PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

An Analysis of the Results from the Falmouth Magnetographs on "Quiet" Days during the Twelve Years 1891 to 1902

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Phil. Trans. R. Soc. Lond. A 1905 **204**, 373-406
doi: 10.1098/rsta.1905.0010

X. *An Analysis of the Results from the Falmouth Magnetographs on "Quiet" Days during the Twelve Years* 1891 *to* 1902.

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(From the National Physical Laboratory.)

Received November 23,—Read December 15, 1904.

Contents.

§ 1. In May, 1903, I communicated to the Society a discussion of the results obtained from the Kew magnetographs during the eleven years 1890 to 1900, on the five quiet days a month selected by the Astronomer Royal. That paper will for shortness be referred to as (A).

When dealing with data from a single station, even when representing many years' observations, one is confronted by the possibility that the results may be appreciably modified by defects peculiar to the apparatus or to the methods of observation employed, or that they may be largely dependent on local conditions, and so of very limited applicability. For these reasons alone, it was desirable to discuss on parallel lines data from a second English observatory. Another reason for such an investigation was the disturbed magnetic conditions introduced at Kew in 1901 by electric trams. In consequence of their action, there is unlikely to be any adequate opportunity for comparing simultaneous undisturbed data from Kew and the new magnetic observatory now under construction in Eskdalemuir. Thus the most promising way of securing continuity is a minute comparison of Kew with some observatory now existent which is likely to continue free from tram disturbances for some time. Both sets of considerations pointed to a discussion of the results obtained at Falmouth Observatory. Magnetographs have been in constant operation at

Falmouth since 1891. They have been under the direct supervision of Mr. KITTO, the Superintendent of the Observatory, who has acted throughout as magnetic observer. The behaviour of the vertical-force magnetograph has been indifferent, and the curves from it have not been measured;* but the declination and horizontal-force magnetographs have worked satisfactorily, and the data obtained from them on the Astronomer Royal's quiet days have appeared in the 'Annual Reports of the Royal Cornwall Polytechnic Society,' and also in the Royal Society's 'Proceedings,' or the 'Reports of the National Physical Laboratory.'

The proposed investigation met with the hearty support of Mr. WILSON FOX, Honorary Secretary of the Royal Cornwall Polytechnic Society, and of Mr. KITTO, and the latter kindly took a number of special curve measurements necessary for the inquiry.

The Falmouth magnetographs, though resembling those at Kew in the size of the magnets and in their general design, are by another maker, and differ in a variety of minor points. Thus the scale of the declination magnetograms is considerably less open than at Kew, and the temperature coefficient of the horizontal-force magnet is so small that its sign even is uncertain. Also the Falmouth magnetic chamber has a considerably smaller diurnal variation of temperature than that at Kew. Again, the position and climate of the two observatories are widely different. Kew is in the level plain of the Thames Valley, some 60 miles from the sea, but the magnetic chamber is only some 20 feet above mean sea level. Falmouth Observatory, though close to the coast, is about 160 feet above sea level. Kew possesses, for England, an almost continental climate, whilst Falmouth enjoys the equable temperature of the Cornish coast.

From these considerations there is strong reason to believe that any phenomenon observed in the records of both observatories is not due to instrumental defects or to purely local peculiarities.

Falmouth Observatory is situated in 50° 9′ 0″ N. latitude, 5° 4′ 35″ W. longitude. Local noon is thus 20 minutes 18 seconds after Greenwich, 19 minutes 3 seconds after Kew.

An 11-year period, 1890 to 1900, was employed in (A). For Falmouth I have employed a 12-year period, 1891 to 1902. This includes all the data published when the investigation commenced, and secures a sun-spot minimum period, 1899 to 1902, equal in length to that of sun-spot maximum, 1892 to 1895. The mean sun-spot frequency after WÖLFER for the whole period and the above sub-divisions was as follows:—

1891 to 1902.	1899 to 1902.	1892 to 1895.
38·27	7·25	74·97

* [*March* 31, 1905.—The working of the instrument was improved in 1902. The curves for 1903 and 1904 have been tabulated since the above was written. The results appear satisfactory and are being published.]

Secular Change.

§ 2. As in (A), use will frequently be made of the letters D, H, N and W to denote respectively Declination, Horizontal Force, Northerly Component and Westerly Component of Force. Only two of these elements, of course, are independent, and they are connected by the relation

$$N/\cos D = W/\sin D = H.$$

The system of absolute observations at Falmouth and the method of standardizing the curves are the same as at Kew (see (A), § 4).

Table I. gives the mean yearly values of D and H as deducible from the diurnal inequality data in the annual Falmouth Reports, with the values of W and N calculated therefrom, and the values thence deduced for the annual changes. The

TABLE I.—Secular Change.

Mean annual values.					Annual changes.				
Year.	D.	H.	W.	N.	Period.	D.	H.	W.	N.
1891	19° 18′·3	·18429	·06093	·17393	1891–2	−5′·2 (0·0)	+15γ (+ 4)	−22γ	+23γ
1892	19 13·1	·18444	·06071	·17416	1892–3	−6·6 (−1·3)	+13γ (−21)	−29γ	+24γ
1893	19 6·5	·18457	·06042	·17440	1893–4	−5·7 (−0·1)	+54γ (+41)	−11γ	+61γ
1894	19 0·8	·18511	·06031	·17501	1894–5	−6·3 (+0·1)	+36γ (+ 9)	−21γ	+45γ
1895	18 54·5	·18547	·06010	·17546	1895–6	−7·0 (+1·0)	+ 7γ (−24)	−33γ	+19γ
1896	18 47·5	·18554	·05977	·17565	1896–7	−5·3 (+0·9)	+41γ (+ 8)	−14γ	+48γ
1897	18 42·2	·18595	·05963	·17613	1897–8	−4·7 (−0·3)	+32γ (+10)	−14γ	+39γ
1898	18 37·5	·18627	·05949	·17652	1898–9	−4·8 (+0·5)	+36γ (+ 7)	−13γ	+42γ
1899	18 32·7	·18663	·05936	·17694	1899–1900	−3·6 (−0·8)	+26γ (− 9)	−11γ	+31γ
1900	18 29·1	·18689	·05925	·17725	1900–1	−3·6	+31γ	− 8γ	+35γ
1901	18 25·5	·18720	·05917	·17760	1901–2	−4·0	+17γ	−16γ	+23γ
1902	18 21·5	·18737	·05901	·17783					
12-year means	18 47·4	·18581	·05985	·17591	Mean annual change (1891 to 1902)	−5·16	+28·0γ	−17·5γ	+35·5γ

absolute values of H, W and N are expressed in C.G.S. measure; the annual changes have for unit $1\gamma \equiv 1 \times 10^{-5}$ C.G.S. In the case of D and H the *differences* from the corresponding annual changes at Kew are given in brackets, the + sign indicating that the Falmouth change was numerically the larger.

The total decrease of declination between 1891 and 1900 at Falmouth was absolutely identical with that at Kew; even in individual years the results at the two stations show a very fair agreement, the mean difference irrespective of sign being only 0′·5. As at Kew, there is subsequent to 1895 a marked slackening in the rate of secular change in D. The annual increase in H at Falmouth from 1891 to 1900 was on the average about 10 per cent. larger than at Kew; but in individual years the two stations show somewhat widely different results. How much of this apparent difference is real it is difficult to say; part is probably due to instrumental or observational uncertainties.

The decrease in W at Falmouth from 1891 to 1900 was about 7 per cent. less, the increase in N about 10 per cent. greater than at Kew.

The total changes from 1891 to 1902 are given by

$$\delta W = -192\gamma, \quad \delta N = +390\gamma.$$

The force of which these are westerly and northerly components lies in a vertical plane which is inclined to the geographical meridian at an angle of 26°·2, and is directed north-easterly. For the period 1891 to 1900 the angle becomes 26°·8, or 4°·1 less than the corresponding angle for Kew (see (A), § 9).

Non-cyclic Effect.

§ 3. As explained in (A), § 13, secular change and annual inequality, if they exist, imply a progressive change in the value of an element from midnight to midnight of the average day. There may also be apparent changes due to instrumental causes.

The contributions to the a-periodic daily variation at Falmouth from secular change and annual inequality are of the same small order of magnitude as the corresponding quantities at Kew ((A), § 13). The results of instrumental change are less exactly known than at Kew, but appear to be similarly small. In H the contributions from these causes constitute but a very trifling part of the observed non-cyclic effect on quiet days. In D the contribution from the secular change—which tends, however, to *reduce* the observed effect—is not relatively negligible. I have, however, as in (A), made no attempt to separate that part of the non-cyclic effect which is attributable to known causes.

Tables II. and III. give a complete analysis of the mean observed values of the non-cyclic effect on quiet days in D and H for each month and year of the 12-year period, while Table IV. shows the corresponding mean values in D, W, H, and N for the whole year and the three seasons, winter (November to February), summer (May to August), and equinox.

When dealing in (A) with the non-cyclic effect in D, I admitted that there was some room to doubt its *bonâ fide* character, but indicated several features which pointed to a real physical origin. A comparison of Table II. with Table V. of (A) tends to strengthen the latter view. Whilst the sign of the mean non-cyclic effect fluctuates from month to month, and even from year to year, there is a clear tendency, as at Kew, for + signs to predominate in winter and equinox, whilst in summer the mean non-cyclic effects at the two places are both negative and fairly similar in size.

TABLE II.—Non-cyclic Effect in D.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Monthly means.	Number of months when effect—		
														+	0	−
January	−0·1	−0·4	+1·6	+0·5	+0·5	−0·5	+0·3	+0·3	−0·1	0·0	+0·1	+0·1	+0·19	7	1	4
February	+0·6	−0·4	+0·1	+1·3	+0·2	0·0	−0·1	−0·5	−0·7	+0·4	0·0	0·0	+0·075	5	3	4
March	+0·5	+1·0	+0·1	−0·4	+0·3	+0·6	+0·2	+0·5	−0·1	−0·3	+0·3	0·0	+0·225	8	1	3
April	+0·2	+0·3	+0·1	+0·3	−0·1	+0·4	0·0	−0·3	+0·2	−0·2	−0·2	+0·2	+0·075	7	1	4
May	+0·2	−0·2	+0·9	−0·5	−0·5	−0·2	0·0	−0·8	+0·2	+0·1	+0·1	−0·3	−0·08	5	1	6
June	+0·3	+0·2	−0·2	−0·4	+0·5	+0·4	−0·4	+0·2	+0·3	−0·1	−0·3	+0·2	+0·06	7	0	5
July	+0·1	−0·2	+0·3	−0·4	+0·2	0·0	−0·3	−0·3	0·0	−0·2	−0·3	+0·2	−0·075	4	2	6
August	+0·1	−0·9	0·0	−0·2	−0·3	−0·4	+0·2	+0·3	0·0	0·0	+0·2	−0·4	−0·12	4	3	5
September	+0·3	−0·3	0·0	+1·4	+0·2	0·0	+0·8	0·0	0·0	0·0	+0·2	+0·7	+0·275	6	5	1
October	+0·2	0·0	−0·4	+1·0	−0·1	+0·4	0·0	+0·2	−0·1	+0·6	0·0	−0·4	+0·12	5	3	4
November	−1·5	+0·1	+1·2	−0·3	−0·5	0·0	−0·4	+0·3	+0·2	+0·1	+0·1	−0·4	−0·09	6	1	5
December	0·0	−0·2	−0·5	−0·1	+0·4	−0·2	0·0	−0·1	0·0	−0·3	0·0	+0·5	−0·04	2	4	6
Mean for year	+0·075	−0·08	+0·27	+0·18	+0·07	+0·04	+0·025	−0·02	−0·01	+0·01	+0·02	+0·03	+0·0507	—	—	—
Number of months when effect—													Total number of months.			
+	9	4	7	5	7	4	4	6	4	4	6	6	66			
0	1	1	2	0	0	4	4	1	4	3	3	2	25			
−	2	7	3	7	5	4	4	5	4	5	3	4	53			

TABLE III.—Non-cyclic Effect in H. (Unit = 1γ.)

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Monthly means.	Number of months when effect—		
														+	0	–
January	0	+ 7	+12	+ 7	+ 4	+ 3	+1	+5	−1	+2	−1	+1	+3·3	9	1	2
February	+1	+ 6	+ 1	+12	+ 4	+ 3	+2	+3	+6	+2	+3	+3	+3·8	12	0	0
March	+3	+12	+ 1	− 2	+ 5	+ 5	+4	+4	+2	+6	+1	+2	+3·6	11	0	1
April	+3	0	+ 2	0	+ 5	+11	+9	+3	+4	+6	+7	+3	+4·4	10	2	0
May	+5	+ 3	+10	− 3	+ 3	+10	+6	0	+1	+4	+1	0	+3·3	9	2	1
June	+2	+ 1	+ 5	+ 3	+ 5	+ 3	+3	−1	+3	−1	+3	0	+2·2	9	1	2
July	+1	+ 2	+ 1	+ 1	+14	+ 3	+2	+4	+3	−1	+2	+2	+2·8	11	0	1
August	+2	+ 7	+ 4	+ 2	− 2	+ 3	+3	+3	+4	+2	−1	+1	+2·3	10	0	2
September	+5	+ 1	+ 2	+ 2	+ 6	+ 5	+7	+5	+1	−1	0	+1	+2·8	10	1	1
October	+6	+ 6	+ 3	+ 8	0	− 2	+2	+2	+2	+4	+2	+2	+2·9	10	1	1
November	+4	+ 9	+ 8	+ 5	+ 8	− 1	+3	+1	+1	−2	0	+1	+3·1	9	1	2
December	−1	− 1	+ 2	+ 1	+ 4	− 5	+5	+2	+3	0	+1	+2	+1·1	8	1	3
Mean for year	+2·6	+ 4·4	+ 4·25	+ 3·0	+ 4·7	+ 3·2	+3·9	+2·6	+2·4	+1·75	+1·5	+1·5	+2·98	—	—	—
Number of months when effect—													Total number of months.			
+	10	10	12	9	10	9	12	10	11	7	8	10	118			
0	1	1	0	1	1	0	0	1	0	1	2	2	10			
–	1	1	0	2	1	3	0	1	1	4	2	0	16			

For the whole year the mean value comes out $+0'{\cdot}051$ for Falmouth as against $+0'{\cdot}044$ for Kew. If, however, we take the years 1891 to 1900 common to the two investigations, these figures become $+0'{\cdot}056$ for Falmouth and $+0'{\cdot}084$ for Kew.

TABLE IV.—Non-cyclic Effect. Seasonal Values. Means from 12 Years. (Unit = 1γ in case of force.)

	D.	W.	H.	N.
Winter	+0·033	+1·08	+2·83	+2·62
Equinox	+0·173	+1·99	+3·44	+2·96
Summer	−0·054	+0·58	+2·67	+2·43
Year	+0·051	+1·22	+2·98	+2·73

Taking the whole 120 months common to the two investigations, the signs of the non-cyclic effects in D at Kew and Falmouth agreed in 69 cases, and differed in only 22, whilst in 29 cases the effect vanished at one or both of the stations. Even if the whole of the observed non-cyclic effect were in every case ascribable to natural agencies—which cannot be claimed—agreement in sign could not be expected to occur invariably at stations so far apart as Kew and Falmouth.

§ 4. In the case of H a comparison of Table III. with Table VII. of (A) shows an exceedingly close agreement. The mean non-cyclic effect throughout the year at Falmouth is, it is true, some 10 per cent. less than that at Kew; but when we take the common period, 1891 to 1900, this difference is reduced to about 5 per cent. The tendency in the non-cyclic effect to be large in years of sun-spot maximum, and small in years of sun-spot minimum, and to be relatively low in June, July, August and December, is as clearly shown at Falmouth as at Kew. Out of the whole 120 months common to the two investigations there are only 5 in which the non-cyclic effects at the two stations differ in sign, as against 99 in which there is agreement, and 16 in which the effect vanishes at one or both stations. From 1891 to 1900 there were only 7 months when the non-cyclic effect was negative at Kew, and in 4 of these its amplitude was only 1γ, while in no case did it exceed 2γ; yet out of these 7 months no less than 5 show a negative non-cyclic effect at Falmouth, the remaining two having zero values. Thus even the incidence of the few exceptions to the general rule exhibits a remarkable agreement at the two stations.

In the case of the mean seasonal non-cyclic effects in Table IV. the largest value appears in each element in the equinox, the smallest or most negative value in summer. The latter phenomenon was also observed at Kew ((A) Table X.), but the maximum values in D and W occurred there in winter, and whilst the equinoctial value for H and N exceeded the winter value, the excess in the case of H is distinctly less than at Falmouth.

TABLE V.—Diurnal Inequality

Hour	Forenoon.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
January (1891 to 1902)	−0′·71	−0′·47	**−0′·28**	−0′·32	−0′·42	−0′·48	−0′·76	−1′·14	**−1′·32**	−0′·65	+0′·57	+1′·98
February ,, ...	−1·04	−1·02	**−0·80**	**−0·80**	−0·88	−1·05	−1·22	−1·34	**−1·47**	−0·82	+0·54	+2·27
March ,, ...	−0·83	**−0·82**	**−0·82**	−1·02	−1·04	−1·34	−1·84	−2·99	**−3·52**	−2·38	+0·21	+3·25
April ,, ...	−0·58	−0·68	−0·89	−1·09	−1·25	−1·85	−3·00	−4·26	**−4·52**	−3·06	−0·35	+3·02
May ,, ...	−0·43	−0·62	−0·77	−1·21	−2·17	−3·37	−4·41	**−4·75**	−4·00	−1·79	+0·90	+3·78
June ,, ...	−0·44	−0·64	−0·83	−1·31	−2·48	−3·97	−4·65	**−4·75**	−4·14	−2·12	+0·37	+3·50
July ,, ...	−0·50	−0·76	−0·92	−1·28	−2·31	−3·68	−4·12	**−4·50**	−4·01	−2·15	+0·22	+3·19
August ,, ...	−0·85	−1·02	−1·28	−1·59	−2·21	−3·19	−4·02	**−4·21**	−3·35	−0·99	+1·89	+4·67
September ,, ...	−0·98	−0·94	−1·12	−1·46	−1·66	−2·26	−2·99	**−3·73**	−3·10	−0·93	+1·70	+4·69
October ,, ...	−0·90	−0·79	**−0·75**	−0·85	−0·93	−1·15	−1·64	−2·75	**−3·02**	−1·95	+0·60	+3·33
November ,, ...	−0·67	−0·44	−0·34	**−0·27**	−0·46	−0·74	−0·98	−1·34	**−1·84**	−0·99	+0·59	+2·36
December ,, ...	−0·58	−0·31	−0·13	**−0·11**	−0·21	−0·48	−0·56	−0·74	**−0·84**	−0·33	+0·64	+1·73
Mean for year (1891 to 1902)	**−0·71**	**−0·71**	−0·74	−0·94	−1·33	−1·96	−2·52	**−3·04**	−2·93	−1·51	+0·66	+3·15
,, ,, (1899 ,, 1902)	−0·42	**−0·41**	−0·42	−0·59	−0·95	−1·50	−1·96	**−2·48**	−2·44	−1·23	+0·61	+2·67
,, ,, (1892 ,, 1895)	**−0·96**	−1·00	−1·10	−1·32	−1·84	−2·58	−3·33	**−3·87**	−3·60	−1·91	+0·72	+3·79

TABLE VI.—Diurnal Inequality of Horizontal

Hour	Forenoon.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10	11.	12.
January (1891 to 1902)	+ 7	+10	+17	+36	+46	+60	**+69**	+ 48	− 9	− 75	**−111**	−106
February ,, ...	+20	+13	**+11**	+22	+38	+50	**+57**	+ 43	− 11	− 78	**−134**	**−118**
March ,, ...	+43	+42	**+40**	+42	+52	**+59**	+49	− 3	− 90	−162	**−194**	−176
April ,, ...	+72	+62	+60	+49	**+48**	**+54**	+31	− 22	−117	−220	**−276**	−243
May ,, ...	+71	+52	+42	+32	+24	− 8	−68	−142	−208	**−242**	−235	−191
June ,, ...	+53	+42	+37	+33	+28	−19	−78	−142	−200	**−242**	−229	−169
July ,, ...	+69	+54	+48	+43	+29	−11	−56	−116	−191	**−247**	−245	−188
August ,, ...	+78	+65	+55	+49	+32	0	−60	−142	−222	**−258**	−235	−161
September ,, ...	+75	+68	+58	+55	+43	+25	−27	−105	−199	**−251**	−232	−147
October ,, ...	+60	**+52**	+54	+62	+67	**+69**	+50	− 5	−102	−194	**−221**	−188
November ,, ...	**+18**	+21	+26	+37	+57	**+66**	+56	+ 22	− 57	−129	**−151**	−132
December ,, ...	**−15**	−12	+ 1	+13	+28	**+45**	+44	+ 31	− 1	− 48	**− 74**	− 72
Mean for year (1891 to 1902)	+46	+39	**+38**	+39	**+41**	+32	+ 6	− 44	−117	−179	**−195**	−157
,, ,, (1899 ,, 1902)	+34	**+28**	+29	+30	**+32**	+23	+ 3	− 33	− 93	−140	**−150**	−116
,, ,, (1892 ,, 1895)	+62	+57	**+53**	+55	**+57**	+44	+ 8	− 58	−147	−225	**−252**	−215

of Declination. (+ to West.)

Afternoon. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	Range.	Sum of 24 differences from the mean.	
+2′·84	+2′·55	+1′·58	+0′·95	+0′·60	+0′·21	−0′·20	−0′·55	−0′·85	−1′·03	**−1′·10**	−1′·00	4′·16	22′·56	January (1891 to 1902).
+3·24	**+3·53**	+2·57	+1·36	+0·74	+0·40	+0·02	−0·29	−0·73	−0·96	−1·12	**−1·19**	5·00	29·40	February ,,
+5·09	**+5·24**	+3·97	+2·23	+0·34	+0·10	−0·23	−0·46	−0·61	−0·74	−0·88	**−0·91**	8·76	40·86	March ,,
+5·31	**+5·81**	+4·50	+2·90	+1·42	+0·37	−0·24	−0·12	−0·17	−0·21	−0·48	−0·63	10·33	46·71	April ,,
+5·33	**+5·50**	+4·20	+2·60	+1·40	+0·49	+0·04	−0·05	−0·12	−0·04	−0·14	−0·36	10·25	48·47	May ,,
+5·03	**+5·32**	+4·48	+3·34	+1·95	+1·07	+0·41	+0·16	+0·01	+0·09	−0·18	−0·32	10·07	51·56	June ,,
+4·99	**+5·66**	+4·81	+3·19	+1·67	+0·65	+0·17	+0·12	0·00	+0·04	−0·15	−0·31	10·16	49·40	July ,,
+6·29	+6·01	+4·21	+2·51	+0·68	−0·31	−0·43	−0·39	−0·47	−0·54	−0·66	−0·78	10·50	52·55	August ,,
+5·85	+5·21	+3·61	+2·03	+0·41	−0·20	−0·36	−0·55	−0·71	−0·77	−0·82	−0·96	9·58	47·04	September ,,
+4·59	+4·40	+3·45	+1·58	+0·66	+0·30	−0·13	−0·36	−0·77	−0·86	−1·03	**−1·08**	7·61	37·87	October ,,
+3·07	+2·78	+1·80	+1·10	+0·62	+0·15	−0·12	−0·43	−0·83	**−1·03**	**−1·03**	−0·99	4·91	24·97	November ,,
+2·19	+2·01	+1·42	+0·88	+0·29	−0·03	−0·35	−0·67	−0·92	**−1·07**	−1·03	−0·89	3·26	18·41	December ,,
+4·49	**+4·50**	+3·38	+2·06	+0·90	+0·27	−0·12	−0·30	−0·51	−0·59	−0·72	**−0·78**	7·54	38·82	Mean for year (1891 to 1902).
+3·77	+3·70	+2·55	+1·37	+0·42	−0·04	−0·30	−0·36	−0·48	−0·45	**−0·54**	−0·51	6·25	30·17	,, ,, (1899 ,, 1902).
+5·46	**+5·60**	+4·43	+2·84	+1·41	+0·55	+0·04	−0·26	−0·54	−0·63	−0·85	**−1·00**	9·47	49·63	,, ,, (1892 ,, 1895).

Force. (Unit = $0·1\gamma \equiv 1 \times 10^{-6}$ C.G.S.)

Afternoon. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	Range.	Sum of 24 differences from the mean.	
− 67	−20	−19	−16	0	+ 18	+ 24	**+ 31**	+ 26	+ 15	+12	**+ 6**	180	849	January (1891 to 1902).
− 86	−48	−26	−22	− 8	+ 22	+ 38	**+ 54**	+ 51	+ 41	+36	+33	191	1061	February ,
−110	−44	+ 2	+21	+ 20	+ 28	+ 70	**+ 73**	+ 64	+ 59	+62	+55	267	1560	March ,,
−169	−86	− 7	+36	+ 66	+ 91	+ 99	**+109**	+100	+ 91	+87	+81	385	2278	April ,
−116	−50	+12	+59	+109	+142	**+148**	+147	+131	+110	+98	+84	390	2521	May ,,
−114	−50	+24	+65	+ 97	+126	**+155**	+154	+137	+119	+97	+77	397	2486	June ,,
−129	−57	+23	+60	+ 97	+123	**+140**	+139	+129	+112	+96	+78	387	2481	July ,,
− 79	−28	+16	+53	+ 70	+ 91	+128	**+137**	+125	+102	+97	+87	395	2372	August ,,
− 58	− 8	+ 9	+21	+ 36	+ 57	+ 98	**+108**	+103	+ 93	+94	+84	359	2056	September ,,
−123	−64	−24	−10	+ 19	+ 52	+ 71	**+ 81**	+ 80	+ 76	+71	+68	302	1863	October ,,
− 95	−49	−22	+ 4	+ 31	+ 45	+ 55	**+ 61**	+ 53	+ 37	+26	+20	217	1273	November ,,
− 47	−30	−15	− 6	+ 14	+ 29	**+ 41**	+ 38	+ 26	+ 19	+ 5	−14	119	667	December ,,
−100	−45	− 2	+22	+ 46	+ 69	+ 89	**+ 94**	+ 85	+ 73	+65	+55	289	1678	Mean for year (1891 to 1902).
− 65	−21	+ 7	+19	+ 30	+ 47	+ 64	**+ 69**	+ 61	+ 54	+46	+42	219	1236	,, ,, (1899 ,, 1902).
−148	−73	−11	+28	+ 61	+ 94	+117	**+121**	+114	+ 97	+87	+74	373	2258	,, ,, (1892 ,, 1895).

TABLE VII.—Diurnal Inequality of Northern

	Forenoon.											
Hour	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
January (1891 to 1902)	+19	+18	+21	+40	+51	+65	+78	+65	+ 14	− 60	−115	−135
February ,,	+37	+30	+24	+35	+51	+66	+75	+64	+ 15	− 60	−136	−151
March ,,	+55	+54	+52	+57	+67	+79	+78	+49	− 24	−110	−187	−223
April ,,	+78	+71	+72	+65	+67	+83	+82	+53	− 32	−155	−255	−283
May ,,	+75	+60	+53	+51	+60	+51	+12	−52	−127	−198	−238	−247
June ,,	+58	+51	+49	+54	+70	+51	+ 7	−52	−117	−192	−223	−221
July ,,	+74	+64	+62	+63	+68	+54	+19	−32	−111	−196	−236	−234
August ,,	+89	+79	+74	+74	+69	+55	+13	−61	−152	−227	−255	−234
September ,,	+88	+81	+74	+78	+70	+63	+26	−35	−135	−222	−249	−221
October ,,	+72	+63	+64	+73	+80	+85	+76	+43	− 44	−150	−220	−236
November ,,	+29	+28	+30	+40	+62	+75	+70	+44	− 22	−105	−153	−166
December ,,	− 4	− 5	+ 3	+14	+30	+51	+51	+42	+ 14	− 40	− 81	− 98
Mean for year (1891 to 1902)	+56	+49	+49	+53	+62	+64	+50	+11	− 60	−143	−196	−203
,, ,, (1899 ,, 1902)	+39	+34	+35	+39	+47	+48	+37	+12	− 46	−111	−153	−156
,, ,, (1892 ,, 1895)	+75	+71	+69	+75	+86	+87	+66	+12	− 77	−180	−251	−270

TABLE VIII.—Diurnal Inequality of Western

	Forenoon.											
Hour	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
January (1891 to 1902)	−34	−21	− 9	− 4	− 7	− 6	− 17	− 43	− 71	− 57	− 7	+ 67
February ,,	−47	−48	−37	−34	− 33	− 38	− 44	− 55	− 79	− 67	− 15	+ 78
March ,,	−29	−29	−29	−38	− 36	− 50	− 78	−154	−209	−174	− 52	+109
April ,,	− 6	−15	−26	−40	− 48	− 77	−144	−225	−269	−227	−107	+ 76
May ,,	+ 1	−15	−26	−52	−103	−175	−248	−289	−272	−170	− 30	+131
June ,,	− 6	−19	−31	−56	−118	−209	−263	−289	−276	−187	− 55	+125
July ,,	− 4	−22	−32	−52	−109	−192	−229	−267	−266	−189	− 68	+103
August ,,	−19	−31	−48	−65	−103	−163	−225	−261	−243	−134	+ 21	+187
September ,,	−26	−26	−38	−57	− 71	−108	−162	−225	−223	−129	+ 12	+193
October ,,	−27	−23	−21	−24	− 26	− 37	− 68	−143	−188	−162	− 40	+110
November ,,	−28	−16	− 9	− 2	− 6	− 17	− 32	− 62	−112	− 92	− 19	+ 79
December ,,	−34	−20	− 6	− 1	− 2	− 10	− 14	− 28	− 43	− 32	+ 9	+ 66
Mean for year (1891 to 1902)	−21	−23	−26	−35	− 55	− 90	−127	−170	−188	−135	− 29	+110
,, ,, (1899 ,, 1902)	−11	−12	−13	−20	− 39	− 70	− 99	−138	−155	−108	− 17	+100
,, ,, (1892 ,, 1895)	−29	−33	−39	−50	− 76	−118	−167	−217	−231	−171	− 44	+125

Component. (Unit = $0{\cdot}1\gamma \equiv 1 \times 10^{-6}$ C.G.S.)

Afternoon. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	Range.	Sum of 24 differences from the mean.	
−113	− 63	−46	−32	−10	+ 13	+ 26	+ 39	**+ 39**	+ 32	+ 31	+23	213	1148	January (1891 to 1902).
−138	−107	−69	−45	−20	+ 14	+ 36	+ 56	**+ 61**	+ 56	+ 54	+52	226	1452	February ,,
−193	−133	−67	−19	+13	+ 25	+ 70	**+ 77**	+ 71	+ 69	+ 74	+68	302	1914	March ,,
−252	−182	−85	−16	+38	+ 80	+ 98	**+105**	+ 98	+ 90	+ 91	+88	388	2519	April ,,
−202	−143	−62	+11	+79	+126	+139	**+140**	+126	+105	+ 95	+86	387	2538	May ,,
−196	−140	−55	+ 3	+58	+101	+140	**+143**	+129	+111	+ 95	+78	366	2394	June ,,
−209	−152	−62	+ 1	+63	+105	**+130**	+129	+122	+105	+ 94	+79	366	2464	July ,,
−184	−131	−58	+ 6	+54	+ 92	+129	**+136**	+127	+106	+103	+96	391	2604	August ,,
−157	− 98	−54	−15	+27	+ 57	+ 99	**+112**	+110	+102	+103	+96	361	2372	September ,,
−196	−137	−83	−37	+ 7	+ 44	+ 69	+ 83	**+ 89**	+ 87	+ 85	+83	325	2206	October ,,
−143	− 95	−52	−15	+19	+ 40	+ 54	**+ 65**	+ 65	+ 53	+ 42	+36	241	1503	November ,,
− 83	− 63	−39	−21	+ 8	+ 28	+ 45	**+ 48**	+ 41	+ 37	+ 23	+ 2	149	871	December ,,
−173	−121	−61	−15	+28	+ 61	+ 86	**+ 94**	+ 89	+ 79	+ 74	+66	297	1943	Mean for year (1891 to 1902).
−127	− 84	−38	− 6	+21	+ 45	+ 66	**+ 72**	+ 66	+ 59	+ 53	+49	228	1443	,, ,, (1899 ,, 1902).
−235	−166	−87	−23	+33	+ 79	+110	**+119**	+117	+103	+ 97	+88	389	2576	,, ,, (1892 ,, 1895).

Component. (Unit = $0{\cdot}1\gamma \equiv 1 \times 10^{-6}$ C.G.S.)

Afternoon. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	Range.	Sum of 24 differences from the mean.	
+123	**+125**	+ 75	+ 44	+ 31	+17	− 2	−18	−36	−48	**−52**	−49	196	963	January (1891 to 1902).
+138	**+166**	+123	+ 63	+ 35	+27	+13	+ 2	−21	−36	−45	**−50**	245	1294	February ,,
+226	**+254**	+204	+121	+ 23	+14	+10	0	−10	−19	−25	−29	463	1922	March ,,
+218	**+270**	+228	+160	+ 94	+48	+20	+29	+24	+19	+ 3	− 6	539	2379	April ,,
+236	**+266**	+219	+152	+107	+71	+50	+44	+36	+33	+25	+ 9	555	2760	May ,,
+220	**+256**	+237	+192	+131	+96	+71	+58	+45	+43	+22	+ 9	545	3014	June ,,
+214	**+272**	+253	+182	+116	+73	+54	+51	+42	+38	+23	+ 9	539	2860	July ,,
+297	**+299**	+221	+146	+ 58	+13	+19	+24	+16	+ 5	− 3	−12	560	2613	August ,,
+281	+264	+188	+111	+ 33	+ 8	+14	+ 7	− 3	− 9	−12	−22	506	2222	September ,,
+195	**+204**	+169	+ 78	+ 40	+32	+16	+ 8	−13	−19	−30	**−33**	392	1706	October ,,
+126	**+126**	+ 85	+ 57	+ 42	+23	+12	− 2	−26	−41	**−45**	**−45**	238	1104	November ,,
+ 97	+ 93	+ 68	+ 43	+ 20	+ 8	− 5	−22	−39	−49	**−51**	−50	148	810	December ,,
+198	**+216**	+172	+112	+ 61	+36	+23	+15	+ 1	− 7	−16	−22	404	1888	Mean for year (1891 to 1902).
+172	**+182**	+133	+ 76	+ 32	+13	+ 6	+ 4	− 5	− 6	−13	−12	337	1436	,, ,, (1899 ,, 1902).
+232	**+263**	+223	+154	+ 92	+58	+40	+26	+ 9	− 1	−16	−27	494	2441	,, ,, (1892 ,, 1895).

§ 5. It is natural to suppose—as was in fact remarked by myself when first discussing the phenomenon*—that the non-cyclic increase in H on quiet days is connected in some way with the considerable decrements in H, which in the majority of instances accompany magnetic storms. It would appear, however, that the mean size of the non-cyclic effect on the Astronomer Royal's quiet days for a year cannot be inferred from the character of that year as disturbed or otherwise. For example, 1894 was much more disturbed than the years immediately preceding or following it; but the mean non-cyclic effect in H at both Kew and Falmouth is distinctly less for 1894 than for 1893 or 1895. There were, in fact, only 4 months out of the 12 in which the non-cyclic effect in 1894 exceeded that in 1895, and only 2 months in which it exceeded that in 1893. Again, during the four sun-spot minimum years, 1899 to 1902, few months showed anything that would be classified as a magnetic storm in years of sun-spot maximum, and yet the proportion of months showing a decidedly positive non-cyclic effect is the same as for the disturbed year 1894.

Solar Diurnal Inequality.

§ 6. The diurnal inequality figures in the annual Falmouth Reports include the non-cyclic effect. This has been eliminated in preparing Tables V. and VI. in the way described in (A) § 18. The hours, it is important to notice, are *Greenwich mean time*. Values of N and W are not given in the Falmouth Tables. The hourly values in Tables VII. and VIII. were deduced from those in Tables V. and VI. by means of the relations—the units being 1γ and $1'$—

$$\delta N = 0{\cdot}947\delta H - 1{\cdot}741\delta D,$$
$$\delta W = 0{\cdot}322\delta H + 5{\cdot}12\delta D,$$

these being the special forms taken by the general formulæ

$$\delta N = \cos D\delta H - H \sin D\delta D,$$
$$\delta W = \sin D\delta H + H \cos D\delta D,$$

when D and H are assigned the mean values at the foot of Table I.

As in (A), D and W are counted positively to the *west*, and to avoid decimals the unit of force employed in the tables is $\gamma/10$. In reality D is measured only to $0'{\cdot}1$, and H to 1γ, so the tables go a figure beyond the observations. This is completely justified so far as Tables V. to VIII. are concerned, because the figures assigned to any one month are means from 12 years, and the yearly means for the two sun-spot periods are based each on 48 months.

In addition to the mean hourly values, the tables give the range (defined as the

* 'B. A. Report for 1895,' p. 212.

difference between the greatest and least mean *hourly* values) and the numerical sum of the differences of the 24 hourly values from their arithmetic mean. All *pronounced* maxima and minima values are printed in heavy type. In most months two maxima and two minima are distinctly shown by each element, but sometimes only one pair appears. The phenomena are so similar to those at Kew, that a brief discussion will suffice.

Declination.

§ 7. From October to March there are in Table V., as at Kew, two pronounced maxima and minima, and in one or two other months there is a suspicion of more than one maximum and minimum. In the mean diurnal inequality for the year there is but a very short interval between the night maximum and minimum. The time at which the needle reaches its extreme westerly position is nearly constant throughout the year. The extreme easterly position is assumed in December about 10 P.M., but in all the other months of the year about 8 to 9 A.M. The hours of maximum and minimum look later than at Kew, but that is mainly, if not wholly, due to the difference in local time.

In addition to the December minimum, prominent in all the elements, the ranges and the sum of the differences show, as at Kew, a second inconspicuous minimum at midsummer. The interval between the two apparent maxima in the ranges is, as at Kew, longer than that between the two maxima in the sum of the differences, the latter appearing at both stations in June and August.

The monthly ranges and sums of the differences appear, on the whole, a trifle smaller than at Kew. This is really attributable to the fact that the mean sun-spot frequency for the Falmouth period 1891 to 1902 was slightly less than that for the Kew period 1890 to 1900. During the common period 1892 to 1895, in the mean diurnal inequality for the year, the Falmouth range was the greater by $0'\cdot10$, whilst the Kew sum of the differences was the greater by $0'\cdot57$. As these differences represent only about 1 per cent. of the quantities themselves, the only safe conclusion is that the amplitudes of the diurnal inequality of declination at Kew and Falmouth are exceedingly nearly equal.

Horizontal Force.

§ 8. Two maxima and minima are shown from October to April, somewhat doubtfully in April; in the remaining five months there is at least a retardation in the fall of H about 3 or 4 A.M. The mean inequality for the year shows two maxima and minima, but the morning maximum and minimum are poorly defined. The least value of the day occurs about 10 or 11 A.M., earlier in summer than in winter. From November to February the largest value is met with at 6 or 7 A.M., but throughout the equinoctial and summer months the absolute maximum occurs

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at 7 or 8 P.M. The slight apparent tendency in the hours of maxima and minima to be later than at Kew is again ascribable to the difference in local time.

As at Kew, the range seems nearly stationary from May to August, the sum of the differences from May to July. In every month of the year the range and the sum of the differences, especially the latter, are larger than at Kew. Judging by the common period 1892 to 1895, the range in the mean diurnal inequality for the year at Falmouth is the greater by some 13 per cent.

Northerly and Westerly Components.

§ 9. The diurnal inequality in N is similar to that in H, but a second maximum and minimum in the morning are generally recognisable even in summer. The chief minimum, near noon, and the afternoon maximum occur somewhat later than in H. The range and the sum of the differences show more clearly than in H a secondary minimum at midsummer; from October to March they are both decidedly larger than in H, but at midsummer the difference is, if anything, the other way.

The general character of the diurnal inequality in W resembles that in D. The afternoon maximum and the forenoon minimum—the only pronounced turning points during the seven months, March to September—seem slightly later than in D. The mean diurnal inequality for the year presents a very slow rate of change from 1 A.M. to 3 A.M., but only one maximum and minimum are shown. In the amplitude of the range there is at least a suggestion of two maxima in summer, with an intervening minimum, but the sum of the differences shows only a single maximum in June.

The range in W is distinctly larger than in N in the mean diurnal inequality for the year, and in every month except November, December and January, but the sum of the differences is larger in N than in W during 7 months of the 12, and in the mean diurnal inequality for the year.

§ 10. For purposes of comparison of different elements at different stations, the annual variation in the ranges and in the sum of the differences is most conveniently exhibited by representing the 12 monthly values as percentages of their arithmetic mean. This is done in Table IX. The small figures in the D and H columns give the excess of the Falmouth percentages over the corresponding Kew percentages in Table XVIII. of (A).

The range and the sum of the differences vary pretty similarly, but the principal maximum is higher for the 24 differences than for the ranges, especially in W.

There is not much difference between the different elements, but the midsummer values are decidedly higher and the midwinter values decidedly lower in W than in N, *i.e.*, the annual variation is greater for the former element than the latter. The Falmouth percentages are, on the whole, distinctly above the Kew in winter and below them in summer, the difference being greater in H than in D. This means that annual variation is less marked at Falmouth than at Kew.

TABLE IX.—Monthly Relative Values, 1891 to 1902 (100 ≡ mean from 12 months).

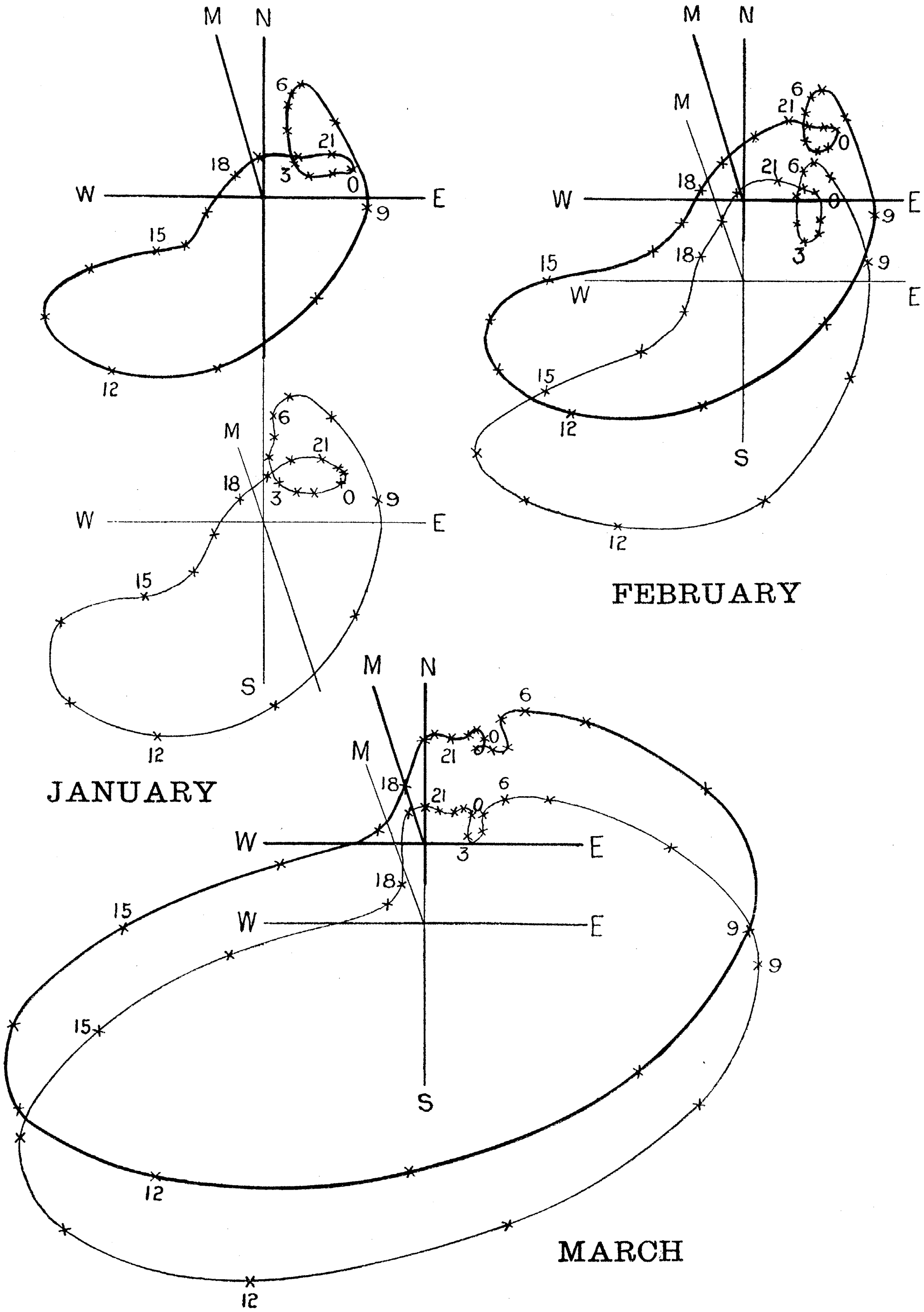
	Range.				Sum of 24 differences from mean.			
	D.	W.	H.	N.	D.	W.	H.	N.
January	53^{+2}	48	60^{+6}	69	58^{+1}	49	48^{+8}	57
February	63^{+4}	60	64^{+5}	73	75^{+1}	66	59^{+5}	73
March	111^{+1}	113	89^{-2}	98	104^{-2}	97	87^{-5}	96
April	131^{-1}	131	129^{+2}	125	119^{-1}	121	127^{-5}	126
May	130^{-6}	135	130^{-5}	125	124^{-4}	140	141^{-2}	127
June	128^{-4}	133	133^{-4}	118	132^{-4}	153	139^{-1}	120
July	129^{+2}	131	129^{-7}	118	126^{-2}	145	139^{-5}	123
August	133^{-4}	136	132^{-2}	126	134^{+2}	132	133^{-5}	130
September	122^{0}	123	120^{-3}	117	120^{+3}	113	115^{-5}	119
October	97^{+4}	96	101^{+5}	105	97^{+3}	87	104^{+2}	110
November	62^{+3}	58	73^{+2}	78	64^{0}	56	71^{+5}	75
December	41^{-1}	36	40^{+3}	48	47^{+3}	41	37^{+8}	44
Arithmetic mean of 12 monthly absolute values	7·883	41·05γ	29·91γ	30·96γ	39·150	197·1γ	178·9γ	199·9γ

Vector Diagrams.

§ 11. The mode of variation throughout the year in the diurnal inequality of the magnetic forces in the horizontal plane is conveniently illustrated by vector diagrams ((A), § 29). The accompanying diagrams refer to the mean monthly diurnal inequalities for Kew (1890 to 1900) and Falmouth (1891 to 1902), thick lines for the former, thin lines for the latter.

NS and EW represent respectively the geographical north-south and east-west directions. Their intersection (thick lines for Kew, thin for Falmouth) answers to the origin. The crosses and the numbers represent hours counted from midnight as 0, the line from the origin to any number or cross representing in magnitude and direction the disturbing force to which the diurnal inequality may be ascribed. The line drawn from M to the corresponding origin marks the direction of the magnetic meridian. For the periods considered the mean values of the declination at Kew and Falmouth were respectively 17° 18′·8 and 18° 47′·4. The distances of the points marked N, E, S, W from their corresponding origin represent in all cases 10γ. Except in the case of December and January the distance between the origins for Kew and Falmouth would represent 5γ.

The hours are G.M.T., so that 12, for instance, on a Falmouth curve answers to 11h. 39·7m. A.M. local mean time, but on a Kew curve to 11h. 58·75m. A.M. local mean time. If local time had been used, corresponding Kew and Falmouth radii would have shown an even closer approach to parallelism than they do.



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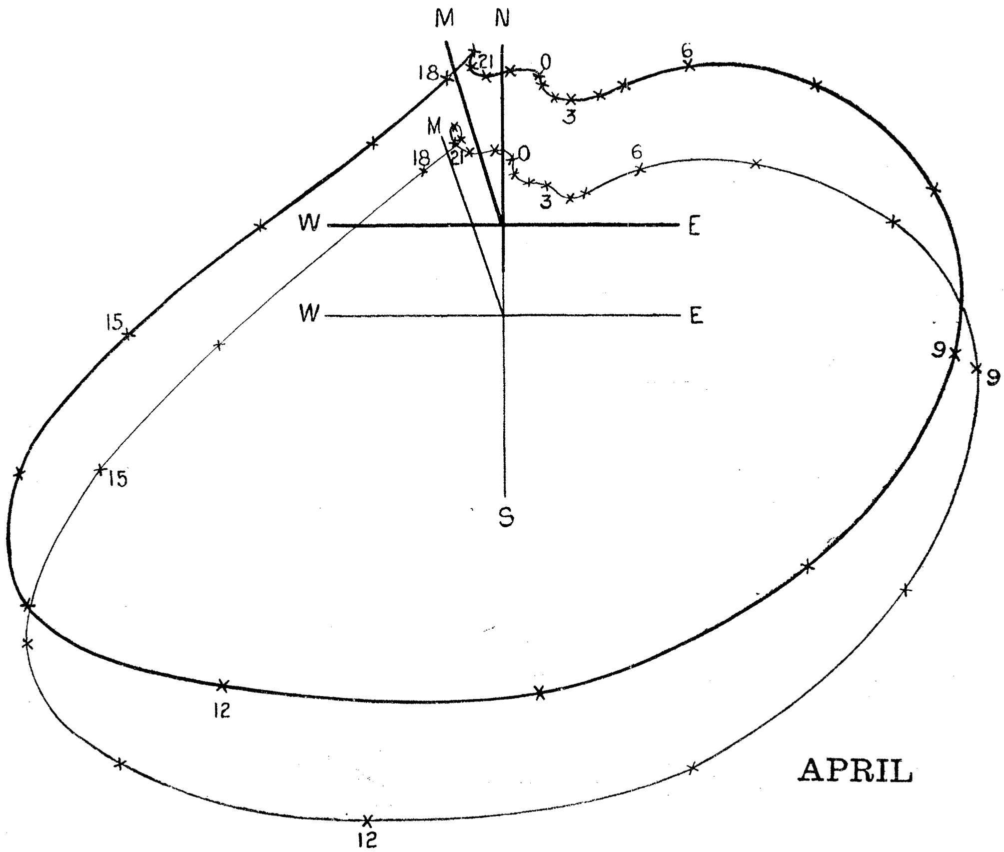

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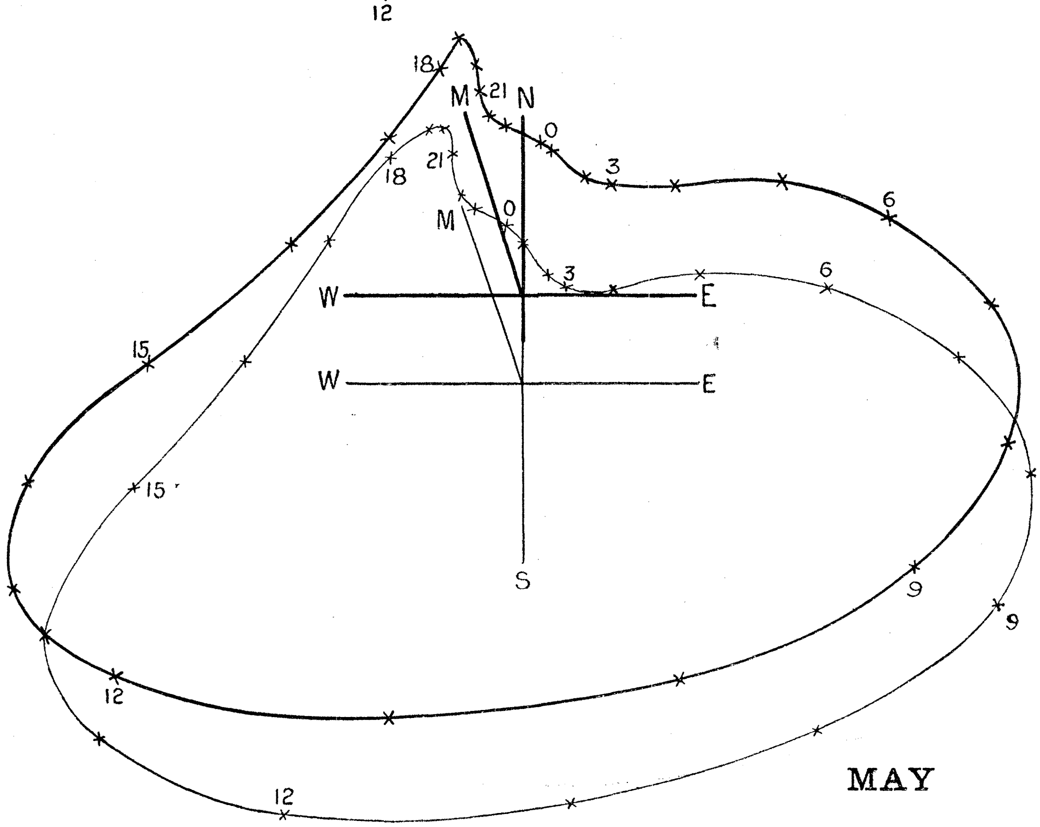

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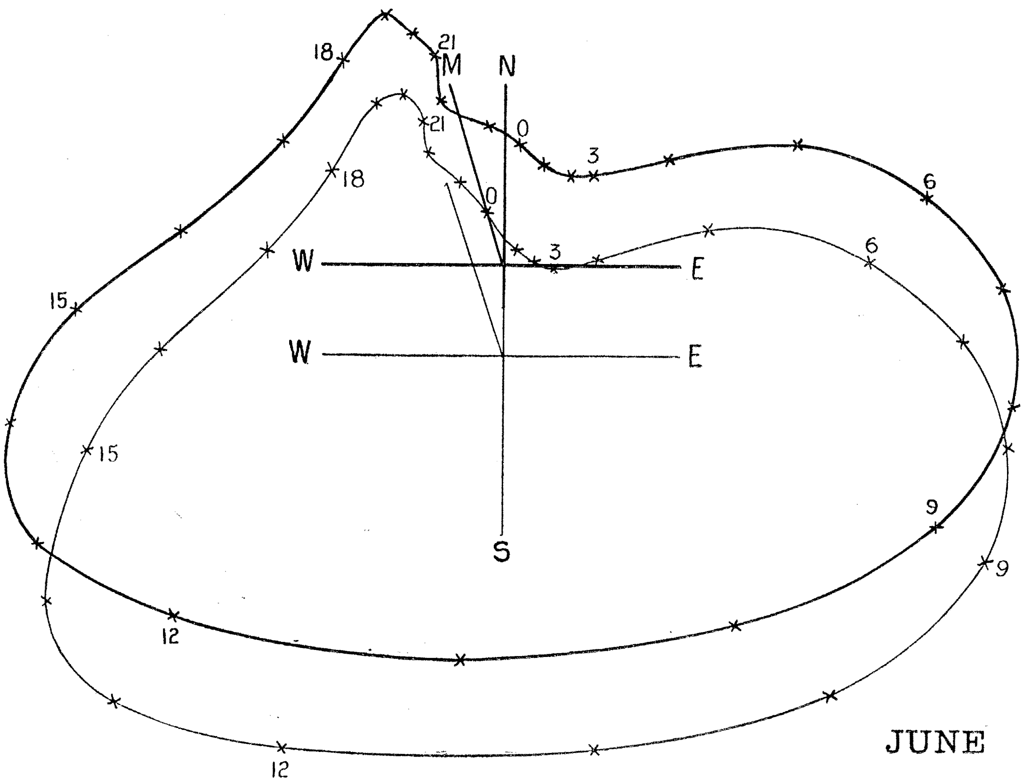
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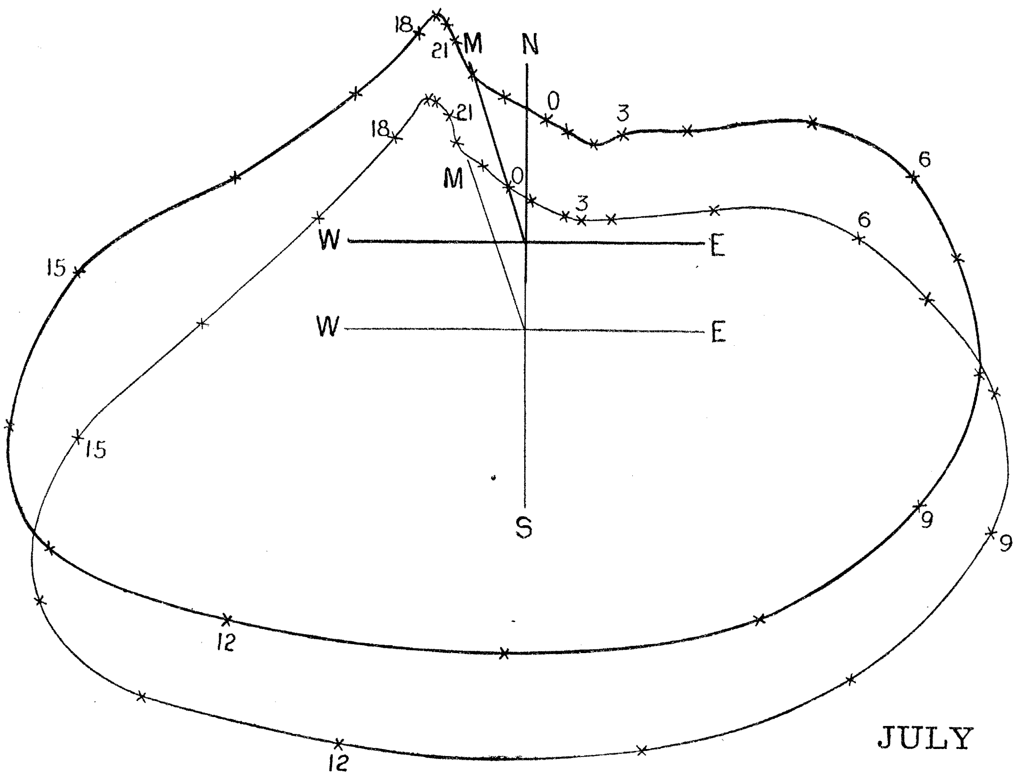
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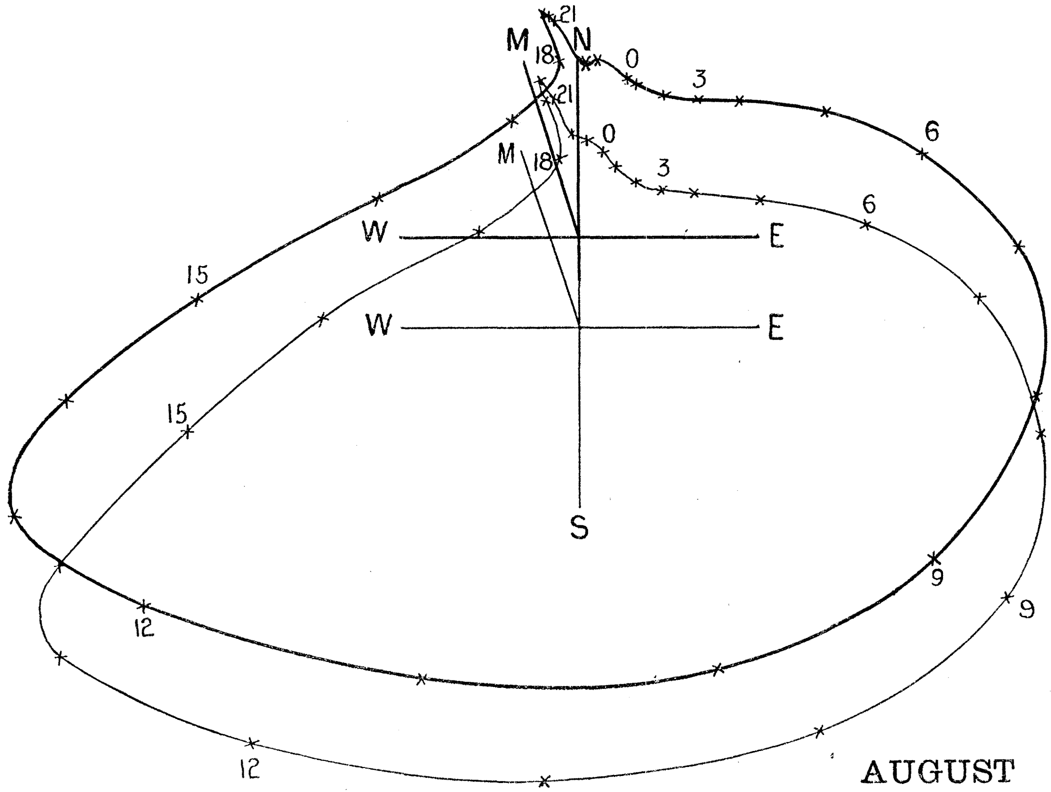

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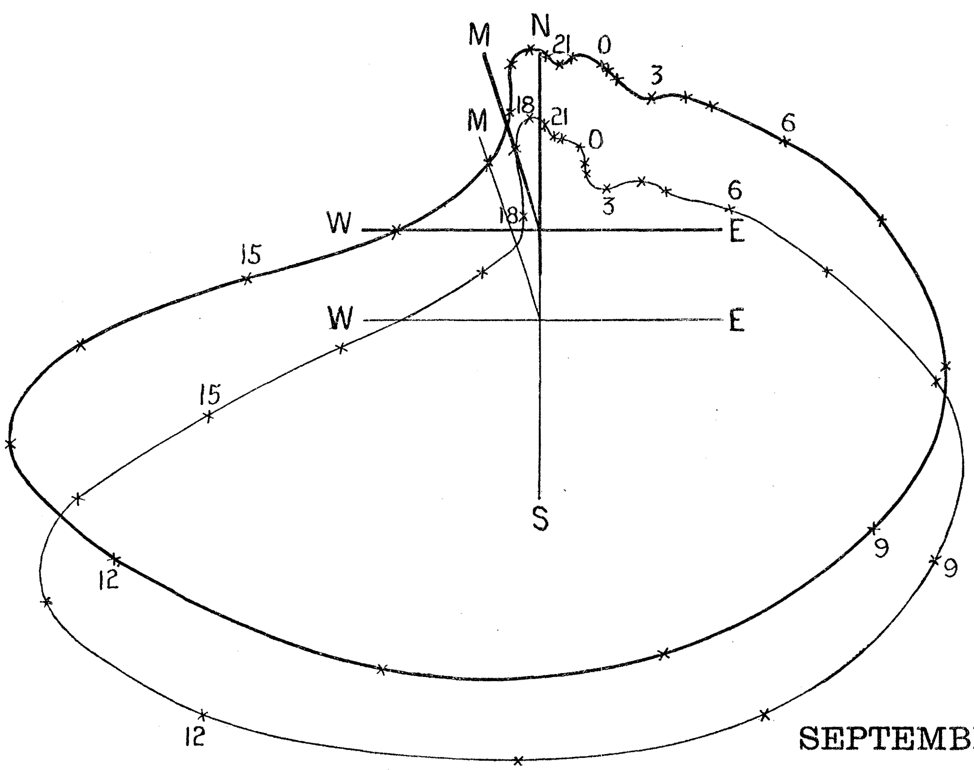
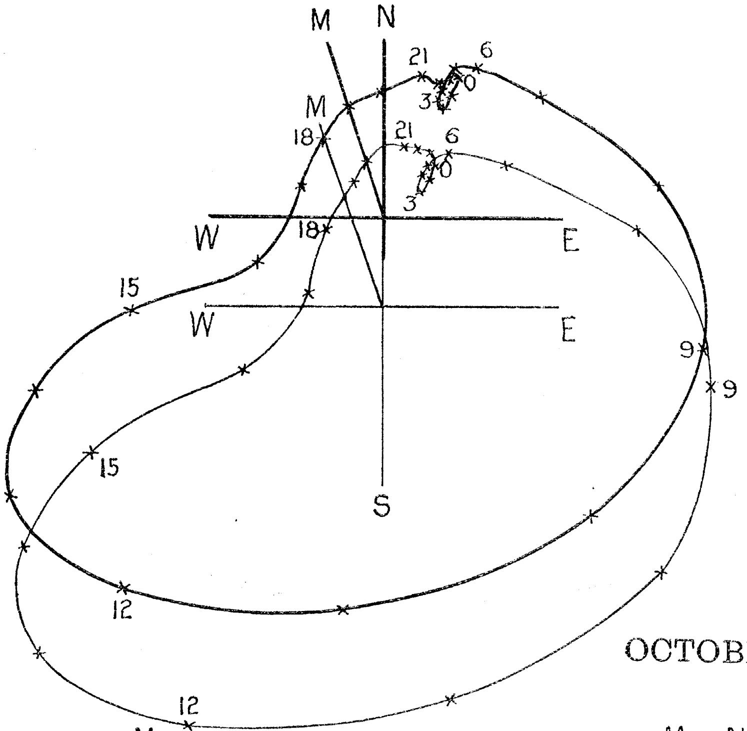
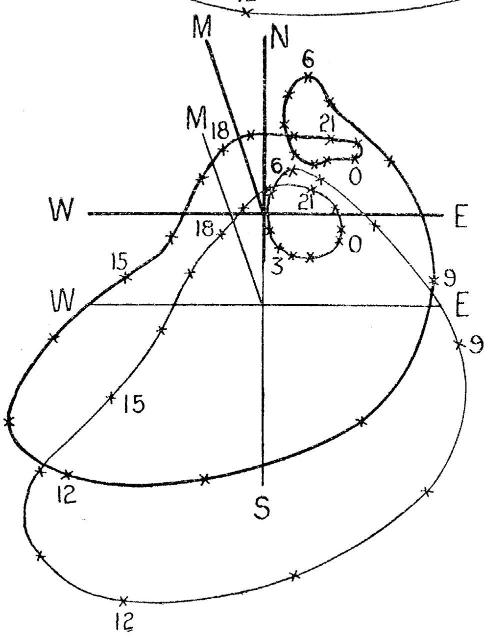


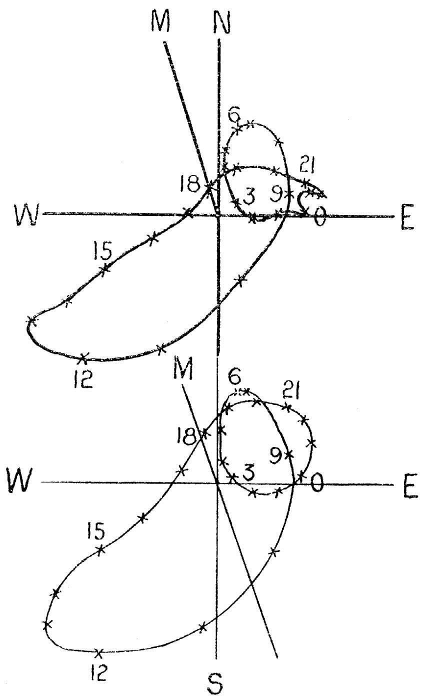
SEPTEMBER



OCTOBER



NOVEMBER



DECEMBER

Perhaps the most comprehensive way of describing the conspicuous seasonal variation in the part of the curve which answers to the night hours is by reference to the two peaks that tend to form, one about 6 A.M., the other about 7 P.M. From November to February the former is dominant. In March the evening peak begins to assert itself, and its predominance remains undisputed during the summer months, whilst the morning peak tends to disappear. In October the morning peak becomes again apparent. In most months there is at least an indication of a subsidiary peak near midnight.

The curves are simplest and most symmetrical in June and July. In August the afternoon peak is remarkably sharp both at Falmouth and Kew. In October a very small loop appears, a retrograde movement setting in about midnight. The loop enlarges in November and becomes most prominent in December, contracting in January and February. In March there is a very tiny loop in the Kew curve shortly after midnight, and a curious indentation. The Falmouth curve shows only the indentation. On the other hand, the April curve shows a tiny loop about 7 P.M. at Falmouth, whilst at Kew there is only a peak.

The Kew curves for three months, December, March and June, appeared in (A).

Vector diagrams for Greenwich were given by Sir G. B. AIRY for each month of the year, for the periods 1841 to 1847 and 1848 to 1857, treated separately,* and later† for the four months January, April, July and October in each of three successive years. In making any comparison it should be noticed that AIRY counted time from Göttingen *noon* in the earlier curves, and from Greenwich *noon* in the later. The different Greenwich curves for the same month of the year differ somewhat widely amongst themselves, and none of them resemble very closely the corresponding Kew or Falmouth curves. There is, on the other hand, a pretty close resemblance between individual Kew and Falmouth vector diagrams and the corresponding ones for Parc St. Maur, from the period 1883 to 1897, given on p. 261 of Professor MASCART's 'Magnétisme Terrestre.'

Analysis of the Diurnal Inequality in Fourier Series.

§ 12. As in (A), § 31, the analysis is supposed to be effected in the two alternative forms

$$a_1 \cos t + b_1 \sin t + a_2 \cos 2t + b_2 \sin 2t + \ldots,$$

$$c_1 \sin (t + \alpha_1) + c_2 \sin (2t + \alpha_2) + \ldots,$$

where t represents Greenwich mean time counted from midnight, and an hour is equivalent to 15°. If local time were used, the corrections required to the phase angles α_1 would be obtained by adding 4° 45′·6 to those given in (A), Table XIX.; for α_2 the addition would be 9° 31′, and so on.

* 'Phil. Trans.' for 1863, Plates 18 and 19.

† 'Phil. Trans.' for 1885, Plate 74.

TABLE X.—Coefficients and Angles in Fourier Series

	Period, 24 hours.				Period, 12 hours.			
	a_1.	b_1.	c_1.	α_1.	a_2.	b_2.	c_2.	α_2.
January	−1′·03	−0′·61	1′·20	239° 35′	+0′·34	+0′·89	0′·95	20° 50′
February	−1·31	−1·07	1·69	230 59	+0·43	+0·96	1·05	24 19
March	−1·37	−1·66	2·15	219 30	+0·90	+1·75	1·97	27 21
April	−1·10	−2·30	2·55	205 42	+1·01	+2·12	2·35	25 30
May	−1·22	−2·53	2·81	205 39	+1·57	+1·88	2·45	39 53
June	−1·12	−2·88	3·09	201 13	+1·41	+1·95	2·41	35 57
July	−1·16	−2·73	2·96	203 0	+1·37	+1·94	2·38	35 16
August	−1·86	−2·24	2·91	219 44	+1·83	+1·73	2·51	46 35
September	−1·79	−1·81	2·55	224 47	+1·52	+1·56	2·18	44 20
October	−1·36	−1·44	1·98	223 12	+0·77	+1·52	1·70	27 2
November	−1·04	−0·76	1·28	233 47	+0·43	+1·02	1·10	22 41
December	−0·94	−0·35	1·00	249 41	+0·30	+0·76	0·82	21 32
Year	−1·274	−1·696	2·121	216 55	+0·991	+1·505	1·802	33 22
Winter	−1·080	−0·694	1·284	237 16	+0·374	+0·905	0·979	22 27
Equinox	−1·405	−1·801	2·284	217 58	+1·053	+1·736	2·030	31 14
Summer	−1·337	−2·594	2·918	207 16	+1·546	+1·875	2·431	39 30

TABLE XI.—Coefficients and Angles in Fourier Series Expansion

	Period, 24 hours.				Period, 12 hours.			
	a_1.	b_1.	c_1.	α_1.	a_2.	b_2.	c_2.	α_2.
January	+ 3·95	+1·23	4·14	72° 46′	−4·35	−0·26	4·36	266° 39′
February	+ 5·66	+0·47	5·68	85 14	−4·80	−1·27	4·96	255 9
March	+ 9·08	−1·50	9·20	99 24	−5·55	+1·32	5·71	283 21
April	+13·26	−3·69	13·76	105 33	−7·74	+1·66	7·92	282 6
May	+13·31	−9·13	16·13	124 28	−5·79	+3·28	6·66	299 31
June	+12·80	−9·39	15·87	126 15	−5·51	+2·98	6·27	298 21
July	+13·25	−8·28	15·62	122 1	−5·98	+3·18	6·77	297 59
August	+13·03	−7·93	15·25	121 19	−4·51	+4·28	6·21	313 31
September	+12·04	−5·53	13·25	114 40	−3·89	+4·14	5·68	316 49
October	+11·09	−1·22	11·15	96 16	−6·11	+1·23	6·24	281 24
November	+ 6·60	−0·55	6·62	94 47	−5·78	+0·32	5·79	273 13
December	+ 2·37	−0·01	2·37	90 9	−3·80	−1·00	3·93	255 19
Year	+ 9·703	−3·794	10·418	111 21	−5·318	+1·656	5·569	287 18
Winter	+ 4·645	+0·285	4·654	86 29	−4·682	−0·549	4·714	263 18
Equinox	+11·366	−2·985	11·752	104 43	−5·824	+2·089	6·187	289 44
Summer	+13·096	−8·683	15·711	123 33	−5·450	+3·429	6·440	302 11

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Expansion of Diurnal Inequality of Declination (1891 to 1902).

Period, 8 hours.				Period, 6 hours.				
a_3.	b_3.	c_3.	α_3.	a_4.	b_4.	c_4.	α_4.	
−0′·38	−0′·32	0′·50	230° 19′	+0′·19	+0′·21	0′·29	42° 3′	January.
−0·37	−0·47	0·60	217 46	+0·10	+0·28	0·29	19 27	February.
−0·60	−1·08	1·24	209 3	+0·25	+0·46	0·53	27 58	March.
−0·62	−1·19	1·34	207 23	+0·23	+0·31	0·39	36 8	April.
−0·81	−0·66	1·04	230 41	+0·14	+0·08	0·16	61 10	May.
−0·66	−0·55	0·86	230 22	+0·06	+0·06	0·08	46 59	June.
−0·57	−0·74	0·94	217 13	−0·02	+0·13	0·13	− 7 20	July.
−0·89	−0·77	1·17	229 17	+0·14	+0·17	0·22	41 19	August.
−0·89	−0·75	1·16	229 53	+0·31	+0·22	0·38	55 6	September.
−0·66	−0·83	1·06	218 46	+0·32	+0·38	0·50	40 50	October.
−0·48	−0·39	0·61	230 57	+0·23	+0·24	0·34	44 9	November.
−0·29	−0·20	0·36	234 53	+0·10	+0·14	0·17	34 55	December.
−0·601	−0·663	0·895	222 12	+0·172	+0·223	0·282	37 39	Year.
−0·379	−0·346	0·513	227 36	+0·155	+0·217	0·267	35 28	Winter.
−0·693	−0·962	1·185	215 46	+0·278	+0·343	0·442	39 1	Equinox.
−0·731	−0·680	0·998	227 4	+0·082	+0·107	0·135	37 28	Summer.

of Diurnal Inequality of Horizontal Force (1891 to 1902). Unit = 1γ.

Period, 8 hours.				Period, 6 hours.				
a_3.	b_3.	c_3.	α_3.	a_4.	b_4.	c_4.	α_4.	
+1·38	−1·66	2·16	140° 16′	−0·51	+1·42	1·51	−19° 43′	January.
+1·67	−1·64	2·34	134 28	−0·59	+1·40	1·52	−22 54	February.
+2·08	−2·74	3·44	142 49	−0·56	+1·57	1·67	−19 34	March.
+3·09	−2·15	3·76	124 46	−0·69	+1·56	1·70	−23 56	April.
+0·22	−1·75	1·76	172 50	+0·69	+0·61	0·93	+48 36	May.
−0·27	−2·09	2·11	187 24	+0·27	+0·39	0·48	+35 11	June.
+0·63	−1·96	2·06	162 7	−0·01	+0·70	0·70	− 1 9	July.
−0·50	−2·99	3·03	189 27	+0·58	+1·36	1·48	+23 0	August.
−0·28	−3·91	3·92	184 2	+0·61	+2·10	2·18	+16 15	September.
+1·67	−2·84	3·30	149 34	−0·07	+1·82	1·82	− 2 9	October.
+1·29	−1·87	2·28	145 22	−0·03	+1·29	1·29	− 1 22	November.
+0·59	−0·98	1·14	148 40	−0·24	+0·71	0·75	−18 29	December.
+0·965	−2·214	2·415	156 27	−0·045	+1·244	1·245	− 2 5	Year.
+1·233	−1·535	1·969	141 13	−0·342	+1·206	1·253	−15 50	Winter.
+1·641	−2·909	3·340	150 34	−0·177	+1·760	1·769	− 5 45	Equinox.
+0·021	−2·198	2·198	179 27	+0·383	+0·766	0·856	+26 34	Summer.

Tables X. and XI. give the values of the coefficients answering to the diurnal inequalities of D and H for the individual months, the three seasons, and the entire year from the whole 12 years' observations. The values of the a and b constants were calculated first, the calculation going a figure further than appears in the tables, and the c and α constants were thence deduced. The phase angles cannot claim an accuracy of 1′, especially the monthly values of α_3 and α_4; reasons for recording the minutes are given in (A), § 32.

Table XII., giving Fourier coefficients for the diurnal inequalities in N and W, is confined to the seasonal and yearly data.

TABLE XII.—Coefficients and Angles in Fourier Series Expansion of Diurnal Inequality of Northern and Western Components. (Unit = 1γ.)

		c_1.	α_1.	c_2.	α_2.	c_3.	α_3.	c_4.	α_4.
N.	Year	11·426	93° 13′	6·842	261° 9′	2·175	115° 40′	0·861	−23° 26′
	Winter	6·451	76 45	5·500	247 36	2·017	114 59	0·968	−37 54
	Equinox	13·183	88 40	7·422	261 55	2·964	111 22	1·253	−31 20
	Summer	15·188	104 7	7·852	269 52	1·574	124 47	0·582	+22 15
W.	Year	10·474	198 56	8·896	22 12	4·953	213 57	1·768	29 19
	Winter	5·315	229 22	4·475	5 13	2·742	214 15	1·651	24 32
	Equinox	10·597	163 53	10·186	20 11	6·592	207 16	2·563	32 13
	Summer	16·289	189 17	12·351	29 55	5·612	221 44	0·964	34 13

The difference between local time at Falmouth and Kew is a little in the way of comparison. But careful study shows that many of the apparently irregular fluctuations in the values of α_3 and α_4, which might be ascribed to observational uncertainties, appear to a greater or less extent at both places. For instance, going to the nearest degree, we have the following consecutive values for α_4 in D:—

	June.	July.	August.
Falmouth	+47°	−7°	+41°
Kew	+70	−15	+50

Whilst amongst the values of α_4 in H we have:—

	April.	May.	June.	July.
Falmouth	−24°	+49°	+35°	−1°
Kew	+6	+62	+28	+11

The amplitude of the 6-hour term at midsummer being of the order $0'\cdot 1$ in D and 1γ in H, I was originally disposed to regard irregularities such as the above at Kew as mainly, if not entirely, accidental. It is now clear that whilst the irregularities may be accidental in the sense that they arise from special features in the days selected by the Astronomer Royal, they cannot be wholly, or even mainly, assigned to errors of measurement, or purely local causes.

A reference to Table XX. of (A) shows that the amplitudes of the several terms in D are closely alike at Kew and Falmouth. In the case of H a reference to Table XXII. of (A) shows that the amplitudes of the 24-hour and 12-hour terms are decidedly larger at Falmouth than at Kew; but the 8-hour and 6-hour terms have similar amplitudes at the two stations.

§ 13. Table XIII. expresses the monthly values of the c coefficients in D and H as percentages of their arithmetic means, and the three seasonal values as percentages of their means. The small figures give the excess of the Falmouth percentages over the corresponding Kew ones ((A), Table XXIV.).

TABLE XIII.—Variation of Fourier Coefficients throughout the Year (1891 to 1902).

	Declination.				Horizontal force.			
	c_1.	c_2.	c_3.	c_4.	c_1.	c_2.	c_3.	c_4.
January	55 −1	52 +6	55 +3	100 +10	38 +9	74 +5	83 +13	113 +11
February	78 +3	58 +2	66 0	101 +9	53 +5	85 +22	90 −1	114 +9
March	98 −1	108 −2	137 +1	182 +7	86 −3	97 −3	132 −1	125 −8
April	117 +1	129 −2	147 −3	135 +7	128 −3	135 −3	144 +9	128 +6
May	129 −1	135 −9	115 −7	55 −1	150 −3	113 +2	68 −6	69 −26
June	141 −3	132 −3	95 0	28 +11	148 −2	107 −7	81 −7	36 −14
July	136 0	130 −2	103 +2	46 −20	145 −6	115 −8	79 −6	52 +11
August	133 0	138 −3	129 −1	76 +12	142 −6	106 −7	116 −7	111 +1
September	117 −1	120 +1	129 −2	131 −44	123 −5	97 −9	150 −3	163 −6
October	91 +2	93 +5	117 +6	171 +6	104 +3	106 −1	126 0	136 +2
November	59 −2	60 +4	68 0	116 +4	61 +6	98 0	87 +6	97 +5
December	46 +2	45 +3	39 +1	59 0	22 +6	67 +11	44 +4	56 +9
Arithmetic mean of 12 monthly absolute values	$2'\cdot 180$	$1'\cdot 822$	$0'\cdot 907$	$0'\cdot 289$	$10\cdot 755\gamma$	$5\cdot 874\gamma$	$2\cdot 608\gamma$	$1\cdot 335\gamma$
Winter	59 0	54 +4	57 +1	95 +3	43 +6	82 +9	79 +6	97 +10
Equinox	106 +1	112 +1	132 +1	157 −9	110 −2	107 −3	133 0	137 −4
Summer	135 0	134 −4	111 −2	48 +6	147 −4	111 −6	88 −6	66 −7

Except in the case of c_4, where there are apparent discontinuities, the irregularities in the difference between the Falmouth and Kew percentages are surprisingly small.

In c_1 for D the differences hardly warrant a conclusion, but on the whole—c_4 for D being a partial exception—the Falmouth values are above the Kew in winter and below them in summer.

Table XIV. gives the ratios borne by c_2, c_3 and c_4 to c_1 in the mean diurnal inequality for the year, and also the excess of the ratios over the corresponding Kew

TABLE XIV.—Relations between Fourier Coefficients in mean Diurnal Inequality for the Year (1891 to 1902).

	c_2/c_1.	c_3/c_1.	c_4/c_1.
Declination	·85 +·08	·42 +·04	·13 +·01
Westerly component	·85 +·07	·47 +·04	·17 +·02
Horizontal force	·53 −·01	·23 −·02	·12 −·02
Northerly component	·60 +·02	·19 ·00	·08 −·01

ones. In D and W the 24-hour term is relatively more important at Kew than at Falmouth, but the reverse is true in the case of H. The differences between the two places are however very small, especially in the case of H and N.

Table XV. gives similar data for the seasonal diurnal inequalities. Corresponding Kew data existed only for D and H. The Kew-Falmouth differences have the same

TABLE XV.—Relations between Fourier Coefficients in Diurnal Inequalities for the Seasons (1891 to 1902).

	c_2/c_1.			c_3/c_1.			c_4/c_1.		
	Winter.	Equinox.	Summer.	Winter.	Equinox.	Summer.	Winter.	Equinox.	Summer.
D	·76 +·11	·89 +·08	·83 +·05	·40 +·04	·52 +·05	·34 +·02	·21 +·03	·19 ·00	·05 +·01
W	·84	·96	·76	·52	·62	·34	·31	·24	·06
H	1·01 −·06	·53 −·01	·41 −·01	·42 −·08	·28 −·02	·14 −·02	·27 −·04	·15 −·02	·05 −·01
N	·85	·56	·52	·31	·22	·10	·15	·09	·04

sign for all three seasons as for the year; they are larger, however, in winter than in summer.

Except in winter the 12-hour and 8-hour terms are decidedly more important relatively to the 24-hour term in D and W than in H and N; and the 8-hour and the 6-hour terms are relatively more important in H than in N. In all cases the 8-hour and 6-hour terms are relatively more important in winter than in summer.

§ 14. To facilitate comparison of the phase angles at Kew and Falmouth,

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Table XVI. gives the values of the angles for the mean diurnal inequalities of the three seasons and the year when Falmouth solar time is used; it corresponds to Table XXVIII. of (A) for Kew.

TABLE XVI.—Seasonal Values of the Angles in Fourier Coefficient Expansions of Diurnal Inequality (1891 to 1902) when Falmouth Solar Time used.

	Declination.				Horizontal force.			
	Winter.	Equinox.	Summer.	Year.	Winter.	Equinox.	Summer.	Year.
α_1	242° 39′	222° 23′	212° 44′	222° 0′	91° 52′	109° 8′	129° 1′	116° 26′
α_2	33 12	40 3	50 25	43 31	274 3	298 33	313 6	297 27
α_3	243 44	229 0	243 27	237 26	157 21	163 48	195 50	171 41
α_4	56 58	56 39	59 18	57 57	5 40	11 53	48 24	18 13

Table XVII. gives the local solar times of the earliest maximum in the day for the several terms. These times, as in (A), Table XXIX.,* are given only to decimals of an hour, it being doubtful whether higher accuracy can be claimed for individual results, especially in the terms of shortest period. In calculating, however, the differences between the local times of occurrence at Falmouth and Kew, I employed the complete

TABLE XVII.—Times of Occurrence of First Maximum in the Terms of the First Four Orders in Fourier Expressions for Diurnal Inequality for the Period 1891 to 1902 (Falmouth Local Time).

Period of term.	Declination.				Horizontal force.			
	Winter.	Equinox.	Summer.	Year.	Winter.	Equinox.	Summer.	Year.
	h.	h.	h.	h.	h.	h.	h.	h.
24 hours . .	13·8 −4	15·2 +3	15·8 +11	15·2 +5	23·9 −35	22·7 −1	21·4 +7	22·2 + 2
12 " . .	1·9 −3	1·7 +3	1·3 + 7	1·5 +4	5·9 + 8	5·0 +7	4·6 +8	5·1 +10
8 " . .	4·6 +2	4·9 +2	4·6 0	4·7 +1	6·5 − 4	6·4 +2	5·6 +6	6·2 + 3
6 " . .	0·6 +1	0·6 +3	0·5 −17	0·5 −1	1·4 + 1	1·3 +1	0·7 −6	1·2 + 1

angles in Table XVI. and the corresponding Table in (A), and, in converting the differences into time, went to the nearest minute. These differences, in minutes, appear in small type in Table XVII., the + sign denoting later occurrence at Falmouth. The approach to coincidence in the local times of occurrence of the maxima at the two stations is truly remarkable. The algebraical mean of all the

* The time 1·1 h. assigned to the Kew 24-hour H-term in winter is in error. It should be 0·5 h.

differences is somewhat under +1 minute, which answers to about 0·25 millim. on the magnetograms. As the sign of individual differences, owing to their exceeding smallness, must be largely fortuitous, the only safe conclusion is that whilst there is a preponderance of + signs (*i.e.*, of cases when the event is later at Falmouth than at Kew), the differences may be accidental and are certainly exceedingly small. The above results refer to the average year, and no inference can safely be drawn as to the differences between Kew and Falmouth in different individual years.

Variation throughout the Year (Fourier Series).

§ 15. The ranges of the diurnal inequalities, the sums of the 24 differences from the mean, and the amplitudes of the 24-, 12-, 8-, and 6-hour terms have had their annual variations expressed in Fourier series, the constants being calculated from the monthly values. Table XVIII. gives the results for the 12-year period. The time t is counted from midnight of December 31 to January 1, and a month is equivalent to 30°. The amplitudes of the annual and semi-annual terms—which suffice to express the variation very completely—are denoted respectively by P_1 and P_2. The table gives the ratio of P_2 to P_1, and also of P_1 and P_2 to M, the mean of the 12 monthly values of the element concerned. The reservations necessary are discussed in (A), § 37.

The excess of the values of P_1/M, &c., at Falmouth, over those at Kew are given as usual in small type; in the case of c_3 and c_4 these differences are omitted for P_2/P_1 as too uncertain. Except in the annual term in c_4 the phase angles differ comparatively little amongst themselves; the same phenomenon appeared at Kew ((A), Table XXX.).

Considering the smallness of c_4, one would be disposed to suspect that the large difference between the phase angles of the annual term in that element and the other angles, though appearing in both D and H, was due to defects in the observations or reductions. Exactly the same phenomenon appeared, however, in the corresponding case at Kew (see (A), Table XXX.).

The ratios borne by the amplitudes of the annual and semi-annual terms to the mean value of the element at Kew and Falmouth differ comparatively little. But if we exclude c_4, where the element and its variable part are both very small, we see that on the whole the annual term at Falmouth is somewhat less important as compared either to the semi-annual term or to the absolute mean than it is at Kew. This is what Tables IX. and XIII. would lead us to expect.

§ 16. The dates of occurrence of the maximum in the annual terms, and of the earliest maximum in the semi-annual terms, are given in Table XIX. As explained in (A), § 38, these dates may be uncertain to the extent of a whole day, for they are based on a treatment which disregarded differences between the lengths of the several months.

TABLE XVIII.—Diurnal Inequalities, Annual Variation in Fourier Series (1891 to 1902).

(Units 1′ for D, 1γ for H.)

		Formulæ.	P_1/M.		P_2/M.		P_2/P_1.	
Ranges	D	$7 \cdot 88 + 3 \cdot 51 \sin(t+275°) + 1 \cdot 26 \sin(2t+277°)$	·44	−·03	·16	+·01	·36	+·04
	H	$29 \cdot 9 + 13 \cdot 0 \sin(t+269°) + 3 \cdot 3 \sin(2t+262°)$	·44	−·04	·11	·00	·26	+·04
Sum of 24 differences from mean	D	$39 \cdot 15 + 15 \cdot 82 \sin(t+272°) + 4 \cdot 79 \sin(2t+292°)$	·40	−·02	·12	·00	·30	+·02
	H	$178 \cdot 9 + 89 \cdot 7 \sin(t+269°) + 20 \cdot 6 \sin(2t+244°)$	·50	−·06	·12	−·02	·23	−·01
c_1	D	$2 \cdot 18 + 0 \cdot 99 \sin(t+274°) + 0 \cdot 18 \sin(2t+306°)$	·45	·00	·08	+·01	·18	+·02
	H	$10 \cdot 75 + 6 \cdot 56 \sin(t+268°) + 1 \cdot 40 \sin(2t+254°)$	·61	−·06	·13	−·02	·21	−·01
c_2	D	$1 \cdot 82 + 0 \cdot 86 \sin(t+274°) + 0 \cdot 24 \sin(2t+274°)$	·47	−·05	·13	·00	·28	+·02
	H	$5 \cdot 87 + 1 \cdot 11 \sin(t+281°) + 0 \cdot 71 \sin(2t+239°)$	·19	−·08	·12	−·02	·64	+·11
c_3	D	$0 \cdot 91 + 0 \cdot 28 \sin(t+278°) + 0 \cdot 31 \sin(2t+276°)$	·31	−·02	·35	·00	1·11	
	H	$2 \cdot 61 + 0 \cdot 23 \sin(t+244°) + 1 \cdot 15 \sin(2t+291°)$	·09	−·06	·44	+·03	5·08	
c_4	D	$0 \cdot 29 + 0 \cdot 08 \sin(t+91°) + 0 \cdot 16 \sin(2t+276°)$	·27	+·03	·56	−·03	2·04	
	H	$1 \cdot 34 + 0 \cdot 24 \sin(t+119°) + 0 \cdot 62 \sin(2t+292°)$	·18	+·09	·46	−·01	2·62	

TABLE XIX.—Annual Variation (1891 to 1902). Date of Occurrence of First Maximum.

	Annual term.		Semi-annual term.	
	D.	H.	D.	H.
Ranges	June 27 +1	July 3 0	March 29 −2	April 6 −1
Sum of 24 differences	,, 29 +1	,, 3 0	,, 21 −1	,, 15 +6
c_1	,, 28 0	,, 4 0	,, 14 −1	,, 10 +4
c_2	,, 28 +2	June 20 −12	,, 31 −2	,, 18 +1
c_3	,, 23 +2	July 28 −3	,, 29 −1	March 22 −1
c_4	December 30 +24	December 2 +7	,, 29 +1	,, 21 −4

The figures in small print denote the differences in *days* between the times of occurrence of corresponding maxima at Falmouth and Kew, the plus sign indicating a later occurrence at Falmouth. The phase angles, though recorded in Table XVIII. and in Table XXX. of (A) only to the nearest whole degree, were really worked out to minutes of arc, and the differences in Table XIX. were derived from these more complete angles. The differences are also nearly free from several sources of uncertainty which enter nearly equally into the absolute values of the phase angles at Kew and Falmouth.

The algebraic mean of the differences, when taken to the nearest 1′ and converted into time, represents +22 hours, but if the somewhat outstanding result from the annual term for c_4 in D be omitted, this becomes −1 hour. Thus no certain conclusions can be drawn as to whether the maxima in the annual variation appear earlier at Kew or at Falmouth. The truly remarkable approach to coincidence between the Kew and Falmouth dates certainly points to the conclusion that the annual and semi-annual terms represent very real phenomena, determined by laws which vary but slightly over large areas.

These results, it must again be pointed out, relate to the mean year of a sun-spot cycle, and so throw no light on the differences that may exist between individual years' results at the same or at different British stations.

Relations with Meteorological Phenomena.

§ 17. Table XX. gives the mean values of certain meteorological elements at Falmouth for the entire period 1891 to 1902, the sun-spot maximum period 1892 to 1895, and the sun-spot minimum period 1899 to 1902. It also gives the algebraic excess of the mean for the sun-spot minimum period over that for the sun-spot maximum period. Corresponding excess data for Kew are given (a) for the same periods as at Falmouth, (b) when the sun-spot minimum period consists of the three

TABLE XX.—Mean Values of Meteorological Elements.

	Mean annual temperature (Fahrenheit).	Mean daily range of temperature.	Mean vapour-pressure.	Mean height of barometer.
Falmouth, 1891 to 1902	50°·53	9°·14	0·315	29·991
,, 1892 ,, 1895	50·15	9·50	0·309	29·980
,, 1899 ,, 1902	50·62	8·95	0·316	29·984
,, sun-spot minimum – sun-spot maximum	+ 0·47	– 0·55	+ 0·007	+ 0·004
Kew (*a*) ,, ,, ,, ,,	+ 0·42	– 0·22	+ 0·004	+ 0·005
,, (*b*) ,, ,, ,, ,,	+ 0·39	– 0·07	+ 0·005	+ 0·006

years 1890, 1899, and 1900. The last set of Kew results are deducible from Table XLVI. of (A). The Falmouth data are from the tables in the annual 'Reports of the Royal Cornwall Polytechnic Society.' They are deduced from the curves given by self-recording instruments of the same pattern as at Kew. There are other temperature data in the Falmouth Reports; but they relate to thermometers in a Stevenson screen and are less comparable with the Kew data. The vapour-pressures and barometric heights in the table are in inches of mercury; the temperatures are in degrees Fahrenheit.

The mean height of the barometer for the whole 12 years was higher than the mean height during either the sun-spot maximum or minimum periods, and the same phenomenon appeared at Kew whether the periods were those of case (*a*) or case (*b*). Again, the mean vapour-pressure for the whole period did not differ from that for the sun-spot minimum period by more than 0·001 inch either at Falmouth or Kew. Thus in these two elements there is less evidence for a connection with sun-spot frequency than might appear at first sight. As regards the mean daily range of temperature, whilst all the differences are of one sign, they vary much in size, and the mean from the 11 years 1890 to 1900 at Kew was smaller than that from either sun-spot period in (*b*).

§ 18. In the case of the mean annual temperature, the long-period mean was intermediate in all three instances between those for the periods of sun-spot maximum and minimum, and the differences between these two latter means are fairly similar. The existence of a difference between the average mean temperature of years of sun-spot maximum and minimum is accepted as an established fact in HANN's 'Climatology.'* According to HANN's figures the mean excess of temperature in a period of four sun-spot minimum years over a period of four sun-spot maximum years, situated relatively to maximum and minimum as in the case of the Falmouth groups of years, is for a tropical station no less than 0°·55 C., the difference between the two

* English Translation by WARD, p. 405.

extreme years of an 11-year period amounting to 0°·73 C. At an average extra-tropical station, according to HANN, this latter figure is reduced to 0°·54 C. Allowing tentatively a corresponding reduction on the 0°·55 C., it becomes 0°·41 C. Thus the differences recorded in Table XX. are not merely of the normal sign, but even of somewhat the same order of magnitude as they should be according to HANN at an average extra-tropical station on the average of a number of sun-spot periods.

The fact that in Table XX. a rise in the mean annual temperature is associated with a diminution in the mean daily range may be accidental, but is possibly worth fuller investigation.

§ 19. Table XXI. shows the variation throughout the year at Falmouth in the mean vapour-pressure for the 24 hours, in the daily range of temperature, and in the amplitudes of the 24-hour and 12-hour terms in the diurnal inequality of temperature.

TABLE XXI.—Monthly Relative Values (100 = mean from 12 months).

	Vapour-pressure.	Ranges.		c_1.		c_2.	
		Temperature.	Magnetics.	Temperature.	Magnetics.	Temperature.	Magnetics.
January	73 +1	77 +15	56 +2	41 + 2	47 +4	81 −19	63 + 5
February	72 +2	82 + 7	64 +2	58 + 6	65 +3	108 − 5	71 +12
March	74 0	98 0	100 −2	92 −10	92 −2	119 −38	103 − 2
April	86 +1	108 − 9	130 +2	116 −10	122 −1	104 − 7	132 − 3
May	96 −3	122 − 3	130 −4	151 + 4	139 −2	75 +35	124 − 3
June	123 −3	122 − 6	130 −2	152 + 8	145 −2	65 +32	119 − 5
July	136 −3	121 − 3	129 −2	161 +15	141 −2	70 +47	123 − 5
August	139 −3	114 − 2	133 0	138 − 1	138 −2	111 +24	122 − 5
September	127 0	106 −13	121 +1	112 −11	120 −3	131 −23	108 − 5
October	102 0	93 − 2	99 +3	80 −11	97 +2	126 −41	100 + 2
November	89 −1	82 + 6	67 +1	54 0	60 +2	108 −16	79 + 2
December	83 +9	75 + 8	41 −1	45 + 8	34 +4	102 +12	56 + 7

The mean monthly values are expressed as percentages of their arithmetic mean. The vapour-pressure and temperature-range data are based on the tables in the Falmouth Reports for 1891 to 1902. The data for c_1 and c_2 relate to the period 1871 to 1882, and are calculated from mean absolute monthly values given by General STRACHEY.* The figures in the columns headed "magnetics" are means from the data for D and H in Tables IX. and XIII. The small figures give the excess over corresponding percentages for Kew. The magnetic data employed here for Kew refer, like the Falmouth, to D and H only, and so differ slightly from those given in Table XLVIII. of (A). There is a general resemblance between the annual variations of vapour-pressure, temperature range, and magnetic range; but, as at Kew, the

* 'Phil. Trans.' for 1893, p. 644.

winter minimum occurs earlier and is more strongly marked in "magnetics" than in either meteorological element.

The resemblance between the annual variations in the amplitude c_1 of the 24-hour term in temperature and magnetics was somewhat striking at Kew ((A), § 68). This resemblance is also visible in Table XXI., but is decidedly less close. In the case of c_2 the annual variations in temperature and magnetics are less conspicuously unlike than at Kew, but still wide apart.

Vapour-pressure and temperature range agree with the several magnetic quantities in showing at Falmouth higher percentages in winter and lower percentages in summer than at Kew. The Falmouth amplitude c_1 in temperature shows relative to the Kew c_1 increased percentages at midwinter, but it differs entirely from the magnetic c_1 in showing still more enhanced percentages at midsummer and largely diminished percentages at the equinoxes.

The mode of difference between the Kew and Falmouth annual variations in c_2 is diametrically opposite for temperature and magnetics.

§ 20. As the existence or non-existence of parallelism between the modes of daily variation of temperature and terrestrial magnetism is of importance in inquiries as to how the diurnal magnetic inequality comes into existence, attention may usefully be called to some further points.

As remarked in §§ 7 and 8, the mean diurnal ranges of declination at Kew and Falmouth are almost exactly equal, whilst the diurnal range in H is somewhat greatest at Falmouth. The mean difference, however, between the daily maximum and minimum of temperature from 1891 to 1902 was only 9°·1 at Falmouth as against 13°·6 at Kew; whilst taking the mean diurnal inequality for the year from the Meteorological Office's "Hourly Readings . . ." during the sun-spot maximum period 1892 to 1895, the range was 5°·7 at Falmouth, 10°·0 at Kew.

Again, the amplitudes of the principal Fourier terms in the mean magnetic diurnal inequality at Falmouth are very similar to those at Kew in D and larger on the whole in H. In the case of temperature, however, General STRACHEY obtained the following values for the amplitudes of the three principal terms during a common period 1871 to 1882:—

	24-hour term.	12-hour term.	8-hour term.
Falmouth	2°·35	0°·60	0°·26
Kew	4·46	0·84	0·38

Further, in § 14 we saw that the local times of occurrence of the maxima in the Fourier terms in the diurnal inequalities for D and H were as nearly as possible identical at Kew and Falmouth. General STRACHEY,* on the other hand, also

* 'Phil. Trans.,' *loc. cit.*, p. 645.

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employing local time, found that the phase angles were in every month of the year larger at Kew than at Falmouth in the 24- and 12-hour temperature terms, whilst the Kew angle for the 8-hour term was the larger in eleven months of the year. The mean of the 12 monthly differences between the Kew and Falmouth phase angles from General STRACHEY's figures are as follows :—

	24-hour term.	12-hour term.	8-hour term.
In angle.	14°·1	11°·2	5°·2
In time (to nearest minute) .	56 minutes	22 minutes	7 minutes

It is thus clear that temperature phenomena *near the earth's surface* in England are modified by local conditions, such as proximity to the sea coast, in a degree to which there is no parallel in the phenomena of terrestrial magnetism.

As in (A), all the Fourier coefficients made use of in the paper were calculated directly from the formulæ. In the laborious arithmetical work involved in this and in some other parts of the paper I have received valuable assistance from Mr. B. FRANCIS, Assistant in the Observatory Department. Amidst such a multiplicity of figures absolute freedom from error can hardly be hoped for, but all calculations have been gone through at least twice, and every reasonable precaution has been taken to avoid mistakes.