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XI. *Records of the Magnetic Phenomena at the Kew Observatory.*—No. IV. *Analysis of the principal Disturbances shown by the Horizontal and Vertical Force Magnetometers of the Kew Observatory, from* 1859 *to* 1864. *By* General Sir EDWARD SABINE, *K.C.B., President.*

THIS paper contains an analysis of the first portion of the Automatic Records obtained at the Kew Observatory by means of the self-recording Horizontal and Vertical Force Magnetometers devised by the late Superintendent of that Observatory, Mr. JOHN WELSH, aided by Mr. BECKLEY, Engineer in that establishment.

The Record of the Horizontal Force commenced on the 1st of January, 1858, and that of the Vertical Force a year later, viz. on the 1st of January, 1859. The present notice includes the records of both to the 31st of December, 1864,—making seven complete years of the Horizontal Force, and six complete years of the Vertical Force. The daily Photograms, from which the results have been derived, are carefully preserved at the Observatory, and hitherto, at least, appear to have suffered little or no deterioration. The apparatus and methods by which the photograms are obtained have been already fully described. The Observatory had the great misfortune of losing the Superintendence of Mr. WELSH by his decease in 1859; but the instruments and methods which he had so ably devised, have continued and still continue in use, unchanged. It was originally his intention to discuss the results obtained with the self-recording magnetic instruments in successive periods, each of six years, beginning with 1858; but in consequence of the illness which preceded his death, no preparations had been made for the commencement of this work. The photograms were indeed preserved with all suitable care, but were liable, as must necessarily be the case even under the most favourable conditions, to deterioration. Under these circumstances I ventured in 1862 to propose to Mr. GASSIOT, Chairman of the Kew Committee (of which I was myself a member), that the photograms of the First of the Periods contemplated by Mr. WELSH, viz. from January 1, 1858, to December 31, 1864, should be entrusted to me, to be tabulated by the non-commissioned Officers at the Woolwich Magnetic Office, and subsequently discussed by myself on the same plan as the Eye-observations at the Colonial Magnetic Observatories had been discussed. This arrangement, so far as the tabulation was concerned, was speedily effected, and the Photograms were forthwith returned for safe custody to Kew, where they remain and are in good preservation. My own time, and that of the Office, having been much occupied latterly in preparing the Maps of the Magnetic Elements corresponding to the Epoch of 1842.5, the deductions from the Photograms, from January 1858 to December 1864, have not been completed at so early a

date as I could have wished, and should otherwise have accomplished ; but I now present them as the first instalment of a research which I hope we may regard as permanently established and provided for by Mr. GASSIOT'S munificent donation.

The method by which the tabulated hourly records of the Horizontal and Vertical Forces have been separated into their two categories of disturbed and (comparatively) undisturbed values, was described originally in the 3rd Volume of the Magnetical Observations at the Toronto Observatory, published in 1847, and has since been frequently employed and discussed in papers printed in the Philosophical Transactions and elsewhere. It is the same which was subsequently adopted by Dr. ALEXANDER DALLAS BACHE, For. Member of the Royal Society, in his admirable discussion of the Results of the Magnetical Observations made at the Girard College Observatory in Philadelphia, in the years 1840 to 1847 inclusive, published in the Smithsonian Contributions to Knowledge, vols. xii. and xiii. In the case of the hourly records of the horizontal Force at Kew between January 1, 1858, and December 31, 1864, the number of instances in which the records indicated an amount of disturbance equalling or exceeding ·150 of an inch, taken as the separating value, was 5932, being about 1 in 10; and in the case of the records of the Vertical Force between the 1st of January 1859 and the 31st of December 1864, 6957, being about 1 in 7 of the whole body. The value of ·150 of an inch in parts of the respective forces in the different years was as follows:—

	Horizontal Force.	Vertical Force.
1858	0·00124	————
1859	0·00141	0·000357
1860	0·00152	0·000377
1861	0·00157	0·000389
1862	0·00162	0·000381
1863	0·00168	0·000377
1864	0·00174	0·000399
Means . .	0·00154	0·000380

Distributed into the several years of their occurrence, these showed the proportions in each year to be as follows:

In the Horizontal Force.

Year ending December 31, 1858	267·893 inches.
,, ,, 1859	369·286 ,,
,, ,, 1860	270·349 ,,
,, ,, 1861	206·748 ,,
,, ,, 1862	183·645 ,,
,, ,, 1863	114·642 ,,
,, ,, 1864	114·725 ,,
Total in the 7 years . . .	1527·288 ,,

Mean Annual Value $\dfrac{1527\cdot288}{7} = 218\cdot184$,,

In the Vertical Force.

Year ending December 31, 1859 . . . . 540·235 inches.

,,   ,,   1860 . . . . 364·208 ,,

,,   ,,   1861 . . . . 226·625 ,,

,,   ,,   1862 . . . . 358·756 ,,

,,   ,,   1863 . . . . 174·712 ,,

,,   ,,   1864 . . . . 238·597 ,,

Total in the 6 years . . . 1903·133 ,,

Mean Annual Value $\dfrac{1903·140}{6} = 317·189$,,

Hence it appears that of the years comprised in the Record, 1859 was manifestly the year of greatest disturbance both in the Horizontal and Vertical Forces; and 1863, or we might say 1863 and 1864, the year or years of least disturbance *.

I proceed to the details in the different years:—

Horizontal Force Disturbances, from 1st January 1858 to 31st December 1864.

The number of the Bifilar observations in which the amount of disturbance equalled or exceeded ·150 inch in the 7 years was 5932, being about 1 in 10 of the whole body of the observations taken from the traces (60491).

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* The earliest indication of what is now so generally recognized as "the Disturbance Period of the Magnetic Variations" is derivable from ARAGO's Observations of the Declination in Paris, commenced in 1820 and terminated in 1830. [Editor's Note, pages 355–357, in the English translation of Metereological Essays by FRANÇOIS ARAGO (LONGMAN), 1855.] The Epoch of Minimum shown by those observations occurred in 1823–24, and the Epoch of Maximum in 1829. The annual increase was progressive and continuous from the minimum to the maximum; and the years preceding 1823 and following 1829 showed portions of a corresponding variation.

From the period of the establishment of the British Colonial Observatories in 1841, however, we may date the existence of a more full and systematic investigation of the phenomena of the Decennial Magnetic Variation, not limited to a single element, viz. the Declination, as in the case of M. ARAGO's observations, but including also the phenomena of the Horizontal and Vertical Forces, observed or recorded by suitable methods. From the concurrent testimony obtained from localities widely separated from each other, such as Toronto in Canada, Hobarton in Tasmania, Munich in Germany, and Girard College in the United States of America, we have learnt that 1843–44 was an Epoch of Minimum, and 1848–49 an Epoch of Maximum Disturbance in each of the three Magnetic Elements. The further evidence contained in this paper, derived from the Automatic Records of the Horizontal and Vertical Forces at the Kew Observatory, shows that 1858–59 was also an Epoch of Maximum, and 1863–64 an Epoch of Minimum.

The facts thus brought together exhibit an accordance (too close to be regarded as accidental) with the Decennial Variation in the phenomena of the Solar Spots observed by HOFRATH SCHWABE, Hon. F.R.S., as announced by himself in the following words:—" The numbers in the accompanying Table leave no doubt that from 1826 to 1850 the occurrence of spots has been so far characterized by periods of ten years, that its maxima have fallen in 1828, 1837, 1848, and its minima in 1833 and 1843." [HUMBOLDT's Cosmos (LONGMAN), vol. iii. pages 291 and 292.]

TABLE I.—Aggregate Values of the disturbed observations.

Year ending December 31st, 1858	. . . .	267·893 inches.
„	„	1859	. . . .	369·286 „
„	„	1860	. . . .	270·349 „
„	„	1861	. . . .	206·748 „
„	„	1862	. . . .	183·645 „
„	„	1863	. . . .	114·642 „
„	„	1864	. . . .	114·725 „
	Total in the 7 years	. . .	1527·288 „

Mean Annual Value $\dfrac{1527 \cdot 288}{7} = 218 \cdot 184$ „

TABLE II.—Ratios in each year to the Mean Annual Value.

Year ending December 31st, 1858	. . . .	1·23
„	„	1859	. . . .	1·69
„	„	1860	. . . .	1·24
„	„	1861	. . . .	0·95
„	„	1862	. . . .	0·84
„	„	1863	. . . .	0·53
„	„	1864	. . . .	0·53

TABLE III.—Aggregate Values in the different years divided into disturbances increasing the Force, and disturbances decreasing the Force.

				Increasing.	Decreasing.
Year ending December 31st, 1858	. . . .	74·949	192·944 inches.
„	„	1859	. . . .	85·256	284·030 „
„	„	1860	. . . .	86·114	184·235 „
„	„	1861	. . . .	27·221	179·527 „
„	„	1862	. . . .	46·342	137·303 „
„	„	1863	. . . .	21·192	93·450 „
„	„	1864	. . . .	20·432	94·293 „
	Total in the 7 years	. . . .	361·506	1165·782 „

The ratio of the value of the disturbances decreasing the Force to those which increased it was, on the average of the 7 years, nearly as 3·23 to 1.

TABLE IV.—Aggregate Values of the disturbed observations distributed into the several *months* of their occurrence, with the ratios which the values in the preceding column (or the sums in the 7 years) bear to the mean monthly value, or average of all the months.

Months.	Years ending December 31.							Sums in the 7 years.	Ratios.	Months.
	1858.	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.	in.		
Jan.	3·557	15·969	8·204	42·588	12·846	17·974	1·071	102·209	0·80	Jan.
Feb.	24·035	25·711	16·041	28·481	8·217	11·089	5·256	118·830	0·93	Feb.
Mar.	44·388	10·497	38·120	18·924	7·195	9·491	8·643	137·258	1·08	Mar.
April	43·457	39·991	26·714	11·169	5·330	10·599	7·420	144·680	1·14	April
May	32·268	14·661	16·990	7·610	6·146	5·511	10·646	93·832	0·74	May
June	18·750	17·897	12·773	7·080	5·458	5·473	21·756	89·187	0·70	June
July	17·574	29·487	39·631	17·260	14·758	11·538	11·901	142·149	1·12	July
Aug.	7·569	45·249	62·801	12·501	37·801	12·265	15·440	193·626	1·52	Aug.
Sept.	12·472	61·234	16·212	8·772	13·781	10·823	9·438	132·732	1·04	Sept.
Oct.	26·163	40·283	13·188	20·996	35·139	8·395	10·029	154·193	1·21	Oct.
Nov.	9·050	31·288	5·223	13·239	8·395	9·364	7·949	84·508	0·66	Nov.
Dec.	28·610	37·019	14·452	18·128	28·579	2·120	5·176	134·084	1·05	Dec.

Total in the 7 years .... 1527·288

Mean monthly value $\dfrac{1527·288}{12} =$ 127·274 = 1·00

Tables V. and VI. exhibit the aggregate monthly values in the different years separated into disturbances increasing the Force and disturbances decreasing the Force.

TABLE V.—Disturbances increasing the Force.

Months.	Years ending December 31.							Sums in the 7 years.	Ratios.	Months.
	1858.	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.	in.		
Jan.	1·345	1·675	1·655	1·566	0·818	1·115	0·158	8·332	0·28	Jan.
Feb.	5·731	1·594	0·625	2·222	0·287	0·942	0·355	11·756	0·39	Feb.
Mar.	10·289	1·916	4·637	2·690	0·340	0·743	1·205	21·820	0·72	Mar.
April	12·252	5·593	7·812	2·625	0·824	4·148	1·691	34·945	1·16	April
May	13·791	7·276	11·926	4·711	3·229	2·441	3·437	46·811	1·55	May
June	10·861	6·379	4·447	3·158	4·563	2·575	3·596	35·579	1·18	June
July	9·368	6·879	14·452	1·029	4·111	2·578	3·584	42·001	1·39	July
Aug.	1·929	4·862	33·578	3·809	14·774	2·667	1·947	63·566	2·11	Aug.
Sept.	3·175	13·568	4·281	2·035	8·273	2·317	1·106	34·755	1·15	Sept.
Oct.	2·793	7·885	1·253	1·561	4·321	0·493	1·252	19·558	0·65	Oct.
Nov.	1·792	10·238	0·301	0·300	1·816	0·654	1·162	16·263	0·54	Nov.
Dec.	1·623	17·391	1·147	1·515	2·986	0·519	0·939	26·120	0·87	Dec.

Total in the 7 years .... 361·506

Mean monthly value $\dfrac{361·506}{12} =$ 30·125 = 1·00

TABLE VI.—Disturbances decreasing the Force.

| Months. | Years ending December 31. | | | | | | | Sums in the 7 years. | Ratios. | Months. |
	1858.	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.	in.		
Jan.	2·212	14·294	6·549	41·022	12·028	16·859	0·913	93·877	0·97	Jan.
Feb.	18·304	24·117	15·416	26·259	7·930	10·147	4·901	107·074	1·10	Feb.
Mar.	34·099	8·581	33·483	16·234	6·855	8·748	7·438	115·438	1·19	Mar.
April	31·205	34·398	18·902	8·544	4·506	6·451	5·729	109·735	1·13	April
May	18·477	7·385	5·064	2·899	2·917	3·070	7·209	47·021	0·48	May
June	7·889	11·518	8·326	3·922	0·895	2·898	18·160	53·608	0·55	June
July	8·206	22·608	25·179	16·231	10·647	8·960	8·317	100·148	1·03	July
Aug.	5·640	40·387	29·223	8·692	23·027	9·598	13·493	130·060	1·34	Aug.
Sept.	9·297	47·666	11·931	6·737	5·508	8·506	8·332	97·977	1·01	Sept.
Oct.	23·370	32·398	11·935	19·435	30·818	7·902	8·777	134·635	1·39	Oct.
Nov.	7·258	21·050	4·922	12·939	6·579	8·710	6·787	68·245	0·70	Nov.
Dec.	26·987	19·628	13·305	16·613	25·593	1·601	4·237	107·964	1·11	Dec.
Total in the 7 years								1165·782		
Mean monthly value $\frac{1165·782}{12}=$								97·149=1·00		

TABLE VII.—Aggregate Values of the disturbed observations distributed into the several *hours* of their occurrence, together with the ratios of the values at the different hours to the mean hourly value or average of all the hours.

| Kew Astronomical hours. | Years ending December 31. | | | | | | | Sums in the 7 years. | Ratios. | Kew Civil Time. |
	1858.	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.	in.		
18	9·766	14·521	9·441	6·209	5·754	3·618	3·800	53·109	0·83	6 A.M.
19	10·897	15·639	12·484	6·257	7·291	4·126	5·933	62·627	0·98	7 ,,
20	11·556	14·883	12·476	7·499	8·536	5·144	6·566	66·660	1·05	8 ,,
21	12·396	14·950	14·853	8·239	8·078	6·502	8·494	73·512	1·16	9 ,,
22	14·117	16·340	14·447	9·459	8·377	7·182	6·781	76·703	1·21	10 ,,
23	12·962	16·527	14·802	8·632	7·691	5·548	5·824	71·986	1·13	11 ,,
0	11·512	18·032	12·799	7·004	6·718	4·464	3·923	64·452	1·01	Noon.
1	11·207	11·284	8·370	7·099	5·418	5·296	4·727	53·401	0·84	1 P.M.
2	10·679	12·367	9·701	7·687	6·188	5·031	4·382	56·035	0·88	2 ,,
3	10·533	16·711	15·310	8·944	5·702	3·708	3·530	64·438	1·01	3 ,,
4	10·951	15·307	13·413	7·954	6·611	4·546	4·924	63·706	1·00	4 ,,
5	10·630	18·109	15·480	7·409	7·210	4·808	4·190	67·836	1·07	5 ,,
6	12·219	13·161	11·239	9·311	8·644	5·131	4·540	64·245	1·01	6 ,,
7	12·141	13·080	8·746	8·266	9·501	3·074	4·405	59·213	0·93	7 ,,
8	10·504	15·408	8·527	11·210	10·296	4·596	3·759	64·300	1·01	8 ,,
9	10·700	13·984	9·911	12·340	9·277	5·228	5·255	66·695	1·05	9 ,,
10	12·210	15·411	10·805	11·059	10·088	7·063	4·823	71·459	1·12	10 ,,
11	14·210	17·396	10·082	13·423	9·024	5·818	6·594	76·547	1·20	11 ,,
12	12·960	17·552	11·286	10·882	9·471	5·073	6·683	73·907	1·16	Midnight.
13	9·551	18·324	10·158	10·536	8·151	4·870	5·008	66·598	1·05	1 A.M.
·14	9·312	16·828	9·211	7·942	7·208	3·494	3·022	57·017	0·90	2 ,,
15	10·663	13·844	9·392	6·794	6·479	2·870	2·263	52·305	0·82	3 ,,
16	9·129	14·315	9·961	5·877	5·027	3·279	2·732	50·320	0·79	4 ,,
17	7·088	15·313	7·455	6·716	6·905	4·173	2·567	50·217	0·79	5 ,,
Total in the 7 years								1527·288		
Mean hourly value $\frac{1527·288}{24}=$								63·637=1·00		

Tables VIII. and IX. exhibit the aggregate values at the different hours separated into disturbances increasing the Force and disturbances decreasing the Force, and also the ratios of the values at each hour of both kinds of disturbance to their respective mean hourly values.

TABLE VIII.—Disturbances increasing the Force.

Kew Astrono- mical hours.	Years ending December 31.							Sums in the 7 years.	Ratios.	Kew Civil Time.
	1858.	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.	in.		
18	1·654	1·537	2·476	0·691	1·262	0·645	0·392	8·657	0·57	6 A.M.
19	1·452	1·644	3·358	0·540	1·059	0·562	0·369	8·984	0·60	7 ,,
20	1·660	2·091	2·663	0·538	1·216	0·519	0·473	9·160	0·61	8 ,,
21	1·559	2·550	2·627	1·303	1·955	0·154	0·163	10·311	0·68	9 ,,
22	2·660	2·542	2·912	1·198	1·491	0·821	0·506	12·130	0·81	10 ,,
23	3·634	3·140	2·971	1·614	1·002	0·690	0·680	13·731	0·91	11 ,,
0	3·127	3·111	2·973	1·967	1·497	0·156	0·362	13·193	0·88	Noon.
1	3·920	4·631	2·781	1·794	1·961	0·667	0·513	16·267	1·08	1 P.M.
2	3·020	6·038	5·121	0·877	2·425	0·869	0·853	19·203	1·27	2 ,,
3	4·488	9·391	10·419	1·719	2·576	1·052	0·748	30·393	2·02	3 ,,
4	5·383	8·398	8·438	2·792	2·180	1·829	1·540	30·560	2·03	4 ,,
5	7·524	11·107	10·866	1·940	3·060	1·520	1·461	37·478	2·49	5 ,,
6	6·307	4·764	6·232	2·903	2·518	1·895	1·243	25·862	1·72	6 ,,
7	4·433	4·139	3·183	0·951	1·371	0·709	1·815	16·601	1·10	7 ,,
8	1·945	2·538	2·197	0·742	3·318	1·032	1·380	13·152	0·87	8 ,,
9	2·044	1·787	1·217	1·333	3·004	1·537	1·405	12·327	0·82	9 ,,
10	1·633	1·771	1·305	0·565	2·008	1·560	1·397	10·239	0·68	10 ,,
11	3·818	2·571	2·335	0·929	1·611	0·747	1·480	13·491	0·90	11 ,,
12	2·366	2·088	1·885	0·514	2·370	0·596	1·229	11·048	0·73	Midnight.
13	1·981	1·535	2·645	0·320	1·703	0·335	0·836	9·355	0·62	1 A.M.
14	2·991	2·224	2·296	0·000	1·357	0·712	0·458	10·038	0·67	2 ,,
15	3·070	1·111	2·006	0·629	1·879	1·132	0·599	10·426	0·69	3 ,,
16	2·221	1·862	1·566	0·746	1·754	0·594	0·380	9·123	0·61	4 ,,
17	2·059	2·686	1·642	0·616	1·765	0·859	0·150	9·777	0·65	5 ,,

Total in the 7 years .... 361·506

Mean hourly value $\dfrac{361·506}{24} =$ 15·063 = 1·00

TABLE IX.—Disturbances decreasing the Force.

Kew Astronomical hours.	Years ending December 31.							Sums in the 7 years.	Ratios.	Kew Civil Time.
	1858.	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.	in.		
18	8·112	12·984	6·965	5·518	4·492	2·973	3·408	44·452	0·92	6 A.M.
19	9·445	13·995	9·126	5·717	6·232	3·564	5·564	53·643	1·10	7 „
20	9·896	12·792	9·813	6·961	7·320	4·625	6·093	57·500	1·18	8 „
21	10·837	12·400	12·226	6·936	6·123	6·348	8·331	63·201	1·30	9 „
22	11·457	13·798	11·535	8·261	6·886	6·361	6·275	64·573	1·33	10 „
23	9·328	13·387	11·831	7·018	6·689	4·858	5·144	58·255	1·20	11 „
0	8·385	14·921	9·826	5·037	5·221	4·308	3·561	51·259	1·06	Noon.
1	7·287	6·653	5·589	5·305	3·457	4·629	4·214	37·134	0·76	1 P.M.
2	7·659	6·329	4·580	6·810	3·763	4·162	3·529	36·832	0·76	2 „
3	6·045	7·320	4·891	7·225	3·126	2·656	2·782	34·045	0·70	3 „
4	5·568	6·909	4·975	5·162	4·431	2·717	3·384	33·146	0·68	4 „
5	3·106	7·002	4·614	5·469	4·150	3·288	2·729	30·358	0·62	5 „
6	5·912	8·397	5·007	6·408	6·126	3·236	3·297	38·383	0·79	6 „
7	7·708	8·941	5·563	7·315	8·130	2·365	2·590	42·612	0·88	7 „
8	8·559	12·870	6·330	10·468	6·978	3·564	2·379	51·148	1·05	8 „
9	8·656	12·197	8·694	11·007	6·273	3·691	3·850	54·368	1·12	9 „
10	10·577	13·640	9·500	10·494	8·080	5·503	3·426	61·220	1·26	10 „
11	10·392	14·825	7·747	12·494	7·413	5·071	5·114	63·056	1·30	11 „
12	10·594	15·464	9·401	10·368	7·101	4·477	5·454	62·859	1·29	Midnight.
13	7·570	16·789	7·513	10·216	6·448	4·535	4·172	57·243	1·18	1 A.M.
14	6·321	14·604	6·915	7·942	5·851	2·782	2·564	46·979	0·97	2 „
15	7·593	12·733	7·386	6·165	4·600	1·738	1·664	41·879	0·86	3 „
16	6·908	12·453	8·395	5·131	3·273	2·685	2·352	41·197	0·85	4 „
17	5·029	12·627	5·813	6·100	5·140	3·314	2·417	40·440	0·83	5 „
Total in the 7 years								1165·782		
Mean hourly value $\dfrac{1165·782}{24}=$								48·574=1·00		

Vertical Force Disturbances, from 1st January 1859 to 31st December 1864.

The number of the Vertical Force Observations in which the amount of disturbance equalled or exceeded ·150 inch in the 6 years was 6957, being about 1 in 7 of the whole number of observations taken from the traces (51,843.)

TABLE I.—Aggregate Values of the disturbed observations.

Year ending 31st December 1859 . . . . 540·235 inches.

„ „ 1860 . . . . 364·208 „

„ „ 1861 . . . . 226·625 „

„ „ 1862 . . . , 358·763 „

„ „ 1863 . . . . 174·712 „

„ „ 1864 . . . . 238·597 „

Total in the 6 years . . . 1903·140 „

Mean Annual Value . . $\dfrac{1903·140}{6} = 317·190$ „

TABLE II.—Ratios in each year to the mean annual value.

Year ending 31st December 1859 . . . 1·70

,, ,, 1860 . . . 1·15

,, ,, 1861 . . . 0·71

,, ,, 1862 . . . 1·13

,, ,, 1863 . . . 0·55

,, ,, 1864 . . . 0·75

TABLE III.—Aggregate Values in the different years divided into disturbances increasing and disturbances decreasing the Force.

	Increasing.	Decreasing.
Year ending 31st December 1859	402·525	137·710 inches.
1860 . , . .	250·629	113·579 ,,
1861	147·988	78·637 ,,
1862	248·391	110·372 ,,
1863	89·371	85·341 ,,
1864	107·248	131·349 ,,
Total in the 6 years . . .	1246·152	656·988 ,,

The ratio of the values of the disturbances increasing the Force to those which decreased it was, on the average of the 6 years, as 1·9 to 1.

TABLE IV.—Aggregate Values of the disturbed observations distributed into the several months of their occurrence, with the ratios which the values in the preceding column bear to the mean monthly value or average of all the months.

Months.	Years ending December 31.						Sums in the 6 years.	Ratios.	Months.
	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.		
Jan.	5·769	6·174	50·091	57·532	23·186	4·885	147·637	0·93	Jan.
Feb.	30·335	35·492	13·270	29·385	13·487	37·106	159·075	1·00	Feb.
Mar.	15·892	39·871	24·130	60·527	6·929	19·932	167·281	1·05	Mar.
April	53·598	36·032	12·550	21·844	11·326	21·197	156·547	0·99	April
May	12·813	27·417	7·636	12·023	4·812	17·412	82·113	0·52	May
June	33·154	16·388	23·825	1·236	8·537	19·621	102·761	0·65	June
July	91·814	32·996	3 176	22·071	17·327	27·676	195·060	1·23	July
Aug.	26·156	96·549	20·396	63·751	14·793	28·591	250·236	1·58	Aug.
Sept.	94·594	36·167	13·045	25·751	33·503	15·814	218·874	1·38	Sept.
Oct.	62·074	9·739	17·688	19·381	21·074	27·285	157·241	0·99	Oct.
Nov.	24·404	2·802	13·060	10·697	15·777	5·164	71·904	0·45	Nov.
Dec.	89·632	24·581	27·758	34·565	3·961	13·914	194·411	1·23	Dec.
Total in the 6 years..............							1903·140		
Mean monthly value $\frac{1903·140}{12}=$							158·595=1·00		

Tables V. and VI. exhibit the aggregate monthly values in the different years separated into disturbances increasing and disturbances decreasing the Force.

TABLE V.—Disturbances increasing the Force.

Months.	Years ending December 31.						Sums in the 6 years.	Ratios.	Months.
	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.		
Jan.	5·175	2·807	44·789	53·229	15·693	·618	122·311	1·18	Jan.
Feb.	28·749	33·134	8·324	9·137	7·430	17·725	104·499	1·01	Feb.
Mar.	8·625	21·598	15·464	59·548	4·827	11·995	122·057	1·17	Mar.
April	28·750	23·253	8·600	14·682	4·999	14·380	94·664	0·91	April
May	10·314	24·516	4·028	5·142	·787	4·099	48·886	0·47	May
June	26·253	11·052	20·166	·536	3·074	10·688	71·769	0·69	June
July	91·627	13·865	1·609	11·162	5·474	10·675	134·412	1·29	July
Aug.	13·208	79·502	8·510	34·432	6·875	6·516	149·043	1·44	Aug.
Sept.	49·395	19·488	5·190	16·810	20·233	5·359	116·475	1·12	Sept.
Oct.	44·824	7·236	8·178	9·791	11·404	10·600	92·033	0·89	Oct.
Nov.	15·536	2·132	9·561	8·340	6·584	4·334	46·487	0·45	Nov.
Dec.	80·069	12·046	13·569	25·582	1·991	10·259	143·516	1·38	Dec.
Total in the 6 years..............							1246·152		
Mean monthly value $\dfrac{1246\cdot152}{12}=$							103·846=1·00		

TABLE VI.—Disturbances decreasing the Force.

Months.	Years ending December 31.						Sums in the 6 years.	Ratios.	Months.
	1859.	1860.	1861.	1862.	1863.	1864.			
	in.	in.	in.	in.	in.	in.	in.		
Jan.	·594	3·367	5·302	4·303	7·493	4·267	25·326	0·46	Jan.
Feb.	1·586	2·358	4·946	20·248	6·057	19·381	54·576	1·00	Feb.
Mar.	7·267	18·273	8·666	·979	2·102	7·937	45·224	0·83	Mar.
April	24·848	12·779	3·950	7·162	6·327	6·817	61·883	1·13	April
May	2·499	2·901	3·608	6·881	4·025	13·313	33·227	0·61	May
June	6·901	5·336	3·659	·700	5·463	8·933	30·992	0·57	June
July	·187	19·131	1·567	10·909	11·853	17·001	60·648	1·11	July
Aug.	12·948	17·047	11·886	29·319	7·918	22·075	101·193	1·85	Aug.
Sept.	45·199	16·679	7·855	8·941	13·270	10·455	102·399	1·87	Sept.
Oct.	17·250	2·503	9·510	9·590	9·670	16·685	65·208	1·19	Oct.
Nov.	8·868	·670	3·499	2·357	9·193	·830	25·417	0·46	Nov.
Dec.	9·563	12·535	14·189	8·983	1·970	3·655	50·895	0·93	Dec.
Total in the 6 years..............							656·988		
Mean monthly value $\dfrac{656\cdot988}{12}=$							54·749=1·00		

TABLE VII.—Ratios of the Values of the Disturbances increasing the Vertical Force in the different *Months* to the Values of those which decrease it.

Months.	Ratios.
January	4·83
February	1·91
March	2·70
April	1·53
May	1·44
June	2·32
July	2·22
August	1·47
September	1·14
October	1·41
November	1·83
December	2·82

TABLE VIII.—Aggregate Values of the disturbed observations distributed into the several *hours* of their occurrence, together with the ratios of the values at the different hours to the mean hourly value, or average of all the hours.

Kew Astronomical Time.	Years ending December 31.						Sums in the 6 years.	Ratios.	Kew Civil Time.
	1859.	1860.	1861.	1862.	1863.	1864.			
h	in.	in.	in.	in.	in.	in.	in.		h
18	14·551	11·978	6·583	11·094	5·876	8·070	58·152	0·73	6 A.M.
19	16·009	8·444	5·071	9·645	4·320	7·515	51·004	0·64	7 ,,
20	13·101	8·325	3·499	9·714	2·311	6·235	43·185	0·54	8 ,,
21	14·957	8·977	3·975	10·247	2·563	5·016	45·735	0·58	9 ,,
22	15·045	10·278	5·175	9·981	2·249	3·970	46·698	0·59	10 ,,
23	16·800	7·892	6·645	11·849	2·925	4·322	50·433	0·64	11 ,,
0	19·440	9·785	6·940	11·117	2·487	4·713	54·482	0·69	Noon.
1	20·729	13·009	7·933	14·418	6·098	6·946	69·133	0·87	1 P.M.
2	31·517	19·449	11·005	16·148	8·546	9·820	96·485	1·22	2 ,,
3	32·969	25·802	14·167	20·785	12·787	12·538	119·048	1·50	3 ,,
4	36·217	32·044	15·142	24·823	13·913	15·888	138·027	1·74	4 ,,
5	45·483	31·387	16·138	25·744	14·056	17·958	150·766	1·90	5 ,,
6	34·717	28·297	18·006	24·216	11·704	15·393	132·333	1·68	6 ,,
7	31·013	22·343	16·719	17·181	9·966	11·246	108·468	1·37	7 ,,
8	23·175	15·562	13·302	18·555	7·017	7·319	84·930	1·07	8 ,,
9	18·584	9·533	10·972	13·430	4·150	4·788	61·457	0·77	9 ,,
10	15·579	6·106	5·173	10·491	5·493	6·773	49·615	0·63	10 ,,
11	17·209	7·469	6·915	13·952	6·137	11·551	63·233	0·80	11 ,,
12	20·943	13·942	7·986	12·890	6·758	14·557	77·076	0·97	Midnight.
13	23·557	12·339	7·568	14·570	7·970	16·748	82·752	1·04	1 A.M.
14	21·794	14·275	11·700	16·408	10·642	13·797	88·616	1·12	2 ,,
15	20·058	17·943	10·057	15·135	10·149	13·039	86·381	1·09	3 ,,
16	19·309	13·910	8·985	14·030	8·385	11·136	75·755	0·95	4 ,,
17	17·479	15·119	6·969	12·340	8·210	9·259	69·376	0·87	5 ,,
Total in the 6 years							1903·140		
Mean hourly value $\dfrac{1903·140}{24} =$							79·297 = 1·00		

Tables IX. and X. exhibit the aggregate values at the different hours, separated into

disturbances increasing and disturbances decreasing the Force, and the ratios of the values
at each hour of both kinds of disturbances to their respective mean hourly values.

TABLE IX.—Disturbances increasing the Force.

Kew Astrono- mical Time.	Years ending December 31.						Sums in the 6 years.	Ratios.	Kew Civil Time.
	1859.	1860.	1861.	1862.	1863.	1864.			
h	in.	in.	in.	in.	in.	in.	in.		h
18	8·670	3·683	1·708	5·992	·374	1·184	21·611	0·42	6 A.M.
19	9·680	2·617	1·850	5·421	·543	1·534	21·645	0·42	7 ,,
20	9·202	3·726	2·634	5·547	·594	1·228	22·931	0·44	8 ,,
21	11·715	4·567	2·828	7·568	·960	1·416	29·054	0·56	9 ,,
22	11·269	6·148	3·631	7·316	·771	1·716	30·851	0·59	10 ,,
23	11·539	5·408	4·907	9·840	·757	2·387	34·838	0·67	11 ,,
0	15·708	6·920	5·224	7·403	1·178	2·590	39·023	0·75	Noon.
1	17·100	10·726	6·140	11·143	4·778	4·321	54·208	1·04	1 P.M.
2	28·780	18·341	9·796	14·091	7·407	7·585	86·000	1·66	2 ,,
3	29·778	24·962	12·914	19·214	11·859	9·772	108·499	2·09	3 ,,
4	33·912	31·484	13·970	23·517	12·190	13·079	128·152	2·47	4 ,,
5	43·464	31·063	15·105	24·939	12·481	14·910	141·962	2·73	5 ,,
6	31·059	27·547	16·974	23·750	10·019	12·529	121·878	2·35	6 ,,
7	28·088	21·830	15·060	16·523	8·724	9·428	99·653	1·92	7 ,,
8	20·543	14·901	12·255	16·943	5·554	5·613	75·809	1·46	8 ,,
9	16·163	8·940	8·483	10·998	2·780	2·649	50·013	0·96	9 ,,
10	11·937	3·914	3·225	7·078	2·676	2·100	30·930	0·59	10 ,,
11	10·265	3·116	1·778	5·528	2·114	2·374	25·175	0·49	11 ,,
12	9·239	2·551	1·458	4·431	·860	1·772	20·311	0·39	Midnight.
13	9·870	2·814	1·162	4·110	·651	2·091	20·698	0·40	1 A.M.
14	9·013	3·634	1·597	4·437	·407	1·351	20·439	0·39	2 ,,
15	9·537	4·620	1·684	3·830	·575	2·029	22·275	0·43	3 ,,
16	8·049	2·961	1·906	4·037	·627	2·042	19·622	0·38	4 ,,
17	7·945	4·156	1·699	4·735	·492	1·548	20·575	0·40	5 ,,
Total in the 6 years							1246·152		
Mean hourly value $\frac{1246·152}{24}=$							51·923=1·00		

TABLE X.—Disturbances decreasing the Force.

Kew Astronomical Time.	Years ending December 31.						Sums in the 6 years.	Ratios.	Kew Civil Time.
	1859.	1860.	1861.	1862.	1863.	1864.			
h	in.	in.	in.	in.	in.	in.	in.		h
18	5·881	8·295	4·875	5·102	5·502	6·886	36·541	1·33	6 A.M.
19	6·329	5·827	3·221	4·224	3·777	5·981	29·359	1·07	7 ,,
20	3·899	4·599	·865	4·167	1·717	5·007	20·254	0·74	8 ,,
21	3·242	4·410	1·147	2·679	1·603	3·600	16·681	0·61	9 ,,
22	3·776	4·130	1·544	2·665	1·478	2·254	15·847	0·58	10 ,,
23	5·261	2·484	1·738	2·009	2·168	1·935	15·595	0·57	11 ,,
0	3·732	2·865	1·716	3·714	1·309	2·123	·15·459	0·57	Noon.
1	3 629	2·283	1·793	3·275	1·320	2·625	14·925	0·55	1 P.M.
2	2·737	1·108	1·209	2·057	1·139	2·235	10·485	0·38	2 ,,
3	3·191	·840	1·253	1·571	·928	2·766	10·549	0·38	3 ,,
4	2·305	·560	1·172	1·306	1·723	2·809	9·875	0·36	4 ,,
5	2·019	·324	1·033	·805	1·575	3·048	8·804	0·32	5 ,,
6	3·658	·750	1·032	·466	1·685	2·864	10·455	0·38	6 ,,
7	2·925	·513	1·659	·658	1·242	1·818	8·815	0·32	7 ,,
8	2·632	·661	1·047	1·612	1·463	1·706	9·121	0·33	8 ,,
9	2·421	·593	2·489	2·432	1·370	2·139	11·444	0·42	9 ,,
10	3·642	2·192	1·948	3·413	2·817	4·673	18·685	0·68	10 ,,
11	6·944	4·353	5·137	8·424	4·023	9·177	38·058	1·39	11 ,,
12	11·704	11·391	6·528	8·459	5·898	12·785	56·765	2·07	Midnight.
13	13·687	9·525	6·406	10·460	7·319	14·657	62·054	2·27	1 A.M.
14	12·781	10·641	10·103	11·971	10·235	12·446	68·177	2·49	2 ,,
15	10·521	13·323	8·373	11·305	9·574	11·010	64·106	2·34	3 ,,
16	11·260	10·949	7·079	9·993	7·758	9·094	56·133	2·05	4 ,,
17	9·534	10·963	5·270	7·605	7·718	7·711	48·801	1·78	5 ,,

Total in the 6 years .... | 656·988

Mean hourly value $\dfrac{656·988}{24}=$ | 27·374 = 1·00