14	39·20	+0·07	
27-10-04 . .		S H	40·42	40·27	—0·15	40·34	+0·08	
,, . .		N H	41·48	41·20	—0·28	41·27	+0·21	
28-10-04 . .		S H	41·98	42·13	+0·15	42·20	—0·22	
,, . .		N H	41·17	41·42	+0·25	41·49	—0·32	
					β=—0·07		±0·15	
29-4-04 . .		S H	2—44·33	2—45·03	+0·70	2—44·74	—0·41	
,, . .	10	,,	44·48	45·13	+0·65	44·84	—0·36	A. M. T.
,, . .		N H	44·65	44·72	+0·07	44·43	+0·22	
,, . .		,,	44·43	44·52	+0·09	44·23	+0·20	
30-4-04 . .		S H	44·53	44·72	+0·19	44·43	+0·10	
,, . .		,,	44·80	44·92	+0·12	44·63	+0·17	
2-5-04 . .		N H	44·40	44·63	+0·23	44·34	+0·06	
,, . .		,,	44·48	44·73	+0·25	44·44	+0·04	
					β=+0·29		±0·19	

TABLE G—*concld.*

Comparison of magnetometers in declination—end of field season 1903-04 and beginning of season 1904-05.

Date.	No. of Instrument.	Site N H or S H.	S (Instrument under comparison).	D D Debra Dun Standard No. 17.	D D−S =β.	D D−β =D.	S−D.	Observer.
			° ′	° ′	′	° ′	′	
1-11-04 . .	10	S H	2—40·55	2—41·07	+0·52	2—40·90	−0·35	N. R. M.
2-11-04 . .		„	40·95	41·17	+0·22	41·00	−0·05	
„ . .		N H	40·45	40·55	+0·10	40·38	+0·07	
„ . .		„	40·45	40·43	−0·02	40·26	+0·19	
3-11-04 . .		„	40·40	40·43	+0·03	40·26	+0·14	
„ . .		„	40·05	40·33	+0·28	40·16	−0·11	
„ . .		S H	39·62	39·93	+0·31	39·76	−0·14	
„ . .		„	39·85	40·23	+0·38	40·06	−0·21	
4-11-04 . .		„	39·47	39·62	+0·15	39·45	+0·02	
„ . .		„	39·48	39·52	+0·04	39·35	+0·13	
„ . .		N H	39·32	39·10	−0·22	38·93	−0·39	
„ . .		„	39·33	39·52	+0·19	39·35	−0·02	
„ . .		„	41·20	41·37	+0·17	41·20	0	
					′ β=+0·17		′ ±0·14	

TABLE H.

Abstract of results of comparison of magnetometers in declination.

No. of Instrument.	End of field season 1903-04.	Beginning of field season 1904-05.
17—	′	′
1	+0·02	+0·07
3	+0·20	−0·06
4	−0·72	−1·02
5	−0·28	−0·33
6	+0·19	−0·07
10	+0·29	+0·17
19	No comparison.	+0·22

NOTE.—No. 19 is a Kew pattern instrument by Elliot Bros., now in use at Toungoo observatory.

These results show that the magnetometers with the exception of No. 4 are in good agreement with the Standard, nor has there been any material change throughout the year.

Comparison of magnetometers with the Standard in H. F.

10. At the end of field season 1903-04 and beginning of field season 1904-05 each observer carried out comparative observations to determine his instrumental difference from the standard.

In the former case observations were as far as possible confined to the N. and S. houses, but in the latter three other sites close to and at a safe distance from the houses were utilized in the manner described last year.

The base line of the magnetograph was derived from special observations taken during the period of the comparisons.

During the present recess season permanent pillars have been erected on these sites, and observations will be carried out during the ensuing cold weather to determine what site differences, if any, exist.

For the present comparisons, these differences have been assumed to be negligible.

TABLE J.

Date.	No. of Instrument.	Site.	S (Instrument under comparison) C. G. S.	D D Dehra Dun Standard No. 17 C. G. S.	D D—S =β	D D—β =D₁.	S—D₁.	Observer.
26-3-04 . .	I	S H	·33440	·33442	+ 2	·33440	0	R. H. T.
" . .		"	439	442	+ 3	440	− 1	
27-3-04 . .		"	413	408	− 5	406	+ 7	
" . .		"	394	401	+ 7	399	− 5	
" . .	Magnet.	"	406	404	− 2	402	+ 4	
" . .		"	387	397	+ 10	395	− 8	
28-3-04 . .	I A	"	430	430	0	428	+ 2	
" . .		"	425	433	+ 8	431	− 6	
" . .		"	428	436	+ 8	434	− 6	
" . .		"	430	438	+ 8	436	− 6	
29-3-04 . .		"	457	450	− 7	448	+ 9	
" . .		"	455	450	− 5	448	+ 7	
" . .		"	458	449	− 9	447	+ 11	
" . .		"	456	449	− 7	447	+ 9	
30-3-04 . .		N H	416	426	+ 10	424	− 8	
" . .		"	419	420	+ 1	418	+ 1	
" . .		"	413	424	+ 11	422	− 9	
" . .		"	416	418	+ 2	416	0	
2-4-04 . .		S H	369	375	+ 6	373	− 4	
" . .		"	362	374	+ 12	372	− 10	
2-5-04 . .		"	407	406	− 1	404	+ 3	
" . .		"	404	406	+ 2	404	0	
" . .		"	406	406	...	404	+ 2	
" . .		"	402	405	+ 3	403	− 1	
" . .		"	400	405	+ 5	403	− 3	
" . .		"	400	404	+ 4	402	− 2	
					β=+2γ		±5γ	
31-11-04 . .		N H	·33395	·33394	− 1	·34396	− 1	R. H. T.
" . .		"	390	387	− 3	389	+ 1	

TABLE J—*contd.*

Date.	No. of Instrument.	Site.	S (Instrument under comparison) C. G. S.	D Dehra Dun Standard No. 17 C. G. S.	D–S =β	D–β =D_1.	S–D.	Observer.
31-10-04 . .		N H	·33392	·33392	·330	·33394	– 2	R. H. T.
„ . .		„	387	385	– 2	387	0	
1-11-04 . .		„	403	405	+ 2	407	– 4	
„ . .		„	395	400	+ 5	402	– 7	
„ . .		„	406	402	– 4	404	+ 2	
„ . .		„	398	397	– 1	399	– 1	
a-11-04 . .		S H	415	410	– 5	412	+ 3	
„ . .		„	397	403	+ 6	405	– 8	
„ . .		„	413	407	– 6	409	+ 4	
„ . .		„	396	401	+ 5	403	– 7	
4-11-04 . .		N H	370	367	– 3	369	+ 1	
„ . .		„	370	361	– 9	363	+ 8	
„ . .		„	368	365	– 3	367	+ 1	
„ . .		„	368	359	– 9	361	+ 8	
					β=–2γ		±4γ	
17-5-04 . .	3	N H	·33383	·33411	+ 28	·33388	– 5	R. P. R.
„ . .		„	396	413	17	390	+ 6	
„ . .		„	395	413	18	390	+ 5	
„ . .		„	392	412	20	389	+ 3	
18-5-04 . .	Mag-net.	No. 3	409	423	19	405	+ 4	
„ . .	3 A	„	403	427	24	404	– 1	
„ . .		„	402	425	23	402	0	
„ . .		„	388	422	34	399	– 11	
19-5-04 . .		N H	400	414	14	391	+ 9	
„ . .		„	394	412	18	389	+ 5	
„ . .		„	395	416	21	393	+ 2	
„ . .		„	382	414	32	391	– 9	
					β=+23γ		±5γ	
22-11-04 . .	3	No. 2	·33355	·33373	+18	·33356	–1	R. P. R.
„ . .		„	348	373	25	356	–8	
„ . .		„	356	374	18	357	–1	
„ . .		„	348	374	28	357	–11	
24-11-04 . .		No. 3	384	390	6	373	+11	
„ . .		„	370	388	18	371	–1	
24-10-04 . .		No. 3	·33363	387	+24	·33370	–7	
„ . .		„	369	387	18	370	–1	

TABLE J—*contd.*

Date.	No. of Instrument.	Site.	S (Instrument under comparison).	D D Dehra Dun Standard No. 17.	D D—S =β.	D D—β =D₁.	S—D₁.	Observer.
24-10-04		No. 3	360	386	26	369	−9	
25-10-04	3	N H	403	406	3	389	+14	
„		„	390	402	12	385	+5	
„		„	393	402	9	385	+8	
26-10-04	Magnet.	No. 1	400	406	6	389	+11	
„		„	382	401	19	384	−2	
„		„	396	405	9	388	+8	
„		„	377	399	22	383	−5	
„	3 A	„	380	396	16	379	+1	
28-10-04		N H	395	416	21	399	−4	
„		„	390	407	17	390	0	
„		„	390	414	24	397	−7	
„		„	385	405	20	388	−3	
					β=+17γ		±4γ	
29-4-04		N H	·33429	·33436	+7	·33434	−5	K. K. D.
„	4	„	436	433	−3	431	+5	
„		„	432	429	−3	427	+5	
„		„	415	424	+9	422	−7	
30-4-04		No. 2	443	436	−7	434	+9	
„		„	434	433	−1	431	+3	
„		„	430	431	−1	429	+3	
„	Magnet.	„	416	429	+13	427	−11	
2-5-04		„	407	401	−6	399	+8	
„	4 A	„	393	403	+10	401	−8	
„		„	398	407	+9	405	−7	
„		„	414	409	−5	407	+7	
„		„	394	409	+15	407	−13	
3-5-04		N H	413	413	0	411	+2	
„		„	413	415	+2	413	0	
„		„	413	415	+2	413	0	
„		„	415	416	+1	414	+1	
„		No. 3	418	417	−1	415	−3	
„		„	411	416	+5	414	−3	
„		„	410	415	+5	413	−3	
„		„	415	416	+1	414	+1	
4-5-04		N H	397	410	+13	408	−11	
			433	430	−3	428	+5	
„		No. 4	·33426	·33433	−7	·33431	−5	
„		„	426	431	−5	429	−3	

TABLE J—*contd.*

Date.	No. of Instrument.	Site.	S (Instrument under comparison.)	D D Dehra Dun Standard No. 17.	D D—S =β.	D D—β =D.	S—D.	Observer.
4-5-05 .		No. 4	426	428	+2	426	0	K. K. D.
,,		,,	21	421	0	419	+2	
					β=+2γ		±5γ	
24-10-04 . .	4	N H	·33353	·33391	+38	·33366	−13	A. M. T.
,, .		,,	58	89	31	64	− 6	
,, . .		,,	51	90	39	65	−14	
,, .		,,	56	87	31	62	− 6	
25-10-04 . .	Magnet. 4 A	No. 1	95	407	12	82	+13	
,, . .		,,	87	04	17	79	+ 8	
,, . .		,,	76	06	30	81	− 5	
,, . .		,,	86	04	18	79	+ 7	
26-10-04 . .		No. 2	88	08	20	83	+ 5	
,, . .		,,	75	04	29	79	− 4	
,, . .		,,	86	06	20	81	+ 5	
,, . .		,,	73	02	29	77	− 4	
29-10-04 . .		No. 3	81	01	20	76	+ 5	
,, . .		,,	75	03	28	78	− 3	
,, . .		,,	77	02	25	77	0	
,, . .		,,	86	04	14	79	+11	
					β=+25γ		± 7γ	
20-4-04 . .	5	N H	·33415	·33411	− 4	·33422	− 7	E. A. M.
,, . .		,,	18	07	−11	18	0	
22-4-04 . .		,,	23	27	+ 4	38	−15	
,, . .		,,	28	28	0	39	−11	
,, . .		,,	30	30	0	41	−11	
,, . .		,,	33	35	+ 2	46	−13	
23-4-04 . .	Magnet. 5 A	,,	58	24	−34	35	+23	
,, . .		,,	43	21	−22	32	+11	
,, . .		,,	43	20	−23	31	+12	
30-4-04 . .		,,	28	18	−10	29	− 1	
,, . .		,,	50	33	−17	44	+ 6	
,, . .		,,	36	31	− 5	42	− 6	
,, . .		,,	21	29	+ 8	40	−19	
2-5-04 . .		,,	25	09	−16	20	+ 5	
,, . .		,,	26	08	−18	19	+ 7	
,, . .		,,	20	07	−19	18	+ 8	
,, . .		,,	20	06	−14	17	+ 3	
					β=−11γ		± 9γ	

TABLE J—*contd.*

Date.	No. of Instrument.	Site.	S (Instrument under comparison.)	D D Dehra-Dun Standard No. 17.	D D—S =β.	D D—β =D₁.	S—D₁.	Observer.
22-10-04 . .	5	N H	·33366	·33371	+ 5	·33363	− 3	E. A. M.
" . .		"	376	372	− 4	364	+12	
" . .		"	363	373	+10	365	− 2	
" . .		"	379	374	− 5	366	+13	
24-10-04 . .		No. 1	386	390	+ 4	382	+ 4	
" . .		"	385	387	+ 2	379	+ 6	
" . .		"	385	389	+ 4	381	+ 4	
" . .		"	383	386	+ 3	378	+ 5	
25-10-04 . .		No. 2	403	406	+ 3	398	+ 5	
" . .		"	395	403	+ 8	395	0	
" . .		"	400	406	+ 6	398	+ 2	
" . .		"	392	403	+11	395	− 3	
26-10-04 . .		No. 3	394	407	+13	399	− 5	
" . .		"	376	401	+25	393	−17	
" . .		"	395	405	+10	397	− 2	
" . .		"	376	399	+23	391	−15	
27-10-04 . .		N H	401	404	+ 3	396	+ 5	
29-10-04 . .		"	384	399	+15	391	− 7	
" . .		"	403	400	− 3	392	+11	
" . .		"	387	401	+14	393	− 6	
" . .		"	399	404	+ 5	396	+ 3	
					β = +8γ		± 6γ	
17-5-04 . .	6	S H	·33427	·33414	−13	·33427	0	P. M.
" . .		"	416	412	− 4	425	− 9	
" . .		"	412	409	− 3	422	−10	
" . .		"	402	405	+ 3	418	−16	
18-5-04 . .		N H	443	428	−15	441	+ 2	
" . .		"	446	428	−18	441	+ 5	
" . .		"	443	427	−16	440	+ 1	
" . .		"	442	424	−18	437	+ 5	
19-5-04 . .		No. 3	437	419	−18	432	+ 5	
" . .		"	433	414	−19	427	+ 6	
" . .		"	430	412	−18	425	+ 5	
" . .		"	427	416	−11	429	− 2	
					β = −13γ		± 5γ	
22-10-04 .	6	No. 1	·33391	·33370	−21	·33385	+6	P. M.
" . .		"	392	372	20	387	+5	
" . .		"	393	373	20	388	+5	
" . .		"	393	374	19	389	+4	
24-10-04 . .		No. 2	410	391	19	406	+4	

TABLE J—*concld.*

Date.	No. of instrument.	Site.	S (Instrument under comparison).	D D Dehra Dun Standard No. 17.	D D—S = β.	D D—β = D_1.	S—D_1.	Observer.
24-10-04 .			·33395	·33387	8	·33402	—7	
„ .			408	390	18	405	+3	
„ .			393	386	7	401	—8	
25-10-04 .		No. 3	420	407	13	422	—2	
„ .			415	405	10	420	—5	
„ .			420	406	14	421	—1	
„ .			414	404	10	419	—5	
26-10-04 .		N H	423	408	15	423	0	
„ .			418	404	14	419	—1	
„ .			421	406	15	421	0	
„ .			416	402	14	417	—1	
					β=−25 γ		±4 γ	
29-4-04 .	10	No. 3	·33405	·33436	+31	·33411	—6	A. M. T
„ .			411	432	21	407	+4	
„ .			407	431	24	406	+1	
„ .			396	429	33	404	—8	
2-5-04 .			383	401	18	376	+7	
„ .			378	403	25	378	0	
„ .			383	407	24	382	+1	
„ .			385	409	24	384	+1	
3-5-04 .			393	412	19	387	+6	
„ .			383	414	31	389	—6	
„ .			386	415	29	390	—4	
„ .			396	415	19	390	+6	
					β=+25 γ		±4 γ	
31-10-04 .		S H	·33385	·33394	+ 9	·33378	+ 7	
„ .			372	390	+18	374	— 2	
1-11-04 .			389	405	+16	389	0	
„ .			388	401	+13	385	+ 3	
„ .			385	403	+18	387	— 2	
„ .			386	399	+13	383	+ 3	
3-11-04 .			399	421	+22	405	— 6	
„ .			399	416	+17	400	— 1	
„ .			396	420	+24	404	— 8	
„ .			396	415	+19	399	— 3	
4-11-04 .		N H	357	369	+12	353	+ 4	
„ .			362	361	— 1	345	+17	
„ .			331	358	+27	342	—11	
					β=+16 γ		±5 γ	

TABLE K.

Abstract of results of comparison of magnetometers in H. F.

	End of field season, 1903-04.		Beginning of field season, 1904-05.	
	1	2	1	2
	Neglecting q term.	Using q term.	Neglecting q term.	Using q term.
17—				
1	+ 2 γ	+10 γ	— 2 γ	+ 3 γ
3	+23 γ	+11 γ	+17 γ	+ 3 γ
4	+ 2 γ	—17 γ	+25 γ	+11 γ
5	—11 γ	—16 γ	+ 8 γ	— 3 γ
6	—13 γ	— 1 γ	—15 γ	— 2 γ
10	+25 γ	+ 5 γ	+16 γ	— 6 γ

Comparison of houses in dip.

11. At the end of the field season, 1903-04, simultaneous observations were taken in the N and S houses using dip circles 44 (the Dehra standard) + 43. The result is given below:—

TABLE.

Simultaneous dip observations.

Date.	No. 44 in SH or $\frac{SH}{44}$	No. 43 in NH or $\frac{NH}{43}$	$\frac{SH}{44} - \frac{NH}{43}$ or X	Remarks.
	° ′	° ′		
27-3-04 . .	43 —15·1	43 —16·9	— 1·8	Observers. S. D. and R. H. T.
29-3-04 . .	16·5	17·7	— 1·2	
30-3-04 . .	14·0	15·5	— 1·5	
31-3-04 . .	15·4	14·2	+ 1·2	
1-4-04 . .	21·7	21·9	— 0·2	44-needles 1·2.
2-4-04 . .	17·2	19·8	— 2·6	43-needles 2·4.
			Mean X= —1·0	
	No. 43 in SH or $\frac{SH}{43}$	No. 44 in NH or $\frac{NH}{44}$	$\frac{SH}{43} - \frac{NH}{44}$ or X,	
	° ′	° ′		
2-3-04 . .	43 —15·9	43 —15·3	+ 0·6	
27-3-04 . .	18·0	14·8	+ 3·2	

Simultaneous dip observations—contd.

Date.	No. 43 in S H or $\frac{S\ H}{43}$	No. 44 in S H or $\frac{NH}{44}$	$\frac{SH}{43} - \frac{NH}{44}$ or X_1	REMARKS.
	′	′	′	
29-3-04 . . .	20·4	16·7	+ 3·7	
30-3-04 . . .	15·6	14·3	+ 1·3	
31-3-04 . . .	14·7	14·3	+ 0·4	
1-4-04 . . .	24·2	24·2	0	
2-4-04 . .	19·4	17·3	+ 2·1	
			MeanX_1 = + 1·6	

Hence S.H — NH = + 0′·3

44 — 43 = — 1′·3

Comparison of Dip Circles with the Standard.

12. At the end of the field season, 1903-04, and beginning of the field season, 1904-05, the dip circles were compared by simultaneous observations with No. 44 which was kept in the S. H. throughout, the field instruments being erected in rotation at the different sites alluded to in the comparisons of H.F.

An analysis of the site errors shows that in all cases the error is less than the probable error of observation and they have therefore been neglected in computing the following abstract :—

TABLE.

Comparison of dips.

44— 1·2	End of field season, 1903-4.	44—. 1·2	Beginning of field season, 1904-5.
	′		′
$43_{2\cdot4}$	− 1·3 } − 1·0 − 0·7 }	$43_{4c\cdot4d}$	− 2·4
$135_{2\cdot3}$	− 4·6	$135_{2\cdot3}$	− 5·4
$136_{2\cdot3}$	− 1·2	$136_{2\cdot3}$	− 4·7
$137_{1\cdot2}$	+ 0·9	$137_{1\cdot3}$	− 1·5
$138_{2\cdot3}$	− 1·7	$138_{2\cdot}$	− 3·9
139	No comparison	$139_{1\cdot2}$	− 1·6
$140_{2\cdot3}$	− 2·0	$140_{2\cdot3}$	− 2·9

The first of the earth inductors has recently (November 13th, 1905) been received, and if it proves to be satisfactory, will replace dip circle No. 44 as the Dehra Dun standard.

At the end of field season, 1904-05, three of the field dip circles were compared with the standard, using a different method of changing sites, whereby the differences of instruments are obtained direct, free of site errors ; the same method has also been used for the comparison of all dip circles in October 1905: the results will be published in the next report.

Moment of inertia.

13. In the report of the magnetic survey operations for 1903-04, a list of the accepted values of π^2 K for various magnets was published, together with certain new values obtained in 1903, which differed largely from those originally obtained.

The inertia bars appeared to be in excellent condition, while the comparison of instruments indicated the absence of any considerable changes in the magnetometers; in default therefore of any adequate explanation of the changes, it was decided to adhere to the original values for the present.

In March 1905, however, Major Fraser, R.E., proceeded on deputation to Europe and advantage was taken of this opportunity to have the dimensions of the two survey inertia bars, *viz.*, Elliott No. 17 and Cooke No. 2 remeasured at Kew.

The results of these measurements together with those originally made in 1901 are given below:—

	Bar No. 2 (Cooke).		Bar No. 17 (Elliott).	
	1905.	1901.	1905.	1901.
Mass . . .	63·857 grms.	63·889 grms.	68·558 grms.	68·577 grms.
Length . . .	9·281 cms.	9·285 cms.	10·028 cms.	10·028 cms.
Diameter . .	·018 cms.	1.018 cms.	1·002 cms.	1·002 cms.

It will be seen that both bars have lost weight, No. 2 markedly so, while this bar has suffered also a diminution in length which is almost proportional to the loss in weight.

The decrease in length of bar No. 2 is inexplicable; it seems to point to a portion of the bar having been cut off by a skilful workman at some time between the first Kew measurement in 1901 and early in 1904 when the bar was remeasured at Sibpur. This measurement gave a weight of 63·859 grammes, almost identical with the last Kew measurement in June 1905: the length however was found to be 9·283 c.m.s. and the mean diameter 1·0147 c.m.s., but though these values of length and diameter are derived from over 50 independent measurements, the discrepancy in the measurement of the diameter is such as to throw considerable doubt upon both measures. All the Cooke inertia bars were made from bars drawn at the same time, and the fact that the Kew measurements of the remaining bars all give 1·018 to 1·017 for the mean diameter clearly shows that this is the more probable value. The loss in weight in No. 17 bar is most probably due to attrition caused by cleaning the bar before use.

The subject of inertia bars and the determination of the moment of inertia of collimator magnets has recently been investigated by Dr. Watson, F.R.S. (*vide* Phil. Mag., July 1905, and Proc. Phy. Soc., London, Vol. XIX) and the author having kindly placed his apparatus at the disposal of Major Fraser, R.E., that officer was enabled, using this new method, to determine the absolute moment of inertia of bars 2 and 17 and a third bar for the gift of which the magnetic survey is indebted to Professor Watson. This bar is of gilt rolled brass with slightly rounded corners and of such dimensions that it will fit the stirrups of all the Indian magnets. In what follows it will be denoted by the symbol S. G. (standard gilt).

The values* obtained were derived by a direct comparison with Dr. Watson's standard bar No. 10, whose moment of inertia must be very nearly absolutely correct and for all practical purposes may be considered free from error.

These values were as follows:—

	Bar 2.	Bar 17.	Bar S. G.
1st series (temp. 22°C).	462·695	579·231	......
2nd series (temp. 24°C).	462·716	579·280	573·891

The coefficients of expansion used in reducing these values to 0°C were as follows:—

Bar.	Material.	Co-efficient of expansion for 1° C.	REMARKS.
S.G. . .	Rolled brass .	0·0000187	Coefficient adopted by Professor Watson.
17	Gunmetal by Elliott .	0·0000170	Value determined recently at
2	Gunmetal (supposed) by Cooke . .	$l_t = l_0\ (1 + 0{\cdot}000017359t + 0{\cdot}0000000059t^2)$	Value determined at Sevres.

These values for Nos. 17 and 2 were also used in reducing the lengths of the inertia bars from 15°C to 0° at Kew.

It has recently been established, however, that the bar 2 is not of gunmetal as supposed, but of commercial drawn brass; the reductions to 0°C are therefore slightly incorrect, due to the use of an erroneous coefficient of expansion. The following co-efficient of linear expansion has been adopted, namely, 0·0000186 per 1°C: there is, however, a slight additional uncertainty introduced in reducing the Kew measurement of the length by this co-efficient, as no detail of the actual measures has been supplied with the certificate, but merely the value reduced to 0°C.

The following are the values of the absolute moments of inertia at 0°C.

Series.	Bar No. 2.	Bar No. 17.	Bar S. G.
First . . .	462·317	578·798	......
Second . . .	462·303	578·808	573·891
Means . . .	462·31	578·80	573·89

It is interesting to compare these values with those computed from the latest Kew dimensions.

Bar.	Absolute.	Computed.	A–C.
No. 2	462·31	462·41	–0·10
No. 17	578·80	578·83	–0·03

*Extracted from a report on the inertia bars of the India Survey by Major H. A. D. Fraser, R.E

From this it seems probable that the bar No. 2, which was selected as the standard from 5 bars as giving a result nearest to the mean of the five, is by no means of uniform density; in form, however, it leaves nothing to be desired, as it is almost a perfect cylinder. On the other hand, bar No. 17 which is most imperfect in form and has a visible defect, proves, as far as results go, to be an almost perfect bar.

The Indian Survey now has three bars the absolute moments of inertia of which are known with considerable accuracy, so that in determining the moments of inertia of the magnets it is immaterial which bar is employed. Of the three bars, S. G. and 17 may be used with any magnet stirrup, but 2 fits only the Cooke stirrups.

In future bar S. G. will be generally used, the remaining bars being kept in reserve as standards. Bar S. G. having rounded corners is less susceptible to damage and being gilt is less easily soiled and will require less cleaning, moreover the fact that the gilding is very thin will at once show up any undue wear and tear.

It is intended as opportunity offers to redetermine the moments of inertia of all the Indian magnets; owing however to various causes, chief of which were the late arrival of the bars from England and the illness of the Dehra Dun observer, it has been found impossible to carry out the work during the recent recess season and it cannot now be undertaken before the hot weather of 1906.

The question of the application of such fresh values of the moments of inertia as may be found and their connection with existing values will be dealt with in the next report.

For the present it will suffice to note that a change in log π^2 K may be due to either a change in the inertia bar or magnet system or both these causes combined. The absolute dimensions of the bars are no longer of importance provided they do not change and the simplest and quickest method of investigating this is by periodical weighing. A balance (recommended by Dr. Chree, F.R.S.) has recently been indented for, of a pattern sensitive to $\frac{1}{500}$ grain, and will be used for weighing the inertia bars at the beginning and end of each season. The magnets with their stirrups and chucks will also be weighed at the same periods, for if the weights of these remain constant, it is practically certain that their moments of inertia have remained unchanged. A change in weight of any system will therefore at once indicate the advisability of redetermining the moment of inertia of that system.

Magnetograph records of the earthquake of April 4th, 1905.

14. The principal shock of the earthquake of the 4th April 1905 was recorded with more or less intensity on all the magnetograph curves, varying with their distances from the point of origin; a considerable number of after shocks were also shown as mechanical displacements on the H. F. curves at Dehra Dun, but, except in one instance at Barrackpore, these were not registered at the more distant observatories.

At Dehra Dun the shock was sufficiently violent to throw the declination magnet out of djustment, the beam being displaced by the mirror becoming unseated in its bearing on the cross bar of the magnet system: the declination records were lost until the instrument was readjusted on the 16th April on the return of the officer in charge. Fortunately the H. F. magnetograph was unaffected in its adjustments and, as there was no stoppage of the driving clock, a continuous record was obtained with this instrument.

At Barrackpore the declination magnet was similarly affected to a less extent. The trace was lost for about 5½ hours owing to the magnet adhering to the side of the damping box, requiring the use of a bar magnet to restore it to its normal position : the base line value was however found to be unaffected.

The times of the principal shock as measured by the magnetographs.

15. Considerable interest attaches to the time of shock recorded on the Dehra Dun magnetographs, these instruments being the only automatically recording instruments in Northern India at the time. The shortness of the time scale however, where 1 minute is represented by ·01 inches, precludes any great accuracy of measurement, and further errors are introduced in the corrections for parallax (being the small quantity by which the curve overlaps the trace or *vice versa*, due to defects or non-parallelism of the reflecting mirrors), clock error, error in estimating the exact moment of the hourly cut off, (the driving clock being unprovided with a second hand), errors in estimating the departure from whole divisions of the glass scale, and corrections to the scale itself. The measurements were made with the glass scale ordinarily used for measuring up the curves; in form it is an hour scale with ten minute divisions : great accuracy could not therefore be expected.

The following are the times found by this method, the measurements being made by three observers independently. The times given throughout this discussion are all reduced to Madras mean time, taken at 5 hours 21 minutes E of Greenwich.

		h.	m.	means.	
Dehra Dun	H.	6	11·7	6—11·6	
		6	11·5		
		6	11·5		
	δ	6	11·8	6—11·7	
		6	11·8		
		6	11·6		
Barrackpore	H.	6	16·2	6—16·4	
		6	16·4		
		6	16·5		
	δ	6	17·1	6—16·9	
		6	16·8		
		6	16·9		
Kodai Kanal	H.	6	21·7	6—21·6	*Note.* The Kodai Kanal indications are faint and difficult to measure accurately.
		6	21·6		
		6	21·5		
	δ	6	22·1	6—22 4	
		6	22·6		
		6	22·5		
Toungoo	H.	6	20·1	6—19·9	This trace is very faint.
		6	19·8		
		6	19·9		
	δ	Very faint—not measured.			

The mean times give the following intervals in minutes between the times at different observatories.

	From H trace.	From δ trace.
Dehra Dun—Barrackpore	4·8	5·2
„ Kodai Kanal	10·0	10·7
„ Toungoo	8·3	...
Barrackpore—Kodai Kanal	5·2	5·5
„ Toungoo	3·5	...

There is however another method of measuring these intervals by determining the interval between the recorded shock and the apices of well marked disturbance points on the same date. They may be measured in two ways either by measuring the absolute times of each, and taking the difference between them and the above mean times from the H. F. traces or by measuring the intervals direct. Both of these methods were employed ; in these measurements errors in measurement of parallax, clock time, and cut-off are eliminated. The method assumes that the times of disturbance are simultaneous, which is probably correct over the area involved: the absolute times of the apices (two of which were used) were therefore scaled off in the first instance. The times found were as follows reduced to Madras time as before :—

Observatory.	Disturbance *(a)*.	Disturbance *(b)*	Difference *b—a*.
	h. m.	h. m.	h.
Dehra Dun	2 31·8	9 12·4	6 40·6
Barrackpore	2 31·7	9 12·2	6 40·5
Kodai Kanal	2 31·8	9 12·3	6 40·5
Toungoo	2 30·6	9 11·2	6 40·6

The accordance of the results for the first three observations in the second and third columns, and of all four in the third, warrant the assumption that these disturbances are practically simultaneous, the discrepancy moreover in the case of Toungoo seems to show that either the clock time there was slow 1.1 minutes, or the measurements were in error by that amount due to difficulties introduced by the faintness of the trace. Subtracting from the absolute times of the disturbances the mean values of the time of shock as recorded on the H. F. traces we obtain the following values for the time interval of the principal shock for each observatory from each disturbance. In the following table the 1st column under the head of each disturbance shows the time interval obtained in this way, the second column that obtained by direct measurement.

Observatory.	Disturbance *(a)*.			Disturbance *(b)*.		
	1	2	Mean of 1 and 2	1	2	Mean of 1 and 2.
	h. m.	h. m.				
Dehra Dun	3 39·8	3 39·9	3 39·9	3 0·8	0·5	3 0·7
Barrackpore	3 44·7	3 44·9	3 44·8	2 55·8	2 55·4	2 55·6
Kodai Kanal	3 49·8	3 49·7	3 49·8	2 50·7	2 50·3	2 50·5
Toungoo	3 49·3	3 49·3	3 49·3	2 51·3	2 51·1	2 51·2

From these means we obtain the following mean intervals, those obtained by direct measurement being repeated for reference.

	minutes.		
Dehra Dun—Barrackpore .	5·0	4·8	intervals by absolute times on H. F. trace.
„ Kodai Kanal .	10·1	10·0	
„ Toungoo .	9·5	8·3	
Barrackpore—Kodai Kanal	5·1	5·2	
„ Toungoo .	4·5	3·5	

The derived intervals have much greater weight than those obtained from the measurement of the absolute times; they have therefore been adopted. Correction is necessary only to the Toungoo absolute time and this has accordingly been corrected by 1·1 minutes.

The following is a summary of the adopted times, together with such times of seismograph effects as are available. It is to be regretted that there was no seismograph at Dehra Dun ; its indication would have been of great value in investigating the relation of magnetic and seismograph records especially with reference to the discrepancy in the Dehra time for the principal shock (which will be noted hereafter) and for comparison with the aftershocks which, except in one instance, were not recorded at the other observatories.

Comparison of times with seismograph effects.

Table of times of commencement of record.

6*h* +

Place.	H. F. trace.	Declination.	V. F.	Seismograph.
	m.	m.		
Dehra Dun	11·6	11·7	......	
Barrackpore . . . . / Alipore	16·4	16·9	......	17·0 (large waves).
Kodai Kanal	21·6	22·4	......	21·8 (large waves).
Bombay . . . . / (Colaba)	22·7	21·7	20·2	13·0 (P. T.) / 17·0 (L. W.)
Toungoo . .	21·0	.....	......	

NOTE.—(1) Alipore is some 14 miles south of Barrackpore.
(2) The magnetographs are all of similar construction, except at Bombay.

From the above table it appears that the magnets of the Watson magnetographs at Barrackpore and Kodai Kanal were affected almost simultaneously with the arrival of the large waves, and it would therefore appear reasonable to suppose that the precisely similar magnets at Toungoo and Dehra Dun would be affected in the same manner : in the case of Toungoo this appears to be the case, that observatory being at practically the same radial distance from the origin as Kodai Kanal, for the slight difference in times, namely, 0·6 minutes, are accounted for by a correction of 20 seconds in the measured times applied in opposite directions, such corrections being well within the probable error of measurement. At Dehra Dun however, though distant only some 130 miles from the origin, there was no appreciable effect shown until some two minutes had elapsed after the probable time of arrival of the large waves.

16. In Kodai Kanal and Toungoo there is merely a blurring of the trace, which at Toungoo is extremely faint in the H. F. and almost imperceptible in the declination record. At Barrackpore and Dehra Dun on the other hand it is possible to measure some phases of the effect.

Character of effects of principal shock on the magnetograph traces.

At Dehra the effect begins sharply with a maximum (the oscillation being so rapid as to fail to register photographically) at 6h. 11·6m.; the maximum continues till 6h. 19·8m., a period of 8·2 minutes ; this is followed by a period of slower oscillation for 3·1 minutes, when a second sharp shock was recorded at 6h. 22·9m : the magnet continued oscillating until 6h. 37·3m., a period of 25·7 minutes, during which there were in addition to the principal shock, three others recorded, namely, at 6h. 22·9m., 6h. 31·3m. and 6h. 36·2m.

A further displacement was registered at 6h. 55·1m. (duration about 1·4 minutes) which corresponds to the only aftershock registered at Barrackpore, which is noted below.

At Barrackpore the effect begins at 6h. 16·4m. with a relatively slower period of oscillation, lasting for 1·9 minutes; a maximum is attained at 6-18·2 and continues till 6h. 26·4m., a period of 8·2 minutes, about the same as at Dehra Dun. Thereafter there is a gradual slowing down and the effect ends roughly speaking about 6h. 42·0m. That the periods of maximum effect at Dehra Dun and Barrackpore should be practically identical is noteworthy, and if this depends on the similarity of the magnets, as the initial times of earthquake disturbance appear to do as far as Barrackpore, Toungoo and Kodai Kanal observatories are concerned (being approximately simultaneous with the arrival of the large seismograph waves), it seems not improbable that the time of arrival of the large waves at Dehra Dun was some two minutes anterior to the beginning of the record, though the reason of the anomaly remains obscure.

This will be further referred to later in discussing the question of the speed of the seismic waves as deduced from the magnetic records.

The only aftershock registered on the magnetographs other than those at Dehra was at Barrackpore at 7h. 2·1m.

List of mechanical displacements of the H. F. magnet at Dehra Dun.

17. The following table shows the times of mechanical displacements of the H. F. magnet at Dehra Dun on the 4th, 5th and 6th April 1905. They have not however been compared with seismograph indications.

Date.	Times in Madras mean time.
4-4-05 . . .	6-11·6, 6-22·9, 6-31·3, 6-36·2, 6-55·1, 7-8·5, 7-17·9, 7-38·8, 7-53·2, 9-6, 13-43?, 14-1, 15-52, 17-57, 18-32?, 22-1, 23-59
5-4-05 . . .	0-2, 7-6?, 21-49
6-4-05 . . .	21-23

Some of these are doubtful and may possibly be due to periodic vibration; in the great majority however they have all the appearance of mechanical displacement, the trace being blurred or wholly obliterated by the rapidity of movement.

The speed of seismic waves as deduced from the magnetograph records.

18. Assuming the origin of seismic disturbance to have been in Lat. 32° N Long. 77° E, we find the distances from this point to the magnetic observatories are as follow:—

Origin to Dehra Dun = 131 miles.
Barrackpore = 944 „
Kodai Kanal = 1,498 „
Toungoo = 1,512 „

Neglecting the Dehra time for the present and making use of the H. F. traces only we have:—

Difference of time, Barrackpore—Kodai Kanal = 306 seconds.
„ „ „ Toungoo = 270 „
„ of radial distances, Barrackpore—Kodai Kanal = 554 miles.
„ „ „ „ Toungoo = 568 „
This gives rates, Barrackpore—Kodai Kanal = 1·81 miles per second.
„ „ „ Toungoo = 2·10 „

For the reasons stated previously, *viz.*: firstly, on account of the difficulties of measuring faint traces, and secondly that the differences of time should be approximately the same and may be made so by corrections well within the probable error of measurement, it seems reasonable to take a mean rate, which is 1·96 miles per second.

The time given by the Dehra Dun H. F. for the principal shock does not at all accord with this mean rate, unless we take the times of commencement of maximum effect at Dehra and Barrackpore when we get a time difference of 402 seconds giving a rate of 2·02 miles per second.

Fortunately we have another means of comparison in the subsequent shock registered by both magnetographs: the times of this shock are 6h.55·1m. at Dehra Dun and 7h. 2·1m. at Barrackpore.

Difference of time—420", and difference of radial distance—813 miles. This gives a rate of 1·96 miles per second, exactly the same as the mean rate above.

This rate compares favourably with that of 1·98 obtained by Mr. R. D. Oldham for the Assam Earthquake of 1897 and with Omori's 3·3 Kilometres per second for the surface waves. This rate if applied to the Barrackpore H.F. time (which appears the most reliable) would give the time at origin as 6h. 8·4m.

Summary.

The following conclusions appear to be justified for magnetographs of the Watson pattern with reference to near earthquakes.

(1) They do not, even so close as 130 miles to the origin, register preliminary tremors.

(2) The record begins practically simultaneously with the arrival of the large surface waves.

(3) That magnets of similar construction are similarly affected. They should, therefore, apart from questions of absolute time, give a fairly good approximate rate for the speed of seismic waves.

Distribution of magnetic instruments.

14. Observatories or field instruments.	Magnetographs.		Magnetometers.	Dip circles.	Remarks.
	H. F.	Declination.			
Dehra Dun . . .	1	1	17	44	Magnetometers 1 to 6 and no. 10 are by Cooke.
Kodai Kanal . .	2	2	16	46	Magnetometers 16, 17, 19 and 20 are old Elliott instruments of Kewapttern altered by Cooke.
Barrackpore . .	3	3	20	45	Dip Circles 135—140 are by Dover. Dip circles, 43—46 by Barrow repaired by Dover. Dip circle 137 was sent to Toungoo at the end of the field season to replace 43 whose results were unsatisfactory.
Toungoo	4	4	19	43	
Major Fraser . .			10	139	
Captain Thomas . .			1	137	
Mr. Morton . . .			6	138	
Babu R. P. Ray . .			3	135	
Mr. Talati . . .			4	136	
Mr. Meyer . . .			5	140	

A new dip circle No. 170 by Dover and the second vertical force magnetograph were received during the year.

General Remarks.

19. The results of the field work are exhibited in the table below and the index chart following shows the situations of the stations occupied up to date.

The investigation of the formulæ for the reduction of the field observations has been initiated by Mr. J. Eccles, M.A., and the results so far seem most promising. With a view to reducing the magnitude of the corrections for diurnal variation, observations in the ensuing field season will not be taken between the hours of 9 A.M. and 3 P.M. during which period the rate of change is, comparatively speaking, most marked.

During the next field season operations will be carried on by four field detachments. Two of these will work in Chota Nagpur, Orissa and the Agency Tracts, a third will traverse the Eastern Bengal and Assam-Bengal Railway systems, while the fourth will be employed in filling up gaps left in previous seasons.

The tabulations of the results obtained at Dehra Dun, Kodai Kanal and Barrackpore observatories are published up to the end of 1904.

The mean values of the magnetic elements at the observatories for 1904.

Name.	Latitude.	Longitude.	Declination.	Dip.	Horizontal Force.	REMARKS.
	° ′ ″	° ′ ″	° ′	° ′	C.G.S.	
Dehra Dun . .	3c 19 19	78 3 19	2 40·8E	43 18N	·33405	
Kodai Kanal . .	10 13 50	77 27 46	0 27·2W	3 11N	·37381	
Barrackpore . .	22 45 29	88 21 39	1 22·4E	30 20N	·37224	

Dehra Dun observatory.

20. This observatory remained in charge of observer Shri Dhar up to the 26th March, when he proceeded on six months' sick leave. The spare observer was placed in charge in addition to his duties of tabulating the base station records: there has consequently been no observer available to carry out special investigations which have had to be postponed. The Horizontal Force instrument has given good results throughout the year but the declination has required readjustment on two occasions.

The pillars for the V. F. instrument were erected in July and the instrument in August. Some experiments were carried out for the elimination of the temperature co-efficient, but the results were unsatisfactory, while the instrument itself has given considerable trouble and is not yet in working order. Further experiments will be carried out in the cold season when it is hoped the earth-inductor will be available.

The measures taken last year to prevent any further stoppage of the instruments by inundation have been successful; they were not however very severely tested owing to the rainfall being less than the normal. The only erious break in the records was due to the earthquake when the declination instrument was thrown out of adjustment for 14 days until the return of the officer in charge. The tabulated results for the year 1904 are appended.

Mean values of magnetic elements at Dehra Dun for 1904.

21. The mean values of the magnetic elements at Dehra Dun for the year 1904 as deduced from the selected quiet days are as follows:—

Declination	2°—40'·8E
Dip	43°—18'
Horizontal Component	33405 C. G. S.

The declination results.

22. The following table gives the mean magnetic collimation of magnet 17 throughout the year, and the mean value of the monthly base line of the declination magnetograph, showing the number of values used in deriving the accepted value. Columns 7 and 8 give the probable errors of the mean base line value and of individual values and are a test of the accuracy of the observations.

Monthly mean value of the declination constants of the Survey Standard and the base line values.

1904. Month.	Monthly mean magnetic collimation.	Mean value of base line for the month.	Total number of values of base line.	Number of values rejected.	Number of values from which the base lines are derived.	Probable error of mean values of base line.	Probable error of a single value of base line.	Remarks.
January	8'-24"	1°—37·98	9	0	9	±0·043	±0·13	
February	24	1—38·32	10	0	10	±0·035	±0·11	

Monthly mean value of the declination constants of the Survey Standard and the base line values.

1904. Month.	Monthly mean magnetic collimation.	Mean value of base line for the month.	Total number of values of base line.	Number of values rejected.	Number of values from which the base lines are derived.	Probable error of mean values of base line.	Probable error of a single value of base line.	REMARKS.
March	25	1—38·23	14	1	13	±0·029	±0·10	
April	25	1—38·18	10	0	10	±0·034	±0·11	
May	23	1—38·30	11	0	11	±0·040	±0·13	
June	25	1—38·44	8	0	8	±0·049	±0·14	
July	25	1—38·22	9	0	9	±0·059	±0·18	
August	26	1—38·26	9	1	8	±0·057	±0·14	From 15th July to 12th August.
September	21	1—38·18	28	1	27	±0·020	±0·10	
October	24	1—38·37	26	3	23	±0·024	±0·12	
November	24	1—38·54	4	0	4	±0·019	±0·04	Up to 5th.
		1—42·39	23	2	21	±0·030	±0·14	From 8th.
December	23	1—42·45	28	2	26	±0·024	±0·12	

REMARKS 1 The trace was lost from 13th August to the end of the month owing to Floods.
2 The base mirror of the declination magnetograph was readjusted on the 8th November.

In the following table the mean monthly declination derived from 5 selected quiet days is compared for corresponding months in 1903 and 1904.

The mean secular change obtained in this way is —0·8 minutes as compared with —1·6 minutes from 1902-3.

Mean monthly declinations at Dehra Dun.

Months.	Values of declination, 1903.	Values of declination, 1904.	Secular change.	REMARKS.
	° ′	° ′	′	
January	E. 2 42·6	E. 2 41·4	—1·2	
February	42·4	41·7	0·7	
March	42·2	41·4	0·8	
April	42·3	41·3	1·0	
May	41·3	41·2	0·1	
June	41·2	40·9	0.3	

Mean monthly declinations at Dehra Dun—contd.

Months.	Values of declination, 1903.	Values of declination, 1904.	Secular change.	REMARKS.
	° ′	° ′	′	
July . . .	E. 2 41·0	E. 2 40·3	—0.7	
August . . .	41·4	40·0	1.4	
September . .	40·0	40·4	+0.4	
October . . .	41·0	40·3	—0.7	
November . .	41·6	40·5	1·1	
December . .	41·7	40·2	1.5	
Mean .	2 41·6	2 40·8	—0·8	

23. The results of the dip observations taken throughout the year 1904 are appended in Table I on page 35.

The dip results.

The following table gives the monthly values of dip for 1903 and 1904 with the deduced secular change.

Monthly mean dips at Dehra Dun, 1904.

Months.	Values of dip, 1903.	Values of dip, 1904.	Secular change.	REMARKS.
	° ′	° ′	′	
January . . .	43 11·0	33 17·0	+6·0	
February . .	12·0	16·5	4·5	
March . . .	10·7	15·4	4·7	
April . . .	12·3	16·4	4·1	
May . . .	11·9	16·4	4·5	
June . . .	13·2	16·8	3·6	
July . . .	13·4	17·4	4·0	
August . . .	14·5	17·2	2·7	
September . .	15·0	17·6	2·6	
October . . .	15·8	19·0	3·2	
November . .	18·5	20·0	1·5	
December . .	18·0	19·9	1·9	
Mean .	43 13·9	43 17·5	+3·6	

24. The following table shows the mean monthly values of the constants of the Survey standard together with the mean monthly base lines of the H. F. magnetograph.

H. F. results.

Monthly mean value of H. F. constants of Survey standard and mean monthly base lines.

1904. Month.	Mean value of mo for the month.	Monthly mean value of P from 22·5 and 30 c. m. s.	Monthly mean value of P from 30 and 40 c. m. s.	Mean values of base line.	Total number of values of base line.	Number of values rejected.	Numbers of value from which the base lines are derived.	Probable error of mean values of base line.	Probable error of a single value of base line.	Remarks.
								γ	γ	
January	915·90	7·54	7·98	·33219	18	0	18	± 0·55	± 2·3	
February	·83	7·67	7·86	220	20	0	20	± 0·77	± 3·5	
March	·71	7·57	8·07	217	21	1	20	± 0·81	± 3·6	
April	·63	7·56	8·21	219	20	0	20	± 0·83	± 3·7	
M	·58	7·53	8·09	218	17	0	17	± 0·58	± 2·4	
June	·55	7·50	8·00	211	19	0	19	± 0·66	± 2·9	
July	·52	7·50	7·92	206	18	1	17	± 0·59	± 2·4	
August	·55	7·48	8·15	198	11	0	11	± 1·27	± 4·2	
September	·62	7·58	7·78	193	14	0	14	± 0·79	± 3·0	Up to 24th September.
October	·72	7·48	8·01	176	35	1	34	± 0·66	± 3·8	From 28th September.
November	·79	7·39	8·88	171	25	0	25	± 0·99	± 5·0	
December	·57	7·31	8·69	176	18	0	18	± 0·86	± 3·7	

A new mirror was fixed to the deflected magnet on 30th October 1904 from which date a change in P's occurred. There was a sudden fall in the base line value on the 28th September the reason for which is unknown.

The following are the monthly mean scale values and temperatures at the Dehra Dun observatory.

1904. Months.	Scale values of	Temperature of H. F. Magnetograph.	Remarks.
	′	° ′	
January	4·05 γ	24·9 C	The base line values are referred to a temperature of 25°C, the temperature co-efficient used being 1°C = —12·6 γ.
February	4·07 ,,	24·1 ,,	
March	4·08 ,,	24·0 ,,	
April	4·08 ,,	24·1 ,,	
May	4·07 ,,	24·7 ,,	
June	4·07 ,,	25·6 ,,	
July	4·06 ,,	25·8 ,,	
August	4·06 ,,	25·9 ,,	
September	4·05 ,,	25·8 ,,	
October	4·07 ,,	25·8 ,,	
November	4·07 ,,	25·7 ,,	
December	4·08 ,,	25·3 ,,	
Mean	4·07 ,,	25·1 ,,	

Table of monthly mean horizontal intensities at Dehra Dun.

Months.	Values of H. F. 1903.	Values of H. F. 1904.	Secular change.	Remarks.
	′	′	′	
January . . .	·33449	·33405	—44 γ	
February . .	451	410	41 „	
March . . .	447	416	31 „	
April . . .	442	411	31 „	
May . . .	443	414	29 „	
June . . .	443	409	34 „	
July . . .	434	407	27 „	
August . . .	429	407	22 „	
September . .	424	399	25 „	
October . . .	413	397	16 „	
November . .	389	389	0 „	
December . .	398	394	4 „	
Mean .	·33430	·33405	—25 „	

TABLE I.

Observations of Dip.

1 Date.	2 L. M. T.		3 Needle No.	4 Dip.		5 Monthly mean dip with each needle.	6 Monthly mean dipw ith both.	7 Difference between 1-2.	8 Remarks.
1904.	h.	m.		°	′	° ′	° ′		
January 4	13	1	1	43	18·0				
			2		15·8	Needle 1			
7	13	21	1		14·6	43 17·2			
			2		16·1				
11	12	57	1		17·9				
			2		18·0	..	43 17·0	+0·5	
14	13	45	1		17·9				
			2		18·9				
18	12	25	1		17·4				
			2		15·2				
21	13	13	1		17·9				
			2		17·4	Needle 2			
25	14	1	1		16·9	43 16·7			
			2		15·3				
28	12	14	1		16·9				
			2		17·1				
February 1	13	24	1		18·3				
			2		17·8	Needle 1			
4	12	28	1		17·5	43 17·0			
			2		15·6				
8	13	37	1	43	16·5	Needle 1			
			2		17·4	43 17·0			
11	12	47	1		17·6				
			2		15·7	...	43 16·5	+1·0	
15	12	40	1		17·5				
			2		16·4				
18	13	23	1		17·4				
			2		17·2				
22	14	41	1		17·7	Needle 2			
			2		16·4	43 16·0			
25	13	6	1		15·2				
			2		14·0				
29	12	4	1		15·2				
			2		13·2				
March 3	12	36	1		15·1	Needle 1			
			2		14·8	43 15·6			
7	12	11	1		17·9				
			2		17·5	...	43 15·4	+0·5	
14	13	26	1		15·3				
			2		14·0				
17	12	32	1		16·6	Needle 2			

TABLE I—*contd.*

Observations of dip.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between. 1-2	REMARKS.
1904. March.	h. m.		° ′	° ′	° ′		
21	13 30	2	15·0	43 15·1			
		1	15·2				
24	13 30	2	15·2				
	14 6	1	15·0				
27	11 59	1	15·6				
		2	14·5				
28	13 23	1	15·0				
		2	14·1				
29	15 8	2	16·1				
		1	16·8				
30	12 11	1	13·2				
		2	14·8				
31	11 46	1	15·5				
		2	15·3				
April 1	15 22	1	22·1				
		2	21·2	Needle 1			
2	12 25	1	17·4	43 16·7			
		2	17·0				
4	13 42	1	15·6				
		2	16·9				
7	12 31	1	18·0				
		2	16·8				
11	13 46	1	18·1				
		2	17·1				
14	12 47	1	16·0	...	43 16·4	+0·7	
		2	16·2				
18	12 19	1	17·0				
		2	14·5				
21	13 31	1	16·4				
		2	15·2				
25	12 24	1	13·1				
		2	12·9				
28	12 47	1	15·3	Needle 2			
		2	15·2	43 16·0			
	14 6	1	15·9				
		2	14·6				
29	11 55	1	16·5				
		2	14·8				
30	12 58	1	43 15·1				
		2	15·6				
May 1	11 53	1	15·2				
		2	15·3				
	12 57	2	15·9				
	13 5	1	16·9				
2	13 41	1	18·5				
		2	17·4				
5	12 50	1	16·6	Needle 1			
		2	14·3	43 16·6			
	14 3	1	16·4				
		2	14·5				
9	13 25	1	17·2				
		2	14·7				
	14 37	1	18·0				
		2	17·5				
11	10 48	1	13·3	...	43 16·4	+0·5	
		2	14·2				
12	12 41	1	16·9				

TABLE I—*contd.*

Observations of Dip.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between 1-2.	REMARKS.
1904. May.	h. m.		° ′	° ′	° ′		
		2	15·8				
14	11 15	1	20·7				
		2	20·3				
16	12 42	1	15·4				
		2	16·2				
	13 44	1	14·6	Needle 2			
		2	15·9	43 16·1			
17	12 12	1	15·1				
		2	14·1				
18	15 47	1	16·9				
		2	17·5				
19	12 28	1	16·4				
		2	15·4				
	13 24	1	15·7				
		2	16·7				
20	12 35	1	17·7				
		2	17·4				
21	11 39	1	15·9				
		2	15·7				
	12 25	1	17·1				
		2	15·1				
22	11 8	1	17·5				
		2	17·0				
	11 56	1	18·1				
		2	16·1				
23	12 32	1	15·4				
		2	16·2				
26	12 34	1	15·9				
		2	16·3				
30	13 26	1	17·4				
		2	17·1				
June 2	13 22	1	43 18·7				
		2	18·9	Needle 1			
6	12 12	1	14·0	43 17·2			
		2	12·7				
9	12 25	1	17·5				
		2	17·2				
13	13 29	1	17·1				
		2	15·1	...	43 16·8	+0·8	
20	12 25	1	43 16·5				
		2	16·3				
23	12 12	1	17·4				
		2	17·2				
27	14 1	1	18·4	Needle 2			
		2	18·3	43 16·4			
30	13 32	1	17·8				
		2	15·8				
July 4	12 21	1	18·6				
		2	16·2				
7	12 43	1	19·8	Needle 1			
		2	17·9	43 17·9			
11	12 37	1	18·3				
		2	18·0				
18	13 47	1	18·3				
		2	16·2	...	43 17·4	+1·1	
21	13 27	1	18·1				
		2	15·3				
25	13 31	1	17·1				

TABLE I—*contd.*

Observations of Dip.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between 1-2.	REMARKS.
1904.	h. m.		° ′	° ′	° ′		
July.		2	17·5				
28	10 57	1	17·8	Needle 2			
		2	17·1	43 16·8			
30	13 22	1	15·0				
		2	15·6				
August 1	12 7	1	15·4				
		2	16·4				
4	12 24	1	17·1				
		2	16·3				
8	11 54	1	17·0				
		2	16·6				
11	12 22	1	18·4				
		2	16·6				
15	13 29	1	16·8				
		2	17·6				
18	13 39	2	17·6	Needle 1			
		1	17·2	43 17·3			
22	12 50	1	18·5	...	43 17·2	+0·2	
		2	18·5				
25	12 21	1	18·7	Needle 2			
		2	18·9	43 17·1			
29	13 29	1	16·4				
		2	15·6				
September 1	13 14	1	18·4				
		2	17·1				
5	13 31	1	16·4	Needle 1			
		2	14·7	43 17·8			
8	13 48	1	18·1				
		2	19·1				
12	13 25	1	18·6				
	13 56	2	17·2				
15	13 38	1	15·9	...	43 17·6	+0·3	
		2	17·2				
19	13 50	1	17·7				
		2	18·2				
22	13 43	1	16·2				
		2	16·2	Needle 2			
26	13 28	1	19·6	43 17·3			
		2	19·0				
29	13 27	1	43 19·6				
		2	17·3				
October 3	13 48	1	18·1	Needle 1			
		2	17·1	43 19·4			
10	13 51	1	20·5				
		2	18·3				
13	13 28	1	20·0				
		2	18·7				
17	13 41	1	19·2				
		2	16·8				
20	13 28	1	16·4				
		2	17·2				
24	12 24	1	18·7				
		2	18·1				
27	14 26	1	19·1				
		2	18·8	...	43 19·0	+0·9	
	15 33	1	19·4				
		2	19·7				
28	14 28	1	20·2				
		2	19·0				

TABLE I—*concld.*

Observations of Dip—concld.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between 1-2.	REMARKS.
1904.	h. m.		° ′	° ′	° ′		
October.	15 27	1	20·8				
		2	19·3				
29	10 50	1	18·8				
		2	17·5				
	11 50	1	20·2				
		2	18·7				
	14 15	1	18·6				
		2	18·2				
	15 11	1	18·4				
		2	18·2				
	15 43	1	18·7	Needle 2			
		2	19·4	43 18·5			
30	9 37	1	19·6				
		2	18·5				
31	15 11	1	21·3				
		2	19·7				
31	16 34	1	20·7				
		2	20·5				
November 1	14 36	1	19·4	Needle 1			
		2	18·4	43 20·5			
	15 37	1	20·5				
		2	19·3				
2	14 29	1	20·9				
		2	19·8				
	15 23	1	21·8				
		2	20·6				
3	14 44	1	20·1				
		2	18·8				
	15 39	1	20·0	...	43 20·0	+1·1	
		2	20·7				
7	14 6	1	20·5				
		2	19·9				
10	13 31	1	20·5				
		2	18·8				
14	13 34	1	19·5				
		2	18·2				
21	13 45	1	21·4				
		2	19·9	Needle 1			
				43 19·6			
24	13 17	1	19·8	43 19·4			
		2	18·4				
28	13 13	1	21·3				
		2	19·9				
December 1	13 26	2	19·6				
		1	21·2	Needle 1			
5	13 52	1	21·2	43 20·3			
		2	20·8				
8	13 1	1	19·2				
		2	19·6				
12	13 28	1	19·6				
		2	18·7				
15	12 26	1	21·5	...	43 19·9	+0·9	
		2	19·6				
19	13 10	1	17·4				
		2	18·0				
22	13 37	1	21·0				
		2	18·5				
26	12 18	1	20·8				
		2	19·5	Needle 2			
29	12 27	1	21·1	43 19·4			
		2	20·6				

TABLE II.

Hourly means of Declination as determined at Dehra Dun from the selected quiet days in 1904.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Means.
E 2°+1													Winter.												
1904. Months.																									
January	41·5	41·5	41·5	41·4	41·3	41·3	41·2	41·4	42·3	**42·6**	42·1	40·9	**4·04**	40·5	40·8	41·3	41·7	41·7	41·4	41·3	41·5	41·5	41·4	41·4	41·4
February	41·7	41·5	41·6	41·5	41·5	41·2	41·2	41·5	42·2	**43·1**	42·9	42·0	41·1	**41·0**	41·2	41·7	42·0	41·7	41·5	41·7	41·7	41·7	41·8	41·6	41·7
March	41·2	41·2	41·2	41·2	41·1	41·2	41·2	42·1	43·2	**44·0**	43·5	42·1	40·8	**39·8**	39·8	40·5	41·1	41·4	41·2	41·1	41·1	41·2	41·2	41·3	41·4
October	40·5	40·5	40·5	40·4	40·4	40·5	40·6	41·2	42·0	**42·1**	41·1	39·7	38·5	**38·4**	39·2	40·1	40·6	40·4	40·1	40·0	40·1	40·1	40·2	40·3	40·3
November	40·7	40·6	40·6	40·5	40·3	40·3	40·3	40·5	41·0	**41·4**	41·1	40·3	**40·1**	40·3	40·7	40·8	40·6	40·2	40·2	40·2	40·2	40·2	40·3	40·4	40·5
December	40·3	40·3	40·3	40·1	40·1	40·0	39·9	39·8	40·1	**40·6**	40·6	39·8	**39·5**	40·0	40·5	40·8	40·7	40·3	40·3	40·3	40·3	40·3	40·3	40·2	40·2
Means	41·0	40·9	41·0	40·9	40·8	40·8	40·7	41·1	41·8	**42·3**	41·9	40·8	40·1	**40·0**	40·4	40·9	41·1	41·0	40·8	40·8	40·8	40·8	40·9	40·9	40·9
													Summer.												
April	41·3	41·5	41·5	41·4	41·2	41·2	42·2	43·6	**44·7**	44·3	42·7	40·6	39·3	**38·7**	38·7	39·6	40·3	41·0	41·3	41·0	40·9	41·0	41·2	41·3	41·3
May	41·3	41·7	41·6	41·5	41·5	41·5	42·8	43·8	**44·3**	43·6	42·0	40·0	38·7	**38·3**	38·6	39·4	40·3	40·9	41·1	41·0	40·8	40·9	41·0	41·1	41·2
June	41·3	41·3	41·4	41·3	41·3	41·5	42·8	44·0	**44·3**	43·4	41·9	39·9	38·4	**37·6**	37·8	38·4	39·5	40·5	41·1	40·8	40·6	40·7	40·8	41·0	40·9
July	40·3	40·4	40·3	40·4	40·5	40·9	42·1	43·1	**43·2**	42·7	42·0	39·6	37·9	37·2	**37·0**	37·9	38·9	40·1	40·6	40·4	40·1	40·2	40·3	40·4	40·3
August	39·8	40·0	40·2	40·1	40·3	40·6	41·8	42·8	**42·8**	41·6	39·9	38·3	**37·4**	37·5	38·1	39·2	40·2	40·8	40·6	39·8	39·7	39·8	39·9	39·9	40·0
September	40·6	40·8	40·8	40·7	40·9	41·0	41·7	42·8	**43·2**	42·2	40·2	38·6	**37·7**	37·7	38·5	39·7	40·4	40·7	40·3	40·2	40·4	40·5	40·5	40·5	40·4
Means	40·8	41·0	41·0	40·9	41·0	41·1	42·2	43·4	**43·8**	43·0	41·5	39·4	38·2	**37·8**	38·1	39·0	39·9	40·7	40·8	40·5	40·4	40·5	40·6	40·7	40·7

When the sign is + the magnet points to the East and when—to the West of the Mean position.

TABLE III.

Diurnal inequality of the Declination at Dehra Dun as deduced from Table II.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11
Winter.																								
Months.																								
January	+0·1	+0·1	+0·1	0	−0·1	−0·1	−0·2	0	+0·9	+1·2	+0·7	−0·5	−1·0	−0·9	+0·6	−0·1	+0·3	+0·3	0	−0·1	+0·1	+0·1	+0	0
February	0	−0·2	−0·1	−0·2	−0·2	−0·5	−0·5	−0·2	+0·5	+1·4	+1·2	+0·3	−0·6	−0·7	−0·5	0	+0·3	0	−0·2	0	0	0	+0·1	−0·1
March	−0·2	−0·2	−0·2	−0·2	−0·3	−0·2	−0·2	+0·7	+1·8	+2·6	+2·1	+0·7	−0·6	−1·6	−1·6	−0·9	−0·3	0	−0·2	−0·3	−0·3	−0·2	−0·2	−0·1
October	+0·2	+0·2	+0·2	+0·1	+0·1	+0·2	+0·3	+0·9	+1·7	+1·8	+0·8	−0·6	−1·8	−1·9	−1·1	−0·2	+0·3	+0·1	−0·2	−0·3	−0·2	−0·2	−0·1	0
November	+0·2	+0·1	+0·1	0	−0·2	−0·2	−0·2	0	+0·5	+0·9	+0·6	−0·2	−0·4	−0·2	+0·2	+0·3	+0·1	−0·3	−0·3	−0·3	−0·3	−0·3	−0·2	−0·1
December	+0·1	+0·1	+0·1	−0·1	−0·1	−0·2	−0·3	−0·4	−0·1	+0·4	+0·4	−0·4	−0·7	−0·2	+0·3	+0·6	+0·5	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	0
Means	+0·1	0	+0·1	0	−0·1	−0·1	−0·2	+0·2	+0·9	+1·4	+1·0	−0·1	−0·8	−0·9	−0·5	0	+0·2	+0·1	−0·1	−0·1	−0·1	−0·1	0	0
Summer.																								
April	0	+0·2	+0·2	+0·1	−0·1	−0·1	+0·9	+2·3	+3·4	+3·0	+1·4	−0·7	+2·0	−2·6	−2·6	−1·7	−1·0	−0·3	0	−0·3	−0·4	−0·3	−0·1	0
May	+0·1	+0·5	+0·4	+0·3	+0·3	+0·3	+1·6	+2·6	+3·1	+2·4	+0·8	−1·2	−2·5	−2·9	−2·6	−1·8	−0·9	−0·3	+0·1	−0·2	−0·4	−0·3	−0·2	−0·1
June	+0·4	+0·4	+0·5	+0·4	+0·4	+0·6	+1·9	+3·1	+3·4	+2·5	+1·0	−1·0	−2·5	−3·3	−3·1	−2·5	−1·4	−0·4	+0·2	−0·1	−0·3	−0·2	−0·1	+0·1
July	0	+0·1	0	+0·1	+0·2	+0·6	+1·8	+2·8	+2·9	+2·4	+1·7	−0·7	−2·4	−3·1	−3·3	−2·4	−1·4	−0·2	+0·3	+0·1	−0·2	−0·1	0	+0·1
August	−0·2	0	+0·2	+0·1	+0·3	+0·6	+1·8	+2·8	+2·8	+1·6	−0·1	1·7	−2·6	−2·5	−1·9	−0·8	+0·2	+0·8	+0·6	−0·2	−0·3	−0·2	−0·1	−0·1
September	+0·2	+0·4	+0·4	+0·3	+0·5	+0·6	+1·3	+2·4	+2·8	+1·8	−0·2	−1·8	−2·7	−2·7	−1·9	−0·7	0	+0·3	−0·1	−0·2	0	+0·1	+0·1	+0·1
Means	+0·1	+0·3	+0·3	+0·2	+0·3	+0·4	+1·5	+2·7	+3·1	+2·3	+0·8	−1·2	−2·5	−2·9	−2·6	−1·7	−0·8	0	+0·1	−0·2	−0·3	−0·2	−0·1	0

When the sign is + the magnet points to the East and when — to the West of the Mean position.

TABLE V.

Diurnal inequality of Horizontal Force at Dehra Dun as deduced from Table V.

Hours.	Mid.		2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11
												Winter.												
1904. Months.	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	−2	−3	−2	−1	−1	0	+1	+1	−1	−9	−12	−6	+2	+6	+7	+3	+1	−2	+1	+3	+1	+1	+1	+1
February	−1	0	−2	−2	−2	−1	0	+1	+3	+3	+5	+6	+8	+7	+6	0	−2	−2	−3	−5	−6	−5	−6	−1
March	−5	−6	−6	−6	−4	−3	−2	−3	−2	+3	+9	+15	+16	+16	+12	+6	0	−3	−5	5	−7	−6	−5	−6
October	−1	−2	−1	0	+1	+2	+1	−3	−7	−9	−4	+3	+10	+12	+10	+7	+1	−7	−5	−5	−6	−5	−1	−1
November	−3	−1	−4	−4	−4	−4	−3	0	+4	+10	+11	+15	+16	+8	+1	−5	−8	−7	−5	−4	−4	−4	−2	+1
December	−5	−4	−3	−5	−3	−3	−2	+1	+7	+10	+9	+9	+8	+7	+3	−2	−6	−4	−3	−3	−6	−8	−5	−3
Mean	−3	−3	−3	−3	−2	−2	−1	−1	+1	+1	+3	+7	+10	+9	+6	+1	−2	−4	−3	−3	−5	−5	−3	−2
												Summer.												
April	−7	−8	−9	−10	−7	−6	−5	−5	−8	−1	+7	+16	+23	+24	+16	+10	+4	−2	−4	−4	−3	−3	−4	−6
May	−7	−8	−7	−8	−6	−6	−5	−6	−6	−5	+1	+12	+19	+20	+19	+13	+7	+3	−2	−6	−7	−7	−6	−6
June	−6	−5	−5	−4	−4	−2	−1	−2	−4	−3	+1	+6	+11	+14	+13	+9	+4	−2	−5	−4	−3	−2	0	0
July	−3	−3	−3	−4	−3	−3	0	−1	−3	−3	+1	+2	+7	+10	+12	+11	+9	+1	−2	−4	−2	−2	−1	−2
August	−4	−5	−5	−5	−5	−6	−3	−5	8	−8	−8	+1	+14	+22	+22	+17	+7	−1	−4	−5	−5	−3	−3	−1
September	−2	0	−1	−1	−0	−1	0	−7	−13	15	−7	0	+8	+13	+13	+8	+4	−1	0	0	−2	−3	−2	−1
Mean	−5	−5	−5	−5	−4	−4	2	−5	−7	−6	−1	+6	+14	+17	+16	+11	+6	0	−3	−4	−4	−3	−3	−3

When the sign is + the magnet points to the East and when—to the West of the Mean position.

TABLE V.

Hourly means of the Horizontal Force in C.G.S. units (corrected for temperature) at Dera Dun from the selected quiet days in 1904.

0·33000 C.G.S.+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mean.
Winter.																									
Months.	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	403	402	403	404	404	405	406	406	404	396	**393**	399	407	411	**412**	408	406	403	406	408	406	406	**406**	406	405
February	409	410	408	408	408	409	410	411	413	413	415	416	**418**	417	416	410	408	408	407	405	**404**	405	404	409	410
March	411	410	410	410	412	413	414	413	414	419	425	431	**432**	432	428	422	416	413	411	411	**409**	410	411	410	416
October	396	395	396	397	398	399	398	394	390	**388**	393	400	407	**409**	407	404	398	390	392	392	391	392	396	396	397
November	386	388	385	385	385	385	386	389	393	399	400	404	05	397	390	384	381	382	384	385	385	385	387	390	389
December	389	390	391	389	391	391	392	395	401	**404**	403	403	402	401	397	392	388	390	391	391	388	**386**	389	391	394
Mean	399	399	399	399	400	400	401	401	403	403	405	409	**412**	411	408	403	400	398	399	399	**397**	397	399	400	402
Summer.																									
April	404	403	402	**401**	404	405	406	405	403	410	418	427	434	**435**	427	421	415	409	407	407	408	408	407	405	411
May	407	**406**	407	406	408	408	409	408	408	409	415	426	433	**434**	433	427	421	417	412	408	407	407	408	408	414
June	**403**	404	404	405	405	407	408	407	405	406	410	415	420	**423**	422	418	413	407	404	405	406	407	409	409	409
July	404	404	404	**403**	404	404	407	406	404	404	408	409	414	417	**419**	418	416	408	405	403	405	405	406	405	407
August	403	402	402	402	402	401	404	402	**399**	399	399	408	421	**429**	429	424	414	406	403	402	402	404	404	406	407
September	397	399	398	398	399	398	399	392	386	**384**	392	399	407	**412**	412	407	403	398	399	399	397	396	397	398	399
Mean	403	403	403	403	404	404	406	403	**401**	402	407	414	422	**425**	424	419	414	408	405	404	404	405	405	405	408

When the sign is + the force is greater than the monthly mean and when — less.

The Statement of loss of Magnetograph records at Dehra Dun during the year 1904.

H. F.					Declination.					Remarks.
From	On	To	On	Period of break.	From	On	To	On	Period of break.	
h. m.		h. m.		h. m.	h. m.		h. m.		h. m.	
					8 0	11th July	11 0	11th July	3 0	Film spoilt.
7 40	13th Aug.	10 8	19th Aug.	146 28	7 40	13th Aug.	12 25	21st Aug.	196 45	Work stopped by floods.
7 36	22nd Aug.	14 4	2nd Sept.	246 28	7 36	22nd Aug.	14 4	2nd Sept.	245 28	Work stopped by floods.
					15 0	8th Sept.	18 0	8th "	3 0	Drum ceased to revolve.
Total ...	...	...	...	392 56	...	...	...	...	396 13	

Dates of Magnetic disturbances at Dehra Dun in 1904.

	°	′	″
Lat. of Observatory	30	19	19
Long.	78	3	19

1904.	Months.											
Dates.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	S	S	C	M	C	C	S	C	—	S	C	S
2	S	S	C	S	C	C	C	M	—	S	M	(C)
3	S	(C)	C	C	C	(C)	C	G	(C)	C	S	S
4	C	C	S	C	(C)	C	(C)	M	S	C	S	S
5	C	S	C	(C)	C	S	C	C	S	C	M	S
6	S	S	(C)	C	C	M	S	C	S	(C)	C	C
7	(C)	S	C	S	(C)	S	S	(C)	S	M	(C)	C
8 . . .	C	S	C	C	S	(C)	C	(C)	S	M	C	(C)
9	C	S	(C)	(C)	C	C	(C)	C	S	S	C	S
10	S	(C)		S	C	C	C	S	(C)	C	(C)	C
11	S	C		S	C	S	C	C	S	(C)	C	C
12	(C)	C	S	S	M	C	C	(C)	S	C	C	C
13	C	S	C	C	M	(C)	S	—	C	S	C	(C)
14 . . .	(C)	(C)	C	(C)	S	C	S	—	(C)	S	C	S
15	S	S	C	S	S	S	S	—	S	S	(C)	S
16	S	S	(C)	C	(C)	M	C	—	S	(C)	S	S
17	C	S	C	C	S	C	C	—	C	C	S	S
18	C	(C)	C	S	S	S	(C)	—	C	C	S	C
19	(C)	C	C	S	S	C	C	—	C	(C)	C	S
20	C	C	S	C	C	C	S	(S)	(C)	C	(C)	C
21	C	C	C	C	C	C	(C)	S	C	M	C	C
22	S	C	(C)	(C)	(C)	(C)	C	—	S	S	S	C
23 . . .	C	C	C	C	C	C	C	—	C	S	C	C
24	S	S	(C)	C	S	C	C	—	C	(C)	(C)	(C)
25	S	S	C	C	C	C	C	—	M	S	M	C
26	C	S	S	C	(C)	S	(C)	—	C	S	S	C
27	(C)	(C)	C	(C)	S	S	S	—	C	S	C	C
28	M	C	C	C	S	S	S	—	(C)	S	C	(C)
29	S	C	C	S	S	(C)	C	—	C	S	C	S
30	S	—	C	C	C	C	C	—	S	C	S	C
31	S	—	C	—	C	—	S	—	—	S	S	C
C	16	15	26	20	19	20	21	8	15	14	19	20
S	14	14	5	9	10	8	10	3	12	14	9	11
M	1	...	...	1	2	2	...	2	1	3	3	...
G	...	...	...	..	..	...	...	1	...	...	..	...
V. G . . .	...	...	...	...	...	...	...	...	...	...	...	...

The magnitudes of disturbances are taken from the H. F. traces. ( )= selected quiet-day. C=calm, S=small, M=moderate, G=great, V. G.=very great.—trace lost.

KODAI KANAL MAGNETIC OBSERVATORY.

General Remarks.

25. The observer appointed in April 1904 resigned his appointment in April 1905, but fortunately through the good offices of the Director, Solar Physics Observatory, a suitable candidate was obtained locally. At the time of writing, however, this observer has given notice of his intention to resign the appointment on the ground of ill-health, and a substitute is now under training at Kodaikanal. The failure to secure a permanent incumbent for this post can only be ascribed to the terms offered not being sufficiently attractive, the post being merely looked upon as a stepping-stone to more lucrative employment elsewhere.

The H. F. instrument continued to give good results throughout the year; the declination instrument, however, again showed signs of interference, and was taken to pieces early in January 1905 and thoroughly cleaned, since when the base line values have been satisfactory. The tabulated results for 1904 are now published, the form of tabulation being the same as for Dehra Dun and Barrackpore. Thanks are due to the Director for his cordial assistance in all matters pertaining to the magnetic work.

Mean values of the magnetic elements at Kodaikanal for 1904.

	°	′
Declination	0	27·2 W.
Dip	3	11 N.
H. F.		·37381 C. G. S.

The declination results.

26. The following table gives the mean monthly magnetic collimation of magnet No. 16 and the mean monthly base line values of the declination magnetograph.

Owing to the interference due to fungoidal growths it has been found necessary to in some instances adopt several base line values for different portions of a month, so that the results cannot be regarded as entirely satisfactory. As soon as the cause was diagnosed, the observer was instructed to give the magnet an artificial deflection at two and later three fixed times during the day, while at the end of May the instrument was opened up. From the 28th May to the 5th July the behaviour was normal, when signs of interference again became manifest. On the 3rd of September the artificial deflections were again resorted to when the base line value returned to the June value. Thence to the end of the year the deflections were continued and these later values are fairly satisfactory. At the end of December, as before noted, the instrument was taken down, all the parts thoroughly cleansed with perchloride of mercury and re-erected, since when the instrument has behaved satisfactorily.

Monthly mean values of Declination and secular change.

Months.	Declination, 1903.	Declination, 1904.	Secular change.	REMARKS.
		° ′		
January	...	W 0 25·1	...	
February	...	25·6	...	
March	...	25·2	...	
April	...	26·0	...	
May	...	26·6	...	

Monthly mean values of Declination and secular change—contd.

Months.	Declination, 1903.	Declination, 1904.	Secular change.	REMARKS.
	° ′	° ′	′	
June	...	26·9	...	
July	...	27·5	...	
August	W 0 22·4	28·0	W 5·6	
September	23·0	28·6	5·6	
October	23·5	28·7	5·2	
November	23·6	29·2	5·6	
December	24·4	29·5	5·1	
Mean .	0 23·4	0 28·8	5·4	Means for the last 5 months.

Kodai Kanal Declination constants.

1904. Months.	Monthly mean of magnetic collimation.	Mean value of base line for the month.	Total number of values of base line.	Number of values rejected.	Number of values from which the base lines are derived.	Probable error of mean values of base line.	Probable error of single value of base line.	REMARKS.
	′ ″	° ′						
January .	2 11	1 40·77	5	0	5	±0·038	±0·08	From 25th December 1903 to 8th.
„ .	...	42·19	8	1	7	±0·058	±0·16	From 12th.
February .	17	41·87	6	1	5	±0·064	±0·14	Up to 16th.
„ .	...	41·08	6	1	5	±0·079	±0·18	From 19th.
March* .	14	41·36	17	3	14	±0·043	±0·16	Up to 12th April.
April . .	10	39·74	16	2	14	±0·041	±0·15	From 15th April.
May . .	7	39·90	17	2	15	±0·033	±0·13	Up to 19th.
„ . .	...	27·37	8	0	8	±0·036	±0·10	From 24th. Instrument opened and cleaned.
June . .	9	27·33	30	2	28	±0·026	±0·14	
July . .	8	27·41	4	0	4	±0·058	±0·12	Up to 5th.
„ . .	...	28·63	15	3	12	±0·043	±0·15	From 6th to 22nd.
„ . .	...	30·19	6	1	5	±0·077	±0·17	From 26th.
August . .	8	29·99	5	1	4	±0·071	±0·14	Up to 9th.
„ . .	...	30·65	5	0	5	±0·024	±0·05	From 12th to 19th.
„ . .	...	31·35	7	2	5	±0·083	±0·18	From 23rd to 26th.
„ . .	...	35·93	6	0	6	±0·069	±0·17	From 29th August to 2nd Sept.
September .	10	27·34	26	3	23	±0·030	±0·14	From 3rd.
October .	9	27·05	29	7	22	±0·023	±0·11	
November .	12	27·41	18	2	16	±0·034	±0·14	Up to 18th.
„ .	...	28·39	11	2	9	±0·046	±0·14	From 19th.
December .	14	27·98	7	0	7	±0·034	±0·09	Up to 8th.
„ .	...	27·34	18	5	13	±0·031	±0·11	From 9th.

The dip results.

27. The observations of dip are published for 1904. The follow ng table shows the mean monthly values of dip and the secular change thereby deduced from the years 1903-04:—

Monthy mean values of dip.

Months.	Values of dip, 1903.	Values of dip, 1904.	Secular change.	Remarks.
	° ′	° ′	′	
January	3 3·4	3 8·4	+5·0	
February	3·5	9·4	5·9	
March	2·5	9·3	6·8	
April	3·5	9·6	6·1	
May	3·5	10·4	6·9	
June	4·1	11·5	7·4	
July	6·6	12·2	5·6	
August	5·8	12·7	6·9	
September	7·2	11·9	4·7	
October	6·9	11·6	4·7	
November	7·9	12·5	4·6	
December	8·6	13·2	4·6	
Mean	3 5·3	3 11·1	+5·8	

The force results.

28. The following table shows the monthly mean values of M_o, P's and H. F. magnetograph base line:—

H. F. constants of No. 16 magnet and monthly mean values of H. F. magnetograph.

1904 Month.	Mean value of Mo for the month.	Monthly mean value of P from 22·5 and 30 c m s.	Monthly mean value of P from 30 and 40 c m s.	Mean values of base line.	Total number of values of base line.	Number of values rejected.	Number of values from which the base lines are derived.	Probable error of mean values of base line.	Probable error of single value of base line.	Remarks.
January	926·58	6·92	8·60	·37023	18	0	18	±1·00 γ	±4·3 γ	
February	·32	6·89	8·60	07	20	3	17	±1·06 "	±4·5 "	
March	·29	6·85	9·13	01	17	1	16	±1·60 "	±6·4 "	
April	·35	6·69	9·06	09	26	2	24	±0·99 "	±4·9 "	
May	·23	6·85	8·94	10	10	0	10	±1·33 "	±4·2 "	Up to 18th.
	...	...	...	08	5	0	5	±1·95 "	±4·8 "	From 25th.
June	·23	6·83	8·61	11	30	1	29	±0·90 "	±4·8 "	
July	·25	6·80	8·75	14	16	0	16	±1·11 "	±4·5 "	
August	·33	6·89	9·10	15	19	0	19	±1·05 "	±4·6 "	
September	·23	6·89	8·71	05	20	0	20	±1·09 "	±4·9 "	The base line values are referred to a temperature of 19°C temperature coefficient for 1° C= —12·6 γ.
October	·33	6·79	8·84	11	21	1	20	±0·99 "	±4·4 "	
November	·20	7·00	8·98	11	23	1	22	±0·96	±4·5 "	
December	·24	7·11	9·00	14	25	0	25	±0·79	±3·9 "	

KODAI KANAL.

Monthly mean scale values and temperatures.

1904 Months.	Scale values.	Temperature of H. F. magnetograph.	REMARKS.
	′	°	
January	6·12 γ	19·3 C	
February	6·15 „	18·9 „	
March	6·16 „	19·0 „	
April	6·15 „	18·9 „	
May	6·14 „	19·0 „	
June	6·13 „	19·2 „	
July	6·14 „	19·1 „	
August	6·15 „	19·1 „	
September	6·14 „	19·1 „	
October	6·15 „	19·1 „	
November	6·13 „	19·1 „	
December	6·14 „	19·0 „	
Mean	6·14	19·1	

Monthly mean values of H. F. and secular change.

Months.	H. F. 1903.	H. F. 1904.	Secular change.	REMARKS.
January	·37378	·37368	− 10 γ	
February	78	65	− 13 „	
March	83	70	− 13 „	
April	71	73	+ 2 „	
May	70	69	− 1 „	
June	63	76	+ 13 „	
July	62	85	+ 23 „	
August	69	98	+ 29 „	
September	68	82	+ 14 „	
October	66	91	+ 25 „	
November	42	91	+ 49 „	
December	52	·37403	+ 51 „	
Mean	·37367	·37381	+ 14 „	

TABLE I.

Observations of dip.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between 2–3C.	REMARKS.
1904	h. m.		° ′	° ′			
January 4	13 48	2	3 10·3				
		3C	9·9	Needle 2			
7	13 37	2	8·8	3 8·5			
		3C	9·5				
11	13 49	2	8·8				
		3C	8·7				
14	13 38	2	6·3		3 8·4	+0·2	
		3C	6·7				
18	13 38	2	9·2				
		3C	8·3				
21	13 37	2	10·5				
		3C	9·4	Needle 3C			
25	13 47	2	7·4	3 8·3			
		3C	7·8				
28	13 41	2	6·5				
		3C	6·3				
February 1	15 43	2	6·9				
		3C	7·8				
2	14 49	2	9·1	Needle 2			
		3C	9·0	3 9·1			
5	16 47	2	8·0				
		3C	9·9				
18	13 36	2	8·6				
		3C	9·6		3 9·4	—0·5	
22	11 4	2	10·3				
		3C	10·4				
	13 50	3C	10·9				
		2	10·5	Needle 3C			
25	13 50	2	9·6	3 9·6			
		3C	9·3				
26	13 59	2	9·0				
		3C	9·7				
29	13 37	2	9·4				
		3C	10·1				
March 3	13 34	2	9·9				
		3C	9·7				
7	13 24	2	10·4	Needle 2			
		3C	10·8	3 9·5			
10	13 18	2	8·2				
		3C	8·0				
14	13 5	2	6·9				
		3C	7·6		3 9·3	+0·5	
17	13 10	2	8·6				
		3C	8·0				
21	12 59	2	7·7				
		3C	6·7	Needle 3C			
24	13 30	2	11·7	3 9·0			
		3C	10·0				
	14 28	2	10·9				
28	13 28	2	10·3				
		3C	11·1				
31	13 35	2	10·7				
		3C	9·1				

TABLE I—*contd.*

Observations of dip—contd.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between 2–3C.	REMARKS.
1904	h. m.		° ′	° ′			
April 7	9 5	2	10·2				
		3C	7·7	Needle			
	12 41	2	8·2	3 10·3			
		3C	8·1				
11	13 50	2	13·9				
		3C	11·2				
14	12 36	2	11·1		3 9·6	+1·4	
		3C	8·8				
18	12 28	2	11·2				
		3C	9·1				
21	12 26	2	9·6	Needle 3C			
		3C	8·6	3 8·9			
25	13 26	2	10·2				
		3C	9·9				
28	12 24	2	9·1				
		3C	7·9				
May 2	13 28	2	8·3				
		3C	7·6				
5	13 35	2	9·9				
		3C	8·6				
9	12 27	2	10·8	Needle 2			
		3C	11·6	3 11·0			
12	13 26	2	13·1				
		3C	11·2				
16	12 29	2	11·8				
		3C	10·0				
19	12 23	2	12·6				
		3C	11·0		3 10·4	+1·2	
20	12 32	2	9·9				
		3C	9·8				
23	14 53	2	13·4				
		3C	11·3				
26	12 18	2	11·1	Needle 3C			
		3C	8·7	3 9·8			
27	13 37	2	10·0				
		3C	8·6				
30	12 36	2	10·4				
		3C	9·4				
June 2	13 37	2	10·9				
		3C	8·2				
3	13 32	2	12·1				
		3C	10·0				
6	13 29	2	13·4				
		3C	12·1				
	15 43	2	12·7				
		3C	11·7				
9	12 21	2	11·5				
		3C	9·3				
	13 14	2	11·4				
		3C	10·7				
13	13 20	2	12·5	Needle 2			
		3C	11·2	3 12·2			
16	12 28	2	12·6				
		3C	12·1		3 11·5	+1·5	
20	12 20	2	13·3	Needle 3C			
	12 45	3C	10·7	3 10·7			
27	12 59	2	11·3				
		3C	11·0				

TABLE I—*contd.*

Observations of dip—contd.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between 2—3C.	REMARKS.
1904.	h. m.		° ′	° ′			
July 4	13 9	3C	12·6				
	13 21	2	14·7				
5	13 55	2	12·5	Needle 2			
		3C	10·3	3 12·8			
8	12 53	2	12·8				
		3C	12·0				
11	12 1	2	7·5				
		3C	8·3				
14	12 31	2	14·0		3 12·2	+1·2	
		3C	12·2				
18	13 34	2	12·6				
		3C	11·6				
21	12 55	2	13·4				
		3C	12·5	Needle 3C			
25	13 36	2	13·8	3 11·6			
		3C	12·2				
28	13 22	2	14·0				
		3C	12·6				
August 1	13 26	2	12·5				
		3C	10·8				
4	13 20	2	12·5	Needle 2			
		3C	11·8	3 13·2			
	13 33	2	14·9				
		3C	14·4				
12	12 20	2	13·1				
		3C	10·7		3 12·7	+1·1	
16	12 13	2	12·3				
		3C	11·5				
18	12 35	2	13·2				
		3C	13·6				
22	13 40	2	15·2				
		3C	13·7	Needle 3C			
27	13 5	3C	11·1	3 12·1			
		2	10·7				
29	13 25	3C	11·5				
		2	14·1				
September 1	13 26	2	11·5				
		3C	10·1				
5	13 27	2	12·2				
		3C	13·3	Needle 2			
8	12 30	2	12·6	3 12·2			
		3C	10·6				
12	12 58	2	13·2				
		3C	10·5		3 11·9	+0·7	
15	13 27	2	12·2				
		3C	11·5				
19	12 44	2	11·2				
		3C	10·2	Needle 3C			
22	13 13	2	13·3	3 11·5			
		3C	13·3				
26	13 22	2	3 11·7				
		3C	11·3				
29	13 28	2	12·3				
		3C	12·8				

TABLE I—*concld.*

Observations of dip—concld.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both.	Difference between 2—3C.	REMARKS.
1904.	h. m.		° ′	° ′			
October 3	13 25	2	10·3				
		3C	10·7				
6	13 21	2	11·5	Needle 2			
		3C	10·6	3 11·5			
10	13 23	2	10·6				
		3C	10·4				
13	13 26	2	12·1				
		3C	11·9				
17	13 10	2	11·7		3 11·6	—0·1	
		3C	12·8				
20	13 30	2	12·1				
		3C	13·2				
24	13 25	2	12·7				
		3C	12·6				
27	13 33	2	10·9	Needle 3C			
		3C	10·3	3 11·6			
31	13 22	2	11·8				
		3C	11·9				
November 3	13 28	2	12·4				
		3C	13·1	Needle 2			
7	12 56	2	14·8	3 12·7			
		3C	13·7				
10	12 31	2	11·0				
		3C	11·7				
14	13 21	2	11·8				
		3C	10·9		3 12·5	+0·4	
17	13 0	2	13·1				
		3C	12·5				
21	12 26	2	13·7				
		3C	13·5	Needle 3C			
24	13 23	2	12·8	3 12·3			
		3C	12·0				
28	13 25	2	12·2				
		3C	11·1				
December 1	13 25	2	13·9				
		3C	14·5	Needle 2			
5	13 28	2	15·4	3 13·2			
		3C	14·1				
8	13 27	2	13·1		3 13·2	+0·1	
		3C	13·1				
12	12 54	2	11·4				
		3C	10·2				
15	13 25	2	13·1				
		3C	13·6	Needle 3C			
19	12 49	2	14·2	3 13·1			
		3C	14·1				
22	12 39	2	3 11·9				
		3C	12·7				
26	12 36	2	12·5				
		3C	12·6				

TABLE II.

Hourly means of the Declination as determined at Kodai Kanal from the selected quiet days in 1904.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Mean.
Winter.																									
1904. Months.																									
January . .	25·3	25·1	25·0	25·1	25·2	25·2	25·2	25·2	24·8	24·6	25·0	25·6	25·3	25·0	25·1	24·9	24·8	24·9	25·2	25·1	25·1	25·1	25·2	25·2	25·10
February . .	25·7	25·7	25·7	25·7	25·9	25·9	26·1	26·3	26·0	25·6	25·4	25·7	25·8	25·5	25·3	25·1	25·0	25·2	25·7	25·6	25·6	25·8	25·6	25·6	25·60
March . .	25·5	25·4	25·5	25·5	25·5	25·6	25·5	25·2	24·9	24·7	24·7	24·9	25·3	25·2	25·2	25·0	24·8	25·0	25·2	25·2	25·4	25·4	25·5	25·5	25·20
October . .	28·4	28·4	28·4	28·4	28·5	28·7	28·5	28·5	28·4	28·8	29·1	29·5	29·5	29·2	28·8	28·4	28·4	28·6	28·7	28·6	28·7	28·7	28·8	28·8	28·70
November . .	29·2	29·2	29·2	29·2	29·3	29·3	29·3	29·6	29·4	29·2	29·3	29·4	29·3	29·0	29·0	29·0	29·0	29·2	29·3	29·2	29·2	29·3	29·3	29·3	29·20
December . .	29·5	29·6	29·6	29·6	29·7	29·8	30·0	30·3	30·1	29·9	29·6	29·4	29·3	29·4	28·9	28·9	29·0	29·3	29·4	29·4	29·4	29·4	29·4	29·4	95·02
Mean . . .	27·3	27·2	27·2	27·3	27·4	27·4	27·4	27·5	27·3	27·1	27·2	27·4	27·4	27·2	27·1	26·9	26·8	27·0	27·3	27·2	27·2	27·3	27·3	27·3	27·20
Summer.																									
April . . .	25·9	25·8	25·8	25·8	25·8	25·9	25·6	24·8	24·7	25·1	25·6	26·6	27·3	27·2	27·0	26·3	26·9	25·7	25·7	26·8	26·2	26·2	26·1	25·9	26·00
May . . .	26·5	26·3	26·3	26·4	26·4	26·4	25·7	25·0	25·0	25·9	27·1	27·9	28·3	28·1	27·5	27·1	26·7	26·2	26·3	26·8	27·0	26·9	26·8	26·7	26·60
June . . .	26·9	26·7	26·7	26·7	26·7	26·6	26·0	25·1	24·7	25·7	26·7	27·9	28·5	28·8	28·1	27·5	26·8	26·7	26·8	27·1	27·3	27·3	27·1	27·0	26·90
July . . .	27·6	27·4	27·4	27·4	27·4	27·2	26·6	25·7	25·8	26·3	27·2	28·2	29·1	29·2	29·1	28·5	27·8	27·2	27·0	27·4	27·6	27·7	27·6	27·5	27·50
August . . .	28·0	28·0	27·9	27·9	27·9	27·8	27·5	26·8	26·7	27·5	28·1	28·7	29·0	29·1	28·6	28·2	27·9	27·8	27·8	27·9	28·0	28·0	28·0	28·0	28·00
September . .	28·5	28·4	28·5	28·5	28·4	28·3	27·9	27·2	27·4	28·3	28·9	29·7	29·9	29·9	29·3	28·7	28·6	28·5	28·5	28·5	28·6	28·6	28·6	28·6	28·60
Mean . . .	27·2	27·1	27·1	27·1	27·1	27·0	26·6	25·8	25·7	26·5	27·3	28·2	28·7	28·7	28·2	27·7	27·3	27·0	27·0	27·3	27·5	27·5	27·4	27·3	27·30

TABLE III.

Diurnal inequalities of Declination at Kodai Kanal as deduced from Table II.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11
Winter.																								
1904. Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	−0·2	0	+0·1	0	−0·1	−0·1	−0·1	−0·1	+0·3	+0·5	+0·1	−0·5	−0·2	+0·1	0	+0·2	+0·3	+0·2	−0·1	0	0	0	−0·1	−0·1
February	−0·1	−0·1	−0·1	−0·1	−0·3	−0·3	−0·5	−0·7	−0·4	0	+0·2	−0·1	−0·2	+0·1	+0·3	+0·5	+0·6	+0·4	−0·1	0	0	−0·2	0	0
March	−0·3	−0·2	−0·3	−0·3	−0·3	−0·4	−0·3	0	+0·3	+0·5	+0·5	+0·3	−0·1	0	0	+0·	+0·4	+0·2	0	0	−0·2	−0·2	−0·3	−0·3
October	+0·3	+0·3	+0·3	+0·3	+0·2	0	+0·2	+0·2	+0·3	−0·1	−0·4	−0·8	−0·8	−0·5	−0·1	+0·3	+0·3	+0·1	0	+0·1	0	0	−0·1	−0·1
November	0	0	0	0	−0·1	−0·1	−0·1	−0·4	−0·2	0	−0·1	−0·2	−0·1	+0·2	+0·2	+0·2	+0·2	0	−0·1	0	0	−0·1	−0·1	−0·1
December	0	−0·1	−0·1	−0·1	−0·2	−0·3	−0·5	−0·8	−0·6	−0·4	−0·1	+0·1	+0·2	+0·1	+0·6	+0·6	+0·5	+0·2	+0·1	+0·1	+0·1	+0·1	+0·1	0
Winter mean	−0·1	0	0	−0·1	−0·2	−0·2	−0·2	−0·3	−0·1	+0·1	0	−0·2	−0·2	0	+0·1	+0·3	+0·4	+0·2	−0·1	0	0	−0·1	−0·1	−0·1
Summer.																								
April	+0·1	+0·2	+0·2	+0·2	+0·2	+0·1	+0·4	+1·2	1·3	+0·9	+0·4	−0·6	−1·3	−1·2	−1·0	−0·3	+0·1	+0·3	+0·3	0	−0·2	−0·2	−0·1	+0·1
May	+0·1	+0·3	+0·3	+0·2	+0·2	+0·2	+0·9	+1·6	+1·6	+0·7	−0·5	−1·3	−1·7	−1·5	−0·9	−0·5	−0·1	+0·4	+0·3	−0·2	−0·4	−0·3	−0·2	−0·1
June	0	+0·2	+0·2	+0·2	+0·2	+0·3	+0·9	+1·8	+2·2	+1·2	+0·2	−1·0	−1·6	−1·9	−1·2	−0·6	+0·1	+0·2	+0·1	−0·2	−0·4	−0·4	−0·2	−0·1
July	−0·1	+0·1	+0·1	+0·1	+0·1	+0·3	+0·9	+1·8	+1·7	+1·2	+0·3	−0·7	−1·6	−1·7	−1·6	−1·0	−0·3	+0·3	+0·5	+0·1	−0·1	−0·2	−0·1	0
August	0	0	+0·1	+0·1	+0·1	+0·2	+0·5	+1·2	+1·3	+0·5	−0·1	−0·7	−1·0	−1·1	−0·6	−0·2	+0·1	+0·2	+0·2	+0·1	0	0	0	0
September	+0·1	+0·2	+0·1	+0·1	+0·2	+0·3	+0·7	+1·4	+1·2	+0·3	−0·3	−1·1	−1·3	−1·3	−0·7	−0·1	0	+0·1	+0·1	+0·1	0	0	0	0
Mean	+0·1	+0·2	+0·2	+0·2	+0·2	+0·3	+0·7	+1·5	+1·6	+0·8	0	−0·9	−1·4	−1·4	−0·9	−0·4	0	+0·3	+0·3	0	−0·2	−0·2	−0·1	0

When the sign is + the magnet points to the East, and when − the West of the mean position for the month.

TABLE IV.

Hourly means of the Horizontal Force in C. G. S. units (corrected for temperature) at Kodai Kanal from the selected quiet days in 1904.

Months.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11.	Means.
·37000 C. G. S. +													Winter.												
1904.	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 . .	352	351	352	352	353	353	352	352	368	390	416	424	417	398	372	358	355	358	360	361	358	357	357	356	368
February . .	350	347	350	347	349	348	347	354	370	402	424	428	416	389	365	350	350	359	358	355	353	354	346	348	365
March . . .	345	346	346	347	348	348	347	354	377	409	436	440	431	410	389	374	366	360	357	352	350	349	348	345	370
October . .	368	368	369	369	370	369	366	372	400	435	472	480	462	429	400	384	376	376	375	372	370	370	371	370	391
November . .	373	374	372	373	372	371	373	384	405	431	445	446	432	414	399	391	386	383	381	378	377	376	375	378	391
December . .	384	386	386	386	386	386	386	398	417	443	457	454	441	426	407	397	394	397	394	392	389	385	387	387	403
Mean . . .	362	362	363	362	363	363	362	369	390	418	442	445	433	411	389	376	371	372	371	368	366	365	364	364	381
													Summer.												
April . . .	346	346	345	346	349	348	347	357	382	419	444	451	444	423	397	373	359	356	358	356	354	353	350	348	337
May . . .	348	349	350	350	351	350	352	360	380	403	423	429	425	407	384	366	356	355	358	358	355	354	354	353	369
June . . .	355	356	357	357	357	357	359	364	380	401	426	437	438	419	397	375	362	358	359	360	360	361	361	362	376
July . . .	369	371	370	370	371	367	370	375	393	413	434	440	434	426	412	391	371	360	366	371	370	369	369	369	385
August . .	373	375	376	376	377	375	378	389	412	440	463	457	448	432	416	403	390	385	384	382	379	378	378	377	398
September .	361	362	363	363	364	363	362	371	397	425	450	450	431	407	386	377	376	374	372	368	365	362	363	362	382
Mean . .	359	360	360	360	362	360	361	369	391	417	440	444	437	419	399	381	369	365	366	366	364	363	363	362	381

TABLE V.

Diurnal inequalities of Horizontal Force at Kodai Kanal as deduced from Table IV.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11
1904. Months.																								
January	−16	−17	−16	−16	−15	−15	−16	−16	0	+22	+48	+56	+49	+30	+4	−10	−13	−10	−8	−7	−10	−11	−11	−12
February	−15	−18	−15	−18	−16	−17	−18	−11	+5	+37	+59	+63	+51	+24	0	−15	−15	−6	−7	−10	−12	−11	−19	−17
March	−25	−24	−24	−23	−22	−22	−23	−16	+7	+39	+66	+70	+61	+40	+19	+4	−4	−10	−13	−18	−20	−21	−22	−5
October	−23	−23	−22	−22	−21	−22	−25	−19	+9	+44	+81	+89	+71	+38	+9	−7	−15	−15	−16	−19	−21	−21	−20	−21
November	−18	−17	−19	−18	−19	−20	−15	−7	+14	+40	+54	+55	+41	+23	+8	−0	−5	−8	−10	−13	−14	−15	−16	−13
December	−19	−17	−17	−17	−17	−17	−17	−5	+14	+40	+54	+51	+38	+23	+4	−6	−9	−6	−9	−11	−14	−18	−16	−16
Mean	−19	−19	−18	−19	−18	−18	19	−12	+9	+37	+61	+64	+52	+30	+8	−5	−10	−9	−10	−13	−15	−16	−17	−17
April	−27	−27	−28	−27	−24	−25	−26	−16	+9	+46	+71	+78	+71	+50	+24	0	−14	−17	−15	−17	−19	−20	−23	−25
May	−21	−20	−19	−19	−18	−19	−17	−9	+11	+34	+54	+60	+56	+38	+15	−3	−13	−14	−11	−11	−14	−15	−15	−16
June	−21	−20	−19	−19	−19	−19	−17	−12	+4	+25	+50	+61	+62	+43	+21	−1	−14	−18	−17	−16	−16	−15	−15	−14
July	−16	−14	−15	−15	−14	−18	−15	−10	+8	+28	+49	+55	+49	+41	+27	+6	−14	−25	−19	−14	−15	−16	−16	−16
August	−25	−23	−22	−22	−21	−23	−20	−9	+14	+42	+65	+59	+50	+34	+18	+5	−8	−13	−14	−16	−19	−20	−20	−21
September	−21	−20	−19	−19	−18	−19	−20	−11	+15	+43	+68	+68	+49	+25	+4	−5	−6	−8	−10	−14	−17	−20	−19	−20
Mean	−22	−21	−21	−21	−19	−21	−20	−12	+10	+36	+59	+63	+56	+38	+18	0	−12	−16	−15	−15	−17	−18	−18	−19

When the sign is + the force is greater than the monthly mean, and when − less.

Dates of magnetic disturbances at Kodai Kanal in 1904.

Latitude of observatory—10°·13′·50″.
Longitude of observatory—77°·27′·46″.

1904.	Months.											
Dates.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
1 . . .	S	S	C	G	S	C	S	C	C	C	C	S
2 . . .	S	C	C	S	C	C	C	M	C	S	S	(C)
3 . . .	S	S	C	C	C	(C)	S	M	(C)	C	S	S
4 . . .	C	S	S	S	(C)	C	(C)	S	S	C	S	S
5 . . .	C	S	C	(C)	C	S	C	C	S	S	S	C
6 . . .	S	(C)	(C)	C	C	S	S	S	S	(C)	C	C
7 . . .	(C)	—	C	S	(C)	S	S	C	C	S	(C)	C
8 . . .	C	—	C	C	S	(C)	C	(C)	S	S	C	(C)
9 . . .	S	S	(C)	(C)	C	C	(S)	C	S	S	C	S
10 . . .	S	C	C	S	S	C	S	C	(C)	C	(C)	S
11 . . .	S	—	S	S	C	S	C	C	C	(C)	C	C
12 . . .	(C)	C	S	C	M	C	C	(C)	C	C	C	C
13 . . .	C	—	C	C	M	(C)	C	C	C	C	C	(C)
14 . . .	(C)	—	C	—	S	C	S	(C)	(C)	S	C	C
15 . . .	S	S	C	C	S	C	C	—	S	C	(C)	S
16 . . .	S	(S)	(C)	(C)	(S)	M	C	—	M	(C)	M	S
17 . . .	C	S	C	C	S	S	C	—	C	C	S	C
18 . . .	C	—	C	S	S	S	(C)	—	C	C	S	S
19 . . .	(C)	—	C	S	S	C	C	—	C	(C)	C	S
20 . . .	C	C	S	S	C	C	S	(S)	(C)	C	(C)	C
21 . . .	S	C	S	S	—	C	(C)	S	C	S	C	C
22 . . .	—	(C)	(C)	(C)	—	(C)	C	S	C	S	C	C
23 . . .	S	S	C	C	—	C	C	S	C	S	C	C
24 . . .	—	S	(C)	S	S	C	C	C	C	(C)	(C)	(C)
25 . . .	S	S	C	S	(C)	C	C	(C)	M	C	S	C
26 . . .	C	C	S	C	(C)	C	(C)	C	C	C	S	C
27 . . .	(C)	(C)	S	(C)	C	S	S	C	C	S	S	S
28 . . .	M	C	C	C	S	S	S	S	(C)	S	C	(C)
29 . . .	S	C	C	C	S	(C)	C	S	C	S	C	S
30 . . .	—	...	C	C	C	C	C	M	C	S	C	C
31 . . .	S	...	C	...	C	...	C	S	...	S	...	C
C. . . .	13	11	24	17	14	21	21	14	22	17	20	20
S. . . .	14	11	7	11	12	8	10	9	6	14	9	11
M. . . .	1	...	...	...	2	1	...	3	2	...	1	...
G. . . .	...	...	...	1	...	...	...	...	...	...	...	...
V. G. . . .	...	...	...	...	...	...	...	...	...	...	...	...

The magnitudes of disturbances are taken from the H, F. traces ( ) = Selected quiet day, C = calm, M = moderate, G = great, V G = very great, —— = trace lost.

The statement of loss of magnetograph record at Kodai Kanal during the year 1904.

Horizontal Force.					Declination.					
From	On	To	On	Period of break.	From	On	To	On	Period of break.	Remarks.
h. m.		h. m.		h. m.	h. m.		h. m.		h. m.	
7 0	18th January	9 49	18th January	2 49	4 0	16th January	9 49	16th January	5 49	Lamp failed.
5 0	20th „	9 49	20th „	4 49	0 0	18th „	9 49	18th „	2 49	„ „
5 0	22nd „	9 49	22nd „	4 49	0 0	20th „	9 49	20th „	9 49	„ „
8 0	23rd „	9 49	23rd „	1 49	5 0	22nd „	9 49	22nd „	4 49	„ „
4 0	24th „	9 49	24th „	5 49	5 30	26th „	9 49	26th „	4 19	„ „
7 0	29th „	9 49	29th „	2 49	...	...	...	...	...	„ „
4 0	30th „	9 49	30th „	5 49	...	...	...	...	...	„ „
...	...	...	...	..	21 10	31st January	0 45	1st February	3 35	Cause not known.
3 5	5th February	9 49	5th February	6 44	7 20	3rd February	9 49	3rd February	...	Lamp failed.
9 49	7th „	10 9	8th „	26 20	...	...	...	...	...	Probably the shutter was not opened.
...	...	...	...	...	7 40	8th February	9 19	8th February	1 39	The drum was not properly set.
16 30	9th February	17 0	9th February	0 30	16 18	9th „	18 4	9th „	1 46	„ „ „
...	...	...	...	...	7 25	10th „	8 10	10th „	0 45	„ „ „
5 50	11th February	9 49	11th February	4 49	5 45	12th „	9 49	12th „	4 4	Lamp failed.
7 20	13th „	9 49	13th „	2 29	...	...	...	...	...	„ „
3 42	14th „	9 49	14th „	6 7	...	...	...	...	...	„ „
7 0	15th „	9 49	15th „	2 49	7 0	15th February	9 49	15th February	2 49	„ „
20 30	18th „	9 49	19th „	13 19	...	...	...	...	...	„ „
6 0	20th „	9 49	20th „	3 49	...	...	...	...	...	
6 0	21st „	9 49	21st „	5 49	...	...	...	...	...	
6 0	7th March	9 49	7th March	3 49	...	...	...	...	...	
10 0	14th April	16 5	14th April	6 5	10 0	14th April	16 5	14th April	6 5	The wheels were not clamped.
16 0	20th May	18 45	22nd May	50 45	14 6	20th May	18 45	22nd May	52 39	Declination magnetograph readjusted.
19 17	22nd „	17 5	23rd „	21 48	19 7	22nd „	11 27	23rd „	16 10	„ „
10 3	15th August	9 49	19th August	95 46	10 1	17th August	3 0	18th August	16 59	Papers exposed.
...	...	...	...	...	9 58	18th „	3 0	19th „	17 2	„ „
9 49	30th Dec.	10 52	1st Jan. '05	49 3	10 40	29th Dec.	10 52	1st Jan. '05	72 12	Declination magnetograph cleaned and reset.
			Total	326 44				Total	223 20	

1

Barrackpore Magnetic Observatory.

29. The observatory remained in charge of K. N. Mukerji throughout the year 1904-05. The whole of the staff suffered considerably from sickness which necessitated frequent reliefs, while the observers of Dehra Dun and Barrackpore have now been interchanged. The instruments worked well and gave no trouble. The vertical force instrument for this observatory has arrived in India, and it is hoped to erect it during the ensuing cold weather. The tabulations for 1904 are appended.

General remarks.

Mean values of the magnetic elements at Barrackpore for 1904.

Declination 1°-22′·4 E.

Dip 30°-20′

H. F. ·37224

30. The following table gives the monthly mean magnetic collimation and base line values of the declination magnetograph.

The declination results.

Monthly mean values of Magnetic Collimation and Declination base lines.

1904. Month.	Monthly mean magnetic collimation.	Mean value of base line for the month.	Total number of values of base line.	Number of values rejected.	Number of values from which the base lines are derived.	Probable error of mean values of base line.	Probable error of single value of base line.	Remarks.
		° ′						
January	—7·41	0· 15·40	19	1	18	±0·043	±0·18	From 1st December 1903.
February	46	15·45	8	2	6	±0·048	±0·12	
March	33	15·53	12	3	9	±0·044	±0·13	
April	33	15·44	11	2	9	±0·040	±0·12	
May	35	15·54	13	1	12	±0·022	±0·08	
June	36	15·63	10	1	9	±0·042	±0·13	
July	33	15·38	11	0	11	±0·028	±0·09	
August	31(1) —6·51(2)	15·36	21	2	19	±0·046	±0·11	(1) Up to 27th. (2) From 29th.
September	54	15·45	27	1	26	±0·024	±0·12	
October	52	15·31	27	1	26	±0·022	±0·11	
November	54	15·38	26	1	25	±0·029	±0·15	
December	56	15·35	27	2	25	±0·028	±0·14	

BARRACKPORE.

Mean monthly values of Declination and secular change.

Months.	Values of declination, 1903.	Values of declination, 1904.	Secular change.	Remarks.
		° ′		
January		E1 24·4		
February		24·1		
March		23·8		

BARRACKPORE—*contd.*

Mean monthly values of Declination and secular change—contd.

Months.	Values of Declination, 1903.	Values of Declination, 1904.	Secular change.	REMARKS.
		′		
April . . .		23·4		
May . . .		23·1		
June . . .		22·7		
July . . .	° ′	22·1	′	
August . . .	E 1 26·6	22·0	−4·6	In 1903 the mean value for this month is derived from 3 quiet days only.
September . .	26·0	21·4	4·6	
October . . .	25·8	21·0	4·8	
November . .	25·6	20·7	4·9	
December . .	25·1	20·2	4·9	
Mean . . .	1° 25·8	1° 21·1	−4·8	Mean for the last 5 months.

The dip results.

31. The results of the dip observations are appended in Table 1.

The following table gives the monthly mean values of dip and the secular change.

Months.	Dip, 1903.	Dip, 1904.	Secular change.	REMARKS.
		° ′		
January . . .		30 17·2	′	Only one observation in January 1904.
February . . .		18·0		
March . . .		17·4		
April . . .		19·6		
May . . .		20·7		
June . . .		20·6		
July . . .	° ′	19·7	′	
August . . .	30 16·6	19·8	+3·2	
September . .	16·7	19·7	3·0	
October . . .	16·8	20·1	3·3	
November . .	18·5	20·8	2·2	
December . .	19·6	20·6	1·0	
Mean . . .	30 17·7	30 20·2	+2·5	Mean for the last 5 months.

Scale values of monthly mean temperature at Barrackpore.

1904. Months.	Scale values.	Temperature of H. F. magnetograph.	Remarks.
January	4·86 γ	29·°3 C.	The base line values are referred to a temperature of 31°C. and temperature co-efficient for 1°C.= 12·5γ.
February	4·87 „	29·5	
March	4·90 „	30·3	
April	4·88 „	31·4	
May	4·89 „	31·3	
June	4·89 „	31·5	
July	4·90 „	31·0	
August	4·89 „	31·1	
September	4·90 „	30·9	
October	4·91 „	30·5	
November	4·92 „	30·1	
December	4·93	30·0	
Mean	4·90	30·6	

Monthly mean values of H. F. and secular change.

Months.	H. F. 1903.	1904.	Secular change.	Remarks.
			γ	
January . .	...	·37210	...	
February . .	...	212	...	
March . .	...	231	...	
April . .	...	222	...	
May . .	...	225	...	
June. . .	...	226	...	
July . . .	...	226	...	
August . .	·37196	229	+33	
September . .	209	224	15	
October . .	201	226	25	
November . .	184	229	45	
December . .	198	232	34	
Mean . .	·37198	·37228	+30γ	Mean for the last 5 months.

Monthly mean values of H. F. constant of magnetometer No. 20 and monthly mean base line values of H. F. magnetograph.

1904. Month.	Monthly mean value of Mo.	Monthly mean value of P, from 22·5 and 30 C. M. S.	Monthly mean value of P, from 30 and 40 C. M. S.	Mean value of base line for the month.	Total number of values of base line.	Number of values rejected.	Number of values from which the base line is derived.	Probable error of mean values of base line.	Probable error of single value of base line.	REMARKS.
January .	952·65	6·70	7·62	·36920	5	0	5	± 2·95 γ	± 6·60 γ	From 27th.
February .	·62	·70	·35	16	25	4	21	± 0·89 „	± 4·1 „	
March . .	·67	·75	·46	22	25	1	24	± 0·92 „	± 4·5 „	
April . .	·72	·78	·50	16	10	0	10	± 1·14 „	+ 3·6 „	Up to 16th.
„ . .	...	...	...	10	8	0	8	± 0·84 „	± 2·4 „	For the rest.
May . .	·70	·74	·74	04	10	0	10	± 1·11 „	± 3·5 „	Up to 18th.
„ . .	...	...	...	01	7	0	7	± 1·24 „	± 3·3 „	For the rest.
June . .	·62	·76	·53	01	9	1	8	± 2·05 „	± 5·8 „	Up to 16th.
„ . .	...	...	...	891	8	0	8	± 0·72 „	± 2·0 „	For the rest.
July . .	·63	·78	·41	82	9	0	9	± 0·86 „	± 2· „	Up to 16th.
„ . .	...	...	...	78	10	0	10	± 1·06 „	± 3·4 „	For the rest.
August . .	·63	·74	·35	77	20	0	20	± 0·59 „	± 2·6 „	
September .	·57	·75	·56	67	17	0	17	± 0·91 „	± 3·8 „	
October .	·58	·74	·49	65	20	0	20	± 0·75 „	± 3·4 „	
November .	·64	·80	·55	63	17	1	16	± 0·82 „	± 3·2 „	Up to 26th.
December .	·59	·79	·40	57	15	0	15	± 0·85 „	± 3·3 „	From 28th November to 20th December
	...	...	...	46	10	0	10	± 1·32 „	± 4·2 „	For the rest.

The base line values show that the instrument was in an unstable condition and was settling down throughout the year. The results in 1905 are considerably better and indicate that the instrument has now settled down entirely.

TABLE I.

Observations of Dip at Barrackpore.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both needle.	Difference between needles 1-2.	REMARKS.
1904.	h. m.		° ′	° ′	° ′	° ′	
January 28	13 1	1	30 17·8		30 17·2	+ 1·3	Observer was sick and could not take any observation in January.
		2	16·5				
February 1	13 0	1	19·9				
		2	18·4				
4	16 13	1	20·0				
		2	18·5				
11	13 9	1	18·4	Needle 1			
		2	17·2	30 18·5			
15	12 46	1	19·1				
		2	18·7		30 18·0	+ 1·0	
18	12 25	1	16·6				
		2	16·8				

TABLE I—*contd.*

Observations of Dip at Barrackpore—contd.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both needles.	Difference between needles 1-2.	REMARKS.
1904.	h. m.		° ′	° ′	° ′	° ′	
19	12 40	1	17·1	Needle 2			
		2	16·4	30 17·5			
22	13 9	1	18·9				
		2	17·6				
25	13 29	1	17·9				
		2	16·2				
29	13 44	1	18·7				
		2	17·5				
March 3	13 41	1	18·1				
		2	17·0				
7	13 25	1	16·6				
		2	16·9				
10	13 0	1	18·1	Needle 1			
		2	18·2	30 17·2			
14	12 7	1	16·6				
		2	17·1				
17	13 3	1	16·9				
		2	17·6				
21	13 13	1	15·7		30 17·4	—0·3	
		2	17·1				
24	13 0	1	17·1				
		2	16·2				
28	13 26	1	17·8				
		2	17·5	Needle 2			
	15 6	1	16·0				
		2	18·2	30 17·5			
31	13 19	1	17·5				
		2	19·0				
	14 1	2	17·9				
	14 48	1	16·9				
		2	17·5				
April 4	13 44	1	30 18·6				
		2	19·1	Needle 1			
7	13 10·0	1	19·2	30 19·4			
		2	19·1				
11	13 26	1	20·2				
		2	19·4				
14	13 10	1	18·3				
		2	16·9		30 19·6	—0·4	
18	13 41·0	1	19·2				
		2	20·4				
	14 15	2	21·0				
21	12 43	1	18·9	Needle 2			
		2	21·2	30 19·8			
25	13 17	1	18·2				
		2	19·8				
26	14 41	1	21·8				
		2	20·8				
28	13 40	1	20·2				
		2	19·9				
May 2	12 49	1	21·1				
		2	22·6				
	13 28	2	21·0				
7	12 48	1	20·0	Needle 1			
		2	19·3	30 20·7			
9	13 43	1	19·4				
		2	18·6				
16	13 2	1	22·8				
		2	21·8				

TABLE I—*contd.*

Observations of Dip at Barrackpore—contd.

1		2	3	4	5	6	7	8
Date.		L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both needles.	Difference between needles 1-2.	REMARKS.
1904. May.		h. m.		° ′	° ′	° ′	° ′	
	19	13 44	1	20·6		30 20·7	0·0	
			2	22·0				
	24	13 25	1	22·6				
			2	20·8				
	26	13 21	1	19·4				
			2	20·3	Needle 2			
	30	13 15	1	19·5	30 20·7			
			2	19·9				
June	2	13 24	1	19·6				
			2	19·0				
	6	13 5	1	18·3				
			2	18·2				
	9	14 38	1	21·3	Needle 1			
			2	21·2	30 21·3			
	14	13 42	1	18·7				
			2	18·3				
	16	9 10	1	24·1				
			2	23·6				
		9 32	1	25·0		30 20·6	+1·4	
	17	13 9	1	21·4				
			2	21·2				
	20	12 58	1	22·2				
			2	19·9	Needle 2			
		13 19	1	21·6	30 19·9			
	23	13 14	1	19·9				
			2	19·5				
	27	13 30	1	22·2				
			2	20·2				
	30	13 27	1	20·9				
			2	18·2				
July	4	13 18	1	30° 19′·2				
			2	20·5				
	7	13 39	1	19·9				
			2	20·1	Needle 1			
	12	13 19	1	19·7	30 19·5			
			2	21·0				
	14	12 48	1	19·6				
			2	19·2				
	18	13 24	1	17·5				
			2	18·1		30 19·7	—0·3	
	21	13 25	1	20·3				
			2	19·1	Needle 2			
	25	13 33	1	20·2	30 19·8			
			2	21·3				
	28	13 7	1	19·8				
			2	19·4				
August	1	13 22	1	20·4				
			2	19·4				
	4	13 39	1	22·1	Needle 1			
			2	23·0	30 19·7			
	8	13 26	1	20·2				
			2	19·5				
	12	13 11	1	19·4				
			2	19·2		30 19·8	—0·1	
	15	13 26	1	20·7				
			2	21·7				
	18	13 38	1	18·1	Needle 2			
			2	16·6	30 19·8			

TABLE I—*contd.*

Observation of Dip at Barrackpore—contd.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both needles.	Difference between needles 1-2.	REMARKS
1904	h. m.		° ′	° ′	° ′	° ′	
August.							
22	13 29	1	20·5				
		2	20·4				
25	12 48	1	18·2				
		2	18·5				
30	13 14	1	18·1				
September 1	13 5	1	19·9				
	13 39	2	20·6				
5	13 22	1	20·1	Needle 1			
		2	17·9	30 20·0			
8	13 25	1	20·2				
		2	20·0				
12	13 41	1	18·3		30 19·7	+0·6	
		2	18·3				
16	13 26	1	19·0				
		2	16·8	Needle 2			
20	13 41	1	19·3	30 19·4			
	14 55	2	19·4				
22	13 56	1	17·8				
		2	17·4				
27	12 48	1	23·6				
	13 34	2	21·8				
29	12 56	1	21·6				
		2	21·5				
October 3	13 44	1	30 19·1				
		2	20·1				
6	13 25	1	20·2	Needle 1			
		2	20·6	30 20·3			
13	13 30	1	19·7				
		2	21·3				
14	13 31	1	21·4				
		2	19·5		30 20·1	+0·4	
17	13 44	1	21·1				
		2	19·9				
21	13 46	1	22·4				
		2	21·3				
24	13 23	1	20·0	Needle 2			
		2	19·1	30 19·9			
27	12 43	1	19·6				
		2	17·5				
31	13 24	1	19·4				
		2	20·0				
November 4	13 52	1	21·1				
		2	21·8				
7	13 47	1	19·4				
		2	20·8	Needle 1			
10	13 40	1	19·3	30 20·1			
		2	19·4				
14	13 45	1	21·1				
		2	19·5		30 20·8	+0·4	
17	13 35	1	22·0				
		2	23·2				
22	13 47	1	22·6	Needle 2			
		2	20·2	30 20·6			
28	12 57	1	21·6				
		2	19·6				
December 1	13 46	1	20·0				
		2	19·7				
5	13 42	1	20·6				

TABLE I.—*concld.*

Observations of Dip at Barrackpore—concld.

1	2	3	4	5	6	7	8
Date.	L. M. T.	Needle No.	Dip.	Monthly mean dip with each needle.	Monthly mean dip with both needles.	Difference between needles 1-2.	REMARKS.
1904	h. m.		°	′	° ′	° ′	
		2	22·4	Needle 1			
6	12 40	1	19·4	30 20·5			
		2	20·2				
8	13 27	1	20·9				
		2	21·5				
15	13 30	1	21·8				
		2	21·3		30 20·6	—0·2	
19	13 10	1	19·0				
		2	19·9				
22	12 54	1	19·0				
		2	20·1	Needle 2			
26	13 41	2	21·5	30 20·7			
		1	22·0				
29	13 32	2	19·9				
	14 8	1	21·7				

TABLE II.

Hourly means of Declination at Barrackpore observatory as determined from the selected quiet days in 1904.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mean.
Declination 0° W+													Winter.												
1904. Months.																									
January	24·4	24·4	24·5	24·4	24·4	24·3	24·2	24·3	25·4	**25·8**	24·8	23·8	**23·4**	23·5	23·9	24·4	25·0	24·7	24·5	24·5	24·4	24·5	24·5	24·4	24·4
February	24·0	24·0	23·8	23·9	23·8	23·7	**23·5**	23·7	24·5	25·0	**25·2**	24·5	23·7	23·6	23·9	24·1	24·4	24·3	23·9	24·1	24·2	24·1	24·0	24·0	24·1
March	23·6	23·6	23·6	23·5	23·5	23·5	23·5	24·4	25·4	**25·8**	25·6	24·5	23·3	**22·5**	22·6	23·0	23·7	23·8	23·6	23·5	23·5	23·5	23·5	23·5	23·8
October	21·2	21·2	21·2	21·2	21·1	21·1	21·1	22·1	**22·4**	22·2	21·0	20·0	**19·0**	19·3	20·4	21·2	21·5	20·9	20·7	20·8	20·9	20·7	20·8	21·0	21·0
November	20·8	20·7	20·7	20·7	20·4	**20·3**	20·4	20·6	21·4	**21·6**	21·3	20·4	20·3	20·8	21·2	21·1	20·9	20·5	20·4	20·5	20·4	20·4	20·5	20·6	20·7
December	20·2	20·2	20·2	20·2	19·8	19·8	19·6	**19·1**	19·7	20·5	20·5	20·2	20·1	20·2	20·7	**21·1**	20·8	20·3	20·4	20·3	20·3	20·2	20·2	20·2	20·2
Mean	22·4	22·4	22·3	22·3	22·2	22·1	22·1	22·4	23·1	**23·5**	23·1	22·2	**21·6**	21·7	22·1	22·5	22·7	22·4	22·3	22·3	22·3	22·2	22·3	22·3	22·4
													Summer.												
April	23·5	23·5	23·5	23·6	23·4	23·3	24·0	25·6	**26·1**	25·7	24·2	22·6	**21·4**	21·4	21·6	22·1	22·9	23·3	23·5	23·2	22·9	23·0	23·2	23·3	23·4
May	23·2	23·3	23·2	23·1	23·1	23·3	24·6	25·6	**25·9**	24·9	23·4	22·2	20·9	**20·6**	21·2	21·7	22·7	23·4	23·4	22·8	22·6	22·6	22·8	22·9	23·1
June	22·9	22·9	23·0	22·9	22·9	23·3	24·4	25·7	**26·1**	25·1	23·4	21·5	20·1	**19·9**	20·2	21·0	22·0	22·5	22·9	22·6	22·4	22·5	22·6	22·7	22·7
July	22·1	22·1	22·2	22·2	22·4	22·6	24·1	25·0	**25·1**	24·2	22·8	21·0	19·9	**19·6**	19·6	20·2	21·4	22·4	22·7	21·1	21·7	21·8	21·8	22·0	22·1
August	21·8	21·8	22·0	22·0	22·1	22·3	24·0	**25·6**	25·2	23·6	21·8	20·2	**19·6**	19·8	20·6	21·5	22·3	22·6	22·2	21·6	21·3	21·3	21·4	21·5	22·0
September	21·4	21·4	21·5	21·5	21·5	21·9	22·8	**24·3**	24·2	22·8	20·9	19·1	**18·4**	18·7	19·7	21·2	22·0	21·8	21·4	21·3	21·3	21·3	21·3	21·3	21·4
Mean	22·5	22·5	22·6	22·5	22·6	22·8	24·0	25·3	**25·4**	24·4	22·8	21·1	20·1	**20·0**	20·5	21·3	22·2	22·7	22·7	22·3	22·0	22·1	22·2	22·3	22·5

TABLE III.

Diurnal inequality of the Declination at Barrackpore as deduced from Table VII.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11
Winter.																								
1904. Months.																								
January	0	0	+·1	0	0	−·1	−·2	−·1	+1·0	+1·4	+·4	−·6	−1·0	−·9	−·5	0	+·6	+·3	+·1	+·1	0	+·1	+·1	0
February	−·1	−·1	−·3	−·2	−·3	−·4	−·6	−·4	+·4	+·9	+1·1	+·4	−·4	−·5	−·2	0	+·3	+·2	−·2	0	+·1	0	−·1	−·1
March	−·2	−·2	−·2	−·3	−·3	−·3	−·3	+·6	+1·6	+2·0	+1·8	+·7	−·5	−1·3	−1·2	−·8	−·1	0	−·2	−·3	−·3	−·3	−·3	−·3
October	+·2	+·2	+·2	+·2	+·1	+·1	+·1	+1·1	+1·4	+1·2	0	−1·0	−2·0	−1·7	−·6	+·2	+·5	−·1	−·3	−·2	−·1	·3	−·2	0
November	+·1	0	0	0	−·3	−·4	−·3	−·1	+·7	+·9	+·6	−·3	−·4	+·1	+·5	+·4	+·2	−·2	−·3	·2	·3	−·3	−·2	−·1
December	0	0	0	0	−·4	−·4	−·6	−1·1	−·5	+·3	+·3	0	−·1	0	+·5	+·9	+·6	+·1	+·2	+·1	+·1	0	0	0
Mean	0	0	−·1	−·1	−·2	−·3	−·3	0	+·7	+1·1	+·7	−·2	−·8	−·7	−·3	+·1	+·3	0	−·1	−·1	−·1	−·2	−·1	−·1
Summer.																								
April	+·1	+·1	+·1	+·1	0	−·1	+·6	+2·2	+2·7	+2·3	+·8	−·8	−2·0	−2·0	−1·8	−1·3	−·5	−·1	+·1	−·2	−·5	−·4	−·2	−·1
May	+·1	+·2	+·1	0	0	+·2	+1·5	+2·5	+[illegible]8	+1·8	+·3	−·9	−2·2	−2·5	−1·9	1·4	−·4	+·3	+·3	−·3	−·5	−·5	−·3	−·2
June	+·2	+·2	+·3	+·2	+·2	+·6	+1·7	+3·0	+3·4	+2·4	+·7	−1·2	−2·6	−2·8	−2·5	−1·7	−·7	−·2	+·2	−·1	−·3	−·2	−·1	0
July	0	0	+·1	+·1	+·3	+·5	+2·0	+2·9	+3·0	+2·1	+·7	−1·1	−2·2	−2·5	−2·5	−1·9	−·7	+·3	+·6	0	−·4	−·3	−·3	−·1
August	−·2	−·2	0	0	+·1	+·3	+2·0	+3·6	+3·2	+1·6	−·2	−1·8	−2·4	−2·2	−1·4	−·5	+·3	+·6	+·2	−·4	−·7	−·7	−·6	−·3
September	0	0	+·1	+·1	+·1	+·5	+1·4	+2·9	+2·8	+1·4	−·5	−2·3	−3·0	−2·7	−1·7	−·2	+·6	+·4	0	−·1	−·1	−·1	−·1	−·1
Mean	0	0	+·1	0	+·1	+·3	+1·5	+2·8	+2·9	+1·9	+·3	−1·4	−2·4	−2·5	−2·0	−1·2	−·3	+·2	+·2	−·2	−·5	−·4	−·3	−·2

When the sign is + the magnet points to the east of the mean position, and when − to the west.

TABLE IV.

Hourly mean of Horizontal Force in C. G. S. units (corrected for temperature) at Barrackpur Observatory from the selected quiet days.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mean.
—37000 C. G. S.+													Winter.												
1904. Months.																									
January	205	203	205	205	208	208	210	210	210	211	208	213	217	219	219	218	213	206	208	210	210	209	209	209	210
February	206	206	207	206	207	207	208	210	213	218	222	228	230	229	222	215	208	208	208	206	204	204	204	204	212
March	222	223	221	221	222	222	224	225	229	239	253	261	261	255	244	234	228	225	225	223	221	220	220	221	231
October	218	220	219	221	222	223	223	222	221	225	233	244	251	246	239	231	224	219	218	217	217	216	221	223	226
November	220	222	222	221	221	221	222	225	233	240	247	254	255	246	237	229	222	219	220	221	221	222	223	224	229
December	225	226	228	226	227	228	229	233	240	245	249	249	246	242	237	233	229	225	229	227	227	225	225	227	232
Mean	216	217	217	217	218	218	219	221	224	230	235	242	243	240	233	227	221	217	218	217	217	216	217	218	223
													Summer.												
April	209	208	207	207	208	211	212	213	219	230	244	251	252	250	243	234	225	219	216	215	215	215	216	213	222
May	213	211	214	213	213	215	216	218	221	231	245	252	256	253	248	240	231	222	219	216	214	215	214	215	225
June	216	215	215	215	217	218	221	226	228	233	242	249	251	248	241	234	226	219	217	219	219	220	221	222	226
July	214	215	216	215	216	216	218	221	224	235	246	253	255	254	248	240	227	219	214	214	215	216	216	216	226
August	220	224	224	224	223	225	224	224	221	225	234	243	249	249	244	240	235	229	226	224	224	224	224	223	229
September	218	219	219	219	221	220	220	215	210	218	230	241	249	248	242	232	225	221	220	220	218	217	217	217	224
Mean	215	215	216	216	216	218	219	220	221	229	240	248	252	250	244	237	228	222	219	218	218	218	218	218	225

TABLE V.

Diurnal inequality of Horizontal Force at Barrackpur as deduced from Table V, winter 1904.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mean.
Months	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	−5	−7	−5	−5	−2	−2	0	0	0	+1	−2	+3	+7	+9	+9	+8	+3	−4	−2	0	0	−1	−1	−1	...
February	−6	−6	−5	−6	−5	−5	−4	−2	+1	+6	+10	+16	+18	+17	+10	+3	−4	−4	−4	−6	−8	−8	−8	−8	...
March	−9	−8	−10	−10	−9	−9	−7	−6	−2	+8	+22	+30	+30	+24	+13	+3	−3	−6	−6	−8	−10	−11	−11	−10	...
October	−8	−6	−7	−5	−4	−3	−3	−4	−5	−1	+2	+18	+25	+20	+13	+5	−2	−7	−8	−9	−9	10	−5	−3	...
November	−9	−7	−7	−8	−8	−8	−7	−4	+4	+11	+18	+25	+26	+17	+8	0	−7	−10	−9	−8	−8	−7	· 6	−5	...
December	−7	−6	−4	−6	−5	−4	−3	+1	+8	+13	+17	+17	+14	+10	+5	+1	−3	−7	−3	−5	−5	−7	−7	−5	...
Mean	−7	−6	−6	−6	−5	−5	−4	−2	+1	+7	+12	+19	+20	+17	+10	+4	−2	−6	−5	−6	−6	−7	−6	−5	...

Summer.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mean.
April	−13	−14	−15	−15	−14	−11	−10	−9	−3	+8	+22	+29	+30	+28	+21	+12	+3	−3	−6	−7	−7	−7	−6	−9	...
May	−12	−14	−11	−12	−12	−10	−9	−7	−4	+6	+20	+27	+31	+28	+23	+15	+6	−3	−6	−9	−11	−10	−11	−10	...
June	−10	−11	−11	−11	−9	−8	−5	0	+2	+7	+16	+23	+25	+22	+15	+8	0	−7	−9	[illegible]	−7	−6	−5	−4	...
July	−12	−11	−10	−11	−10	−10	−8	−5	−2	+9	+20	+27	+29	+28	+22	+14	+1	−7	−12	−12	−11	−10	−10	−10	...
August	−9	−5	−5	−5	−6	−4	−5	−5	−8	−4	+5	+14	+20	+20	+15	+11	+6	0	−3	−5	−5	−5	−5	−6	...
September	−6	−5	−5	−5	−3	−4	−4	−9	−14	−6	+6	+17	+25	+24	+18	+8	+1	−3	−4	−4	−6	−7	−7	−7	...
Mean	−10	−10	−9	−9	−9	−7	−6	−5	−4	+4	+15	+23	+27	+25	+19	+12	+3	−3	−6	−7	−7	−7	−7	−7	...

When the sign is + the force is greater than the mean value for the months, and when − less.

Dates of Magnetic disturbances at Barrackpore in 1904.

Lat. of observatory 22°-46′-29″.

Long. of observatory 88°-21′-39″

1904. Dates.	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	S	S	C	M	S	C	S	C	C	C	C	S
2	S	C	C	S	C	C	C	—	C	S	M	(C)
3	S	(C)	C	C	C	(C)	C	M	(C)	C	S	S
4	C	C	S	C	(C)	C	(C)	M	S	C	S	S
5	C	S	C	(C)	C	S	C	C	S	C	S	C
6	S	S	(C)	C	C	M	S	C	S	(C)	C	C
7	(C)	S	C	S	(C)	S	S	C	S	S	(C)	C
8	C	S	(C)	C	S	(C)	C	(C)	S	S	C	(C)
9	C	S	C	(C)	C	C	(C)	C	S	S	C	C
10	S	(C)	C	S	C	C	S	S	(C)	C	(C)	S
11	S	C	S	S	C	S	C	C	S	(C)	C	C
12	(C)	C	S	S	M	C	C	(C)	C	C	C	C
13	C	S	C	C	M	(C)	S	C	C	S	C	(C)
14	(C)	(C)	C	(C)	S	C	S	(C)	(C)	S	C	S
15	S	S	C	C	S	S	S	S	S	C	(C)	S
16	S	S	(C)	C	(C)	M	C	S	S	(C)	S	S
17	C	S	C	S	S	C	C	C	C	C	S	S
18	C	(C)	C	S	S	S	(C)	S	C	C	C	C
19	(C)	C	C	S	S	C	C	(C)	C	(C)	C	S
20	C	C	S	C	C	C	S	S	(C)	C	(C)	S
21	C	C	C	C	C	C	(C)	S	C	S	C	C
22	S	C	(C)	(C)	(C)	(C)	C	S	C	S	S	C
23	C	C	C	C	C	C	C	C	C	S	C	C
24	C	S	(C)	C	S	C	C	C	C	(C)	(C)	(C)
25	S	S	C	S	C	C	C	(C)	M	S	--	C
26	C	C	S	C	(C)	S	(C)	C	C	S	—	S
27	(C)	(C)	C	(C)	S	S	S	C	C	S	C	S
28	M	C	C	C	S	C	S	C	(C)	S	C	(C)
29	S	C	C	S	S	(C)	C	S	C	S	C	S
30	S	...	C	C	C	C	C	S	S	C	C	C
31	S	...	C	...	C	...	C	C	...	C	...	C
G.	17	17	26	19	18	21	21	19	19	17	21	18
S.	13	12	5	10	11	7	10	9	10	14	6	13
M.	1	...	...	1	2	2	...	2	1	...	1	...
G.	...	...	...	...	...	...	...	...	...	...	...	...
V. G.	...	...	...	...	...	...	...	...	...	...	...	...

The magnitudes of disturbances are taken from the H. F. traces. ( ) = selected quiet day. C = calm.. M = moderate. G = great. V. G. = very great — traces lost.

The statement of loss of magnetograph record at Barrackpore during the year 1904.

Horizontal Force.					Declination.					Remarks.
From	On	To	On	Period of break.	From	On	To	On	Period of break.	
H. M.		H. M.		H. M.	H. M.		H. M.		H. M.	
10 32	9th March	14 0	9th March	3 28	10 32	9th March	10 32	11th March	48 0	Paper exposed.
10 32	10th "	14 0	10th "	3 28	...	...	...	...	...	Paper exposed.
23 0	25th April	1 15	26th April	2 15	...	...	...	...	...	Film spoilt.
1 37	2nd Aug.	9 14	2nd Aug.	7 37	1 37	2nd Aug.	9 14	2nd Aug.	7 37	The clock failed.
17 8	25th Nov.	7 17	26th Nov.	14 19	...	...	...	...	...	The Lamp failed.
Total	...	...	...	31 7	...	...	...	...	55 37	

TOUNGOO MAGNETIC OBSERVATORY.

Site.

32. The circumstances which necessitated the abandonment of the observatory already built at Rangoon and the selection of a site for a new building at Toungoo were fully detailed in the last report.

The new observatory is situated on the south side of the old parade ground at Toungoo and about 100 yards south-west of the buildings formerly used as a hospital for British Infantry.

The experience of the past year has shown the site to be exceptionally healthy.

Description of the buildings.

33. The observatory consists of the following buildings:—

(*a*) The magnetograph house with which is combined the dark room.
(*b*) The absolute house.
(*c*) Lamp and oil godown.
(*d*) Observer's quarters.
(*e*) Recorder's quarters.

The magnetograph and absolute houses have been modelled on the plan of the similar buildings at Barrackpore described in the report for 1902-03 with some minor differences of detail.

The magnetograph house.

As it was found difficult in the magnetograph room at Barrackpore to keep the annual range of temperature as small as was desired, extra precautions to this end were taken at Toungoo. The walls of the instrument room were therefore made double, the interior being packed with saw-dust, while a verandah of wood framing filled in with bamboo matting runs all round the building whereby it is screened from direct sunshine.

The dimensions of the interior room are 20′ × 15′, the walls and roof of this room being 4″ thick and packed saw dust. All round this room runs a 2′ 6″ passage, the outer walls of which are double, 18″ thick in all and with sawdust packed as above. The flat roof of this passage is of similar construction, the airs pace over the roof of the instrument room being 2 feet.

The verandah is 6′ 9″ wide and a third roof of timber framing, with Willesden rot-proof canvas on boarding covers the whole; the pitch of this roof s ½. Into the air space between this outer roof and the flat roof over the passage and instrument chamber emerge the ends of the zinc ventilators, nine in all, of which five are connected with the instrument chamber and four with the passage. These ventilators are provided with caps, so that any or all can be shut off at will.

The entrance is on the north side and gives access to a vestibule, on the east side of which is the dark room and on the south the door giving access to the passage and thence to the instrument room.

The flooring is of teak planking on 2 feet of rammed sand resting on 6 inches of concrete.

Pillars for the vertical force instrument indented for but not yet received have been built in addition to those required for the H. F. and declination instruments.

The absolute house.

The absolute house is about 40 yards south-west of the magnetograph house. It is a simple rectangular structure of teak and pyingado framing supported on blocks of concrete. The walls are double and packed with saw dust.

There are two observing pillars, both being solid teak blocks on concrete pillars; of these the south pillar is reserved for force and declination observations, the north for dip.

34. The referring mark is embedded in a masonry pillar about 200 yards north of the absolute house, arrangements are provided for illuminating it at night and the pillar is also provided with grooves to take a theodolite for star observations.

The referring mark.

Observations are taken for time to E. and W. stars once or twice a week to correct and rate the chronometers. The azimuth of the referring mark was determined by observations to Polaris from the north pillar with a 6" micrometer theodolite. The mean of several sets on different nights by two observers gave the azimuth reckoned westwards from south as 181°—7′—42″.

The south pillar is exactly on the line joining the R. M. and north pillar.

The latitude and longitude of the observatory taken from a reliable map are—

Latitude 18°—55′—45″ N.

Longitude 96°—27′— 3″ E.

The longitude is referrable to that of Madras taken at its latest value, *viz.*, 80°—14′—47″ East.

35. The instruments at present installed are horizontal force and declination magnetographs of the pattern designed by Professor Watson, F.R.S., and made by the Cambridge Scientific Instrument Company.

Installation of the instruments.

They are similar to those already working at Dehra Dun, Kodaikanal and Barrackpore with the addition of an alternative gearing by which, when required, the drums may be made completely to rotate in 8 hours instead of the usual 24.

The instruments were erected by Major Fraser, R.E., assisted by Lieutenant Thomas and K. K. Dutta, the observer appointed to hold charge of the observatory. A commencement was made on November 25th, 1904, and after various trials for focus the instruments were ready for fair work on December 4th.

It was found that the definition was improved by fixing circular stops with an aperture equivalent to a square of $_8$ side in front of the circular lens.

The deflection distance for the H. F. instrument and the scale value of the declination magnetograph were found in the manner described in the report for 1901-02. The deflection distance in the H. F. instrument proved to be

100·23 c.m.s.

The scale value in the declination instrument was found to be 62″·1 for a scale division of $\frac{1}{25}$ inch.

36. As the temperature co-efficient of the magnet system of this instrument had not been previously determined, experiments to this end were carried out immediately the instruments were ready for fair work.

Determination of temperature co-efficient.

Three magnetometers were used to record the actual changes in the magnetic elements, two being used for H. F. and one for declination. Three separate experiments were made and a preliminary reduction of the first of these gave a probable value of—4·71 per + 1° Fahrenheit.

L

The latter portion, however, of this experiment gave results considerably differing from the above, the reason for which was at the time obscure; but after the lapse of some weeks it became obvious that the H. F. magnet was losing moment rapidly, which with a possible slight giving away of the fibre, would account for the discordant results.

As further experiments for determining the temperature co-efficient are to be carried out in the ensuing cold weather, a description of the method employed is held over until the next report.

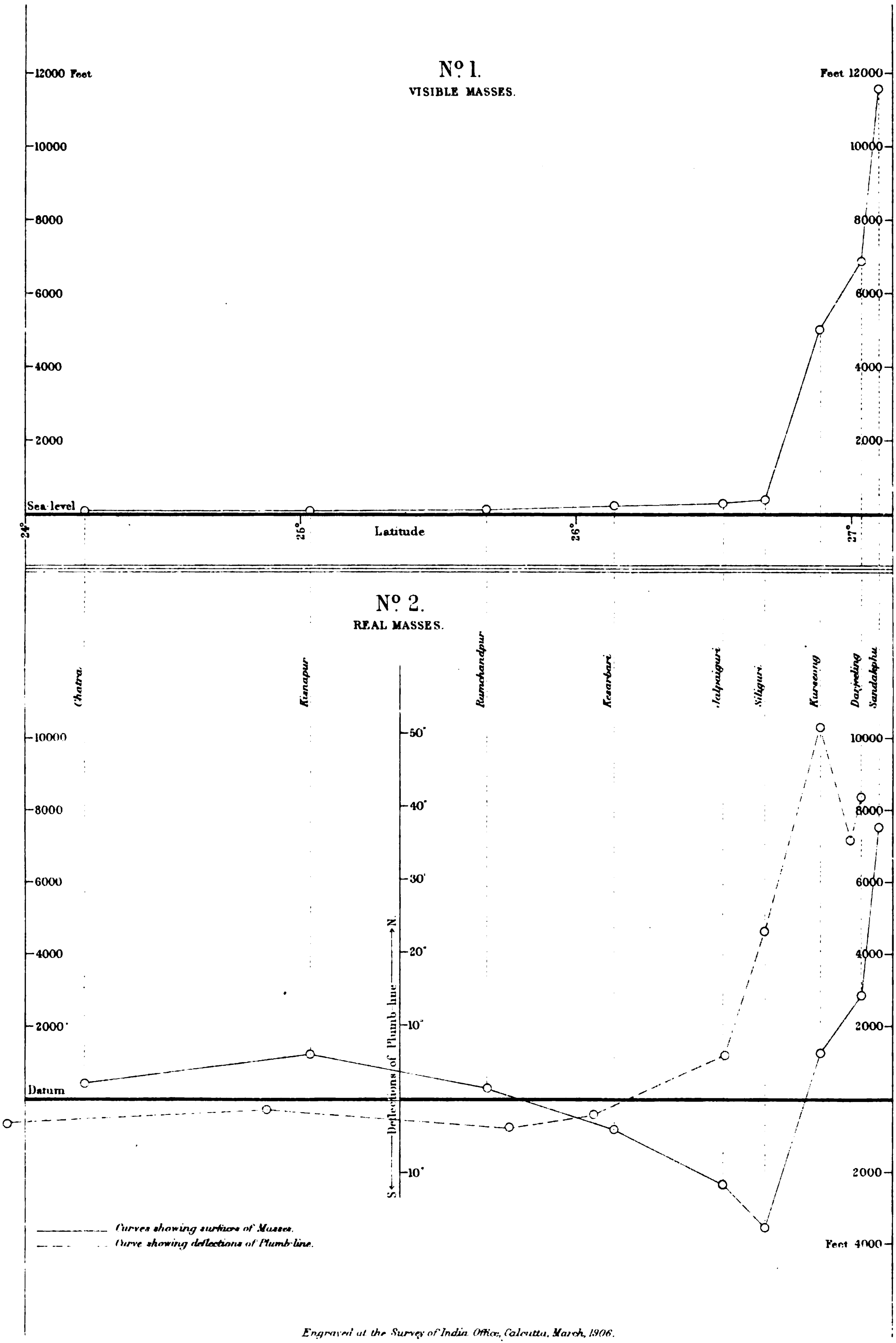
Behaviour of the instruments during 1905.

37. The declination instrument gave good results throughout the year, but the horizontal force instrument was extremely unsatisfactory. The loss of moment continued to be very rapid and it was necessary in consequence to give orders to the observer to read just by means of the torsion head whenever the trace began to approach the base line. The readjustment had to be carried out as often as two or three times in a month and for the tabulations it will be necessary to often use base line values derived from single observation. The observer was ordered therefore to take observations for vibration or deflection five days each week to supplement the complete determinations taken twice per week.

Using the mean value of M_0 base line values will in this way be available for each day of the month. Major Fraser while in England consulted Professor Watson on the subject who recommended that the magnet should be "aged" by keeping it immersed in boiling water for a period not less than 48 hours The officer in charge visited Toungoo in August 1905 and carried out this work. Matters were much improved, but soon afterwards signs of interference were noticeable and it will be necessary to reopen the instrument in the working season.

38. The instruments have given very good traces throughout: the tabulations for 1905 are now in hand and will be published in the next report.

DIAGRAMS
ILLUSTRATING THE RESULTS OF
PENDULUM OBSERVATIONS IN BENGAL.



Engraved at the Survey of India Office, Calcutta, March, 1906.

II

THE PENDULUM OPERATIONS.

Extracted from the Narrative Report of Major G. P. Lenox Conyngham, R.E., in charge No. 23 Party (Pendulum) for Season 1904-05.

1. During the season 1904-05 the party was engaged in making pendulum observations at stations extending from Cuttack in Orissa to the hills beyond Darjeeling.

The programme of work.

Captain Cowie's latitude observations, made in 1901-02, revealed the fact that the deflection of the plumb line varies in a very peculiar way as we pass across the great alluvial plains of the Ganges, enter the terai country and then commence to ascend the outer ranges of the Himalayas. From latitude 24° to 26°, that is from a little south of Moorshidabad to a point some 25 miles north of Dinajpur, the plumb line is deflected to the south, then at Jalpaiguri a small northerly deflection of 6″ is found, which increases to 23″ at Siliguri and to 51″ at Kurseong. The persistence of the southerly deflections for such a long distance and then their sudden disappearance, succeeded by the immensely rapid rise of the northerly deflections, presented a very perplexing problem and it was thought that no more interesting theatre of operations could be selected for the first regular season of work with the new pendulum apparatus.

In accordance with the wishes expressed by the International Geodetic Association, at the conference held in Copenhagen in 1903, it was decided to include in the programme some stations in the hills and the list of stations ultimately decided upon was as follows:—

	Latitude. ° ′ ″	Longitude. ° ′ ″	Height. Feet.
1. Cuttack	20 29 5	85 54 28	92
2. Chatra	24 12 40	88 25 54	64
3. Kisnapur	25 2 26	88 30 56	113
4. Ramchandpur . . .	25 40 57	88 35 25	132
5. Kesarbari	26 7 41	88 33 53	204
6. Jalpaiguri	26 31 16	88 46 40	268
7. Siliguri	26 41 46·6	88 27 17·5	387
8. Kurseong	26 52 51	88 19 12	4,915
9. Darjeeling	27 2 47	88 13 35	6,966
10. Sandakphú	27 6 6	88 2 42	11,766

Stations 2 to 5 belong to the Calcutta Meridianal Series; they are not identical with those visited by Captain Cowie but are distributed over the same region.

Hitherto no pendulum observations had been taken, except in houses, and it was now necessary to provide means of doing so at places where no buildings would be available. A good single poled tent was obtained for this purpose and arrangements were made for the erection, inside it, of a sort of hut made of bamboos and ruberoid. It was hoped that the ruberoid would entirely protect the apparatus from the Sun's radiation and would go some way towards preventing rapid changes of temperature.

2. A variable temperature is extremely prejudicial to pendulum work, for two reasons; the first is that even the most

Effect of variable temperature.

carefully compensated clock is not perfect, and is sure to be affected to some extent; and the second, and more important, is that it is almost impossible to find out what the temperature of the pendulum's stem is at any instant, unless the temperature of the surrounding air is steady and has been so for some time. A small error in the estimation of the temperature of the stem has a large effect on the deduced time of vibration, and therefore observations taken in places where the temperature conditions are unfavourable, can never attain a very high precision.

At Cuttack, Jalpaiguri, Siliguri, Kurseong, Darjeeling and Sandakphú, buildings more or less suitable were available, but at the other four the tent had to be used. At the first two stations, Chatra and Kisnapur, I was dissatisfied with the temperature conditions and determined to try to improve them, consequently at Kesarbari a hut of bamboo mats and grass was built inside the tent and inside this again the ruberoid was put up. There was an improvement in the steadiness of the temperature but the test was not very searching as at this station the weather was very wet and cloudy almost the whole time. At Ramchandpur I had a more substantial hut of bamboos, grass and mud plaster, erected under a mango tree, and only used part of the tent as a protection from rain; the results were fair but by no means altogether satisfactory.

Measures to counteract the effects of variable temperature.

3. In order to make the most of the observations taken under these adverse conditions, I made complete series of swings under the same conditions at Dehra Dun, both before starting for the field and after my return; these were in addition to those taken in the new pendulum room, which had been got ready during the summer of 1904.

These double sets of observations put us in possession of two advantages. We are able by comparing the results obtained in the tent at Dehra with those obtained in the tent elsewhere, to obtain a value of the difference in *g* which is to some extent free from the uncertainty caused by a varying temperature; for the conditions being nearly the same at both places the errors in the times of vibration will probably be of the same sign and of the same order of magnitude at each, and they will therefore be at least partially eliminated from the ifference.

The lag correction.

4. Further, by a comparison between the observations made at Dehra in the tent and the room respectively, we may estimate the effect of a varying temperature, and assuming it to be due to the pendulums not taking up the temperature of the air so rapidly as the thermometers, we may express this as a "lag" correction, depending on the rate at which the temperature is changing, and may compute its value at each station.

A lag correction was employed last year, but its value was taken from some experiments made in Germany with a similar but not identical apparatus, as I had no observations of my own from which to derive it. The evidence I now have indicates that the value I used was too small, and this agrees with my expectations, for in the German experiments the thermometer's bulb was inserted in a dummy pendulum, whereas mine was not enclosed in any way, so that it was natural to suppose that the difference between the temperature of the pendulum and that indicated by the thermometer would be greater in the latter case than in the former. The result of the German experiments was to show that if the temperatures were changing at the rate of 1° per hour the lag would amount to about $0^{\circ}.5$, and my result is that the lag, under the same circumstances, will be about $0^{\circ}.8$.

Visit of Dr. Hecker.

5. An important incident of the season was the arrival in India of Professor Dr. Hecker, of the Prussian Geodetic Institute, who had been making several long voyages in order to determine the value of *g* in mid-ocean, by means of comparisons between the height of the column of mercury in a barometer and the pressure of the air as measured by hypsometers. Besides the apparatus for effecting these comparisons with the necessary precision, the Professor carried with him a complete pendulum equipment, and had made series of observations at several seaports at which he had touched.

Some months earlier Professor Helmert had written to point out the great advantages that would be gained if Dr. Hecker were to swing his pendulums at one of our stations, and we were prepared to do all we could to assist him in the matter. Eventually, Dr. Hecker asked to be allowed to join me in camp and to swing his pendulums alongside of mine, using the same clock and time observations, so as to render the deduced times of vibration strictly comparable.

When Dr. Hecker arrived in Calcutta I was at Kisnapur, a place far from any railway, so I suggested that he should join me at Jalpaiguri, which would be easy for him to reach and where we should enjoy the advantage of being able to make our observations in a room.

I arrived at Jalpaiguri on January 29th in the morning and Dr. Hecker arrived the same evening.

The wagon with the instruments had missed connection on the way from Dinajpur and did not arrive till the following day. Dr. Hecker was eager to begin the observations, so having got the pillars built on Monday, the 30th, we commenced work on Tuesday, though the cement in the pillars was far from dry.

Effect of freshly built pillar.

6. The objection to this is that as the cement hardens the yielding of the pillar under the influence of the oscillating pendulum becomes less and less, and the wag correction continually decreases. This decrease is probably not proportional to the time, so that it is not sufficient to determine the wag at the beginning and at the end and then interpolate between the values obtained. If it were possible to ascertain the amount of the wag during the observations, as one ascertains the temperature by reading the thermometers, no difficulty would arise; but a determination of wag is a long business which takes not less than an hour and involves the employment of a special apparatus, so that it cannot be undertaken very often. In the following table the times at which I made determinations and their results are shown :—

Date.	Time.	Number of observations.	Deduced correction.
January 31st	6 P.M.	2	$53{\cdot}2 \times 10^{-7}$ s
February 1st	6-15 P.M.	2	44·1
February 2nd	3-30 P.M.	2	44·3
February 3rd	6-15 P.M.	2	41·6

By plotting these values and drawing a smooth curve to represent more exactly the actual decrease from hour to hour, I obtained the following values for the correction to be applied to each set of observed times of vibration:—

January 31st evening	50
February 1st morning	46
„ 1st evening	44
„ 2nd morning	44
„ 2nd evening	43
„ 3rd morning	42

Dr. Hecker made observations at about the same times, but I do not yet know what results he obtained.

Connection with Potsdam.

7. It was not Dr. Hecker's intention to make any further series of observations until he reached Potsdam; there is therefore good hope that his pendulums will have retained their lengths satisfactorily and that we shall thus obtain a good value of the difference in g at Potsdam and Jalpaiguri, and so, through the Indian pendulums, between Potsdam and Dehra Dun. This will afford a valuable check on the value of g at Dehra Dun which was deduced from the Kew-Dehra observations made in 1903-04.

The remaining observations in the plains call for little comment; they were a good deal interfered with by clouds and rain but were otherwise uneventful. The country through which we had to march was easy and uninteresting, though the astonishing badness of the roads in Bengal was an unending source of wonder.

Observations at Darjeeling and Kurseong.

8. After finishing work at Siliguri I went up to Darjeeling in order to take advantage of the offer of a room in the Secretariat Building for the pendulums, which only held good up to the date of the return of the Local Government from the plains and for which I might have been too late had I gone to Kurseong first, as would have been the natural course.

The observations both at Darjeeling and Kurseong were accomplished without incident and the latter came to a conclusion on April 1st.

Observations at Sandakphú.

9. Attention had now to be turned to the more difficult business of Sandakphú. The severe and late winter had been accompanied by much heavier snow than usual, and in consequence the Nepal Frontier Road was impassable, except for lightly laden coolies, up to a late date. Most of the time that I was observing at Darjeeling, the whole of the Sandakphú ridge was covered with snow, and to carry the pendulum equipment through snow drifts is not an operation to be contemplated without anxiety. However, the weather improved somewhat while I was at Kurseong, and the day after I finished the observations there the Advance Party was able to set out from Ghoom. I followed a week later and reached Sandakphú in three marches. The weather was cold and misty, and though the instruments were ready by sunset on the day of my arrival, it was impossible to obtain any star observations.

At night there was a storm with high wind, but a fine morning followed, giving a magnificent view of the snowy ranges. In the evening clouds came up again, and I feared that another night was going to be lost. However, at about 10 P.M. there was an improvement, and my assistant Babu Hanuman Prasad succeeded in getting a very fair number of observations between that hour and midnight, sufficient to enable me to begin the pendulum work, and the first set of swings was therefore made between midnight and 4 A.M.

The next morning was again cloudy and very cold, but at night it became clearer and a very fair programme of stars was observed between 7 and 9. We had thus one complete determination of the time of vibration to our credit. The pendulum swings were continued that evening and next morning, and all was going on satisfactorily, when at about 4 P.M., a very severe thunderstorm accompanied by high wind and heavy snow came on. I had serious fears for the observatory tent and the men had a trying time taking care of it.

Inclement weather.

Babu Hanuman Prasad made every effort to obtain some stars, remaining at his post in the bitter cold till 2 A.M., but without success. There were occasional rifts in the clouds, but they closed up too quickly to allow of their being turned to account. During this time I was, of course, continuing the pendulum observations and went on with them again next morning. The clouds and mist had not cleared away, and the outlook was far from cheering. Only occasional glimpses of the distance could be obtained, but as far as could be made out the snow was local, for Tonglu did not seem to have any on it, and Phallut no more than before.

In the late afternoon, between about 5 and 7 o'clock there was another furious snowstorm and there seemed no prospect of star observations. However, the sky cleared at about 8 o'clock, and although there was still a hurricane of wind, driving the powdery snow round and into the observatory, Babu Hanuman Prasad and his recorder, Sub-surveyor, F. Kerr, did not give in, and succeeded in obtaining transits of eight zenithal and three circumpolar stars which I considered sufficient to give a good value of the clock error and to justify me in bringing the observations to an end.

To make trustworthy time observations under such conditions is quite impossible, except with a large instrument, erected in a semi-permanent manner on a masonry pillar, and with an electric chronograph for recording the transits; so that although the cumbrousness of the equipment seemed appalling when the coolies for its transport were being engaged, it nevertheless vindicated itself from the charge of being a useless burden, for I do not think that with a light portable instrument satisfactory time determinations could have been made on any of the six nights of our stay at Sandakphú.

Value of large instruments.

Next day the instruments were packed and on the day after that the return march began. It was accomplished without mishap or incident.

There remained only the closing observations in Dehra Dun, and after completing them the party returned to recess quarters.

Closing observations at Dehra Dun.

10. During the recess the formidable task of computing the orographical corrections for the stations in the hills had to be undertaken. Last year owing to unfamiliarity with all the computations, and to the fact that the Kew and Greenwich observations had also to be gone into with great care, there was not time to carry out the computations of the orographical corrections for the two Mussorie stations, and these had therefore to be done besides those for the stations visited this year, *viz.*, Siliguri, Kurseong, Darjeeling and Sandakphú.

The orographical correction.

Captain Basevi's admirable treatment of the surroundings of Mussoorie with Colonel Herschel's discussion of the method, was taken as a general guide but several important simplifications were made, for the most part in accordance with suggestions made by Professor Helmert in "Die höhere Geodäsie" or in "Die Schwerkraft im Hochgebirge."

In Volume V of the "Account of the operations of the Great Trigonometrical Survey of India" Captain Basevi computed the attraction of the whole mass from sea-level upwards, but on page [187] it is pointed out that it is convenient to subtract this from the attraction of an infinite plain, of a thickness equal to the height of the station above sea-level, and to use this defect due to "inequality of surface" as a secondary correction. The defect due to the inequality of surface is what is now called the orographical correction. We do not now, however, compute the attraction of the existing masses, but only that of the difference between the existing masses and the imaginary infinite plain. Thus obtaining immediately the defect due to inequality.

Simplification of the computation.

The great advantage of this is that when we divide the region surrounding the station into cylindrical zones by a series of concentric circles, the station is at the same level as the upper surface of each of these cylinders of defect, whereas if the actual masses are being dealt with, the height of the station above the surface of the cylinders is variable. This uniformity of position leads to a very material simplification of the formula expressing the attraction.

Restriction of area.

11. I have not taken into account so large a region as Captain Basevi did, but have confined the detailed enquiry within a radius of 35 miles. My reasons for this were twofold. The first is that, in the case of all the hill stations I have so far had to deal with, long before a radius of 35 miles is reached, we pass beyond the limits of all existing maps of a sufficiently accurate character to give heights which are worth using in such a calculation. To guess at the mean height of a piece of ground, say, 5 miles square with nothing to guide one except the heights of one or two peaks situated perhaps 10, perhaps 30 miles away, is an exceedingly disheartening and futile business.

The second reason for restricting the radius is that the effect of zones beyond 35 miles is small. Take, for instance, Mussoorie, here the effect of the zone contained between radii of 20 and 25 miles is 0·00043 c.m., of that between 25 and 30 miles 0·00032 c.m., and of that between 30 and 35 miles 0·00019 c.m. Now, as we extend the radii, the character of the compartments of which the zones are composed will not change very much; the southern halves of the zones will all lie in the plains, the northern compartments among the higher ranges, and the eastern and western among the outer hills. Thus there will be no great increase in the effects of the zones because of changes in their mean height, and there will be a continual decrease on account of their increasing distance from the centre. This decrease is proportional to the decrease in the difference between the reciprocals of the radii. For the 30—35 miles zone this difference is 0·0047, for the 35—40 miles zone 0·0036, for the 40—45 miles zone 0·0028, for the 45—50 miles zone 0·0022 and so on. Therefore a rough approximation to the effect of a zone 15 miles wide between the 35 and 50 miles radii, would be

$$\overset{\text{c.m.}}{0{\cdot}00019} \times \left(\frac{{\cdot}0036 + {\cdot}0028 + {\cdot}0022}{{\cdot}0047}\right)$$
$$= 0{\cdot}00019 \times 1{\cdot}62$$
$$= 0{\cdot}00031$$

But a better way of examining the matter is as follows:—

Let us assume that as we increase the radii of the zones the mean heights of the compartments of which they are composed remain the same, then in order to find the widths of zones which shall have the same effect as that between the 30 and 35 miles radii, we must make the difference between the reciprocals of the successive pairs of radii constant, thus we obtain the following series of radii 35, 42, 52, 69, 102, 196, 2,500.

Thus by stopping at 35 miles we have neglected 5 zones each of which would have an effect of about 0·00019 c.m. or in the aggregate 0·00095 c.m.

Case of Sandakphú.

The same figures apply to Kurseong and Darjeeling with very little change, but at Sandakphú the case is somewhat different on account of the very large differences between the height of the station and the heights of the southern compartments in the plains on the one hand, and the heights of the tremendous snowy ranges to the north on the other.

The effect of the 30—35 miles zone is here 0·00095 so that to neglect 5 outer zones of equal effect would be to cause an error in the value of g reduced to sea-level of 0·005 c.m.

I have therefore increased the computed orographical correction at this station by 0·005. This is of course merely an estimate, but as Sandakphú is within a few yards of the Nepal Boundary, and as no trustworthy maps of that country are to be had, the heights of the compartments in a large portion of the circumference of the zones, even quite near the station, are merely guesses, and therefore the inclusion of a quantity, such as the above, is not inadmissible.

It would take too long to discuss the whole question of the computation of the orographical correction, and enough has now been said to explain the more important departures from the procedure explained in Volume V.

Results of the season's work.

12. I now turn to the results of the season's work and the connection between them and the deflection of the plumbline.

The observations at the Base station, Dehra Dun, must first be considered. They are shown in the following table :—

Date.	Time of vibration of mean pendulum.	
	New Pendulum Room.	Field Station Tent.
	sec	sec
November 1904	0·5072523	0·5072518
May 1905	0·5072510	0·5072510
Mean .	0·5072517	0·5072514

All the above times of vibration have received corrections for lag of temperature.

There is evidence of an appreciable change in the length of the mean pendulum, which is disquieting; a careful examination of the differences between the individual pendulums and the mean pendulum has been made in order to see whether this change could be ascribed to any particular pendulum or was the result of a slow diminution of length affecting all equally. It appears that the latter is what took place for the differences between each pendulum and the mean remains very fairly constant throughout the season. It is impossible to say whether the change took place gradually or more or less suddenly. The idea that at first occurs is that it may have been a consequence of the large variations of temperature to which the pendulums were exposed when carried from the plains to Sandakphú (11,800 feet high) and back, and afterwards on the long railway journey to Dehra Dun.*

But there is no evidence, and I have thought it better to use a simple mean of the two values obtained in the pendulum room, rather than to make an elaborate interpolation based on some conjectural hypothesis.

13. In the next table the time of vibration at each station is compared with that at Dehra and the value of *g* deduced. At Dehra *g* is taken to be 979·065 c.m. which was the result of the determination of the difference between Dehra and Kew made in 1903-04, assuming *g* at Kew to be 981·200. The times of vibration obtained at stations where no house was available have also been compared with those obtained in the tent at Dehra, no lag correction being applied to either:—

Station.	Final results.		Results obtained where no house was available. Lag correction not applied.	
	Time of vibration in room.	*g*	Time of vibration in tent.	*g*
	s.	c.m.	s.	c.m.
Dehra Dun	0·5072517	979·065	0·5072503	979·065
Cuttack	3559	978·663	3554	978·659
Chatra	2996	978·880	2983	978·880
Kisnapur	2793	978·958	2780	978·958
Ramchandpur	2759	978·972	2754	978·958
Kesarbari	2803	978·955	2794	978·953
Jalpaiguri	2881	978·924		
Siliguri	2971	978·890		
Kurseong	3649	978·628		
Darjeeling	3974	978·503		
Sandakphú	4777	978·193		

The constant of the lag correction was deduced from the observations at Dehra Dun only, and it is satisfactory to notice that at the two stations, Chatra and Kisnapur, where the tent was arranged in exactly the same way as it had been at Dehra, the same result is obtained whether we correct the observation for lag and compare it with the value obtained in the pendulum room or omit the lag and compare it with the value obtained at Dehra in the tent. At Kesarbari, as has been mentioned already, the protection afforded by the tent was slightly supplemented by bamboo mats, and here we find a difference of ·002 in the two values of *g*. At Cuttack there was a sort of shed with fairly good walls and roof but with ill-fitting shutters to the windows and with a good deal of open space at the eaves; and at Ramchandpur there was a hut made of bamboos, thatch and mud plaster, at both these places therefore the conditions were appreciably different from those in the tentand we find a discordance of 0·004 between the two values of *g*. This shows the necessity for a lag correction

* I always take the pendulums in the carriage with me on railway journeys, they are never put into the goods van with the rest of the equipment.

unless it is possible to take all the observations under the same conditions; and the agreement between the two values of g at Chatra and Kisnapur show, I think, that the adopted constant is not very far from the truth.

Having now obtained the value of g at each of the stations, the next process is to reduce to sea-level and to compare the results with the theoretical value computed by Helmert's formula, *viz.*:—

$$\gamma_0 = 978{\cdot}00\ (1 + {\cdot}005310 \sin^2 \phi)$$

which gives the normal force of gravity at sea-level at a place in latitude ϕ

REDUCTION TO SEA-LEVEL.

Station.	Height.	g	$g\frac{2}{R}$	$\frac{3}{4}\frac{h}{R}$	Oro-graphical. correction.	g reduced to sea-level $= g_0''$.
	Feet.	c.m.	c.m.	c.m	c.m.	c.m.
Cuttack . .	92	978·663	+·009	—·003	0	978·669
Chatra . . .	64	·873	+·006	—·002	0	·884
Kisnapur . .	113	·958	+·011	—·004	0	·965
Ramchandpur .	132	·972	+·013	—·005	0	·980
Kesarbari . .	204	·955	+·019	—·007	0	·967
Jalpaiguri . .	268	·924	+·025	—·009	0	·940
Siliguri . .	387	·890	+·036	—·014	+·001	·913
Kurseong . .	4,915	·628	+·400	—·173	+·017	·932
Darjeeling . .	6,966	·503	+·646	—·242	+·024	·931
Sandakphú . .	11,766	·193	+1·096	—·411	+·053	·931

Comparison with Theoretical value.

Station.	Latitude.	γ_0	g_0''	$g_0'' - \gamma_0$.	Thickness of corresponding disc of density 2·8.
	° ′ ″	c.m	c.m,	c.m.	feet.
Cuttack . . .	20 29 5	978·636	978·669	+·033	940
Chatra . . .	24 12 40	·873	·884	+·011	310
Kisnapur . . .	25 2 26	·930	·965	+·035	1,000
Ramchandpur . .	25 40 57	·975	·980	+·005	140
Kesarbari . .	26 7 41	979·007	·967	—·040	1,140
Jalpaiguri . .	26 31 16	·035	·940	—·095	2,700
Siliguri . . .	26 41 47	·048	·913	—·135	3,840
Kurseong . .	26 52 51	·062	·932	—·130	3,700
Darjeeling . .	27 2 47	·074	·931	—·143	4,070
Sandakphú . . .	27 6 6	·078	·931	—·147	4,180

In computing the several quantities required in the reduction to sea-level all masses lying above the level of the sea have in the first instance been assumed to have a density of 2·8, and the figures in the last column of the second table give the thickness of a disc of this density, which would suffice to produce the excess of the actual force of gravity over the normal force or *vice versâ*.

If therefore the masses were all of the density 2·8 the heights of the several stations above sea-level would be as follows:—

Station.	Height.	Thickness of corresponding disc of density 2·8.	Sum.
	Feet.	Feet.	Feet.
Cuttack	92	+940	1,032
Chatra	64	+310	374
Kisnapur	113	+1,000	1,113
Ramchandpur	132	+140	272
Kesarbari	204	−1,140	−936
Jalpaiguri	268	−2,700	−2,432
Siliguri	387	−3,840	−3,453
Kurseong	4,915	−3,700	+1,215
Darjeeling	6,966	−4,070	+2,896
Sandakphú	11,766	−4,180	+7,586

These figures show how extremely misleading an attempt to calculate deflections of the plumb line from the visible masses may be in country which has not been subjected to an examination by the pendulum.

14. In the accompanying diagrams these figures are shown graphically.

No. 1 is the projection of the profile of the actual surface of the ground on a meridian plane.

No. 2 shows the projection of the profile as it would be if all the rocks were brought to a uniform density of 2·8. The dotted line in this diagram indicates the deflection of the plumb line found by Captain Cowie in 1901-02.

It will be seen that the course of the rise and fall of the deflections is not by any means so unaccountable as it at first appeared.

The southerly deflections met with before the great dip at the foot of the hills is reached, do not seem so strange, nor does the extremely rapid rise of the northerly deflections after we have passed the lowest point of the dip and are climbing up the slopes.

It is noteworthy that the deficiency under the Himalayas is of fairly constant amount and does not materially increase with the height.

The position of the datum line depends on two factors, namely, the value of g at the base station and the constants employed in the formula for calculating γ. Supposing for instance that the value of g at Kew were found to be 981·300 instead 981·200, the datum line in the second diagram would be depressed by

2,840 feet and we should then regard the Himalayas as being of almost precisely normal density, but should conclude that the density of the strata at about latitude 25° was largely in excess of normal. Similarly if we suppose the formula for γ to be—

$$977 \cdot 900 \, (1 + \cdot 005310 \sin^2\phi)$$

instead of $978 \cdot 00 \, (1 + \cdot 005310 \sin^2\phi)$ the same effect would be produced.

Neither of the above suppositions is at all probable, but they are mentioned in order to show that we must exercise caution in considering the question of densities, as the pendulum observations by themselves are only capable of giving us information as to differences of density.

III

TIDAL AND LEVELLING OPERATIONS.

Extracted from the Narrative Report of Mr. J. P. Barker, in charge of No. 25 Party (Tidal and Levelling) for Season 1904-05.

Work of the year.

1. During the year tidal registrations were obtained by means of self-registering tide-gauges at nine observatories. The reduction by harmonic analysis of the observations of 1904 of 8 stations has been completed in the office at Dehra Dun. The tide-tables for Indian Ports for the year 1906 of 40 ports have been published in England and are now on their way to India. Data for the tide predictions for 1907 have been sent to England and for 1908 are in course of preparation.

List of Tidal Stations.

2. The following table gives a complete list of the 42 ports at which observations have been and are still being taken, 33 have been closed, 9 are still working. The permanent stations are shown in italics; the others are temporary stations at which only a few years' registrations are necessary.

	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	No. of years of observations.	Remarks.
1	Suez	Automatic	1897	1903	7	
2	Perim	Ditto	1898	1902	5	
3	*Aden*	Ditto	1879	Still working	25	
4	Maskat	Ditto	1893	1898	5	
5	Bushire	Ditto	1892	1901	8	
6	*Karachi*	Ditto	1881	Still working	24	
7	Hanstal	Ditto	1874	1875	1	Tide Tables not published.
8	Nowanagar	Ditto	1874	1875	1	
9	Okha point	Ditto	1874 re-started 1904	1875	1	
10	Porbandar	Personal	1893	1894	2	
10A	Porbandar	Automatic	1898	1902	5	With certain interruptions.
11	Port Albert Victor (Káthiáwádar).	Personal	1881	1882	1	
11A	Port Albert Victor (Káthiáwádar).	Automatic	1900	1903	4	
12	Bhavnagar	Ditto	1889	1894	5	
13	*Bombay (Apollo Bandar)*	Ditto	1878	Still working	27	
14	„ *(Prince's Dock)*	Ditto	1888	Ditto	17	Property of Port Trust.
15	Mormugâo (Gôa)	Ditto	1884	1889	5	
16	Karwar	Ditto	1878	1883	5	
17	Beypore	Ditto	1878	1884	6	

	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	No. of years of observations.	Remarks.
18	Cochin	Automatic	1886	1892	6	
19	Tutitcorin	Ditto	1888	1893	5	
20	Minicoy	Ditto	1891	1896	5	
21	Galle	Ditto	1884	1890	6	
22	Colombo	Ditto	1884	1890	6	
23	Trincomalee	Ditto	1890	1896	6	
24	Pamban Pass	Ditto	1878	1882	4	
25	Negapatam	Ditto	1881	1888	6	Year 1884-85 is excluded.
26	*Madras*	Ditto	1880 re-started 1895	1890 Still working	10 10 } 20	
27	Cocanada	Ditto	1886	1891	5	
28	Vizagapatam	Ditto	1879	1885	6	
29	False Point	Ditto	1881	1885	4	
30	Dublat (Saugor Island)	Ditto	1881	1886	5	
31	Diamond Harbour	Ditto	1881	1886	5	
32	*Kidderpore*	Ditto	1881	Still working	24	
33	Chittagong	Ditto	1886	1891	5	
34	Akyab	Ditto	1887	1892	5	
35	Diamond Island	Ditto	1895	1899	5	
36	Bassein (Burma)	Ditto	1902	1903	2	
37	Elephant Point	Ditto	1880 re-started 1884	1881 1888	1 5 } 6	
38	*Rangoon*	Ditto	1880	Still working	25	
39	Amherst	Ditto	1880	1886	6	
40	Moulmein	Ditto	1880	1886	6	
41	Mergui	Ditto	1889	1894	5	
42	*Port Blair*	Ditto	1880	Still working	25	

Observatories closed or opened during the year.

3. No observatory was closed or any new one opened during the yea .

In 1896 Mr. Belcham made an examination of the Isthmus of Kra between Burma and the Malay Peninsula just above Lat. 10° N. with a view to discovering suitable sites for tidal stations on each side of the Peninsula and a practicable route for spirit levelling, the object of the work being to test by means of a line of levels, connecting the two observatories, whether the mean level of the ocean was the same on both sides.

Mr. Belcham explored about 70 miles of country, his route being along a path from Victoria Point to Pakchan *viâ* Malewun and Bansonpan, 50 miles of which he found to be unsuitable for levelling of precision on account of hills and dense jungle; a distance of about 30 miles between Pakchan and Champawn point on the east coast, towards which Mr. Belcham was making, was left unexplored. Pakchan is on the border between Burma and Siam and the Siamese Government stopped Mr. Belcham's further progress, as he was not provided with the necessary passports. He therefore returned to Victoria

Point. A careful examination of the coast line from Victoria Point to Woody Island, a distance of about 10 miles, was made to discover a site for a tidal observatory, but no suitable site between these places could be found. The coast is exposed to the south-west monsoon and in some places the tide recedes for more than a mile from the coast. An observatory could be erected at Victoria Point, but Mr. Belcham reported that it was inaccessible. His reconnaissance therefore ended in failure. But the scheme has never been lost sight of. At the suggestion of Professor Darwin, the Malay Peninsula was again approached in 1904 with the same object as in 1896. This time lower down in about Lat. 6° N. Kedah on the west coast near Penang and Singora on the east coast, were, after much deliberation, thought to be the best places for tidal observatories. The road between seemed to be favourable for levelling of precision. Mr. H. G. Shaw was deputed to do the reconnaissance and his operations commenced at Kedah. He never reached Singora as he could not find a suitable site on the west coast. Mr. Shaw's report in full is as follows:—

"My instructions were to select a site for a tidal station near Kedah on the west and another near Singora on the east coast of the Malay Peninsula, and to reconnoitre the road joining the two observatories along which a line of levels of precision would have to be run.

"If no suitable site could be obtained in the vicinity of Kedah, I was to return to India.

"To ensure success the following conditions were absolutely necessary:—

(i) The sites of the tidal observatories must be on open coasts, exposed to the sea but sheltered from heavy weather, and on a suitable foreshore. The gauge should be so placed that there should be about five feet of water at low water springs conveniently close to the shore.

(ii) The line connecting the two observatories must be suited to first class levelling of precision and not be taken over hilly and swampy ground.

"Kedah (Alostar), the principal town of the Saiburi District, one of the Siamese Malay States, is situated about eight miles up the river of the same name. A tidal station at the town itself was therefore out of the question.

"I examined about 35 miles of the coast, 15 miles to the north, and 20 miles to the south of the Kedah river, and found that this stretch of coast line was fringed by a belt of mangrove swamps beyond which were paddy fields protected from the sea by a bund. It is a low-lying shore and is exposed to the full force of the south-west monsoons, the average rainfall about these parts being about 150 inches. I was informed that very rough weather is experienced during the south-west monsoons. The foreshore is muddy and shelving

"From observation and from soundings I took along the coast at springs, I ascertained that at low water springs the tide recedes several hundred feet from the shore leaving the foreshore more or less a mud flat, and that a sufficient depth of water, for the purpose of working the gauge, namely, about five feet at low water springs, is only obtainable at a distance from the shore of over 1,000 feet.

"Landing in small country boats drawing about a foot of water is possible only at high water springs, at places where there are small creeks.

"The conditions above mentioned rendered it absolutely impossible to find a site for a tidal observatory, and I therefore returned to Penang and thence to India.

"From what I saw I do not think it would be possible to establish a tidal observatory anywhere for about 6 miles up the Kedah river on account of extensive mangrove swamps on both banks. Between this point and Kedah it is probable a site could be found, but I do not think the river is deep, and I estimate its width to be about 300 feet. As the banks dry to some distance out at low tides, it would be necessary to have a pipe communication to deep water, and unless some arrangements were made for flushing the pipes fortnightly, probably more frequently at high waters, there would be innumerable interruptions in the tidal registrations, as the water in the Kedah river is very muddy.

"In comparison with the Hooghly and Rangoon rivers, the Kedah river would be considered a small stream. I was informed that the largest draught vessels (steam launches under 50 tons) plying on the river up to Kedah only, are those drawing between 6 to 7 feet of water. I was also informed that the Kedah river is subject to floods during the monsoons."

Consequent on these failures and the knowledge gained by information obtained from various reliable sources, that no suitable site for an observatory is to be found anywhere on the west coast, the scheme of erecting tidal observatories in the Malay Peninsula has been finally abandoned.

4. The Port Officer at Moulmein wishes to have the tidal observatory re-opened at that port, as he considers that personal observations taken to a tide-pole are unreliable. With this object he has placed the scheme before Government. This observatory was closed in 1886 after six years' observations had been obtained. In anticipation of the sanction of Government, steps are being taken to select a site and provide the necessary instruments.

5. Tidal observations taken at Aden and Suez between 1897 and 1903 disclosed peculiarities in the tides of the Red Sea, and this led to the question of having an observatory midway between, as it was thought that the results thus obtained would be of great value to science. Suakim was selected as the port for fresh operations, but owing to its inaccessibility, which rendered the annual inspection and erection of the observatory difficult to arrange for, the scheme has, up to the present, been allowed to lie dormant. Now that the Berber Suakim railway has reached a terminus on the coast, the project will be revived.

Personal tidal observations.

6. In addition to the automatic registrations made at the stations enumerated above, personal tidal observations to graduated staves were taken daily at the closed tidal stations of Bhavnagar, Chittagong, Akyab and Moulmein, with the object of comparing actual times and heights of high and low water with the predicted times and heights.

Inspection of observatories.

7. All the tidal observatories were inspected during the year.

Working of tidal observatories.

8. The following is a description of the working of the several tidal observatories during the year, commencing with Aden and following the order of the stations round the coast to Burma.

Aden.

9. *Aden.*—This observatory was inspected by Major Burn, R.E., in March 1905. There were several minor breaks in the tidal registrations due to the band

of the tide-gauge sticking. The auxiliary instruments have worked well throughout the year. Bench-mark B near the tidal observatory was found damaged. Bench-mark A in the Post Office verandah, which has hitherto been used as the Bench-mark of reference, has been rendered unsuitable, owing to the erection of a stamp vendor's cabin, the counter of which comes directly over the Bench-mark; it has therefore been abandoned. In lieu of these Bench-marks two others have been laid down, one on the west side of the Post Office pier, close to the observatory, and the other which has now been adopted as the Bench-mark of reference, in the verandah of the Port Engineer's Office.

Karachi.

10. *Karachi.*—This observatory was inspected by Surveyor Dhondu Vinayek in January 1905. There were a few short interruptions in the tidal curves due either to the stoppage of the driving clock or to faulty communication between the sea and cylinder of the gauge. There was only one short break in the registrations of the self-registering aneroid. The anemograph has been out of order since 22nd June last; it will be replaced by a new one at the next inspection. The small anemometer has worked well.

Okha Point.

11. *Okha Point.*—The tide gauge worked without a break from 20th March to 9th October 1904, when registrations were interrupted due to the flexible pipe being damaged. It was repaired and the gauge restarted on 13th October. On 6th November the tidal curves were again faulty and two days later the gauge stopped working. Surveyor Dhondu Vinayek was sent in December to report on the cause of the break down and to restart the gauge. He found that communication between the cylinder and sea was interrupted on account of the flexible pipe being damaged beyond repair. A new pipe had to be substituted when the tides were favourable; the gauge was restarted on 26th December 1904. There has since been no break in the tidal registrations. The auxiliary instruments have worked well during the year. It is intended to close this observatory early in January next. A line of levels will be run from Okha tidal station to Gadichi, a distance of about 10 miles inland. The data thus obtained from the tidal and levelling operations will be sufficient to determine whether any secular change has taken place in this vicinity during the past 30 years.

Bombay (Apollo Bandar).

12. *Bombay* (*Apollo Bandar*).—This observatory was inspected by Surveyor Dhondu Vinayek between 26th November and 1st December 1904. The tide-gauge was found to be in good working order, but very much in need of cleaning. There has been only one break of less than 24 hours in the tidal registrations during the year, when the stud wheel pin got loose and fell into the well, thus throwing the instrument out of gear. Major Burn visited the observatory in February 1905, and found the gauge in adjustment and in good working order.

Bombay (Prince's Dock).

13. *Bombay* (*Prince's Dock*).—This observatory was inspected by Surveyor Dhondu Vinayek between 26th and 29th January 1905. The tide-gauge was found working satisfactorily. There were five short interruptions in the registrations during the year, due either to the pencil breaking or to the sticking of the weight attached to the pencil. Major Burn visited this observatory in February 1905 and found the gauge working well.

Madras.

14. *Madras.*—This observatory was inspected by Mr. Shaw between 28th November and 3rd December 1904. The tide-gauge and auxiliary instruments worked well throughout the year.

Kidderpore.

15. *Kidderpore.*—This observatory was inspected by Major Burn and Mr. Shaw between 20th and 26th December 1904. The registrations by the tide-gauge are complete. The self-registering aneroid gave an uninterrupted record, but the driving clock was, during the whole period, steadily in advance of true time by 1 hour. The self-registering anemometer frequently got out of order; at the next inspection another will be set up in its place.

Rangoon.

16. *Rangoon.*—This observatory was inspected by Major Burn between 20th and 27th February 1905; there was only one break in the record of the self-registering tide-gauge during the year; this occurred on the morning of the 21st April when a cargo boat collided with the observatory doing considerable damage to the piles and bracings, the shock causing a disconnection of the float band from the stud wheel; the band was soon adjusted and the gauge restarted working satisfactorily after a break of 2¾ hours; the auxiliary instruments were not affected by the shock. The anemometer clock stopped on a few occasions and was out of order from 14th to 18th August. The aneroid worked well.

Port Blair.

17. *Port Blair.*—This observatory was inspected by Mr. Shaw in December 1904. During the past year the tide-gauge made an uninterrupted record. An interruption of 2 hours occurred in the registrations of the self-registering aneroid and was due to the clock stopping. On 19th November 1904, the velocity of wind registered by the anemometer was 1,112 miles, the greatest on record since 1st December 1897, on which day 918 miles was registered.

Tidal diagrams and daily reports.

18. The tidal, aneroid and anemometer diagrams and daily reports have been submitted regularly to the office at Dehra Dun.

Tidal constants.

19. The tidal observations for a year at 8 stations have been reduced and the tabulated values of the tidal constants thus derived are appended. There are no arrears.

VALUES OF THE TIDAL CONSTANTS, ADEN, 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Aden, and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

$A_0 = 5{\cdot}872$ feet.

S_1	H = R =	·083	M_6	R =	·006	Q_1	R =	·141	T_2	R =	·075
	κ = ζ =	170°· 46		ζ =	214°· 29		ζ =	119°· 16		ζ =	223°· 09
S_2	H = R =	·657		H =	·005		H =	·1 4		H =	·075
	κ = ζ =	242°· 31		κ =	333°· 99		κ =	29°· 27		κ =	224°· 78
S_4	H = R =	·011	M_8	R =	·001	L_2	R =	·019	$(MS)_4$	R =	·019
	κ = ζ =	254°· 93		ζ =	275°· 71		ζ =	66°· 48		ζ =	138°· 2y
S_6	H = R =	·006		H =	·001		H =	·020		H =	·019
	κ = ζ =	221°· 86		κ =	75°· 31		κ =	236°· 32		κ =	178° ·19

M

Short Period Tides—contd.

S_8	H = R = ·003	O_1	R = ·541	N_2	R = ·466	$(2SM)_2$	R = ·023
	κ = ζ = 265°·60		ζ = 183°·83		ζ = 122°·00		ζ = 166°·89
			H = ·669		H = ·450		H = ·022
			κ = 36°·36		κ = 219°·47		κ = 126°·99
M_1	R = ·067	K_1	R = 1·150	λ_2	R = ...	$2N_2$	R = ·106
	ζ = 142°·89		ζ = 206°·20		ζ = ...		ζ = 37°·19
	H = ·045		H = 1·302		H = ...		H = ·103
	κ = 60°·03		κ = 34°·75		κ = ...		κ = 192°·23
M_2	R = 1·624	K_2	R = ·132	ν_2	R = ·152	$(M_2N)_4$	R = ·010
	ζ = 185°·66		ζ = 36°·53		ζ = 224°·92		ζ = 91°·83
	H = 1·565		H = ·175		H = ·147		H = ·009
	κ = 225°·56		κ = 233°·83		κ = 247°·44		κ = 229°·20
M_3	R = ·022	P_1	R = ·416	μ_2	R = ·081	$(M_2K_1)_3$	R = ·032
	ζ = 334°·27		ζ = 221°·70		ζ = 106°·78		ζ = 84°·33
	H = ·021		H = ·416		H = ·075		H = ·035
	κ = 214°·12		κ = 32°·10		κ = 186°·58		κ = 312°·78
M_4	R = ·004	J_1	R = ·110	R_2	R =	$(2M_2K_1)_3$	R = ·005
	ζ = 211°·43		ζ = 276°·05		ζ = ...		ζ = 192°·41
	H = ·004		H = ·133		H = ...		H = ·006
	κ = 291°·23		κ = 45°·85		κ = ...		κ = 83°·66

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide	·062	55·86	·055	358·29
„ Fortnightly „	0·23	154·75	·037	309·58
Luni-Solar „ „	·009	171·13	·009	131·23
Solar-Annual „	·423	76·53	·423	356·13
„ Semi-Annual „	·062	346·01	·062	185·21

VALUES OF THE TIDAL CONSTANTS, KARACHI, 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Karachi, and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

$A_0 = 7·210$ feet.

S	H = R = ·090	M_6	R = ·050	Q_1	R = ·146	T_2	R = ·119
	κ = ζ = 178°·21		ζ = 78°·37		ζ = 130°·93		ζ = 295°·83
S_2	H = R = ·965		H = ·045		H = ·180		H = ·119
	κ = ζ = 322°·93		κ = 202°·53		κ = 43°·38		κ = 297°·58
S_4	H = R = ·007	M_8	R = ·005	L_2	R = ·060	$(MS)_4$	R = ·018
	κ = ζ = 352°·20		ζ = 348°·41		ζ = 148°·70		ζ = 240°·38
S_6	H = R = ·007		H = ·004		H = ·065		H = ·018
	κ = ζ = 285°·04		κ = 153°·96		κ = 319°·24		κ = 281°·76
S_8	H = R = ·002	O_1	R = ·543	N_2	R = ·666	$(2SM)_2$	R = ·013
	κ = ζ = 63°·44		ζ = 192°·85		ζ = 176°·99		ζ = 161°·02
			H = ·673		H = ·642		H = ·013
			κ = 46°·93		κ = 276°·74		κ = 119°·63
M_1	R = ·062	K_1	R = 1·171	λ_2	R = ...	$2N_2$	R = ·129
	ζ = 154°·51		ζ = 217°·74		ζ = ...		ζ = 97°·39
	H = ·041		H = 1·326		H = ...		H = ·124
	κ = 72°·39		κ = 46°·23		κ = ...		κ = 255°·51

Short Period Tides—contd.

M_2	R =	2·702	K_2	R =	·189	ν_2	R =	·212	$(M_2N)_4$	R =	·020
	ζ =	251°· 97		ζ =	118°· 49		ζ =	275°· 87		ζ =	215°· 57
	H =	2·605		H =	·252		H =	·204		H =	·019
	κ =	293°· 36		κ =	315°· 67		κ =	300°· 56		κ =	356°· 72
M_3	R =	·047	P_1	R =	·408	μ_2	R =	·072	$(M_2K_1)_3$	R =	·046
	ζ =	85°· 19		ζ =	231°· 73		ζ =	175°· 49		ζ =	136°· 92
	H =	·044		H =	·408		H =	·067		H =	·050
	κ =	327°· 28		κ =	42°· 19		κ =	258°· 27		κ =	6°· 80
M_4	R =	·012	J_1	R =	·116	R_2	R =	...	$(2M_2K_1)_3$	R =	·013
	ζ =	345°· 47		ζ =	291°· 44		ζ =	...		ζ =	32°· 57
	H =	·011		H =	·132		H =	...		H =	·014
	κ =	68°· 24		κ =	60°· 38		κ =	...		κ =	286°· 86

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide	·038	183·25	·034	124·88
„ Fortnightly „	·025	12·56	·040	165·78
Luni-Solar „ „	·038	107·69	·037	66·30
Solar-Annual „	·174	98·42	·174	17·95
„ Semi-Annual „	·054	327·26	·054	165·33

VALUES OF THE TIDAL CONSTANTS, BOMBAY (APOLLO BANDAR), 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Bombay (Apollo Bandar), and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

A_0 = 10·191 feet.

S_1	H = R =	·074	M_6	R =	·018	Q_1	R =	·142	T_2	R =	·178
	κ = ζ =	188°· 92		ζ =	265°· 41		ζ =	134°· 60		ζ =	341°· 52
S_2	H = R =	1·572		H =	·016		H =	·176		H =	·178
	κ = ζ =	4°· 16		κ =	30°· 77		κ =	47°· 68		κ =	343°· 30
S_4	H = R =	·026	M_8	R =	·010	L_2	R =	·032	$(MS)_4$	R =	·069
	κ = ζ =	259°· 38		ζ =	199°· 70		ζ =	154°· 89		ζ =	330°· 65
S_6	H = R =	·004		H =	·009		H =	·035		H =	·067
	κ = ζ =	103°· 33		κ =	6°· 84		κ =	325°· 60		κ =	12°· 44
S_8	H = R =	·002	O_1	R =	·532	N_2	R =	1·0[illegible]8	$(2MS)_6$	R =	·017
	κ = ζ =	119°· 75		ζ =	194°· 14		ζ =	214°· 45		ζ =	106°· 90
				H =	·658		H =	1·000		H =	·016
				κ =	48°· 63		κ =	314°· 81		κ =	65°· 11
M_1	R =	·072	K_1	R =	1·226	λ_2	R =	...	$2N_2$	R =	·227
	ζ =	156°· 81		ζ =	217°· 21		ζ =	...		ζ =	130°· 51
	H =	·048		H =	1·381		H =	...		H =	·218
	κ =	74°· 89		κ =	45°· 68		κ =	...		κ =	289°· 45
M_2	R =	4·189	K_2	R =	·299	ν_2	R =	·290	$(M_2N)_4$	R =	·027
	ζ =	289°· 60		ζ =	155°· 14		ζ =	309°· 61		ζ =	117°· 35
	H =	4·038		H =	·399		H =	·286		H =	·025
	κ =	331°· 39		κ =	352°· 29		κ =	334°· 89		κ =	259°· 50
M_3	R =	·085	P_1	R =	·407	μ_2	R =	·216	$(M_2K_1)_3$	R =	·028
	ζ =	151°· 21		ζ =	232°· 60		ζ =	211°· 71		ζ =	189°· 77
	H =	·080		H =	·407		H =	·201		H =	·031
	κ =	33°· 89		κ =	43°· 08		κ =	295°· 28		κ =	60°· 03

Short-Period Tides—contd.

M_4	R =	·109	J_1	R =	·113	R_2	R =	...	$(2M_2K_1)_3$	R =	·044
	ζ =	218°·92		ζ =	295°·32		ζ =	...		ζ =	154°·68
	H =	·101		H =	·136		H =	...		H =	·047
	κ =	302°·49		κ =	64°·03		κ =	...		κ =	49°·78

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide	·046	115·09	·041	56·51
„ Fortnightly „	·037	249·80	·059	42·59
Luni-Solar „ „	·005	195·12	·005	153·33
Solar-Annual „	·232	55·48	·232	335·00
„ Semi-Annual „	·124	29·78	·124	228·82

VALUES OF THE TIDAL CONSTANTS, BOMBAY (PRINCE'S DOCK), 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Bombay (Prince's Dock), and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

$A_0 = 8·177$ feet.

S_1	H = R =	·079
	κ = ζ =	191°·55
S_2	H = R =	1·606
	κ = ζ =	5°·56
S_4	H = R =	·017
	κ = ζ =	243°·89
S_6	H = R =	·002
	κ = ζ =	160°·35
S_8	H = R =	·002
	κ = ζ =	186°·71
M_1	R =	·071
	ζ =	154°·52
	H =	·047
	κ =	72°·60
M_2	R =	4·266
	ζ =	290°·24
	H =	4·112
	κ =	332°·02
M_3	R =	·095
	ζ =	152°·49
	H =	·090
	κ =	35°·17
M_4	R =	·118
	ζ =	254°·24
	H =	·109
	κ =	337°·82

M_6	R =	·009
	ζ =	353°·33
	H =	·008
	κ =	118°·69
M_8	R =	·008
	ζ =	262°·46
	H =	·007
	κ =	69°·61
O_1	R =	·535
	ζ =	193°·84
	H =	·662
	κ =	48°·34
K_1	R =	1·226
	ζ =	217°·31
	H =	1·388
	κ =	45°·78
K_2	R =	·296
	ζ =	158°·08
	H =	·395
	κ =	355°·23
P_1	R =	·406
	ζ =	232°·71
	H =	·406
	κ =	43°·18
J_1	R =	·110
	ζ =	294°·79
	H =	·133
	κ =	63°·50

Q_1	R =	·145
	ζ =	134°·66
	H =	·180
	κ =	47°·74
L_2	R =	·048
	ζ =	148°·44
	H =	·052
	κ =	319°·16
N_2	R =	1·059
	ζ =	215°·35
	H =	1·021
	κ =	315°·71
λ_2	R =	...
	ζ =	...
	H =	...
	κ =	...
ν_2	R =	·281
	ζ =	312°·49
	H =	·270
	κ =	337°·77
μ_2	R =	·212
	ζ =	220°·97
	H =	·197
	κ =	304°·54
R_2	R =	...
	ζ =	...
	H =	...
	κ =	...

T_2	R =	·186
	ζ =	344°·02
	H =	·186
	κ =	345°·79
$(MS)_4$	R =	·101
	ζ =	1°·07
	H =	·077
	κ =	42°·86
$(2SM)_2$	R =	·033
	ζ =	140°·49
	H =	·032
	κ =	98°·70
$2N_2$	R =	·252
	ζ =	131°·79
	H =	·243
	κ =	290°·74
$(M_2N)_4$	R =	·023
	ζ =	193°·29
	H =	·022
	κ =	335°·44
$(M_2K_1)_3$	R =	·049
	ζ =	210°·90
	H =	·054
	κ =	81°·16
$(2M_2K_1)_3$	R =	·056
	ζ =	165°·89
	H =	·058
	κ =	60°·99

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide . . .	·049	110·58	·043	52·00
„ Fortnightly „ . . .	·047	240·19	·075	32·99
Luni-Solar „ „ . . .	·012	66·69	·012	24·91
Solar-Annual „ . . .	·237	52·83	·237	332·35
„ Semi-Annual „ . . .	·131	33·18	·131	232·23

VALUES OF THE TIDAL CONSTANTS, MADRAS, 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Madras, and also the ***mean*** values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

A_0 = 2·304 feet.

S_1	H = R =	·030	M_6	R =	·005	Q_1	R =	·006	T_2	R =	·050
	κ = ζ =	86°· 91		ζ =	342°· 35		ζ =	134°· 29		ζ =	227°· 97
S_2	H = R =	·447		H =	·005		H =	·007		H =	·050
	κ = ζ =	270°· 06		κ =	109°· 21		κ =	48°· 16		κ =	229°· 76
S_4	H = R =	·002	M_8	R =	·001	L_2	R =	·046	$(MS)_4$	R =	·002
	κ = ζ =	233°· 13		ζ =	353°· 66		ζ =	104°· 82		ζ =	183°· 01
S_6	H = R =	·002		H =	·001		H =	·043		H =	·002
	κ = ζ =	26°· 57		κ =	162°· 81		κ =	275°· 77		κ =	225°· 30
S_8	H = R =	·000	O_1	R =	·072	N_2	R =	·257	$(2SM)_2$	R =	·016
	κ = ζ =	315°· 00		ζ =	112°· 47		ζ =	128°· 38		ζ =	250°· 64
				H =	·089		H =	·247		H =	·015
				κ =	327°· 49		κ =	229°· 52		κ =	208°· 35
M_1	R =	·032	K_1	R =	·259	λ_2	R =	...	$2N_2$	R =	·052
	ζ =	45°· 26		ζ =	149°· 99		ζ =	...		ζ =	49°· 91
	H =	·021		H =	·293		H =	...		H =	·050
	κ =	323°· 59		κ =	338°· 44		κ =	...		κ =	209°· 90
M_2	R =	1·136	K_2	R =	·087	ν_2	R =	·080	$(M_2N)_4$	R =	·004
	ζ =	197°· 73		ζ =	68°· 60		ζ =	230°· 10		ζ =	84°· 81
	H =	1·095		H =	·115		H =	·077		H =	·003
	κ =	240°· 02		κ =	265°· 71		κ =	256°· 12		κ =	228°· 23
M_3	R =	·003	P_1	R =	·101	μ_2	R =	·035	$(M K_1)_3$	R =	·016
	ζ =	160°· 97		ζ =	169°· 85		ζ =	106°· 40		ζ =	80°· 85
	H =	·003		H =	·101		H =	·033		H =	·017
	κ =	44°· 41		κ =	340°· 35		κ =	190°· 98		κ =	311°· 59
M_4	R =	·008	J_1	R =	·022	R_2	R =	...	$(2M_2K_1)_3$	R =	·002
	ζ =	122°· 31		ζ =	213°· 25		ζ =	...		ζ =	76°· 61
	H =	·008		H =	·027		H =	...		H =	·002
	κ =	206°· 88		κ =	341°· 67		κ =	...		κ =	332°· 73

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide	·050	68·66	·044	9·81
„ Fortnightly „	·010	276·92	·016	69·17
Luni-Solar „ „	·044	56·68	·042	14·40
Solar-Annual „	·303	311·59	·303	231·09
„ Semi-Annual „	·214	314·24	·214	153·25

VALUES OF THE TIDAL CONSTANTS, KIDDERPORE, 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

A_0 = 10·830 feet.

S_1	H = R =	·085	M_6	R =	·201	Q_1	R =	·017	T_2	R =	·102
	κ = ζ =	184°·78		ζ =	191°·98		ζ =	67°·82		ζ =	85°·51
S_2	H = R =	1·583		H =	·180		H =	·021		H =	·102
	κ = ζ =	94°·95		κ =	320°·48		κ =	342°·55		κ =	87°·33
S_4	H = R =	·097	M_8	R =	·092	L_2	R =	·199	$(MS)_4$	R =	·743
	κ = ζ =	94°·98		ζ =	102°·39		ζ =	264°·40		ζ =	28°·95
S	H = R =	·015		H =	·079		H =	·215		H =	·716
	κ = ζ =	341°·57		κ =	273°·72		κ =	75°·60		κ =	71°·78
S_8	H = R =	·004	O_1	R =	·171	N_2	R =	·687	$(2SM)_2$	R =	·093
	κ = ζ =	305°·91		ζ =	161°·16		ζ =	295°·56		ζ =	52°·59
				H =	·211		H =	·662		H =	·089
				κ =	16°·75		κ =	37°·54		κ =	9°·76
M_1	R =	·046	K_1	R =	·373	λ_2	R =	...	$2N_2$	R =	·123
	ζ =	92°·88		ζ =	223°·31		ζ =	...		ζ =	251°·80
	H =	·030		H =	·422		H =	...		H =	·119
	κ =	11°·48		κ =	51°·74		κ =	...		κ =	52°·92
M_2	R =	3·971	K_2	R =	·312	ν_2	R =	·254	$(M_2N)_4$	R =	·320
	ζ =	12°·34		ζ =	246°·77		ζ =	9°·58		ζ =	235°·75
	H =	3·828		H =	·416		H =	·245		H =	·297
	κ =	55°·17		κ =	83°·84		κ =	36°·39		κ =	20°·56
M_3	R =	·062	P_1	R =	·145	μ_2	R =	·221	$(M_2K_1)_3$	R =	·124
	ζ =	67°·70		ζ =	229°·33		ζ =	104°·91		ζ =	173°·93
	H =	·058		H =	·145		H =	·205		H =	·136
	κ =	311°·95		κ =	39°·85		κ =	190°·57		κ =	45°·19
M_4	R =	·864	J_1	R =	·026	R_2	R =	...	$(2M_2K_1)_3$	R =	·042
	ζ =	305°·41		ζ =	286°·96		ζ =	...		ζ =	15°·93
	H =	·803		H =	·031		H =	...		H =	·044
	κ =	31°·08		κ =	55°·06		κ =	...		κ =	273°·16

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide	·256	67·79	·227	8·65
„ Fortnightly „	·218	241·34	·346	33·01
Luni-Solar „ „	1·004	83·10	·968	40·27
Solar-Annual „	2·558	225·06	2·558	144·54
„ Semi-Annual „	1·014	114·60	1·014	313·56

VALUES OF THE TIDAL CONSTANTS, RANGOON, 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Rangoon, and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

A_0 = 10·275 feet.

S_1	H = R =	·096
	κ = ζ =	129°·18
S_2	H = R =	2·127
	κ = ζ =	165°·60
S_4	H = R =	·078
	κ = ζ =	254°·76
S_6	H = R =	·014
	κ = ζ =	45°·00
S_8	H = R =	·003
	κ = ζ =	48°·01
M_1	R =	·036
	ζ =	148°·35
	H =	·024
	κ =	67°·22
M_2	R =	6·204
	ζ =	84°·63
	H =	5·980
	κ =	128°·00
M_3	R =	·048
	ζ =	109°·30
	H =	·045
	κ =	354°·35
M_4	R =	·486
	ζ =	76°·53
	H =	·451
	κ =	163°·26
M_6	R =	·263
	ζ =	310°·79
	H =	·236
	κ =	80°·89
M_8	R =	·101
	ζ =	278°·01
	H =	·087
	κ =	91°·48
O_1	R =	·229
	ζ =	168°·71
	H =	·284
	κ =	24°·85
K_1	R =	·615
	ζ =	204°·59
	H =	·696
	κ =	33°·00
K_2	R =	·405
	ζ =	325°·48
	H =	·540
	κ =	162°·51
P_1	R =	·190
	ζ =	234°·63
	H =	·190
	κ =	45°·18
J_1	R =	·056
	ζ =	308°·61
	H =	·068
	κ =	76°·41
Q	R =	·014
	ζ =	100°·45
	H =	·018
	κ =	16°·01
L_2	R =	·440
	ζ =	349°·44
	H =	·476
	κ =	160°·89
N_2	R =	1·132
	ζ =	7°·99
	H =	1·091
	κ =	110°·78
λ_2	R =	...
	ζ =	...
	H =	...
	κ =	...
ν_2	R =	·412
	ζ =	98°·41
	H =	·397
	κ =	126°·00
μ_2	R =	·526
	ζ =	200°·92
	H =	·488
	κ =	287°·65
R_2	R =	...
	ζ =	...
	H =	...
	κ =	...
T_2	R =	·284
	ζ =	120°·56
	H =	·284
	κ =	122°·40
$(MS)_4$	R =	·409
	ζ =	160°·93
	H =	·394
	κ =	204°·30
$(2SM)_2$	R =	·155
	ζ =	87°·46
	H =	·150
	κ =	44°·09
$2N_2$	R =	·134
	ζ =	340°·79
	H =	·129
	κ =	143°·01
$(M_2N)_4$	R =	·207
	ζ =	3°·62
	H =	·193
	κ =	149°·78
$(M_2K_1)_3$	R =	·120
	ζ =	232°·97
	H =	·131
	κ =	104°·75
$(2M_2K_1)_3$	R =	·099
	ζ =	138°·80
	H =	·104
	κ =	37°·12

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide	·158	82·31	·140	22·89
„ Fortnightly „	·161	217·60	·256	8·69
Luni-Solar „ „	·453	85·41	·437	42·04
Solar Annual „	1·228	219·49	1·228	138·95
„ Semi-Annual „	·146	116·46	·146	315·38

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Values of the Tidal Constants, Port Blair, 1904.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1904 Observations at Port Blair; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1904 Observations.

Short Period Tides.

A_0=4·787 feet.

S_1	H = R =	·020	M_6	R =	·003	Q_1	R =	·012	T_2	R =	·098
	κ = ζ =	60°·29		ζ =	131°·99		ζ =	341°·88		ζ =	286°·91
S_2	H = R =	·950		H =	·003		H =	·014		H =	·098
	κ = ζ =	315°·56		κ =	261°·39		κ =	257°·08		κ =	288°·73
S_4	H = R =	·002	M_8	R =	·003	L_2	R =	·061	$(MS)_4$	R =	·017
	κ = ζ =	52°·66		ζ =	276°·34		ζ =	118°·35		ζ =	66°·62
S_6	H = R =	·002		H =	·003		H =	·066		H =	·016
	κ = ζ =	46°·85		κ =	88°·88		κ =	289°·69		κ =	109°·75
S_8	H = R =	·002	O_1	R =	·120	N_2	R =	·408	$(2SM)_2$	R =	·023
	κ = ζ =	305°·54		ζ =	84°·15		ζ =	171°·43		ζ =	196°·16
				H =	·148		H =	·394		H =	·022
				κ =	300°·04		κ =	273°·86		κ =	153°·02
M_1	R =	·042	K_1	R =	·357	λ_2	R =	...	$2N_2$	R =	·095
	ζ =	50°·26		ζ =	139°·27		ζ =	...		ζ =	103°·55
	H =	·028		H =	·405		H =	...		H =	·091
	κ =	328°·95		κ =	327°·69		κ =	...		κ =	265°·29
M_2	R =	2·085	K_2	R =	·183	ν_2	R =	·113	$(M_2N)_4$	R =	·005
	ζ =	237°·94		ζ =	116°·11		=	268°·77		ζ =	297°·60
	H =	2·016		H =	·244		H =	·109		H =	·005
	κ =	281°·08		κ =	313°·15		κ =	296°·02		κ =	83°·17
M_3	R =	·008	P_1	R =	·136	μ_2	R =	·077	$(M_2K_1)_3$	R =	·019
	ζ =	171°·43		ζ =	152°·39		ζ =	209°·08		ζ =	115°·02
	H =	·007		H =	·136		H =	·072		H =	·020
	κ =	56°·13		κ =	322°·93		κ =	295°·35		κ =	346°·57
M_4	R =	·027	J_1	R =	·030	R_2	R =	...	$(2M_2K_1)_3$	R =	·009
	ζ =	30°·19		ζ =	205°·03		ζ =	...		ζ =	281°·04
	H =	·025		H =	·036		H =	...		H =	·009
	κ =	116°·46		κ =	332°·96		κ =	...		κ =	178°·89

Long Period Tides.

	R	ζ	H	κ
		°		°
Lunar Monthly Tide	·035	79·87	·031	20·57
" Fortnightly "	·021	231·72	·033	23·06
Luni-Solar " "	·036	62·28	·035	19·15
Solar-Annual "	·143	188·94	·143	108·41
" Semi-Annual "	·128	352·44	·128	191·37

Date of commencement of computations.

20. The tidal computations for the several stations commenced on the 1st January.

State of Tidal computations.

21. The present state of the tidal computations is shown in the following table together with their state at the end of September 1904. The letters A. P. in this table indicate that the actual times and heights of high and low water have been measured either from the tidal diagrams or from graduated staves, and compared with predicted values published in the tide-tables.

Statement of the ordinary reductions of the yearly registrations at the beginning and end of the Survey year 1904-05.

Tidal observatory.	Statement at end of September 1904.	Statement at end of September 1905.
Suez	1902 and 1903. Calculations completed, A. P. 1903.	Closed.
Aden	1903 Incomplete, A. P. 1903	1903 and 1904. Calculations completed, A. P. 1904.
Karachi	1903 Calculations completed. A. P 1903.	1904. Calculations completed, A. P. 1904.
Port Albert Victor	1903. Incomplete, A. P. 1903	1903. Calculations completed. Closed.
Bhavnagar	A. P. 1903	A. P. 1904.
Bombay (Apollo Bandar)	1902 and 1903 Calculations completed, A. P. 1903.	1904. Calculations completed, A. P. 1904.
Bombay (Prince's Dock)	1902. Calculations completed, 1903. Long Period Tides incomplete, A. P. 1903.	1903 and 1904. Calculations completed, A. P. 1904.
Madras	1903. Calculations completed, A. P. 1903.	1904. Calculations completed, A. P. 1901.
Kidderpore	1903. Calculations completed, A. P. 1903.	1904. Calculations completed, A. P. 1904.
Chittagong	A. P. 1903	A. P. 1904.
Akyab	A. P. 1903	A. P. 1904.
Bassein (Burma)	1903. Calculations completed, A. P. 1903.	Closed.
Rangoon	1903. Long Period Tides incomplete, A. P. 1903.	1903 and 1904. Calculations completed, A. P. 1904.
Moulmein	A P. 1903	A. P. 1904.
Port Blair	1903. Calculations completed, A. P. 1903.	1904. Calculations completed, A. P. 1904.

Auxiliary Reports.

22. In addition to the computations enumerated in the foregoing tables, reports on the operations carried on in the Bombay Presidency and in Burma were prepared and submitted, the former to the Local Government and the latter to the Principal Port Officer, Burma, Rangoon.

Errors in predicted times and heights of high and low water.

23. The usual tabular statements Nos. 1 to 5 are appended showing the percentage and amount of errors in the predicted times and heights of high and

low water for the year 1904 at 12 stations, as determined by comparison of the predictions given in the tide-tables with actual values measured from the tidal diagrams at 8 stations, and from tide poles at 4 stations; the former are made by assistants in this office, and the latter by port officials.

No. 1.

Statement showing the percentage and the amount of the errors in the Predicted Times of High-water at the various Tidal Stations for the year 1904.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Au.	689	32	44	13	9	2
Karachi	Au.	702	42	44	8	5	1
Bhavnagar	T. P.	366	25	72	2	1	...
Bombay { Apollo Bandar	Au.	706	45	41	7	5	2
Bombay { Prince's Dock	Au.	707	30	42	13	11	4
Madras	Au.	706	48	40	7	4	1
Kidderpore	Au.	708	12	25	12	25	26
Chittagong	T. P.	366	20	42	12	11	15
Akyab	T. P.	366	99	1	...	...	...
Rangoon	Au.	707	20	33	15	22	10
Moulmein	T. P.	366	5	64	22	8	1
Port Blair	Au.	706	35	48	10	6	1

No. 2.

Statement showing the percentage and the amount of the errors in the Predicted Times of Low-water at the various Tidal Stations for the year 1904.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Au.	665	25	39	13	17	6
Karachi	Au.	706	35	40	11	10	4
Bhavnagar	T. P.	366	12	76	9	2	1
Bombay { Apollo Bandar	Au.	704	16	36	19	22	7
Bombay { Prince's Dock	Au.	707	37	41	9	10	3
Madras	Au.	707	51	42	4	3	...
Kidderpore	Au.	707	29	37	12	14	8
Chittagong	T. P.	365	13	38	10	20	19
Akyab	T. P.	366	98	1	...	...	1
Rangoon	Au.	706	23	34	13	18	12
Moulmein	T. P.	366	6	58	21	12	3
Port Blair	Au.	708	47	43	6	4	...

No. 3.

Statement showing the percentage and the amount of the errors in the Predicted Heights of High Water at the various Tidal Stations for the year 1904.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs in feet.	Errors of 4-inches and under.	Errors over 4-inches and under 8-inches.	Errors over 8-inches and under 12-inches.	Errors over 12-inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Au.	689	6·7	96	4	...	...
Karachi	Au.	702	9·3	78	19	3	...
Bhâvnagar	T. P.	366	31·4	44	40	10	6
Bombay — Apollo Bandar	Au.	706	13·9	78	20	2	...
Bombay — Prince's Dock	Au.	707	13·9	77	21	2	...
Madras	Au.	706	3·5	76	24	...	...
Kidderpore	Au.	708	11·7	36	27	18	19
Chittagong	T. P.	366	13·3	34	24	15	27
Akyab	T. P.	366	8·3	85	14	1	...
Rangoon	Au.	707	16·4	51	30	14	5
Moulmein	T. P.	366	12·7	26	20	19	35
Port Blair	Au.	706	6·6	86	14	...	...

No. 4.

Statement showing the percentage and the amount of the errors in the Predicted Heights of Low-Water at the various Tidal Stations for the year 1904.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs in feet.	Errors of 4-inches and under.	Errors over 4-inches and under 8-inches.	Errors over 8-inches and under 12-inches.	Errors over 12-inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Au.	665	6·7	96	4	...	...
Karachi	Au.	706	9·3	78	19	3	...
Bhâvnagar	T. P.	366	31·4	47	31	13	...
Bombay — Apollo Bandar	Au.	704	13·9	78	19	3	...
Bombay — Prince's Dock	Au.	707	13·9	71	23	6	...
Madras	Au.	707	3·5	77	23	...	...
Kidderpore	Au.	707	11·7	44	32	16	8
Chittagong	T. P.	365	13·3	44	30	16	10
Akyab	T. P.	366	8·3	89	10	1	...
Rangoon	Au.	706	16·4	27	26	24	23
Moulmein	T. P.	366	12·7	42	27	10	21
Port Blair	Au.	708	6·6	92	8	...	...

No. 5.

Table of average errors in the Predicted Times and Heights of High and Low Water at the several Tidal Stations for the year 1904.

Stations.	Automatic or Tide-pole observations.	Mean range at springs in feet.	Average errors. Of Time in Minutes.		Of Height in terms of the range.		Of Height in inches.	
			H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Open coast.								
Aden	Au.	6·7	11	14	·025	·025	2	2
Karachi	Au.	9·3	8	11	·027	·027	3	3
Bhávnagar	T. P.	31·4	8	10	·013	·016	5	6
Bombay Apollo Bandar	Au.	13·9	8	16	·018	·018	3	3
Bombay Prince's Dock	Au.	13·9	12	10	·018	·018	3	3
Madras	Au.	3·5	7	7	·071	·071	3	3
Akyab	T. P.	8·3	2	2	·030	·020	3	2
Port Blair	Au.	6·6	9	8	·025	·025	2	2
General mean			8	10	·028	·028	...	...
Riverain.								
Kidderpore	Au.	11·7	22	13	·057	·043	8	6
Chittagong	T. P.	13·3	16	19	·063	·038	10	6
Rangoon	Au.	16·4	16	16	·025	·046	5	9
Moulmein	T. P.	12·7	13	15	·066	·059	10	9
General mean			17	16	·053	·047	...	...

The foregoing statement for the year 1904 may be thus summarised :—

Percentage of time predictions within 15 minutes of actuals.

		High Water. Per Cent.	Low Water. Per Cent.
Open Coast Stations	6 at which predictions were tested by S. R. Tide gauge	82	75
	2 " " " by Tide pole	99	94
Riverain Stations	2 " " " S. R. Tide gauge	45	61
	2 " " " Tide pole	66	57

Percentage of height predictions within 8 inches of actuals.

		High Water. Per Cent.	Low Water. Per Cent.
Open Coast Stations	6 at which predictions were tested by S. R. Tide gauge	99	98
	2 " " " Tide pole	92	89
Riverain Stations	2 " " " S. R. Tide gauge	72	65
	2 " " " Tide pole	52	72

Percentage of height predictions within one-tenth of mean range at springs.

			High Water. Per Cent.	Low Water. Per Cent.
Open Coast Stations	6 at which predictions were tested by	S. R. Tide gauge	96	96
	2 " " "	Tide pole	100	100
Riverain Stations	2 " " "	S. R. Tide gauge	94	95
	2 " " "	Tide pole	81	91

The predictions for the riverain stations for 1904 have been compared with those for 1903. At Kidderpore they were found to be worse in times of high water but a little better for low water; for the heights of high and low water they are better. At Rangoon they are the same. At Chittagong, a tide pole station, there is a marked improvement in the predictions for times of both high and low water ; for heights, they are the same for high water and much better for low water. At Moulmein, a tide pole station, they are a little worse for time and about the same for height.

At Kidderpore the greatest difference between the actual and predicted heights of low water was 1 foot 8 inches on 11th April, the actual being in excess. At Rangoon it was 2 feet 6 inches on 24th and 27th October, the prediction being higher. At Chittagong it was 2 feet 9 inches, on 15th June, the actual being in excess. At Moulmein it was 5 feet 9 inches on 10th July, the actual being in excess.

REPORT ON THE LEVELLING OPERATIONS, SEASON 1904-05.

24. The levelling detachment was employed in Sind at the request of the Bombay Government carrying out a line of levels urgently required by the Irrigation Branch, Public Works Department, Sind.

25. The *personnel* of the detachment is shown in the margin. Mr. Corridon held charge of the detachment throughout the year.

Personnel.

LEVELLERS.

Mr. E. H. Corridon, 1st Leveller.
Munshi Syed Zille Hasnain, 2nd Leveller.

RECORDERS.

Rikhi Ram, Lachman Singh, Gopal Singh.

Mr. Corridon had received orders to level from Sujawal a point in the Section Navánár to Tatta, connected in season 1889-90, along the high road to Tando Muhammad Khan, a railway station on the Hyderabad Badin extension of the North-Western Railway, and thence to continue along the railway line *viâ* Hyderabad and Rohri to the Bahawalpore boundary, connecting at Kotri with the old line of levels executed between 1858 and 1862.

The detachment left Dehra for the field on the 21st October 1904 and reached Sujawal on the 28th October.

After all preliminary arrangements were completed, levelling operations were commenced from the embedded bench-mark at the Mukhtyárkár's Kacheari, Sujawal, and continued according to the programme laid down.

As orders were received too late in the season to permit of the bench-marks between Rohri and Shikarpur being constructed and the work being extended to the latter place, it was decided to close operations at Sukkur.

The line from Sujawal to Sukkur was, including branch lines, 289 miles. It was completed on the 18th April 1905 and the detachment returned to Dehra on the 21st April.

26. On account of the earthquake which happened on the 4th April, it was decided to revise the line of levels between Dehra and Mussoorie executed the previous year. The work was taken in hand on 28th April 1905 and completed on the 29th May.

27. A difference in height of 0·468 of a foot was found at the terminal point between the results of the two years' observations. The first 11 miles of the revised work was carried out by double levelling, and the remaining 8 miles, owing to Mr. Corridon's illness, had to be done by single levelling. It has since been thought advisable to re-do the work from Mussoorie to Dehra in October 1905.

28. A branch line of single levelling was also carried out between Dehra and the Mohan Pass *viâ* the East End of the Dehra Dun base Line. This work was commenced on the 5th June and closed at Asarori on the 15th June 1905. There was a difference of 0·112 of a foot between the results of the old and new levelling.

29. With reference to the earthquake of 4th April it may be interesting to note that the tremors were observed by the levellers as far away as Sind by the continuous oscillation of the level bubble which lasted for about 37 minutes.

30. The total outturn of work for the season was 318 miles, in the course of which the instrument was set up at 4,619 stations and the total rises and falls amounted to 7,487 feet. The heights of 31 embedded and 174 inscribed bench-marks were determined; 52 old bench-marks embedded and inscribed and 1 standard bench-mark were connected..

Four Great Trigonometrical Survey stations, 11 Railway and 9 Public Works Department bench-marks were also connected.

31. The health of the detachment during the season under report was on the whole good.

32. The usual tabular statements are appended.

Tabular statement of outturn of work for field season 1904-05.

Section.	Month.	No. of Miles Double-Levelling.						No. of Miles Single-Levelling.						Total Levelling.			Total No. of Feet.		No. of stations at which instrument was set up.	No. of Bench-marks connected.								Remarks.
		Main Line.			Branch Line.			Main Line.			Branch Line.																	
		Ms.	Chs.	lks.	Ms.	Chs.	lks.	Ms.	Chs.	lks.	Ms.	Chs.	lks.	Ms.	Chs.	lks.	Rise.	Fall.		Reference.	Old.	Standard.	Embedded.	Inscribed.	G. T. S.	Railway.	P. W. D.	
Sujawal to Sukkur *viâ* Rohri	November 1904	39	51	30	7*	29	72	...	...	...	...	...	...	47	1	2	259·709	240·519	664	...	8	...	4	18	1	...	6	* Includes 4 Ms. 78 Chs. 46 lks. check levelling of old work (1889-90) about Sujawal for verification.
	December „	34	25	14	9	2	44	...	...	...	...	...	...	43	27	58	155·900	134·407	599	...	4	...	4	21	...	9	3	
	January 1905	41	63	24	10†	28	80	...	...	...	...	...	...	52	12	4	148·631	132·198	667	...	1	...	6	35	...	2	...	† Includes 10 Ms. 19 Chs. 80 lks. check levelling of old work (1858-62) about Kotri for verification.
	February „	50	65	34	...	...	...	...	...	...	...	...	...	50	65	34	180·992	138·783	644	...	...	...	6	31	...	...	...	
	March „	59	58	38	...	14	2	...	...	...	...	...	...	59	72	40	216·421	166·489	712	...	...	...	7	35	...	...	...	
	April „	35	53	38	...	25	...	...	...	...	...	...	...	35	78	38	175·433	153·039	426	...	...	...	4	23	...	...	...	
	Totals	261	76	78	26	99	98	...	...	...	...	...	...	289	16	76	1137·086	965·435	3712	...	13	...	31	163	1	11	9	
Dehra Dun to Mussoorie.	April 1905	1	47	62	...	14	68	...	...	...	...	...	...	1	62	30	113·489	0·079	30	...	6	1	...	...	...	...	...	Revision work.
	May „	9	12	20	...	6	48	7	34	98	...	76	84	17	50	50	4829·346	39·536	714	...	29	...	...	...	2	...	...	
	Totals	10	59	82	...	21	16	7	34	98	...	76	84	19	32	80	4942·835	39·615	744	...	35	1	...	...	2	...	...	
Dehra Dun to East End of Dehra Dun Base line.	June 1905	...	...	...	...	...	...	6	20	90	3	21	84	9	42	74	65·104	337·411	163	...	4	...	...	11	1	...	...	Revision work.
	GRAND TOTALS	272	56	60	27	41	14	13	55	88	3	98	68	318	12	30	6145·025	1342·461	4619	...	52	2	31	174	4	11	9	

Results of Comparison of Staves, Season 1904-05.

Place and Date of Comparison.	Staff No. 04.	Staff No. 05.	Staff No. 01.	Staff No. 03.	Remarks.
Sujawal 4th November 1904	+0·0007049	+0·0016333	—0·0023977	—0·0024103	
Mirpur Batoro, 13th „ „	+0·0004124	+0·0014158	—0·0029713	—0·0028060	
Bulri 21st „ „	+0·0004951	+0·0010168	—0·0032847	—0·0035585	
Tando Muhammad Khan, 2nd December 1904.	—0·0001807	+0·0004141	—0·0037720	—0·0044737	
Tando Muhammad Khan, 8th December 1904.	—0·0003322	+0·0001773	—0·0041505	—0·0047086	
Hyderabad (Sind) 17th December 1904.	—0·0006053	—0·0000083	—0·0044143	—0·0047397	
Hyderabad, (Sind), 24th December 1904.	—0·0003079	+0·0000702	—0·0042079	—0·0039343	
Kotri, 31st December 1904 . .	—0·0002479	+0·0002270	—0·0040604	—0·0042355	
Khatian Road, 8th January 1905 .	—0·0004695	+0·0000025	—0·0043192	—0·0043568	
Allahdino Sánd, 15th „ „ .	—0·0008912	—0·0005038	—0·0048319	—0·0054163	
Udero Lal 21st „ „ .	—0·0008611	+0·0001090	—0·0042348	—0·0046487	
Shahdádpur 29th „ „ .	—0·0009145	—0·0000957	—0·0044017	—0·0047550	
Lundo 4th February 1905 .	—0·0004469	+0·0003219	—0·0040639	—0·0043624	
Nawábsháh 17th „ „ .	—0·0006147	—0·0001084	—0·0042644	—0·0047770	
Bandhi 26th „ „ .	—0·0010861	—0·0002359	—0·0045512	—0·0052949	
Pad-Idan 5th March „ .	—0·0007566	—0·0001974	—0·0044550	—0·0051519	
Bhiria Road 12th „ „ .	—0·0008483	—0·0000295	—0·0043512	—0·0048638	
Mahrabpur 18th „ „ .	—0·0012184	—0·0004044	—0·0048325	—0·0054762	
Setharja 25th „ „ .	—0·0011171	—0·0005422	—0·0050719	—0·0054265	
Tándo Masti Khán 2nd April „ .	—0·0012021	—0·0008842	—0·0055062	—0·0062458	
Khairpur Mirs 9th „	—0·0014068	—0·0011357	—0·0056644	—0·0064966	
Sukkur 17th „ „ .	—0·0018971	—0·0012161	—0·0058163	—0·0073911	
Dehra Dun 28th „ „ .	—0·0024133	—0·0018525	—0·0066556	—0·0077980	
Rajpur 5th May „ .	—0·0028881	—0·0021975	—0·0069817	—0·0079129	
Bhatta 15th „ „ .	...	...	—0·0063985	—0·0071877	
Mussoorie 22nd „ „ .	...	...	—0·0070673	—0·0076315	
Mussoorie 29th „ „ .	...	...	—0·0063122	—0·0073155	
Dehra Dun 5th June „ .	...	...	—0·0052742	—0·0057461	Single levelling only.
Asarori 12th „ „ .	...	...	—0·0058435	—0·0059372	
Dehra Dun 20th „ „ .	...	...	—0·0059446	—0·0062585	

List of Great Trigonometrical Survey Stations connected by spirit-levelling, Season 1904-05.

Name of station.	Height in feet above mean sea-level.		Error of height by triangulation in feet.	Remarks.
	By spirit levelling.	By Triangulation.		
Kanád T. S. of the Western Longitudinal Triangulation.	82·588	87·1	+4·512	Mark stone 1 ft. below summit of tower.
East End of Dehra Dun Base line .	1,959·07 * 1,958·992†	1,956	3	Upper mark in floor.
Mussoorie Dome Observatory, H.S. .	6,935·959‡ 6,935·509†	6,937	1	Top of pillar.
Eagles Nest, h.s.	6,924·160‡ 6,923·708†	6,927	3	Top of pillar.

* Value obtained in 1869. † Values obtained in 1904-05. ‡ Values obtained in 1903-04.

33. A scheme for the erection of bench-marks of architectural and substantial design and solidly built in carefully chosen places in all important towns throughout India was initiated in 1903-04. These bench-marks have been designated standard bench-marks. A great deal has been done during the year under report towards the fulfilment of this scheme. The following interesting particulars of the work executed, which are both descriptive and instructive, have been copied *verbatim* from Major Burn's report.

Standard bench-marks.

34. In 1901, it had been brought to the notice of the Surveyor General of India by the Superintendent of Trigonometrical Surveys that a large number of bench-marks were annually being lost or destroyed, from causes which were beyond the power of the Survey Department to prevent, such as the doubling of railway lines, extension of cantonments and cities and so forth, and that consequently the results of levelling operations extending as far back as 1858, were likely to be seriously jeopardized. It was therefore proposed to erect at all the principal stations or towns of India a certain number of standard bench-marks, of permanent design, which should humanly speaking last for all time. On these should be suitably engraved, for easy and ready reference, the height of the reference mark above the mean sea-level of Karachi. It is clear that it would be n.possible to undertake such a vast task in any one year, and so it was decided to undertake province by province until the whole area of India be covered. For the year under review it was decided to take the United Provinces.

General question of standard bench-marks.

35. The first question that arose was a suitable choice of quarry and stone from which to procure and prepare the stone of reference, from which heights were to be finally taken in future years. It was determined, after consultation by Major Burn with the Superintendent, Trigonometrical Surveys, that this stone must have the following qualifications :—(*a*) heaviness; so that it could not be easily removed by reckless persons, or damaged by animals, etc., (*b*) toughness; that it should be as weather-proof as any stone can possibly be, the reason for this being obvious, (*c*) cost and ornamental properties to be duly considered. At first marble, granite, or some hard sandstone were thought of, but Major Burn hearing that Mr. Holland, Director of the Geological Survey of India, was touring in the Central Provinces, decided to go and see Mr. Holland and discuss the whole question with him. Before doing this, however, Major Burn went to Jabalpur early in November 1904, to see the nature of the marble and sandstone in the vicinity of this town. He was fortunate enough to be able to find in the old cemeteries of Jabalpur ample evidence to prove to his satisfaction the nature of the stone that would be required. Numerous specimens of marble, evidently taken from quarries adjacent to the celebrated "Marble rocks," in the form of memorial crosses and slabs, were to be seen, but in every single instance they had weathered badly. A marble cross, of what must have been originally beautiful pure white stone, only erected in 1876, had suffered much from wind and rain. It had got tinged with brown, had flaked badly in many places, probably owing to the presence of mica in the stone, and was much pitted and marked from the effects of bad weather. In fact, such marble would never have suited our purposes. Local enquiries proved too that granite, suitable as it might have been in some ways, was out of the

Stone required for monolith or stone of reference.

question. Not only is it somewhat difficult to procure in India, but its cost is great, in fact prohibitive, and would be difficult to procure of the dimensions that we require. Moreover, the polishing of granite (and a certain portion of our stones would have to be polished) presents great difficulties. Special machinery and tools are required under skilled workmen, and it is believed that such can only be obtained in Bombay and Calcutta. A stone. however, was to be seen all over the place, used for innumerable purposes, which seemed to answer all our requirements, and that was the red purple sandstone, generally known as Chunar stone, obtained from quarries in the Chunar district, from the outlying crops of solid rock which form a portion of the great Vindhyan range of hills which extend right across India from north of Calcutta to Rajputana. Major Burn saw many specimens of this stone in quarries around Jabalpur, Katni, Mirzapur, and Chunar, all more or less suitable, though the hardness varies somewhat in different localities. However, in the middle of November he met Mr. Holland at Jabalpur and obtained from him an opinion that no stone would be more suitable than the sandstone from Chunar. In this connection, however, it would be as well to remember that though Chunar stone suits the requirements of the United Provinces, it by no means follows that such stone need necessarily be used as our operations extend into other parts of India. In fact, it would be wise to annually consult the Director of the Geological Survey as to the *locale* of the most suitable quarry, and Mr. Holland is fully aware of our requirements. It was then decided to obtain our stone from the firm of Thakoor and Sons, of Chunar, and the rate fixed for the rough hewn, and in places fine dressed monoliths, was R1-4 per cubic foot, delivered at Chunar Railway Station.

Design for standard bench-mark.

36. The design for a standard bench-mark was by no means an easy one to frame. The question was very fully gone into, officials of many grades were asked for their opinions, and all the pros and cons were laid before the Superintendent, Trigonometrical Surveys, for his suggestions and advice. In making such a design certain difficulties presented themselves. When the monolith is placed *in situ*, it is manifestly impossible to have engraved on it at the time the required levelled height, as the data is not then forthcoming. Moreover, it would be unwise to level to the top of such a heavy stone (each monolith weighs close on 2,000 lb) unless the structure on which it rests had ample time to settle down, and for this purpose we consider a year is necessary, at any rate one monsoon period. Again, once the monolith is *in situ*, permanently fixed, and the spirit levelled height finally deduced, it would appear to be a dangerous thing to allow a stone mason to use his hammer and chisel and engrave any inscription on the monolith itself, in case any movement might take place. Personal supervision over such cutting would be almost impossible, and for these reasons it has been deemed advisable to leave the monolith alone, absolutely untouched, after it has once been spirit levelled up to. On each stone, as it comes from the quarry, on the fine dressed upper portion of the stone, is cut in deep black letters 1″ high.

G. T. S.
STANDARD BENCH-MARK.
1904.

while later on, when the final reduced levels can be obtained, a stone slab, 2′×1′×½′ will be carefully let into the brick-work surrounding the monolith, laid in best cement, with a slight slope to keep the rain off, and with an inscription of the following nature :—

THE HEIGHT OF THE TOP
OF THIS PILLAR IS
1704·78 FEET ABOVE
THE MEAN LEVEL OF
THE SEA AT KARACHI.

This will entail on this office great care that the proper stones or slabs are sent to the correct sites, and this will be fully borne in mind when the time comes for necessary action. A full report showing all steps taken to ensure accuracy, will be sent to the Superintendent, Trigonometrical Surveys, to convince him that no error has occurred. The rest of the design calls for no special comment, except that in every case railings to keep stragglers and straying cattle off the bench-mark have been erected. It was found impossible to use any standard pattern for such railings, as each Engineer entrusted with the building of the structure had his own ideas on the subject, and besides the necessity of varying degrees of ornamental features had to be considered depending on the site chosen.

Cost of standard bench-marks.

37. Before operations commenced it was calculated that each bench-mark would cost about R150 and every endeavour was made to keep to this figure; this being exclusive of the monolith, which cost at Chunar Railway Station R15. The expenditure incurred has approximated to estimate being R170 and has all been borne by this Department.

Standard bench-marks where erected.

38. The amount of money available had to be duly considered, and the names of selected towns were given to the Superintendent, Trigonometrical Surveys, for his approval. The limit was fixed at about 25, and though this involved leaving out some towns at which they might have been placed, care was taken to leave out such as were far away from the existing lines of spirt levelling of precision. Below will be found the names of the towns at which they have been erected, with a brief description of the sites selected.

Benares.

Site.—In Commissioner's office compound in open space of ground well free from trees — 80 feet to south-east of most south-easterly corner of Court house, and 139 feet south-south-west of pucca well in compound. On Government land. In charge of District Engineer, Public Works Department.

Mirzapur.

Site.—Some difficulty arose in choosing this site owing to the proximity of the town of Mirzapur to the river Ganges. This river here makes a large horse-shoe bend in which the town lies, and as it is quite possible that in future years the river may change its course and cut across the neck of the bend, it was deemed wise to select a site on or near solid rock, never likely to be affected by river detrition. The site was chosen on a hard bare patch of ground, at the foot of the Baraunda hills, between them and the city junction road, about 1¼ miles south of present railway station. The site is not on Government land, but the necessary space has been acquired by the Collector of Mirzapur.

The bench-mark remains for maintenance in the charge of the District Engineer, Public Works Department, Mirzapur.

Allahabad.

Site.—It was considered advisable to have two bench-marks at this important station, one in cantonments and another in the civil lines. The site chosen in cantonments was in the compound of the Scotch church, and due west of it, 264 feet south of No. 24 Cantonment Boundary Pillar, and 223 feet west of north-west corner of church. The site has no adjacent trees whose roots could displace it and is in every way a suitable one, and sanction has been obtained from the Church Trustees to erect this bench-mark. It remains in the charge of Commanding Royal Engineer, Allahabad.

In the civil lines the site chosen, after various other sites had been duly considered, was in the Treasury Compound, and within sight of the Treasury Guard, about 12 feet from the front face prolonged of the Treasury and 11½ paces from its most southerly corner. It is situated on Government land, unlikely to be ever alienated, and will be in charge of the District Engineer, Public Works Department.

Fyzabad.

Site.—On a grass plot, in the centre and front of the Divisional Engineer's (Public Works Department) office, and 45 feet from the front face of the building. The bench-mark is under the charge of the Divisional Engineer.

Gorakhpur.

Site.—In a perfectly open space of ground in the Civil Judge's Court compound, 100 feet straight in front of the western porch of Court house. It is in charge of the District Engineer, Public Works Department.

Ghazipur.

Site.—In open clear ground 60 feet from the west front of the Judge's Court, in his compound, and 98 feet from the north-west corner of the same, and 174 feet 6 inches from the south-west corner of the same building. In the charge of the District Surveyor, Public Works Department.

Lucknow.

Cantonment site.—In the compound of the Cantonment Church 100 feet in front of the northern face. In charge of the Commanding Royal Engineer, Lucknow Division.

As to the erection of a bench mark in the civil lines, after consultation with the Superintendent, Trigonometrical Surveys, the matter was allowed to drop, as so many difficulties were raised as to an available site.

Saharanpur.

Site.—In open clear ground of the Church of England compound, 100 feet from, and at right angles to, the plinth of the church steeple. In charge of District Surveyor, Publio Works Department.

Muzaffarnagar.

Site.—In open ground, on the Police Rifle range, 56 feet to south-east of south-easterly corner of mortuary, which is 181 feet to the north of present rifle range butts. In charge of District Overseer, Public Works Department.

Meerut.

Site in Civil lines.—On Government land behind, and about 100 feet to the west of the Circle Divisional and District offices, Public Works Department, in perfectly open ground. In charge of the District Engineer, Public Works Department.

Site in Cantonments.—In open ground in the compound of St. John's church, and 125 feet to the north-east of church. As the Commanding Royal Engineer wished ornamental rails, this bench-mark cost more than the average, costing R290. It was deemed advisable to pay this sum. In charge of Garrison Engineer.

Aligarh.

Site.—In open ground in the District Engineer's (Public Works Department) office compound, to the north-west of office building, and 31 feet 6 inches to the north of cook house, which is 62 feet to the west of the office. In charge of District Engineer, Public Works Department.

Muttra.

Site.—In open ground in the Sessions Judge's office compound, 80 feet in front and at right angles to the main entrance, and to the east of it. In charge of District Overseer, Public Works Department. This officer had some difficulty in procuring the necessary railings.

Bareilly.

Site.—In a triangular grass plot to the north-east of Judge's Court, and in his compound, and 54 feet 6 inches from north-east corner of the Court. On Government land and in charge of District Engineer, Public Works Department.

Sitapur.

Site.—In Judge's Court compound in clear open space at the back of District Judge's Court, and to the west of it. The centre of monolith is 43 feet 2 inches from north-west corner of Court, and 73 feet 3 inches at right angles to the building. In charge of District Surveyor, Public Works Department.

Agra.

Site.—In centre of grass plot which is right in front of the Delhi gate of the Agra Fort. It is in charge of the Commanding Royal Engineer, Bundelkhand District, Military Works Services.

Gwalior.

This town is of course not in the United Provinces, but as it lies on the line of railway between Agra and Jhansi, both in the United Provinces, it was thought advisable to get this work done this season, and the Gwalior Durbar gave the necessary permission, after being approached through the Resident. A very good site was chosen, after viewing several others, 86 feet right in front of, and to the east of the main porch of the Victoria Memorial Hospital. It is in charge of the Sub-Engineer, Imarat Department (Public Works Department), Gwalior State, Gwalior.

Jhansi.

Site.—In the compound of English church in the cantonments, a good position, on the south side of church, 74 feet at right angles from the compound wall on the east, and 100 feet from the wall on the south. In charge of the Commanding Royal Engineer, Jhansi.

Shahjahanpur.

Site.—An old Great Trigonometrical Survey pillar 20 feet high was found in the Club compound, a sort of milestone giving distance of neighbouring towns, but as this may fall down in future years, it was not considered desirable to build near it. Consequently a good site was chosen north-east of the Mutiny

Memorial on Government land, and about 300 feet north of North Transept door of the Cantonment Church, in open ground. In charge of District Engineer, Public Works Department.

39. During the recess season the work of the levelling computations has been completed.

40. A second Levelling Detachment has been organised, which is of equivalent strength to and as fully equipped as the first Levelling Detachment. The two Detachments will in future be known as Levelling Detachment No. 1 and Levelling Detachment No. 2.

41. During the year 18 bench-marks were reported to have been destroyed.

IV

TRIANGULATION IN BALUCHISTAN.

Extracted from the Narrative Report of Captain H. H. Turner, R.E., in charge of No. 24 Party (Triangulation) for Season 1904-05.

1. In July 1904 the programme of the party was changed and instead of continuing the triangulation in the North Shan States, the party was ordered to take up triangulation work in Baluchistan.

2. There being no principal work near Quetta on which to base a new principal series, orders were at first issued for the party to measure a base line, three or four hundred miles west of Quetta. On the matter being further considered, it was decided that the personnel and equipment available would not suffice, and this project was given up.

3. The only alternative that remained, since the Topographical Survey represented, that they required trigonometrical points at once, was to base principal work on a secondary base. The side Zibra-Zawa of the triangle Harboi-Zibra-Zawa of the Kalat secondary meridional series was the base selected. The idea was to carry the series due west, keeping as nearly as ossible to the parallel of latitude 29.°

4. The party assembled at Quetta on the 1st October and all preparations for the march to Kalat were completed by the evening of the 4th, a start being made at daybreak on the 5th. The transport used was camels obtained from the Registration Transport Officer, Quetta district.

5. Kalat was reached on the morning of the 11th, Mr. Hunter having been eft on Zibra hill *en route* to build a station over the old secondary mark. At Kalat the party was divided up into its various squads, Mr. Simons being despatched to Anguri, while the building of the station at Zawa was undertaken by Munshi Ibrahim Khan. Owing to the change of programme, there had been no opportunity to build stations in advance, so that delay was experienced before observations could be commenced; however, on the 25th October, Zawa and Zibra stations being completed, Captain Turner was enabled to commence operations by observing an azimuth at Zawa. As soon as this was completed the forward stations of Istarab and Anguri were ready, and from that date although the observer was on the heels of the advance parties until just the end of the season very little further delay was experienced.

6. The country passed through and some of the hills on which observations were taken are probably amongst the most desolate and barren in the world. Māhr hill station is only reached by climbing up the face of the rock, and the ascent to Kopahdār hill station is little better. Istarab, the central station of the first figure, is probably the second highest principal station of the Indian survey, being 9,142 feet high. Around Kalat, the country is fairly well populated and fruitful but west of longitude 66°, miles may be covered without meeting a human being or seeing so much as a blade of grass. Water although not plentiful was generally procurable within reach of the hill tops, and was on the

whole free from salt. Further west the water becomes so brackish that it will be necessary for the party in extending the triangulation to arrange for water for khalasis and every body to be distilled.

7. The weather up to the end of December, with the exception of being at times very hazy, was all that could be desired for observing. Strong winds generally prevailed, but they did not seriously affect the observations. With January came a change, and there were hardly a dozen days on which observations were possible between the 5th January and the 7th March, the day on which the party commenced the return journey. As in other parts of India the winter was the coldest that had been experienced within the memory of the inhabitants of the country. The last station visited Kisānen Chappar, heigh 4,344 feet, was twice covered with snow, and a man of about 50 who had lived all his life within sight of the hill volunteered the information that he had never seen snow on it before. The worst part of this very cold weather was spent by the observer on Kopahdār hill station vainly endeavouring to obtain observations; when it was not snowing or raining a dense haze overspread the landscape, and nothing beyond a few miles could be seen. Before the observations on this hill could be completed, a violent storm sprang up and in trying to dismantle the observatory tent, one of the uprights was broken. This necessitated returning to Padag to get the tent repaired.

8. The party all assembled at Kishingi on the 18th March and by kind permission of Mr. Woodside, the Superintendent of the Quetta-Nushki Railway, was taken up to Quetta by special train, arriving there on the morning of the 20th March, from thence the khalasis were sent straight to their homes, the majority of them leaving Quetta that same evening.

9. The observations were taken with Troughton and Simms No. III, 12″ micrometer theodolite on the usual 12 zeroes, six to eight measures being taken on each zero.

10. The method of observing was to take 4 consecutive measures on each zero either to lamps or helios, then at another time two more observations were taken on the same zero, but if possible to a different object, that is if the first four were taken to lamps, the other two would be to helios, if the six measures thus obtained did not agree within 4 seconds two more measures were taken on that zero. Two whole figures, both of them tetragons and one triangle of a third figure (a quadrilateral), were completed. The average triangular error of the first figure was 0·41, and of the second figure 0·48. In the single triangle of the quadrilateral of which all three angles were measured a very large error was obtained 2·46. This large error is probably due to the fact, that one of the rays grazes along the side of one of the hills for a mile of its length, this might have been obviated somewhat had the station been built higher, but it is very doubtful whether a satisfactory result would ever be obtained. The hill Kisanen Chappar on which this particular station stands, rises from the middle of the plain, and there is no position either on the hill itself or in the immediate neighbourhood to which the station could be removed. It is possible that the very bad weather conditions, and also the fact that a large sheet of water had collected between this station and Pulchotau hill station may have affected the observations, but the large error is more probably due to the grazing ray. When the work is again proceeded with the station should be raised and the observations on the rays be re-made both at Pulchotau hill station and Kisanen Chappar hill station.

11. An astronomical azimuth was observed at Zāwa H. S. Two circum-polar stars were employed for the observations. The results of the computations were as below :—

Name of Star.	Corrected mean.		
	°	′	″
δ. Ursae Minoris, W. Elongation	178	40	55·90
Cephei 51 Hev, E. Elongation	178	40	55·46
Final Azimuth of Zibra, H. S., by observations	178	40	55·6
*Ditto. of do. by secondary triangulation.	178	41	4·8
Astronomical—Geodetic	...	...	″ 9·12

* NOTE.—The Geodetic value is derived from secondary triangulation.

12. On return to Mussoorie, Mr. Hunter was sent to Banog to take vertical observations to the snow peaks. He remained there for 16 days, but was able to obtain observations to the snows at the time of minimum refraction on two days only. He was recalled in order to take up, in conjunction with Mr. Simon, the revision of the triangulation round Mussooree. The idea of this revision was to discover if any appreciable movement of the old stations had taken place from the severe shock of earthquake which occurred on the morning of 4th April 1905.

The following is a comparison of the results of the computations with the observations taken in 1902 and 1903.

Name of Station, A.	Azimuth of B.			Name of station, B.	Latitude N.	Longitude E of Greenwich.
	°	′	″		° ′ ″	° ′ ″
Sirkanda H. S. .	119	23	57·652	Nag Tat H. S.	30-34-10·250	78-0-21·197
Sirkanda H. S. .	*119*	*23*	*57·554*	,,	...	...
Banog H. S. .	154	43	18·896	,,	...	...
Banog H. S. .	*154*	*43*	*18·237*	,,	*30-34-10·250*	*78-0-21·196*
Sirkanda H. S. .	145	51	15·349	Nag Tiba H. S.	30-35-11·085	78-11-36·756
Sirkanda H. S. .	*145*	*51*	*15·006*	,,	...	...
Banog H S. .	227	16	25·335	,,	...	...
Banog H. S. .	*227*	*16*	*24·357*	,,	...	...
Nag Tat H. S. .	264	0	36·872	,,	...	.
Nag Tat H. S. .	*264*	*0*	*36·384*	,,	*30-35-11·087*	*78-11-36·753*

The values of 1902-1903 are shown in italics.

13. The season's outturn of work was as follows :—

Principal Triangulation.

Number of stations newly fixed	8
Number of figures completed	2
Length of series completed in miles	130
Area of triangulation in square miles	2,464
Number of stations at which astronomical azimuths were observed	1
Mean triangular error from 9 triangles	·667

Secondary Triangulation.

Number of stations newly fixed	*Nil.*
Number of figure completed	1
Length of series completed in miles	10
Area of triangulation in square miles	120
Mean triangular error	1·47

V

SURVEY OPERATIONS WITH THE SOMALILAND FIELD FORCE.

Extracted from the Narrative Report of Captain G. A. Beazeley, R.E., Survey Officer, with the Somaliland Field Force.

Preliminary movements.

Orders were received by me at the end of December 1902 to assemble a small Survey Party with all necessary stores and equipment and to proceed for field service in Somaliland.

Strength.

The Party under my charge consisted of :—

3 Sub-Surveyors (Mahomed Nabi, Mahomed Khan, Bhamba Ram).
30 Khalasis including 1 Duffadar in charge.
3 Private followers, 1 horse and 1 pony.

3. The Party assembled at Dehra Dun and drew its equipment from the Trigonometrical Office there and left for Bombay on 10th January 1903 embarking on board the R. I. M. S. "Hardinge" on 14th January, with the exception of 1 Surveyor (Bhamba Ram) and 4 Khalasis, who arrived at Bombay later and finally reached Obbia on the east coast of Somaliland on 10th February 1903.

Landing in Somaliland.

4. The Party sailed to Berbera *viâ* Aden and thence by B. I. S. S. "Nowshera" with other troops to Obbia arriving off that place on 28th January 1903. As there was a strong easterly breeze blowing and the roadstead an open one the disembarkation of the troops was carried out with some difficulty the next day, my charger being drowned when being landed.

Survey work taken in hand on landing.

5. On landing preparations were made at once for commencing a survey of the country either side of the line of march and the Party finally got away from Obbia on 11th February 1903, after observations had been made for latitude and azimuth and at the stations in the neighbourhood of Obbia and a base had been measured. The strong sea breeze by day and night which occasionally raised clouds of sand and driving clouds at night rendered an accurate determination of the latitude and azimuth impossible. The longitude was obtained from the Naval authorities. Equipment had to be cut down to the lightest scale possible owing to the limited amount of transport available (as every animal that could possibly be spared was required for hastening up stores to the advanced base). Stores and Equipment that were left behind at Obbia were sent round by ship and stored at Berbera.

Obbia Dibit Survey.

Once the Party got under way the triangulation was pushed forward, points computed out daily and given to Surveyors Mahomed Nabi and Mahomed Khan working on either flank, Bhamba Ram acting as computer and office hand. Dibit (57 miles north-west of Obbia) was the advanced base and was reached on February 25th and the work completed up to that post.

Dibit to Galkayu Survey.

6. The main column under General Manning marched out of Dibit on the 27th February; triangulation had to be abandoned as the country was too flat and the survey had to be maintained by means of a plane table traverse, the distances being taken off the measuring wheel and the scale was altered from ¼″ to 1″ to the mile.

Galkayu was reached on 3rd March after a most trying march carried out in the heat of the day under a burning sun and with a very limited supply of water, the marches were:—

Dibit-Inindeenli, 16½ miles, Rakhn, 13½ miles, Bhirokhode 10¾, Wargallo, 15¾ miles, Balamabalad, 20¼ miles, Galkayu, 17¼ miles.

From Rakhn onwards the troops were limited to ½ gallon of water a day and the last march was very severely felt, some of the stragglers not getting into camp till nearly midnight.

Work done at Galkayu.

7. A halt was made at Galkayu to rest the column and get up supplies and as I was not permitted to accompany the various expeditions (there being no spare transport) the work already accomplished was brought up to date and a triangulation started in the vicinity. Surveyor Mahomed Nabi was employed on making a large scale map of the surroundings of the post.

Galkayu-Galadi Survey.

8. A column under General Manning marched out of Galkayu on 26th March, the triangulation had to be abandoned owing to lack of transport and to other causes. I accompanied the column with plane table equipment only and 5 khalasis; the theodolite could not be taken as only one camel could be spared, transport having to be cut down to the lowest limit possible; 6 days' rations had also to be carried on the camel in addition.

Galadi (83 miles west of Galkayu) was reached on 31st March, the distances being as follows:—

To Bera, 16½ miles (halt for 36 hours), Gondu, 18½ miles, 3rd March, 17 miles, Dudub, 8½ miles, Galadi, 23½ miles.

A small body of the enemy were encountered at Galadi and driven off.

A halt was made there to get up stores and consider what the next move should be.

Short description of country traversed.

9. The country from Obbia towards Galadi presented few features of any interest. A low range of hills runs parallel to the coast a few miles inland reaching a height of nearly 1,000 feet west of Obbia, descending gently to about 480 feet where the line of march to Dibit crosses it and then gently undulating ground as far as that post which is about 400 feet above sea level.

The country then gradually rises to the north-west, Galkayu being 900 feet and Galadi 1,300 feet above sea-level. Here and there a gentle ridge and a few isolated kopjes such as Guntis, Koreli and Dafurteg hills. No river courses or marked line of drainage. Open plains covered with grass, low scrub or scattered trees and bushes alternate with low flat-topped thorn bushes, thick in places but not rising higher than 3 or 4 feet at the most. Behind and in front of the maritime ranges sand hills appear. Water is obtained at fairly frequent intervals from a succession of wells till Bera is reached when a long gap has to be passed over without water till Dudub is reached.

At Galadi there were some 2,500 wells.

Between Bera and Galadi dense belts of high bush and mimosa wood are met with. At Gondu open mimosa forest and good grazing exists.

10. A remarkable chasm called Yamis exists near Galkayu bell shaped with smooth sides, the opening at the top being about 100 feet in diameter, lower down it splays out to some 160 feet. From the top to the water-level is 160 feet. The bottom shelves rapidly down towards the north and ends in a subterranean tunnel of unknown depth. The water is 30 feet deep at one side but rapidly gets deeper towards the north. The water is excellent for drinking purposes but like all well water in Somaliland is so hard that soap will not lather in it but immediately curdles. The country provides its own antidote in the shape of a bulbous soap root that lathers very well and has a pleasant aromatic smell.

Remarkable water hole at Galkayu.

The thick bush renders accurate measuring with a wheel somewhat difficult in places and the high dense bush beyond Bera rendered planetabling almost an impossibility in places.

The nights were cool in March and April and there was a heavy dew but the sun was very powerful during the day. No rain fell till the middle of April.

11. As I was not allowed to accompany the reconnaissance column to Gumburu a valuable opportunity of fixing its site accurately was lost and I had to content myself while at Galadi with fixing Yegallo and the latitude of Galadi and a large scale survey of the 2,500 wells there.

Work carried out at Galadi.

12. An eclipse of the moon occurred in April and was seen at Galadi.

Eclipse of moon.

Before the main column retired to Galkayu I was able to get up my theodolite and Surveyor Bhámba Ram and fix the latitude of Galadi.

13. After the reverse at Gumburu all hands including non-combatants were employed in strengthening the defences of Galadi, filling water tins, etc., and the survey had to be stopped. On April 23rd the Survey Party marched back with the column under Colonel Fasken to Galkayu arriving there on 27th April.

Return to Galkayu.

14. The Party left Galkayu for Bohodle on the afternoon of 29th April and reached its destination on the morning of 7th May. The Party was accompanied by a small escort and some spare transport and 4 or 5 transport officers, the whole being under my command.

Party leave Galkayu for Bohodle.

The country was open and slightly undulating as far as Badwein after which dense bush and mimosa wood predominated, with occasional open spaces and plains. The column marched too fast to admit of a planetable being used, it had to be kept closed up and no straggling allowed as there was always a chance of encountering bodies of the enemy on its left flank.

15. The survey of the line of march had to depend on a prismatic compass traverse entered in a book and which was plotted on halting during the heat of the day and on reaching camp at nightfall.

Galkayu to Bohodle Survey.

The total distance was 147 miles giving an average daily march at 19 miles.

16. I had orders to fix the position of Bohodle accurately and then carry on a regular survey from Damot to Burao which latter place I was informed had been fixed by Colonel Swayne and data were asked for from the War Office.

Work carried out at Bohodle.

The latitude was fixed by astronomical observations and the longitude by telegraphic signals from Berbera (the Naval Authorities there kindly assisting). Thunderstorms and rain delayed this work.

Elevated towers were built to obtain a clear view over the surrounding forest and every preparation made to extend the triangulation at the first available opportunity but the presence of bodies of the enemy rendered further work out of the question.

Narrow escape of Party.

17. My squad had a narrow escape once, I was working without an escort some $3\frac{1}{2}$ miles away from the post to the south-west in a dense mimosa wood building a large trestle station when a body of the enemy's mounted men passed within 200 yards of where we were working (their foot tracks being discovered the next day) without discovering us although there was a good deal of noise at the time owing to felling of timber. On returning to camp we were met by a Party of mounted infantry who warned us of our danger; 2 Royal Engineer Officers were also out shooting and had a narrow escape. Survey work in the neighbourhood being out of the question owing to the presence of bodies of the enemy, I decided to take the matter in my own hands and march to Berbera and commence a regular survey from there. The War Office could furnish me with no data respecting Colonel Swayne's triangulation. On June 24th I was placed in command of a sick convoy and an escort of 2 officers and 150 men and together with my Party marched out of Bohodle that afternoon. Military precautions had to be observed as bodies of the enemy had been raiding the country to the north of Bohodle. The march, however, was an uneventful one and the small column reached Burao safely where I handed over command to another officer which set me free to reconnoitre the country along the line of march for suitable hills for stations, and cairns were built to mark the sites when time permitted.

Party leave Bohodle for Berbera.

Reconnaissance for triangulation carried out on the march.

18. Upper Sheikh was reached on the morning of 3rd July and as a halt had to be made till the 7th for transport the opportunity was seized to reconnoitre the surrounding hills in the neighbourhood and build stations, 3 khalasis were sent off to build a station on the highest point of the Wagger range under escort.

Short description of country traversed.

19. From Obbia the ground rises steadily in a north-west direction, Bohodle is 2,300 feet above sea-level, where a decided change in the temperature was noticeable being much cooler than Galkayu. Rain in the form of thundershowers began to fall over the country in April; heavy rain occurred 2 or 3 times at Bohodle in May and formed quite a lake in the depression near the old Fort.

The first signs of any hills occur at Damot 40 miles to the south-east of Bohodle in the shape of low plateau fringed by low hills like the Ringi to the west of Damot and others to the east of that post. The ground steadily rises to the north and is slightly undulating until the next ridge of hills to the south of Garrero is reached and which form the northern edge of the Haud and the southern watershed of the Nogal Valley.

From Garrero *viâ* Kerrit as far as Elkadalanleh a low ridge of broken hills borders the line of communications to the west and which gradually merge into the level plain stretching to the west towards Abyssinia.

On the east is a vast plain stretching right away to the Golis and Asharet Ranges and their outlying spurs, broken only by the Burdab range which runs in a northerly and southerly direction from Shimber Berris to Labagardai, east of Olasan and then bends sharply to the east and loses itself in the Nogal Valley beyond and to the north of Badwein. The Burdab slopes gently down on its western and southern sides and falls abruptly in precipices on its eastern and northern faces and is cut by deep ravines.

There is a well-marked drainage eastward towards the Nogal Valley, Garrero, Olasan and Kerrit marking the head waters at the western extremity of that valley.

The wide plain above mentioned which forms the valley of the river Der is broken at Elkadalanleh by a small low cluster of hills to the east of that place, called the Yerrowa.

East and west of Upper Sheikh rise the Golis ranges which fall abruptly to the north in steep terraces.

Elkadalanleh is 3,120 feet and Burao 14½ miles to the north 3,420 feet, Upper Sheikh is 4,712 feet, then comes an abrupt fall to Lower Sheikh about 2,300 feet.

The highest point of the Burdab is 4,000 feet, of the Golis the peak Tawaou in the Wagger mountains is the highest, being 6,570 feet.

The whole of Somaliland is covered with open and thick bush and open plains sometimes covered with grass and scrub and at other times almost bare of any vegetation except a few scattered bushes and trees.

Another upheaval occurs at Bihendhula, 22 miles south of Berbera, rising to about 2,400 feet and consisting of an intricate mass of broken hills. At nine miles from Berbera rise the maritime ranges, reaching a height of 3,120 feet at Biyogora and precipitous to the north, bare hills covered with thin thorn bush.

The ground round the maritime range averages 600 feet above sea-level and gradually descends to the coast and ends in a low ridge about 20 feet above high water mark. Cedar, large Euphorbia and box trees are met within the Golis ranges.

A good supply of water issues at intervals along the foot of the hills in the form of rivulets and springs. The Golis range forms the backbone of Somaliland, and streams draining its northern slopes run north and lose themselves in the sands on the coast, and those draining south lose themselves in the vast plains at the foot of the hills. There are practically no perennial rivers if we except the Juba and Webbe Shebeli and a few small streams that find their way from the hills near the coast to the sea. In rainy weather the dry watercourses become raging torrents for a few hours and then dry up, the water being absorbed by the dry sandy bed as the flood presses onward.

The Party marched into Berbera on the morning of the 11th July and while halted there refitted; sick khalasis were sent to Hospital or invalided to India, and stations were selected round Berbera and in the maritime ranges with a view to carrying a triangulation from Berbera to Sheikh. Daimoleweina, a prominent granite peak between Bihendhula and the Golis range at Sheikh were cairned on the way down to Berbera.

"Karif" wind hinders work.

20. The Karif, a strong south-west wind which blows persistently day and night from the end of May to the end of September, was at its height and delayed observations. The latitude and longitude of the Pier head at Berbera were taken from the Admiralty chart and on these co-ordinates the triangulation was

Work carried out at Berbera.

based. An azimuth was observed and I marched out of Berbera on 26th July (all spare hands and equipment being sent to Upper Sheikh by convoy) and carried the triangulation up to Sheikh and thence along the Golis to the Wagger mountains. I then returned to measure a short base at Upper Sheikh and brought the triangulation down to it, and by September 3rd had computed out the co-ordinates of all the points and furnished Sub-surveyor Mahomed Khan with a ready plotted board on $\frac{1}{125,000}$ Scale (approximately 1 inch to 2 miles) and started him to survey the country round Sheikh that falls on sheet 68 K. Surveyor Mahomed Nabi, who was at Berbera, was at the same time given a ready plotted board on 6 inches to the mile scale for a survey of Berbera.

Triangulation carried to Upper Sheikh.

Surveys taken in hand.

21. I left on 3rd September to extend the triangulation to the east of the Wagger mountains but failing to get Burao by helio and finding the few khalasis I had were not equal to carrying the instruments, etc., over the rough ground, the idea of extending the triangulation eastward was abandoned till a more favourable opportunity occurred, and I marched to Burao which was fixed by interpolation from the stations on the Golis ranges. The triangulation was then extended south as far as Kerrit, the work was much handicapped by want of independent escort and hampered and delayed by having to conform to the movements of convoys.

Triangulation extended to Kerrit.

A small base was measured and latitude and azimuth observed at Kerrit and the triangulation completed as far as Burao, a latitude and azimuth being observed at Elkadalanleh, the angles from Burao to the stations in the Golis strengthened, and I reached Upper Sheikh by 15th October and completed my observations there to Burao by helio.

Work carried out at Kerrit.

Return to Upper Sheikh.

22. On arrival at Upper Sheikh I started to re-organise my party. Captain C. G. Hunter, R.E., joined as Assistant Survey officer and proceeded to Berbera to obtain stores and the necessary transport, and on his return was put through a course of surveying by planetable and prismatic compass traverse; the 3 Surveyors (those in the field surveying having in the meantime been recalled) were also practised at the same work.

Re-organisation of Party. Captain Hunter joins as Assistant Survey officer.

23. The party having been strengthened by 10 khalasis from India and by 15 Porter Coolies from Berbera (to replace further casualties amongst the khalasis so as to bring the effective strength up to 36 khalasis or their equivalent), left fully equipped on the afternoon of 4th November for Kerrit. On the march down Captain Hunter and the 3 Surveyors were still practised in planetable and compass traverse work. On arrival at Kerrit Surveyor Mahomed Nabi went sick and eventually had to be sent to the Base Hospital. Surveyor Mahomed Khan was put on to ¼ inch survey work of the ground round the Burdab range and Kerrit. Captain Hunter and Surveyor Bhamba Ram assisted me to extend the triangulation from Kerrit *viâ* Wadamago to Eil Dab.

Additions to strength of Party.

Party leaves Sheikh.

Survey work taken in hand.

Triangulation extended from Kerrit to Eil Dab.

Further Survey work carried out.

24. A base line over 4 miles long was cleared between Kerrit and Wadamago and measured and the triangulation carried to Eil Dab; latitude and azimuth being observed at Wadamago. The co-ordinates of the points were computed out and Surveyor Bhamba Ram was put on to survey the ground between Garrero and Wadamago and Mahomed Khan on to the ground between Wadamago and Eil Dab.

Halt at Eil Dab pending further movements.

Survey work in advance of regular detail work in rear, arranged for.

The triangulation was finished by 23rd December 1903 and a halt was made to complete the computations at Eil Dab and work off arrears in office work as no escort could be spared and the enemy's mounted men were known to be in the neighbourhood. Preparations were made to carry on the survey when the troops advanced by means of an advanced Survey Section as well as push on the regular survey work based on triangulation in rear of the column.

Captain Hunter takes charge of advanced Survey Section.

Reconnaissance Eil Dab to Yaguri.

25. Captain Hunter with a squad of 7 khalasis was detached from the party towards the end of November to hold himself in readiness to proceed as advanced Survey officer with any reconnaissance that might be sent out. On 1st December he accompanied Colonel Wallace's reconnaissance from Eil Dab to Yaguri, 40 miles to the south-east. A rough sketch was made with prismatic compass and measuring wheel including Lassader and Higloli. The reconnaissance returned to Eil Dab, 8th December.

Reconnaissance Eil Dab to Jidbali.

Captain Hunter accompanied Colonel Kenna's reconnaissance from Eil Dab to Jidbali, 46 miles to the east. He left on December 17th, and after a rapidly executed march they came in contact with the main body of the enemy who were encamped at Jidbali, and then retired to Eil Dab, reaching that post on 21st December.

Captain Hunter's squad strengthened.

Captain Hunter joins 1st Brigade.

26. On 3rd January 1904 Mahomed Khan was told off as Assistant Surveyor to Captain Hunter and left Eil Dab on the 4th with a small column under Major Beresford to join the 1st Brigade under General Manning (who was marching from Bohodle) at Yaguri, arriving there on 7th January.

I join 2nd Brigade.

In the mean time I had been ordered to stop all further regular survey work and to form a small squad and accompany the 2nd Brigade down the Nogal Valley.

Bhamba Ram accompanied me as Assistant Surveyor and 9 khalasis were taken, as the theodolite accompanied me, the instrument received from the Commanding Royal Engineer not being a suitable one for astronomical observations and could not be taken by Captain Hunter.

2nd Brigade marches out of Eil Dab.

Halt at Turgol, 1st Brigade arrives.

27. The 2nd Brigade under General Fasken marched out of Eil Dab early on the morning of 8th January 1904 and halted at Turgol, $13\frac{1}{2}$ miles from Jidbali, for the night of the 9th January, and were joined there by the 1st Brigade.

The combined force marched out early on the morning of the 10th January and came in contact with the enemy at Jidbali and defeated them with a loss of nearly 1,500 men. Captain Hunter having been near Jidbali before was selected to guide the troops into action and took his squad with him, the remainder of the combined squad and myself remaining behind at Turgol with the troops left to guard the transport till the fight was over when the camp was moved to Jidbali and arrived there at nightfall.

Fight at Jidbali.

Captain Hunter guides the force to Jidbali.

I arrive at Jidbali.

28. I moved on to Adur with the Sappers and Miners on the 12th January and completed the Survey work as far as that place and observed for latitude which was found to agree with that deduced from the planetabling. I afterwards returned to Jidbali to survey the battlefield, but the stench of the corpses rendered this an impossible task.

29. The 1st Brigade left Jidbali on 12th January and marched to Dariali and Adadero and then up to Jlalin and reconnoitred the passes to the north-east of Halin leading up to the Sorl and then marched to Taleh. The 2nd Brigade marched out of Jidbali on 15th January and marched to Dariali and then to Lanleh and Gaolo and then reconnoitred the Annane pass and returned to Taleh just before the 1st Brigade arrived there. No signs of the enemy were seen by either Brigade except of few mounted men. The 1st Brigade remained in the Nogal Valley and the 2nd returned to Eil Dab *viâ* Hansoga and Hudin, reaching Eil Dab on 12th February. Captain Hunter joined me at Didayha on 5th February.

Movements of 1st and 2nd Brigade after Jidbali.

Mileage accomplished by each Survey Section.

30. I marched some 415 miles and Captain Hunter some 470 miles, and the combined map included nearly all the Nogal Valley except round Kallis and to the east of that place, and the Shiloleh Valley.

31. The head waters of the Nogal Valley originate in two main branches, the more important one being the river Der which rises in the Gollis Range in the neighbourhood of Upper Sheikh and flows southward past Burao as far as Elkadalanleh; it then turns suddenly to the east and is joined by important tributaries which drain into it from the mountains to the east of Upper Sheikh and the drainage from the eastern and northern slopes of the Burdab range. The second branch includes the streams that drain the western and southern slopes of the Burdab and the hills round Olasan Kerrit, Garrero and Wadamago.

Short description of Nogal Valley.

Beyond Wadamago and Elkadalanleh the well-marked watercourses spread out into the plain which gradually widens out. The river Der debouches into the plain a little south of Upper Sheikh and the two arms of the Nogal Valley which consist of wide level plains unite to the west of the Bur Anod range where the valley is about 50 miles wide. The course of the Der is marked by trees and marshy ground till Jidbali is reached where the drainage line disappears and merges into one broad level plain.

From Jidbali eastward the central plain is bounded by steep and precipitous hills broken here and there by watercourses, that drain the country behind the hills. The valley comes to a termination by a line of hills running north and south as far as Kallis where the hills to the north and south converge and the broad Nogal Valley narrows down suddenly and is then known as the valley of the river Dun which finally finds its way to the sea to the north of Illig.

Water is plentiful and grazing is good in places.

The new sheets when published will give a very good idea of the district hitherto very imperfectly explored.

Survey work during Nogal expedition no *sinecure.*

Both Captain Hunter and myself found the work very hard. The 2nd Brigade marched very quickly at the rate of nearly 4 miles an hour when on the move, with halts every hour for 5 minutes only. During the midday halt work had to be brought up to date and inked up allowing of very little rest. Captain Beazeley was not allowed to get in front of the advanced guard or fall behind the rear guard and work was often very much hustled. Captain Hunter was given more liberty but his marches were on an average longer.

Latitudes observed at Dariali and Gaolo.

32. Latitudes were observed at Dariali and Gaolo and found to agree within a ⅛ mile of that deduced from the planetable.

2nd Brigade returns to Sheikh *viâ* Eil Dab.

33. The 2nd Brigade marched out of Eil Dab on 15th February and reached Upper Sheikh on 22nd, advantage being taken on the march back to sketch in the gaps in the detail between Kerrit and Gololi.

Captain Hunter halts at Waggons Rust, Captain Beazeley moves on to Berbera.

34. Captain Hunter and myself and the squads augmented by men left at Upper Sheikh and other posts on the line marched down to Waggons Rust on 23rd February.

Captain Hunter accompanies expeditions in northern Somaliland.
Triangulation and survey extended from Berbera in a south-easterly direction.

35. A force was afterwards sent through northern Somaliland east of Berbera early in March to co-operate with the 1st Brigade in the Nogal Valley and Captain Hunter, Surveyor Mahomed Khan and 9 khalasis were detailed to accompany the expedition and left behind with equipment at Waggons Rust. The remainder and myself left on 24th February for Berbera, and after observing for azimuth and latitude and measuring a base there pushed on as far as Las Dureh, selecting and building stations on the way. A soldier surveyor joined the party at Berbera and was instructed in planetabling but went sick at Las Dureh and had to be sent back to Berbera. A base was measured with subtense bar at Las Dureh, latitude and azimuth observed and some triangulation carried out and the results computed. Surveyor Bhamba Ram was put on to survey the country embraced by the triangulation while I pressed on with the triangulation. The detail survey was delayed for a short time by Bhamba Ram falling ill but he recovered afterwards and pressed on manfully with his work.

Work beyond Las Dureh stopped. Field Force broken up.
Return to Berbera and completion of triangulation *en route.*
Captain Hunter returns to Berbera, work accomplished.
Final work carried out by Mahomed Khan.

36. It had been my intention to extend the triangulation along the hills to the south of Las Dureh in order to fix Bur Anod and the hills to the north of that range, but orders were suddenly received from head-quarters to close operations and return to Berbera as the field force was about to be demobilised and the field operations terminated. I therefore completed the triangulation in the neighbourhood of Las Dureh first and then observed from the stations to connect the eastern portion with Berbera getting back there at the end of May. In the meantime Captain Hunter had returned

viâ Laskorai having surveyed the line of march as far east as Rat and Laskorai where he embarked for Berbera; he marched some 408 miles and mapped some 7,500 square miles of country. After a short rest at Berbera Surveyor Mahomed Khan was put on to survey the country south of Berbera and was recalled by me early in June on demobilisation of the party.

Winding up of triangulation.
Demobilisation of party and return of personnel to England and India.
Karif rendered further work impossible.

37. On reaching Berbera I re-observed from some of the stations there, re-measured my base, paid up my party, returned stores and completed my ledgers, sent the men back to India or arranged for their passage and left myself for England in B.I.S.S. "Goorka" on 21st June 1904. Captain Hunter had left for England before the end of May. Even had I been able to stop in Somaliland longer the Karif wind, which was blowing hard by the time I left, would have hindered if not stopped further survey operations.

Disadvantages party worked under.

38. I was hindered a good deal by want of another officer to assist me during the first six months of the campaign. Had it been possible for me to have detached an assistant and 2 surveyors to run a triangulation as far as Damot and survey the country embraced by it during the first six months of 1903 and while the enemy's forces were away south in the Haud it would have been possible to have surveyed a great deal more country. Lack of independent escort much impeded my work too and much valuable time was lost when halted at Galkayu, Bohodle and other places and I was put at a disadvantage by not being able to start from Berbera sooner. Had I left Galadi immediately on arriving there and returned *viâ* Galkayu straight to Bohodle and Berbera I could have fixed Bohodle by triangulation from Berbera and put 3 surveyors on to the detail survey by the beginning of July even without an assistant officer. All this would have already been done as well as the country to the east and west if I had had an assistant.

Survey work accomplished.

39. 14,809 square miles of triangulation were completed, also 181 miles of 1 inch planetable traverse work, 1,396 square miles of $\frac{1}{125,000}$ detail survey, 1,253 square miles of ½ inch detail survey, 4,953 square miles of ¼ inch detail survey, 12,224 square miles of ¼ inch planetable reconnaissance (of which Captain Hunter contributed 9,023 square miles), and 180 miles of ¼ inch prismatic compass route traverse were run. Obbia and Galadi were surveyed on the 12-inch scale and Galkayu and Berbera on the 6-inch. A large scale survey was commenced of Bohodle but abandoned, as I left before much could be accomplished. Other minor surveys were made.

Mileage covered.

I marched about 2,500 miles of which 2,000 miles were covered on foot.

Captain Hunter, a most efficient Assistant Survey officer.

40. Captain Hunter was of the greatest assistance to me, he was indispensable in the Nogal Valley and northern Somaliland. Without his assistance the work he accomplished could hardly have been done as the surveyors, though excellent plane tablers when given fixed points, were not experienced enough to turn out the work Captain Hunter did.

41. Captain Hunter's work may be taken as an excellent example of good rapid reconnaissance survey done by planetable traverse and with measuring wheel, and work was very accurately done when compared with planetable work

on fixed points over the same ground considering the limited time allowed for filling in the detail.

Surveyor Mahomed Khan commended.

42. Captain Hunter reports that Surveyor Mahomed Khan was of the greatest assistance to him, and worked very hard and rapidly and showed the greatest zeal in his work.

Surveyor Bhamba Ram specially recommended.

43. Surveyor Bhamba Ram was also of the greatest assistance to me as computer and office clerk as well as Assistant Surveyor in the Nogal Valley, and was of the greatest of use to me in many ways; was most diligent and zealous over his work. He proved himself to be a native of more than average ability and intelligence and pluck.

44. The health of the party, as was the case with all the Indian troops, suffered a good deal from scurvy. In June 1904, of the original strength of 3 surveyors 1 duffadar and 29 khalasis, only 2 surveyors, the duffadar and 12 khalasis were effective, and of the 10 khalasis that joined later only 5 remained.

45. The climate though very hot at times is very dry and healthy, and there was practically no fever or malaria amongst the men.

46. The Somalis could not understand my work at first, and thought I must be the General's magician and the angles I called out when observing at night were the numbers of the Mullah's men that would be killed. I did not hear of this till afterwards, and this would account for the awe they seemed to have for me at the beginning of the campaign.

G. I. C. P. O.—No. 23 S. G.—26-4-07.—350—R. S. W.

EXTRACTS

FROM

NARRATIVE REPORTS

OF OFFICERS OF THE

Survey of India

FOR THE SEASON

1904-05.

PREPARED UNDER THE DIRECTION OF

COLONEL F. B. LONGE, R.E.,
SURVEYOR GENERAL OF INDIA.

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