minutes past eight it increased from 16 to 43 lbs. in the short space of two or three minutes; the barometer, being at its minimum, suddenly rose about three-hundredths of an inch, and during the heaviest part of the storm it continued to rise at the rate of about one-tenth of an inch an hour. The oscillations in the mercurial column, as will be seen by the diagram, were large and frequent during the storm, one of the most remarkable being immediately after 10^h A.M. and nearly coincident with two of the heaviest gusts of wind; the depression in this case amounted to between four and five hundredths of an inch, the rise following the fall so quickly that the clock moved the recording-cylinder only through just sufficient space to cause a double line to be traced by the pencil.

III. "On the Criterion of Resolubility in Integral Numbers of the Indeterminate Equation

$$f=ax^2+a'x'^2+a''x''^2+2bx'x''+2b'xx''+2b''x'x=0."$$

By H. J. Stephen Smith, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford. Received January 20, 1864.

It is sufficient to consider the case in which f is an indefinite form of a determinant different from zero. We may also suppose that f is primitive, *i. e.* that the six numbers a, a', a'', b, b', b'' do not admit of any common divisor. We represent by Ω the greatest common divisor of the minors of the matrix of f, by $\Delta\Omega^2$ the determinant of f, and by ΩF the contravariant of f, *i. e.* the form

$$(b^2-a'a'')x^2+\ldots\ldots;$$

$\Omega\Delta^2$ will then be the determinant of F, and Δf its contravariant. By $\overline{\Omega}$, $\overline{\Delta}$, and $\overline{\Omega\Delta}$ we denote the quotients obtained by dividing Ω, Δ, and $\Omega\Delta$ by the greatest squares contained in them respectively; ω is any uneven prime dividing $\overline{\Omega}$, but not $\overline{\Delta}$; δ is any uneven prime dividing $\overline{\Delta}$, but not $\overline{\Omega}$; and θ is any uneven prime dividing both $\overline{\Omega}$ and $\overline{\Delta}$, and consequently not dividing $\overline{\Omega\Delta}$. We may then enunciate the theorem—

"The equation $f=0$ will or will not be resoluble in integral numbers different from zero according as the equations included in the formulæ

$$\left(\frac{\overline{\Omega}}{\delta}\right)=\left(\frac{F}{\delta}\right),\qquad \left(\frac{\overline{\Delta}}{\omega}\right)=\left(\frac{f}{\omega}\right),\qquad \left(\frac{-\overline{\Omega\Delta}}{\theta}\right)=\left(\frac{f}{\theta}\right)\left(\frac{F}{\theta}\right)$$

are or are not satisfied."

The symbols $\left(\frac{\overline{\Omega}}{\delta}\right)$, $\left(\frac{\overline{\Delta}}{\omega}\right)$, and $\left(\frac{-\overline{\Omega\Delta}}{\theta}\right)$ are the quadratic symbols of Legendre; the symbols $\left(\frac{F}{\delta}\right)$, $\left(\frac{F}{\theta}\right)$, $\left(\frac{f}{\omega}\right)$, $\left(\frac{f}{\theta}\right)$ are generic characters of f (see the Memoir of Eisenstein, "Neue Theoreme der höheren Arithmetik," in his 'Mathematische Abhandlungen,' p. 185, or in Crelle's Journal, vol. xxxv. p. 125).

The theorem includes those of Legendre and Gauss on the resolubility of equations of the form $ax^2+a'x'^2+a''x''^2=0$ (Legendre, Théorie des Nombres, vol. i. p. 47; Gauss, Disq. Arith. arts. 294, 295, & 298). It is equally applicable whether the coefficients and indeterminates of f are real integers, or complex integers of the type $p+qi$.

It will be observed that if f, f', f'' . . . are forms contained in the same genus, the equations $f=0, f'=0, f''=0$, &c. are either all resoluble or all irresoluble.

IV. "Results of a Comparison of certain traces produced simultaneously by the Self-recording Magnetographs at Kew and at Lisbon; especially of those which record the Magnetic Disturbance of July 15, 1863." By Senhor CAPELLO, of the Lisbon Observatory, and BALFOUR STEWART, M.A., F.R.S. Received January 14, 1864.

The National Portuguese Observatory established at Lisbon in connexion with the Polytechnic School, and under the direction of Senhor da Silveira, has not been slow to recognize the advantage to magnetical science to be derived from the acquisition of self-recording magnetographs. Accordingly that institution being well supported by the Portuguese Government, despatched Senhor Capello, their principal observer (one of the writers of this communication), with instructions to procure in Great Britain a set of self-recording magnetographs after the pattern of those in use at the Kew Observatory of the British Association.

These instruments were made by Adie of London, and when completed were sent to Kew for inspection and verification, and Senhor Capello resided there for some time in order to become acquainted with the photographic processes. The instruments were then taken to Lisbon, where they arrived about the beginning of last year, and they were forthwith mounted at the Observatory, and were in regular operation by the beginning of July last.

It had been agreed by the writers of this paper that the simultaneous magnetic records of the two observatories at Kew and Lisbon should occasionally be compared together, and the opportunity for such a comparison soon presented itself in an interesting disturbance which commenced on the 15th of July last. The curves were accordingly compared together, and the results are embodied in the present communication.

We shall in the first place compare the Kew curves by themselves, secondly the Lisbon curves in the same manner, and lastly the curves of the two Observatories together.

Comparison of Kew Curves.

The disturbance, as shown by the Kew curves, commenced on July 15th, at $9^h\ 13^m{\cdot}5$ G.M.T., at which moment the horizontal-force curve recorded an abrupt augmentation of force. The vertical component of the earth's magnetic force was simultaneously augmented, but to a smaller extent; while only a very small movement was visible in the declination curve.

The disturbance, which began in this manner, continued until July 25th, if not longer; but during the period of its action there was not for any of the elements a very great departure from the normal value; probably in this respect the declination was more affected than either of the other components.

While frequently there is an amount of similarity between the different elements as regards disturbances of long period, yet there is often also a want of likeness. If, however, we take the small but rapid changes of force, or *peaks* and *hollows*, as has been done by one of the writers of this paper in a previous communication to the Royal Society (Phil. Trans. 1862, page 621), we shall find that a disturbance of this nature which increases or diminishes the westerly declination at the same time increases or diminishes both elements of force. This will be seen more distinctly from the following Table, in which + denotes an increase and — a diminution of westerly declination, horizontal, and vertical force respectively, and the proportions are those of the apparent movements of the elements on the photographic paper.

TABLE I.

Date.	Greenwich Mean Time.	Declination.	Horizontal force.	Vertical-force change = unity in each instance.
1863.				
July 17	2 46·5	−1·0	−1·9	−1·0
17	2 53·5	−1·1	−2·0	−1·0
17	3 21·5	−1·0	−2·0	−1·0
17	7 58·5	not similar.	−2·0	−1·0
17	16 13·0	+3·5	+2·2	+1·0
18	21 23·5	+3·0	+2·0	+1·0*
19	0 15·5	not similar.	+1·8	+1·0
19	2 13·5	+1·1	+1·9	+1·0
19	2 38·0	+1·1	+1·7	+1·0
19	3 22·5	+1·0	+1·9	+1·0
19	17 51·0	+2·8	+2·0	+1·0†
19	18 0·0	+3·6	+2·0	+1·0†
19	20 29·5	+3·2	+2·0	+1·0
20	3 21·0	+1·0	+1·6	+1·0
20	18 52·5	+4·0	+2·2	+1·0
21	0 22·0	−1·6	−2·3	−1·0
21	{ 2 2·0 to 2 15·0 }	−1·4	−2·1	−1·0
21	5 38·0	+1·4	+2·0	+1·0
22	19 20·5	−4·0	−2·0	−1·0
22	19 32·5	−3·4	−2·0	−1·0
22	21 40·0	+3·5	+2·0	+1·0
23	18 34·5	+3·5	+2·2	+1·0
23	19 26·5	+3·4	+2·0	+1·0†
24	3 31·0	+1·2	+2·0	+1·0
24	16 44·5	+3·1	+2·0	+1·0†

* Doubtful. † Vertical force too small to be accurately measured, but horizontal-force change reckoned = 2·0.

From this Table it will be seen that the signs are always alike for the different elements, and also that the small and rapid movements of the horizontal force are double of those of the vertical force—a result in conformity with that already obtained by one of the writers in a previous communication. On the other hand, the declination peaks and hollows do not bear an invariable proportion to those of the horizontal and vertical force, but present the appearance of a daily range, being great in the early morning hours, and small in those of the afternoon. Indeed this is evident by a mere glance at the curves, which, it so happens, present unusual facilities for a comparison of this nature.

Comparison of Lisbon Curves.

1. *Declination- and vertical-force curves.*—The peaks of the waves, or the elevations in the curve of declination, are always shown in hollows or depressions in the vertical-force curve, and *vice versâ*. We have never seen an instance to the contrary either in the curves under comparison or during the whole time of the operation of these instruments. This curious relation is exhibited in a Plate appended to this communication, from which it will be seen that we have not only a reversal, but also a very nearly constant ratio between the ordinates of the two curves. At Lisbon therefore an increase of westerly declination corresponds to a diminution of vertical force, and *vice versâ*; also an almost constant proportion obtains between the corresponding changes of these two elements.

2. *Bifilar and Declination Curves.*—July 15. A great disturbance, which at 8^h 37^m Lisbon mean time, or 9^h $13^m{\cdot}5$ Greenwich mean time, abruptly and suddenly augmented the horizontal force.

The curve of the declination continues nevertheless nearly undisturbed for about 30 minutes after this, and only at 9^h $41^m{\cdot}5$ G.M.T. it commences to descend very slowly.

July 16.—At about 13^h 6^m G.M.T., a very regularly shaped prominence of some duration occurs in the declination, but is quite invisible in the horizontal force.

July 17.—We see in the bifilar curve half-a-dozen small peaks reproduced in the declination in the same direction, but to a smaller extent.

July 18.—One or two accordant peaks. A large prominence of some duration in the declination at about 17^h 56^m G.M.T. is reproduced as a slight depression in the horizontal force.

July 19.—A reproduction in the declination of several small peaks of the horizontal force; nevertheless there are others also small which one does not see there, or only reproduced to a small extent. Not much accordance between the great and long-continued elevations and depressions.

July 20.—An accordance between the small peaks.

July 21.—The same.

July 22.—The curve is well marked with small peaks. Coincidence of several small peaks, but a want of agreement between the more remarkable peaks. The peaks of the horizontal force more developed than those of the declination.

July 23.—The same appearance of the horizontal-force curves. One remarks on 22nd and 23rd that the small peaks of the declination and horizontal-force are more numerous and more developed in the morning hours.

July 24.—Agreement between the small peaks. A strong disturbance about $10\frac{1}{2}^{h}$ G.M.T., no agreement between the waves. A well-marked prominence of declination ($15\frac{1}{2}^{h}$) does not alter at all the horizontal-force curve.

We derive the following conclusions from the comparison which we have made between the Lisbon curves:—

1. The waves and the peaks and hollows of declination are always reproduced at the same instant in the vertical force, but in an opposite direction; that is to say, that when the north pole of the declination-needle goes to the east, the same pole of the vertical-force magnet is invariably plunged below the horizon, and *vice versâ*. During five months of operation of these instruments there has not been an example of the contrary.

2. The more prominent disturbances of the horizontal force do not in general agree with those of the declination or vertical force either in duration or time.

It is certain that when one of the two elements (bifilar or declination) is disturbed, the other is also; and sometimes one appears to see even for several periods of one of the curves, an imitation of the general march of the other; but when this is examined a little more minutely, and rigorous measures are attempted, one easily perceives that the phases do not arrive at the same time, but sometimes later and sometimes earlier, without any fixed rule.

In the same curve one generally sees contradictions of this kind. Nevertheless it is certain that the agreement in direction and time is more complete when the elevations or depressions are of shorter duration.

3. The small peaks and hollows are generally simultaneous for the three curves. The direction of these is the same for the horizontal force and declination, while that for the vertical force is opposite.

The ratio in size of the peaks and hollows is generally variable between the horizontal force and the declination, while it is always constant between the latter and the vertical force.

Our next deduction requires a preliminary remark. It has been shown by General Sabine, that if the disturbances of declination at various places be each divided into two categories, easterly and westerly, these obey different laws of daily variation, this difference not being the same for all stations.

This would seem to indicate that for every station there are at least two simultaneous disturbing forces acting independently, and superposed upon one another.

This interesting conclusion, derived by General Sabine, appears to be

[To face page 115.

TABLE II.—Comparison of the time of the principal corresponding points of the Horizontal-Force Curves at Kew and at Lisbon.

		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
July 15 ...	Kew	9 10	9 15	9 34	10 17	11 43	13 43	17 51	19 42	20 40										
	Lisbon	8 37	8 42	9 1	9 43	11 9	13 10	17 15	19 10	20 9										
	Differences	0 33	0 33	0 33	0 34	0 34	0 33	0 36	0 32	0 31										
16 ...	Kew	0 23	0 32	1 24	1 40	2 33	2 58	3 50	4 09	4 42	9 50	18 43	20 1							
	Lisbon	(15) 23 44	(15) 23 54	0 46	1 2	1 55	2 22	3 13	3 31	4 4	9 12	18 6	19 22							
	Differences	0 39	0 38	0 38	0 38	0 38	0 36	0 37	0 38	0 38	0 38	0 37	0 39							
17 ...	Kew	1 30	1 32	1 37	1 56	2 12	2 25	2 42	2 51	3 20	4 6	5 43	6 38	6 59	7 6	7 22	7 57	11 00	11 12	11 51
	Lisbon	0 57	1 00	1 3	1 22	1 39	1 51	2 8	2 16	2 47·5	3 32	5 09	6 4	6 25	6 32	6 48	7 22·5	10 25	10 38	11 18
	Differences	0 33	0 32	0 34	0 34	0 33	0 34	0 34	0 35	0 32·5	0 34	0 33	0 34	0 34	0 34	0 34	0 34·5	0 35	0 34	0 33
18 ...	Kew	1 23	1 48	2 5	5 52	6 43	12 10	14 56												
	Lisbon	0 47	1 11	1 29	5 15	6 7	11 35	14 20												
	Differences	0 36	0 37	0 36	0 37	0 36	0 35	0 36												
19 ...	Kew	(18) 23 24	0 14	2 12	3 21	4 42	5 48	10 35	13 12	19 17	20 28	21 58								
	Lisbon	(18) 22 50	(18) 23 41	1 38	2 47	4 9	5 13	10 1	12 37	18 42	19 54	21 24								
	Differences	0 34	0 33	0 34	0 34	0 33	0 35	0 34	0 35	0 35	0 34	0 34								
20 ...	Kew	0 12	2 42	3 19·5	4 15	4 58	5 13	10 33	11 04	18 51										
	Lisbon	(19) 23 40	2 10	2 46·5	3 42	4 23	4 39	9 58	10 29	18 18·5										
	Differences	0 32	0 32	0 33	0 33	0 35	0 34	0 35	0 35	0 32·5										
21 ...	Kew	1 32·5	2 00·5	5 36·5	7 00	10 45	11 47	15 1												
	Lisbon	0 57	1 24·5	5 00	6 22	10 12	11 11	14 26												
	Differences	0 35·5	0 36	0 36·5	0 38	0 33	0 36	0 35												
22 ...	Kew	1 24	4 02	5 6	8 26	12 57	15 49	16 27	19 19	19 31	21 38·5									
	Lisbon	0 51	3 29	4 33	7 53	12 26	15 18	15 56	18 47	18 58	21 5									
	Differences	0 33	0 33	0 33	0 33	0 31	0 31	0 31	0 32	0 33	0 33·5									
23 ...	Kew	2 32	3 11	3 35	7 4	7 18	10 12	11 34	12 21	16 10	18 33	21 52								
	Lisbon	1 57	2 37	3 1	6 29	6 42	9 40	11 1	11 48	15 37	18 00	21 19								
	Differences	0 35	0 34	0 34	0 35	0 36	0 32	0 33	0 33	0 33	0 33	0 33								
24 ...	Kew	3 29·5	4 21	4 50	5 25	5 56	8 40	9 53	11 27	12 54	16 23	18 41								
	Lisbon	2 56	3 49	4 19	4 53	5 23	8 6	9 20	10 55	12 23	15 48	18 8								
	Differences	0 33·5	0 32	0 31	0 32	0 33	0 34	0 33	0 32	0 31	0 35	0 33								

verified by the behaviour of the Lisbon curves. From the relation, always invariable, between the waves of declination and vertical force, as well as from the almost total absence of agreement between these two curves and the horizontal force, one has a right to conclude—

1. That there is approximately only one independent force which acts at Lisbon, if we consider the vertical plane bearing (magnetic) east and west. Now the ratio of the disturbing forces for the vertical force and declination is, in units of force, between 26 : 48 and 26 : 36. This would give the inclination of the resultant between 29° and 36°.

2. The absence of agreement in time, and the variability in direction, between the waves of the horizontal force and those of the declination and vertical force, appear to lead to the conclusion that there is another disturbing force besides that already mentioned, which acts in the direction of the magnetic meridian and almost horizontally.

Comparison of the Kew and Lisbon Curves (14–24 July).

1. *Horizontal force* (*north and south disturbing force*).—The curves of the horizontal force at Kew and at Lisbon exhibit a very great similitude *, as will be seen at once from the Plate appended to this communication. Almost all the waves and peaks and hollows are reproduced at both places. At the same time one does not see the same resemblance during the great disturbance of 15th July. In the commencement, and for the first four hours, there is a resemblance for all the waves, but from that time until $19\frac{1}{2}^{h}$ G.M.T. one remarks little agreement between the different elevations and depressions. But from $19\frac{1}{2}^{h}$ until the end of the disturbance the likeness reappears. There are, however, one or two cases of small resemblance in the other curves, but these are of short duration.

In order to demonstrate the similarity between the two curves, reference is made to Table II., in which the principal points are compared together with respect to time; that employed being the mean time for both stations.

From this Table it will be found that the average difference between the local times of corresponding points is $34^{m}\cdot3$, while that due to difference of longitude is $35^{m}\cdot3$. We attribute this apparent want of simultaneity to various causes :—

(1) Loss of time in the commencement of movements of the registering cylinder.

(2) Difficulty in estimating precisely the commencement of certain curves.

(3) It was only in the month of August that the exact Lisbon time of the astronomical observatory was obtained by a telegraphic connexion.

(4) To these must be added the uncertainty in estimating the exact turning-point of an elevation or depression of a blunt or rounded form.

* We speak of the Kew curves reversed so as to have their base-lines above, the disposition of the registering arrangement at Kew being the opposite of that at Lisbon. This reversal has been made in the Plate which accompanies this paper.

The following Table exhibits approximately the proportion between the disturbance-waves of the horizontal force at Lisbon and at Kew.

TABLE III.

Date.	Proportion between the disturbance-waves of the horizontal force reduced at both places to English units (Lisbon wave = unity).
July 15.	Variable between 1 : 1·3 and 1 : 1·9
16.	,, 1 : 1·8 and 1 : 1·9
17.	,, 1 : 1·6
18.	,, 1 : 1·9 and 1 : 2·5
19.	,, 1 : 1·7
20.	,, 1 : 1·5 and 1 : 2·0
21.	,, 1 : 1·5 and 1 : 2·0
22.	,, 1 : 1·7
23.	,, 1 : 2·0
24.	,, 1 : 2·0
	Mean . . 1 : 1·8

From this Table it will be seen that while this proportion is variable, yet one may generally regard the disturbing force at Kew as greater than that at Lisbon in the proportion of 1·8 to 1.

2. *Declination* (*east and west disturbing force*).—The declination-curves for Kew and Lisbon are very like each other, and the waves as well as the peaks and hollows are for the most part simultaneously produced in the two collections of curves. Since, however, at Kew the waves are greater, one does not always easily perceive the resemblance. Certain peaks or waves very prominent at Kew, are reproduced but slightly at Lisbon; but a careful scrutiny shows that all, or very nearly all, of the Kew waves and peaks occur at Lisbon also.

In Table IV. we have a comparison of the principal points of the declination-curves with respect to time. From this Table it will be found that the average difference between the local times of corresponding points is $34^{m}\cdot0$, that due to difference of longitude being $35^{m}\cdot3$.

The following Table exhibits approximately the proportion between the disturbance-waves of the declination at Lisbon and at Kew.

TABLE V.

Date.	Proportion between the disturbance-waves of the declination reduced at both places to English units (Lisbon wave=unity).
July 15.	Variable from 1 : 1·8 to 1 : 2·1
16.	,, 1 : 1·5
17.	,, 1 : 1·4 to 1 : 1·6
18.	,, 1 : 1·5
19.	,, 1 : 1·5
20.	,, 1 : 1·7
21.	,, 1 : 1·3
22.	,, 1 : 1·4
23.	,, 1 : 1·8
24.	,, 1 : 1·6
	Mean . . 1 : 1·6

Table IV.—Comparison of the times of the principal corresponding points of the Declination Curves at Kew and Lisbon.

		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
July 15 …	Kew	10 15	13 15	14 36	17 47	18 00	18 53	19 49	21 51						
	Lisbon	9 35	12 36	13 56	17 08	17 21	18 16	19 12	21 17						
	Differences	0 40	0 39	0 40	0 39	0 39	0 37	0 37	0 34						
16 …	Kew	0 18	2 17	2 30	3 51	12 48	14 11	16 22	18 26	20 13	21 16				
	Lisbon	(15) 23 41	1 41	1 54	3 16	12 14	13 37	15 45	17 52	19 37	20 42				
	Differences	0 37	0 36	0 36	0 35	0 34	0 34	0 37	0 34	0 36	0 34				
17 …	Kew	(16) 22 55	(16) 23 49	1 46	2 45	2 52	3 20	3 59	5 40	5 57	8 33	11 11	16 11·5	18 37	19 51
	Lisbon	(16) 22 21	(16) 23 16	1 11	2 11	2 20	2 48	3 22	5 5	5 22	8 0	10 39	15 39	18 6	19 20
	Differences	0 34	0 33	0 35	0 34	0 32	0 32	0 37	0 35	0 35	0 33	0 32	0 32·5	0 31	0 31
18 …	Kew	(17) 23 20	0 22	2 7	3 37	7 18	8 5	9 33	12 50	13 58	15 43	16 41	17 54		
	Lisbon	(17) 22 46	(17) 23 48	1 33	3 3	6 44	7 32	8 58	12 16	13 24	15 11	16 10	17 22		
	Differences	0 34	0 34	0 34	0 34	0 34	0 33	0 35	0 34	0 34	0 32	0 31	0 32		
19 …	Kew	(18) 23 20	00 14	2 12	2 36·5	3 21	5 45	9 14	17 49·5	17 58·5	18 3	20 28			
	Lisbon	(18) 22 45	(18) 23 42	1 36·5	2 2	2 46	5 12	8 39	17 18	17 25	17 28	19 56			
	Differences	0 35	0 32	0 35·5	0 34·5	0 35	0 33	0 35	0 31·5	0 33·5	0 35	0 32			
20 …	Kew	0 54	3 19·5	3 56	4 13	5 52	10 59	12 31	15 1	18 51	19 24	20 25	21 4		
	Lisbon	0 18	2 46·5	3 22	3 41	5 20	10 23	11 56	14 26	18 18·5	18 53·5	19 51	20 31		
	Differences	0 36	0 33	0 34	0 32	0 32	0 36	0 35	0 35	0 32·5	0 30·5	0 34	0 33		
21 …	Kew	0 20·5	2 10	2 13	4 19	5 36·5	7 12	11 5	12 7	16 12	17 28	20 15			
	Lisbon	(20) 23 47	1 36	1 40	3 46	5 01·5	6 38	10 31	11 34	15 39	16 55	19 44			
	Differences	0 33·5	0 34	0 33	0 33	0 35	0 34	0 34	0 33	0 33	0 33	0 31			
22 …	Kew	(21) 23 20	0 42	3 51	5 6	8 26	12 56	14 11	16 58	17 39	18 47	19 19	19 31	21 38·5	
	Lisbon	(21) 22 48	0 8	3 17	4 33	7 51	12 22	13 36	16 25	17 6	18 14	18 47	18 58	21 5	
	Differences	0 32	0 34	0 35	0 33	0 35	0 34	0 35	0 33	0 33	0 33	0 32	0 33	0 33·5	
23 …	Kew	2 24	3 09	3 34	7 26	9 23	10 54	11 32	14 36	18 33	19 25	19 50	21 50		
	Lisbon	1 52	2 34	3 00	6 52	8 48	10 22	10 59·5	14 3	18 1	18 52	19 18	21 17		
	Differences	0 32	0 35	0 34	0 34	0 35	0 32	0 32·5	0 33	0 32	0 33	0 32	0 33		
24 …	Kew	1 14	3 29·5	4 18	6 2	8 36	11 20	12 30	15 36	16 43	18 8	19 27	20 22	21 39	
	Lisbon	0 40	2 57	3 46	5 28	8 1·5	10 48	11 53	15 1	16 6·5	17 35	18 55	19 50	21 6	
	Differences	0 34	0 32·5	0 32	0 34	0 34·5	0 32	0 37	0 35	0 36·5	0 33	0 32	0 32	0 33	

It would thus appear that the declination at Kew, judging from the waves, is subject to greater disturbing forces than at Lisbon in the proportion of 1·6 : 1. This ratio is not, however, quite so great as that for the horizontal force.

3. *Vertical disturbing force.*—The curves of vertical force are nearly quite dissimilar. Sometimes the general march of the curves appears to coincide during some time; but in these cases we do not find an appreciable general agreement for the majority of the various points of the wave.

On the other hand, the small peaks and hollows of the Kew curves are generally reproduced in those of Lisbon, but in the opposite direction, that is to say, a sudden augmentation of the vertical force at Kew corresponds to a sudden diminution of the same at Lisbon, and *vice versâ*.

In Table VI. we have a comparison of the principal points of the vertical-force curves with respect to time.

TABLE VI.—Comparison of the time of the principal corresponding points of the Curves of Vertical Force at Kew and Lisbon.

		h m	h m	h m	h m	h m	h m
July 15 ...	Kew	No similarity.					
	Lisbon ...						
	Differences						
16 ...	Kew.........	2 21	21 17				
	Lisbon......	1 47	20 45				
	Differences	0 34	0 32				
17 ...	Kew.........	2 45·0	2 52	3 20	7 57	16 11·5	
	Lisbon......	2 11·5	2 19·5	2 49	7 23	15 39	
	Differences	0 33·5	0 32·5	0 31	0 34	0 32·5	
18 ...	Kew.........	7*00	9*33	21 22			
	Lisbon......	6 29	9 00	20 50			
	Differences	0 31	0 33	0 32			
19 ...	Kew.........	0*10	2 12	2 36·5	3 21	17 49·5	17 58·5
	Lisbon......	23 38	1 36·5	2 02	2 46	17 18	17 25
	Differences	0 32	0 35·5	0 34·5	0 35	0 31·5	0 33·5
20 ...	Kew.........	3 19·5	18 51	22 03			
	Lisbon......	2 46·5	18 18·5	21 31			
	Differences	0 33	0 32·5	0 32			
21 ...	Kew.........	2 10	5 36·5	6 43			
	Lisbon......	1 36	5 01·5	6 09			
	Differences	0 34	0 35	0 34			
22 ...	Kew.........	5 06	8 24	12 56	19 19	19 31	21 38·5
	Lisbon......	4 33	7 51	12 22	18 46	18 57	21 4
	Differences	0 33	0 33	0 34	0 33	0 34	0 34·5
23 ...	Kew.........	18 33	18 37	21 54			
	Lisbon......	18 01	18 05	21 22			
	Differences	0 32	0 32	0 32			
24 ...	Kew.........	3 29·5	4 10	5 59	16 43		
	Lisbon......	2 56	3 37	5 26	16 8·5		
	Differences	0 33·5	0 33	0 33	0 34·5		

* Only the points marked with this sign are in the same direction, all the others are in the opposite direction; that is to say, an augmentation of force at Kew corresponds to a diminution of the same at Lisbon, and *vice versâ*.

From this Table it will be seen that the average difference between the local times of corresponding points is $33^{m} \cdot 1$, while for the horizontal force this was $34^{m} \cdot 3$, and for the declination $34^{m} \cdot 0$, the mean of the three being $33^{m} \cdot 8$. The measurements from which these numbers were obtained were made at Lisbon independently for each element: another set of measurements, made at Kew, but of a less comprehensive description, gave a mean difference in local time of $33^{m} \cdot 7$, which is as nearly as possible identical with the Lisbon determination. We have already observed that we attribute the difference between $33^{m} \cdot 8$ and $35^{m} \cdot 3$, the true longitude-difference of local times, to instrumental errors, and not to want of simultaneity in the corresponding points.

In Table VII. we have a comparison in magnitude and sign of the peaks and hollows at the two stations.

From this Table it will be seen that the magnitude of these is generally greater at Kew than at Lisbon. The curious fact of the reversal in direction of the vertical-force peaks between Kew and Lisbon has been already noticed.

We shall now in a few words recapitulate the results which we have obtained.

1. In comparing the Kew curves together for this disturbance, the peaks and hollows of the horizontal force always bear a definite proportion to those of the vertical force, the proportion being the same as that observed in previous disturbances. On the other hand, the declination peaks and hollows do not bear an invariable proportion to those of the other two elements, but present the appearance of a daily range, being great in the early morning hours, and small in those of the afternoon. The peaks and hollows are in the same direction for all the elements.

2. In comparing the Lisbon curves together, the elevations of the declination-curve always appear as hollows in the vertical-force curve, and *vice versâ*, and there is always a very nearly constant ratio between the ordinates of the two curves. The horizontal-force curve, on the other hand, presents no striking likeness to the other two. We conclude from this that there are at least two independent disturbing forces which jointly influence the needle at Lisbon, but that the declination and vertical-force elements are chiefly influenced by one force.

The peaks and hollows are generally simultaneous for the three curves. The direction of these is the same for the horizontal force and declination, while that for the vertical force is opposite. The ratio in magnitude of the peaks and hollows is generally variable between the horizontal force and the declination, while it is always constant between the latter and the vertical force.

3. When the Kew and Lisbon curves are compared together, there is a very striking likeness between the horizontal-force curves, one perhaps somewhat less striking between the declination-curves, and very little likeness between the vertical-force curves. It is perhaps worthy of note that

This Table has been constructed with the following values of K, the coefficient for one inch.

	Kew. English unit.		Lisbon. English unit.
Horizontal force ...	K=0·041	...	K (17 and 18) ... =0·066; For the other days K=0·041
Declination	K=0·024	...	.......................K=0·040
Vertical force	K=0·024	...	.......................K=0·026

TABLE VII.—Magnitude and Sign of the Peaks and Hollows at Kew and Lisbon.

	Declination.				Horizontal force.				Vertical force.			
	Kew.		Lisbon.		Kew.		Lisbon.		Kew.		Lisbon.	
	Inch.	English unit.	Inch.	English unit.	Inch.	English nit.	Inch.	English unit.	Inch.	English unit.	Inch.	English unit.
July 17	−0·040	0·00096	−0·010	0·00040	−0·065	0·00267	−0·030	0·00198	−0·035	0·00084	+0·015	0·00039
	−0·040	0·00096	−0·010	0·00040	−0·075	0·00307	−0·030	0·00198	−0·035	0·00084	+0·015	0·00039
	−0·050	0·00120	−0·010	0·00040	−0·100	0·00410	−0·040	0·00264	−0·050	0·00120	+0·010	0·00026
	...	...	...	...	−0·090	0·00369	−0·055	0·00363	−0·045	0·00108		
	+0·070	0·00168	+0·015	0·00060	+0·045	0·00184	+0·030	0·00198	+0·020	0·00048	−0·015	0·00039
18	+0·045	0·00108	+0·030	0·00120	+0·030	0·00123	very small	„	?	?	−0·040	0·00104
19	...	...	+0·025	0·00100	+0·100	0·00410	+0·050	0·00205	+0·055	0·00132	−0·025	0·00065
	+0·050	0·00120	?	...	+0·075	0·00307	+0·055	0·00225	+0·045	0·00108	−0·015	0·00039
	+0·035	0·00084	+0·015	0·00060	+0·050	0·00205	+0·040	0·00164	+0·030	0·00072	−0·015	0·00039
	+0·035	0·00084	+0·020	0·00080	+0·065	0·00267	+0·045	0·00184	+0·035	0·00084	−0·025	0·00065
	+0·035	0·00084	+0·015	0·00060	+0·025	0·00103	+0·015	0·00061	very	...	−0·015	0·00039
	+0·065	0·00156	+0·025	0·00100	+0·035	0·00143	+0·025	0·00102	small	...	−0·025	0·00065
	+0·065	0·00156	+0·035	0·00140	+0·040	0·00164	+0·010	0·00041	+0·020	0·00048	−0·030	0·00078
20	+0·020	0·00048	+0·010	0·00040	+0·040	0·00164	?	?	+0·025	0·00060	−0·010	0·00026
	+0·090	0·00216	+0·030	0·00120	+0·045	0·00184	+0·015	0·00061	+0·020	0·00048	−0·030	0·00078
21	−0·025	0·00060	−0·010	0·00040	−0·035	0·00143	very small	...	−0·015	0·00036	+0·010	0·00026
	−0·050	0·00120	−0·035	0·00140	−0·075	0·00307	−0·040	0·00164	−0·035	0·00084	+0·030	0·00078
	+0·035	0·00084	+0·015	0·00060	+0·050	0·00205	+0·035	0·00143	+0·025	0·00060	−0·010	0·00026
22	−0·100	0·00240	−0·035	0·00140	−0·050	0·00205	−0·030	0·00123	−0·025	0·00060	+0·040	0·00104
	−0·085	0·00204	−0·035	0·00140	−0·050	0·00205	−0·025	0·00102	−0·025	0·00060	+0·045	0·00117
	+0·070	0·00168	+0·015	0·00060	+0·040	0·00164	+0·020	0·00082	+0·020	0·00048	−0·010	0·00026
23	+0·070	0·00168	+0·030	0·00120	+0·045	0·00184	+0·025	0·00102	+0·020	0·00048	−0·040	0·00104
	+0·060	0·00144	+0·025	0·00100	+0·035	0·00143	+0·030	0·00123	very small	...	−0·030	0·00078
24	+0·055	0·00132	+0·025	0·00100	+0·090	0·00369	+0·080	0·00328	+0·045	0·00108	−0·030	0·00078
	+0·050	0·00120	+0·010	0·00040	+0·030	0·00123	+0·025	0·00102	very small			

the Lisbon horizontal-force curve, in which we may suppose two independent forces to be represented, is probably on the whole the most like the corresponding Kew curve. Corresponding points occur at the same absolute time for both stations.

The disturbance-waves for the horizontal force and declination are greater at Kew than at Lisbon.

The Kew peaks and hollows are simultaneously produced at Lisbon in all the elements, but to a smaller extent than at Kew; also the direction is reversed in the case of the vertical force, so that a sudden small increase of vertical force at Kew corresponds to a diminution of the same at Lisbon.

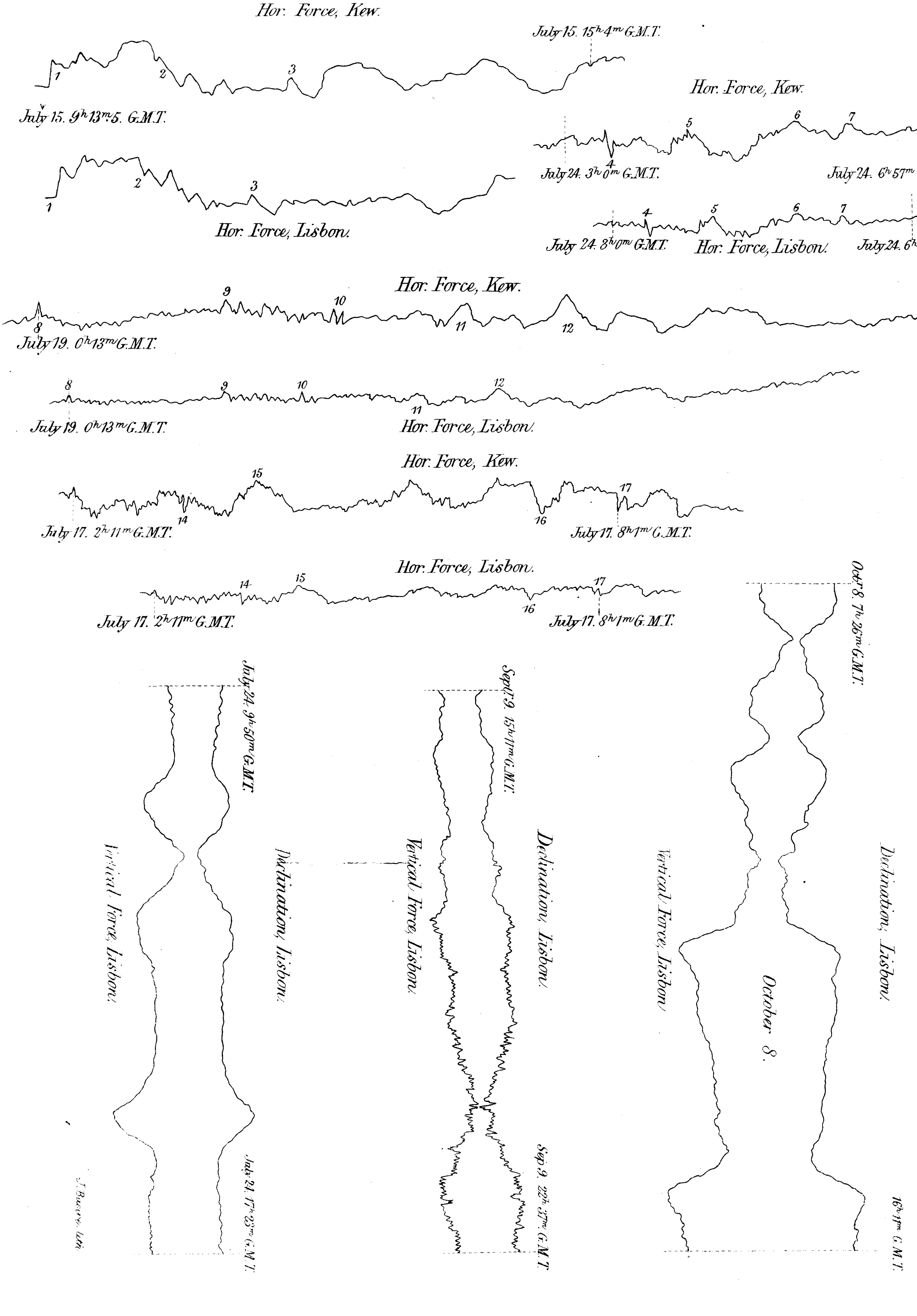
The writers of this paper are well aware that before the various points alluded to in their communication can be considered as established, a more extensive comparison of curves must be made. But as the subject is new and of great interest, they have ventured thus early to make a preliminary communication to the Royal Society. They will afterwards do all in their power to confirm their statements, which in the meantime they submit to this Society as still requiring that proof which only a more prolonged investigation can afford.

Note regarding the Plates.

Increasing ordinates denote increasing westerly declination, and also increasing horizontal and vertical force.

The following are the scale coefficients applicable to the different diagrams:—

Horizontal force,	Kew.	One inch	represents	0·041	English unit.	
Ditto	Lisbon.	,,	,,	0·035	,,	for July 15
Ditto	do.	,,	,,	0·066	,,	for July 17.
Ditto	do.	,,	,,	0·041	,,	for the other curves.
Declination	do.	,,	,,	0·040	,,	
Vertical force	do.	,,	,,	0·026	,,	



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