XIX. *Experiments to ascertain the Correction for Variations of Temperature, within the limits of the natural temperature of the Climate of the South of England, of the Invariable Pendulum recently employed by British observers. By Captain* EDWARD SABINE *of the Royal Artillery, Secretary to the Royal Society.*

Read March 25th, 1830.

HAVING obtained the rate of the invariable pendulum, No. 12, in the Royal Observatory at Greenwich at the temperature of 63°.53 in the month of August 1829, as given in the preceding paper, the pendulum was laid aside until the cold weather of the winter season had set in, when the observations detailed in Table C were made with it, at the mean temperature of 31°.15; the results of which are exhibited in the following abstract:

Greenwich, December 1829, and January 1830: Experiments with Pendulum 12.

	Therm.	Barom.		Vibrations.	Corrected to 31.15.
Dec. 29	28.50	30.212	27.0	85973.99	85972.82
29	28.55	30.227	27.0	85973.84	85972.70
30	29.30	30.307	28.0	85973.66	85972.85
30	29.65	30.311	28.5	85973.52	85972.86
Jan. 1	31.35	30.497	30.5	85972.82	85972.91
1	32.00	30.472	31.0	85972.33	85972.70
2	31.80	30.371	31.0	85972.46	85972.75
3	33.85	30.285	33.0	85971.78	85972.97
5	35.40	30.149	34.5	85970.94	85972.81
		30.315	30		85972.81
		−.002 Red^{n}. to 32°		Red^{n}. for 30.33 in. of air at 31.15	+10.77
	31.15	+.019 Capillary			
		30.332 at 32°			85983.58 at 31.15

Comparing this result with 85969.33 vibrations at the temperature of 63°.53 obtained in August 1829, we have 14.25 vibrations per diem corresponding to 32°.38 of FAHRENHEIT; which gives a correction of 0.44 of a vibration per diem for each degree of FAHRENHEIT between 30° and 60°.

The experiments which I formerly made with two pendulums similar to the present, in a chamber artificially heated to between 80° and 90°, gave for the correction for each degree of FAHRENHEIT, respectively for the two pendulums, 0.432 and 0.430, corresponding to that part of the thermometer scale which is included between 45° and 85°. Those results accord well with each other, and are somewhat different from that which is now obtained, and which correspond to the part of the scale comprised between 30° and 60°. But in the experiments in the chamber artificially heated, the fluctuations of temperature, in spite of every precaution, were considerable, and rendered the determination of the mean temperature more difficult, and probably less exact than in the natural temperatures: hence it would be unsafe to conclude in favour of the inference to which these facts would otherwise lead, that the correction at high temperatures is less than at low temperatures, or that the metal expands a smaller proportion of its length for one degree between 85° and 45°, than for one degree between 60° and 30°.

The experiments at Greenwich were made in those extremes of natural temperature afforded by the climate, in which a tolerably uniform temperature is maintained for several days; a condition requisite in such delicate determinations. The clock by GRAHAM was going well on both occasions, and its rate was assigned by Mr. TAYLOR from comparisons with the transit clock of the Observatory, with probably as much accuracy as the rates of clocks are ever obtained. The thermometer is entitled, by its comparison with those of Mr. DANIELL and of M. BESSEL, to be regarded as one of good authority, having, in the absence of a standard thermometer in this country, received the sanction of what must be considered the best existing authorities. Every precaution was adopted, which the experience I have had in obtaining the rates of pendulums has suggested, for maintaining a uniform temperature in the apartment. The examination of the partial observations will best show the success of these precautions. Viewing all these particulars, I regard 0.44 of a vibration per diem for each degree of FAHRENHEIT as a result obtained under circumstances

of a very favourable nature, and as not likely to be surpassed in the confidence which may be due to it, until by a better command of artificial temperatures the experiments can be made to include, with tolerable certainty of determination, a greater difference of temperature than is afforded by the natural climate of this country.

As the many invariable pendulums which have been employed of late years by British observers have all been made of the same kind of brass, it is probable that the same correction for temperature will apply equally to all.

When, as in ordinary cases, the differences of temperature between observations designed to be comparative amount only to a few degrees, the probable error which may be incurred by employing the correction 0.44 for each degree as now determined, can only be very inconsiderable: but when the differences of temperature amount to 50°, which is a case of actual experience in pendulum observations, the question of whether 0.43 or 0.44, for example, be the more correct value, involves an uncertainty in the ultimate result of no less than half a vibration a day. It seems therefore desirable, for the sake of experiments, which are becoming greatly multiplied, and which are daily increasing in accuracy, that means should be devised of obtaining the rates of pendulums in artificial temperatures, embracing a wider range than the natural temperatures, but capable of being determined with equal accuracy.

TABLE C.—Vibrations of Pendulum 12 at Greenwich, December 1829, and January 1830, on the fixed iron support in the Pendulum room. The Barometer employed was the standard barometer of the Royal Observatory; the Thermometer was Captain SABINE's standard thermometer; the Arc was distant 60 inches from the point of suspension, and was divided into degrees, each of 0.8 of an inch in length; the registered arc therefore multiplied by 0.764, gives degrees of the true arc of vibration.

EXP. 1. Dec. 29th. Clock making 86552.75 Vibrations. Barom. $\left\{\begin{matrix}30.205\\30.220\end{matrix}\right\}$ 30.212 27°.

No. of Coincid.	Therm.	Times of Reapp.	Times of Disapp.	Times of Coincidence.	Registered Arc.	True Arc.	Mean Therm.	Mean Interval.	Correction for Arc.	Vibrations in 24 hours Mean Solar Time.
	°	m s	m s	h m s	°	°		s	s	
1	28.6	15 37	15 42	1 15 39.5	0.84	0.64	28.5	298.97	+0.24	85973.99
53	28.4	34 38	34 54	5 34 46	0.24	0.18				

TABLE C. (Continued.)

EXP. 2. Dec. 29th. Clock making 86552.75 Vibrations. Barom. {30.220 / 30.234} 30.227 27°.

No. of Coincid.	Therm.	Times of Reapp.	Times of Disapp.	Times of Coincidence.	Registered Arc.	True Arc.	Mean Therm.	Mean Interval.	Correction for Arc.	Vibrations in 24 hours Mean Solar Time.
	°	m s	m s	h m s	°	°	°	s	s	
1	28.5	40 3	40 9	5 40 6	0.78	0.59	28.55	298.92	+0.20	85973.84
55	28.6	9 1	9 15	10 9 8	0.19	0.15				

EXP. 3. Dec. 30th. Clock making 86552.75 Vibrations. Barom. {30.314 / 30.300} 30.307 28°.

	°	m s	m s	h m s	°	°	°	s	s	
1	29.4	42 27	42 32	10 42 29.5	0.90	0.67	29.30	298.82	+0.22	85973.66
63	29.2	51 9	51 24	3 51 16.5	0.18	0.14				

EXP. 4. Dec. 30th. Clock making 86552.75 Vibrations. Barom. {30.300 / 30.322} 30.311 28°.5.

	°	m s	m s	h m s	°	°	°	s	s	
1	29.5	0 0	0 5	4 0 2.5	0.90	0.67	29.65	298.77	+0.18	85973.52
78	29.8	23 15	23 40	10 23 27.5	0.12	0.09				

EXP. 5. Jan. 1st. Clock making 86552.75 Vibrations. Barom. {30.515 / 30.480} 30.497 30°.5.

	°	m s	m s	h m s	°	°	°	s	s	
1	31.0	17 37	17 40	11 20 7.5	0.98	0.75	31.35	298.36	+0.26	85972.82
2	.....	22 34	22 39							
62	.....	20 52	21 4	4 23 27.25	0.18	0.14				
63	31.7	25 51	26 2							

EXP. 6. Jan. 1st. Clock making 86552.75 Vibrations. Barom. {30.480 / 30.465} 30472 31°.

	°	m s	m s	h m s	°	°	°	s	s	
1	32.0	40 50	40 53	4 40 51.5	0.86	0.64	32.0	298.14	+0.17	85972.33
74	32.0	43 29	43 43	10 43 36	0.13	0.10				

EXP. 7. Jan. 2nd. Clock making 86552.75 Vibrations. Barom. {30.378 / 30.365} 30.371 31°.

	°	m s	m s	h m s	°	°	°	s	s	
1	31.6	37 24	37 27	11 37 25.5	1.01	0.77	31.8	298.17	+0.24	85972.46
76	32.0	50 1	50 15	5 50 8	0.13	0.10				

TABLE C. (Continued.)

EXP. 8. Jan. 3rd. Clock making 86552.75 Vibrations. Barom. {30.300 / 30.270} 30.285 33°

No. of Coincid.	Therm.	Times of Reapp.	Times of Disapp.	Times of Coincidence.	Registered Arc.	True Arc.	Mean Therm.	Mean Interval.	Correction for Arc.	Vibrations in 24 hours Mean Solar Time.
	°	m s	m s	h m s	°	°	°	s	s	
1	33.8	13 27	13 35	2 13 31	0.92	0.68	33.85	297.86	+0.18	85971.78
78	33.9	35 38	35 54	8 35 46	0.11	0.08				

EXP. 9. Jan. 5th. Clock making 86552.75 Vibrations. Barom. {30.110 / 30.188} 30.149 34°.5

	°	m s	m s	h m s	°	°	°	s	s	
1	35.4	16 25	16 31	2 16 28	0.98	0.75	35.4	297.42	+0.20	85970.94
81	35.4	52 52	53 11	8 53 1.5	.12	0.08				