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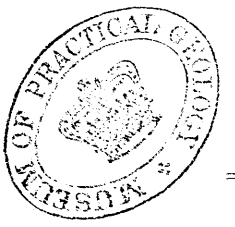

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XIII. *Results deduced from the Measures of Terrestrial Magnetic Force in the Horizontal Plane, at the Royal Observatory, Greenwich, from* 1841 *to* 1876.

By Sir G. B. Airy, *K.C.B., F.R.S., late Astronomer Royal.*

Received June 24,—Read November 26, 1885.

[Plate 74.]

In offering to the Royal Society some results deduced from the systems of magnetic observation and magnetic self-registration established several years since at the Royal Observatory, Greenwich, during a portion of the time in which I presided over that institution, I think it desirable to premise a short statement on the origin of the Magnetic Department of the Royal Observatory, and on the successive steps in its constitution.

It appears to have been recognised many years ago, that magnetic determinations would form a proper part of the business of the Royal Observatory. When I commenced residence at the Royal Observatory, at the end of 1835, I found in the garden a small wooden building, evidently intended for the examination of compasses, perhaps of the size of those used in the Royal Navy. But the locality was inconvenient, and the structure was totally unfit for any delicate magnetic purpose; for instance, the balance-weights of the sliding windows were of iron. For some preliminary experiments a small observatory was borrowed from Captain Fitzroy, but no real progress was made in magnetism.

In the beginning of 1836, a scheme for the erection of a Magnetical Observatory was brought before the Board of Visitors. The Board approved the plan, and recommended it favourably to the Admiralty. The Government Department superintending the Park gave their consent to an extension of the grounds of the Observatory, and the ground was inclosed in 1837. The Magnetic Observatory was built, from my plans, in the spring of 1838. Since that time, no alteration has been made in

the building, except in 1864, when the ground below the east, west, and south arms, was excavated, in order to obtain positions for the three fundamental instruments in which the severity of the temperature-changes would be much diminished. Small accidental interruptions of observations occurred in 1847, January, and 1861, July.

The interest taken in the subject of terrestrial magnetism in the first half of this century was occasioned principally by the enterprise of GAUSS and other German philosophers. Magnets were, therefore, established at the Royal Observatory, furnished with apparatus adapted to eye-observations corresponding to those of GAUSS, and some observations were made in concert with the Germans. The observations to the end of 1847 with these instruments were made entirely by eye; the instruments (magnets 2 feet in length) being furnished with small plane reflectors, to which telescopes were directed, and by which fixed marks were observed. The observations were made at every two hours, day and night; proper precautions were taken for assurance of the general accuracy of the times of observation; and I do not doubt that the results interpreted from these observations are each as good as those derived from the succeeding system; though the intervals of two hours were longer than I could wish. But the labour was great, and (as measured by the interruption of assistants' work) was expensive.

The idea of self-registration by photography of the movements of the instruments (an idea little entertained before that time) then suggested itself; and, at the Cambridge Meeting of the British Association in 1845, it was proposed for consideration of the Council of that body, that the Government should be requested to promote, by offer of a pecuniary reward, the construction of a photographic self-registering instrument. This proposal was adopted by the Council; letters were addressed by Sir JOHN HERSCHEL, President of the Association, to Her Majesty's Treasury, and by myself to the Admiralty; and, finally, the assistance of Dr. CHARLES BROOKE was secured, for forming an efficient apparatus, and making the necessary chemical arrangements adapted to our wants.

I do not propose here to describe the photographic recording apparatus. Allusions to the construction will be found in the Introductions to the Greenwich Observations for successive years, and especially, and in great detail, in the introduction to the volume for 1847. The only alteration that was made in it for several years is the following. Mr. BROOKE had conceived that advantage would be gained by making the recording barrel to revolve in twelve hours. But this caused a doubling of the

curves traced on the photographic paper which is wrapped upon the barrel; and the inconvenience produced by this doubling was soon found to be so great that I thought it necessary to alter the clock-work so as to produce a revolution of the barrel in twenty-four hours. The records of the change of western declination from the north, and of the change of horizontal force, are made on the same barrel; and by alterations, first suggested by myself about 1881, and carried out by the present Astronomer Royal (then Chief Assistant), the two curves are now so traced that the simultaneous records of the two instruments at all times are in close juxtaposition.

While the observations were made by eye, at every two hours, the mean of the two-hourly readings was adopted as base for the day, and the excess of each two-hourly reading above the mean was adopted as "magnetic inequality" of that ordinate for that hour; producing twelve measures of "inequality" for each day. When the photographic system was introduced, the elevation of a pencil curve drawn by eye so as to smooth down the irregularities of the photographic trace above a photographic base was measured for every hour, producing twenty-four measures of "inequality."

In the instances of excessive and rapid disturbances of the magnets during magnetic storms, no measures of ordinates were taken for the present purposes.

Thus the daily measures at each hour or two hours were obtained.

The next step was to collect for each month all the daily measures on corresponding hours through each month, and to take their mean. These are the measures for the hours which are actually treated in the present memoir. By combining (for each month) the inequality of magnetic horizontal force at every two hours or each hour, as abscissa, with the inequality of magnetic declination (on the same scale of measure) at the same two hours or hour, as ordinate, points were defined in every monthly curve representing completely the mean diurnal changes of magnetism for each month. On the recommendation of the Board of Visitors of the Royal Observatory, reduced photographic copies of these curves were prepared by the Astronomer Royal for publication with the volume of Greenwich Observations for 1884.

The number, and the character, of the curves produced uninterruptedly on this plan, and the circumstance that they are intended for publication in the Greenwich Observations, appear to render them unfit for dissemination in the Royal Society's

Transactions. I have, therefore, decided on the following course. With the permission of the Astronomer Royal, I have adopted the three years 1863, 1864, and 1865, for partial exhibition of results. (Any other years would have answered equally well, for general exhibition.) For each of these years I have attached to this paper the curves for the months January, April, July, October, which suffice for showing generally the characteristic changes of magnetism for the several months. But some general account may be given, for which this is perhaps a suitable place.

The form of the curves, and the position of the points on them corresponding to hours of solar time, leave no doubt that the diurnal inequality is due mainly—and, as far as I can judge, entirely—to the radiant heat of the sun; and, it would seem, not to the sun's heat on the earth generally, but to its heat on parts of the earth not very distant from the magnets. In the hot months of the year, the curve, though far from circular, surrounds the central point in a form which, as viewed from that central point, never crosses itself; and is, roughly speaking, usually symmetrical with regard to E. and W. But in the cold months, the space included in the curve is much smaller; in many cases, probably not more than one-sixth of what it is in the summer months; and the curve often crosses itself in the most bizarre fashion with irregular loops stretching out, three crossings in one curve occurring very frequently. In the summer months there is a certain degree of symmetry; but here is, constantly, a preponderance on the west side, which leads me to imagine that the magnetic effect of the radiant heat upon the sea is considerably greater than the effect on the land.

To obtain some numerical basis for a report, which though exceedingly imperfect may convey some ideas on this wonderful subject, I have adopted the following course. I have confined myself to the months of June and July as probably the two hottest, and the months of December and January as probably the two coldest. For each of the curves applying to these months, I have laid down a system of rectangular co-ordinates, corresponding to the Greenwich meridian and to the line at right angles to the meridian (or the geographical E. and W.). The extreme north ordinate and the extreme south ordinate are measured, and their sum is taken, and interpreted by a scale of measure formed in accordance with the theory of the instruments; and this interpreted sum forms the "Range of Meridian Force" in terms of the whole Meridian Force. In the same manner, the "Range of Transversal Force" is measured. As the time of each of the two-hourly or hourly records

is marked on the curve, there is no difficulty in fixing approximately on the solar times corresponding to the extreme N. and S. values, and the extreme E. and W. values, mentioned above. These are all the elements of the magnetic record which are described in the subjoined table.

The changes in the monthly records are very remarkable. They leave no doubt in my mind that the diurnal magnetic changes are produced by the sun. But I cannot account for every change that takes place in the course of a day; nor can I undertake to say whether we can found, on these, the theory that general terrestrial magnetism is a part of solar radiation, perhaps sometimes acting through or sometimes impeded by the masses of land and sea on which that radiation acts.

Still I think that a considerable step is made by the establishment of a connexion between terrestrial magnetism (on one hand), and the radiation, or, at least, the visibility of the sun (on the other hand).

MONTHLY Means of Daily Range of Horizontal Magnetic Force at

Mean Daily Range of Horizontal Force in the Direction of Astronomical Meridian.

Year.	Month.	Range of Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Minimum Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Meridian Force.	Month.	Range of Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Minimum Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Meridian Force.
			h. m.	h. m.			h. m.	h. m.
1841	June . . .	·0032	23 50	8 0				
	July . . .	·0033	23 50	8 0	December . .	·0012	2 0	18 0
					January . .	·0009	23 50	20 0
1842	June . . .	·0022	0 0	12 0				
	July . . .	·0028	0 0	9 0	December . .	·0010	0 0	18 0
					January . .	·0014	0 0	18 0
1843	June . . .	·0027	23 20	8 30				
	July . . .	·0028	23 50	8 0	December . .	·0011	2 0	12 0
					January . .	·0013	0 0	7 30
1844	June . . .	·0029	23 20	8 0				
	July . . .	·0030	23 40	8 0	December . .	·0016	0 10	6 0
					January . .	·0010	0 0	6 0
1845	June . . .	·0025	22 40	8 0				
	July . . .	·0022	23 30	8 0	December . .	·0015	0 0	9 0
					January . .	·0011	0 20	19 0
1846	June . . .	·0030	22 40	7 50				
	July . . .	·0033	23 10	7 50	December . .	·0016	0 0	8 10
					January . .	Observations interrupted.		
1847	June . . .	·0026	23 40	8 0				
	July . . .	·0032	23 30	8 0	December . .	·0015	0 40	20 0
					January . .	·0023	0 10	18 30
1848	June . . .	·0033	0 30	8 0				
	July . . .	·0045	0 0	8 0	December . .	·0018	0 30	19 0
					January . .	·0019	0 0	19 0
1849	June . . .	·0035	1 0	7 10				
	July . . .	·0036	0 0	8 0	December . .	·0013	0 0	19 0
					January . .	·0015	0 10	18 0
1850	June . . .	·0028	0 0	19 0				
	July . . .	·0026	23 50	8 0	December . .	·0019	23 40	19 0
					January . .	·0021	1 0	19 0
1851	June . . .	·0027	0 0	8 0				
	July . . .	·0026	0 0	9 0	December . .	·0015	4 50	18 0
					January . .	·0021	1 10	20 0
1852	June . . .	·0029	0 15	18 10				
	July . . .	·0028	1 0	17 40	December . .	·0017	2 0	18 30

Göttingen Mean Solar Time is greater by 40^m than

Greenwich expressed as factors of the Mean Horizontal Magnetic Force.

Mean Daily Range of Horizontal Force in the Direction Transversal to the Astronomical Meridian.								
Month.	Range of Transversal Force.	In Göttingen Mean Solar Time. Approximate Hour of		Month.	Range of Transversal Force.	In Göttingen Mean Solar Time. Approximate Hour of		Year.
		Maximum Easterly Force.	Maximum Westerly Force.			Maximum Easterly Force.	Maximum Westerly Force.	
		h. m.	h. m.			h. m.	h. m.	
June . . .	·0036	20 0	2 0					1841
July . . .	·0027	20 0	3 0					
				December . .	·0016	10 0	2 0	
				January . .	·0019	12 0	1 50	1842
June . . .	·0026	20 10	3 0					
July . . .	·0029	20 10	2 10					
				December . .	·0016	10 0	2 0	
				January . .	·0018	12 0	2 0	1843
June . . .	·0035	20 30	2 10					
July . . .	·0036	20 20	2 30					
				December . .	·0014	10 0	2 0	
				January . .	·0016	14 0	1 50	1844
June . . .	·0033	20 0	2 15					
July . . .	·0029	20 0	2 0					
				December . .	·0014	12 0	2 10	
				January . .	·0020	14 0	1 50	1845
June . . .	·0032	20 0	2 20					
July . . .	·0036	20 0	2 40					
				December . .	·0015	10 0	2 0	
				January . .	·0018	10 20	1 50	1846
June . . .	·0038	20 0	2 10					
July . . .	·0038	20 20	3 0					
				December . .	·0015	12 0	2 0	
				January . .	Observations interrupted.			1847
June . . .	·0034	19 50	3 30					
July . . .	·0038	19 30	2 20					
				December . .	·0026	14 0	2 0	
				January . .	·0028	10 0	2 20	1848
June . . .	·0037	20 30	2 10					
July . . .	·0041	20 50	2 20					
				December . .	·0019	13 20	2 0	
				January . .	·0022	11 0	2 0	1849
June . . .	·0041	20 0	3 0					
July . . .	·0039	20 20	2 40					
				December . .	·0015	12 0	1 30	
				January . .	·0022	10 40	2 30	1850
June . . .	·0034	20 0	2 0					
July . . .	·0034	20 30	2 0					
				December . .	·0012	9 0	1 0	
				January . .	·0015	10 0	2	1851
June . . .	·0027	20 20	2 50					
July . . .	·0029	20 40	2 10					
				December . .	·0017	9 40	1 0	
				January . .	·0015	11 0	2 0	1852
June . . .	·0028	21 0	2 0					
July . . .	·0022	21 0	2 10					
				December . .	·0015	9 40	2 10	

Greenwich Mean Solar Time for the same instant.

Monthly Means of Daily Range of Horizontal Magnetic Force at Greenwich

Mean Daily Range of Horizontal Force in the Direction of Astronomical Meridian.

Year.	Month.	Range of Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Minimum Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Meridian Force.	Month.	Range of Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Minimum Meridian Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Meridian Force.
			h. m.	h. m.			h. m.	h. m.
1853	June . . .	·0031	22 50	9 50	January . .	·0019	1 10	20 0
	July . . .	·0026	23 10	7 0				
					December . .	·0020	3 0	19 0
1854	June . . .	·0021	23 40	8 0	January . .	·0019	1 0	19 0
	July . . .	·0024	0 0	18 0				
					December . .	·0012	23 10	19 0
1855	June . . .	·0020	0 0	18 0	January . .	·0014	0 0	19 0
	July . . .	·0022	1 0	18 0				
					December . .	·0015	2 0	19 0
1856	June . . .	·0023	23 10	17 30	January . .	·0014	1 0	19 0
	July . . .	·0020	0 20	19 0				
					December . .	·0013	2 0	20 0
1857	June . . .	·0027	0 0	18 0	January . .	·0020	0 30	20 0
	July . . .	·0025	0 0	18 0				
					December . .	·0020	0 0	19 0
			In Greenwich Mean Solar Time.				In Greenwich Mean Solar Time.	
1858	June . . .	·0037	23 50	16 30	January . .	·0024	1 0	18 0
	July . . .	·0033	23 0	16 40				
					December . .	·0023	0 0	18 0
1859	June . . .	·0032	0 0	17 0	January . .	·0028	0 0	17 30
	July . . .	·0031	1 0	16 0				
					December . .	·0023	0 0	18 0
1860	June . . .	·0034	22 40	6 30	January . .	·0026	1 0	17 0
	July . . .	·0035	23 50	13 0				
					December . .	·0020	0 0	17 0
1861	June . . .	·0025	0 10	7 0	January . .	·0031	0 0	18 0
	July . . .	Observations interrupted.						
					December . .	·0021	0 0	18 0
1862	June . . .	·0028	22 50	8 0	January . .	·0014	0 0	17 0
	July . . .	·0024	20 0	6 0				
					December . .	·0014	0 0	18 0
1863	June . . .	·0033	23 0	6 0	January . .	·0014	23 0	17 0
	July . . .	·0028	22 40	7 30				
					December . .	·0013	0 0	10 30
1864	Observations interrupted during construction of the Magnetic Basement.							

Göttingen Mean Solar Time is greater by 40m than

expressed as factors of the Mean Horizontal Magnetic Force (continued).

Mean Daily Range of Horizontal Force in the Direction Transversal to the Astronomical Meridian.

Month.	Range of Transversal Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Easterly Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Westerly Force.	Month.	Range of Transversal Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Easterly Force.	In Göttingen Mean Solar Time. Approximate Hour of Maximum Westerly Force.	Year.
		h. m.	h. m.			h. m.	h. m.	
				January . .	·0014	12 0	2 0	1853
June . . .	·0032	21 0	3 0					
July . . .	·0030	19 40	2 50					
				December . .	·0015	10 20	20 0	
				January . .	·0019	9 0	1 0	1854
June . . .	·0027	20 50	2 20					
July . . .	·0026	22 0	3 0					
				December . .	·0013	10 0	1 0	
				January . .	·0015	12 0	2 30	1855
June . . .	·0021	21 0	2 10					
July . . .	·0017	19 50	2 0					
				December . .	·0012	9 20	1 0	
				January . .	·0010	7 0	18 30	1856
June . . .	·0022	21 0	2 10					
July . . .	·0022	21 0	2 15					
				December . .	·0013	9 0	1 3	
				January . .	·0014	11 0	0 0	1857
June . . .	·0013	21 0	15 0					
July . . .	·0011	6 20	2 0					
				December . .	·0012	9 40	1 30	
		In Greenwich Mean Solar Time.				In Greenwich Mean Solar Time.		
				January . .	·0012	9 30	1 0	1858
June . . .	·0022	20 40	2 0					
July . . .	·0028	20 0	2 10					
				December . .	·0014	9 30	2 0	
				January . .	·0013	9 20	1 30	1859
June . . .	·0036	19 30	2 20					
July . . .	·0032	20 0	2 10					
				December . .	·0014	10 0	1 30	
				January . .	·0012	9 0	2 0	1860
June . . .	·0041	19 30	1 30					
July . . .	·0038	19 0	2 20					
				December . .	·0018	10 0	2 0	
				January . .	·0015	10 0	0 30	1861
June . . .	·0034	19 30	2 30					
July . . .	Observations interrupted.							
				December . .	·0019	10 0	1 0	
				January . .	·0020	12 0	1 50	1862
June . . .	·0037	19 40	2 0					
July . . .	·0030	20 0	3 30					
				December . .	·0011	13 0	1 30	
				January . .	·0026	10 0	1 0	1863
June . . .	·0033	19 50	2 20					
July . . .	·0030	20 0	2 0					
				December . .	·0020	10 0	1 0	
Observations interrupted during construction of the Magnetic Basement.								1864

Greenwich Mean Solar Time for the same instant.

Monthly Means of Daily Range of Horizontal Magnetic Force at Greenwich

Mean Daily Range of Horizontal Force in the Direction of Astronomical Meridian.									
Year.	Month.	Range of Meridian Force.	In Greenwich Mean Solar Time. Approximate Hour of		Month.	Range of Meridian Force.	In Greenwich Mean Solar Time. Approximate Hour of	
			Minimum Meridian Force.	Maximum Meridian Force.			Minimum Meridian Force.	Maximum Meridian Force.
			h. m.	h. m.			h. m.	h. m.
1865	June . . .	·0025	23 30	11 0	January . .	Obser	vations inter	rupted.
	July . . .	·0024	22 10	7 0	December . .	·0009	23 10	18 0
1866	June . . .	·0020	0 0	7 30	Janaary . .	·0011	0 0	19 0
	July . .	·0022	22 10	7 0	December . .	·0008	23 0	18 0
1867	June . . .	·0024	23 0	7 0	January . .	·0010	23 20	8 0
	July . . .	·0022	23 0	9 0	December . .	·0009	23 0	18 0
1868	June . . .	·0025	23 0	7 0	January . .	·0007	0 0	19 0
	July . . .	·0026	0 0	8 0	December . .	·0010	23 20	18 0
1869	June . . .	·0036	23 0	7 0	January . .	·0014	23 50	19 0
	July . . .	·0033	22 30	7 0	December . .	·0012	23 0	17 0
1870	June . . .	·0041	23 0	7 0	January . .	·0016	23 40	17 0
	July . . .	·0037	23 0	7 0	December . .	·0017	0 30	18 0
1871	June . . .	·0035	0 0	7 0	January . .	·0019	0 0	11 0
	July . . .	·0036	23 40	7 0	December . .	·0017	23 30	18 0
1872	June . . .	·0037	23 0	7 0	January . .	·0017	0 0	18 0
	July . . .	·0031	0 10	7 0	December . .	·0010	0 0	18 0
1873	June . . .	·0027	23 30	7 10	January . .	·0017	0 0	18 0
	July . . .	·0031	22 30	6 50	December . .	·0008	23 20	17 30
1874	June . . .	·0024	23 0	6 20	January . .	·0011	0 0	18 0
	July . . .	·0023	23 0	7 30	December . .	·0007	0 0	18 30
1875	June . . .	·0019	23 0	7 20	January . .	·0007	23 0	18 30
	July . . .	·0021	23 0	7 30	December . .	·0008	23 20	20 0
1876	June . . .	·0018	22 30	8 0	January . .	·0009	0 0	19 0
	July . . .	·0020	23 30	7 0	December . .	·0006	0 0	19 0

expressed as factors of the Mean Horizontal Magnetic Force (continued).

Mean Daily Range of Horizontal Force in the Direction Transversal to the Astronomical Meridian.

Month.	Range of Transversal Force.	In Greenwich Mean Solar Time. Approximate Hour of		Month.	Range of Transversal Force.	In Greenwich Mean Solar Time. Approximate Hour of		Year.
		Maximum Easterly Force.	Maximum Westerly Force.			Maximum Easterly Force.	Maximum Westerly Force.	
		h. m.	h. m.			h. m.	h. m.	
June . . .	·0032	20 0	2 0	January . .	Observations interrupted.			1865
July . . .	·0028	18 50	2 0	December . .	·0015	10 30	1 0	
June . . .	·0029	19 30	2 30	January . .	·0019	10 40	1 0	1866
July . . .	·0029	19 30	2 10	December . .	·0013	9 0	1 0	
June . . .	·0027	20 0	1 40	January . .	·0013	10 20	1 0	1867
July . . .	·0026	20 0	2 0	December . .	·0012	9 0	1 0	
June . . .	·0029	20 0	2 0	January . .	·0016	10 0	1 0	1868
July . . .	·0030	19 30	2 0	December . .	·0017	10 0	1 30	
June . . .	·0042	19 50	2 10	January . .	·0018	12 10	2 0	1869
July . . .	·0038	19 30	2 30	December . .	·0015	10 30	1 0	
June . . .	·0046	20 10	2 10	January . .	·0020	10 20	1 0	1870
July . . .	·0047	20 0	2 10	December . .	·0017	10 40	2 0	
June . . .	·0046	20 10	2 20	January . .	·0021	11 10	2 0	1871
July . . .	·0043	20 0	2 30	December . .	·0019	12 0	1 30	
June . . .	·004	20 0	2 0	January . .	·0023	11 10	2 0	1872
July . . .	·0038	20 0	2 10	December . .	·0022	11 0	1 0	
June . . .	·0032	20 30	2 50	January . .	·0026	10 30	2 0	1873
July . . .	·0036	20 0	2 20	December . .	·0017	11 0	1 0	
June . . .	·0032	19 50	2 0	January . .	·0021	11 0	1 0	1874
July . . .	·0033	20 20	2 0	December . .	·0012	10 30	1 0	
June . . .	·0027	19 40	2 0	January . .	·0014	10 50	1 0	1875
July . . .	·0024	20 0	2 10	December . .	·0012	10 0	1 0	
June . . .	·0029	19 30	2 20	January . .	·0014	10 0	1 0	1876
July . . .	·0030	19 20	2 0	December . .	·0012	9 30	1 0	