strong hydrochloric acid, and heated to about 140° for two or three hours. After cooling, a layer of colourless liquid was observed floating on the top of the brown tarry contents. It immediately became gaseous on opening the tubes, and was presumedly chloride of methyl, as the issuing gases were found to be free from carbonic acid. The residue in the tubes, when dissolved in water and precipitated by carbonate of sodium, yielded, on extraction with ether and agitation with hydrochloric acid, a crystalline chloride having, when purified by recrystallization, all the properties of the chloride of apomorphia derived from morphia. It gave the same qualitative reactions, produced the same remarkable physiological effects, and yielded the following numbers on combustion with chromate of lead and oxygen:—

0·3120 gramme gave 0·7680 carbonic acid and 0·1740 water.

	Calculated.		Found.
C_{17}	204	67·22	67·13
H_{18}	18	5·93	6·19
N	14	4·61	
O_2	32	10·54	
Cl	35·5	11·70	
$C_{17}H_{17}NO_2HCl$	303·5	100·00	

Hence the reaction which takes place is in accordance with formula (4) above, viz.

$$\underset{\text{Codeia.}}{C_{17}H_{17}(CH_3)HNO_3}+HCl=CH_3Cl+H_2O+\underset{\text{Apomorphia.}}{C_{17}H_{17}NO_2}.$$

Doubtless there is an intermediate reaction, viz. either that indicated by formula (3), where morphia is the intermediate product, or that in accordance with (2), where a base homologous with apomorphia, and thence called apocodeia, is first produced, and subsequently split up into apomorphia and chloride of methyl, thus—

$$\underset{\text{Apocodeia.}}{C_{18}H_{19}NO_2}+HCl=CH_3Cl+\underset{\text{Apomorphia.}}{C_{17}H_{17}NO_2}.$$

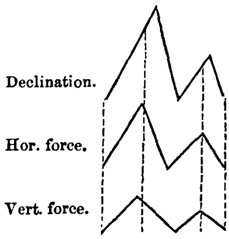
We are at present engaged in investigating the nature of this intermediate reaction.

V. "A Preliminary Investigation into the Laws regulating the Peaks and Hollows exhibited in the Kew Magnetic Curves for the first two years of their production." By Balfour Stewart, LL.D., F.R.S., Superintendent of the Kew Observatory. Received May 20, 1869.

The Kew magnetographs began to be in regular operation in May 1858, and have continued so up to the present date. The curves derived from these instruments, representing the changes which take place in the three components of the earth's magnetism at Kew, are often found to be studded with small serrated appearances, which have been denominated peaks and hollows; and the following remarks will serve to show that the study of these may be attended with considerable advantage.

The labours of General Sabine have been instrumental in showing that there are at least two forces concerned in producing disturbances; and this conclusion is confirmed by the appearance of the Kew curves, from which it may be seen that no disturbance of any magnitude is due to the action of a single force merely varying in amount and not in direction; for if this were the case the distance at any moment of a point in the curve of one of the elements from its normal position should bear throughout such a disturbance an invariable proportion to the distance of a corresponding point in the curve of another of the elements from its normal; but this is by no means the case.

It becomes therefore a question of interest to endeavour to find the elementary forces concerned in producing a disturbance; and it is thought that this knowledge may to some extent be attained by a study of those small and rapid changes of force which are denoted by peaks and hollows. For if several independent forces are at work, it may be thought unlikely that at the same moment a sudden change should take place in all; there is thus a probability that sudden changes of force, as exhibited in peaks and hollows, are changes in one of the elementary forces concerned, which may thus enable us to determine the nature of that force. Even if the change is not a very abrupt one, provided that we confine ourselves to such peaks and hollows as present a similar appearance for all the curves, we may suppose that we are observing changes in one only of the elementary disturbing forces; for it is unlikely that two or more independent forces, changing independently, should produce similar appearances in all of the three curves. Thus what we have to look for is similar appearances; and the precise meaning attached to this expression will be rendered clear by means of the annexed graphical representation.



We see here that (time being reckoned horizontally) we have a disturbance commencing at the same moment in each of the three elements, that for the declination being throughout three times as large, and that for the annexed force twice as large as the corresponding vertical-force disturbance.

In a paper communicated by me to the Royal Society, and published in the Transactions (1862, page 621), it was stated that, as a rule, small and abrupt disturbances at Kew tend either to increase at the same moment both components of magnetic force and the westerly declination, or to decrease these elements, as the case may be. As in the Kew curves of 1862, increasing ordinates represented decreasing horizontal force, decreasing vertical force, and decreasing declination, the above statement is the asme as saying that, as a rule, peaks and hollows in one element correspond to peaks and hollows in the other two.

Nevertheless one notable exception to this rule was mentioned in the above paper, namely, that at the beginning of the great disturbance of August–September 1859, an abrupt fall of the declination curve corresponded to a rise of the other two components. It was also shown in this paper that while the horizontal-force peaks are always as nearly as possible double in size of the vertical-force peaks, the proportion between the declination peaks and those of the other components appeared to be variable. Some light was thrown upon this variability in a subsequent paper by Senhor Capello and myself, in which the peaks and hollows at Lisbon and at Kew were compared together (Proc. Roy. Soc. 1864, p. 111). It was found that these phenomena occurred simultaneously at these two observatories; and it was stated that, as far as Kew is concerned, the proportion of the declination peaks and hollows to those of the horizontal and vertical force presents the appearance of a daily range, being great at the early morning hours and small in those of the afternoon.

Thus the type of small and abrupt changes, judging from the behaviour of the declination, seemed to vary from two causes, being in the first place subject to a diurnal variation, and in the second place appearing to vary with the disturbance, inasmuch as that for the great disturbance August–September 1859 was, as above stated, entirely different from the usual type.

This complexity seems puzzling; but the results of a preliminary comparison between the Stonyhurst and Kew declination magnetographs (Sidgreaves and Stewart, Proc. Roy. Soc. 1869, p. 236) appear to throw some light upon its cause. It was there stated that when the declination-curves of Stonyhurst and Kew are compared together during rather slow disturbances, the scales are such that the traces seem exactly to coincide even to their most minute features; but, on the other hand, when the disturbance is abrupt, there is an excess of Stonyhurst over Kew, which appears to vary with the abruptness of the disturbance, being great when this is great. In fine, there appears to be superimposed upon a disturbance, which is mainly cosmical, a comparatively small effect, which appears to be of a more local nature, and may perhaps be caused by earth-currents. This circumstance renders it prudent, in discussing the laws of the small and abrupt changes of force (peaks and hollows) at Kew, to avoid all great and excessively abrupt disturbances, confining ourselves to those cases in which there is only a moderate abruptness. The result obtained for the great disturbance August–September 1859 may therefore be dismissed as probably effected by this local cause, inasmuch as the disturbance measured was very abrupt. The question then arises—Rejecting very great and abrupt disturbances, has the peak-and-hollow force only a regular diurnal variation, or is it subject besides to other changes of type?

Mr. Whipple, magnetical assistant at Kew, has carefully selected and measured all the similar peaks and hollows for the first two years of the Kew curves; and the result exhibits a manifest diurnal variation in the type of the peak-and-hollow force.

In the following Table we have these various measurements ranged in order of date, the unit of the scale adopted being $\frac{1}{200}$ of an inch.

Table I.

Measurements of the Peaks and Hollows in the Kew Magnetograph Curves.

Date.	Time.	Declination.	Horizontal force.	Vertical force.	Date.	Time.	Declination.	Horizontal force.	Vertical force.
1858.	h m				1858.	h m			
May 22.	15 15	30	21	10	Dec. 13.	21 10	24	16	8
22.	18 30	35	15	7	16.	17 15	39	18	10
29.	16 15	49	28	16	16.	23 0	17	13	9
June 3.	16 10	22	9	5	17.	15 12	55	45	20
3.	17 25	45	19	11	18.	20 6	64	58	25
4.	16 15	42	23	11	23.	19 18	23	14	6
4.	19 10	24	11	6	1859.				
July 6.	18 17	23	11	5	Jan. 8.	23 45	42	32	14
23.	15 10	20	13	6	10.	20 0	103	82	32
24.	17 10	35	19	6	17.	15 40	19	9	4
26.	13 55	52	51	25	17.	21 45	23	15	7
30.	17 55	20	13	7	18.	23 15	36	22	12
Aug. 1.	2 0	17	23	14	19.	18 20	17	13	5
10.	2 16	14	11	5	19.	20 10	47	34	12
12.	4 20	15	18	10	29.	14 55	23	14	7
13.	17 30	24	17	8	30.	14 10	9	7	4
13.	18 43	19	12	5	30.	21 48	21	17	9
17.	12 54	14	18	9	Feb. 1.	20 50	54	36	14
24.	18 14	19	11	5	10.	2 27	55	41	19
26.	1	16	25	11	10.	15 50	20	13	7
28.	20 20	33	23	10	14.	18 0	32	21	7
Sept. 2.	18 0	20	10	5	15.	23 30	21	15	7
11.	16 2	11	7	4	16.	19 45	18	11	5
13.	21 47	16	12	4	21.	2 50	37	40	17
23.	10 50	8	19	6	22.	14 50	35	41	17
23.	11 55	9	15	7	22.	16 10	82	55	24
23.	12 56	10	18	6	March 2.	21 30	25	16	7
25.	23 10	40	39	20	3.	21 40	21	15	5
26.	0 30	19	18	10	9.	18 40	27	14	8
26.	3 20	32	38	23	10.	20 40	42	22	10
29.	19 35	21	13	4	10.	22 10	25	21	10
29.	20 10	16	11	6	11.	0 55	18	18	8
Oct. 2.	18 10	15	9	5	11.	1 30	17	18	8
8.	20 20	28	22	10	11.	16 50	63	40	17
15.	1 22	14	14	5	11.	18 30	19	10	4
15.	3 48	10	15	4	12.	22 10	21	13	6
18.	23 52	108	70	31	13.	18 45	18	9	4
21.	19 27	27	17	7	16.	17 50	15	10	5
24.	18 56	28	16	7	16.	20 50	54	42	18
27.	22 40	43	40	19	16.	22 35	93	83	40
27.	23 7	44	38	27	17.	20 30	45	28	13
28.	19 20	12	7	5	22.	5 30	11	12	7
29.	14 0	28	32	15	26.	19 30	28	20	10
Nov. 2.	12 50	20	31	10	27.	23 40	18	15	6
2.	22 50	26	18	7	29.	20 10	61	38	22
12.	3 20	43	47	19	30.	20 0	59	38	18
19.	21 17	30	20	7	31.	19 30	101	53	26
23.	1 28	32	27	12	April 6.	18 55	25	16	8
24.	0 50	20	19	11	7.	23 4	23	21	8

TABLE I. (*continued*).

Date.	Time.	Declination.	Horizontal force.	Vertical force.	Date.	Time.	Declination.	Horizontal force.	Vertical force.
1859.	h m				1860.	h m			
April 11.	17 55	36	26	11	Jan. 10.	22 5	29	17	9
12.	16 20	13	9	4	16.	17 50	34	18	9
12.	16 50	12	13	4	20.	20 45	24	18	9
12.	18 50	29	17	7	21.	20 35	50	29	14
13.	17 30	22	16	8	26.	23 15	21	16	7
13.	18 10	42	20	10	27.	17 50	21	9	4
13.	20 30	34	21	10	28.	15 20	13	5	2
13.	22 45	25	23	13	28.	21 40	21	10	5
13.	23 25	22	21	10	29.	21 35	41	22	9
14.	13 50	14	13	7	Feb. 12.	15 55	12	8	4
14.	17 40	22	15	7	15.	21 10	31	21	9
14.	18 5	34	15	7	16.	11 20	13	23	12
15.	17 25	20	14	5	16.	16 10	21	11	5
16.	18 50	25	12	5	Mar. 5.	18 25	25	13	5
17.	2 10	35	49	27	7.	15 10	22	37	19
20.	8 0	8	11	5	7.	19 30	50	22	11
20.	20 33	22	11	6	8.	21 5	36	17	9
May 4.	19 0	24	15	7	9.	3 50	13	15	8
5.	16 25	24	13	5	9.	19 2	69	32	10
6.	17 55	17	7	4	12.	20 10	129	59	27
8.	17 30	43	23	10	12.	21 10	34	23	11
9.	16 20	27	19	6	14.	18 5	112	64	29
Aug. 4.	17 15	13	7	3	14.	19 15	41	19	10
7.	1 35	14	24	12	14.	21 45	28	23	9
9.	16 30	19	13	5	15.	19 40	71	34	13
10.	2 50	13	18	10	19.	18 40	35	19	9
10.	7 45	49	39	24	19.	19 0	56	26	13
22.	17 58	20	8	4	20.	1 20	24	16	8
Sept. 15.	18 10	27	11	5	20.	2 55	17	20	10
15.	21 55	25	20	9	22.	19 45	19	10	5
17.	23 10	15	16	8	22.	20 0	39	29	13
26.	4 10	44	56	37	April 2.	0 55	21	21	10
30.	18 55	31	21	11	2.	2 45	15	17	7
Oct. 1.	0 10	21	25	11	2.	3 30	16	21	10
2.	16 20	59	34	17	3.	4 15	15	22	11
21.	18 50	38	23	11	4.	18 15	22	17	5
Nov. 2.	18 30	23	12	6	11.	17 40	17	13	(6)
6.	4 20	11	14	7	11.	20 45	15	9	(4)
6.	19 5	21	9	5	11.	23 10	29	35	(17)
12.	3 58	29	23	14	17.	3 35	15	20	9
16.	17 40	27	15	7	19.	22 5	20	9	4
17.	15 20	24	23	10	20.	2 20	32	33	18
17.	16 50	21	15	8	21.	16 40	15	10	5
Dec. 4.	20 50	33	18	7	29.	14 5	19	21	10
4.	21 20	30	21	10	29.	20 30	41	38	19
5.	20 10	38	18	8	30.	0 50	30	20	10
6.	2 25	17	19	9	30.	2 30	18	16	8
6.	17 5	63	41	20	30.	21 10	111	98	43
10.	18 10	97	55	28	May 1.	1 10	13	18	9
15.	22 10	37	27	14	1.	17 50	17	4	2
1860.					4.	11 10	8	17	4
Jan. 5.	20 40	21	15	7	4.	15 10	19	10	5
10.	19 10	30	20	9	27.	19 5	22	12	5

In the following Table each disturbance is entered under its appropriate hour.

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Table II.—HOURLY RATIOS OF PEAKS AND HOLLOWS.

First Year, 1858–59.

0–1.	1–2.	2–3.	3–4.	4–5.	5–6.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
19 18 10	16 25 11	17 23 14	32 38 23	15 18 10	11 12 7
20 19 11	14 14 5	14 11 5	10 15 4		
18 18 8	32 27 12	55 41 19	43 47 19		
20 23 10	17 18 8	37 40 17			
		35 49 27			
77 78 39	79 84 36	158 164 82	85 100 46	15 18 10	11 12 7

6–7.	7–8.	8–9.	9–10.	10–11.	11–12.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
....	8 11 5	8 11 5	....	8 19 6	9 15 7
....	8 11 5	8 11 5	....	8 19 6	9 15 7

12–13.	13–14.	14–15.	15–16.	16–17.	17–18.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
14 18 9	52 51 25	28 32 15	30 21 10	49 28 16	45 19 11
10 18 6	28 32 15	23 14 7	20 13 6	22 9 5	35 19 6
20 31 10	14 13 7	9 7 4	55 45 20	42 23 11	20 13 7
		35 41 17	19 9 4	11 7 4	24 17 8
			20 13 7	82 55 24	20 10 5
				63 40 17	39 18 10
				13 9 4	32 21 7
				12 13 4	15 10 5
				24 13 5	36 26 11
				27 19 6	22 16 8
					22 15 7
					20 14 5
					17 7 4
					43 23 10
44 67 25	94 96 47	95 94 43	144 101 47	345 216 96	390 228 104

18–19.	19–20.	20–21.	21–22.	22–23.	23–0.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
35 15 7	24 11 6	33 23 10	16 12 4	43 40 19	40 39 20
23 11 5	21 13 4	16 11 6	30 20 7	26 18 7	108 70 31
19 12 5	27 17 7	28 22 10	24 16 8	17 13 9	44 38 27
19 11 5	12 7 5	64 58 25	23 15 7	25 21 10	17 13 9
20 10 5	23 14 6	103 82 32	21 17 9	21 13 6	42 32 14
15 9 5	103 82 32	47 34 12	25 16 7	93 83 40	36 22 12
28 16 7	18 11 5	54 36 14	21 15 5	25 23 13	21 15 7
17 13 5	28 20 10	42 22 10			18 15 6
32 21 7	59 38 18	54 42 18			23 21 8
27 14 8	101 53 26	45 28 13			22 21 10
19 10 4	24 15 7	61 38 22			
18 9 4		59 38 18			
25 16 8		34 21 10			
29 17 7		22 11 6			
42 20 10					
34 15 7					
25 12 5					
24 15 7					
451 246 111	440 281 126	662 466 206	160 111 47	250 211 104	371 286 144

Second Year, 1859–60.

0–1.	1–2.	2–3.	3–4.	4–5.	5–6.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
21 25 11	14 24 12	13 18 10	29 23 14	44 56 37	....
21 21 10	24 16 8	17 19 9	13 15 8	11 14 7	
30 20 10	13 18 9	17 20 10	16 21 10	15 22 11	
		15 17 7	15 20 9		
		32 33 18			
		18 16 8			
72 66 31	51 58 29	112 123 62	73 79 41	70 92 55	....

6–7.	7–8.	8–9.	9–10.	10–11.	11–12.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
....	49 39 24	....	....	....	13 23 12
					8 17 4
....	49 39 24	....	....	....	21 40 16

12–13.	13–14.	14–15.	15–16.	16–17.	17–18.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
....	....	19 21 10	24 23 10	19 13 5	13 7 3
			13 5 2	59 34 17	20 8 4
			12 8 4	21 15 8	27 15 7
			22 37 19	21 11 5	63 41 20
			19 10 5	15 10 5	34 18 9
					21 9 4
					17 13 (6)
					17 4 2
....	....	19 21 10	90 83 40	135 83 40	212 115 55

18–19.	19–20.	20–21.	21–22.	22–23.	23–0.
D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.	D. HF. VF.
27 11 5	21 9 5	33 18 7	25 20 9	37 27 14	15 16 8
31 21 11	30 20 9	38 18 8	30 21 10	29 17 9	21 16 7
38 23 11	50 22 11	21 15 7	21 10 5	20 9 4	29 35 (17)
23 12 6	69 32 10	24 18 9	41 22 9		
97 55 28	41 19 10	50 29 14	31 21 9		
25 13 5	71 34 13	129 59 27	36 17 9		
112 64 29	56 26 13	39 29 13	34 23 11		
35 19 9	19 10 5	15 9 (4)	28 23 9		
56 26 13	39 29 13	41 38 19	111 98 43		
22 17 5	22 12 5				
466 261 122	418 213 94	390 233 108	357 255 114	86 53 27	65 67 32

It will be seen from this Table that there is great constancy in the type of the peak-and-hollow force for the same hour. Bearing in mind the difficulty of finding exactly similar appearances denoting an unmixed force, and remembering also the small size of many of the peaks and hollows observed, it is not too much to say that, as far as these two years' observations are concerned, there is no trace of anything else than a diurnal change in the type of the peak-and-hollow force. But this question cannot be finally decided until more observations are discussed.

In the following Table the final results of Table II. are brought before the eye in a condensed form.

TABLE III.

Hourly Ratios and Frequency of the Peaks and Hollows, the vertical force being taken as unity.

Hour.	Declination.		Horizontal force.		Mean of both years.		Number of observations.
	1858–59.	1859–60.	1858–59.	1859–60.	Declination.	Horizontal force.	
0–1	1·97	2·32	2·00	2·13	2·14	2·06	7
1–2	2·19	1·76	2·33	2·00	1·97	2·16	7
2–3	1·92	1·81	2·00	1·98	1·86	1·99	11
3–4	1·84	1·78	2·17	1·93	1·81	2·05	7
4–5	1·50	1·27	1·80	1·67	1·38	1·73	4
5–6	1·57	……	1·71				
6–7							
7–8	1·60	2·04	2·20	1·62			
8–9	1·60	……	2·20				
9–10							
10–11	1·33	……	3·16				
11–12	1·29	1·31	2·14	2·50			
12–13	1·76	……	2·68				
13–14	2·00	……	2·04				
14–15	2·21	1·90	2·18	2·10	2·10	2·14	5
15–16	3·06	2·25	2·15	2·07	2·65	2·11	10
16–17	3·59	3·37	2·25	2·07	3·48	2·16	15
17–18	3·75	3·85	2·19	2·09	3·80	2·14	22
18–19	4·06	3·82	2·22	2·14	3·94	2·18	28
19–20	3·49	4·45	2·23	2·27	3·97	2·25	21
20–21	3·21	3·61	2·26	2·16	3·41	2·21	23
21–22	3·40	3·13	2·36	2·24	3·26	2·30	16
22–23	2·40	3·19	2·03	1·96	2·79	2·00	10
23–0	2·58	2·03	1·99	2·10	2·30	2·04	13

From this Table it will be seen that, as was formerly stated, the ratio between simultaneous peaks and hollows of the two components of the force is very nearly constant, the horizontal force disturbance being very nearly double of that of the vertical force.

It will also be seen that there is a very marked diurnal range in the ratio which the declination peak or hollow bears to that of the vertical force, this ratio being greatest about 7 A.M. About this hour we have also most peaks and hollows, while in the evening and very early morning hours there is a comparative absence of these phenomena. So much is this the case that for the two years investigated I have not succeeded in finding a single example of a peak or hollow, suitable for this research, between the hours of 6 and 7 P.M., or between those of 9 and 10 P.M.

I forbear to make further remarks on this subject, but hope in a short time to extend the investigation up to the present date, and to bring the results before this Society.

VI. "On a new Astronomical Clock, and a Pendulum Governor for Uniform Motion." By Sir WILLIAM THOMSON, LL.D., F.R.S. Received June 10, 1869.

It seems strange that the dead-beat escapement should still hold its place in the astronomical clock, when its geometrical transformation, the cylinder escapement of the same inventor, Graham, only survives in Geneva watches of the cheaper class. For better portable time-keepers, it has been altered (through the rack-and-pinion movement) into the detached lever, which has proved much more accurate. If it is possible to make astronomical clocks go better than at present by merely giving them a better escapement, it is quite certain that one on the same principle as the detached lever, or as the ship-chronometer escapement, would improve their time-keeping.

But the inaccuracies hitherto tolerated in astronomical clocks may be due more to the faultiness of the mercury compensation pendulum, and of the mode in which it is hung, and of the instability of the supporting clock-case or framework, than to imperfection of the escapement and the greatness of the arc of vibration which it requires; therefore it would be wrong to expect confidently much improvement in the time-keeping merely from improvement of the escapement. I have therefore endeavoured to improve both the compensation for change of temperature in the pendulum, and the mode of its support, in a clock which I have recently made with an escapement on a new principle, in which the simplicity of the dead-beat escapement of Graham is retained, while its great defect, the stopping of the whole train of wheels by pressure of a tooth upon a surface moving with the pendulum, is remedied.

Imagine the escapement-wheel of a common dead-beat clock to be mounted on a collar fitting easily upon a shaft, instead of being rigidly attached to it. Let friction be properly applied between the shaft and the collar, so that the wheel shall be carried round by the shaft unless resisted by a force exceeding some small definite amount, and let a governor giving uniform motion be applied to the train of wheel-work connected with this shaft, and so adjusted that, when the escapement-wheel is unresisted, it will move faster by a small percentage than it ought to move when the clock is keeping time properly. Now let the escapement-wheel, thus mounted and carried round, act upon the escapement, just as it does in the ordinary clock. It will keep the pendulum vibrating, and will, just as in the ordinary