IX. *On the Solar Variations of Magnetic Declination at Bombay. By* CHARLES CHAMBERS, *Esq., Superintendent of the Colaba Observatory. Communicated by* BALFOUR STEWART, *F.R.S.*

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1. THE observations discussed in the following pages were made at the Government Observatory at Bombay, during the years 1859 to 1865, and constitute a portion of a much larger series of observations of which the remaining part is still awaiting reduction. With the exception of Sundays, and eight or ten complete days in each year, the observations were taken continuously at hourly intervals throughout the period of seven years. The observers were carefully trained Brahmins, who were under the immediate oversight of highly intelligent assistants of the same caste.

2. The instrument used was made by GRUBB of Dublin, and consists of a rectangular bar-magnet suspended horizontally, and carrying a divided scale and a lens, by means of which its position can be determined from time to time by reading the scale with a fixed telescope properly placed. The dimensions of the magnet are 15 inches by 0·86 inch by 0·25 inch, and the broad surface is made to lie horizontal; the suspension-thread was formed of about forty fibres of untwisted silk, and is 35 inches long, being protected (but not concealed from view) by a glass tube 1·3 inch in diameter: the bottom of the glass tube rests upon the top of a cylindrical mahogany box (8·5 inches in height) which surrounds the magnet, and the top supports a horizontal divided circle (the torsion-circle), and a brass cross piece to which the suspension-thread is attached. The tube is secured in a vertical position by a mahogany cross bar which has a circular hole in its centre that fits over the upper end of the tube, and which is fixed at its extremities to two copper pillars whose feet are screwed into the marble basement of the instrument; and the upper aperture of the tube with the attachments is screened from the outer air and dust by an inverted hemispherical glass vessel. A sliding-frame which carries above a finely divided scale etched upon glass is fixed by a binding-screw near the northern extremity of the magnet, and a similar frame carrying a lens, whose focal length is about 12·7 inches, is secured to the magnet at that distance to the southward of the glass scale, so that the latter is approximately in the principal focus of the lens. The vertical lines which form the scale are equidistant and generally of uniform length; but every fifth division is slightly and every tenth division considerably prolonged, and over the tenth divisions numbers are marked in consecutive order, thus allowing a numerical designation to be given with facility to every point of the scale when viewed by the telescope. To permit the scale to be viewed through its lens by a telescope outside

the mahogany box, the latter has two small windows of flat glass suitably inserted in its curved side, and a lamp is placed on a stool to the northward of the masonry pillar which supports the declinometer, and is kept constantly burning. The joints and crevices, and. for greater security, the whole outside surface of the cylindrical box was covered with paper to keep out small spiders or other insects.

3. The observations are made by a transit instrument (30 inches long and with pivots 15 inches apart) which is fixed on an isolated pillar of masonry, at a distance of 27 feet to the southward of the declinometer pillar, and which in this position is capable of being used also for observing the transits of stars through an opening (provided with shutters) in the roof of the observatory. This instrument was adjusted in a line with the centres of the scale and lens attached to the magnet, and its basement was then firmly imbedded in masonry, and the telescope was focused so as to give a distinct view of the scale. A vertical spider-line is placed in the common principal focus of the object-glass and eye-piece, and the instrument was adjusted so that an object on the true meridian should be cut by this line. With these arrangements any change in the azimuth of the freely suspended magnet is indicated by a change of corresponding magnitude in the position of the image of the collimator scale, as seen in the field of view of the telescope; and the actual position of the magnet at any moment may be found by noting the scale-division that is cut by the reading-wire of the telescope, if only we know the position corresponding to any one reading of the scale, and the change of position for a change of unity in the reading. The latter constant, the scale-coefficient, is easily determined by substituting an azimuth instrument in the place of the transit instrument, and observing with it the horizontal angle included between any two widely different divisions of the scale when the magnet is at rest. Experiments recorded on pages x and xi of the Introduction to the Bombay Magnetical Observations for 1864 showed that the scale was very correctly placed in the principal focus of its lens, and that the scale-coefficient is 6′·806; but the actual value of the coefficient used in the reduction of the observations was 6′·841, that having been the result of a first determination made in 1865, when the scale and lens were apparently differently adjusted with respect to each other. No correction has, however, been applied to the reduced observations for the present purpose, since the *laws of periodical variations* are exhibited with equal clearness whatever the unit with which they are expressed; and it will only be necessary to bear in mind what is the real unit made use of if we should wish to compare the variations of this element of the terrestrial magnetic force at Bombay with those of either or both of the two others, or with the results of observations made elsewhere, so that all may be reduced to a common unit as a preliminary step*.

4. The direction of the magnetic axis of the bar corresponding to a particular scale-reading was found in the following manner:—

First, the level and collimation errors of the transit instrument were approximately destroyed, and the telescope was then pointed upon Polaris when on the true meridian,

* It has not been deemed requisite to do this for any of the discussions that follow.

and the azimuthal adjusting-screw turned until the star was bisected by the vertical spider-line at the proper moment, as taken from the Nautical Almanac: it appeared, from observations made in May 1866, and described in detail in the Introduction to the Bombay Magnetical Observations for 1864, pages x to xii, that this adjustment was at that time very nearly correct. Secondly, a bundle of about forty threads of untwisted silk having been prepared with care to avoid entangling the different fibres, a brass bar of the same weight as the magnet was suspended and allowed to swing until it took up a position of rest; the arms of the torsion-circle and the attached suspension-pin, to which the upper end of this thread was bound, were then turned in azimuth until the brass bar lay at rest approximately in the true meridian: the magnet was now substituted in place of the brass bar, and a reading of the scale was taken and recorded; next, the magnet being provided with a suspension-hook that allows the bar to be inverted about its own length as an axis, without disturbing any of the attachments, this inversion was made and the scale again read. Now the position of the magnetic axis of the bar in the direct and reverse positions would be the same, but the scale-reading would be increased in the one case and diminished in the other, by an amount corresponding to the deviation of the magnetic axis from true meridian; hence the average of the two readings will give the reading that would be found if the magnet lay with its axis in the true meridian, and half their difference represents the deviation (in scale-divisions) from that position. When the instrument was last adjusted, on the 9th November, 1861, the true meridian reading was 28·2733; and the scale being placed in an inverted position it appeared erect in the telescope, so that increase of reading represents an easterly movement of the north end of the magnet.

5. One other element, taking account of the magnet being restrained from responding fully to the changes of magnetic force by the torsion-force of the suspension-thread, enters into the reduction of the observations:—the torsion-force is assumed, as in COULUMB'S Electrometer, to be proportional to the angle of torsion, that is, to the deviation of the magnet from the position of no torsion—in this case the true meridian; the torsion-coefficient, or unity *plus* the ratio between the torsion-force and the directive force of the earth acting upon the particular magnet, is determined by observing the change of scale-reading produced when the arms of the torsion-circle are turned through 90°, dividing the corresponding angle (α) by ($90°-\alpha$), and adding unity to the quotient. In November 1861 its value was found to be 1·0028, and this has been used without alteration over since.

6. The formula used in the reduction of the observations was

$$D=6'{\cdot}841(f-R)\,.\,c,$$

where $6'{\cdot}841$ is the adopted value of a unit of the declinometer scale, R the true meridian reading, c the torsion-coefficient, and D is the absolute easterly declination when f is the observed scale-reading. The values of D thus obtained, in which form the declination records have been printed in the several volumes of 'Bombay Magnetical Observations,' form the fundamental data for the following discussion*.

7. It ought to be mentioned that the sliding tube of the transit instrument with which the declinometer was read was rather loosely fitted in its socket, a fault which might cause sensible change in the collimation-error whenever the focusing adjustment was used; now the instrument was once every month turned upon a divided scale fixed upon the north wall of the magnetometer-room and adjusted for distinct vision, after which the adjustment was restored for the collimator scale of the magnetometer. It is suspected that small but important irregularities in the observations, which will be pointed out later, are due chiefly to this fault.

8. Throughout the periods January 1, 1859 to July 2, 1861, and November 13, 1861 to December 31, 1865, the adjustments of the instrument were undisturbed; but between July 3 and November 12, 1861 the adjustments were several times renewed, and the action of the instrument was at times so unsatisfactory that the observations of July 3 to 8, August 7 to 12, and October 28 to November 12 are considered unfit for incorporation with the general body. The following statement shows the several periods made use of, the observed and adopted values of the true meridian reading, and the values of the torsion-coefficient as experimentally determined:—

Periods.	True meridian reading.		Torsion-coefficient.
	Observed.	Adopted.	
January 1, 1859 to July 2, 1861	28·3064	28·379	1·003009
July 9, 1861 to August 6, 1861	28·5334	31·153	1·00039
August 13, 1861 to October 27, 1861	28·2515	28·2515	1·00088
November 13, 1861 to December 31, 1865	28·2733	28·2733	1·0028

No reason is assigned in the records for the adoption for the first two periods of a different true-meridian reading to that which was observed; but it may be presumed that in the latter case the intention was to produce that accordance, which doubtless existed in fact, between the values of declination in that and the preceding and following periods. Any periodical variations which the observations may, however, exhibit will be unaffected by the meridian reading, so long as none of the observations of any single period involved belong to more than one series, or so long as each series of observations is treated independently of the others; and it is only when combining the different series together for the elimination of secular variation and for the evaluation of absolute declination at a given epoch, that regard must be paid to the actual disconnexion of the several series. In the investigations of solar and lunar diurnal variations which follow or are in progress, no incomplete days, nor any comprising observations from different series have been made use of.

* I should have preferred to operate directly upon the observed quantities (f), but was led to believe, at the commencement of the work, that part of the original registers had been destroyed; I have since found that this was incorrect.

9. *Method of Reduction of the Observations.*—The singularly fruitful nature of the mode of treatment of observations of a like character with those now under discussion, introduced and extensively applied by Lieut.-General SABINE, P.R.S., is such as to leave no doubt as to the propriety of its adoption in the present instance, especially as the whole series of observations, the greater part of which remains still unreduced, extends over nearly a quarter of a century. That mode of treatment is described by General SABINE as follows *:—"The hourly directions of the magnet [in this case expressed in minutes of deviation of the north end of the magnet to the eastward of true north] are entered in monthly tables, having the days of the month in successive horizontal lines, and the hours of the day in vertical columns. The 'means' of the entries in each vertical column indicate the mean direction of the magnet at the different hours of the month to which the table belongs, and have received the name of 'First Normals.' On inspecting any such monthly table, it is at once seen that a considerable portion of the entries in the several columns differ considerably from their respective means or first normals, and must be regarded as 'disturbed observations.' The laws of their relative frequency and amount of disturbance, in different years, months, and hours, are then sought ought, by separating for that purpose a sufficient body of the most disturbed observations, computing the amount of departure in each case from the normal of the same month and hour, and arranging the amounts in annual, monthly, and hourly tables. In making these computations, the first normals require to be themselves corrected, by the omission in each vertical column of the entries noted as disturbed, and by taking fresh means, representing the normals of each month and hour after this omission, and therefore uninfluenced by the larger disturbances. These new means have received the name of 'Final Normals,' and may be defined as being the mean directions of the magnet in every month and every hour, after the omission from the record of every entry which differed from the mean a certain amount either in excess or in defect.

"In this process there is nothing indefinite; and nothing arbitrary save the assignment of the particular amount of difference from the normal which shall be held to constitute the measure of a large disturbance, and which, for distinction sake, we may call 'the separating value.' It must be an amount which will separate a sufficient body of disturbed observations to permit their laws to be satisfactorily ascertained; but in other respects its precise value is of minor significancy; and the limits within which a selection may be made, without materially affecting the results, are usually by no means narrow; for it has been found experimentally on several occasions that the ratios by which the periodical variations of disturbance in different years, months, and hours are characterized and expressed do not undergo any material change by even considerable differences in the amount of the separating value. The separating value must necessarily be larger at some stations than at others, because the absolute magnitude of the disturbance-variation itself is very different in different parts of the globe, as well as its comparative magnitude in relation to the more regular solar-diurnal variation; but it

* Proceedings of the Royal Society, vol. x. pp. 624–626.

must be a constant quantity throughout at one and the same station, or it will not truly show the relative proportion of disturbance in different years and different months."

In two instances only were days of a certain month included, in consequence of interruption of the observations, in the monthly Tables of a different month, viz.:—the 1st and 2nd of July with the month of June 1861, and from the 1st to the 6th of August with the month of July 1861; and the only incomplete months were those of August, October, and November 1861. The first step to be taken was to fix upon a suitable *separating value*, and in doing this regard was paid to the desirableness of having the results derived for Bombay comparable with those for some one of the stations where similar observations had been made and similarly treated. Now the ordinary reductions of the Bombay observations already made showed that the station amongst those which it most nearly resembled was St. Helena; for whilst both are equatorial stations in the sense of the ordinary solar-diurnal variation being at certain seasons overridden by the semiannual inequality of that variation, Bombay has very nearly the same preponderance of the character of a north-latitude station that St. Helena has as a south-latitude station. The separating value adopted by General SABINE in the reduction of the St. Helena observations was 1'·78, or a disturbing force equal to ·0029 English units; a force of this magnitude acting at Bombay would produce a deviation of the declination-magnet of 1'·25. The value finally fixed upon was 1'·4, which gives the ratio of the number (3516) of disturbed observations to the total number (50736) of observations in the seven years as 1 to 14·4, the similar ratio for St. Helena having been 1 to 13·7.

10. Trials were also made with separating values 1'·0 for the years 1859 and 1860, and 1'·7 for 1860, the results of which (being further confirmatory of the position taken above that "the *ratios* by which the periodical variations of disturbance in different hours are characterized and expressed, do not undergo any material change by even considerable differences in the amount of the separating value") are shown in the subjoined Tables, and by Curves Nos. 1 to 4 of Plate XXV.

TABLE I.—Showing, for each hour of the day, the aggregates of Easterly disturbances of Declination exceeding 1′·0, 1′·4, and 1′·7 respectively, in the years 1859 and 1860, and the corresponding ratios of the aggregate disturbance at each hour to the average aggregate hourly disturbance for the twenty-four hours.

Bombay Astronomical Hours.	Aggregates of Easterly Disturbances.					Ratios.				
	1859.		1860.			1859.		1860.		
	Separating value.					Separating value.				
	1′·0.	1′·4.	1′·0.	1′·4.	1′·7.	1′·0.	1′·4.	1′·0.	1′·4.	1′·7.
h m										
4 12	51·757	35·466	46·246	29·107	18·025	0·90	0·88	0·90	0·83	0·70
5 12	51·593	29·690	42·672	19·311	13·192	0·90	0·74	0·83	0·56	0·52
6 12	43·782	28·741	31·687	22·608	19·348	0·76	0·71	0·61	0·65	0·76
7 12	48·294	34·288	35·280	35·102	30·890	0·84	0·85	0·68	1·01	1·21
8 12	61·750	43·332	37·917	29·834	21·345	1·08	1·07	0·73	0·86	0·83
9 12	50·127	31·550	39·530	26·678	23·296	0·88	0·78	0·76	0·77	0·91
10 12	59·087	41·861	40·473	23·614	15·830	1·03	1·04	0·78	0·68	0·62
11 12	47·550	40·412	42·193	21·482	12·942	0·83	1·00	0·82	0·62	0·51
12 12	44·935	36·934	25·639	22·429	8·458	0·78	0·91	0·50	0·65	0·33
13 12	41·108	31·866	36·812	18·459	14·828	0·72	0·79	0·71	0·53	0·58
14 12	36·100	29·017	28·555	16·674	11·715	0·63	0·72	0·55	0·48	0·46
15 12	32·732	25·540	36·595	25·299	17·069	0·57	0·63	0·71	0·73	0·67
16 12	32·534	22·446	40·806	17·891	13·079	0·57	0·56	0·79	0·52	0·51
17 12	37·221	22·906	51·522	31·804	28·145	0·65	0·57	1·00	0·92	1·10
18 12	53·392	37·587	77·986	60·232	51·330	0·93	0·93	1·51	1·74	2·01
19 12	68·025	59·644	83·650	61·639	47·653	1·19	1·48	1·62	1·78	1·86
20 12	84·294	43·181	61·085	40·580	31·984	1·47	1·07	1·18	1·17	1·25
21 12	82·185	49·738	71·760	31·803	19·012	1·44	1·23	1·39	0·92	0·74
22 12	116·645	71·755	63·296	49·933	38·281	2·04	1·78	1·23	1·44	1·50
23 12	101·169	90·538	82·663	56·567	29·285	1·77	2·24	1·60	1·63	1·14
0 12	74·977	57·241	65·006	51·857	41·839	1·31	1·42	1·26	1·50	1·64
1 12	55·486	45·681	69·136	57·587	41·671	0·97	1·13	1·34	1·66	1·63
2 12	42·152	30·646	78·016	40·832	38·878	0·74	0·76	1·51	1·18	1·52
3 12	56·927	29·154	49·720	40·975	25·997	0·99	0·72	0·96	1·18	1·02

TABLE II.—Showing, for each hour of the day, the aggregates of Westerly disturbances of Declination exceeding 1′·0, 1′·4, and 1′·7 respectively, in the years 1859 and 1860, and the corresponding ratios of the aggregate disturbance at each hour to the average aggregate hourly disturbance for the twenty-four hours.

Bombay Astronomical Hours.	Aggregates of Westerly Disturbances.					Ratios.				
	1859.		1860.			1859.		1860.		
	Separating value.					Separating value.				
	1′·0.	1′·4.	1′·0.	1′·4.	1′·7.	1′·0.	1′·4.	1′·0.	1′·4.	1′·7.
h m										
4 12	24·787	15·013	50·816	32·064	26·760	0·71	0·72	1·27	1·27	1·49
5 12	10·189	7·905	26·883	19·412	16·416	0 29	0·38	0·67	0·77	0·91
6 12	10·201	4·717	17·461	8·013	8·013	0·29	0·23	0·44	0·32	0·45
7 12	6·486	3·263	10·855	10·143	0·000	0·19	0·16	0·27	0·40	0·00
8 12	1·011	0·000	9·468	1·609	0·000	0·03	0·00	0·24	0·06	0·00
9 12	3·310	0·000	7·202	3·117	0·000	0·07	0·00	0·18	0·12	0·00
10 12	1·395	0·000	7·959	6·438	0·000	0·04	0·00	0·20	0·25	0·00
11 12	3·237	2·024	8·552	1·569	0·000	0·09	0·10	0·21	0·06	0·00
12 12	1·887	1·896	14·075	0·000	0·000	0·05	0·09	0·35	0·00	0·00
13 12	0·000	0·000	7·433	3·114	0·000	0·00	0·00	0·19	0·12	0·00
14 12	2·198	0·000	10·457	5·461	2·159	0·06	0·00	0·26	0·22	0·12
15 12	3·535	0·000	11·472	6·754	2·025	0·10	0·00	0·29	0·27	0·11
16 12	4·749	0·000	10·787	2·011	2·156	0·14	0·00	0·27	0·08	0·12
17 12	7·771	2·881	21·923	11·698	4·078	0·22	0·14	0·55	0·46	0·23
18 12	44·972	25·868	33·496	7·822	9·742	1·30	1·24	0·84	0·31	0·54
19 12	48·941	13·587	51·874	25·168	16·693	1·41	0·65	1·29	1·00	0·93
20 12	41·231	23·262	64·509	40·914	18·695	1·19	1·11	1·61	1·62	1·04
21 12	73·392	51·357	78·574	69·518	61·456	2·12	2·46	1·96	2·75	3·42
22 12	65·552	53·587	119·854	78·239	65·378	1·89	2·57	2·99	3·09	3·64
23 12	125·160	71·600	97·152	68·135	65·226	3·61	3·43	2·40	2·70	3·63
0 12	109·060	83·193	102·258	69·272	52·325	3·15	3·99	2·55	2·74	2·91
1 12	113·927	75·811	84·736	60·539	33·296	3·29	3·63	2·11	2·39	1·85
2 12	90·291	47·939	58·058	46·296	22·661	2·60	2·30	1·45	1·83	1·26
3 12	39·807	16·962	55·962	29·424	24·285	1·15	0·81	1·40	1·16	1·35

The number of observations reckoned as disturbed with the different separating values was as follows:—

TABLE III.

	Number of disturbed observations.			Number of observations out of which on an average one is disturbed.		
Separating value...	1'·0	1'·4	1'·7	1'·0	1·4	1'·7
1859	1259	672	......	5·8	10·9	
1860	1318	685	434	5·6	10·7	16·9

11. *Disturbance-variations, Diurnal, Annual, and Decennial.*—The following Tables exhibit the general results as to diurnal, annual, and decennial variations of disturbance when the separating value made use of is 1'·4.

TABLE IV.—Showing the aggregates of Easterly disturbances exceeding 1'·4 in amount for each hour of the day in each of the years 1859 to 1865, and in the whole period of seven years; also, for the whole period, the ratios of aggregate disturbance at the several hours to the average aggregate hourly disturbance in the twenty-four hours.

Bombay Astronomical Hours.	Aggregates of Easterly Disturbance.								Ratios.
	1859.	1860.	1861.	1862.	1863.	1864.	1865.	Seven years, 1859 to 1865.	
h m									
4 12	35·466	29·107	17·153	33·364	22·841	10·058	22·777	170·766	0·94
5 12	29·690	19·311	7·649	48·925	16·214	17·529	15·789	155·107	0·86
6 12	28·741	22·608	6·637	26·097	23·345	18·817	25·042	151·287	0·84
7 12	34·288	35·102	13·825	20·864	18·871	5·743	13·132	141·825	0·78
8 12	43·332	29·834	20·293	30·670	19·230	8·054	16·396	167·809	0·93
9 12	31·550	26·678	14·459	19·417	7·742	10·225	19·112	129·183	0·71
10 12	41·861	23·614	16·697	14·826	3·987	4·817	11·363	117·165	0·65
11 12	40·412	21·482	21·490	23·522	6·162	3·819	5·607	122·494	0·68
12 12	36·934	22·429	26·900	21·564	0·000	5·079	9·773	122·679	0·68
13 12	31·866	18·459	25·131	14·455	8·746	7·880	13·594	120·131	0·66
14 12	29·017	16·674	13·612	21·417	7·993	9·229	14·274	112·216	0·62
15 12	25·540	25·299	22·647	28·693	12·297	16·307	20·598	151·381	0·84
16 12	22·446	17·891	20·821	13·856	10·591	14·974	16·375	116·954	0·65
17 12	22·906	31·804	13·247	15·917	6·514	15·691	8·254	114·333	0·63
18 12	37·587	60·232	18·583	19·855	3·238	9·840	14·236	163·571	0·90
19 12	59·644	61·639	27·029	26·175	14·956	13·030	13·250	215·723	1·19
20 12	43·181	40·580	27·107	27·248	9·460	12·929	5·265	165·770	0·92
21 12	49·738	31·803	32·626	45·258	12·444	13·964	19·449	205·282	1·14
22 12	71·755	49·933	32·302	71·258	18·259	30·885	30·277	304·669	1·69
23 12	90·538	56·567	38·052	68·850	33·287	24·832	29·167	341·293	1·89
0 12	57·241	51·857	27·281	63·044	63·427	32·828	29·614	325·292	1·80
1 12	45·681	57·587	26·204	58·423	45·320	30·713	25·231	289·159	1·60
2 12	30·646	40·832	22·609	44·571	34·410	36·667	34·197	243·932	1·35
3 12	29·154	40·975	21·219	32·459	17·198	20·459	29·100	190·564	1·05

The hourly ratios are also represented, in the usual manner, by curve No. 5, Plate XXV.

TABLE V.—Showing the aggregates of Westerly disturbances exceeding 1'·4 in amount for each hour of the day in each of the years 1859 to 1865, and in the whole period of seven years; also, for the whole period, the ratios of aggregate disturbance at the several hours to the average aggregate hourly disturbance in the twenty-four hours.

Bombay Astronomical Hours.	Aggregates of Westerly Disturbance.								Ratios.
	1859.	1860.	1861.	1862.	1863.	1864.	1865.	Seven years, 1859 to 1865.	
h m									
4 12	15·013	32·064	14·454	32·204	6·893	11·174	9·100	120·902	1·08
5 12	7·905	19·412	9·513	12·966	1·418	9·040	8·438	68·692	0·61
6 12	4·717	8·013	6·502	11·999	1·404	2·512	9·008	44·155	0·39
7 12	3·263	10·143	5·509	17·113	0·000	3·768	7·906	47·702	0·43
8 12	0·000	1·609	1·733	8·432	3·140	0·000	5·486	20·400	0·18
9 12	0·000	3·117	0·000	7·209	1·504	0·000	2·908	14·738	0·13
10 12	0·000	6·438	0·000	6·841	1·472	0·000	3·568	18·319	0·16
11 12	2·024	1·569	0·000	1·655	1·518	0·000	1·561	8·327	0·07
12 12	1·896	0·000	0·000	3·661	0·000	0·000	0·000	5·557	0·05
13 12	0·000	3·114	1·550	6·526	0·000	0·000	4·854	16·044	0·14
14 12	0·000	5·461	2·137	6·513	1·655	0·000	0·000	15·766	0·14
15 12	0·000	6·754	0·000	6·413	0·000	0·000	1·710	14·877	0·13
16 12	0·000	2·011	1·464	4·880	3·653	0·000	6·662	18·670	0·17
17 12	2·881	11·698	0·000	6·891	5·446	1·567	13·378	41·861	0·37
18 12	25·868	7·822	6·827	23·963	3·607	4·765	13·781	86·635	0·77
19 12	13·587	25·168	21·578	18·685	9·431	8·544	16·417	113·410	1·01
20 12	23·262	40·914	23·882	33·729	31·408	15·059	17·349	185·603	1·66
21 12	51·357	69·518	25·055	43·036	32·460	28·909	15·863	266·198	2·37
22 12	53·587	78·239	48·552	41·718	37·928	27·151	26·749	313·924	2·80
23 12	71·600	68·135	37·509	37·271	41·551	28·587	25·384	310·037	2·76
0 12	83·193	69·272	49·884	42·012	20·564	17·270	26·744	308·939	2·75
1 12	75·811	60·539	46·012	41·489	26·947	21·303	11·828	283·929	2·53
2 12	47·939	46·296	22·632	33·045	34·339	12·880	15·951	213·082	1·90
3 12	16·962	29·424	23·511	37·265	15·289	21·635	9·483	153·569	1·37

The hourly ratios are also represented, in the usual manner, by curve No. 6, Plate XXV.

TABLE VI.—Showing, for the period 1859 to 1865, the algebraical sum of all disturbances, those to the Eastward being reckoned as positive, those to the Westward as negative, exceeding 1'·4 in amount for each hour of the day.

	Bombay Astronomical Hours.											
	h m 4 12	h m 5 12	h m 6 12	h m 7 12	h m 8 12	h m 9 12	h m 10 12	h m 11 12	h m 12 12	h m 13 12	h m 14 12	h m 15 12
Excess of Easterly Disturbances.	+49·864	+86·415	+107·132	+ 94·123	+147·409	+114·445	+98·846	+114·167	+117·122	+104·087	+96·450	+136·504
	Bombay Astronomical Hours.											
	h m 16 12	h m 17 12	h m 18 12	h m 19 12	h m 20 12	h m 21 12	h m 22 12	h m 23 12	h m 0 12	h m 1 12	h m 2 12	h m 3 12
Excess of Easterly Disturbances.	+98·284	+72·472	+ 76·936	+102·313	− 19·833	− 60·916	− 9·255	+ 31·256	+ 16·353	+ 5·230	+30·850	+ 36·995

The curve which represents the disturbance diurnal variation, constructed from these numbers, is marked fig. 7 on Plate XXV.

TABLE VII.—Showing, for the period 1859 to 1865, the aggregates of Easterly and of Westerly disturbance in each month of the year, the corresponding ratios to the average aggregate monthly disturbance, and the numbers of observations separated as disturbed in each month.

Months.	Easterly Disturbances.			Westerly Disturbances.			Easterly and Westerly Disturbances.		
	Aggregates.	Ratios.	Numbers of disturbed observations.	Aggregates.	Ratios.	Numbers of disturbed observations.	Aggregates.	Ratios.	Numbers of disturbed observations.
January	304·347	0·84	155	198·089	0·88	105	502·436	0·86	260
February ...	323·306	0·89	165	150·901	0·67	79	474·207	0·81	244
March	465·344	1·29	225	209·485	0·93	114	674·829	1·15	339
April	376·052	1·04	185	289·836	1·29	153	665·888	1·14	338
May	207·107	0·57	110	224·211	1·00	117	431·318	0·74	227
June	264·433	0·73	136	183·258	0·82	96	447·691	0·76	232
July	428·079	1·18	211	409·885	1·83	204	837·964	1·43	415
August	592·799	1·64	270	288·258	1·29	155	881·057	1·50	425
September ...	434·502	1·20	195	234·283	1·04	127	668·785	1·14	322
October	551·198	1·52	245	293·979	1·31	151	845·177	1·44	396
November ...	144·255	0·40	76	91·034	0·41	51	235·289	0·40	127
December ...	247·163	0·68	126	118·117	0·53	65	365·280	0·62	191

TABLE VIII.—Showing the aggregates of Easterly and of Westerly disturbance in each of the years 1859 to 1865, and in the whole seven years, and the ratios of the aggregates for the individual years to the average annual aggregate; also the numbers of observations separated as disturbed in each year and in the whole period.

Years.	Easterly Disturbances.			Westerly Disturbances.			Easterly and Westerly Disturbances.		
	Aggregates.	Ratios.	Numbers of disturbed observations.	Aggregates.	Ratios.	Numbers of disturbed observations.	Aggregates.	Ratios.	Numbers of disturbed observations.
1859.	969·214	1·56	417	500·865	1·30	255	1470·079	1·46	672
1860.	832·297	1·34	385	606·730	1·58	300	1439·027	1·43	685
1861*.	513·573	0·83	262	348·304	0·91	189	861·877	0·86	451
1862.	790·728	1·28	388	485·518	1·26	262	1276·246	1·27	650
1863.	416·532	0·67	217	281·627	0·73	157	698·159	0·70	374
1864.	374·369	0·60	198	214·164	0·56	120	588·533	0·59	318
1865.	441·872	0·71	232	254·128	0·66	134	696·000	0·69	366
Seven years.	4338·585	......	2099	2691·336	......	1417	7029·921	......	3516

12. *Remarks on the Disturbance-variations.*—At nearly all stations whose disturbance-diurnal variation curves have been found by the process described above, one or other of these curves, either the easterly or the westerly, closely corresponds in shape to a general type. The westerly disturbance- diurnal variation curve for Bombay conforms to this type, of which the characteristics are, that during about half the day the ordinates are very small, whilst there is a gradual and regular rise on either side of this quiescent period towards a maximum, which occurs near the middle of the remaining

* The deficiency in the ratios and numbers of observations for the year 1861 is partly accounted for by the fact that during an aggregate of thirty-one days in the months of July, August, October, and November the instrument was acting irregularly or was under adjustment, and the observations had to be rejected.

part of the day; such curves are the easterly for Kew, St. Helena, Toronto, and the Cape of Good Hope, and the westerly for Hobarton, St. Helena, Pekin, and Nertschinsk. The correspondence as to shape does not, however, hold as to time, either absolute or local, for the hours of maxima are not confined to any particular portion of the day. The Bombay astronomical hours of little or no westerly disturbance are from 6 to 17, the considerable and regular variation from hour to hour occurring during the remaining hours. The principal features of the easterly disturbance- diurnal variation curve for Bombay are like those of the westerly curve, with this distinction, that there is a considerable amount of easterly disturbance at all hours of the day, the least hourly ratio being 0·62; the easterly curve is also less remarkably regular than the westerly. There is great similarity in the declination-disturbance diurnal variations of St. Helena and Bombay, and the principal inflections of the curves occur at the same local hours; but the night hours at St. Helena are, unlike the same at Bombay, almost entirely free from easterly disturbance. In the disturbance- annual variations there is, as at Toronto, a tendency, though not very decided, towards maxima at the equinoxes and minima at the solstices. Having regard to the note at foot of Table VIII., it is seen that the decennial variation of aggregate disturbance is distinctly indicated, as far as seven years are capable of showing it, both in the easterly, westerly, and combined disturbances, the minimum occurring in 1864 and the maximum about the end of 1859. The aggregate of disturbances in the latter year exceeds that in the former in the proportion of 2·5 to 1. The disturbance- diurnal variation curve shows a preponderance of easterly disturbance at all hours except 20^h and 21^h; from 5^h to 19^h the preponderance is great, but is less considerable during the remaining hours: on the whole the proportion of aggregate easterly disturbance to westerly is as 1·6 to 1.

13. *The regular Solar-diurnal Variation.*—After the separation of disturbed observations differing from the final normals by $1'{\cdot}4$, the averages were taken of the monthly final normals of each hour—in the first place for every month, and in the second place for each of the fourteen half years; and by means of these averages were calculated the diurnal variations* for each month (on an average of seven years), for the whole year, and for each individual half year from 1859 to 1865, the one half year comprising the months April to September, and the other the months January to March and October to December. The diurnal variations are shown in the following Tables.

* By diurnal or annual variations is always to be understood the series of hourly or monthly values expressed by the excess of each above the mean value for the whole day or for the whole year respectively.

TABLE IX.—Showing, for the period 1859 to 1865, the mean diurnal variation of Declination for each month of the year and for the whole year*.

Bombay Astronomical Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
h m													
0 12	−0·554	−0·460	−1·217	−2·226	−2·536	−2·424	−1·969	−2·849	−2·937	−1·382	−0·256	−0·213	−1·585
1 12	−0·183	−0·421	−1·389	−2·182	−2·099	−2·428	−2·172	−2·574	−2·588	−1·090	+0·244	+0·225	−1·388
2 12	+0·003	−0·183	−0·639	−1·610	−1·599	−2·067	−1·860	−1·881	−1·416	−0·266	+0·427	+0·342	−0·896
3 12	+0·136	−0·072	−0·153	−0·704	−0·751	−1·279	−1·097	−0·847	−0·183	+0·311	+0·280	+0·321	−0·337
4 12	+0·210	+0·066	+0·146	−0·065	−0·088	−0·395	−0·372	+0·021	+0·508	+0·412	+0·136	+0·280	+0·072
5 12	−0·019	−0·130	−0·261	−0·024	+0·184	−0·017	+0·004	+0·417	+0·266	−0·157	−0·125	+0·040	+0·015
6 12	+0·005	−0·289	−0·508	−0·267	+0·065	−0·038	−0·030	+0·225	−0·110	−0·268	−0·026	+0·069	−0·098
7 12	+0·169	+0·012	−0·301	−0·323	−0·333	−0·385	−0·407	−0·200	−0·092	−0·073	+0·163	+0·269	−0·125
8 12	+0·168	+0·098	−0·201	−0·253	−0·402	−0·395	−0·594	−0·210	−0·064	−0·057	+0·212	+0·220	−0·123
9 12	+0·155	+0·067	−0·082	−0·052	−0·223	−0·298	−0·401	−0·163	−0·033	−0·064	+0·173	+0·211	−0·059
10 12	+0·131	+0·056	−0·081	+0·084	−0·077	−0·173	−0·240	−0·098	+0·020	+0·074	+0·238	+0·209	+0·012
11 12	+0·164	+0·113	+0·090	+0·203	+0·034	+0·028	−0·082	+0·055	+0·099	+0·144	+0·334	+0·239	+0·118
12 12	+0·107	+0·175	+0·149	+0·302	+0·151	+0·236	+0·073	+0·147	+0·190	+0·183	+0·282	+0·223	+0·185
13 12	+0·051	+0·176	+0·166	+0·414	+0·276	+0·366	+0·256	+0·249	+0·291	+0·218	+0·218	+0·161	+0·237
14 12	−0·115	+0·130	+0·109	+0·453	+0·341	+0·460	+0·346	+0·307	+0·302	+0·113	+0·111	+0·026	+0·215
15 12	−0·224	−0·014	−0·037	+0·267	+0·293	+0·477	+0·368	+0·358	+0·294	+0·019	−0·033	+0·092	+0·155
16 12	−0·400	−0·230	−0·136	+0·116	+0·326	+0·478	+0·435	+0·420	+0·312	−0·080	−0·251	−0·173	+0·068
17 12	−0·443	−0·330	−0·155	+0·162	+0·630	+0·870	+0·850	+0·882	+0·533	−0·150	−0·502	−0·465	+0·157
18 12	−0·551	−0·367	+0·007	+0·974	+1·873	+2·080	+2·064	+2·068	+1·582	+0·218	−0·608	−0·687	+0·721
19 12	−0·648	−0·249	+0·693	+1·962	+2·641	+2·708	+2·544	+2·937	+2·494	+0·898	−0·705	−0·971	+1·192
20 12	+0·066	+0·409	+1·486	+2·242	+2·426	+2·507	+2·344	+2·586	+2·310	+1·338	−0·178	−0·445	+1·424
21 12	+0·978	+0·840	+1·582	+1·532	+1·136	+1·455	+1·272	+0·996	+1·009	+0·904	+0·199	+0·172	+1·006
22 12	+1·055	+0·660	+1·012	+0·188	−0·501	−0·216	−0·020	−0·742	−0·713	−0·081	+0·048	+0·119	+0·067
23 12	−0·264	−0·053	−0·280	−1·194	−1·778	−1·537	−1·326	−2·104	−2·080	−1·176	−0·376	−0·277	−1·037

The variation for the year is also represented by curve No. 8, Plate XXV.

TABLE X.—Showing, for the period 1859 to 1865, the excess of the mean diurnal variation of Declination for each month over the mean diurnal variation for the year.

Bombay Astronomical Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
h m												
0 12	+1·031	+1·125	+0·368	−0·641	−0·951	−0·839	−0·384	−1·264	−1·352	+0·203	+1·329	+1·372
1 12	+1·205	+0·967	−0·001	−0·794	−0·711	−1·040	−0·784	−1·186	−1·200	+0·298	+1·632	+1·613
2 11	+0·899	+0·713	+0·257	−0·714	−0·703	−1·171	−0·964	−0·985	−0·520	+0·630	+1·323	+1·238
3 12	+0·473	+0·265	+0·184	−0·367	−0·414	−0·942	−0·760	−0·510	+0·154	+0·648	+0·617	+0·658
4 12	+0·138	−0·006	+0·074	−0·137	−0·160	−0·467	−0·444	−0·051	+0·436	+0·340	+0·064	+0·298
5 12	−0·034	−0·145	−0·276	−0·039	+0·169	−0·032	−0·011	+0·402	+0·251	−0·172	−0·140	+0·025
6 12	+0·103	−0·191	−0·410	−0·169	+0·163	+0·060	+0·068	+0·323	−0·012	−0·170	+0·072	+0·167
7 12	+0·294	+0·137	−0·176	−0·198	−0·208	−0·260	−0·282	−0·075	+0·033	+0·052	+0·288	+0·394
8 12	+0·291	+0·221	−0·078	−0·130	−0·279	−0·272	−0·471	−0·087	+0·059	+0·066	+0·335	+0·343
9 12	+0·214	+0·126	−0·023	+0·007	−0·164	−0·139	−0·342	−0·104	+0·026	−0·005	+0·232	+0·270
10 12	+0·119	+0·044	−0·093	+0·072	−0·089	−0·185	−0·252	−0·110	+0·008	+0·062	+0·226	+0·197
11 12	+0·046	−0·005	−0·028	+0·085	−0·084	−0·090	−0·200	−0·063	−0·019	+0·026	+0·216	+0·121
12 12	−0·078	−0·010	−0·036	+0·117	−0·034	+0·051	−0·112	−0·038	+0·005	−0·002	+0·097	+0·038
13 12	−0·186	−0·061	−0·071	+0·177	+0·039	+0·129	+0·019	+0·012	+0·054	−0·019	−0·019	−0·076
14 12	−0·330	−0·085	−0·106	+0·238	+0·126	+0·245	+0·131	+0·092	+0·087	−0·102	−0·104	−0·189
15 12	−0·379	−0·169	−0·192	+0·112	+0·138	+0·322	+0·213	+0·203	+0·139	−0·136	−0·122	−0·063
16 12	−0·468	−0·298	−0·204	+0·048	+0·258	+0·410	+0·367	+0·352	+0·244	−0·148	−0·319	−0·241
17 12	−0·600	−0·487	−0·312	+0·005	+0·473	+0·713	+0·693	+0·725	+0·376	−0·307	−0·659	−0·622
18 12	−1·272	−1·088	−0·714	+0·253	+1·152	+1·359	+1·343	+1·347	+0·861	−0·503	−1·329	−1·408
19 12	−1·840	−1·441	−0·499	+0·770	+1·449	+1·516	+1·352	+1·745	+1·302	−0·294	−1·897	−2·163
20 12	−1·358	−1·015	+0·062	+0·818	+1·002	+1·083	+0·920	+1·162	+0·886	−0·086	−1·602	−1·869
21 12	−0·028	−0·166	+0·576	+0·526	+0·130	+0·449	+0·266	−0·010	+0·003	−0·102	−0·807	−0·834
22 12	+0·988	+0·593	+0·945	+0·121	−0·568	−0·283	−0·087	−0·809	−0·780	−0·148	−0·019	+0·052
23 12	+0·773	+0·984	+0·757	−0·157	−0·741	−0·500	−0·289	−1·067	−1·043	−0·139	+0·661	+0·760

The curves corresponding to these excess variations are numbered 9 to 20, Plate XXVI.

* In this and all the Tables that follow, the positive sign indicates a movement of the north end of the declination-magnet to the eastward of its normal direction, and the deviations from the normal are expressed in minutes of arc.

TABLE XI.—Showing, for the half years including the months from April to September in the several years 1859 to 1865, and in the whole period of seven years, the mean diurnal variation of Declination.

Bombay Astronomical Hours.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	Seven Years, 1859 to 1865.
h m								
0 12	−2·715	−2·867	−2·590	−2·354	−2·461	−2·325	−2·118	−2·490
1 12	−2·625	−2·623	−2·436	−2·245	−2·304	−2·128	−2·021	−2·349
2 12	−2·038	−1·992	−1·748	−1·508	−1·657	−1·689	−1·537	−1·738
3 12	−1·108	−0·997	−0·777	−0·605	−0·785	−0·717	−0·682	−0·810
4 12	−0·138	−0·122	+0·022	+0·149	−0·086	−0·115	−0·165	−0·065
5 12	+0·065	+0·223	+0·262	+0·135	+0·119	+0·102	+0·063	+0·138
6 12	−0·010	+0·164	+0·028	−0·111	−0·013	−0·109	−0·130	−0·026
7 12	−0·320	−0·206	−0·302	−0·326	−0·274	−0·313	−0·288	−0·290
8 12	−0·297	−0·281	−0·312	−0·383	−0·353	−0·360	−0·250	−0·319
9 12	−0·153	−0·208	−0·218	−0·223	−0·181	−0·209	−0·162	−0·193
10 12	−0·095	−0·064	−0·101	−0·102	−0·078	−0·079	−0·046	−0·081
11 12	+0·011	−0·001	+0·078	−0·008	+0·084	+0·073	+0·160	+0·057
12 12	+0·180	+0·109	+0·166	+0·157	+0·247	+0·182	+0·243	+0·183
13 12	+0·294	+0·259	+0·295	+0·308	+0·336	+0·336	+0·332	+0·309
14 12	+0·277	+0·282	+0·384	+0·350	+0·419	+0·417	+0·449	+0·368
15 12	+0·282	+0·222	+0·325	+0·351	+0·434	+0·407	+0·385	+0·344
16 12	+0·300	+0·301	+0·326	+0·300	+0·403	+0·409	+0·395	+0·348
17 12	+0·590	+0·758	+0·704	+0·626	+0·683	+0·612	+0·609	+0·655
18 12	+1·969	+2·008	+1·925	+1·794	+1·643	+1·613	+1·464	+1·774
19 12	+2·797	+2·969	+2·775	+2·497	+2·348	+2·287	+2·162	+2·548
20 12	+2·854	+2·891	+2·426	+2·235	+2·156	+2·243	+2·013	+2·403
21 12	+1·676	+1·556	+1·145	+1·107	+1·007	+1·242	+0·901	+1·233
22 12	−0·141	−0·348	−0·459	−0·472	−0·229	−0·314	−0·372	−0·334
23 12	−1·651	−2·025	−1·917	−1·674	−1·459	−1·555	−1·406	−1·670

Curves representing these variations are figured 23 to 30 on Plate XXVII.

TABLE XII.—Showing, for the half years including the months from January to March and October to December in the several years 1859 to 1865, and in the whole period of seven years, the mean diurnal variation of Declination.

Bombay Astronomical Hours.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	Seven Years, 1859 to 1865.
h m								
0 12	−0·493	−0·556	−0·749	−0·754	−0·664	−0·664	−0·881	−0·680
1 12	−0·410	−0·458	−0·591	−0·446	−0·333	−0·332	−0·479	−0·436
2 12	−0·135	−0·156	−0·287	+0·270	+0·029	−0·087	+0·001	−0·052
3 12	−0·006	−0·019	+0·076	+0·285	+0·134	+0·158	+0·333	+0·137
4 12	−0·075	+0·126	+0·225	+0·305	+0·226	+0·192	+0·462	+0·209
5 12	−0·412	−0·236	−0·096	−0·215	−0·011	+0·024	+0·186	−0·109
6 12	−0·540	−0·468	−0·046	−0·187	−0·071	−0·037	+0·164	−0·169
7 12	−0·077	−0·077	+0·018	+0·013	+0·032	+0·079	+0·294	+0·040
8 12	+0·011	−0·034	+0·089	−0·011	+0·106	+0·089	+0·264	+0·073
9 12	−0·016	−0·039	+0·062	+0·050	+0·124	+0·106	+0·254	+0·077
10 12	+0·073	−0·021	+0·045	+0·065	+0·105	+0·187	+0·280	+0·105
11 12	+0·181	+0·141	+0·132	+0·098	+0·192	+0·213	+0·308	+0·181
12 12	+0·158	+0·140	+0·158	+0·120	+0·193	+0·285	+0·254	+0·187
13 12	+0·160	+0·154	+0·106	+0·138	+0·162	+0·229	+0·209	+0·165
14 12	+0·078	+0·073	+0·057	+0·055	+0·066	+0·124	−0·014	+0·063
15 12	−0·056	−0·058	−0·088	+0·166	−0·079	−0·041	−0·071	−0·032
16 12	−0·284	−0·242	−0·210	−0·158	−0·274	−0·140	−0·171	−0·211
17 12	−0·230	−0·396	−0·366	−0·313	−0·390	−0·361	−0·311	−0·338
18 12	−0·365	−0·431	−0·105	−0·267	−0·426	−0·393	−0·328	−0·331
19 12	−0·178	−0·058	−0·053	−0·139	−0·329	−0·260	−0·127	−0·163
20 12	+0·756	+0·688	+0·608	+0·431	+0·257	+0·216	+0·169	+0·446
21 12	+1·236	+1·207	+0·865	+0·783	+0·643	+0·524	+0·214	+0·782
22 12	+0·764	+0·864	+0·515	+0·311	+0·771	+0·246	−0·189	+0·469
23 12	−0·139	−0·144	−0·357	−0·561	−0·454	−0·350	−0·824	−0·404

Curves representing these variations are figured (in broken lines) on Plate XXVII. Nos. 23 to 30. Viewed together with the continuous curves from April to September, they show very distinctly the consistent character of the semiannual inequality in the diurnal variation of declination in different years.

The half-excess for each hour of the numbers in the last column of Table XI. over those in the last column of Table XII., or the semiannual inequality of the mean diurnal variation of declination, is as follows, the excesses being written in the order of the hours 0 to 23:—

−0·905 −0·952 −0·843 −0·473 −0·137 +0·123 +0·071 −0·165 −0·175 −0·135 −0·093 −0·062
−0·002 +0·072 +0·152 +0·188 +0·279 +0·496 +1·052 +1·355 +0·978 +0·225 −0·399 −0·633

Fig. 21, Plate XXVI. is constructed from these numbers.

TABLE XIII.—Showing the mean diurnal variation of Declination for each of the years 1859 to 1865.

Bombay Astronomical Hours.	1859.	1860.	1861.	1862.	1863.	1864.	1865.
h m							
0 12	−1·604	−1·711	−1·669	−1·554	−1·562	−1·494	−1·499
1 12	−1·517	−1·540	−1·513	−1·345	−1·318	−1·230	−1·250
2 12	−1·086	−1·074	−0·917	−0·619	−0·814	−0·888	−0·768
3 12	−0·557	−0·508	−0·350	−0·160	−0·325	−0·279	−0·174
4 12	−0·106	+0·002	+0·123	+0·227	+0·070	+0·038	+0·148
5 12	−0·173	−0·006	+0·083	−0·040	+0·054	+0·063	+0·124
6 12	−0·275	−0·152	−0·009	−0·149	−0·042	−0·073	+0·017
7 12	−0·198	−0·141	−0·142	−0·156	−0·121	−0·117	+0·003
8 12	−0·143	−0·157	−0·111	−0·197	−0·123	−0·135	+0·007
9 12	−0·084	−0·123	−0·078	−0·086	−0·028	−0·051	+0·046
10 12	−0·011	−0·042	−0·028	−0·018	+0·013	+0·054	+0·117
11 12	+0·096	+0·070	+0·105	+0·045	+0·138	+0·143	+0·234
12 12	+0·169	+0·124	+0·162	+0·138	+0·220	+0·233	+0·248
13 12	+0·227	+0·206	+0·200	+0·223	+0·249	+0·282	+0·271
14 12	+0·177	+0·177	+0·220	+0·202	+0·242	+0·270	+0·217
15 12	+0·113	+0·082	+0·118	+0·258	+0·177	+0·183	+0·157
16 12	+0·008	+0·029	+0·058	+0·071	+0·064	+0·134	+0·112
17 12	+0·180	+0·181	+0·169	+0·156	+0·146	+0·125	+0·149
18 12	+0·802	+0·788	+0·910	+0·763	+0·608	+0·610	+0·568
19 12	+1·309	+1·455	+1·361	+1·179	+1·009	+1·013	+1·017
20 12	+1·805	+1·789	+1·517	+1·333	+1·206	+1·229	+1·091
21 12	+1·456	+1·381	+1·005	+0·945	+0·825	+0·883	+0·557
22 12	+0·311	+0·258	+0·028	−0·080	+0·271	−0·034	−0·280
23 12	−0·895	−1·084	−1·137	−1·117	−0·956	−0·952	−1·115

14. *Remarks on the regular Solar-diurnal Variations.*—Although the semiannual inequality in the diurnal variation of declination has been established by the researches of General SABINE as beyond a doubt a general feature in that variation, possessing the same characteristics in all parts of the globe, yet the regular progression from month to month in the diurnal variation has not, that I am aware, been much dwelt upon. It is shown, however, so distinctly in the Bombay Observations as to lead, on a first inspection of the curves, figs. 9 to 20, Plate XXVI., to the supposition that the law of variation is identical throughout the year, the extent only (including a reversal of direction) varying from month to month. But in this respect a different exposition of the character of the variation in different months shows that the first thought would be inaccurate. The deviations from the normal position of the magnet (δ_h) at each hour (h) may be expressed by the series

$$\delta_h = A_1 \cos n + B_1 \sin n + A_2 \cos 2n + B_2 \sin 2n + A_3 \cos 3n + B_3 \sin 3n + \&c. \ldots (y),$$

where $n = h \times 15°$; and it is easy from each complete set of hourly values to deduce the values of the coefficients A_1, B_1, A_2, B_2, A_3, B_3, &c. This has been done for the mean solar-diurnal variation for each month of the year, and also for each half year in the period 1859 to 1865, with results as shown in the following Tables:—

TABLE XIV.—Showing the calculated values of the coefficients A_1, B_1, A_2, B_2, A_3 and B_3 in the series (y) which expresses the mean solar-diurnal variation for each month of the year, for the whole year, and for different half years*.

Months.	Values of the coefficients of the first three pairs of terms of the series (y).					
	A_1.	B_1.	A_2.	B_2.	A_3.	B_3.
January	+0·147	+0·028	−0·247	+0·025	+0·183	+0·202
February	−0·060	−0·003	−0·221	+0·034	+0·187	+0·184
March	−0·407	−0·175	−0·267	+0·367	+0·535	+0·220
April	−0·908	+0·048	−0·097	+0·828	+0·799	+0·153
May	−1·038	+0·044	+0·197	+1·057	+0·839	−0·051
June	−1·271	−0·011	+0·090	+1·119	+0·777	+0·075
July	−1·151	−0·130	+0·102	+1·018	+0·700	+0·059
August	−1·123	+0·160	+0·296	+1·262	+0·898	−0·059
September	−0·910	+0·230	+0·300	+1·090	+0·943	−0·096
October	−0·305	+0·063	+0·032	+0·379	+0·573	−0·040
November	+0·183	+0·200	−0·091	−0·187	+0·076	+0·019
December	+0·250	+0·225	−0·046	−0·196	+0·013	+0·082
Year	−0·549	+0·057	+0·004	+0·566	+0·544	+0·062
Half Years. April to September	−1·067	+0·057	+0·148	+1·062	+0·826	+0·013
Half Years. October to March	−0·032	+0·056	−0·140	+0·070	+0·261	+0·111
Half Years. January to June	−0·589	−0·011	−0·091	+0·572	+0·553	+0·130
Half Years. July to December	−0·509	+0·125	+0·099	+0·561	+0·534	−0·006

TABLE XV.—Showing the calculated values of the coefficients A_1, B_1, A_2, B_2, A_3 and B_3 in the series (y), which expresses the mean solar-diurnal variation for each half year, April to September and October to March, in the period 1859 to 1865.

Years.		Values of the coefficients of the first three pairs of terms of the series (y).					
		A_1.	B_1.	A_2.	B_2.	A_3.	B_3.
April to September.	1859	−1·183	−0·007	+0·037	+1·230	+0·916	+0·073
	1860	−1·168	+0·046	+0·138	+1·308	+0·954	+0·020
	1861	−1·084	+0·085	+0·217	+1·125	+0·882	−0·028
	1862	−0·996	+0·042	+0·216	+0·989	+0·823	−0·043
	1863	−1·040	+0·088	+0·158	+0·973	+0·760	+0·041
	1864	−1·029	+0·048	+0·139	+0·952	+0·766	+0·030
	1865	−0·967	+0·096	+0·133	+0·857	+0·681	+0·001
October to March.	1859	−0·141	−0·103	−0·300	+0·043	+0·246	+0·141
	1860	−0·102	−0·107	−0·266	+0·058	+0·288	+0·188
	1861	−0·073	+0·028	−0·151	+0·165	+0·294	+0·143
	1862	−0·033	+0·042	−0·045	+0·048	+0·268	+0·053
	1863	+0·037	+0·076	−0·147	+0·031	+0·237	+0·141
	1864	+0·006	+0·147	−0·096	+0·022	+0·223	+0·108
	1865	+0·079	+0·309	+0·031	+0·127	+0·272	+0·002

The curves (Nos. 31 to 33, Plate XXVIII.) are constructed to exhibit the variations, in magnitude and direction, of the resultants of A_1 and B_1, A_2 and B_2, A_3 and B_3 respectively; O being the centre of coordinates, the A coefficients are set off in a vertical direction, upward if positive, and the B coefficients in a horizontal direction, to the right if positive, so that the distances from O to the points marked 1, 2, 3, &c. to 12 and $\odot r$

* Göttingen time was inadvertently used instead of Bombay time in the calculation of the coefficients A_1, B_1, &c.

indicate the maximum deviations expressed by each pair of terms in the respective months January, February, March, &c. to December, and for the whole year, and the angles A O1, A O2, A O3, &c., reckoned in a right-handed direction from A O, when converted into time, show the hours at which the several maxima occur. The curves having reference to Göttingen astronomical hours, it will be necessary, in order to adapt them to Bombay time, to turn backward (*i. e.* in a left-handed direction) the zero direction line A O by an equivalent in each figure to $4^h\,12^m$. It will be seen that this method of exhibiting variations brings to light in the regular solar-diurnal variations niceties of change in character which would fail to be noticed on a mere inspection of the respective ordinary representative curves. For instance, if the supposition mentioned above, that the change from month to month in the character of the solar-diurnal variation was one of extent only, not affecting the relative deviation at different hours, the variation at different parts of the year might be expressed in the form

$$\delta_h = C\{(A)_1 \cos n + (B)_1 \sin n + (A)_2 \cos 2n + (B)_2 \sin 2n + (A)_3 \cos 3n + (B)_3 \sin 3n + \&c.\},$$

where $(A)_1$, $(B)_1$, $(A)_2$, B_2, &c. would be constants, and C a function of the day of the year, or of the concurrent variable, the declination or right-ascension of the sun. In this case a change in the value of any one of the coefficients A_1, B_1, A_2, B_2, &c. (equal respectively to $C\times(A)_1$, $C\times(B)_1$, $C\times(A)_2$, $C\times(B)_2$, &c.) would be attended by a proportional change in all the others, and the *direction* of the resultants of A_1 and B_1, A_2 and B_2, A_3 and B_3, &c. respectively, would be invariable throughout the year. Thus in the curves Nos. 31 to 33, Plate XXVIII., the points 1, 2, 3, &c. to 12 and ⊙ r should in each case lie upon a straight line directed through the centre of coordinates. To such a requirement their positions do roughly conform; but there is sufficient evidence of system in their departures from the rule to render the latter worthy of independent consideration. The most striking feature about all the three curves is undoubtedly the existence of the semiannual inequality in the values of the several maximum deviations, the greater values occurring about the northern solstice, the lesser about the southern solstice: this is in accord with the now well-known semiannual inequality in the diurnal variation, which inequality is shown for Bombay by the curve No. 21, Plate XXVI., and by the numbers at the foot of Table XII., and possesses the character commonly attributed to it as general throughout the globe. The points n, s, a, d in figures 31 to 33, Plate XXVIII., mark the mean values of the coefficients respectively for the half years, April to September, October to March, January to June, and July to December. Let us now confine our attention to the monthly excess or defect of the coefficients A_1, B_1, A_2, B_2, A_3, B_3, &c. over the annual mean values; or, what is to the same effect, let us imagine the centre of coordinates in the figures 31 to 33, Plate XXVIII. removed to the points ⊙ r, and let vertical lines be drawn upward from these points to A'; then will the lines r 1, r 2, r 3, &c. to r 12 represent in magnitude and direction the monthly maximum deflections that must be geometrically superimposed upon the annual mean maximum deflection in order to produce the actual monthly maximum deflections; and the angles $A'r$ 1, $A'r$ 2, $A'r$ 3, &c., converted into time, will show the hours at which the monthly superimposed variation gives a maximum of deflection for each pair of terms of the series (y) which expresses it. Now, on a single glance at the three curves, it is perceived that (speaking generally) the points 1, 2, 3, &c. to 12 circulate in each case in a left-handed direction about the points $\odot\ r$, the equinoctial months (3 and 4) and (9 and 10) lying on opposite sides of the closed curves. Moreover, the half-yearly points n and s and a and d lie in the same order about $\odot\ r$; and the interval between the latter two, though smaller, is not inconsiderable in comparison with the interval between the two former points; and the relation of the four points to each other is much the same in each of the three figures, the straight line joining a and d approaching a direction at right angles to the line of junction of n and s. This would seem to imply that the summer form of the diurnal variation merges into the winter form, not solely by the gradual fading away (and inversion at other places) of the former, in which case the diurnal variation at the opposite equinoxes would be the same, but also partly by the superposition of a distinct variation, whose turning-points are considerably removed from those of the ordinary diurnal variation, and the extent of which is much more limited, and which moreover has an inverse character at the opposite equinoxes, at which times its influence on the ordinary mean diurnal variation is most sensible. It does not imply a retrograde rotation of the hours of maxima and minima accompanied by a gradual fading away of the variation, the variation still preserving a constant character in all respects except extent and turning-points, because in that case, whilst a single rotation occurs in the arrangement of the points 1, 2, 3, &c. to 12 in figure 31, there should be two and three rotations respectively in figures 32 and 33, and, in fact, there is only a single rotation in each of the three curves. Now, on referring to plate xxv. of the Philosophical Transactions of the Royal Society for 1863, where appear similar figures representing (in part) the diurnal variations of declination at Toronto and St. Helena, it is seen that these figures possess the characteristics just described of those for Bombay, with the exception that the rotation in the St. Helena curve is in a right-handed instead of a left-handed direction. To examine now more directly whether there be a semiannual inequality in the diurnal variation of declination having opposite characteristics at the opposite equinoxes, and at the same time to eliminate that other semiannual inequality whose times of opposition are the solstices, the mean diurnal variation was calculated for the half year January to June, and compared with the same for the half year July to December; half the excess, for each hour, of the former half year over the latter was taken to represent the inequality sought, which proved to be of so definite a character, and so similar for Bombay and Toronto, as to tend to the extension of the examination to all other stations for which reduced observations were accessible. Distinct similarity was then found to exist in the curves representing the inequality at all the north-latitude stations, Toronto, Kew, Greenwich, Pekin, and Bombay, whilst curves of form approaching to an inversion, with some modifications of the above, was found for the south-latitude stations, St. Helena and the Cape of Good Hope. Table XVI. and curves Nos. 37 to 43, Plate XXX., show the character of this inequality for each station.

TABLE XVI.—Showing, for different stations, the mean diurnal variation of Declination for the half year including the months January to June, and for the half year including the months July to December, and also the half excess, at each hour, of the former over the latter.

Local Astronomical Hours (nearest).	Toronto.			Kew.			Greenwich.			Pekin.			Bombay.			Five North-Latitude Stations.	St. Helena.			Cape of Good Hope.			Two South-Latitude Stations.
	January to June.	July to December.	Half excess.	January to June.	July to December.	Half excess.	January to June.	July to December.	Half excess.	January to June.	July to December.	Half excess.	January to June.	July to December.	Half excess.	Mean of Half excess.	January to June.	July to December.	Half excess.	January to June.	July to December.	Half excess.	Mean of Half excess.
h 0	−3·86	−4·19	+0·16	−5·11	−5·15	+0·02	−3·82	−4·13	+0·15	−1·38	−1·72	+0·17	−1·57	−1·60	+0·02	+0·06	+0·81	+0·70	+0·05	+0·13	−0·16	+0·14	+0·09
1	−5·05	−5·08	+0·01	−6·28	−6·11	−0·08	−5·40	−5·30	−0·05	−2·37	−2·15	−0·11	−1·45	−1·33	−0·06	−0·12	+0·79	+0·60	+0·09	+1·12	+0·67	+0·22	+0·15
2	−4·99	−4·75	−0·12	−6·02	−5·59	−0·21	−5·88	−5·20	−0·34	−2·68	−1·95	−0·36	−1·02	−0·78	−0·12	−0·25	+0·49	+0·31	+0·09	+1·54	+1·11	+0·21	+0·15
3	−4·14	−3·51	−0·31	−4·54	−4·03	−0·25	−4·93	−4·03	−0·45	−2·35	−1·35	−0·50	−0·47	−0·20	−0·13	−0·34	+0·16	−0·08	+0·12	+1·28	+1·05	+0·11	+0·11
4	−2·82	−2·14	−0·34	−2·83	−2·37	−0·23	−3·38	−2·40	−0·49	−1·63	−0·79	−0·42	−0·02	+0·16	−0·09	−0·31	−0·24	−0·48	+0·12	+0·74	+0·52	+0·11	+0·11
5	−1·51	−1·07	−0·22	−1·47	−1·05	−0·21	−1·73	−0·83	−0·45	−0·96	−0·33	−0·31	−0·04	+0·07	−0·06	−0·21	−0·48	−0·63	+0·07	+0·32	+0·08	+0·12	+0·09
6	−0·69	−0·26	−0·21	−0·48	−0·29	−0·09	−0·38	+0·15	−0·26	−0·39	−0·19	−0·10	−0·17	−0·02	−0·07	−0·12	−0·33	−0·44	+0·05	+0·21	+0·13	+0·04	+0·04
7	−0·28	−0·04	−0·12	+0·18	+0·25	−0·03	+0·58	+0·88	−0·15	−0·19	−0·22	+0·01	−0·19	−0·06	−0·07	−0·06	−0·02	−0·13	+0·05	+0·37	+0·35	+0·01	+0·03
8	−0·12	−0·24	+0·06	+0·57	+0·79	−0·11	+1·20	+1·38	−0·09	−0·14	−0·24	+0·05	−0·16	−0·08	−0·04	−0·03	+0·09	+0·06	+0·01	+0·44	+0·46	−0·01	0·00
9	+0·42	+0·62	−0·10	+0·88	+1·09	−0·10	+1·67	+1·88	−0·10	−0·07	−0·13	+0·03	−0·07	−0·05	−0·01	−0·05	+0·18	+0·19	0·00	+0·46	+0·51	−0·02	−0·01
10	+0·68	+0·72	−0·02	+1·12	+1·35	−0·11	+1·90	+2·07	−0·08	+0·08	−0·08	+0·08	−0·01	+0·03	−0·02	−0·02	+0·26	+0·29	−0·01	+0·46	+0·50	−0·02	−0·01
11	+0·76	+0·66	+0·05	+1·27	+1·48	−0·10	+1·98	+2·02	−0·02	+0·25	+0·06	+0·09	+0·11	+0·13	−0·01	+0·01	+0·29	+0·28	0·00	+0·41	+0·54	−0·06	−0·03
12	+0·61	+0·64	−0·01	+1·24	+1·62	−0·19	+1·83	+1·82	0·00	+0·43	+0·16	+0·13	+0·19	+0·18	0·00	0·00	+0·29	+0·18	+0·05	+0·40	+0·56	−0·08	−0·01
13	+0·60	+0·52	+0·04	+1·18	+1·39	−0·10	+1·67	+1·48	+0·09	+0·57	+0·33	+0·12	+0·24	+0·23	0·00	+0·02	+0·20	+0·07	+0·06	+0·46	+0·56	−0·05	0·00
14	+0·55	+0·49	+0·03	+1·29	+1·49	−0·10	+1·33	+1·22	+0·05	+0·59	+0·40	+0·09	+0·23	+0·20	+0·01	+0·02	+0·17	0·00	+0·08	+0·42	+0·48	−0·03	+0·02
15	+0·75	+0·68	+0·03	+1·46	+1·57	−0·05	+1·17	+1·03	+0·07	+0·38	+0·46	−0·04	+0·13	+0·19	−0·03	+0·01	+0·17	−0·05	+0·11	+0·42	+0·40	+0·01	+0·06
16	+1·25	+1·00	+0·12	+1·86	+1·89	−0·01	+1·25	+1·00	+0·12	+0·55	+0·50	+0·02	+0·03	+0·11	−0·04	+0·04	+0·18	−0·11	+0·14	+0·37	+0·30	+0·03	+0·08
17	+2·00	+1·86	+0·07	+2·62	+2·40	+0·11	+1·40	+1·15	+0·12	+0·62	+0·52	+0·05	+0·12	+0·19	−0·03	+0·08	+0·27	−0·02	+0·14	+0·30	+0·24	+0·03	+0·08
18	+3·08	+2·89	+0·09	+3·24	+2·89	+0·17	+1·73	+1·35	+0·19	+0·93	+0·94	0·00	+0·67	+0·77	−0·06	+0·08	+0·50	+0·38	+0·06	+0·19	−0·09	+0·14	+0·10
19	+3·97	+4·02	−0·02	+3·86	+3·30	+0·28	+2·07	+1·62	+0·22	+1·47	+1·55	−0·04	+1·18	+1·20	−0·01	+0·11	−0·10	−0·07	−0·01	−0·50	−0·63	+0·06	+0·02
20	+4·55	+4·33	+0·11	+4·18	+3·41	+0·38	+2·47	+1·82	+0·32	+2·13	+1·99	+0·07	+1·52	+1·33	+0·10	+0·21	−1·14	−0·52	−0·31	−2·08	−1·67	−0·20	−0·25
21	+3·85	+3·41	+0·22	+3·64	+2·58	+0·53	+2·40	+1·62	+0·39	+2·40	+1·80	+0·30	+1·25	+0·76	+0·25	+0·35	−1·62	−0·65	−0·48	−3·16	−2·29	−0·43	−0·45
22	+1·52	+1·14	+0·19	+0·88	+0·04	+0·42	+1·28	+0·35	+0·46	+1·55	+0·93	+0·31	+0·37	−0·23	+0·30	+0·32	−1·15	−0·36	−0·39	−2·84	−2·60	−0·12	−0·25
23	−1·45	−1·94	+0·24	−2·43	−2·94	+0·25	−1·03	−1·78	+0·37	+0·03	−0·43	+0·23	−0·85	−1·22	+0·19	+0·21	+0·04	+0·32	−0·14	−1·48	−1·34	−0·07	−0·10

Now an inspection of plate xiv. in the Philosophical Transactions for 1863 suffices to convince that the mean diurnal variation of declination, whilst subject at different places to differences of character of a minor order, is mainly of the same general type throughout the globe: the range may vary or even the inflections of the representative curve may be inverted, but the relation as to the kind of flexure of any one principal feature of the curve to the remaining principal features is the same everywhere: in the typical variation a maximum or minimum occurs between twenty and twenty-one hours, and a minimum or maximum between one and two hours; and the great amount of change takes place between the hours seventeen and five, whilst deviations from the normal position of the magnets of comparatively only small extent occur during the remaining hours. To the same type belongs that semiannual inequality which has opposite features at the opposite solstices, and which may be called the solstitial semiannual inequality to distinguish it from the equinoctial semiannual inequality, as that might be named which has opposite characteristics at the opposite equinoxes,—with this difference, that the turning-point, which in the typical mean variation occurs at twenty or twenty-one hours, takes place in the inequality a full hour earlier. Thus the mean diurnal variation for each of the half years, April to September and October to March, being the result of the combination of two variations of the same kind, will also be of the typical character, but with a small difference in the time of the occurrence of the twenty to twenty-one hours turning-point. Let us now examine the character of the equinoctial semiannual inequality as exhibited in the curves 37 to 43, Plate XXX., and compare it with the type curve of the mean diurnal variation. In the first place, it is seen that, as in the type, there is scarcely any change during the night hours, and that the main variation occurs during half the day, in this case between eighteen hours and six hours; secondly, the range of variation differs from about half a minute to nearly one minute of arc; thirdly, the hour of noon is that at which the deviations due to this variation pass through zero, and on each side of which the inflections of the curve are inversely, but in respect to north-latitude stations symmetrically disposed; fourthly, the turning-points are twenty-one hours and three hours, the former being a maximum and the latter a minimum for north-latitude stations from January to June, and for south-latitude stations from July to December, and *vice versâ*, for north-latitude stations from July to December, and for south-latitude stations from January to June. The concurrent testimony of the five widely distributed north-latitude stations leaves, I think, very little room for doubt that this inequality is an expression of real phenomena common to the whole of the northern magnetic hemisphere. From the general agreement, qualified by the fact that the afternoon inflections are comparatively much subdued, of the curves of two stations of such comparative proximity as St. Helena and the Cape of Good Hope, it would be less safe to generalize as to the southern magnetic hemisphere; but there is abundant evidence of the existence of a definite, and in some respects different law to that which prevails in the northern hemisphere to encourage further inquiry in this direction*. So far as

* An examination of the Hobarton observations (including all disturbances) resulted in a curve corresponding closely with those of the north-latitude stations, but of small range.

I am aware, this is the first time that any diurnal variation of magnetical phenomena has been pointed out in which the sun's position relatively to the meridian of the place appears so directly related to the expressed phenomena. To exhibit the general character of this variation more distinctly the curves Nos. 44 and 45, Plate XXX., are drawn on a larger scale to represent the average variation for the north- and south-latitude stations respectively. For all the stations, except St. Helena and Greenwich, the above are the results derived from the observations after the separation of the larger disturbances by the method above described; for St. Helena the effect of disturbances on the diurnal variation is very slight, and all observations are included; for Greenwich complete days of large disturbance are thrown aside, and the remainder used for the calculation of the diurnal variation.

15. *Solar-diurnal Inequality.*—The following Table shows the mean diurnal inequality when all observations, disturbed and undistubed, are included in the calculations as compared with the mean diurnal variation after the exclusion of disturbances exceeding 1′·4 in amount; and it is seen that at Bombay the disturbances have a very slight effect on the diurnal variation, the largest difference at any hour not exceeding 0′·061.

TABLE XVII.

	Bombay Astronomical Hours.											
	h m 0 12	h m 1 12	h m 2 12	h m 3 12	h m 4 12	h m 5 12	h m 6 12	h m 7 12	h m 8 12	h m 9 12	h m 10 12	h m 11 12
Mean diurnal inequality.	−1·590	−1·424	−0·936	−0·342	+0·064	+0·023	−0·088	−0·108	−0·084	−0·032	+0·025	+0·144
Mean diurnal variation.	−1·585	−1·388	−0·896	−0·337	+0·072	+0·015	−0·098	−0·125	−0·123	−0·059	+0·012	+0·118
Excess of inequality over variation.	−0·005	−0·036	−0·040	−0·005	−0·008	+0·008	+0·010	+0·017	+0·039	+0·027	+0·013	+0·026
	Bombay Astronomical Hours.											
	h m 12 12	h m 13 12	h m 14 12	h m 15 12	h m 16 12	h m 17 12	h m 18 12	h m 19 12	h m 20 12	h m 21 12	h m 22 12	h m 23 12
Mean diurnal inequality.	+0·212	+0·258	+0·238	+0·174	+0·084	+0·159	+0·719	+1·216	+1·388	+0·951	+0·006	−1·052
Mean diurnal variation.	+0·185	+0·237	+0·215	+0·155	+0·068	+0·157	+0·721	+1·192	+1·424	+1·006	+0·067	−1·037
Excess of inequality over variation.	+0·027	+0·021	+0·023	+0·019	+0·016	+0·002	−0·002	+0·024	−1·036	−0·055	−0·061	−0·015

16. *Variation from year to year in the range of the mean diurnal variation of Declination.*

TABLE XVIII.—Showing the range of the mean diurnal variation of Declination for the several years 1859 to 1865, and for the component half years (April to September, and January to March and October to December).

Years.	Range.		
	Year.	Half year, April to September.	Half year, October to March.
1859.	2·913	5·569	1·776
1860.	3·500	5·836	1·763
1861.	3·186	5·365	1·614
1862.	2·887	4·851	1·537
1863.	2·768	4·809	1·435
1864.	2·723	4 612	1·188
1865.	2·590	4·280	1·343

The regular progression in these numbers, the equivalent of which is shown also by the varying range of the curves Nos. 23 to 29, Plate XXVII., is very marked, and tends towards maxima in 1859–60 and minima in 1864–65, in near correspondence with the maxima and minima of the decennial variation of aggregate annual disturbance. In order to show the periodicity, the ranges have also been calculated of the mean diurnal inequality (including disturbances) for the larger number of years 1848 to 1864; and the same has been done for the Greenwich observations (excluding certain complete disturbed days), with the results subjoined.

TABLE XIX.—Showing the range of the mean diurnal inequality of Declination at Bombay in the several years 1848 to 1864, and at Greenwich in the several years 1848 to 1857, with the corresponding ratios of the range of each year to the average range.

Years		1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.
Bombay	Range.	3·491	3·248	3·294	2·965	2·611	2·728	2·416	2·576	2·453	2·459	2·720	3·117	3·551	3·282	2·790	2·568	2·652
Bombay	Ratios.	1·24	1·16	1·17	1·06	0·93	0·97	0·86	0·92	0·87	0·88	0·97	1·11	1·26	1·17	0·99	0·91	0·94
Greenwich	Range.	11·4	10·3	10·0	8·4	8·0	6·9	7·2	7·0	5·9	5·6							
Greenwich	Ratios.	1·42	1·29	1·25	1·05	1·00	0·86	0·90	0·87	0·74	0·70							

In calculating the average range (2′·808) for Bombay, double value was given to the ranges from 1853 to 1859; for Greenwich it was taken of such a value (8′·0) as would make the sum of the ratios equal to the sum of the ratios at Bombay for the same years. Two periods of maximum range are now seen to exist not far from the years of maximum disturbance with a minimum intervening, and an approach to a second minimum near the last year (1864). The diminishing progression of the ranges for Greenwich being (with one slight exception) continuous, shows no signs of periodicity when viewed by itself; but the succession of ratios so much resembles that which appears for the same years (1848 to 1857) at Bombay, that it is reasonable to suppose that on the extension of the results for Greenwich beyond 1857 an increasing progression would begin to show itself, as is the case at Bombay. The proportion, however, of the maximum to the minimum range at Greenwich is about 2, whilst at Bombay it is only about 1·5.

The variation in the range of the mean diurnal variation of declination is also indicated by the corresponding variation in the magnitude of the maximum deflections for the half years April to September, for each of the first three pairs of terms of the series (y) as delineated on Plate XXIX. figs. 34 to 36; but there is also in these figures a curious likeness, though not equivalent as to time, in the arrangement of the points for the successive years about the centre of coordinates indicative of systematic change from year to year in the law as well as in the extent of variation.

17. *Annual Variation and Secular Change.*—The observations having been repeatedly interrupted in the year 1861, it is better perhaps to reject that year and use only the two continuous series of observations, 1859 and 1860, and 1862 to 1855, in the deduction of secular and annual variations. The following Tables will, however, be filled up for that year, although no use is made of the numbers in the calculations applied.

TABLE XX.—Showing the mean monthly and annual values of Easterly Declination as deduced from the readings of GRUBB'S Declinometer in the several years 1859 to 1865.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1859.	20·592	20·835	21·130	20·868	21·227	21·258	21·366	21·190	21·569	22·092	22·375	22·913	21·451
1860.	23·021	23·037	23·498	23·460	23·562	24·045	24·209	24·506	24·226	24·294	24·932	25·150	23·995
1861.	25·414	25·685	26·158	26·136	26·023	26·100	25·902	28·861	29·041	29·185	28·632	28·897	27·169
1862.	29·04[illegible]	29·014	29·178	29·703	29·367	30·416	30·992	31·049	31·303	31·677	31·820	32·464	30·502
1863.	32·696	32·755	33·948	34·334	33·633	33·424	33·802	33·783	34·407	34·742	34·529	35·471	33·960
1864.	35·262	35·032	35·379	35·331	35·710	36·016	36·459	36·716	37·126	38·043	38·167	38·198	36·453
1865.	38·568	38·618	38·680	37·816	39·004	39·499	40·143	41·251	41·489	41·717	41·241	42·311	40·028
Mean of six years omitting 1861	29·863	29·882	30·302	3·0252	30·417	30·776	31·162	31·416	31·687	32·094	32·177	32·751	

The numbers in the last column of Table XX. give values of the annual secular increase of easterly declination as follows:—

From 1859 to 1860 the increase $=2'·544$
1862 to 1863 „ $=3·458$
1863 to 1864 „ $=2·493$
1864 to 1865 „ $=3·575$
Mean . . . $=3·017$*.

This gives a secular increase at the rate of $0'·2515$ per month; and applying corrections

* It will be seen by a reference to Table III. on page 4 of the Tables of Results of the 'Bombay Magnetical Observations for 1864,' that the annual secular increase of Declination, which from 1846 to 1865 had an average value of only $1'·24$, has since the year 1859 been considerably greater, as shown above.

at this rate to reduce the mean numbers at the foot of Table XX. to the common epoch, the 1st January of the mean year, we have

TABLE XXI.

Months.........	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Mean for mean year	29·863	29·882	30·302	30·252	30·417	30·776	31·162	31·416	31·687	32·094	32·177	32·751	
Correction	·000	−·251	−·503	−·754	−1·006	−1·257	−1·509	−1·760	−2·012	−2·263	−2·515	−2·766	
Means corrected.	29·863	29·631	29·799	29·498	27·411	29·519	29·653	29·656	29·675	29·831	29·662	29·985	29·682
Annual variation	+·181	−·051	+·117	−·184	−·271	− ·163	− ·029	− ·026	− ·007	+ ·149	− ·020	+ ·303	

The last line of numbers is far from presenting the decidedly systematic and regular appearance that is found by General SABINE (see Philosophical Transactions, 1863, pages 291 to 295) from the similar treatment of the observations of Kew and Hobarton; let us therefore examine, as the similar results for those places and for St. Helena and the Cape of Good Hope would suggest, whether (failing a regular periodical progression from month to month) there be any semiannual inequality of Declination at Bombay. Combining together the months April to September and the months January to March, and October to December, so as to eliminate secular change, we get the following results.

TABLE XXII.—Showing the mean values of Easterly Declination for April to September, and for January to March, and October to December in each of the years 1859, 1860, and 1862 to 1865; and the excess of the mean for the former half year over the mean for the latter in each year.

Years........	1859.	1860.	1861.	1862.	1863.	1864.	1865.
April to September	21·246	24·001	......	30·472	33·897	36·226	39·867
January to March, and October to December	21·656	23·989	......	30·532	34·023	36·680	40·189
Excess of April to September over October to March	−·410	+·012	......	−·060	−·126	−·454	−·322
Mean excess	−0′·227						

The signs of the differences in five of the six years are negative, whilst the difference for the sixth year has a slight positive value. The inference to be drawn thence is that there is some probability that the north end of the declination-magnet points at Bombay 0′·227 * more to the westward in the months April to September than in the months January to March and October to December; and the same result exactly is arrived at if all the disturbed observations are included in the calculation of the mean values of declination. I cannot regard the evidence as conclusive, however, for two reasons,—first, because the observations at the four stations Kew, Hobarton, St. Helena, and the Cape of Good Hope agree in showing that at those places the north end of the declination-

* The fact that this is exactly the magnitude of the semiannual inequality at St. Helena renders the correctness of the inference more probable.

magnet points, when the sun is north of the equator, to the eastward of its mean annual position, which is contrary to what is found for Bombay; and, secondly, because the annual variations at Bombay, calculated, as in Table XXI., for each individual year, are irregular and inconsistent with each other to an extent much exceeding the whole range of the semiannual inequality. These irregularities are attributable, I believe, almost entirely to the defect of the reading-transit instrument of the declinometer alluded to in paragraph 7. The annual variations found for the different years are as follows:—

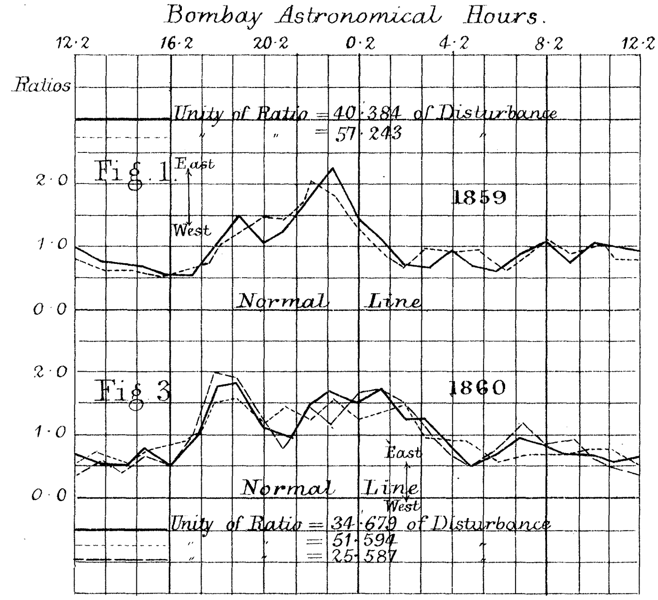
TABLE XXIII.—Showing the annual variation of Declination calculated, after the elimination of secular change at the rate of 0′·2515 per month, for the several years 1859, 1860, and 1862 to 1865.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1859.	+·524	+·516	+·559	+ ·046	+·153	−·067	−·211	−·638	−·511	− ·239	−·208	+·079
1860.	+·409	+·174	+·383	+ ·094	−·056	+·176	+·088	+·134	−·398	− ·581	−·195	−·228
1861.												
1862.	−0·77	−·356	−·444	− ·170	−·758	+·040	+·364	+·170	+·172	+ ·295	+·186	+·579
1863.	+·119	−·073	+·868	+1·003	+·050	−·410	−·284	−·554	−·182	− ·098	−·563	+·128
1864.	+·192	−·289	−·194	− ·493	−·366	−·311	−·120	−·114	+·042	+1·410	+·582	+·362
1865.	−·077	−·278	−·468	−1·583	−·647	−·403	−·011	+·846	+·832	+ ·809	+·081	+·900

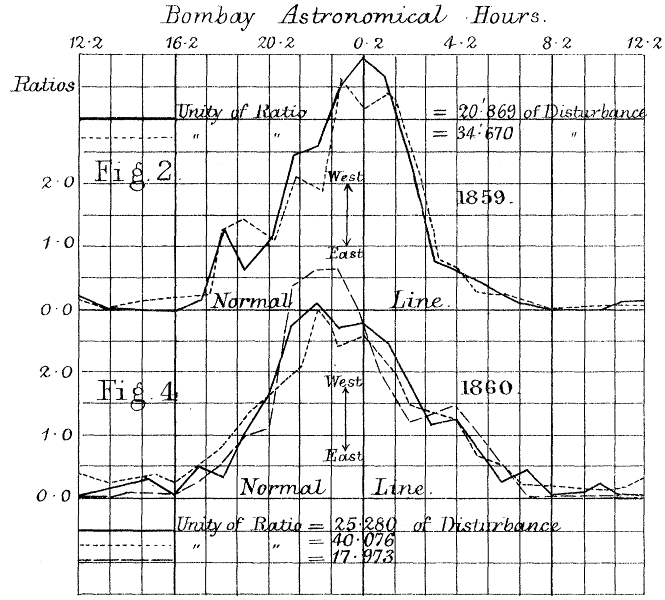
Diurnal Variations of Easterly and of Westerly Disturbance with different separating values.

Separating Value = 1'. 0 (dotted line) = 1 . 4 (thin line) = 1 . 7 (thick line).

Easterly Disturbances.

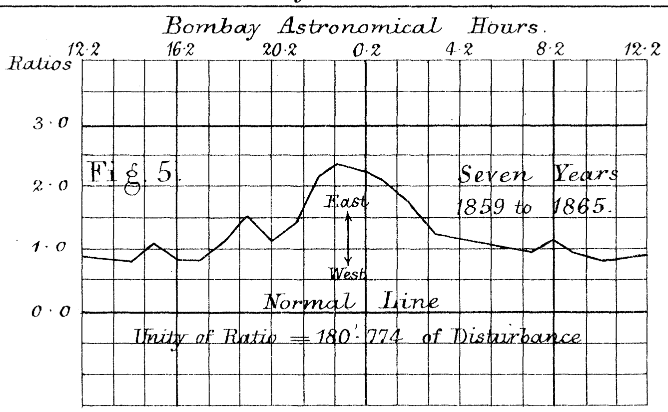


Westerly Disturbances.

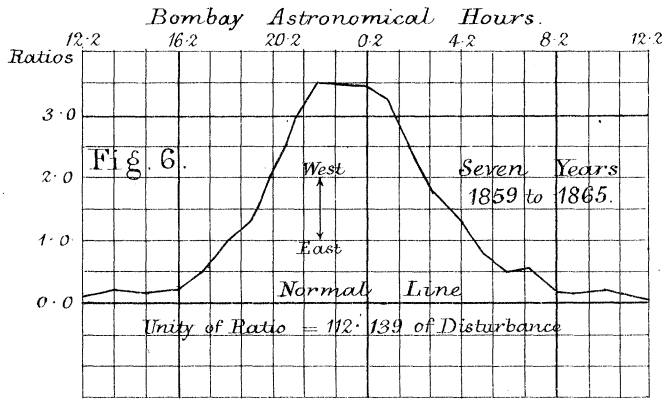


Diurnal Variations of Easterly and of Westerly Disturbance. Separating Value = 1'·4

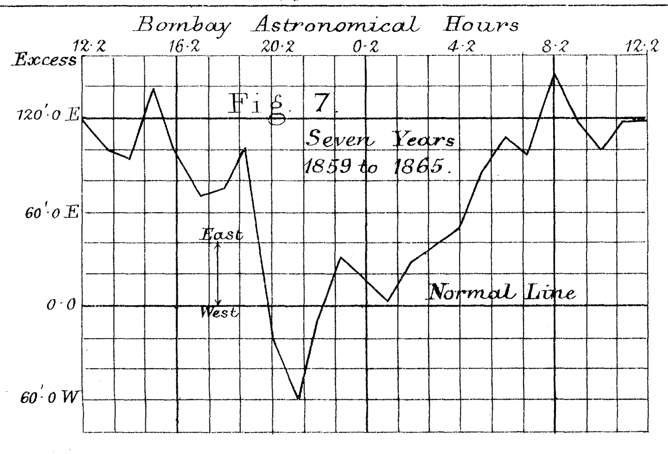
Easterly Disturbances.



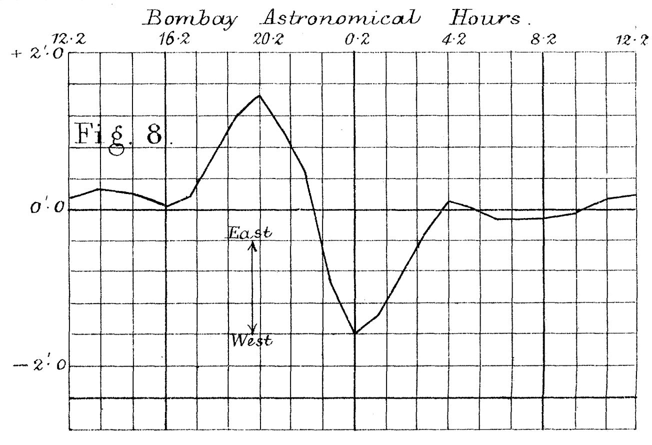
Westerly Disturbances.



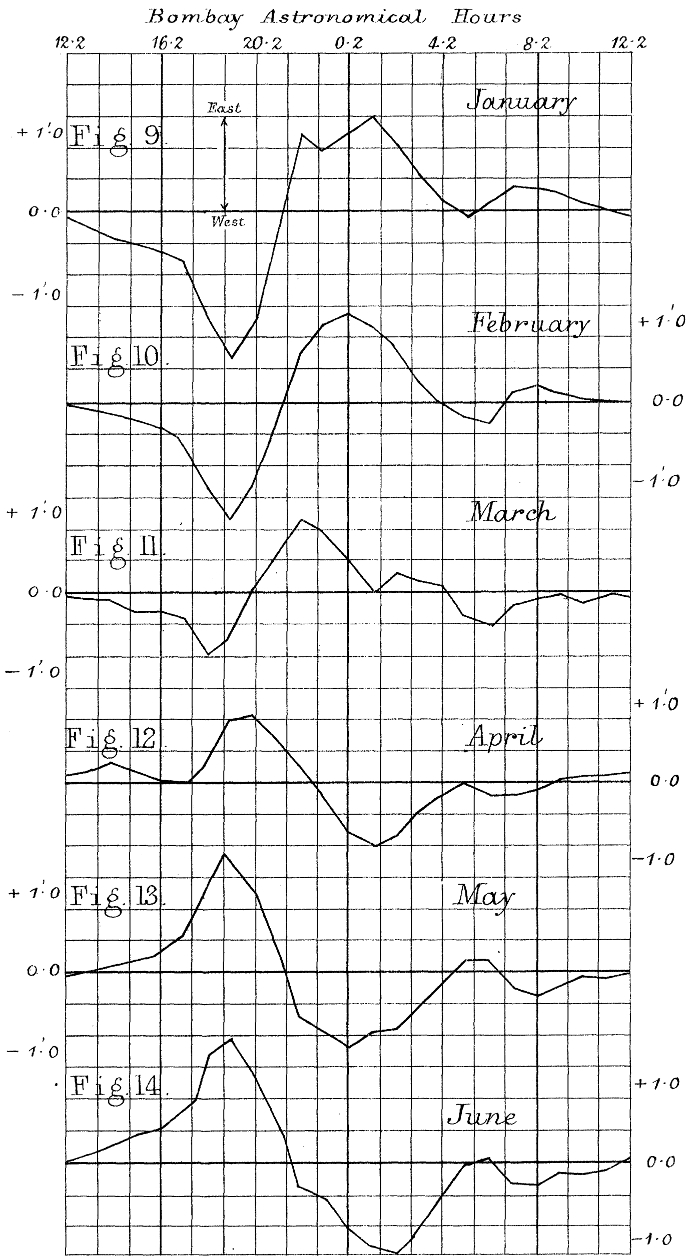
Disturbance Diurnal Variation, or the excess, at each hour, of the aggregate of Easterly Disturbances over the aggregate of Westerly Disturbances.

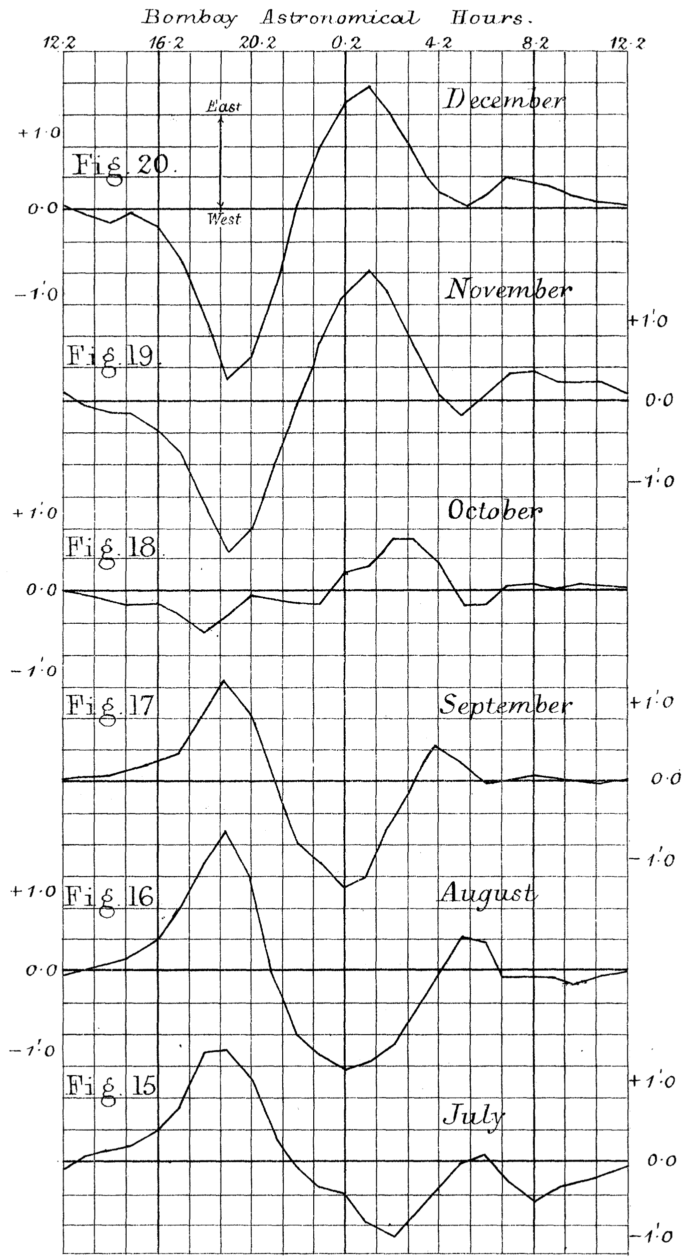


Mean Diurnal Variation of Declination for the seven years 1859 to 1865.

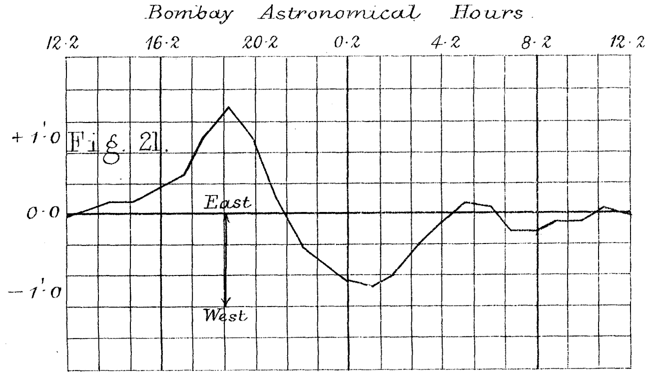


Excess of the Diurnal Variation of Declination in each month over the Mean Diurnal Variation for the whole year.

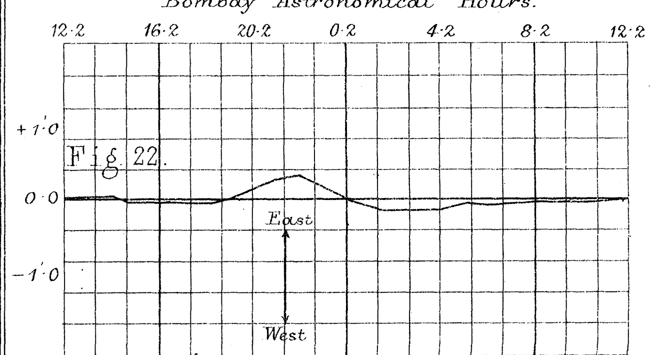




Excess of the Diurnal Variation of Declination for the half-year April to September over the Mean Diurnal Variation for the whole year.



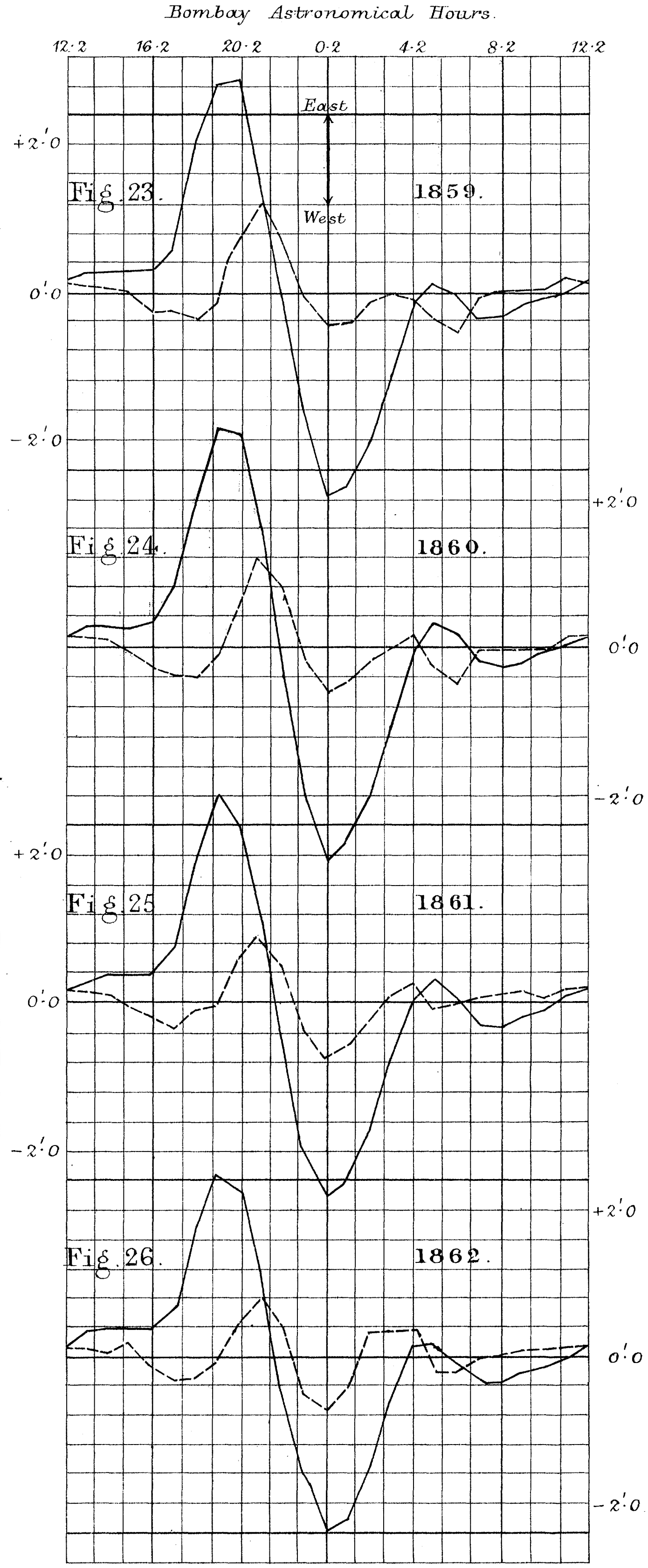
Excess of the Diurnal Variation of Declination for the half-year January to June, over the Mean Diurnal Variation for the whole year.

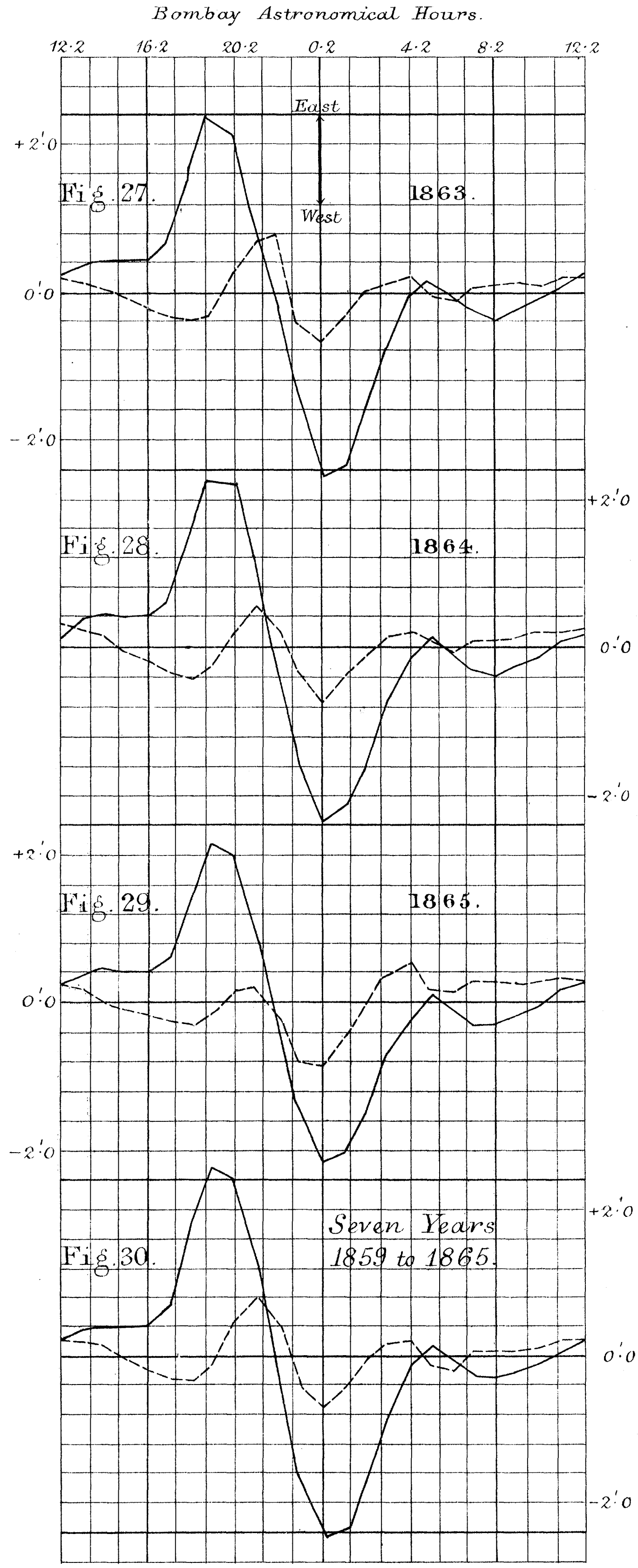


Mean Diurnal Variation of Declination for the half-years April to September and October to March in each of the years 1859 to 1865 and for the whole Period of seven years.

——————— *April to September.*

– – – – – – *October to March.*

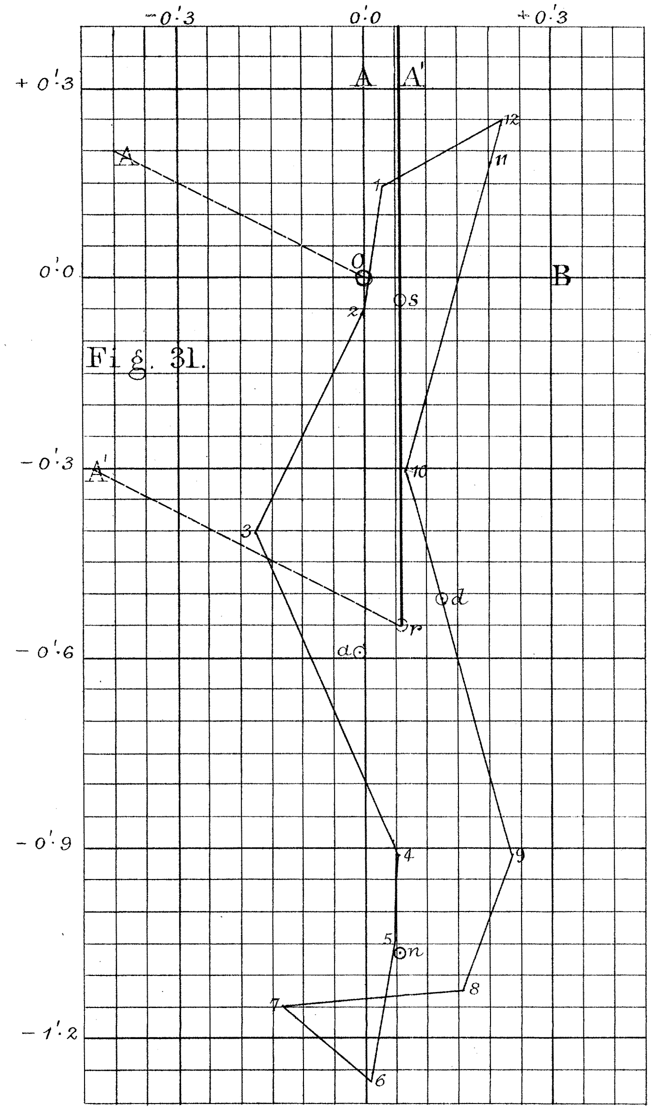




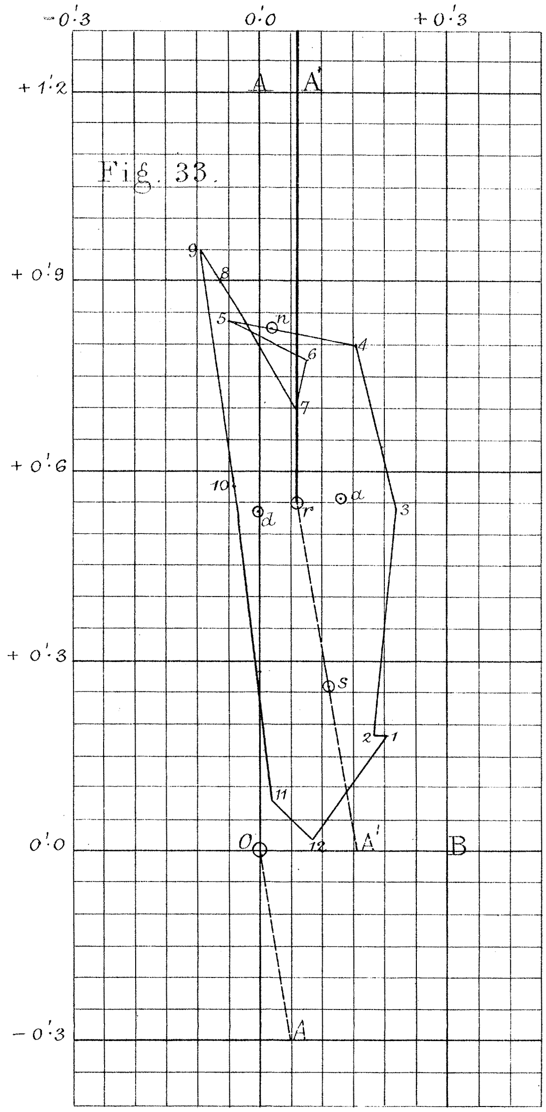
W. H. Wesley lith.

Values of the coefficients of the series (y) which expresses the Mean Diurnal Variation of Declination at Bombay in each month of the year. See paragraph 14. The numbers 1, 2, 3, 4 &c represent the months January, February, March, April &c

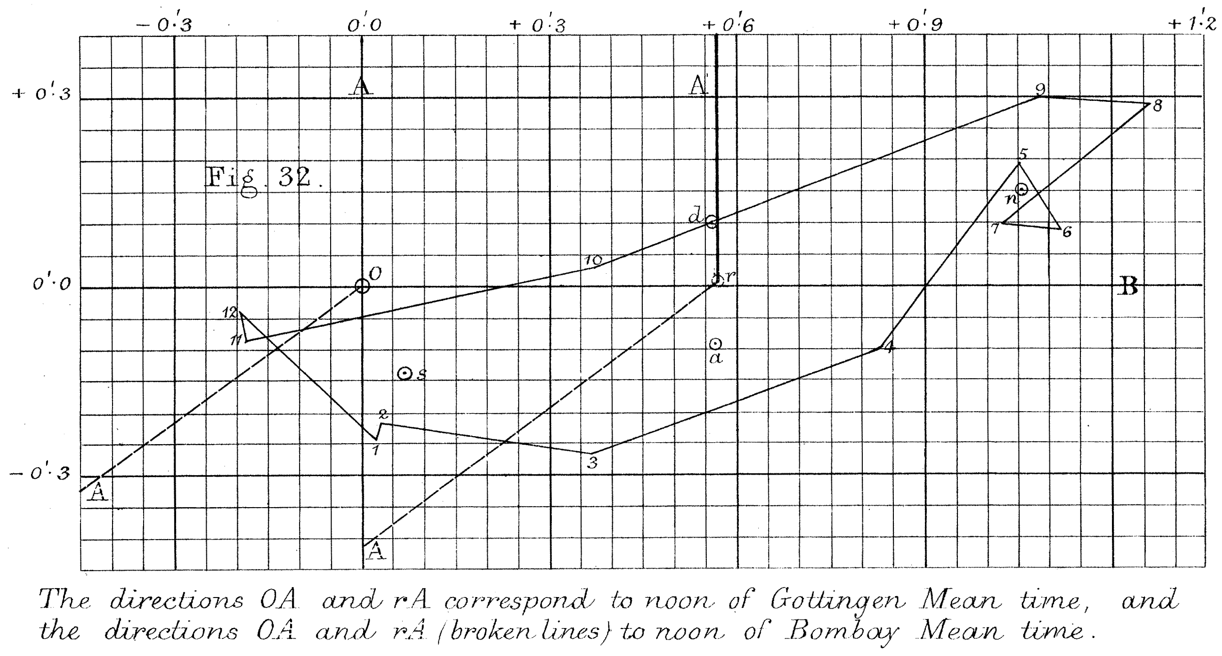
A_1 and B_1



A_2 and B_2



A_3 and B_3



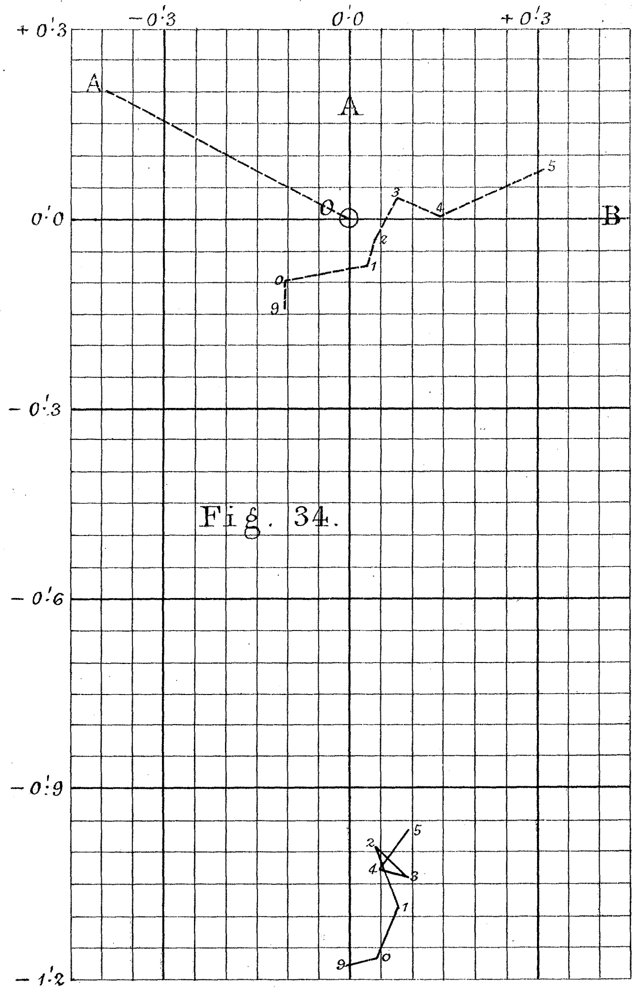
The directions OA and rA correspond to noon of Gottingen Mean time, and the directions OA and rA (broken lines) to noon of Bombay Mean time.

W. H. Wesley lith.

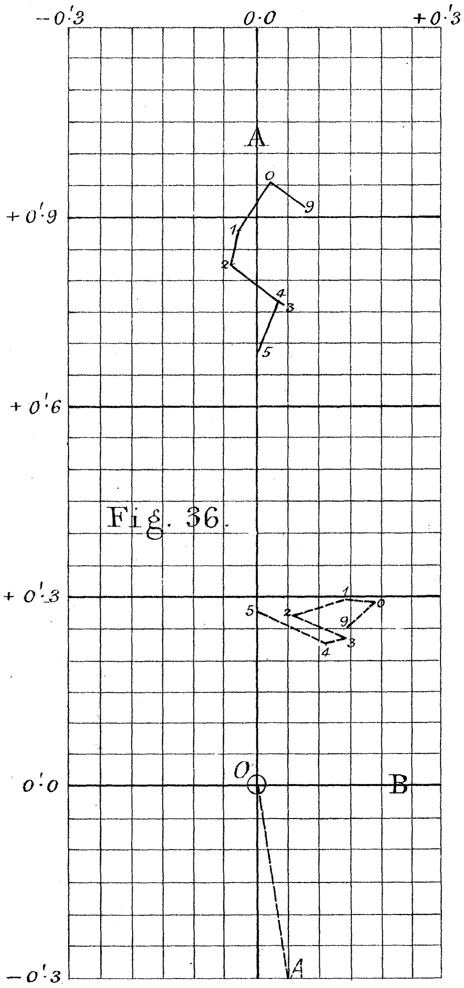
Values of the coefficients of the series (y) which expresses the Mean Diurnal Variation of Declination at Bombay in each of the half-years of 1859 to 1865. See paragraph 14. The numbers 9, 0, 1, 2, 3, 4 and 5 represent the years 1859 to 1865 respectively.

——— April to September. - - - - - - October to March.

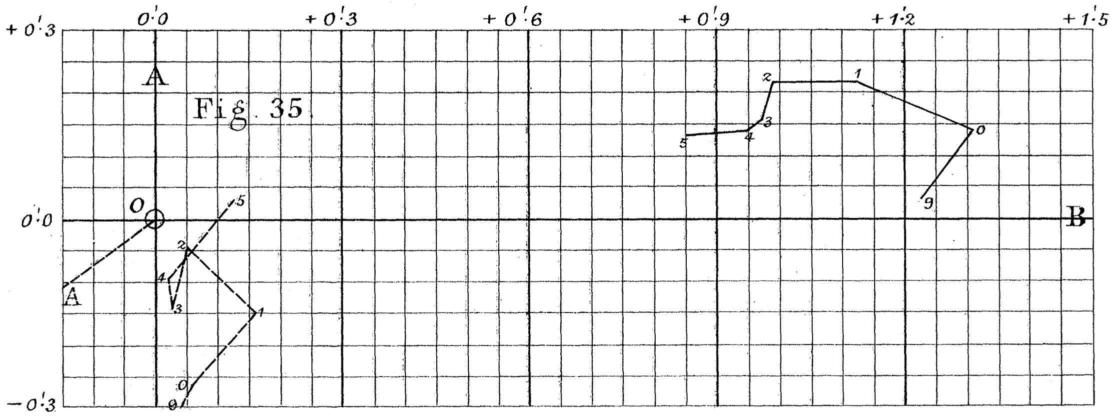
A_1 and B_1



A_2 and B_2



A_3 and B_3

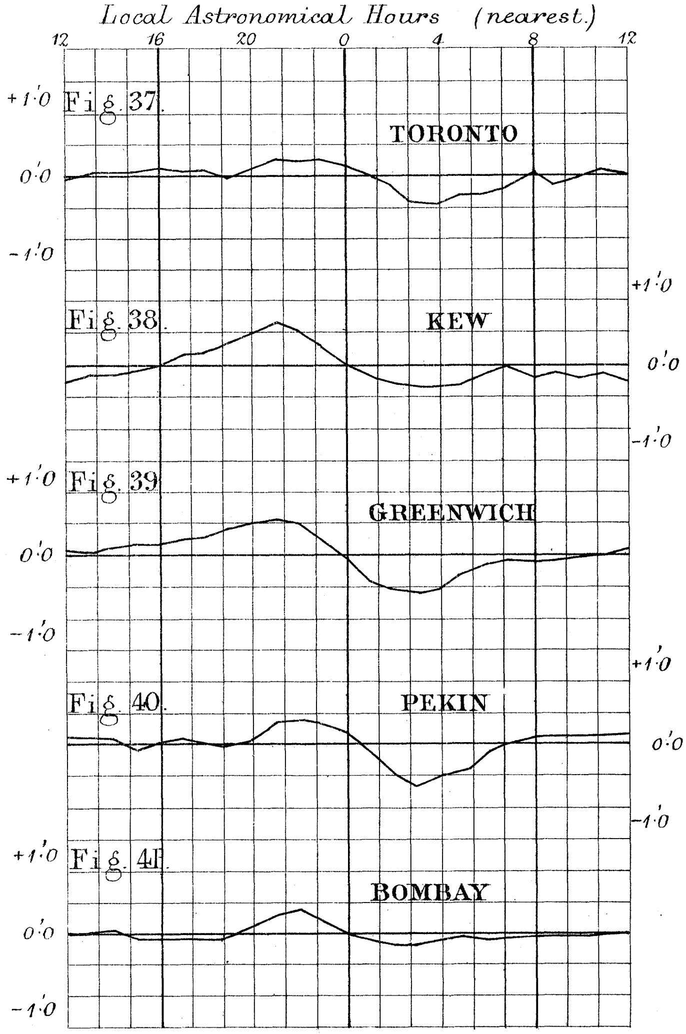


The directions OA correspond to noon of Göttingen Mean time, and the directions OA (broken lines) to noon of Bombay Mean time.

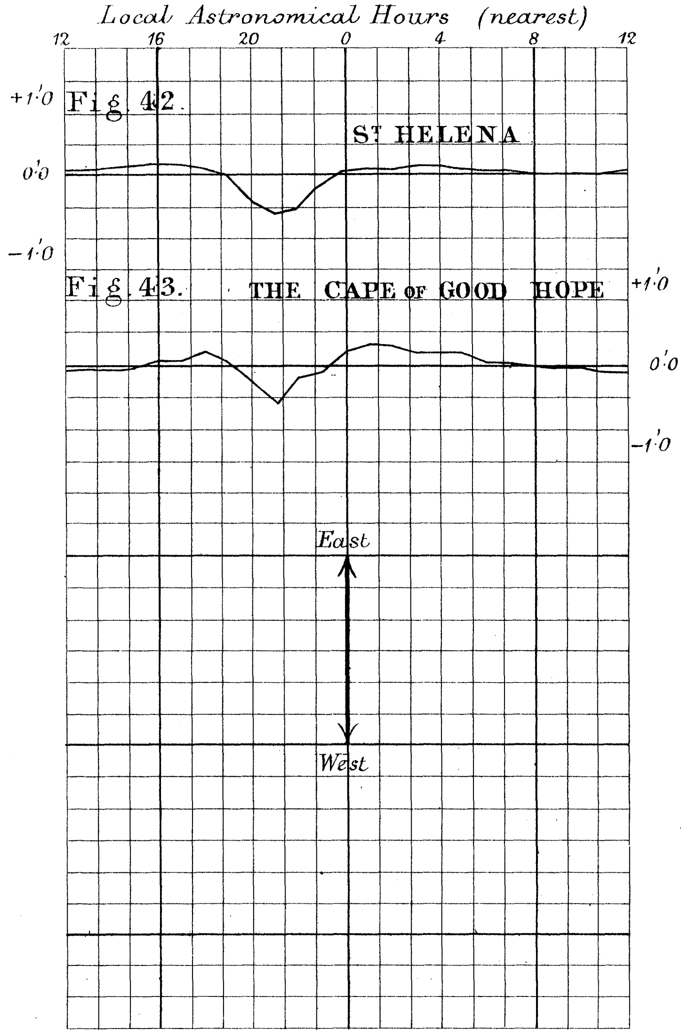
W. H. Wesley lith.

Excess of the Diurnal Variation of Declination for the half-year January to June over the Mean Diurnal Variation for the whole year at different stations.

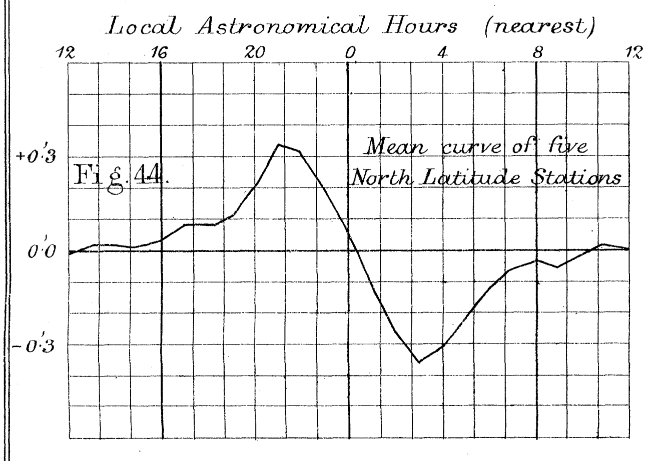
North Latitude Stations.



South Latitude Stations.



Mean for the five North Latitude Stations, of the Excess Variations represented by Figures 37 to 41.
Scale enlarged four times.



Mean for the two South Latitude Stations, of the Excess Variations represented by Figures 42 and 43.
Scale enlarged four times.