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XII. *Results of the Magnetic Observations at the Kew Observatory, from* 1857 *and* 1858 *to* 1862 *inclusive.*—No. I.

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Received May 21,—Read June 18, 1863.

§ 1. *A tabular synopsis of ninety-five of the principal disturbances of the magnetic declination recorded by the Kew Photograms between January* 1858 *and December* 1862 *inclusive; and a comparison of the Laws of the Disturbances derived therefrom, with the Laws derived by the more usual method.*

It seems difficult to understand how any one having the opportunity of examining the daily photographic records of a magnetic observatory, and viewing them with an intelligent eye, can fail to discern in the magnetic disturbances the systematic operation of laws depending upon the solar hours; and to perceive that these laws are different from those which govern the regular solar-diurnal variation (upon which the disturbances, whensoever occurring, are superposed).

There are, however, many persons who have not the opportunity of examining for themselves these full and complete records, but who may, nevertheless, be desirous of obtaining a clearer and more distinct understanding of the true character of these remarkable phenomena, in the belief that such knowledge is indispensable as the *first step* of an inductive inquiry which may ultimately reveal to us their causes, and the nature of the causation by which they are produced; and also from the prominency which is given to such an investigation in the Report of the Royal Society in 1840, wherein it is asserted that "the progressive and periodical variations are so mixed up with the casual and transitory changes, that it is *impossible* to separate them so as to obtain a correct knowledge and analysis of the progressive and periodical variations, *without taking express account of and eliminating the casual and transitory changes.*" The elimination of the disturbances was thus early foreseen to be an essential preliminary step in the systematic investigation of the periodical magnetic variations generally. The whole course of subsequent research has manifested the sagacity and importance of this early precept, and the necessity of placing this fundamental point of our investigations on a secure basis. I have thought, therefore, that it might be desirable to place before the Royal Society a synopsis of the deflections from the normal positions of the declinometer, tabulated from the photograms of the Kew Observatory, in a large portion of the most notable disturbances which occurred between January 1858 and December 1862, showing the direction and the amount of disturbance at twenty-four equidistant epochs in each of the disturbed days—in the belief that those who may desire to do so will obtain, by a careful examination of such a tabular view, and of the appended comments, a more distinct and definite perception of the character of the magnetic disturbances than appears to be usually possessed.

In forming the Table which occupies pages 276 and 277, the principle of selection adopted, and invariably adhered to, has been to take all those days in which twelve at the least of the twenty-four equidistant epochs have been disturbed to an amount equalling or exceeding 0·15 inch of the photographic scale, or 3'·3 of arc, on either side of the normal of the month and hour to which the recorded position corresponds, the normal itself having been obtained by recomputation after the omission of all disturbances amounting to 3'·3. The figures in the Table are the differences of the disturbed positions from the normals as above defined. By the process thus described the solar-diurnal and other minor variations are eliminated. There have been ninety-five such days in the five years. The Summary at the close of Table I. shows the resulting aggregate values, both of Easterly and of Westerly deflection, at each of the twenty-four equidistant epochs in each of the five years, as well as in the whole period. The hours of astronomical time at the Kew Observatory have been taken for the twenty-four equidistant epochs.

It is obvious, on the most cursory view of the Summary at the close of the Table (page 277), that the Easterly and Westerly deflections are both subject to systematic laws, and that these laws are distinct and dissimilar in the two cases. Thus the easterly deflections prevail during the hours of the night, and the westerly during the hours of the day. In the day-hours the easterly are small, and vary but slightly; they begin to increase about 5 or 6 P.M., and augment progressively until 11 or 12 P.M., when they attain a value (speaking always of aggregate values) nine or ten times as great as on the average of the day-hours. This great development of easterly disturbance continues until one or two hours after midnight, when it as steadily and progressively subsides until 5 or 6 A.M. The westerly deflections, on the other hand, are distinguished not only by their great prevalence at the hours when the easterly deflections are small, viz. 5 A.M. to 6 P.M., but also by having two distinct epochs of maximum about eight or nine hours apart, viz. one about 6 or 7 A.M., and the other about 3 P.M. This last-named distinction between the two classes of deflection, viz. a single maximum in the one, and a double maximum in the other, is the more worthy of notice, because, as will be shown hereafter, a similar distinction prevails at the greater part of the stations where the laws of the disturbances have been investigated, although, whilst in certain localities of the globe it is, as at Kew, the easterly disturbances which have the single maximum, and the westerly the double maximum, in other localities the converse is found to take place. The increased prevalence of each of the two classes of deflection for about half the twenty-four hours, and diminished prevalence during the other half, appears also to be a usual characteristic,—but with the reservation, that the hours of the prevalence of each class are not the same in different localities, and that they vary *independently of each other*—so much so that at some stations the two classes of disturbance, instead of affecting opposite parts of the twenty-four hours as at Kew, may even have their greatest prevalence at the same hours.

If we now take the pains to compare the summaries of the easterly and westerly deflections in *each* year with those of the means of the *five* years, the accordance is too manifest to admit of a doubt remaining as to the general and systematic character of the laws which have been thus placed in evidence. And if we further proceed to examine *seriatim* the general progression of disturbance in each of the ninety-five days, we shall see reason to conclude that by far the greater part of the disturbances are in conformity with these laws (which are of course more fully and clearly shown by the annual and quinquennial summaries)—thus manifesting the general prevalence of a common type in the disturbing action, even when the days are regarded individually.

In the greater part of the ninety-five days it is easy to trace the presence of *both* the features which may be regarded as the leading characteristics of a disturbance: viz., 1, a deflection (of very considerable amount at certain hours) from the mean or normal position of the magnet; and 2, rapid fluctuations on either side of the deflected position. All days of disturbance are marked by one or the other of these two features, and frequently by both. The *deflections* from the normal are variable in *amount*, but in *direction* they are generally conformable to the systematic laws which have been already adverted to, and which will be more fully discussed in the sequel. The *fluctuations* are extremely irregular both in direction and amount, conveying the impression that the magnet at such times is under the action of two opposing forces, of which sometimes the one and sometimes the other preponderates. A tremulous motion of the magnet is occasionally shown by the photographic traces unaccompanied by changes of direction, as if both the opposing forces were at such times in a state of agitation, but without more than a merely momentary preponderance of either. When large and rapid fluctuations present themselves, we sometimes find considerable and apparently irregular differences in the successive tabulated directions of the magnet (taken, as must be remembered, at the precise instants of the equidistant epochs); but the more regular and systematic prevalence of easterly deflection at particular hours, and of westerly deflection at other hours, usually overrides, even in the individual cases as it does altogether in the means, the partial influence of the fluctuations.

The excess of easterly over westerly, or of westerly over easterly deflection at the several hours in the ninety-five days is a measure of the influence which the disturbances would necessarily exercise on the "diurnal inequality" derived from the hourly means of the ninety-five days, if the elimination of the disturbances were unattended to: the excess thus referred to constitutes, in fact, the *disturbance-diurnal variation* due to that portion of the disturbances occurring in the five years which is included in the ninety-five days contained in the Table. This part of the subject will be resumed in the third section of this paper.

TABLE I.—Synopsis of Ninety-five days of most notable Disturbance of the Magnetic Declination in the years 1858 to 1862 inclusive.

From the Kew Photograms.

Dates.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	Kew Astronomical Hours.																							
1858.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
Jan. 8.	…	…	…	…	E. 9·8	…	E. 3·6	E. 4·7	…	…	…	E. 24·3	E. 10·0	W. 4·4	E. 4·0	…	…	W. 9·1	W. 10·8	W. 21·0	…	W. 12·2	W. 5·7	…
Mar. 13.	W. 7·6	W. 5·1	W. 5·2	W. 10·3	W. 10·4	W. 10·1	W. 9·8	W. 7·1	E. 10·9	W. 7·4	…	…	W. 14·0	E. 7·1	E. 14·5	E. 12·0	E. 15·8	…	E. 5·5	…	…	…	…	…
14.	…	…	W. 7·2	W. 6·5	W. 7·1	W. 7·6	…	E. 11·1	E. 6·4	E. 10·1	E. 3·4	…	E. 4·1	E. 4·5	W. 6·6	…	W. 5·9	…	…	W. 9·2	…	…	…	…
April 9.	…	W. 4·4	W. 11·0	W. 14·2	W. 43·9	W. 18·5	W. 36·6	…	W. 5·6	W. 5·3	E. 4·7	E. 4·3	E. 10·6	E. 7·2	E. 3·5	…	…	…	…	…	W. 10·7	W. 3·7	…	…
10.	W. 5·9	W. 4·2	W. 5·5	W. 8·3	W. 5·7	W. 5·9	W. 5·0	E. 15·5	E. 3·4	…	…	E. 8·4	E. 13·4	…	E. 4·0	E. 7·3	E. 7·2	…	…	W. 3·4	W. 3·8	W. 4·1	…	W. 5·1
24.	E. 13·5	E. 14·8	E. 13·5	E. 9·9	E. 6·7	E. 4·6	…	…	…	…	…	…	…	…	…	…	…	W. 4·6	W. 6·6	W. 9·5	W. 10·5	W. 6·2	…	E. 6·3
May 18.	E. 12·2	E. 12·9	E. 11·5	E. 7·9	E. 5·7	E. 4·2	…	…	…	…	…	…	…	…	…	…	W. 6·0	W. 7·9	W. 10·5	W. 12·6	W. 9·6	W. 4·1	…	E. 5·3
19.	E. 10·7	E. 12·5	E. 10·5	E. 8·0	E. 5·3	E. 4·1	…	…	…	…	…	…	…	…	…	…	W. 3·8	W. 5·3	W. 7·3	W. 9·2	W. 8·3	W. 4·3	…	…
June 3.	W. 4·2	W. 6·7	W. 5·5	W. 4·8	…	…	W. 3·9	…	…	W. 6·1	W. 3·7	…	…	W. 10·5	…	E. 6·6	…	W. 9·1	W. 6·2	…	…	…	…	W. 4·1
22.	…	…	…	E. 3·6	E. 4·6	E. 4·3	…	…	…	…	E. 13·1	…	…	E. 7·9	E. 4·5	E. 4·8	E. 7·0	E. 3·8	W. 6·1	W. 21·0	W. 8·7	…	…	…
23.	…	…	…	…	W. 7·2	E. 3·5	W. 8·4	E. 5·8	E. 9·5	…	E. 26·2	…	…	E. 10·3	E. 3·6	W. 9·3	W. 8·1	…	W. 9·9	W. 8·3	W. 10·6	W. 6·2	W. 7·8	W. 3·3
24.	W. 3·2	…	…	…	…	…	E. 3·4	E. 10·1	E. 6·1	E. 9·0	E. 6·1	E. 5·1	E. 7·6	E. 9·5	E. 7·5	W. 3·7	W. 9·2	W. 4·7	W. 11·0	W. 10·5	W. 5·8	W. 6·2	…	…
July 5.	E. 4·8	…	…	…	…	…	…	E. 6·1	E. 4·6	E. 4·1	E. 10·3	E. 8·3	E. 14·9	E. 7·2	…	W. 5·0	E. 4·8	E. 4·8	E. 4·0	E. 3·2	…	…	…	…
Sept. 20	W. 8 7	…	W. 6·2	W. 5·3	E. 4·2	W. 3·9	W. 3·8	…	…	E. 4·4	…	E. 11·5	…	E. 14·8	E. 9·1	E. 6·5	…	…	…	W. 8·2	W. 6·6	W. 5·3	…	…
21.	…	…	…	W. 4·6	E. 5·8	…	…	…	E. 6·4	W. 6·1	E. 10·1	E. 11·8	E. 10·3	E. 12·5	W. 4·1	E. 4·3	W. 4·4	W. 6·7	W. 5·2	W. 5·6	…	…	…	…
Oct. 18.	…	…	E. 4·5	E. 3·8	E. 4·0	…	…	…	…	…	W. 6·8	E. 6·4	E. 16·1	E. 3·8	E. 5·1	E. 5·3	E. 6·2	…	…	W. 3·3	W. 8·3	W. 8·3	…	…
Dec. 4.	…	…	…	…	…	…	…	…	W. 6·2	E. 13·2	E. 6·6	E. 10·7	E. 16·5	E. 10·1	E. 15·0	E. 23·5	W. 3·5	W. 12·7	W. 13·0	W. 20·6	W. 6·8	…	W. 3·3	…
22.	…	…	W. 4·1	W. 5·7	W. 4·0	…	…	…	…	E. 4·3	…	…	E. 4·3	E. 5·4	…	…	…	W. 6·0	W. 6·3	W. 3·5	W. 3·4	W. 4·6	W. 6·3	W. 3·7
23.	W. 9·8	W. 4·8	…	W. 4·9	W. 4·9	W. 3·7	W. 4·0	E. 5·4	…	…	…	…	E. 3·8	E. 18·4	E. 9·4	…	…	…	W. 4·4	…	W. 3·3	…	…	W. 3·9
1859.																								
Jan. 15.	W. 6·9	W. 7·1	W. 4·7	W. 8·3	W. 8·7	W. 6·0	W. 7·6	E. 5·4	E. 5·6	E. 6·1	E. 7·2	E. 12·4	E. 6·7	E. 10 5	E. 11·1	E. 8·0	…	W. 3·4	W. 3·5	W. 5·5	W. 6·5	W. 6·1	W. 4·2	W. 4·3
Feb. 9.	…	…	W. 4·9	W. 6·0	W. 6·5	W. 5·5	W. 13·0	…	…	E. 6·5	E. 6·3	…	E. 3·2	…	E. 12·3	E. 4·5	W. 6·7	W. 13·8	W. 3·4	W. 5·2	…	…	W. 4·5	…
23.	…	…	…	…	…	…	E. 7·0	E. 10·9	E. 5·9	…	E. 3·9	E. 15·3	E. 8·6	E. 5·2	E. 3·9	E. 3·9	…	W. 4·0	W. 7·8	W. 12·4	W. 8·6	W. 11·7	W. 11·4	W. 5·9
April 21.	…	…	W. 6·8	W. 10·4	W. 21·7	W. 17·4	W. 16·8	W. 15·0	…	E. 5·7	E. 16·9	E. 9·0	E. 4·7	E. 8·9	E. 14·8	E. 14·9	…	E. 4·8	…	…	…	…	…	…
29.	W. 3·5	W. 6·8	…	W. 7·1	W. 12·2	W. 5·7	…	…	E. 4·9	E. 3·7	E. 12·4	E. 8·3	E. 5·8	E. 9·9	W. 4·4	…	W. 4·2	…	…	W. 8·0	W. 8·5	W. 6·6	…	…
June 8.	W. 9·9	…	E. 6·1	W. 8·6	W. 14·9	W. 14·0	W. 13·5	E. 9·2	…	W. 3·7	…	…	…	…	…	…	W. 24·7	E. 3·4	W. 15·2	W. 11·1	W. 11·3	W. 5·9	W. 6·0	W. 4·6
16.	…	W. 5·7	W. 6·5	W. 5·4	W. 5·8	W. 3·6	…	…	…	…	E. 3·3	…	E. 4·0	E. 3·5	…	W. 3·3	W. 3·6	…	W. 3·4	…	W. 4·4	W. 3·7	…	…
July 11.	…	…	…	W. 3·6	…	W. 4·5	E. 5·4	…	…	W. 4·5	…	E. 3·5	E. 7·3	E. 6·1	E. 14·0	E. 10·8	E. 11·5	E. 8·4	E. 7·9	…	…	W. 4·2	W. 5·0	…
18.	W. 4·3	W. 6·1	W. 12·2	W. 10·8	…	W. 6·1	W. 3·5	…	…	…	…	W. 4·0	…	…	W. 4·2	…	W. 4·8	W. 7·4	W. 5·6	W. 4·8	…	W. 4·4	…	…
Aug. 26.	W. 5·3	W. 6·2	W. 4·8	…	…	…	…	…	…	E. 4·9	E. 3·4	E. 5·3	E. 4·3	E. 4·9	E. 5·9	…	…	…	E. 5·3	E. 5·1	E. 5·1	E. 3·3	…	…
28.	…	…	…	…	…	W. 3·5	W. 4·2	E. 8·9	E. 5·9	…	E. 3·4	E. 6·4	…	E. 24·7	E. 32·6	…	W. 17·8	W. 47·8	W. 34·4	…	…	W. 26·1	W. 25·2	…
Sept. 1.	W. 8·3	W. 4·7	W. 4·5	W. 4·5	…	…	…	…	…	…	E. 3·9	…	…	…	…	…	E. 8·5	W. 52·3	W. 55·1	E. 20·9	E. 27·8	E. 4·4	E. 13·7	…
2.	E. 17·3	…	…	W. 6·2	W. 4·3	W. 6·9	E. 6·8	…	W. 4·8	E. 25·9	W. 8·4	E. 7·6	W. 15·5	…	E. 11·4	E. 5·3	W. 7·4	…	…	…	…	…	…	…
3.	W. 6·8	W. 9·0	W. 11·7	W. 25·3	W. 16·4	W. 13·4	E. 36·3	…	…	…	…	W. 10·7	W. 12·0	…	…	…	W. 5·9	…	W. 5·1	W. 7·4	…	…	…	…
4.	W. 4·0	W. 7·9	W. 6·0	…	…	…	…	…	W. 3·4	…	…	E. 7·6	W. 7·9	E. 4·8	W. 5·4	…	…	…	E. 4·4	E. 4·9	…	W. 5·3	…	W. 9·8
5.	…	…	…	W. 8·3	W. 8·5	…	…	W. 5·9	W. 4·1	W. 12·3	…	…	…	W. 6·3	W. 5·5	…	W. 4·1	W. 3·5	W. 3·8	W. 4·9	W. 9·4	W. 4·2	W. 3·5	W. 11·5
24.	…	W. 4·8	W. 5·4	W. 3·3	W. 4·1	W. 5·2	W. 13·9	W. 5·0	W. 7·4	…	E. 15·9	E. 4·7	E. 5·0	B. 8·7	…	…	…	…	…	…	…	…	…	…
Oct. 17.	W. 3·7	…	…	…	…	…	…	…	…	E. 32·3	E. 12·9	E. 16·9	…	E. 3·9	E. 3·8	E. 7·0	E. 12·6	W. 6·7	W. 4·3	W. 16·0	W. 10·3	W. 10·2	W. 14·1	W. 10·0
18.	W. 6·4	W. 4·9	…	…	W. 3·5	…	…	…	…	…	E. 6·0	E. 10·2	E. 8·8	W. 5·2	E. 8·6	E. 6·6	…	…	W. 5·5	…	W. 5·1	W. 4·1	…	W. 4·0
20.	W. 5 5	W. 7·0	W. 3·6	W. 7·9	W. 5·0	…	…	…	…	E. 5·8	…	E. 5·9	…	…	E. 4·7	…	…	…	W. 5·1	W. 3·4	W. 5·5	W. 4·1	W. 4·0	…
21.	……	W. 4·5	W. 3·9	W. 7·3	W. 10·0	W. 4·8	…	W. 4·1	W. 3·5	…	…	…	…	…	…	…	E. 3·5	…	W. 5·2	…	W. 5·0	W. 5·5	W. 4·1	…
Nov. 12.	…	W. 3·9	W. 3·6	W. 5·3	W. 5·3	…	E. 4·1	…	…	E. 7·9	E. 10·6	E. 9·7	E. 9·1	E. 18·5	E. 5·4	…	…	W· 7·0	W. 7·6	W. 14·8	W. 10·9	…	W. 10·1	W. 4·3
Dec. 6.	W. 7·1	W. 5·1	…	W. 4·6	…	E. 6·5	W. 5·0	…	E. 5·2	…	…	…	E. 4·2	E. 4·1	…	W. 11·7	W. 4·1	…	W. 3·4	W. 3·3	…	…	…	…
1860.																								
Feb. 21.	W. 4·2	W. 11·5	…	W. 8·5	W. 7·8	…	…	…	…	E. 5·0	E. 9·9	W. 20·3	E. 14·2	E. 11·0	E. 11·9	E. 10·4	E. 10·5	E. 8·2	…	…	…	W. 5·5	W. 8·3	W. 3·7
22.	W. 7·7	W. 7·7	W. 6·1	W. 6·4	W. 7·9	E. 6·5	…	…	E. 6·8	E. 4·9	E. 6·6	E. 3·2	…	W. 3·3	W. 4·2	…	…	…	…	…	…	…	…	…
Mar. 17.	…	W. 3·8	…	…	W. 5·2	W. 3·4	E. 7·3	…	…	E. 5·9	E. 7·0	E. 7·9	E. 8·1	E. 11·8	E. 6·0	E. 4·6	E. 6·1	…	W. 4·4	…	W. 4·0	W. 5·8	W. 7·2	W. 7·2
28.	W. 17·6	W. 7·4	W. 8·4	…	…	…	…	…	…	…	…	E. 3·7	W. 3·9	E. 4·2	E. 12·8	W. 4·4	W. 5·3	W. 10·0	W. 20·2	W. 14·2	W. 9·5	W. 14·1	W. 7·3	W. 8·3
29.	W. 10·7	W. 4·8	W. 12·7	W. 30·0	W. 37·3	…	W. 3·2	…	E. 12·8	…	…	…	E. 8·3	E. 3·6	…	W. 3·4	…	…	…	…	…	W. 5·9	W. 6·2	W. 5·6
Apr. 9.	W. 6·2	W. 9·5	W. 8·1	W. 20·4	W. 12·5	W. 15·7	W. 16·2	…	W. 4·5	E. 7·9	W. 3·5	E. 14·9	E. 16·1	E. 6·3	E. 8·3	…	…	…	…	W. 4·0	W. 6·3	W. 9·3	W. 7·3	W. 8·4
13.	…	…	…	…	…	…	…	E. 4·5	…	E. 4·8	…	E. 7·0	E. 9·6	E. 3·4	E. 6·6	E. 9·5	…	…	W. 3·3	W. 3·3	W. 4·7	W. 6·2	W. 6·9	…
May 5.	…	W. 3·2	W. 6·7	W. 7·8	W. 5·9	…	…	…	…	…	…	…	E. 4·0	E. 3·3	E. 5·5	E. 8·1	E. 4·4	…	…	…	…	E. 6·0	E. 6·0	E. 3·5
6.	…	W. 5·0	W. 9·1	W. 9·2	W. 3·3	…	…	E. 7·8	E. 5·3	…	E. 3·3	E. 3·3	E. 9·4	E. 4·1	E. 8·2	E. 10·4	E. 7·6	E. 7·2	…	…	…	…	…	…
June 30.	W. 5·3	W. 3·2	W. 8·7	…	E. 5·9	E. 4·2	E. 4·9	E. 7·9	E. 6·5	E. 9·7	E. 10·7	E. 17·2	E. 7·6	E. 21·2	E. 27·1	E. 6·7	E. 6·4	E. 14·3	…	W. 6·2	E. 4·1	E. 8·8	E. 14·1	E. 21·1
July 1.	…	…	…	E. 7·1	…	E. 5·4	E. 5·4	E. 4·4	E. 20·6	E. 20·7	E. 14·3	E. 5·4	E. 9·6	E. 7·5	E. 7·0	E. 8·3	E. 9·4	E. 7·5	E. 7·7	E. 5·1	E. 10·4	E. 4·5	E. 7·7	E. 5·7
4.	W. 3·7	W. 5·2	W. 4·6	W. 4·4	W. 6·2	W. 4·3	…	…	W. 3·4	W. 3·4	…	…	E. 9·2	E. 7·8	E. 18·2	E. 12·9	…	E. 11·3	…	E. 6·0	…	…	…	W. 6·2

Aug. 6.	...	E. 3·7	E. 3·5	E. 4·6	...	...	E. 4·5	...	...	...	...	...	E. 5·1	E. 7·8	E. 5·4	...	E. 12·4	E. 5·6	E. 8·4	E. 26·2	...	E. 13·9	W. 6·2	E. 6·1
10.	...	...	...	E. 4·4	W. 4·9	...	...	W. 4·9	W. 5·5	W. 5·5	E. 3·4	W. 7·2	W. 14·1	W. 17·3	E. 5·4	W. 3·7	...	...	...	...	...	...	...	E. 4·2
12.	W. 5·5	...	W. 9·0	W. 21·7	E. 3·5	E. 13·0	W. 3·7	W. 7·8	...	...	...	W. 17·4	W. 19·2	...	W. 13·3	E. 15·5	E. 8·0	E. 4·8	...	...	...	...	...	E. 6·9
Sept. 15.	...	...	...	...	...	...	...	...	...	E. 11·3	E. 4·6	E. 7·9	E. 4·0	E. 11·0	E. 10·1	E. 8·4	E. 13·2	E. 7·4	W. 4·8	W. 12·7	W. 9·0	W. 8·7	W. 11·3	...
Oct. 4.	W. 6·9	...	W. 3·4	...	...	W. 4·8	...	E. 12·6	...	...	E. 3·8	E. 5·0	E. 5·7	E. 5·4	E. 5·6	E. 5·4	...	...	W. 5·5	...	...	W. 3·3	W. 3·3	...
Nov. 2.	W. 4·6	W. 4·9	W. 7·7	W. 10·0	W. 3·9	...	W. 7·8	W. 8·7	W. 21·5	W. 23·1	W. 24·0	...	W. 3·7	W. 4·6	W. 6·3	...	...	...	...	...	W. 3·3	W. 3·6	...	W. 3·7
4.	W. 3·8	...	...	...	...	...	W. 3·8	W. 3·6	W. 4·9	W. 4·2	W. 4·1	...	E. 4·6	E. 14·1	E. 9·8	E. 6·6	E. 3·4	E. 3·7	...	...	W. 3·4	...	...	W. 7·8
Dec. 10.	...	W. 4·5	W. 12·2	W. 10·7	W. 10·8	W. 10·6	...	E. 3·8	E. 16·5	E. 14·1	E. 5·1	E. 10·4	E. 12·0	E. 15·5	E. 15·4	...	E. 7·6	...	W. 8·3	W. 8·4	W. 7·2	W. 9·0	W. 3·8	W. 7·3
1861.																								
Jan. 24.	W. 6·4	W. 4·8	W. 14·9	W. 5·0	W. 6·1	...	...	W. 4·5	E. 13·6	...	E. 10·6	E. 15·9	...	W. 3·6	E. 3·3	E. 4·0	...	...	W. 3·3	...	...	...	W. 3·2	W. 7·9
25.	W. 3·9	W. 7·2	W. 7·7	W. 3·5	W. 9·4	E. 10·9		E. 6·7	...	E. 4·8	E. 3·5	E. 4·4	E. 3·7	E. 4·0	E. 9·8	E. 3·3	W. 10·8	...	W. 8·0	W. 6·1	W. 7·3	W. 3·3	...	...
26.	W. 6·4	...	W. 6·8	W. 4·5	W. 5·9	...	W. 4·7	...	...	E. 8·5	E. 3·9	E. 32·8	E. 16·4	...	W. 3·6	...	...	W. 5·0	W. 21·8	W. 15·0	W. 8·5	W. 4·4	W. 8·1	W. 6·7
Feb. 27.	W. 3·3	W. 7·2	W. 6·9	W. 7·9	W. 6·8	W. 4·9	...	W. 9·5	E. 6·5	...	E. 7·9	E. 14·1	E. 20·3	E. 10·1	E. 9·4	E. 12·5	E. 12·7	...	...	...	...	W. 3·5	W. 4·1	W. 5·9
28.	W. 6·1	W. 7·9	...	W. 5·5	W. 5·0	W. 5·2	...	E. 5·9	...	E. 12·9	E. 8·7	E. 6·4	E. 12·3	E. 15·1	...	E. 9·3	E. 4·9	W. 9·5	W. 9·1	W. 6·1	W. 5·5	...	...	...
Mar. 1.	...	...	W. 4·9	W. 6·2	W. 5·7	E. 12·4	...	W. 5·3	E. 9·7	E. 4·4	...	E. 3·7	E. 7·8	...	...	E. 4·5	...	...	...	W. 4·5	W. 5·1	W. 4·0	...	...
9.	...	W. 6·4	W. 3·9	...	...	W. 7·9	...	...	E. 7·2	E. 6·5	E. 29·6	E. 13·8	E. 10·3	E. 14·2	E. 13·7	E. 9·9	E. 19·1	E. 20·9	E. 21·9	E. 19·9	E. 19·1	E. 17·6	E. 17·4	...
25.	W. 5·2	W. 6·5	W. 4·7	W. 4·0	W. 4·5	W. 5·1	...	E. 4·1	...	E. 8·2	...	E. 3·9	E. 5·5	E. 5·0	E. 10·6	E. 7·2	E. 6·9	...	...	...	W. 5·2	W. 4·7	W. 6·4	W. 6·2
Aug. 2.	W. 4·8	W. 9·9	W. 9·4	W. 5·7	W. 5·3	W. 3·9	W. 4·4	W. 3·7	...	...	E. 3·7	E. 6·1	E. 11·8	...	E. 3·9	...	E. 3·6	...	...	...	...	...	...	...
19.	...	...	...	...	E. 6·7	...	E. 4·8	E. 13·9	...	...	...	E. 3·3	...	...	W. 3·3	...	...	W. 5·2	W. 4·3	W. 3·6	W. 5·9	W. 4·2	W. 5·2	W. 4·5
Sept. 19.	W. 4·4	W. 7·0	W. 3·5	W. 5·5	E. 4·2	...	...	...	E. 3·4	...	...	...	...	E. 10·1	...	...	...	W. 11·0	W. 4·3	W. 5·0	W. 7·8	W. 4·9	...	...
Oct. 10.	W. 8·5	W. 13·1	W. 14·9	W. 6·8	W. 4·5	...	...	E. 16·4	...	E. 20·8	E. 10·4	E. 24·7	E. 16·7	...	E. 16·1	...	...	W. 5·5	W. 4·0	...	...	...	...	...
24.	W. 5·5	W. 7·3	W. 9·3	...	W. 15·6	W. 9·8	...	...	E. 6·3	E. 15·3	E. 9·6	E. 7·9	...	...	E. 7·0	E. 12·3	E. 8·0	W. 8·3	...	W. 11·0	...	...	...	...
Nov. 7.	W. 4·1	W. 3·3	W. 3·7	W. 6·2	W. 5·6	...	...	E. 16·4	E. 5·2	E. 7·7	...	...	E. 8·7	...	...	...	...	W. 4·2	W. 4·3	W. 13·0	W. 9·1	W. 6·4	W. 4·4	...
18.	...	...	...	...	...	...	...	...	...	E. 6·5	E. 3·7	E. 4·5	E. 4·1	E. 3·9	E. 7·8	E. 3·6	...	...	...	W. 7·5	W. 6·5	W. 6·4	W. 5·2	W. 3·9
Dec. 4.	...	W. 3·6	W. 7·3	W. 6·8	W. 11·5	W. 5·4	...	E. 3·5	E. 6·6	W. 11·8	E. 5·8	...	...	...	W. 5·7	...	...	...	...	...	W. 3·3	W. 6·9	W. 5·6	...
9.	...	...	...	...	...	E. 8·5	...	...	E. 11·1	...	E. 7·4	E. 10·0	E. 4·5	E. 4·8	E. 4·3	...	...	W. 8·1	W. 5·3	W. 4·4	W. 6·4	W. 6·7	W. 6·6	W. 5·8
1862.																								
Jan. 15.	...	...	...	...	...	W. 5·0	E. 4·2	E. 3·9	E. 4·2	...	E. 12·2	E. 5·6	E. 12·7	E. 18·4	E. 15·4	E. 11·5	E. 7·2	...	W. 4·5	W. 7·1	W. 8·5	E. 19·6	E. 19·1	...
Feb. 21.	W. 4·4	W. 6·7	W. 11·7	W. 7·2	W. 12·8	W. 7·4	W. 8·7	E. 7·4	E. 26·7	...	E. 5·9	E. 3·5	E. 8·3	E. 10·7	...	...	...	...	...	...	...	...	...	...
Mar. 16.	...	...	...	...	...	...	...	...	...	...	E. 4·4	E. 5·0	E. 5·2	E. 5·5	E. 6·7	E. 3·8	E. 7·3	E. 4·9	...	W. 4·9	W. 8·0	W. 9·9	W. 9·5	W. 8·1
April 2.	W. 7·9	W. 6·4	W. 14·5	W. 6·0	W. 6·3	...	E. 8·9	E. 4·2	E. 6·5	E. 13·2	E. 18·6	E. 5·4	...	...	...	...	...	W. 5·1	...	...	...	...	...	...
10.	W. 5·1	W. 5·9	W. 8·8	W. 8·9	W. 7·4	W. 5·2	W. 3·5	...	...	...	E. 5·1	E. 4·7	E. 4·8	E. 7·3	E. 11·7	E. 16·4	E. 20·5	E. 7·6	...	W. 11·7	W. 9·8	W. 8·3	W. 8·3	W. 7·2
27.	...	...	...	...	...	...	...	E. 5·1	...	E. 7·7	E. 9·0	E. 10·7	E. 18·7	E. 9·9	E. 14·1	E. 9·5	E. 5·2	...	...	...	W. 9·0	W. 6·8	W. 8·5	W. 4·2
July 5.	...	E. 4·2	...	...	...	...	W. 6·1	...	E. 12·4	...	E. 4·6	E. 3·8	E. 3·3	...	E. 4·4	...	...	...	W. 5·4	W. 9·5	W. 8·7	W. 3·3	W. 4·9	W. 4·3
30.	...	...	W. 4·3	W. 4·4	W. 3·3	...	...	E. 4·4	...	...	...	E. 5·4	E. 7·0	E. 5·6	...	...	...	...	...	E. 3·3	E. 4·7	E. 6·2	E. 5·5	E. 4·1
August 4.	...	W. 10·0	W. 7·5	W. 8·5	...	W. 5·6	...	...	W. 3·6	...	...	...	...	W. 11·1	W. 8·7	E. 9·1	W. 8·7	W. 5·3	W. 16·7	W. 3·3	W. 4·9	W. 10·9	...	...
28.	...	...	...	W. 3·6	W. 4·9	...	W. 4·8	...	...	E. 19·3	E. 7·5	E. 6·4	E. 6·6	...	W. 7·4	W. 6·8	...	...	...	W. 5·3	W. 9·0	W. 10·6	W. 5·9	W. 3·6
30.	...	W. 3·3	...	...	...	...	E. 18·0	E. 4·9	...	...	...	...	E. 3·8	W. 9·8	E. 6·6	E. 8·2	W. 4·6	W. 7·3	W. 10·8	W. 14·5	W. 9·5	W. 6·6	...	...
Sept. 29.	...	...	...	E. 3·7	E. 5·4	E. 4·3	...	...	...	...	W. 4·4	W. 5·7	W. 5·1	W. 4·6	W. 6·8	W. 5·2	W. 7·0	W. 7·2	W. 4·5	...	...	...	...	...
Oct. 3.	...	W. 3·8	W. 4·4	...	...	...	...	E. 4·4	E. 24·0	E. 15·4	E. 49·9	E. 24·4	E. 19·2	E. 14·6	E. 14·8	E. 8·6	W. 3·8	W. 25·1	W. 37·0	W. 33·4	W. 20·4	W. 28·2	W. 9·9	W. 4·2
22.	W. 7·9	W. 11·3	W. 5·6	W. 10·3	E. 21·0	W. 3·3	...	E. 6·3	...	W. 16·5	...	E. 16·5	...	W. 4·8	...	...	...	W. 10·7	W. 4·9	W. 4·4	W. 6·1	W. 6·2	...	W. 5·7
Dec. 14.	...	...	...	W. 11·2	W. 6·3	E. 12·2	E. 5·3	W. 23·1	E. 14·6	E. 32·9	E. 28·1	E. 13·7	E. 29·5	E. 20·5	E. 14·9	E. 8·5	...	...	W. 3·6	...	...	...	...	...
24.	W. 4·2	...	W. 3·9	...	E. 3·4	...	E. 9·9	E. 7·0	E. 13·2	E. 7·5	E. 18·1	E. 19·4	E. 20·3	E. 22·4	E. 29·9	E. 16·1	...	E. 6·9	...	W. 10·9	W. 11·7	W. 5·2	W. 5·9	W. 4·8

Summary.

Easterly Deflections.	1858.	41·2	40·2	40·0	33·2	46·1	20·7	7·0	58·7	47·3	45·1	80·5	90·8	111·6	118·7	80·2	70·3	41·0	8·6	9·5	3·2	...	...	...	11·6
	1859.	17·3	...	6·1	...	...	6·5	59·6	34·4	27·5	98·8	106·1	122·8	71·7	113·7	128·5	61·0	36·1	16·6	17·6	30·9	32·9	7·7	13·7	...
	1860.	...	3·7	3·5	16·1	9·4	29·1	22·1	41·0	68·5	84·3	68·7	85·9	127·5	138·0	163·3	106·8	89·0	70·0	16·1	37·3	14·5	33·2	27·8	47·5
	1861.	...	...	...	...	10·9	31·8	4·8	66·9	69·6	95·6	104·8	151·5	122·1	67·2	85·9	66·6	55·2	20·9	21·9	19·9	19·1	17·6	17·4	...
	1862.	...	4·2	...	3·7	29·8	16·5	46·3	47·6	101·6	96·0	163·4	124·5	139·4	114·9	118·5	91·7	40·2	19·4	...	3·3	4·7	25·8	24·6	4·1
Sums ...		58·5	48·1	49·6	53·0	96·2	104·6	139·8	248·6	314·5	419·8	523·5	575·5	572·3	552·5	576·4	396·4	261·5	135·5	65·1	94·6	71·2	84·3	83·5	63·2
Westerly Deflections.	1858.	39·4	25·2	44·7	64·6	83·2	49·7	71·5	7·1	11·8	24·9	10·5	...	14·0	14·9	10·7	18·0	40·9	66·1	97·3	145·9	96·4	65·2	23·1	20·1
	1859.	71·7	83·7	78·6	132·9	126·9	96·6	77·5	30·0	23·2	20·5	8·4	14·7	35·4	11·5	19·5	15·0	83·3	145·9	168·4	96·8	85·5	102·1	92·1	54·4
	1860.	76·7	70·7	96·7	129·1	105·7	38·8	34·7	25·0	39·8	36·2	31·6	44·9	40·9	25·2	23·8	11·5	5·3	10·0	46·5	48·8	47·4	71·4	67·8	58·2
	1861.	58·6	84·2	97·9	67·6	85·9	42·2	9·1	23·0	...	11·8	...	...	...	3·6	12·6	...	10·8	56·8	64·4	76·2	70·6	55·4	48·8	40·9
	1862.	29·5	47·4	60·7	60·1	41·0	26·5	23·1	23·1	3·6	16·5	4·4	5·7	5·1	30·3	22·9	12·0	24·1	60·7	87·4	105·0	105·6	96·0	52·9	42·1
Sums ...		275·9	311·2	378·6	454·3	442·7	253·8	215·9	108·2	78·4	109·9	54·9	65·3	95·4	85·5	89·5	56·5	164·4	339·5	464·0	472·7	405·5	390·1	284·7	215·7

§ 2. *Comparison of the laws of the disturbance-diurnal variation derived from the ninety-five days of disturbance tabulated in the first section of this paper, with the conclusions derived, at the same place and for the same period, from the wider basis of investigation supplied by the process first introduced and published by myself eighteen years ago.*

The process here referred to consists, as is well known, in separating from the whole body of observations employed, *all*, without exception and whensoever occurring, which differ from their respective normals of the same month and hour by a certain value, constant for the same element at the same station—the amount of this arbitrary standard, or minimum value of a disturbance, being regulated by one condition only, viz. that it shall not be so small as to endanger the inclusion amongst the separated observations of any in which the cause of the irregularity may with probability be ascribed to any other source than that of the class of phenomena whose laws we desire to study. In the case of the hourly positions tabulated from the Kew Photograms from January 1858 to December 1862, 0·15 inch of the photographic scale, or 3·3 minutes of arc measured from the normal of the same month and hour after the omission of the disturbed observations, has been taken as the standard or minimum value of a disturbance. There are altogether in the photograms of the five years at Kew the effective records of 43,456 hourly positions; the number of failures in the photographic registration from *all* causes being only 368. Of these 43,456 recorded positions, 5941, being about 1 in 7 of the whole body, differed by an amount equalling or exceeding 3'·3 from their respective normals. The aggregate value of the differences of the disturbed positions, measured from the normals, was 36,580·8 minutes of arc, of which 19,748'·7 were easterly, and 16,832'·1 were westerly deflections.

Table II. exhibits the *aggregate values* of the disturbances distributed into easterly and westerly deflections, and into the several *hours* of their occurrence. The easterly deflections derived from the ninety-five days are in column 2, and those derived from the 5941 disturbed positions (*i. e.* from all disturbances equalling or exceeding 3'·3) in column 3; the westerly deflections derived from the ninety-five days occupy column 4, and those obtained from the 5941 disturbed positions column 5. The *Ratios* which the aggregate values of easterly and westerly deflection at the different hours bear to their respective mean hourly values are shown in the same Table (II.), the easterly in columns 6 and 7; the westerly in columns 8 and 9. By comparing the values in columns 6 and 7 with each other, it will be seen that the Ratios of the easterly deflections exhibit approximately the same law, whether obtained from the ninety-five days, or from all disturbances equalling or exceeding 3'·3; and by comparing the ratios in columns 8 and 9, it will be seen, in like manner, that there is a similar general accordance in the ratios of the westerly deflections, whether obtained from the ninety-five days, or from the more extensive induction: the *laws*, when examined by the *ratios*, are seen to be approximately the same when derived by either process, although the aggregate values are very dissimilar—being more than three times as great when the method of investigation is such as to comprehend all disturbances equalling or exceeding 3'·3, as when it is limited to the disturbances in ninety-five days of principal note.

TABLE II.

Kew Astronomical Hours.	Aggregate Values. Easterly Deflections. From 95 Days.	Aggregate Values. Easterly Deflections. From all Disturbances.	Aggregate Values. Westerly Deflections. From 95 Days.	Aggregate Values. Westerly Deflections. From all Disturbances.	Ratios. Easterly Deflections. From 95 Days.	Ratios. Easterly Deflections. From all Disturbances.	Ratios. Westerly Deflections. From 95 Days.	Ratios. Westerly Deflections. From all Disturbances.	Kew Astronomical Hours.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0	59	247	276	1074	0·25	0·30	1·15	1·53	0
1	48	269	311	1157	0·21	0·33	1·57	1·65	1
2	50	308	379	1232	0·21	0·37	1·56	1·76	2
3	53	245	454	1175	0·23	0·30	1·88	1·67	3
4	96	371	443	1039	0·41	0·45	1·86	1·48	4
5	105	478	254	718	0·46	0·58	1·07	1·02	5
6	140	647	216	506	0·60	0·79	0·89	0·72	6
7	249	999	108	314	1·07	1·21	0·44	0·45	7
8	315	1322	78	233	1·35	1·61	0·33	0·33	8
9	420	1562	110	257	1·81	1·90	0·45	0·37	9
10	524	1983	55	160	2·26	2·41	0·23	0·23	10
11	576	1978	65	156	2·47	2·40	0·27	0·22	11
12	572	1946	95	301	2·46	2·36	0·40	0·43	12
13	553	1706	86	371	2·38	2·07	0·35	0·53	13
14	576	1558	90	441	2·48	1·89	0·37	0·63	14
15	396	1245	57	376	1·71	1·51	0·24	0·54	15
16	262	862	164	488	1·12	1·05	0·68	0·70	16
17	136	419	340	839	0·58	0·51	1·40	1·20	17
18	65	243	464	1058	0·28	0·30	1·91	1·51	18
19	95	262	473	1175	0·41	0·32	1·95	1·67	19
20	71	289	406	1039	0·31	0·35	1·67	1·48	20
21	84	274	390	981	0·36	0·33	1·61	1·40	21
22	84	287	285	838	0·36	0·35	1·18	1·19	22
23	63	250	216	910	0·27	0·30	0·89	1·30	23
Sums...	5592	19750	5815	16838	233=1·00	823=1·00	243=1·00	701=1·00	Mean hourly values.
Means..	233	823	243	701					

For the convenience of those who prefer graphical to tabular representation, the diurnal course of the easterly deflections, corresponding to the Ratios in columns 6 and 7 of Table II., is exhibited in Plate XIII. figure 1, where the broken line shows the diurnal march indicated by the ratios obtained from the ninety-five days, and the unbroken line the diurnal march obtained from all the disturbances equalling or exceeding 3'·3. Figure 2 is a similar representation of the diurnal march of westerly disturbance-deflection, obtained, as shown by the broken line, from the ninety-five days, and by the unbroken line from the more comprehensive investigation. The general aspect of the two figures seems to establish in the most conclusive manner—

1. That the disturbances have systematic laws:

2. That the easterly and westerly deflections have each their own systematic laws, distinct and different from each other:

3. That these laws are approximately the same, whether derived from the more limited or from the more comprehensive basis, although in the latter case the *aggregate values* of disturbance are more than three times as great as when the disturbances of the ninety-five days only are taken into account.

Hence it follows that by taking only the most notable days of disturbance in five years (averaging nineteen in each year), we may gain an approximately correct view of the *character* of the disturbance-diurnal variation; but if we desire not only to learn its character, but also to *eliminate its influence*, in compliance with the prescribed condition of "eliminating the casual and transitory changes as a first and essential step towards a correct knowledge of the more regular periodical variations," then we see that *the mere omission of those ninety-five days is altogether inadequate for the desired object*, as it would scarcely eliminate a third part of the systematically disturbing element, shown to admit of elimination by a more suitable process.

§ 3. *Disturbance-diurnal Variation.*

Table III. exhibits the excess of easterly over westerly, or of westerly over easterly deflection at twenty-four equidistant epochs of the solar day, derived, in column 2, from the disturbances in the ninety-five days, and in column 3, from all disturbances equalling or exceeding 3′·3 from their respective normals. These columns consequently show the disturbance-diurnal variation corresponding to the more complete, and to the less complete, process of elimination. The *character* of the progression is seen to be substantially the same in both cases, but the *amount* of disturbance is between three and four times as great in column 3 as in column 2.

TABLE III.—Disturbance-diurnal Variation; or Excess of Easterly over Westerly, or of Westerly over Easterly Deflection, at twenty-four equidistant epochs in the twenty-four hours.

Kew Astronomical Hours.	Derived from the ninety-five days of most notable disturbance.	Derived from all disturbances equalling or exceeding 3′·3.	Kew Astronomical Hours.
(1)	(2)	(3)	(4)
0	21′7 W.	82′6 W.	0
1	263 W.	889 W.	1
2	329 W.	924 W.	2
3	401 W.	930 W.	3
4	347 W.	607 W.	4
5	149 W.	240 W.	5
6	76 W.	141 E.	6
7	141 E.	686 E.	7
8	237 E.	1089 E.	8
9	310 E.	1305 E.	9
10	469 E.	1823 E.	10
11	511 E.	1822 E.	11
12	477 E.	1644 E.	12
13	467 E.	1336 E.	13
14	486 E.	1117 E.	14
15	340 E.	869 E.	15
16	97 E.	374 E.	16
17	204 W.	420 W.	17
18	399 W.	815 W.	18
19	378 W.	913 W.	19
20	334 W.	750 W.	20
21	206 W.	706 W.	21
22	201 W.	551 W.	22
23	153 W.	660 W.	23

For those who prefer graphical representation, the curved line in Plate XIII. fig. 3 exhibits the excess of easterly over westerly, or of westerly over easterly deflection, *i. e.* the disturbance-diurnal variation, obtained from the 5941 disturbances equalling or exceeding $3'\cdot 3$ from the respective normals, as shown in column 3 of Table III. The straight horizontal line in figure 3 represents the mean or normal position of the magnet at the several hours, after the omission of the disturbances. It is figured for convenience as a straight line, though in reality it is itself a curve following the progression of the solar-diurnal variation. The lengths of the ordinates which are *above* the normal line indicate the excess of the easterly over the westerly deflections at the hours when the easterly preponderate, and those which are *below* the normal line the excess of the westerly over the easterly at the hours when the westerly deflections predominate.

The easterly portion of the disturbance-diurnal variation is seen to be continuous for about ten hours, or from about 6 P.M. to 4 A.M. The westerly portion is also continuous, extending over the remaining fourteen hours, or from about 4 A.M. to 6 P.M. The easterly has a single maximum occurring about midway between its commencement and its termination. The westerly is more complex, having two maxima separated by an interval of about 8 or 9 hours. But whilst the westerly excess extends over more hours than the easterly, the areas of the two portions have nearly the same dimensions; or, in other words, the sums of the hourly deflections in opposite directions are at Kew nearly equal, and any small difference between them is not a persistent one, the easterly exceeding in some years and in others the westerly. The equality or otherwise of the sum of the deflections in opposite directions is apparently a point of some theoretical significance, as will be further noticed when the analogous phenomena in other localities come to be discussed.

As we find the same general forms of the two portions of the disturbance-diurnal variation, which have been thus derived from the Kew photograms, reproduced in other localities in the separated portions of the easterly and westerly deflections (with only such slight variations as may well be supposed to be due to accidental or subordinate causes), it may be desirable to examine somewhat more closely what may be viewed as the characteristic differences of the deflections in the two directions. The easterly deflection is represented, as we have already seen, in Plate XIII. fig. 1: it is distinguished by its approximately conical form and single maximum, and by the small and nearly equable amount of variation during the ten or eleven hours when the ratios are least. Its general form thus bears a striking resemblance to the diurnal curve of the solar-diurnal variation (as obtained after the careful separation and omission of the casual and transitory changes); but the two phenomena differ from each other in the important circumstance, that in the solar-diurnal variation the solar hours corresponding to its different features are *the same* in all meridians in the extra-tropical parts of the same hemisphere, whilst in the portion of the disturbance-diurnal variation which is now under notice, the solar hours corresponding to its different features *vary*, apparently without limit, in different meridians. This is a distinction which may well be supposed to indicate a difference in the *mode* of causation, although it would not justify an inference that the sun may not be the originating cause in both cases.

The westerly deflections at Kew, represented in Plate XIII. fig. 2, have a decided double maximum, with an intervening interval of about eight or nine hours. The analogous form in other localities has the double maximum sometimes more and sometimes less decidedly marked. The interval intervening between the maxima is usually of about the same duration at stations in the northern hemisphere; at some stations in the southern hemisphere it is apparently somewhat longer.

The conical form and single maximum which characterize the *easterly* deflections at Kew belong also to the easterly deflections in all localities in North America where the laws of the disturbances have been investigated. But when we view the phenomena at Nertschinsk and Pekin, which are the only two localities in Northern Asia for which the investigation has yet been made, we find, on the contrary, that the conical form and single maximum characterize the *westerly* deflections, whilst the easterly have the double maximum. Further, we find that at the two Asiatic stations the aggregate values of the *westerly* deflections decidedly predominate, whilst in America the *easterly* deflections are no less decidedly predominant; and at Kew, which we may regard as an intermediate locality, the amount of deflection in the two directions may be said to be balanced, there being in some years a slight preponderance of westerly, and in other years of easterly deflection.

There is another circumstance which seems to connect, in what may prove even a more instructive relation, the westerly deflections in Northern Asia with the easterly in other parts of the northern hemisphere. I refer here to an approximate accordance in *absolute time* which appears in the most marked features of the diurnal curve at the widely separated localities of Pekin, Nertschinsk, Kew, and Toronto, at each and all of which the curves as they are presented in Plate XIII. figs. 1, 4, 5, and 6 are the mean result of several years of hourly observation*. These localities appear to be particularly well suited for a comparison of this nature, being not very dissimilar in geographical latitude, whilst they include a difference in longitude of no less than 195°. If we select the epoch of the maximum deflection (or the apex of the curve) as the most marked feature, the comparison would stand nearly as follows; commencing with the most easterly, and proceeding in succession from east to west:—

* The figures 1, 4, 5, and 6 in Plate XIII., representing respectively the Easterly deflections at Kew and Toronto and the Westerly at Nertschinsk and Pekin, are delineated from the following formulæ, in which a, expressed in degrees 15 to the hour, is reckoned from the mean noon at the station:—

Kew . . .	$1+0{\cdot}98\,(\sin a+280^{\circ}\,22')-0{\cdot}417\,(\sin 2a+286^{\circ}\,29')$:
Toronto . .	$1+1{\cdot}05\,(\sin a+285\;58)-0{\cdot}332\,(\sin 2a+334\;07)$:
Nertschinsk .	$1-0{\cdot}94\,(\sin a+309\;02)-0{\cdot}238\,(\sin 2a+\;13\;11)$:
Pekin . . .	$1-0{\cdot}76\,(\sin a+289\;12)-0{\cdot}200\,(\sin 2a+\;1\;42)$.

Assuming that the formulæ represent correctly the ratios at the several hours, the observed values are in very tolerable accord with them; at Kew and Nertschinsk they are the most so; at Kew the probable error of a single hourly ratio is $\pm 0{\cdot}056$, at Nertschinsk $\pm 0{\cdot}062$.

Deflections.	Localities.	Latitudes.	Longitudes.	Approximate	
				Local solar Hour.	Absolute Hour at Kew.
		° ′	° ′ h		
Westerly......	Pekin	39 54 N.	116 6 E. = 7·8	22	14
	Nertschinsk......	51 19 N.	114 9 E. = 7·7	21	13
Easterly	Kew..............	51 29 N.	0 = 0·0	11	11
	Toronto	43 40 N.	79 0 W. = 5·3	10	15

It must be remembered that the time of the occurrence of the apex (or maximum of deflection) scarcely admits of very *precise* determination; and further, that assuming for the disturbing impulse a common origin at any other point of the terrestrial surface than at the geographical pole, and an equable but appreciable velocity of propagation, the difference of the geographical meridians would not be the sole consideration in deducing the absolute epoch from the local hours at different stations.

Could we thus identify the westerly deflections in Asia with the easterly in Europe and America, we should have a confirmation on a very extended scale of M. GAUSS's conclusion derived from the comparison of synchronous disturbances at stations remote from each other, viz. that "the synchronous disturbances of the same element not only differ widely in amount, but occasionally appear to be even *reversed* in direction."

It may be that this may prove the first step in the inductive inquiry which may lead eventually to a complete understanding of the systematic distinction which we find in comparing the solar-diurnal with the disturbance-diurnal variations,—by referring the first to causes which, within the sphere of their operation, produce the same phenomena at the same solar hours; and the second to effects originating (as far as the terrestrial surface is concerned) in special localities from whence they are propagated, and admitting of classification by means of the absolute hours to which they approximately correspond. For a conclusion of such moment, however, much preliminary investigation is still required, for which materials either do not yet exist, or have not yet been submitted to the necessary processes of examination. It seems especially important that the laws of the disturbances, and of their respective easterly and westerly deflections, should be known at a station or stations intermediate between Nertschinsk and Kew.

The propriety of making the easterly and the westerly deflections the subjects of distinct investigation will be still more apparent by reverting to Plate XIII. fig. 3, and remembering that the areas containing respectively the ordinates above and below the normal line are subject at different stations to horizontal displacements, each independent of the other; and thus that at some stations the opposite deflections may have a tendency to mask each other's influence in the resultant mean deflection (*i. e.* in the *excess* of easterly over westerly, or of westerly over easterly deflection). It happens at Kew that the large disturbances in opposite directions take place at opposite hours of the twenty-four, and that they thus record themselves in great measure independently of each other; but experience has already shown that there are stations where large disturbances show themselves in both directions, on different days, at the same hours; and such deflections would of course tend to neutralize each other in the resultant mean, thus masking the operation of the general causes whose laws we desire to learn. This inconvenience is in great measure remedied by the method of analysis which has been adopted, whereby the deflections are exhibited separately as well as in their com-

§ 4. TABLE IV.—Kew, Diurnal Inequality of the Declination from January 1, 1858 to December 31, 1862.

Months.	Astronomical Hours. 0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
January	w. 3·67	w. 4·19	w. 3·95	w. 2·74	w. 1·75	w. 1·05	w. 0·84	E. 0·10	E. 1·21	E. 1·80	E. 2·63	E. 2·86	E. 2·26	E. 1·87	E. 1·53	E. 1·31	E. 1·08	E. 0·86	E. 0·70	E. 0·56	E. 0·93	E. 1·10	w. 0·33	w. 2·23
February	w. 4·47	w. 5·83	w. 5·72	w. 4·51	w. 2·88	w. 1·99	w. 0·77	E. 0·17	E. 1·46	E. 2·33	E. 2·65	E. 2·92	E. 2·75	E. 2·12	E. 1·86	E. 1·77	E. 1·42	E. 1·34	E. 1·38	E. 1·52	E. 2·06	E. 2·10	E. 0·52	w. 2·14
March	w. 6·57	w. 8·07	w. 7·49	w. 6·04	w. 3·74	w. 1·35	E. 0·04	E. 0·91	E. 1·77	E. 1·77	E. 2·52	E. 2·41	E. 2·65	E. 2·42	E. 2·26	E. 2·14	E. 2·37	E. 2·25	E. 2·21	E. 2·73	E. 3·98	E. 3·42	E. 0·79	w. 3·46
April	w. 6·91	w. 8·77	w. 8·29	w. 6·16	w. 4·27	w. 1·84	w. 0·45	E. 0·91	E. 1·17	E. 1·25	E. 2·06	E. 2·57	E. 2·54	E. 2·20	E. 2·25	E. 2·21	E. 2·29	E. 2·35	E. 3·25	E. 4·43	E. 5·43	E. 4·12	E. 1·01	w. 3·28
May	w. 5·90	w. 6·81	w. 6·34	w. 4·95	w. 3·31	w. 1·67	w. 0·26	E. 0·42	E. 0·57	E. 0·60	E. 0·82	E. 1·25	E. 1·30	E. 1·11	E. 1·27	E. 2·05	E. 2·39	E. 3·31	E. 4·17	E. 4·88	E. 4·78	E. 3·23	E. 0·32	w. 3·20
June	w. 5·89	w. 7·15	w. 7·23	w. 6·06	w. 4·33	w. 2·38	w. 1·03	E. 0·02	E. 0·25	E. 0·44	E. 0·86	E. 0·87	E. 0·98	E. 1·27	E. 1·99	E. 2·25	E. 2·90	E. 4·42	E. 4·96	E. 5·64	E. 5·15	E. 3·85	E. 0·90	w. 2·87
July	w. 5·65	w. 7·32	w. 7·31	w. 6 07	w. 4·33	w. 2·58	w. 1·11	w. 0·35	E. 0·20	E. 0·24	E. 0·74	E. 1·19	E. 2·02	E. 1·99	E. 1·96	E. 2·08	E. 2·78	E. 4·37	E. 5·14	E. 5·27	E. 4·78	E. 3·23	E. 1·05	w. 2·45
August	w. 6·88	w. 8·32	w. 7·76	w. 5·59	w. 3·14	w. 0·63	E. 0·50	E. 1·03	E. 0·78	E. 1·04	E. 1·47	E. 1·72	E. 1·93	E. 1·89	E. 2·36	E. 2·53	E. 2·91	E. 3·42	E. 4·09	E. 5·00	E. 4·43	E. 2·30	w. 0·96	w. 4·17
September	w. 7·25	w. 8·26	w. 7·08	w. 5·04	w. 2·62	w. 0·80	E. 0·69	E. 1·16	E. 1·49	E. 2·05	E. 3·05	E. 2·42	E. 2·04	E. 2·22	E. 2·20	E. 2·59	E. 2·75	E. 2·26	E. 2·52	E. 3·50	E. 3·86	E. 2·15	w. 1·06	w. 4·88
October	w. 6·50	w. 7·40	w. 6·76	w. 4·73	w. 2·53	w. 1·21	w. 0·38	E. 0·90	E. 2·01	E. 3·14	E. 3·78	E. 3·74	E. 3·29	E. 2·36	E. 2·32	E. 2·05	E. 1·62	E. 0·69	E. 0·98	E. 1·67	E. 2·70	E. 2·30	w. 0·12	w. 3·86
November	w. 4·62	w. 5·11	w. 4·73	w. 3·62	w. 1·89	w. 1·14	w. 0·17	E. 0·75	E. 1·76	E. 2·65	E. 2·35	E. 2·78	E. 2·67	E. 1·81	E. 1·34	E. 1·24	E. 1·14	E. 1·00	E. 0·98	E. 0·89	E. 1·26	E. 1·45	w. 0·10	w. 2·73
December	w. 3·52	w. 4·06	w. 3·95	w. 2·94	w. 1·67	w. 0·94	w. 0·76	E. 0·29	E. 1·86	E. 2·33	E. 3·21	E. 2·91	E. 2·79	E. 2·13	E. 1·92	E. 0·92	E. 0·54	E. 0·25	E. 0·21	E. 0·20	E. 0·40	E. 0·63	w. 0·51	w. 2·15
Semiannual Means … Apr. to Sept.	w. 6·41	w. 7·77	w. 7·34	w. 5·65	w. 3·67	w. 1·65	w. 0·28	E. 0·53	E. 0·74	E. 0·94	E. 1·50	E. 1·67	E. 1·80	E. 1·78	E. 2·01	E. 2·29	E. 2·67	E. 3·36	E. 4·02	E. 4·79	E. 4·74	E. 3·15	E. 0·21	w. 3·48
Oct. to Mar.	w. 4·89	w. 5·78	w. 5·43	w. 4·10	w. 2·41	w. 1·28	w. 0·48	E. 0·52	E. 1·68	E. 2·34	E. 2·86	E. 2·94	E. 2·74	E. 2·12	E. 1·87	E. 1·57	E. 1·36	E. 1·06	E. 1·08	E. 1·26	E. 1·89	E. 1·83	E. 0·04	w. 2·76
Annual Means	w. 5·65	w. 6·77	w. 6·38	w. 4·87	w. 3·04	w. 1·46	w. 0·38	E. 0·53	E. 1·21	E. 1·64	E. 2·18	E. 2·30	E. 2·27	E. 1·95	E. 1·94	E. 1·93	E. 2·02	E. 2·21	E. 2·55	E. 3·02	E. 3·31	E. 2·49	E. 0·13	w. 3·12

§ 4. TABLE V.—Kew, Solar-diurnal Variation of the Declination from January 1, 1858 to December 31, 1862.

Months.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
January	w. 3·10	w. 3·78	w. 3·50	w. 2·12	w. 1·32	w. 0·89	w. 0·48	E. 0·09	E. 0·92	E. 1·40	E. 1·68	E. 1·66	E. 1·48	E. 1·13	E. 1·01	E. 0·66	E. 0·89	E. 1·11	E. 1·09	E. 1·21	E. 1·47	E. 1·25	w. 0·10	w. 1·83
February	w. 3·65	w. 4·72	w. 5·07	w. 3·78	w. 2·30	w. 1·35	w. 0·76	w. 0·14	E. 0·68	E. 1·22	E. 1·90	E. 1·76	E. 1·69	E. 1·58	E. 1·23	E. 1·17	E. 1·21	E. 1·56	E. 1·72	E. 1·79	E. 2·32	E. 2·48	E. 1·09	w. 1·70
March	w. 5·87	w. 7·24	w. 6·81	w. 5·13	w. 2·94	w. 1·11	w. 0·22	E. 0·47	E. 0·80	E. 1·36	E. 1·66	E. 1·76	E. 1·74	E. 1·34	E. 1·49	E. 1·46	E. 1·74	E. 2·41	E. 2·48	E. 3·39	E. 4·43	E. 4·01	E. 1·41	w. 2·66
April	w. 6·62	w. 8·44	w. 7·87	w. 5·73	w. 3·34	w. 1·43	w. 0·12	E. 0·45	E. 0·81	E. 0·95	E. 1·00	E. 1·33	E. 1·21	E. 1·22	E. 1·53	E. 1·79	E. 2·07	E. 2·47	E. 3·39	E. 5·26	E. 6·39	E. 4·86	E. 1·60	w. 2·79
May	w. 5·79	w. 6·63	w. 6·04	w. 4·61	w. 2·91	w. 1·74	w. 0·44	E. 0·31	E. 0·26	E. 0·20	E. 0·32	E. 0·62	E. 0·72	E. 0·85	E. 1·09	E. 1·68	E. 2·30	E. 3·52	E. 5·00	E. 5·36	E. 5·12	E. 5·37	E. 0·48	w. 2·94
June	w. 5·66	w. 6·86	w. 6·83	w. 5·86	w. 4·17	w. 2·30	w. 0·85	w. 0·12	w. 0·03	E. 0·15	E. 0·17	E. 0·49	E. 0·61	E. 0·96	E. 1·41	E. 1·98	E. 2·94	E. 4·66	E. 5·75	E. 6·16	E. 5·37	E. 3·90	E. 0·80	w. 2·64
July	w. 5·50	w. 6·96	w. 6·77	w. 5·45	w. 3·96	w. 2·14	w. 1·10	w. 0·58	w. 0·26	E. 0·02	E. 0·19	E. 0·47	E. 1·36	E. 1·12	E. 1·48	E. 1·68	E. 2·81	E. 4·23	E. 5·38	E. 5·73	E. 5·23	E. 3·69	E. 0·95	w. 1·94
August	w. 6·94	w. 8·21	w. 7·66	w. 5·40	w. 2·97	w. 0·68	E. 0·46	E. 0·67	E. 0·87	E. 0·76	E. 1·18	E. 1·09	E. 1·57	E. 1·63	E. 1·84	E. 2·29	E. 2·83	E. 3·92	E. 4·81	E. 5·37	E. 4·91	E. 2·72	w. 0·65	w. 4·24
September	w. 6·38	w. 7·43	w. 6·45	w. 4·22	w. 2·13	w. 0·53	E. 0·16	E. 0·60	E. 1·00	E. 1·05	E. 1·34	E. 1·43	E. 1·66	E. 1·60	E. 2·01	E. 2·18	E. 2·55	E. 2·77	E. 3·22	E. 3·96	E. 4·18	E. 2·88	w. 0·89	w. 4·54
October	w. 5·51	w. 6·24	w. 5·61	w. 3·79	w. 2·11	w. 0·93	w. 0·48	E. 0·20	E. 0·91	E. 1·48	E. 1·85	E. 2·03	E. 1·92	E. 1·54	E. 1·41	E. 1·64	E. 1·47	E. 1·58	E. 1·89	E. 2·46	E. 3·56	E. 3·33	E. 0·60	w. 3·14
November	w. 3·92	w. 4·41	w. 3·90	w. 2·96	w. 1·82	w. 1·20	w. 0·26	E. 0·37	E. 1·24	E. 1·81	E. 1·92	E. 1·95	E. 1·70	E. 1·28	E. 1·14	E. 0·96	E. 1·02	E. 1·12	E. 1·22	E. 1·42	E. 1·65	E. 1·69	E. 0·27	w. 2·18
December	w. 2·66	w. 3·39	w. 3·15	w. 2·35	w. 1·23	w. 0·80	w. 0·55	E. 0·27	E. 0·98	E. 1·42	E. 1·61	E. 1·89	E. 1·49	E. 1·17	E. 1·07	E. 0·68	E. 0·69	E. 0·78	E. 0·84	E. 0·84	E. 0·93	E. 1·18	w. 0·03	w. 1·59
Semiannual Means … Apr. to Sept.	w. 6·15	w. 7·42	w. 6·94	w. 5·21	w. 3·25	w. 1·47	w. 0·32	E. 0·22	E. 0·44	E. 0·52	E. 0·70	E. 0·90	E. 1·19	E. 1·23	E. 1·56	E. 1·93	E. 2·58	E. 3·60	E. 4·59	E. 5·31	E. 5·20	E. 3·57	E. 0·38	w. 3·18
Oct. to Mar.	w. 4·12	w. 4·96	w. 4·67	w. 3·35	w. 1·95	w. 1·05	w. 0·46	E. 0·21	E. 0·92	E. 1·45	E. 1·77	E. 1·84	E. 1·67	E. 1·34	E. 1·22	E. 1·09	E. 1·17	E. 1·43	E. 1·54	E. 1·85	E. 2·40	E. 2·32	E. 0·54	w. 2·18
Annual Means	w. 5·13	w. 6·19	w. 5·81	w. 4·28	w. 2·60	w. 1·26	w. 0·39	E. 0·22	E. 0·68	E. 0·99	E. 1·24	E. 1·37	E. 1·43	E. 1·29	E. 1·39	E. 1·51	E. 1·88	E. 2·51	E. 3·07	E. 3·58	E. 3·80	E. 2·95	E. 0·46	w. 2·68

§ 4. *Diurnal Inequality and Solar-diurnal Variation.* Tables IV. and V. p. 284.

The diurnal inequality (which is by no means identical with the solar-diurnal variation as has been sometimes assumed) has in fact two principal constituents, viz. the solar-diurnal variation itself, and the disturbance-diurnal variation. It is obtained for each month by taking the differences between the mean positions of the magnet at each of the twenty-four hours and the mean position in the month (the latter being the mean of all the days and all the hours in the month). It is the first step in the process of obtaining in a separate form the several periodical variations from the combination in which they appear in the photographic records, and includes all the positions tabulated from the records, without the exception of any. Table IV. (page 284) exhibits the diurnal inequality in each month, on the average of the five years, from January 1858 to December 1862 inclusive.

The *solar-diurnal variation*, shown in Table V. (page 284), is obtained by a similar process from the hourly positions in the same period, exclusive of those which differed 3′·3 or more from their respective normals of the same month and hour—the normals being the hourly means in each month after the exclusion of all the disturbed positions. By this process the effects of the "casual and transitory changes" become in a very great degree "eliminated;" and we obtain a measure of the solar-diurnal variation which is only very slightly affected by the small portion of the disturbance-diurnal variation which remains after the separation and omission of the disturbances equalling or exceeding 3′·3 from their respective normals.

Plate XIV. exhibits the solar-diurnal variation at Kew (fig. 2), in comparison with the same at Toronto (fig. 1), Nertschinsk (fig. 3), Pekin (fig. 4), St. Helena (fig. 5), Cape of Good Hope (fig. 6), and Hobarton (fig. 7). Figs. 1, 2, 3, & 4 show the march of the solar-diurnal variation at stations in the middle latitudes of the northern hemisphere, fig. 5 in the equatorial region, and figs. 6 & 7 in the middle latitudes of the southern hemisphere.

In figs. 3 & 4, compared with 1 & 2, we see the gradual flattening of the curve as the magnetic equatorial region is approached. In fig. 5 (geographical latitude of St. Helena, 15° 55′ S.) we perceive the incipient reversal of the diurnal march; whilst in figs. 6 & 7, and particularly in fig. 7 (Hobarton, where the dip is more than 70°, and the total force 13·6 in British units), we see the reversal completed, and the full development of the characteristic features appertaining to the southern hemisphere.

It is seen in the Plate that at the stations in the northern hemisphere *generally*, the north end of the magnet passes rapidly from its extreme eastern limit (about 8 A.M., or nearer 9 A.M. at Pekin) to its extreme western limit (about 1 P.M., or rather later at Pekin), the motion being more rapid between 10 and 11 A.M. than at any other hour of the twenty-four; and that during the remaining nineteen hours the north end returns to its eastern limit by a progression tolerably rapid from about 2 to 7 P.M., scarcely sensible from 7 P.M. to 3 or 4 A.M., and again more rapid until 8 A.M. The turning hours are approximately the same at the four stations, having apparently no relation whatsoever to the varied circumstances of sea or land in the vicinity. Taking Hobarton as the best representative which we possess of the southern hemisphere, we see in the Plate the analogy of its phenomena to those of the northern stations. We have the same rapid movement from one extreme to the other, occupying the same portion of time, viz. five hours, and the return occupying the remaining nineteen hours; but the *directions* of the two movements are inverted, the 5-hour movement being in the southern hemisphere from West to East, and the slower, or 19-hour return, being from East to West. The epochs are nearly but not quite the same, being apparently about an hour later in the southern hemisphere.

In the curve of the Cape of Good Hope (fig. 6) we have the same general features as at Hobarton, but with a more flattened curve, indicating a nearer proximity to the equatorial region.

If, now, we permit ourselves to depart from the general custom of expressing the variations of the Declination in the northern as well as in the southern hemisphere by the directions of the *north* end of the magnet, and to speak of the solar-diurnal variation in the southern portion of the magnetic sphere as a movement of the *south* end of the magnet (using the same phraseology as before for the northern hemisphere), we appear to gain a greater simplicity in describing the general characteristics of the phenomena in the two hemispheres. In such case the Hobarton curve is reversed,—the westerly deflections of the north end becoming easterly deflections of the south end, and *vice versâ*,—the inflections of the curve of the annual solar-diurnal variation at Hobarton then appear altogether as the counterparts of those at Kew and Toronto (excepting in the one feature peculiar to the southern hemisphere, of the turning hours being about an hour later than in the northern hemisphere). This correspondence is shown in plate 1 of the first volume of the Hobarton Observations, published in 1850, and in fig. 7 of Plate XIII. accompanying this paper. In like manner the annual curve at the Cape of Good Hope, when reversed, becomes the counterpart of those at Pekin and Nertschinsk; whilst at St. Helena, so near the dividing line between the hemispheres, the *annual* solar-diurnal variation has almost entirely disappeared, the small remaining inflections, seen in Plate XIV. fig. 5, being due, for the most part at least, to the *semiannual inequality*, which is the subject of the next section (§ 5).

§ 5. *Semiannual Inequality of the Solar-diurnal Variation.*

The solar-diurnal variation exhibited in Table V. is seen by the semiannual means, April to September, and October to March, to be subject to a systematic difference in the two halves of the year, coinciding, or nearly so, with the sun's position on opposite sides of the equator. In Plate XV. fig. 1, the curve corresponding to the mean solar-diurnal variation at Toronto, from April to September, is represented by the black line, and the curve corresponding to October to March by the red line. The systematic character of this half-yearly variation is shown by the corresponding curves similarly represented by black and by red lines for Kew (fig. 2), Nertschinsk (fig. 3), Pekin (fig. 4), St. Helena (fig. 5), Cape of Good Hope (fig. 6), and Hobarton (fig. 7). The scale is the same in all the figures. It will be seen that at all these stations the curve from April to September is on the upper or East side of the October to March curve, from about midnight, or a little later, to about 9 or 10 A.M. in the northern hemisphere, and about 10 or 11 A.M. in the southern hemisphere; and on the lower or West side of the October to March curve during the remainder of the twenty-four hours. On successively considering the figures in Plates XIV. and XV., we perceive that the *annual* curves progressively lessen as the equatorial region is approached, reappearing in a reversed direction in the southern hemisphere, and gradually increasing in magnitude so as to have at Hobarton, in the middle latitudes of the southern hemisphere, nearly the same magnitude as at Toronto and Kew in the northern hemisphere; but that through all these changes both of magnitude and direction in the annual curves, the *semiannual variation* (or the difference between the two semiannual curves in each case) remains persistent throughout; the same in direction at the same hours, and the amount approximately the same in all parts of the globe. Thus in the equatorial region, where the *annual* inflection almost or entirely disappears, the semiannual portion still subsists, and presents in each of the half years, separately viewed, the phenomenon of a solar-diurnal variation. This is approximately exemplified at St. Helena, which, however, is a little on the southern side of the magnetically dividing line between the hemispheres. As the southern magnetic latitude increases, the annual solar-diurnal variation, as shown in Plate XIV., progresively increases in magnitude, but in a reversed direction from those of the analogous phenomena in the north, as has already been noticed. Thus it will be seen that the two portions, viz. the annual and the semiannual, both of which we recognize to be due to the sun's action, inasmuch as they follow the order of the solar hours, evince apparently a dissimilarity in the mode of operation of the producing cause; in the one class of effects, viz. in the annual, the north end of the magnet is deflected in opposite directions in the two hemispheres, the deflection disappearing altogether at the magnetic equator; whilst in the other class, viz. the semiannual difference, no such inversion takes place, and the deflections are approximately the same in amount and direction in the equatorial as in all other parts of the terrestrial surface*.

* The general custom of speaking always of the north end of the Declination magnet is here followed: if this were modified as suggested in page 286, the reasoning upon the characteristic distinction between the two phenomena would, it is obvious, remain essentially the same.

§ 6. *Lunar-diurnal Variation.*

Table VI. contains the lunar-diurnal variation on the mean of each year, from 1858 to 1862 inclusive, and a general average taken for the five years.

TABLE VI.—Lunar-diurnal Variation in Seconds of Arc.

Lunar Hours.	Years ending December 31,					Means.	Lunar Hours.
	1858.	1859.	1860.	1861.	1862.		
0	W. 6″·0	E. 0″·6	W. 12″·6	W. 5″·4	W. 7″·8	W. 6″·2	0
1	W. 14·4	W. 7·2	W. 12·6	W. 6·0	W. 6·6	W. 9·6	1
2	W. 10·8	W. 9·6	W. 5·4	W. 7·2	W. 9·0	W. 8·4	2
3	W. 7·8	W. 4·2	W. 3·0	E. 2·4	E. 2·4	W. 2·0	3
4	W. 3·0	W. 4·2	W. 2·4	E. 4·2	E. 2·4	W. 0·6	4
5	E. 5·4	W. 6·6	E. 5·4	E. 6·6	E. 9·0	E. 4·0	5
6	E. 12·0	E. 1·2	E. 3·0	E. 14·4	E. 14·4	E. 9·0	6
7	E. 9·0	E. 4·2	E. 9·6	E. 16·2	E. 17·4	E. 11·3	7
8	E. 9·6	E. 8·4	E. 7·8	E. 6·6	E. 14·4	E. 9·6	8
9	E. 7·2	E. 6·6	W. 0·9	W. 1·2	E. 12·0	E. 4·7	9
10	E. 3·0	E. 7·2	W. 1·8	W. 6·6	W. 2·4	W. 0·1	10
11	W. 3·6	W. 1·2	W. 4·2	W. 10·8	W. 7·8	W. 5·5	11
12	W. 4·8	W. 9·0	W. 18·0	W. 8·4	W. 7·8	W. 9·6	12
13	W. 3·0	W. 13·2	W. 15·0	W. 13·2	W. 12·0	W. 11·3	13
14	W. 3·0	W. 8·4	W. 9·6	W. 10·8	W. 15·6	W. 9·5	14
15	W. 7·2	W. 3·6	E. 4·2	W. 8·4	W. 12·0	W. 5·4	15
16	E. 3·0	E. 3·6	E. 7·8	W. 6·6	W. 10·8	W. 0·6	16
17	E. 7·8	E. 9·6	E. 13·8	W. 2·4	W. 4·2	E. 5·1	17
18	E. 7·8	E. 14·4	E. 17·4	E. 3·0	0·0	E. 8·5	18
19	E. 4·8	E. 18·0	E. 15·0	E. 9·0	E. 2·4	E. 9·8	19
20	E. 3·0	E. 12·6	E. 6·0	E. 10·2	E. 12·0	E. 8·8	20
21	W. 2·4	F. 18·6	E. 2·4	E. 10·8	E. 7·8	E. 7·4	21
22	W. 7·8	E. 9·6	W. 3·0	E. 7·8	E. 5·4	E. 2·4	22
23	W. 6·0	E. 5·4	W. 3·6	E. 0·6	W. 4·2	W. 1·6	23

We see in this Table a form of diurnal variation systematically and essentially different from that of the solar-diurnal variation. This characteristic form, which is shown alike by each of the three magnetic elements in all parts of the globe for which the investigation has been made, consists in a double fluctuation taking place in every twenty-four hours, with two extreme deflections in each direction,—the zero-line, or line in which the moon's action produces no deflection, being passed through four times at nearly equal intervals of six lunar hours. At Kew the extreme westerly deflections occur at 1 and 13 hours, and the extreme easterly at 7 and 19 hours. The extremes at 7 and 13 hours appear to be somewhat larger than those at 1 and 19 hours (the two greater elongations being each 11″·3, and the lesser 9″·8 and 9″·6, on the average of the five years). This difference may have an important theoretical bearing if confirmed by the results in future years, and in other parts of the globe.

In considering the lunar-diurnal variation of the three elements in different parts of the globe, the division of the lunar day into four alternate and nearly equal deflections in opposite directions appears, as already stated, to be a general feature; but the *amount* of deflection (speaking of the declination) appears to diminish as the equator is approached, reincreasing in the southern hemisphere, and attaining at Hobarton nearly the same value as at Kew. The hours of extreme deflection are not the same at all stations: the north end of the magnet has its extreme westerly deflections at Kew (in the northern hemisphere), and its extreme easterly deflections at Hobarton (in the southern hemisphere) at the same hours, and *vice versâ*; there is a similar correspondence of hours in the opposite deflections of the same end of the magnet at Pekin in the northern, and at the Cape of Good Hope in the southern hemisphere; but the hours at Kew and Hobarton are different from those at Pekin and the Cape of Good Hope: however, results at more stations must be obtained before we can draw any certain inferences as to the systematic character and theoretical bearing of such differences. There are six stations where the lunar-diurnal variation of the declination has been computed by myself, viz. Toronto, Kew, Pekin, St. Helena, the Cape of Good Hope, and Hobarton: the results at these stations are published in the second volume of the Magnetical and Meteorological Observations at St. Helena, pp. cxlvi–cxlviii.

Results of the Magnetic Observations at the Kew Observatory, from 1857 *to* 1862 *inclusive.* No. II.

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§ 7. *Secular Change and Annual Variation of the Declination.*

It is desirable to advert briefly to the process by which these results are elaborated from the photographic records. The twenty-four equidistant hourly positions having been tabulated from the photograms, are written in monthly tables, having the days of the month arranged vertically, and the twenty-four hourly positions in each day horizontally. The hourly positions in each *vertical* line are then examined, and those in which the difference from the *normal* of the same hour equals or exceeds 0·15 in. in the photographic scale, or 3'·3 in arc, are marked as disturbed positions, and are put aside for separate consideration. This process is repeated until the *final normals* are the means of the positions in each vertical line after the omission of all those which differ from them by an amount equal to 3'·3 or upwards. A mean is then taken of the positions which remain in each *horizontal* line after the exclusion of the disturbed positions, omitting only days on which the disturbed hours equalled or exceeded six in number, or one-fourth of the whole number of the tabulated positions. The means thus obtained are considered to show the mean declination at the observatory for each day. The daily values are then collected in weekly groups, of which there are consequently fifty-two in each year, and mean *weekly* values are taken, such as are exhibited in columns 2 to 6 of Table VII. (page 292), for the five years commencing in January 1858 and ending in December 1862. The mean of the weekly values in each year corresponds to the mean declination on the 1st of July of that year; and these mean values are placed at the foot of each annual column in Table VII., whilst the means of the values in the several horizontal lines, seen in column 7, show the weekly values *in a mean or typical year*, derived from the hourly positions in the five years, and corresponding chronologically, in the case of Table VII., to the successive weeks in the year 1860. The mean declination of the whole Table, corresponding to July 1, 1860, is seen at the foot of column 7; it is 21° 39' 18''·1 W., and is based upon 260 weekly values, or upon 6240 hourly positions (diminished by the positions omitted, as above stated, on account of disturbance). The differences from this mean value seen in the several weekly means in the typical year (column 7) are ascribable (partly, of course, to casual errors, but) chiefly, as will be seen, to the effects of systematic variations. The presence of one of these, known commonly by the name of *secular change* (inasmuch as its period is of long and yet undetermined duration), is conspicuous, and its mean amount during the five years embraced by Table VII. becomes known by comparing with each other the mean declination in each successive year, placed at the foot of the respective columns. Here we find that

							′	″
From July 1858	to July 1859,	the West Declination	decreased				6	45·9
„ 1859	„ 1860,	„	„	„			7	31·0
„ 1860	„ 1861,	„	„	„			8	15·7
„ 1861	„ 1862,	„	„	„			8	03·6

whence we have 7′ 39″ as the mean annual amount of decrease in the West Declination at Kew in the five years, corresponding, (as a precise deduction,) to July 1, 1860, the middle epoch of the mean or typical year.

It is obvious that if we apply a proportional part of this secular change to the several weekly values in the mean or typical year, we obtain fifty-two corrected values of the declination, each of which, if there were no other systematic variation than that of the secular change, should agree with 21° 39′ 18″·1; or should show only such small and unsystematic differences as might reasonably be ascribed to casual errors. The character of the differences actually presented sufficed to show that something more was involved, not explicable by the small variation in the rate of secular change itself which appeared to be pointed out by the Table. Small, however, as was this last-named variation, it seemed proper that it should be taken into account before we should be prepared to take a final view of the results.

It is well known that a few years ago the secular change in London was a small annual *increase* of west declination, and that from causes yet but imperfectly understood, this increase first diminished and then ceased, giving place to a change in the opposite direction, at first slow, but becoming progressively more rapid; so that at present the rate of decrease is very nearly if not quite equal to the rate of increase which existed at the time first spoken of. Thus the secular change at Kew (which we may regard as the same as at London) appears to have been somewhat less in 1858 and 1859 than in 1861 and 1862, and therefore, inferentially, less in the earlier than in the later portions of each year; so that we may possibly obtain more exact values of the corrections to be applied for secular change in the different parts of the mean or typical year by substituting for a *mean* value of $\frac{7' \, 39''}{52} = 8''.83$, weekly corrections commencing with 8″·5 and progressively increasing to 9″·1. These corrections are shown in column 8, and produce the corrected values in column 9. The differences of the values in column 9, from 21° 39′ 18″·1, have been placed in column 10, to which I desire to direct attention. The mere aspect of the + and − signs in this column appears to point to a semiannual inequality coinciding very nearly with the sun's position in respect to the equator. If we arrange the differences in two categories, one including the twenty-six weeks from March 26 to September 23, and the other the twenty-six weeks from September 24 to March 25 (which is the division of weeks most nearly according with the equinoxes), the almost constant prevalence of the − sign in the first, and of the + sign in the second category, indicates with a very high degree of probability an *annual variation*, whereby the north end of the magnet points more towards the east when the sun is north, and towards the west when the sun is south of the equator; and we obtain in the first category (corresponding to the interval between March 26 and September 23) an average weekly diminution of 28″·95 of West Declination, and in the second category (corresponding to the interval between September 24 and March 25) an average weekly augmentation of 29″·90 of West Declination,—making together an annual variation amounting to 58″·85.

TABLE VII.—Weekly Means of West Declination at Kew, from January 1, 1858 to December 31, 1862.

Period.	1858. 21°+	1859. 21°+	1860. 21°+	1861. 21°+	1862. 21°+	Means. 21°+	Corrections for secular change.	Mean weekly values corrected for secular change. 21°+	Differences of the several weekly corrected values from 21° 39′ 18″·1.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Jan. 4.	56′ 32″·6	52′ 30″·6	43′ 15″·2	35′ 00″·6	28′ 47″·7	43′ 13″·3	−3′ 41″·1	39′ 32″·2	+14″·1
11.	54 49·5	52 46·5	42 26·3	34 24·9	28 50·3	42 39·5	−3 32·6	39 06·9	−11·2
18.	55 23·8	52 42·5	42 44·8	33 43·9	28 37·1	42 38·4	−3 24·1	39 14·3	− 3·8
25.	55 56·9	52 35·9	42 17·0	34 22·3	28 33·1	42 45·0	−3 15·5	39 29·5	+11·4
Feb. 1.	57 11·0	52 30·6	42 14·4	34 51·4	27 24·4	42 50·4	−3 06·9	39 43·5	+25·4
8.	57 53·3	52 39·8	41 57·2	34 48·7	27 04·6	42 52·7	−2 58·4	39 54·3	+36·2
15.	58 34·3	51 54·9	41 46·6	35 00·6	26 56·6	42 50·6	−2 49·8	40 00·8	+42·7
22.	57 00·4	51 41·7	41 22·8	35 20·5	27 15·1	42 32·1	−2 41·2	39 50·9	+32·8
March 1.	56 32·6	51 08·6	41 04·3	35 32·3	26 44·7	42 12·5	−2 32·6	39 39·9	+21·8
8.	56 23·3	51 16·6	40 49·7	35 04·6	26 50·0	42 04·8	−2 23·9	39 40·9	+22·8
15.	56 53·8	51 41·7	41 54·5	34 55·3	27 07·2	42 30·5	−2 15·3	40 15·2	+57·1
22.	56 20·7	51 16·6	40 36·5	34 27·5	26 20·9	41 48·4	−2 06·7	39 41·7	+23·6
29.	56 19·4	51 25·8	40 51·1	33 36·0	26 07·7	41 40·0	−1 58·0	39 42·0	+23·9
April 5.	56 06·2	50 38·2	41 00·3	33 08·2	24 58·9	41 10·4	−1 49·3	39 21·1	+ 3·0
12.	54 40·2	49 58·6	41 17·5	33 45·2	24 47·0	40 53·7	−1 40·6	39 13·1	− 5·0
19.	55 11·9	49 54·5	40 44·5	34 03·8	25 10·9	41 01·1	−1 33·0	39 29·1	+11·0
26.	54 17·7	50 02·5	40 28·6	33 10·9	25 12·2	40 38·4	−1 23·3	39 15·1	− 3·0
May 3.	53 52·6	48 51·2	40 02·1	32 23·3	24 12·7	39 52·4	−1 14·6	38 37·8	−40·3
10.	54 03·2	47 11·9	40 35·2	32 23·3	24 06·1	39 39·9	−1 05·8	38 34·1	−44·0
17.	53 24·8	47 09·2	40 19·3	32 07·4	24 32·5	39 30·6	−0 57·1	38 33·5	−44·6
24.	53 57·9	47 17·2	40 51·1	31 59·5	23 23·7	39 29·9	−0 48·3	38 41·6	−36·5
31.	54 11·1	46 33·5	39 54·2	32 25·9	23 05·2	39 14·0	−0 39·6	38 34·4	−43·7
June 7.	53 55·3	46 07·1	39 48·9	31 37·0	22 57·3	38 53·1	−0 30·8	38 22·3	−55·8
14.	54 03·2	45 47·3	39 58·2	30 37·4	23 01·3	38 41·5	−0 22·0	38 19·5	−58·6
21.	54 52·1	45 22·1	40 03·5	31 10·5	22 08·3	38 43·3	−0 13·2	38 30·1	−48·0
28.	53 27·5	46 01·8	40 51·1	31 15·8	21 55·1	38 42·3	−0 04·4	38 37·9	−40·2
July 5.	53 08·9	44 46·4	38 11·1	30 29·5	21 52·5	37 41·7	+0 04·4	37 46·1	−92·0
12.	53 34·1	45 06·3	39 07·9	30 46·7	21 48·5	38 04·7	+0 13·2	38 17·9	−60·2
19.	53 15·6	44 57·0	39 05·3	30 30·8	21 20·8	37 49·9	+0 22·1	38 12·0	−66·1
26.	53 12·9	44 49·1	38 01·8	30 52·0	21 45·8	37 44·3	+0 31·0	38 15·3	−62·8
August 2.	52 39·8	45 01·0	37 27·4	31 06·5	22 00·4	37 39·0	+0 39·8	38 18·8	−59·3
9.	53 23·5	45 06·3	38 23·0	31 26·4	21 51·2	38 02·1	+0 48·7	38 50·8	−27·3
16.	54 09·8	46 08·5	38 20·3	31 51·5	21 34·0	38 24·8	+0 57·6	39 22·4	+47·3
23.	53 16·9	45 34·1	38 49·4	31 14·5	21 03·5	37 59·7	+1 06·6	39 06·3	−11·8
30.	52 18·7	45 30·1	39 22·5	30 34·8	21 39·2	37 53·1	+1 15·5	39 08·6	− 9·5
Sept. 6.	52 01·5	44 21·3	40 33·9	30 28·2	21 14·1	37 43·8	+1 24·4	39 08·2	− 9·9
13.	51 39·1	45 27·4	40 33·9	30 01·7	21 35·3	37 51·5	+1 33·4	39 24·9	+ 6·8
20.	52 43·9	44 28·0	40 20·7	30 28·2	21 22·1	37 52·6	+1 42·3	39 34·9	+16·8
27.	52 10·8	44 55·7	41 13·5	29 08·9	21 41·9	37 50·2	+1 51·3	39 41·5	+23·4
Oct. 4.	52 45·2	45 10·3	40 27·3	28 25·2	22 30·8	37 51·8	+2 00·3	39 52·1	+34·0
11.	53 14·3	44 53·0	40 15·4	28 51·7	22 14·9	37 53·9	+2 09·3	40 03·2	+45·1
18.	52 51·8	44 54·4	40 22·0	29 02·3	22 30·8	37 56·3	+2 18·3	40 14·6	+56·5
25.	52 30·6	44 21·3	40 35·2	29 07·6	22 44·0	37 51·7	+2 27·3	40 19·0	+62·9
Nov. 1.	52 41·2	44 47·8	39 15·9	28 35·8	21 47·2	37 25·6	+2 36·3	40 01·9	+43·8
8.	52 08·2	44 18·7	38 19·0	28 51·7	20 59·6	36 55·4	+2 45·4	39 40·8	+22·7
15.	52 46·5	44 18·7	36 45·1	28 23·9	21 34·0	36 45·6	+2 54·4	39 40·0	+21·9
22.	52 16·1	44 45·1	36 47·8	28 43·7	21 48·5	36 52·2	+3 03·5	39 55·7	+37·6
29.	52 26·6	45 53·0	36 59·6	28 45·1	21 23·4	36 53·5	+3 12·5	40 06·0	+47·9
Dec. 6.	52 57·1	45 03·7	36 26·6	28 56·9	20 39·8	36 48·8	+3 21·6	40 10·4	+52·3
13.	53 22·2	44 54·4	36 13·4	28 31·9	20 04·0	36 37·2	+3 30·7	40 07·9	+49·8
20.	52 49·1	44 06·8	35 50·9	28 37·1	19 37·6	36 12·3	+3 39·8	39 52·1	+34·0
27.	52 46·5	43 21·8	35 12·5	28 25·2	19 31·0	35 51·4	+3 49·0	39 40·4	+22·3
Annual Means	54 08·0	47 22·1	39 51·1	31 36·4	23 32·8	39 18·1			

We may compare with Table VII., and the conclusions derived from it, a corresponding Table (VIII. page 294) of the weekly means of the hourly observations of the Declination at the Hobarton Observatory, between October 1843 and September 1848, made by Captain KAYE, R.N., and his assistants in that establishment. The observations themselves are published in the second and third volumes of the Hobarton Observations, and have been treated for the present purpose precisely in the same way as those of the Kew Observatory, $2'{\cdot}13$ having been taken as the standard of a disturbance, instead of $3'{\cdot}3$ as at Kew, a somewhat lower standard being required at Hobarton to separate the same proportion of disturbed observations for the investigation of their laws, and being otherwise unobjectionable. The mean declination in the successive years is placed at the foot of columns 2, 3, 4, 5, and 6 of Table VIII., and from these we obtain the secular change in those years as follows:—

								′	″
From April	1844	to March	1845,	the East	Declination	increased		1	27·6
„	1845	„	1846,	„	„	„		2	02·2
„	1846	„	1847,	„	„	„		1	07·3
„	1847	„	1848,	„	„	„		0	55·8

Whence we have $1'\ 23''{\cdot}2$ as the mean annual increase of East Declination at Hobarton in the five years, corresponding precisely to the middle epoch of the mean or typical year, *i. e.* the beginning of April 1846, and which has for its mean declination $9°\ 56'\ 13''{\cdot}9$ E. Column 7 of Table VIII. contains the weekly means in the typical year, each on the average of the five years. Column 8 shows the corrections for secular change, being proportional parts of an annual change of $1'\ 23''{\cdot}2$. Column 9 contains the weekly means in column 7 corrected for secular change to the beginning of April 1846; and column 10 the differences in the values in column 9 from the mean declination $9°\ 56'\ 13''{\cdot}9$, derived directly from all the weekly means in the five years.

The aspect of the + and − signs in column 10 appears conclusive in respect to the existence at Hobarton of a semiannual inequality analogous to that which has been shown to exist at Kew. The direction of the inequality in the two semiannual periods is also the same in the two hemispheres, the north end of the magnet pointing more towards the east both at Kew and at Hobarton when the sun is north of the equator and to the west when the sun is south of the equator. If we regard the equinoxes as the approximate epochs of the semiannual change, we find in the weeks from April to September an average increase of east declination of $19''{\cdot}1$, and in the weeks from October to March an average decrease of east declination of $19''{\cdot}0$, making together an annual variation of $38''{\cdot}1$.

TABLE VIII.—Weekly Means of East Declination at Hobarton, from October 1, 1843 to September 30, 1848.

Period.	Years ending September 30, 1844. 9°+	1845. 9°+	1846. 9°+	1847. 9°+	1848. 9°+	Means. 9°+	Corrections for secular change.	Mean weekly values corrected for secular change. 9°+	Difference of the several weekly corrected values from 9° 56′ 13″·9.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Oct. 4.	51′ 57″·0	54′ 39″·6	55′ 25″·8	57′ 06″·6	58′ 09″·6	55′ 27″·7	+40″·8	56′ 08″·5	−05″·4
11.	51 57·6	53 56·4	55 48·0	57 16·8	58 09·0	55 25·6	+39·2	56 04·8	−09·1
18.	51 45·6	53 18·4	55 39·6	57 31·4	58 40·8	55 23·2	+37·6	56 00·8	−13·1
25.	51 46·2	53 37·6	55 42·0	57 15·2	57 34·2	55 11·0	+36·0	55 47·0	−26·9
Nov. 1.	52 05·4	53 23·4	55 39·0	57 22·8	58 22·2	55 22·6	+34·4	55 57·0	−16·9
8.	51 51·6	53 34·8	55 57·6	57 26·4	57 40·8	55 18·2	+32·8	55 51·0	−22·9
15.	51 46·8	53 00·0	55 51·6	57 17·4	57 40·2	55 07·2	+31·2	55 38·4	−35·5
22.	51 40·8	53 22·2	55 34·2	57 29·4	57 16·8	55 04·7	+29·6	55 33·8	−40·1
29.	51 52·2	53 08·4	55 01·2	57 06·3	58 24·0	55 06·4	+28·0	55 34·4	−39·5
Dec. 6.	52 06·8	53 11·4	56 02·4	57 01·2	57 46·8	55 13·7	+26·4	55 40·1	−33·8
13.	52 02·6	53 18·6	55 27·9	56 55·2	57 57·6	55 08·4	+24·8	55 33·2	−40·7
20.	52 04·8	53 46·8	55 22·2	56 52·8	57 35·7	55 08·5	+23·2	55 31·7	−42·2
27.	52 05·6	53 49·2	55 30·9	57 10·8	57 39·0	55 15·1	+21·6	55 36·7	−37·2
	1844.	1845.	1846.	1847.	1848.				
Jan. 3.	52 37·8	53 22·8	55 27·6	57 06·3	57 40·2	55 14·9	+20·0	55 34·9	−39·0
10.	52 55·2	54 01·2	55 32·4	56 48·0	57 48·0	55 25·0	+18·4	55 43·4	−30·5
17.	52 27·0	53 55·8	55 40·2	56 57·6	57 47·4	55 21·6	+16·8	55 38·4	−35·5
24.	52 34·2	53 42·6	55 45·6	57 25·5	57 51·6	55 27·9	+15·2	55 43·1	−30·8
31.	52 58·8	53 58·2	55 25·8	57 03·6	58 10·8	55 31·4	+13·6	55 45·0	−28·9
Feb. 7.	52 59·4	54 27·0	55 58·8	57 26·4	58 40·2	55 54·4	+12·0	56 06·4	−07·5
14.	52 55·8	54 19·8	56 12·0	57 13·2	58 05·4	55 45·2	+10·4	56 55·6	−18·3
21.	53 08·4	54 43·8	56 26·4	57 28·4	58 24·3	56 02·3	+ 8·8	56 11·1	−02·8
28.	52 59·4	54 39·6	56 25·2	57 45·6	58 27·6	56 03·5	+ 7·2	56 10·7	−03·2
Mar. 7.	53 55·8	54 31·8	56 21·0	58 03·0	59 03·0	56 22·9	+ 5·6	56 28·5	+14·6
14.	53 42·0	54 43·8	56 53·4	58 07·2	58 47·7	56 26·8	+ 4·0	56 30·8	+16·9
21.	53 42·0	55 07·2	56 42·0	57 57·8	59 30·3	56 35·9	+ 2·4	56 38·3	+24·4
28.	53 31·2	54 46·8	56 58·2	57 52·2	58 52·2	56 24·1	+ 0·8	56 24·9	+11·0
April 4.	53 57·6	55 07·8	57 15·6	58 16·8	58 33·0	56 38·2	− 0·8	56 37·4	+23·5
11.	53 49·8	55 10·2	57 12·6	58 18·3	59 06·9	56 43·6	− 2·4	56 41·2	+27·3
18.	53 40·8	55 07·2	57 20·4	58 06·6	59 13·2	56 41·6	− 4·0	56 37·6	+23·7
25.	53 39·6	55 08·4	57 09·0	58 08·1	58 44·7	56 34·0	− 5·6	56 28·4	+14·5
May 2.	54 03·6	55 06·6	57 23·4	58 33·6	58 58·2	56 49·1	− 7·2	56 41·9	+28·0
9.	53 50·4	55 13·2	57 24·6	58 09·6	59 27·0	56 49·0	− 8·8	56 40·2	+26·3
16.	54 00·0	55 28·8	57 12·3	58 27·6	59 15·0	56 52·7	−10·4	56 42·3	+28·4
23.	54 01·2	55 24·6	57 17·4	58 31·2	59 15·6	56 54·0	−12·0	56 42·0	+28·1
30.	54 10·2	55 35·4	57 30·6	58 27·0	59 18·6	57 00·4	−13·6	56 46·8	+32·9
June 6.	53 57·0	55 01·2	57 24·0	58 27·6	59 17·4	56 49·4	−15·2	56 34·2	+20·3
13.	54 02·4	55 30·0	57 28·2	58 39·6	59 31·8	57 02·4	−16·8	56 45·6	+31·7
20.	53 39·0	55 39·0	57 30·6	58 24·0	59 30·6	56 56·6	−18·4	56 38·2	+24·3
27.	53 45·0	55 33·6	57 31·8	58 22·8	59 21·0	56 54·8	−20·0	56 34·0	+20·1
July 4.	53 37·2	55 24·0	57 59·4	58 16·8	59 27·6	56 57·0	−21·6	56 35·4	+21·5
11.	53 47·4	55 26·4	57 53·4	58 36·6	59 31·8	57 03·1	−23·2	56 39·9	+26·0
18.	53 51·6	55 24·6	57 36·6	58 28·2	59 30·3	56 58·3	−24·8	56 33·5	+19·6
25.	53 52·2	55 24·6	57 40·8	58 25·8	59 14·4	56 55·6	−26·4	56 29·2	+15·3
Aug. 1.	53 59·4	55 26·4	57 49·2	58 10·8	59 36·0	57 00·4	−28·0	56 32·0	+18·1
8.	53 55·4	55 25·2	57 44·4	58 24·6	59 24·0	56 58·7	−29·6	56 29·1	+15·2
15.	53 54·2	55 29·4	57 27·6	58 07·2	59 20·1	56 51·7	−31·2	56 20·5	+06·6
22.	54 06·1	55 30·0	57 40·2	57 54·9	59 40·8	56 58·4	−32·8	56 25·6	+11·7
29.	54 01·9	55 35·4	57 29·4	58 11·4	59 31·2	56 57·9	−34·4	56 23·5	+09·6
Sept. 5.	54 04·2	55 30·6	57 40·2	58 12·6	59 14·4	56 56·4	−36·0	56 20·4	+06·5
12.	54 07·2	55 29·4	57 27·0	58 07·2	59 24·0	56 55·0	−37·6	56 17·4	+03·5
19.	53 40·8	55 33·6	58 00·6	57 42·0	59 39·0	56 55·2	−39·2	56 16·0	+02·1
26.	53 41·4	55 27·6	57 34·2	58 18·3	60 02·4	57 00·8	−40·8	56 20·0	+06·1
Annual means	9 53 12·4	9 54 40·0	9 56 42·2	9 57 49·5	9 58 45·3	9 56 13·9			
Secular change	1′ 27″·6	2′ 02″·2	1′ 07″·2	0′ 55″·8					

In volume II. of the Magnetic Observations at St. Helena, p. v, an examination is made of the monthly values of the declination obtained from eight years of observation, corrected for secular change, and collected in a Table. These also indicate the existence of a semiannual inequality having epochs coincident, or nearly so, with the equinoxes—the north end of the magnet pointing, as at Kew and Hobarton, more to the east in the months from April to September, and to the west from October to March. The amount of the inequality is less than at Kew or Hobarton, "the semiannual difference being about 14 seconds of arc."

The first volume of the Magnetical Observations at the Cape of Good Hope, published in 1851, contains the fortnightly means of the hourly observations of the declination from July 1842 to July 1846; these are corrected for secular change in Table III. of that volume, and the differences of the declination in each fortnight (so corrected) from the mean declination of the whole period, are shown in the final column. The mean of the thirteen fortnights (in the four years) between March 26 and September 23 is $0'\cdot40$ more *easterly*, and of the thirteen fortnights between September 24 and March 25 $0'\cdot40$ more *westerly* than the mean of the year,—thus showing an annual variation of $0'\cdot80$ or $(48''\cdot0)$, or a semiannual inequality averaging $24''$ to the East in the thirteen fortnights from March 26 to September 23, and $24''$ to the West in the thirteen fortnights from September 24 to March 25. This is in accordance with the other stations previously discussed.

The fact of the existence of an annual variation with analogous phenomena at the four widely separated stations of Hobarton, St. Helena, the Cape of Good Hope, and Kew appears to be thus substantiated; its amount is least at St. Helena, intermediate at the Cape and Hobarton, and greatest at Kew; the difference in amount is doubtless to be ascribed, in part at least, to the difference in the amount of the antagonistic force of the earth's magnetism, tending to retain the magnet in its mean place in opposition to all disturbing causes. This force (the horizontal component of the earth's magnetic force) is, in British units, approximately 5·6 at St. Helena, 4·5 at the Cape and Hobarton, and 3·8 at Kew.

§ 8. *Annual Variation, or semiannual inequality, of the Dip, and of the Horizontal and Total Force.*

In the year 1850 I communicated to the Royal Society a paper entitled "On the means adopted in the British Colonial Magnetic Observatories for determining the absolute values, secular changes, and annual variations of the Magnetic Force." This paper is published in the Philosophical Transactions for the same year, No. IX.

In this communication I endeavoured to show the importance of introducing into such determinations greater accuracy than had previously been customary; and by making known the success which had attended the improvements adopted in the instruments and methods employed in the Colonial Magnetic Observatories, I hoped to be the means of promoting the adoption of similar instruments and processes (or the devisal and employment of others which might serve the purpose as well, or still more effectually) in other observatories which had been instituted for the purpose of cooperating with or aiding in the plan of magnetic research proposed by the Royal Society.

Amongst the results referred to in that paper, obtained by means of the instruments and processes therein described, there was one which appeared to myself to be highly deserving the confirmation (or otherwise) which it might receive from similar researches. By a comparison of the monthly determinations of the Dip and of the Horizontal Force at Toronto and Hobarton, between the years 1843 and 1848, there was shown a high probability of the existence of an "annual variation" in the direction and intensity of the magnetic force, common to both hemispheres, the mean values being passed through about the equinoxes, and the intensity of the force being greater, and the inclination more nearly vertical, in the months when the sun is south of the equator than in the months in which the sun is north of the equator. The facts thus made known appeared to indicate the existence of a general affection of the globe having an annual period, and conducting us naturally to the position of the earth in its orbit as the first consideration towards an explanation of the periodic change. The importance of following up without delay, and in the most effective manner, a branch of research which gave so fair a promise of establishing a conclusion of so much theoretical moment upon the basis of competent experiment was earnestly pointed out, and specially so with reference to those national observatories in which magnetical researches were professed objects, and from which exact determinations might most reasonably be expected.

In 1856 the Committee of the Kew Observatory, impressed with the importance of prosecuting an investigation which appeared to lead to the establishment of a previously unsuspected cosmical relation in the minor variations of terrestrial magnetism, and perceiving that no adequate provision had been made for this purpose in any establishment in the British Islands, took the matter in hand, and having obtained permission from the tenant under the Crown, caused a suitable wooden building, copper fastened, to be erected in Richmond Old Deer Park, at a distance of 300 feet from the observatory itself, and having no other buildings in its vicinity. A series of monthly determinations of the dip and of the horizontal force was commenced in this building in April 1857, with inclinometers made by Mr. HENRY BARROW, and with a unifilar magnetometer made by the late Mr. WILLIAM JONES. These instruments were the property of Her Majesty's Government, having been originally made (under my own direction) for the Arctic Expedition under Sir JAMES CLARK ROSS in 1846–1847, and replaced in my charge, on the return of the expedition, for repair and subsequent use. Several minor modifications, which experience had suggested since the publication of the memoir in 1850 already adverted to, were introduced in the instruments previous to April 1857, and in this improved state they have been described and practical directions given for their use in the "Instructions for Magnetic Surveys by Land and Sea," published in 1859 in the third edition of the Admiralty Manual of Scientific Inquiry. The series of determinations with these instruments has been steadily maintained from April 1857 to the present time, and still continues. The unifilar magnetometer employed has been the same throughout, no change whatsoever having been made either in the instrument itself, or in its collimator magnet. In respect to the dip observations, from April 1857 to September 1860 inclusive, twelve dip circles and twenty-four needles, all by BARROW and all of the same size and pattern, were employed, the mean of *all* the observations made in a month with *any* of Barrow's 6-inch circles furnished with microscopes and verniers having been taken as the mean dip of that month. A detailed statement of the results of these observations, specifying in each case the name of the observer and the distinguishing marks of the circle and needle, has been published in the 'Proceedings of the Royal Society,' vol. xi. p. 144–162. In the discussion accompanying that communication it was shown that the probable error of a single determination of the dip with instruments of this pattern does not exceed $\pm 1'{\cdot}5$, this being the conclusion derived from 282 determinations on 121 different days, chiefly by four observers, employing twelve different circles and twenty-four needles all of the same size and pattern. Between October 1860 and March 1863, the mean monthly dip has been obtained with *one* of the twelve circles alone, viz. Barrow's circle No. 33 (one of the twelve previously adverted to), and was generally the mean of a single determination in each month with each of the two needles of that circle. This department of the Kew observations has been placed by the Director, Mr. STEWART, in the charge of Mr. CHARLES CHAMBERS, one of the assistants in the establishment, and to that gentleman I am indebted for the results which are embodied in Tables IX. and XI., and which afford most satisfactory evidence of Mr. CHAMBERS's skill and devotion to the duties with which he is charged.

With reference to the values of the Horizontal Force in Table IX. Mr. CHAMBERS remarks, "The constants for the reduction of observations with collimator magnet 'K C 1' are as follows:—

"K the moment of inertia, being the mean of independent determinations with six different inertia-cylinders by the late Mr. WELSH, F.R.S., $=4{\cdot}4696$ ($\log K=0{\cdot}65027$ at 60° Fahr.).

"Hence

$$\begin{aligned}\log \pi^2 K \text{ at } 30^\circ &= 1{\cdot}64439, \text{ at } 70^\circ = 1{\cdot}64463\\ ,, \quad 40^\circ &= 1{\cdot}64445, \text{ at } 80^\circ = 1{\cdot}64469\\ ,, \quad 50^\circ &= 1{\cdot}64451, \text{ at } 90^\circ = 1{\cdot}64475\\ ,, \quad 60^\circ &= 1{\cdot}64457.\end{aligned}$$

"The correction for the decrease of the magnetic moment of the collimator magnet produced by an increase of 1° Fahr. $=(q)=0{\cdot}000119(t_0-t)+{\cdot}000000213(t_0-t)^2$, t_0 being the observed temperature, and $t=35^\circ$. The induction coefficient $(\mu)={\cdot}000194$. These were both determined by Mr. WELSH. The angular value of one division of the collimator scale$=2'{\cdot}50$. Comparisons of the deflection-bar with the verified standard measure of the Kew Observatory gave the errors of graduation as follows:—

At 1·0 foot distance $=-{\cdot}000075$ of a foot at 62° Fahr.
At 1·3 foot distance $=-{\cdot}000097$.

"The arc of vibration was always too small to require any correction; and none has been applied on account of the rate of the chronometer when the rate was less than five seconds, as was generally the case. The constant P was determined from twenty-four repetitions of experiments of deflection made nearly simultaneously at each of the two distances 1·0 and 1·3 feet, giving P=−·00192.

"Generally there have been three or four observations of deflection and two of vibration made in each month."

TABLE IX.—Monthly Values of the Horizontal Component of the Magnetic Force at Kew, computed from the Experiments of Deflection and Vibration with the Collimator Magnet "K C 1".

April to September.	1857.	1858.	1859.	1860.	1861.	1862.	Means of the six years.
April	3·7887	3·7932	3·7897	3·8038	3·8078	3·8162	3·7999
May	3·7920	3·7984	3·8008	3·8022	3·8157	3·8209	3·8050
June	3·7901	3·7889	3·8053	3·8142	3·8189	3·8150	3 8054
July	3·7950	3·7980	[3·8052]	3·8065	3·8115	3·8179	3·8057
August	3·7871	3·7942	3·8052	3·7979	3·8113	3·8162	3·8020
September	3·7883	3·7920	3·7995	3·8056	3·8115	3·8158	3·8021
Means, April to September	3·7902	3·7941	3·8010	3·8050	3·8128	3·8170	3·8033
October to March.	1857 and 1858.	1858 and 1859.	1859 and 1860.	1860 and 1861.	1861 and 1862.	1862 and 1863.	Means of the six years.
October	3·7925	3·7962	3·7914	3·8066	3·8081	3·8144	3·8015
November	[3·7906]	3·7964	3·7963	3·8074	3·8085	3·8161	3·8025
December	[3·7887]	3·7919	3·8056	3·8075	3·8113	3·8124	3·8029
January	3·7868	3·7951	3·8038	3·8101	3·8144	3·8127	3·8038
February	3·7917	[3·7967]	3·8016	3·8071	3·8136	3·8188	3·8052
March	3·7873	3·7983	3·8036	3·8075	3·8125	3·8212	3·8051
Means, October to March	3·7896	3·7958	3·8004	3·8077	3·8114	3·8159	3·8035
Yearly means	3·7899	3·7950	3·8007	3·8063	3·8121	3·8165	3·8034

The values within brackets [ ] are interpolated.

The absolute values of the horizontal force, corresponding to the beginning of October in each of the years comprehended in Table IX., and the secular change in each year, were therefore as follows:—

From April 1857 to March 1858 . . .	3·7899	
		sec. ch. +·0051.
From April 1858 to March 1859 . . .	3·7950	
		sec. ch. +·0057.
From April 1859 to March 1860 . . .	3·8007	
		sec. ch. +·0056.
From April 1860 to March 1861 . . .	3·8063	
		sec. ch. +·0058.
From April 1861 to March 1862 . . .	3·8121	
		sec. ch. +·0044.
From April 1862 to March 1863 . . .	3·8165	
Mean of the six years, corresponding to the middle epoch, April 1860 . . .	3·8034	with a mean annual secular increase of ·0053.

The "Annual Variation" or "Semiannual Inequality" (April to September, and October to March) may be shown from the monthly values in Table IX. to have been as follows:—

TABLE X.

Date.	Corrections for Secular Change.	3·8034 ±Secular Change.	Observed Values.	Observed—Calculated.	
				April to September.	October to March.
July 1, 1857	—·0146	3·7888	3·7902	+·0014	....
Jan. 1, 1858	—·0119	3·7915	3·7896	....	—·0019
July 1, 1858	—·0093	3·7941	3·7941	·0000	....
Jan. 1, 1859	—·0066	3·7968	3·7958	....	—·0010
July 1, 1859	—·0040	3·7994	3·8010	+·0016	....
Jan. 1, 1860	—·0013	3·8021	3·8004	....	—·0017
July 1, 1860	+·0013	3·8047	3·8050	+·0003	....
Jan. 1, 1861	+·0040	3·8074	3·8077	....	+·0003
July 1, 1861	+·0066	3·8100	3·8128	+·0028	....
Jan. 1, 1862	+·0093	3·8127	3·8114	....	—·0013
July 1, 1862	+·0119	3·8153	3·8170	+·0017	....
Jan. 1, 1863	+·0146	3·8180	3·8159	....	—·0021
Mean differences between the observed and calculated values in the respective semiannual periods				+·0013	—·0013

It is seen then by Table X. that there exists a variation in the amount of the horizontal force having an annual period; that the value of this variation is on the average of the six years approximately ·0026; and that it consists of a semiannual inequality, the horizontal force being on the average ·0013 higher in the six months from April to September, and ·0013 lower in the six months from October to March than would be due to its mean value.

I pass to the contemporaneous determinations of the Dip.

TABLE XI.—Monthly Values of the Magnetic Dip at Kew.

April to September.	1857.	1858.	1859.	1860.	1861.	1862.	Means of the six years.
	68°+	68°+	68°+	68°+	68°+	68°+	68°+
April …………	27′·2	22′·5	21′·1	20′·5	17′·6	18′·1	21′·17
May …………	24·9	23·0	19·4	19·3	15·7	14·1	19·40
June …………	24·0	22·7	[20·5]	19·1	17·7	14·0	19·67
July …………	26·1	23·7	21·6	18·4	16·8	14·0	20·10
August ………	24·1	21·5	20·6	16·6	18·7	15·1	19·43
September ……	24·9	21·4	22·0	19·4	17·1	13·8	19·77
Means, April to September …	25·20	22·47	20·87	18·88	17·27	14·85	19·92
October to March.	1857 and 1858.	1858 and 1859.	1859 and 1860.	1860 and 1861.	1861 and 1862.	1862 and 1863.	Means of the six years.
	68°+	68°+	68°+	68°+	68°+	68°+	68°+
October ………	24′·3	23′·8	24′·0	19′·6	18′·4	16′·0	21′·02
November ……	25·6	23·7	22·4	20·8	17·9	15·8	21·03
December ……	[24·8]	21·2	20·8	18·5	17·9	15·6	19·80
January ………	24·0	22·3	22·4	19·5	19·0	14·5	20·28
February ……	24·0	[22·4]	21·1	19·4	15·1	14·2	19·37
March ………	24·6	22·5	21·0	20·4	17·1	13·5	19·85
Means, October to March …	24·55	22·65	21·95	19·70	17·57	14·93	20·22
Yearly means…	24·87	22·56	21·41	19·29	17·42	14·89	20·07

The values within brackets [ ] are interpolated.

The absolute values of the dip corresponding to the beginning of October in each of the years comprehended in Table XI., and the secular change in each year, are as follows:—

From April 1857 to March 1858 . . 68° 24′·87
} sec. ch. −2′·31
From April 1858 to March 1859 . . 68 22·56
} sec. ch. −1·15
From April 1859 to March 1860 . . 68 21·41
} sec. ch. −2·12
From April 1860 to March 1861 . . 68 19·29
} sec. ch. −1·87
From April 1861 to March 1862 . . 68 17·42
} sec. ch. −2·53
From April 1862 to March 1863 . . 68 14·89

Mean of the six years, corresponding to middle epoch, April 1, 1860 . } 68 20·07 { with a mean annual secular decrease of 2′·00.

The "Annual Variation" or "Semiannual Inequality" (April to September, and October to March) may be shown from the monthly values in Table XI. to have been as follows:—

TABLE XII.

Date.	Corrections for Secular Change.	68° 20′·07 ±Secular Change.	Observed Values.	Observed—Calculated.	
				April to September.	October to March.
	′	° ′	° ′	′	′
July 1, 1857	+5·50	68 25·57	68 25·20	−0·37	......
Jan. 1, 1858	+4·50	68 24·57	68 24·55	......	−0·02
July 1, 1858	+3·50	68 23·57	68 22·47	−1·10	......
Jan. 1, 1859	+2·50	68 22·57	68 22·65	......	+0·08
July 1, 1859	+1·50	68 21·57	68 20·87	−0·70	......
Jan. 1, 1860	+0·50	68 20·57	68 21·95	......	+1·38
July 1, 1860	−0·50	68 19·57	68 18·88	−0·69	......
Jan. 1, 1861	−1·50	68 18·57	68 19·70	......	+1·13
July 1, 1861	−2·50	68 17·57	68 17·27	−0·30	......
Jan. 1, 1862	−3·50	68 16·57	68 17·57	......	+1·00
July 1, 1862	−4·50	68 15·57	68 14·85	−0·72	......
Jan. 1, 1863	−5·50	68 14·57	68 14·93	......	+0·36
Mean differences between the observed and calculated values in the respective semiannual periods				−0·65	+0·66

It is seen therefore by Table XII. that there exists a variation in the amount of the Dip having an annual period; that the value of this variation is on the average of the six years approximately 1′·31; and that it consists of a semiannual inequality, the dip being on the average 0′·65 lower in the six months from April to September, and 0′·66 higher in the six months from October to March than would be due to its mean value.

Total Force.—We find in Table IX. that the mean of the April to September values of the *horizontal* component of the force in the six years is 3·8033, corresponding in epoch to January 1, 1860; and in Table XI. that the mean of the April to September values of the dip in the same six years is 68° 19′·92, corresponding to the same epoch.

We find also in Table IX. that the mean in the six years of all the October to March values of the horizontal component is 3·8035, and of the dip (Table XI.) 68° 20′·22, corresponding to the epoch (six months later) of July 1, 1860.

We may reduce these values to a common epoch by applying to either (with the proper signs) a proportional part of the mean secular change derived from the observations of the six years. The mean secular change of the horizontal force is an annual increase of ·0053 (page 298), and of the dip an annual decrease of 2′·00 (page 300). Hence we have the corrections for the secular change (in six months), of the horizontal force =+·00265, and of the dip =−1′·00, to be applied to the mean values of April to September (corresponding in epoch to January 1, 1860) in order to bring them into strict comparison with the mean values, October to March, corresponding to the later epoch of July 1, 1860. The values then become as follows:—

From the April to September observations,

Values of the Horizontal Force, January 1, 1860	3·8033; and of the Dip		68° 19′·92
Corrections for Secular Change	+0·00265;		− 01·00
Corresponding values July 1, 1860	3·80595	. . . . .	68 18·92

And from the October to March observations (Table IX.), also corresponding to July 1, 1860 } 3·80350 and from Table X. 68 20·22

whence 3·80595 sec. 68° 18′·92=10·30032 from the April to September observations, and 3·80350 sec. 68° 20′·22=10·30349 from the October to March observations, are the values of the total force derived respectively for the same epoch (July 1, 1860) from the determinations of the dip and horizontal force in the two semiannual periods; these show a difference of 0·00317 in British units, as the measure of the greater intensity of the terrestrial magnetic force in the October to March period, than in the April to September period.

For the satisfaction of those who are accustomed to be guided by the theory of probabilities in their estimate of the dependence to be placed on the results of physical investigations, it may be desirable to state the "probable errors" of the mean results of the seventy-two monthly determinations of the Horizontal Force and of the Dip in Tables IX. and XI., as well as the probable error of a single monthly determination of each of these values.

The mean result of the seventy-two monthly determinations of the Horizontal Force, shown in Table IX., is 3·8034 in British units: this has a "probable error" of $\pm$·00027. The mean result of the seventy-two monthly determinations of the Dip (Table XI.) is 68° 20′·07: this has a probable error of $\pm$0′·083.

The probable error of a *single* monthly determination of the Horizontal Force, derived from the seventy-two monthly determinations, and after the application of the corrections for secular change and annual variation have been made, is $\pm$·00233; and of a single monthly determination of the Dip, after the application of the corrections for secular change and annual variation have been made, is $\pm$0′·71.

It has been already stated that for rather more than half the whole period, viz. from April 1857 to September 1860 inclusive, twelve dip circles and twenty-four needles were employed in the monthly determinations of the Dip, the circles and needles being all made by the same artist (Mr. HENRY BARROW), and of the same size and pattern; there were also several observers, but chiefly four, viz. the late Mr. JOHN WELSH, Mr. STEWART, Dr. BERGSMA, Director of the Netherlands Magnetic Observatory at Batavia, and Mr. CHAMBERS. The means of all the observations thus made at the Kew Observatory in the same month, and recorded in the books of the Kew Observatory, have been taken as the mean Dip in that month. From October 1860 to April 1863 there has been only a single observer, Mr. CHAMBERS, with one circle, viz. No. 33, one of the twelve in previous use, with its two needles. Some relative advantages or disadvantages may be supposed to attend observations made by one or by more observers, and with one or with several instruments; and it may therefore be useful to see how far these circumstances have modified the probable error in the two periods. The forty-two monthly determinations from April 1857 to September 1860, give a probable error of $\pm 0'\cdot 70$ for a single determination; and the thirty from October 1860 to March 1863, give a probable error of $\pm 0'\cdot 73$; whence we may infer that the greater number of partial results which contributed to produce the monthly mean in the earlier period rather more than counterbalanced the diversities which may be supposed to have been occasioned by the peculiarities of the different observers, and of the different instruments employed. But the small amount of probable error in either case is well worthy of the notice of those who have been engaged, or who are likely to be engaged, in similar investigations.

In Tables XIII. and XIV. are placed the residual errors of the observed monthly determinations of the Horizontal Force and of the Dip, after the application of the corrections for secular change and annual variation.

TABLE XIII.—Residual Errors in the Monthly Determinations of the Horizontal Force.

	1857.	1858.	1859.	1860.	1861.	1862.	1863.	Means.	
April	—·0003	—·0011	—·0099	—·0011	—·0024	+·0007	......	—·0023	
May	+·0026	+·0037	+·0007	—·0031	+·0051	+·0049	......	+·0024	·0000
June	+·0003	—·0062	+·0048	+·0085	+·0079	—·0013	......	+·0023	Sun north
July	+·0047	+·0024	+·0043	+·0004	0000	+·0011	......	+·0021	of the
August	—·0036	—·0018	+·0038	—·0088	—·0006	—·0010	......	—·0020	equator.
September ...	—·0028	—·0044	—·0023	—·0015	—·0008	—·0018	......	—·0023	
October	+·0035	+·0020	—·0082	+·0017	—·0021	—·0011	......	—·0007	
November ...	+·0012	+·0017	—·0038	+·0021	—·0021	+·0001	......	—·0001	+·0001
December ...	—·0011	—·0032	+·0051	+·0018	+·0002	—·0040	......	—·0002	Sun south
January	......	—·0034	—·0004	+·0031	+·0039	+·0029	—·0041	+·0003	of the
February ...	......	+·0010	+·0006	+·0005	+·0004	+·0017	+·0015	+·0009	equator.
March	......	—·0039	+·0019	+·0021	+·0004	+·0001	+·0035	+·0006	

TABLE XIV.—Residual Errors in the Monthly Determinations of the Dip.

	1857.	1858.	1859.	1860.	1861.	1862.	1863.	Means.	
April	+1′·8	—0′·8	—0′·2	+1′·2	+0′·3	+2′·8	......	+0·85	
May	—0·3	—0·2	—1·8	+0·1	—1·5	—1·1	......	—0·80	+0′·01
June	—1·0	—0·3	—0·5	+0·1	+0·7	—1·0	......	—0·33	Sun north
July	+1·3	+0·9	+0·8	—0·4	0·0	—0·8	......	+0·30	of the
August	—0·6	—1·2	—0·1	—2·1	+2·0	+0·4	......	—0·25	equator.
September ...	+0·4	—1·1	+1·5	+0·9	+0·6	—0·7	......	+0·27	
October	—1·4	+0·1	+2·3	—0·1	+0·7	+0·3	......	+0·32	
November ...	+0·1	+0·2	+0·9	+1·3	+0·4	+0·3	......	+0·53	—0′·02
December ...	—0·6	—2·2	—0·5	—1·1	+0·6	+0·2	......	—0·47	Sun south
January	......	—1·2	—0·9	+1·2	+0·3	+1·8	—0·7	+0·09	of the
February ...	......	—1·0	—0·6	+0·1	+0·4	—1·9	—0·8	—0·63	equator.
March	......	—0·2	—0·3	+0·2	+1·5	+0·2	—1·3	+0·03	

The errors have no systematic appearance; and thus the Tables are thoroughly confirmatory of a semiannual inequality having its epochs coincident, or nearly so, with the sun's passage of the equator.

The second volume of the Hobarton Magnetic Observations, published in 1852, contains the particulars of the monthly determinations of the absolute values of the horizontal force from January 1846 to December 1850 inclusive, all made with the same unifilar magnetometer, and preserving throughout the same experimental process. The mean value, corresponding to July 1, 1848, is 4·50427. The secular change obtained by least squares from the sixty equations of condition is correctly stated in the publication referred to, as an annual diminution of 0·0006. Treating these results in the same manner that the Kew results have been treated in this paper, we obtain 4·5036 in the months from April to September, and 4·5048 in the months from October to March; or a diminution in the horizontal component of the force of 0·0007 in the months when the sun is north of the equator, and an increase of 0·0005 in the months when the sun is south of the equator; constituting a semiannual inequality of 0·0012. When the corrections for secular change and annual variation are applied, the probable error of a single monthly determination is found to be $\pm$0·00125; and the probable error of the mean result of the sixty months is less than 0·0002.

The first volume of the Hobarton Observations, published in 1850, contained the details of a series of monthly determinations of the Inclination, commencing in January 1841 and ending in December 1847. The second volume, published in 1852, contained a similarly detailed account of the continuation of the series to December 1850; comprising, with the observations stated in the preceding volume, an uninterrupted series of monthly determinations during ten years. The mean secular change derived from sixty-eight monthly results obtained with the same circle and needle throughout, was found to be a decrease of 0′·067 in each year—an amount so small as to be practically insignificant in the consideration of the questions at present under notice. The mean value of the Inclination in the ten years, taking all the months into account, was $-70°$ 36′·01; the mean of the months from April to September inclusive was $-70°$ 35′·42, and from October to March inclusive $-70°$ 36′·6. The difference between these half-yearly values is 1′·18, the (south) dip being 0′·59 less in the months from April to September, and 0′·59 greater in the months from October to March, than on the mean of the whole year.

We have therefore for the values of the total force at Hobarton in the two semiannual periods, 4·5048 sec. 70° 36′·6=13·5688 (in British units) from October to March, and 4·5036 sec. 70° 35′·42=13·5520 from April to September. The difference, viz. 0·0168, expresses the greater intensity of the terrestrial magnetic force in the semiannual period from October to March than in the semiannual period from April to September. This value may undergo a slight alteration, when the results of the continuation of the series of monthly determinations of the horizontal force and of the inclination until the final close of the Hobarton Observatory are added to those already stated; but it will be substantially the same. The later results will be published in the fourth Hobarton volume, now preparing for the press.

In the second and third volumes of the Toronto Observations are published the details of the monthly determinations of the Horizontal Force and of the Dip during eight years, viz. 1845 to 1852 inclusive. From these we may form the following Tables, similar to Tables IX. and XI. of the Kew Observations.

TABLE XV.—Monthly determinations of the Horizontal Component of the Magnetic Force at Toronto, 1845 to 1852 inclusive.

April to September.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	Means of the 8 years.
April	3·5446	3·5414	3·5348	3·5361	3·5378	3·5373	3·5311	3·5054	3·5336
May	3·5481	3·5414	3·5386	3·5386	3·5413	3·5366	3·5328	3·5142	3·5365
June	3·5514	3·5458	3·5399	3·5366	3·5389	3·5380	3·5311	3·5083	3·5363
July	3·5508	3·5446	3·5366	3·5376	3·5428	3·5284	3·5317	3·5139	3·5358
August	3·5473	3·5397	3·5424	3·5360	3·5394	3·5199	3·5318	3·5138	3·5338
September	3·5466	3·5390	3·5338	3·5332	3·5382	3·5217	3·5286	3·5119	3·5319
Means, April to Sept.	3·5481	3·5420	3·5385	3·5363	3·5397	3·5303	3·5312	3·5113	3·53465
October to March.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	Means of the 8 years.
January	3·5472	3·5475	3·5435	3·5329	3·5319	3·5344	3·5249	3·5305	3·5366
February	3·5471	3·5413	3·5426	3·5352	3·5312	3·5354	3·5243	3·5231	3·5350
March............	3·5471	3·5441	3·5386	3·5372	3·5339	3·5387	3·5321	3·5237	3·5369
October	3·5466	3·5386	3·5345	3·5263	3·5343	3·5320	3·5311	3·5110	3·5318
November	3·5471	3·5360	3·5366	3·5249	3·5366	3·5361	3·5304	3·5140	3·5327
December	3·5479	3·5433	3·5347	3·5318	3·5351	3·5283	3·5286	3·5149	3·5331
Means, Oct. to Mar.	3·5472	3·5418	3·5384	3·5314	3·5338	3·5341	3·5286	3·5195	3·53435
Yearly means...	3·5476	3·5419	3·5384	3·5339	3·5367	3·5322	3·5299	3·5154	3·53451

The two half-yearly results are intercomparable, requiring no correction for secular change, as they have both the same mean epoch, viz. January 1, 1849.

TABLE XVI.—Monthly Values of the Magnetic Inclination at Toronto, 1845 to 1852 inclusive.

April to September.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	Means of the 8 years.
	75°+	75°+	75°+	75°+	75°+	75°+	75°+	75°+	
April	11·5	14·3	15·9	18·0	18·4	19·7	21·9	20·0	75° 17′·46
May	15·4	14·4	16·1	17·2	18·4	19·5	20·0	20·8	75 17·73
June	15·2	14·8	13·1	16·8	18·5	19·1	20·7	20·8	75 17·37
July	14·2	14·0	11·6	16·4	18·0	19·9	19·0	19·9	75 16·63
August	14·4	14·4	12·6	19·0	19·3	18·4	19·8	20·0	75 17·24
September......	16·6	15·7	15·4	17·3	21·6	21·0	20·8	21·6	75 18·75
Means, April to Sept.	75 14·55	75 14·60	75 14·12	75 17·45	75 19·03	75 19·60	75 20·37	75 20·52	75 17·53

October to March.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	Means.
	75°+	75°+	75°+	75°+	75°+	75°+	75°+	75°+	
January	11·4	13·9	15·0	20·3	19·5	19·9	21·6	19·3	75° 18′·49
February	19·5	14·2	15·2	18·7	18·1	18·7	20·0	19·6	75 18·00
March	14·5	13·8	16·3	17·2	16·7	18·0	21·5	19·6	75 17·20
October	14·3	15·4	17·6	19·0	20·6	21·8	20·0	22·2	75 18·86
November	16·8	15·0	17·7	19·4	20·1	21·3	20·4	21·3	75 19·00
December	15·2	15·1	17·0	20·6	18·1	22·5	19·4	21·2	75 18·64
Means, Oct. to March	75 16·45	75 14·57	75 16·47	75 19·20	75 18·85	75 20·37	75 20·48	75 20·53	75 18·36

These two half-yearly results are also intercomparable, requiring no correction for secular change, as they have both the same mean epoch, viz. January 1, 1849.

We have then for the Total Force corresponding to the semiannual period April to September, 3·53465 sec. 75° 17′·53=13·9220 (in British units), and for the Total Force corresponding to the semiannual period October to March, 3·53435 sec. 75° 18′·36 =13·9336; the difference, 0·0116, is the measure of the greater intensity of the terrestrial magnetic force in the October to March period than in the April to September period: or, applying to the values of the horizontal force the induction-correction of —·0040 (Toronto Observations, vol. iii. pp. cxv, cxvi), we have the total force in the April to September period 3·53065 sec. 75° 17′·53=13·9062, and in the October to March period 3·53035 sec. 75° 18′·36=13·9178; and the corresponding difference, ·0116, as the excess of the total force in the October to March period over the April to September period.

The observations of the Inclination at Toronto were carried on previous to 1845 and continued subsequent to 1852, completing a series of fifteen years, for which period, therefore, a corresponding inference, in regard to the annual variation of the Inclination, may be drawn, resting on a still wider basis. The second volume of the Toronto Observations, published in 1853, and the third volume, published in 1857, contain the details of 1920 determinations of the dip nearly equally distributed in the different months of the fifteen years, 1841 to 1855 inclusive, of which the following is a summary, arranged in the two categories, April to September, and October to March:—

April to September.	° '	October to March.	° '
April	75 18·33	January	75 18·78
May	75 18·08	February	75 18·43
June	75 17·38	March	75 18·17
July	75 17·13	October	75 19·09
August	75 17·33	November	75 19·53
September	75 19·09	December	75 19·15
	75 17·90		75 18·86

The semiannual results require no correction for secular change, as they have both the same mean epoch. They show a semiannual inequality in the Dip at Toronto, causing its value to be, on the average, 0'·96 higher in the months from October to March than in those from April to September. Table XVI., resting on a smaller number of years, gave a semiannual inequality of 0'·83.

We have therefore the concurrent evidence of the three observatories of Toronto, Hobarton, and Kew for the existence of an annual variation in the dip, and in the intensity of the total magnetic force, referable apparently to the earth's position in its orbit, with epochs of maxima and minima coincident, or nearly so, with the solstices. The conclusion terminating the previous section of this paper (§ 7) has shown the probability, resting also on the concurrent evidence obtained at four observatories, Hobarton, the Cape of Good Hope, St. Helena, and Kew, of the existence of a corresponding semiannual inequality in the Declination.

The phenomena thus submitted to the consideration of the Royal Society may be briefly stated to be an increase of the Dip and of the Total Force, and a deflection of the north end of the Declination magnet towards the West, in both hemispheres, in the months from October to March, as compared with those from April to September. It seems difficult to assign to such effects any other than a cosmical cause. The greater proximity of the earth to the sun in the December compared with the June solstice most naturally presents itself as a not improbable cause; but we are as yet too little acquainted with the mode of the sun's action on the magnetism of the earth to enter more deeply into the question at present. The inequalities may in themselves seem to be small, but judged of *scientifically*, *i. e.* by the proportions they bear to their respective probable errors, they are not so.

The tabulation from the Photograms, and the calculation of the values contained in the Tables, have been performed by the Non-commissioned Officers of the Royal Artillery, under the superintendence of the principal clerk, Mr. JOHN MAGRATH, in the Government Establishment at Woolwich for the reduction and publication of magnetic observations.