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Chronograph No. 5, Coast and Geodetic Survey.

Sidereal break circuit chronometer, Bond & Sons, No. 387, Coast and Geodetic Survey.

Sidereal break-circuit chronometer, Negus No. 1539, Transit of Venus Commission.

Mean time break-circuit chronometer, Negus No. 1490, Transit of Venus Commission.

Green cistern barometer, Coast and Geodetic Survey.

The following Kater pendulums and apparatus turned over to the Coast and Geodetic Survey, by Major Herschel, R. E., viz:

1. A clock with gridiron pendulum, by Shelton, of London, marked R. S. and 34 on the face, and No. 2* on the plate at back, which carries the supports of the pendulum. The clock is accompanied with Herschel's disks for observing coincidences.

2. Kater invariable pendulums Nos. 4, 6 (1821), and 11, and a dummy. Each pendulum is provided with a carriage and planes with corresponding number.

3. A copper vacuum chamber with glass bell for top, air-pump, &c.

4. Wooden frame-work support and accessories.

5. Telescope for observing coincidences.

6. Lens for bringing the image of clock pendulum in same plane with tail-piece of the detached pendulum.

7. Thermometers by Adie, Nos. 3, 4, 714, and 715. Nos. 714 and 715 were attached to the dummy, as in the Indian work.

8. Siphon barometer, by Adie. A quantity of moisture having accumulated in the glass tube, a new one was obtained from Green, of New York, and used at Auckland, Sydney, and Singapore. At Tokio it was found broken, and the old tube was broken while trying to drive the moisture and air out. At Tokio and San Francisco observations were made at full pressure of the atmosphere, the Green cistern barometer being used. A new siphon tube was obtained from Green for the Washington observations.

A detailed description of these pendulums and apparatus is given in Vol. V of the Great Trigonometrical Survey of India, and it is thought unnecessary to repeat it here.

METHOD OF OBSERVATION.

The work with these pendulums being purely differential, and intended for comparison with the observations made by Major Herschel, his methods were adopted as nearly as practicable.

The pressure in the vacuum chamber was kept such that the density would be nearly that of air at 32° F. under a pressure of 26 inches.

The pendulum was started with an arc of about 75' (1.1 inches), and swung for about six hours, when the arc was about 8' (.12 inch). A coincidence, the arc, temperature, and pressure were observed at the beginning and end of the set, and also an occasional intermediate coincidence. Four such sets were observed in the position called M (marked face towards observer), and four sets in position called P (marked face from observer). Thus each pendulum was swung forty-eight hours, twenty-four in each position. The observations with the three pendulums at each station, except Washington, were completed in 144 to 168 consecutive hours. At Washington double the number of observations were made.

In observing coincidences the disappearance and re-appearance of the Herschel dots were noted on only one side of the tail-piece of the pendulum—always the apparent right. The observer called "tip," and the time was noted and recorded by an assistant standing by the clock. At Washington we had no recorder, and as the face of the clock could not be seen by the observer, the time of coincidence was noted with mean-time chronometer, Bond & Sons, No. 196, and from the comparisons of time-pieces the R. S. Clock times of coincidences were deduced.

The coincidences were observed by Prof. H. S. Pritchett or myself at all the stations except Washington, where Mr. H. Farquhar, of the Coast and Geodetic Survey, took part in the observations in place of Professor Pritchett.

* In the inventory received from Major Herschel with this apparatus, it stated that the number on the plate at back which carries the supports of the pendulum is 1. When this clock was unpacked at the Coast and Geodetic Survey Office, in January, 1884, the case was so much damaged that a new one was made, and it was then discovered that the number is 2.—E. S.

METHOD OF REDUCTION.

As I have no definite knowledge of the precise method of reduction adopted by Major Herschel, I have practically adopted that given in Vol. V of the Great Trigonometrical Survey of India. In this report are given all the data necessary to make a complete new reduction, or additional corrections, as may be deemed necessary. The results are or may be made strictly comparable with all observations heretofore made with these pendulums.

The preliminary number of vibrations R' in a mean solar day corresponding to each set was computed as follows:

$$R' = R - \frac{2mR}{N}$$

N being the interval in clock seconds between the first and last coincidence, and m the number of coincidence intervals in the set, and R the number of vibrations made by the clock pendulum in a mean solar day. The rate of the clock having been obtained in sidereal time except at Washington.

$$R = 86636.555 - \left(r + \frac{r}{365} \right)$$

and for Washington

$$R = 86400 - r$$

R' then received three corrections.

1. Reduction to infinitely small arc.

$$\text{Correction} = R' \left(\frac{D - d}{16rD} \right)^2 \left\{ (a + b)^2 - \frac{(a - b)^2}{3} \right\}$$

$D = 84$ inches, being the distance of the objective of the telescope from the scale by which the arcs were measured, d the distance of the tail-piece of pendulum from this scale, and $r = 50$ inches, the distance of knife-edge of pendulum above this scale, a and b the arcs in inches at the beginning and end of set.

2. Reduction to density of air under pressure of 26 inches, and temperature 32° F.

$$\text{Correction} = 0.32 \left(\frac{P}{1 \times .0023(t-2)} - 26 \right)$$

P being the mean pressure, and t the mean temperature of the set.

3. Reduction to mean temperature of all the sets with each pendulum.

Pendulum No. 4: Correction = 0.458 ($t - t_m$)

Pendulum No. 6: Correction = 0.442 ($t - t_m$)

Pendulum No. 11: Correction = 0.450 ($t - t_m$)

t being the temperature of the set, and t_m the mean temperature of all the sets with the pendulum.

These results were afterwards reduced to 62° F. by the use of the above co-efficients.

Determination of the rate of the R. S. Clock.

Observations of the transits of stars were made as frequently as the weather would permit during pendulum observations at each station. Sidereal chronometer, Negus No. 1539, was used in recording the star observations, except at Sydney, and was compared with the other two chronometers, and the R. S. Clock at the time of star observations, and at the beginning and end of each set of pendulum observations.

At Sydney, Negus No. 1539 was first compared with the Sydney Observatory Clock, Frodsham No. 987, whose rate was determined by transits of stars observed by H. C. Russell, the director of the Sydney Observatory.

The time observations at Auckland and Singapore were made with meridian telescope No. 13, and at Tokio with the transit of the Tokio Observatory, by Professor Pritchett. At Singapore no chronograph was used. At San Francisco the first two night's observations were made by Professor Pritchett, and the remaining nights by myself. At Washington the rate of the R. S. Clock was determined from signals received from the Naval Observatory.

In reducing the time observations, the times of transit over the mean of the wires were corrected for aberration, rate, and level. The collimation constant was then computed from the stars observed, clamp west and east, and an azimuth constant was computed for each of these positions of the instrument by the method of least squares, as given in Appendix No. 14 of the Coast and Geodetic Survey Report for 1880.

The rate of the R. S. Clock has been taken as uniform between star observations. The comparisons of the other time-pieces were made as checks, but have not been used.

THERMOMETERS.

I was furnished with two Baudin thermometers that had been compared and examined by Prof. C. S. Peirce, and it was intended that frequent comparisons should be made between them and Nos. 714 and 715. At Auckland and Sydney there was no opportunity, and at Batavia they were accidentally carried off to England with my trunk, in which they had been placed for safety. They were finally obtained without injury on my return to the United States. On completion of the observations at Washington in April, 1884, all the thermometers were turned over to Prof. C. S. Peirce for comparison, and I here give his letter addressed to you concerning them:

UNITED STATES COAST AND GEODETIC SURVEY,
Baltimore, April 29, 1884.

DEAR SIR: I have determined the corrections to the thermometers of the Kater pendulum apparatus; they are as follows:

	No. 714.	No. 715.	Temp.
First comparison.	— 0.95	— 0.35	68.95
Second comparison.	— 0.09	— 0.39	68.61
Third comparison.	— 0.07	— 0.37	70.43
Means.	— 0.07	— 0.37	

In these comparisons the bulbs were down. When 715 is inverted it reads $0^{\circ}2$ more, and its correction is larger.

The Kew certificate dated November, 1881, gives the following corrections:

Temp.	No. 714.	No. 715.
°	°	°
32	— 0.45	— 0.50
42	— 0.40	— 0.60
52	— 0.35	— 0.65
62	— 0.30	— 0.70
72	— 0.30	— 0.60
82	— 0.30	— 0.70
92	— 0.42	— 0.70

Subsequently the following corrections were found at Kew Observatory:

Hour.	[Nov. 9. Temp. 60° .]		[Nov. 11. Temp. 70° .]		
	714	715	Hours.	714	715
Noon.	— 0.25	— 0.95	11 a. m.	0.30	0.65
2 p. m.	— 0.25	— 0.70	1 p. m.	0.30	— 0.65
3 p. m.	— 0.25	— 0.70	2 p. m.	0.30	— 0.70
4 p. m.	— 0.30	— 0.70	3 p. m.	0.30	— 0.70
7 p. m.	— 0.30	— 0.60			

I suppose that in these observations 715 was right side up. (It is used upside down.)

Owing to the peculiar manner of determining the fixed points at Kew, the corrections obtained there will be more negative than those I should get.

They will take a calibrated thermometer, and first keep it in ice for hours, until the glass has considerably contracted and the mercury has risen, and will then mark the freezing point. They will then raise it to the boiling point and mark the boiling point. Suppose, then, such a thermometer shows 20° C., without correction according to them. I should take the thermometer and place it in ice for about 100 seconds, and observe the freezing point. It would mark a lower point than zero, and would have a positive correction, according to me.

The discrepancy would be a little less owing to my 100° occupying a longer range on the stem but still there would be a difference at ordinary temperatures of $0^{\circ}2$ or $0^{\circ}3$ F. The inference is, therefore, that these thermometers have not changed since the Kew determinations, especially as the negative correction ought, with time, to increase instead of diminishing. Therefore, since the absolute temperature is not desired, but the difference from Herschel's temperatures, the Kew corrections should be adhered to in reducing Mr. Smith's work.*

Yours, very respectfully,

C. S. PEIRCE,
Assistant.

Prof. J. E. HILGARD,
Superintendent.

A correction of $-0^{\circ}50$ to the mean of the readings of Nos. 714 and 715 has been used throughout.

PROBABLE ERRORS.

No probable errors have been assigned to the results, and as no correction has been made for hourly rate, I do not see that any probable error can be assigned from the observations themselves, except from the means of days at Washington, and the differences of the results in the two positions of the pendulums at the various stations, and these are not sufficient in number.

COMPUTATIONS.

The first reduction of the observations at all the stations except Washington was made by myself, and a complete revision by Mr. H. Farquhar. The reduction of the Washington observations has been made jointly by Mr. Farquhar and myself, each step having been gone over twice.

On the following pages are given the details of the observations at each station in the order in which they were occupied. With what has already been said the headings of the various columns are sufficient explanation.

* The correctness of this inference by Mr. Peirce is shown by the following statement which I received from Mr. Farquhar, November 11, 1884: "1884, July 20.—Thermometers 714 and 715 were immersed in ice water about 40° C. for five minutes; being then in pounded ice for half-an-hour, both read $32^{\circ}4$." As 715 reads $0^{\circ}2$ greater when inverted, the correction to the mean of the two thermometers would be $-0^{\circ}5$ F. S.

AUCKLAND, NEW ZEALAND.

To the southwest of the Transit of Venus station, in the reservation known as the Domain, was a brick building called the Block House. The building was at first rented as a store-house, and was afterwards found to be the best place we could get to swing the pendulums. In the east room was constructed a pier of scoriae and lime seven feet square, and one and a half feet deep, upon which the apparatus was mounted. The clock was attached to the east wall of the building.

The position of this pier is: Latitude $36^{\circ} 51' 51''$ S.; longitude $11^{\circ} 39' 07.1$ E.; height, 261 feet.

The latitude is from observations made by Professor Pritchett with Meridian Tel. No. 13; the longitude and height from geodetic connection with the New Zealand Survey.

Just before the beginning of these observations I began to suffer with a severe infliction in my eyes which soon compelled me to give up all observing, and after the first day all the observations at this station were made by Professor Pritchett.

Auckland, New Zealand.—Time observations.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT	
h. m. s.												
1882												
Nov. 27	ζ Arietis.	W.	3 07 40.08	-0.02	+0.01	-0.58	0.08	-0.01	39.56	3 08 12.62	+33.06	
	ι Hydry.	W.	18 22.98	-0.09	+2.02	-0.48	-0.05	25.34	18 58.43	.09		
	ϵ Eridani.	W.	26 53.88	-0.02	-0.35	-0.12	-0.01	53.67	27 26.81	.14		
	η Tauri.	W.	40 01.38	-0.02	-0.62	-0.07	-0.01	00.80	40 33.88	.08		
	γ Hydry.	E.	48 33.20	-0.07	+1.26	+0.23	+0.04	34.66	49 07.78	.12		
	γ Eridani.	E.	3 52 02.92	-0.02	-0.23	-0.07	-0.01	02.75	3 52 36.02	.27		
	α^1 Eridani.	E.	4 05 38.14	-0.02	-0.01	-0.28	+0.07	+0.01	37.91	4 06 11.04	.13	
	β Tauri.	E.	4 12 37.52	-0.02	-0.01	-0.45	-0.05	-0.01	37.10	4 13 10.11	+33.01	
Nov. 28	β Hydry.	W.	0 19 02.20	-0.09	+0.01	+1.70	0.00	-0.52	03.30	0 19 36.20	+32.90	
	θ Ceti.	W.	0 37 11.46	-0.02	-0.15	-0.12	11.14	0 37 44.06	.92			
	δ Hydry.	W.	2 19 09.26	-0.05	+0.82	-0.31	09.72	2 19 42.64	.92			
	ξ^2 Ceti.	W.	2 21 25.66	-0.02	-0.39	-0.11	25.14	2 21 58.04	+32.90			
Nov. 29	ω Piscium.	W.	23 52 47.04	-0.02	+0.01	-0.50	-0.09	-0.18	46.26	23 53 19.21	+32.95	
	β Piscium.	W.	23 58 49.49	-0.02	+0.01	-0.37	-0.10	-0.18	48.83	23 59 21.73	+32.90	
	α Andromeda.	W.	0 01 49.78	-0.02	+0.01	-0.74	-0.06	-0.21	48.74	0 02 21.76	+33.02	
	γ Pegasi.	W.	06 41.89	-0.02	-0.59	-0.08	-0.19	41.01	07 13.85	+32.84		
	β Hydry.	W.	19 02.26	-0.09	+2.29	-0.43	-0.86	03.17	19 36.10	.93		
	β Ceti.	E.	37 11.27	-0.02	-0.24	-0.12	-0.19	11.08	37 44.06	.97		
	ζ Andromeda.	E.	40 37.42	-0.02	-0.69	-0.06	-0.20	36.85	41 09.73	.88		
	δ Piscium.	E.	42 05.57	-0.02	-0.50	-0.08	-0.18	05.15	42 38.00	.85		
	ε Piscium.	E.	0 56 21.13	-0.02	-0.52	-0.08	-0.18	20.69	0 56 53.61	+32.92		
	β Andromeda.	E.	1 02 40.50	-0.02	-0.85	-0.04	-0.22	39.80	1 03 12.81	+33.01		
	κ Tucanae.	E.	1 11 15.54	-0.03	-0.01	+1.12	-0.28	-0.51	16.83	1 11 49.76	+32.93	
Nov. 30	ϵ Eridani.	W.	3 26 55.22	-0.02	+0.01	-0.30	-0.14	-0.20	54.57	3 27 26.82	+32.25	
	γ Hydry.	W.	48 35.24	-0.07	+1.48	-0.43	-0.75	35.44	49 07.73	.29		
	γ Eridani.	W.	3 52 04.32	-0.02	-0.20	-0.13	-0.21	03.68	3 52 36.03	.35		
	α^1 Eridani.	E.	4 05 38.98	-0.02	-0.29	-0.13	-0.20	38.74	4 06 11.05	.31		
	δ Pegase.	E.	5 25 26.54	-0.10	+2.39	-0.65	-1.21	29.39	26 01.67	.28		
	α Tauri.	E.	4 28 42.56	-0.02	-0.47	-0.09	-0.21	42.19	4 29 14.45	+32.26		
Dec. 1	θ Ceti.	W.	1 17 40.49	-0.02	0.00	-0.26	-0.07	-0.39	39.72	1 18 11.80	+32.08	
	α Eridani.	W.	1 32 50.97	-0.03	+0.36	-0.13	-0.71	50.46	1 33 22.53	+32.07		

Auckland, New Zealand.—Time observations—Continued.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
h. m. s.											
1882											
Dec. 1	α Piscium.	W.	1 38 43.34	-0.02	0.00	-0.39	-0.05	-0.39	42.49	1 39 14.59	+32.10
	ζ Ceti.	W.	1 45 11.21	-0.02	-0.24	-0.07	-0.39	10.49	1 45 42.52	+32.03	
Dec. 2	β Andromeda.	W.	1 02 42.50	-0.02	0.00	-0.88	+0.04	-0.69	40.95	1 03 12.79	+31.84
	κ Tucanae.	W.	1 18 18.12	-0.05	+1.17	+0.23	-1.63	17.84	1 18 49.65	.81	
	η Piscium.	W.	17 40.96	-0.02	-0.37	+0.09	-0.58	40.08	18 11.79	.71	
	π Piscium.	E.	24 44.30	-0.02	-0.62	+0.06	-0.59	43.13	25 14.94	.81	
	α Eridani.	E.	30 23.16	-0.02	-0.41	+0.21	+0.58	23.52	30 55.34	.82	
	ν Piscium.	E.	32 48.76	-0.03	+0.35	+0.55	+1.07	50.70	33 22.50	.80	
	σ Piscium.	E.	34 49.82	-0.02	-0.35	+0.23	+0.58	50.26	35 22.06	.80	
	ρ Piscium.	E.	1 38 42.32	-0.02	-0.38	+0.23	+0.58	42.73	1 39 14.49	+31.76	
Dec. 4	β Ceti.	E.	0 37 13.10	-0.02	+0.01	-0.19	+0.04	+1.02	13.96	0 37 44.00	+30.04
	δ Piscium.	E.	0 42 07.30	-0.02	+0.01	-0.39	+0.03	+0.97	07.90	0 42 37.96	+30.06
	β Andromeda.	E.	1 02 42.26	-0.02	+0.01	-0.65	+0.02	+1.17	42.78	1 03 12.77	+29.99
	θ Ceti.	E.	1 17 40.96	-0.02	0.00	-0.27	+0.04	+0.98	41.69	1 18 11.78	+30.09
	δ Hydry.	W.	2 19 14.19	-0.05	-0.01	-0.80	+0.16	-2.71	12.38	2 19 42.45	.07
	ξ^2 Ceti.	W.	2 29.32	-0.02	-0.01	-0.38	+0.05	-0.98	27.98	2 30.03	.05
	δ Ceti.	W.	2 33 02.01	-0.02	-0.01	-0.32	+0.05	-0.96	00.75	2 33 30.80	+30.05
Dec. 5	β Ceti.	E.	0 37 14.70	-0.02	+0.01	-0.08	+0.03	-0.07	14.57	0 37 43.99	+29.42
	θ Ceti.	E.	1 17 42.64	-0.02	-0.11	+0.03	-0.07	-0.47	1 18 11.77	.30	
	η Piscium.	E.	24 45.96	-							

UNITED STATES COAST AND GEODETIC SURVEY.

Auckland, New Zealand.—Time Observations—Continued

[Comparisons with clock.]						
Date.	Negus 1539.			R. S. clock.	Daily rate of R. S. clock.	
1882.	<i>h. m. s.</i>			<i>h. m. s.</i>		
Nov. 27	1 50 05			1 40 41		
	2 20 15			2 10 45	+284.15	
	8 00 17			7 49 40		
28	1 33 10			1 19 05		
29	20 06 20			19 48 35	284.68	
	2 15 00			1 56 02		
30	3 00 16			2 36 25	283.63	
Dec. 1	21 19 33			20 52 05	284.10	
	3 18 24			2 49 45		
2	22 02 11			21 29 50	284.29	
	4 06 01			3 32 28		
4	22 06 12			21 24 21	283.74	
	3 54 40			3 11 40		
5	2 37 29.06			1 50 00	+283.64	

Auckland, New Zealand.—Pendulum No. 4.

[d=0, incl]

Auckland, New Zealand.—Pendulum No. 6.

[$d=0.8$ inc]

UNITED STATES COAST AND GEODETIC SURVEY.

Auckland, New Zealand.—Pendulum No. 11.

[d=0.8 inch.]

Date.	Number of reset.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.		Corrected number of vibrations in mean solar day.	Temperature to 63°56'	Means.
									Arc.	Pressure.			
1882. Dec. 2	XVIII	M.	•	h. m. s.	Inches.	°	Inches.						
				1 21 21 36.80	1.11	66.05	27.74						
				3 21 40 48.70									
				37 3 08 35.50	.14	64.00	27.61	86052.84	+ .16	-.09	+ .66	86053.57	
				1 3 20 22.90	0.98	64.00	27.73						
				37 9 07 58.60	.12	62.15	27.62	3.92	+ .13	-.06	- .22	3.77	
				1 9 16 52.00	1.30	62.20	27.64						
				37 15 04 31.80	.15	61.70	27.61	3.98	+ .22	-.05	- .72	3.43	
				1 15 12 02.88	1.28	61.90	27.62					86053.62	
				37 20 59 37.80	.16	63.60	27.68	3.91	+ .22	-.06	- .36	3.71	
3	XXII	P.	•	1 21 29 38.38	1.19	64.25	27.84						
				37 3 16 10.25	.15	63.80	27.78	3.00	+ .19	-.03	+ .21	3.37	
				1 3 23 36.70	1.21	63.80	27.81						
				37 9 10 18.60	.13	63.40	27.77	3.15	+ .19	-.03	+ .02	3.33	
				1 9 17 36.90	1.12	63.60	27.78						
				37 15 04 16.40	.14	63.40	27.76	3.11	+ .17	-.04	+ .03	3.21	
				1 15 11 35.50	1.11	63.50	27.78					86053.24	
				37 20 57 56.80	.13	64.15	27.78	3.85	+ .16	-.04	+ .12	3.09	
				1 21 06 10.70	1.08	64.25	27.80						
				37 2 52 26.75	.13	64.30	27.80	2.77	+ .15	-.04	+ .32	3.20	
				38 3 02 05.15									

SYDNEY, NEW SOUTH WALES.

It was intended to swing the pendulums at Fort Macquarie, where Freycinet and Duperry had swung pendulums in 1819-22-25, but it was found impracticable to do so. The magazine was the only place at the fort suitable for pendulum work, and was not large enough to admit the Kater apparatus.

Mr. H. C. Russell very kindly offered the facilities of the Sydney Observatory, of which he is the Director. The pendulums were hung in the cellar under the transit room. The floor and walls are concreted. The foundation is very solid and the temperature very constant. It would be difficult to find a more suitable place for pendulum observations—as the results show. The apparatus was set upon the floor, and the clock attached to the west wall. The position of this station as given in the volume of Sydney Observations, 1877-'78, is: Latitude, 33° 51' 41".1 S.; longitude, 10° 04' 50".81 E.; height, 140 feet.

After the apparatus was set up at this station the work was conducted entirely by Professor Pritchett, my eyes being still in such a condition that I could make no observations.

Our sincere thanks are due to Mr. Russell for his many attentions and personal assistance in the pendulum work.

UNITED STATES COAST AND GEODETIC SURVEY.

Time observations, with Sydney Observatory meridian circle and sidereal clock Frodsham, No. 987, as furnished by Mr. H. C. Russell.

Date.	Star.	R. A.	Corrected transit.	Δ T of observation clock.
1883. Jan. 5	κ Orionis.	5 42 14.53	5 41 45.11	+29.42
	μ Geminorum.	6 15 55.40	6 15 25.92	.48
	α Argus.	6 21 23.82	6 20 54.38	+29.44
	A Tauri.	3 57 48.81	3 57 17.95	+30.86
	ε Tauri.	4 21 49.23	4 21 18.37	.86
	η Eridani.	39 41.10	39 10.18	.92
	ε Aurige.	4 49 24.99	4 48 54.14	.85
	ε Leporis.	5 00 32.45	5 00 01.47	.98
	α Aurigæ.	5 08 05.90	5 08 34.93	+30.97
	γ Tauri.	4 13 10.18	4 12 38.01	+32.17
Jan. 6	ε Tauri.	21 49.22	21 16.97	.25
	α Tauri.	29 14.53	28 42.31	.27
	η Eridani.	39 41.10	39 08.89	.21
	ε Aurige.	4 49 24.99	4 48 52.87	.12
	ε Leporis.	5 00 32.44	5 00 00.13	.31
	β Orionis.	08 05.91	07 33.62	.29
	δ Orionis.	5 26 03.86	5 25 31.58	+32.28
	β Geminorum.	7 38 11.80	7 38 38.18	+33.67
	ξ Argus.	7 44 24.72	7 43 51.03	+33.69
	ν Orionis.	6 00 53.85	6 00 21.23	+34.62
Jan. 7	η Cancri.	8 36 13.08	8 35 53.43	.65
	ε Hydre.	8 46 36.92	8 46 02.32	+34.62
	ε Aurige.	9 49 24.05	9 48 43	+36.54
	ε Leporis.	10 00 32.42	4 59 55.87	.55
Jan. 8	β Orionis.	5 08 56.89	5 08 20.37	+36.52
Jan. 9				
Jan. 11				

H. Ex. 43—57

[Corrections and Rates of Sidereal Clock, Frodsham No. 987.]				
Date.	T ₀		ΔT	Daily rate
1883.				
Jan. 5	h. m.		s.	
	6 06		+ 29.45	+ 1.547
	6 439		+ 30.91	+ 1.323
	7 46		+ 32.24	+ 1.284
	8 741		+ 33.68	+ 0.937
	9 745		+ 34.62	+ 1.019
11	4 59		+ 36.54	

Date.	Negus Chronometer 1539:	Frodsham Clk. 987.	Correction to Frodsham 987.	Correction to Negus 1539.	Daily rate Negus
1883.					
Jan. 5	5 58 04.70	5 57 59	+ 29.44	+ 23.74	- 0.19
6	5 18 06.40	5 17 59	30.95	23.55	- 0.04
7	5 59 07.80	5 58 59	32.30	23.50	- 0.33
8	7 03 09.50	7 02 59	33.65	23.45.	- 0.57
9	7 55 11.08	7 54 59	34.63	22.55	- 0.51
11	5 22 13.98	5 21 59	+ 36.56	+ 21.58	

Date.	Negus 1539.	R. S. clock.	Daily rate R. S. clock
1883.			
Jan. 5	6 07 36	11 06 00	
6	6 53 07	11 46 25	+ 296.42
7	5 44 .08	10 42 34	+ 296.10
8	7 09 30	11 52 52	+ 296.12
9	8 00 27	12 38 42	+ 295.93
11	5 19 50	9 48. 45	+ 296.02

[Number of vibrations of R. S. clock pendulum in mean solar day.]		
Date.	Sets.	
1883.		86636.55
Jan. 5-6	I-IV	86339.34
6	V	.62
6-7	VI-VIII	.62
7	IX	.62
7-8	X-XIII	.62
8-9	XIV-XVII	.82
9-11	XVIII-XXIV	.72

Sydney, New South Wales.—Pendulum No. 4

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.		Corrected number of vibrations in mean solar day.	Mean of M. and P.
									Arc.	Pressure.		
1883.	Jan. 5	I	M.	h. m. s.	Inches.	°	Inches.	7.48 + .15	.00	.02	7.61	86087.63
				1 5 51 08.40	1.06	68.75	28.05					
	5	II		32 11 45 22.90	.13	68.60	28.05	86087.47	+ .15	-.04	-.05	86087.63
				1 12 04 19.19	1.04	68.65	28.19					
	6	III		32 17 58 34.60	.14	68.40	28.16	7.48 + .15	.00	.02		
				1 18 09 58.30	1.05	68.55	28.17					
	7	IV		32 0 04 12.20	.14	68.40	28.15	7.46 + .15	-.01	-.04		
				1 0 13 36.50	1.11	68.80	28.17					
	V	P.		2 0 25 00.10								
				31 5 56 23.10	.14	68.60	28.16	7.44 + .16	-.01	+.06		
	VI			1 6 20 31.30	1.04	68.90	28.08					
				31 12 03 47.10	.15	68.50	28.04	8.10 + .15	-.04	-.06		
	VII			1 12 13 10.20	0.97	68.60	28.05					
				31 17 56 36.90	.13	68.25	28.04	8.25 + .13	-.04	-.06		
	7	VIII		1 18 07 58.90	1.04	68.50	28.22					
				31 23 51 17.30	.13	68.35	28.21	8.15 + .14	+.01	-.06		
				1 0 00 42.75	1.17	68.55	28.22	8.12 + .19	+.01	-.00		
				31 5 43 58.70	.17	68.55	28.22					

UNITED STATES COAST AND GEODETIC SURVEY.

Sydney, New South Wales.—Pendulum No. 6.

[d = 0.85 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.	Corrected number of vibrations in mean solar day.	Mean of M and P.		
											Arc.	Pressure.	Means.
1883.	Jan. 7	IX	M.	1 6 27 02.20	1.13 70.75	28.20							
				42 12 01 04.75	.15 68.85	28.10	85986.39	.17 .03 + .34	85986.87				
			X	1 12 09 32.60	1.11 68.85	28.11							
				2 12 17 41.25									
				44 18 00 15.50	.13 68.45	28.08	6.76 + .10 - .03 - .17	6.72					
		XI		1 18 07 13.70	1.11 68.65	28.10							
				44 23 58 04.00	.13 68.60	28.09	6.88 + .10 - .03 - .19	6.82					
			XII	1 0 05 26.90	1.12 68.70	28.10							
				44 5 56 11.40	.13 69.10	28.09	6.79 + .10 - .03 - .06	6.86					
				43 6 15 56.30	1.01 69.50	28.25							
8	8	XIII	P.										
				43 11 58 55.75									
				44 12 07 06.50	.11 69.05	28.21	7.22 + .13 - .00 + .11	7.46					
			XIV	1 12 16 26.70	1.01 69.05	28.21							
				44 18 07 44.00	.11 68.90	28.21	7.52 + .13 - .00 - .03	7.62					
		XV		1 18 14 37.70	1.04 69.10	28.21							
				44 0 05 54.25	.12 69.05	28.20	7.51 + .14 - .00 + .02	7.67					
				1 0 13 34.20	1.06 69.05	28.21							
				44 6 04 50.38	.11 69.00	28.20	7.51 + .14 - .00 - .01	7.64					
				85987.21									

UNITED STATES COAST AND GEODETIC SURVEY.

Sydney, New South Wales.—Pendulum No. 11.

[d = 0.85 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.	Corrected number of vibrations in mean solar day.	Temperature to 69°.45	Means.	Mean of M and P.
1883.	Jan. 9	VII	M.	1 6 54 37.40	1.08 70.35	28.19							
				38 12 48 15.80	.12 69.25	28.10	86038.70	.15 - .04 + .16	86038.97				
				1 12 56 44.80	1.10 69.45	28.10							
				37 18 49 33.40	.15 69.15	28.09	8.81 + .18 - .04 - .07						
				1 18 49 53.00	1.08 69.30	28.10							
		XX		2 18 58 25.88									
				37 0 33 13.70	.12 69.05	28.10	8.84 + .15 - .04 - .12						
				1 0 43 25.10	1.13 69.35	28.23							
				37 6 27 43.10	.14 69.45	28.23	8.80 + .17 - .00 - .02						
				37 1 42 00.90	1.13 70.00	28.23							
10	10	XXI	P.	1 12 25 42.80	.13 69.35	28.18	8.27 + .17 - .01 + .10						
				37 12 33 33.70	.16 69.65	28.19							
		XXII		39 18 36 28.40	.13 69.25	28.18	8.37 + .17 - .02 + .00						
				1 18 43 25.50	1.10 69.35	28.19							
11	11	XXIII		38 0 36 53.90	.12 69.35	28.18	8.46 + .15 - .02 - .04						
				1 0 45 00.10	1.12 69.60	28.19							
		XXIV		38 6 38 27.40	.13 69.30	28.17	8.45 + .16 - .02 + .00						

SINGAPORE, STRAITS SETTLEMENTS.

At Singapore the pendulums were swung in the laboratory of the New European Hospital. This is a large, massive building on a slight rise of ground to the west of the town. The laboratory on the ground floor was at this season protected from the sun, and has a solid, tiled floor. It was very well suited for pendulum work. The apparatus was set upon the floor, and the clock was attached to a beam on the north wall. The laboratory is 4,765 feet south and 3,870 feet west of the flag-staff at Fort Canning. The position of this flag-staff is given by the United States Hydrographic Office as: Lat., 1° 17' 33".7 N.; long., 6° 55' 23".5 W.; from which we find the position of the laboratory to be: Lat., 1° 16' 46" N.; long., 6° 55' 21" E. The height of floor is 45 feet.

The transit pier was built of brick near the northwest corner of the building. Permission to occupy this building was granted by his excellency Governor Weld. Dr. Simon, the resident physician, gave us quarters, and every facility of the institution, and to Captain McCallum, R. E., in charge of the office of colonial engineers, we are indebted for very important assistance.

UNITED STATES COAST AND GEODETIC SURVEY.

Singapore, Straits Settlements.—Time observations.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
<i>1883.</i>											
March 1	α^a Geminorum.	E.	7 27 40.18	-0.02	-0.01	-1.26	+0.01	-1.06	37.84	7 27 10.62	-27.22
	α Canis Minoris.	E.	33 41.18	-0.02	-0.01	-0.15	+0.01	-0.91	40.10	33 12.86	.24
	β Geminorum.	E.	38 41.48	-0.02		-1.06	+0.01	-1.02	39.39	38 11.82	.57
	ξ Argus.	E.	44 52.03	-0.02		-0.90	+0.01	-0.08	52.03	44 24.91	.42
	δ Cancer.	W.	7 56 50.18	-0.02		-1.28	+0.02	-1.02	49.92	7 56 22.37	.55
	15 Argus.	W.	8 03 01.20	-0.02		-1.16	+0.02	-0.98	03.34	8 02 55.94	.40
	β Cancer.	W.	10 39.37	-0.02	+0.01	-0.30	+0.02	-0.92	39.94	10 12.54	.40
	η Cancer.	W.	8 26 26.12	-0.02	+0.01	-0.90	+0.02	+0.06	26.10	8 25 59.09	-27.19
March 2	α Columbae.	W.	5 35 51.64	-0.02	-0.01	-0.19	+0.10	+1.21	52.73	5 35 26.05	-20.68
	κ Orionis.	W.	42 39.86	-0.02	-0.01	-0.05	+0.10	+1.02	49.92	42 13.95	.07
	α Orionis.	W.	5 59 17.50	-0.02		-0.03	+0.10	+1.01	18.02	5 48 52.01	.61
	ν Orionis.	W.	6 01 21.02	-0.02		-0.06	+0.10	+1.04	22.20	6 00 55.41	.79
	η Geminorum.	W.	08 16.38	-0.02		-0.11	+0.10	+1.08	17.05	07 59.92	.73
	μ Geminorum.	E.	16 22.76	0.02		-0.10	+0.08	+1.08	21.84	15 55.95	.79
	α Argus.	E.	21 51.36	-0.03		-0.33	+0.07	+1.64	49.43	21 22.70	.73
	γ Geminorum.	E.	31 26.90	-0.02	+0.01	+0.07	+0.08	+1.04	26.00	30 50.17	.81
	ξ Geminorum.	E.	6 39 13.02	-0.02	-0.01	+0.05	+0.08	+1.03	12.19	38 45.42	-26.69
March 3	μ Geminorum.	W.	6 16 22.66	-0.02	-0.01	-1.83	+0.17	+0.27	21.24	6 15 55.04	.20
	α Argus.	W.	21 41.98	-0.03		-6.19	+0.17	+0.41	48.72	21 22.06	.06
	γ Geminorum.	W.	31 26.22	-0.02		-1.32	+0.17	+0.26	25.31	30 59.18	26.13
	ξ Geminorum.	W.	39 11.80	-0.02		-1.03	+0.17	+0.26	11.18	38 45.41	25.77
	θ Canis Majoris.	E.	49 12.26	-0.02		-1.06	+0.14	+0.26	13.18	48 47.10	26.08
	ϵ Canis Majoris.	E.	54 27.06	-0.02		-2.61	+0.14	-0.28	29.51	54 03.49	.02
	γ Canis Majoris.	E.	6 58 54.68	-0.02		-1.37	+0.14	-0.26	55.91	6 58 29.80	.05
	δ Geminorum.	E.	7 13 38.42	-0.02	+0.01	-1.79	+0.14	-0.27	36.49	7 13 10.46	-26.03
March 5	α Orionis.	W.	5 49 16.92	-0.02	-0.01	+0.04	+0.01	+0.56	17.50	5 48 51.06	-25.54
	ν Orionis.	W.	6 01 20.26	-0.02	-0.01	+0.08	+0.01	+0.57	20.80	6 00 55.36	.53
	η Geminorum.	W.	08 15.60	-0.02		+0.13	+0.01	+0.59	16.31	07 50.87	.44
	μ Geminorum.	W.	16 19.66	-0.02		+0.13	+0.01	+0.59	20.61	15 55.00	.67
	α Argus.	W.	21 47.62	-0.03		-0.43	+0.01	+0.90	48.07	21 22.53	.54
	γ Geminorum.	E.	31 25.30	-0.02		+0.07	0.00	-0.57	24.78	30 59.14	.64
	ξ Geminorum.	E.	39 11.38	-0.02		+0.06	0.00	-0.57	10.85	38 45.37	.48
	ϵ Canis Majoris.	E.	54 29.84	-0.02	+0.01	-0.14	0.00	-0.63	29.06	54 03.45	.61
	γ Canis Majoris.	E.	6 58 55.94	-0.02	+0.01	-0.08	0.00	-0.57	55.28	6 58 29.82	-25.46
March 6	μ Geminorum.	W.	6 16 19.82	-0.02	-0.01	+0.18	0.00	-0.48	20.45	6 15 54.98	-25.47
	α Argus.	W.	21 47.88	-0.03		-0.60	0.00	+0.72	47.97	21 22.55	.42
	γ Geminorum.	W.	31 24.02	-0.02		+0.13	0.00	+0.46	24.59	30 59.12	.47
	ξ Geminorum.	W.	39 10.22	-0.02		+0.10	0.00	+0.45	10.75	38 45.35	.40
	θ Canis Majoris.	E.	49 13.16	-0.02		-0.05	-0.02	-0.45	12.62	48 47.04	.58
	ϵ Canis Majoris.	E.	54 29.54	-0.02		-0.12	-0.02	-0.50	28.88	54 03.43	.45
	γ Canis Majoris.	E.	6 58 55.70	-0.02		-0.06	-0.02	-0.40	55.14	6 58 29.80	.34
March 7	α^a Geminorum.	W.	7 27 34.28	-0.02	-0.01	+0.31	+0.05	+0.64	35.25	7 27 10.52	-24.73
	β Geminorum.	W.	38 35.76	-0.02		+0.26	+0.04	+0.61	36.65	38 11.74	.91
	ξ Argus.	W.	44 48.88	-0.02		-0.24	+0.04	+0.59	49.25	44 24.52	-24.73

UNITED STATES COAST AND GEODETIC SURVEY.

Singapore, Straits Settlements.—Time observations—Continued.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
<i>1883.</i>											
March 7	δ Cancer.	E.	7 56 48.14	-0.02		-0.41	+0.02	-0.61	47.12	7 56 22.29	-24.83
	β Cancer.	E.	8 10 37.92	-0.02		-0.11	+0.02	-0.55	37.26	8 10 12.47	.79
	η Cancer.	E.	8 26 24.52	-0.02		-0.29	+0.02	-0.58	23.66	25 58.94	-24.72
March 8	η Geminorum.	W.	6 08 14.82	-0.02	-0.01	-0.10	-0.02	+0.54	15.41	6 07 50.81	-24.60
	μ Geminorum.	W.	16 18.84	-0.02	-0.01	-0.10	-0.02	+0.54	19.43	15 54.94	.49
	α Argus.	W.	21 46.52	-0.03		-0.33	-0.01	+0.82	46.97	21 22.48	.49
	γ Geminorum.	W.	31 22.90	-0.02		-0.07	-0.02	+0.52	23.45	30 59.09	.36
	θ Canis Majoris.	E.	39 10.20	-0.02		-0.03	0.00	-0.52	09.69	38 45.32	.37
	ϵ Canis Minoris.	E.	49 12.12	-0.02		-0.03	0.00	-0.51	11.56	48 47.01	.55
	γ Canis Majoris.	E.	54 28.58	-0.02		-0.07	0.00	-0.57	27.92	54 03.39	.53
	δ Geminorum.	E.	6 58 54.74	-0.02		-0.04	0.00	-0.57	54.11	6 58 29.77	-34
		E.	7 13 35.43	-0.02	-0.01	-0.05	0.00	-0.54	34.94	7 13 10.37	-24.57

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Singapore, Straits Settlements.—Time observations—Continued

[Comparisons of chron. and R. S. clock.]				[Number of vibrations of clock pendulum in mean solar day.]			
Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.	Date.	Sets.		
1883. Mar. 1	8 44 33	9 54 20	+403.073	1883. Mar. 2	I	86636.555	
2	6 52 00	7 55 46	403.105	2-3	II-IV	$(r + \frac{r}{395})$.34
3	7 26 19	8 23 13	402.753	3	V	.55	
5	7 08 25	7 51 59	402.497	3-5	VI-XII	.69	
6	7 24 53	8 01 40	402.946	5	XIII	.85	
7	8 35 20	9 05 05	+402.486	5-6	XIV-XVI	.95	
8	7 19 32	7 42 56		6	XVII	.67	
				6-7	XVIII-XX	.50	
				7	XXI	.69	
				7-8	XXII-XXIV	.96	

Singapore.—Pendulum No.

Singapore.—Pendulum No.

Singapore.—Pendulum No.

UNITED STATES COAST AND GEODETIC SURVEY.

TOKIO, JAPAN.

On arrival at Tokio an invitation was received from Mr. Koto, the president of the Imperial University of Tokio, to swing the pendulums at the university where Professor Mendenhall had made such observations in 1880. The Kater apparatus could not be set up in the physical laboratory where Mendenhall had made his observations, and so a new "go-down" (mud fire-proof building) was placed at our disposal. The ground at the university is low and wet, and does not afford a good foundation, but after several days were spent in examining various localities, it was concluded that the university would be the best point.

By Mr. Koto's direction a portion of the floor of the "go-down" was taken up, and piles driven very closely together, upon which was built a solid stone pier, 7 feet square and 5 feet deep. Upon this pier the apparatus was mounted. The clock was attached to the wall.

The Tokio Observatory is nearly 2 miles distant from the university, but is connected with it by telegraph. By the kindness of H. M. Paul, professor of astronomy, the time observations were made at the observatory, and recorded on the chronograph at the university. The position of the observatory transit, as furnished by Professor Paul, is, latitude $35^{\circ} 42' 40''$ N., longitude $9^{\circ} 19' 04''$ E.

The position of the pendulum pier is not so well known, but is given as latitude $35^{\circ} 42'$ N., longitude $9^{\circ} 19' 04''$ E.; height, 20 feet.

On April 23 the apparatus was set up and ready to begin observations. About 10 p. m. quite a severe earthquake took place, which fortunately did no harm. The seismographs gave no indication of any other earthquakes till May 2, the day after the observations were completed.

Mr. Koto assigned to our aid three of the assistants of the university, who had taken part in Professor Mendenhall's observations, Messrs. Tmoka, Yamada, and Ono. One or other of these gentlemen was always present acting as interpreter, recorder, &c. We were also given quarters and servants in the main building, during our stay in Tokio, by the authorities of the university, and to them we are much indebted for attention and assistance, without which our work would have been difficult.

Tokio, Japan.—Time observations.

Date.	Star.	α	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
1883.				h. m. s.							m. s.	
Apr. 24	θ Virginis.	E.	13 48 48.86	-0.02	-0.01	+0.39	-0.07	+0.07	49.22	13 43 56.42	-4 52.80	
	20 Canum Venaticorum.	E.	17 13.30	-0.02		-0.08	-0.12	+0.09	13.17	12 20.37	.80	
	ζ Urse Majoris.	E.	24 08.82	-0.03		-0.36	-0.15	+0.12	8.40	19 15.59	.81	
	ζ Virginis.	W.	33 39.22	-0.02		+0.51	-0.06	-0.07	39.58	28 46.76	.82	
	η Urse Majoris.	W.	47 51.94	-0.02		-0.33	-0.12	-0.11	51.36	42 58.54	.82	
	η Bootis.	W.	13 54 02.20	-0.02	+0.01	+0.27	-0.08	-0.07	2.31	13 49 09.55	-4 52.76	
Apr. 26	χ Urse Majoris.	W.	11 07 59.08	-0.02	-0.01	-0.20	-0.03	-0.10	58.72	11 03 07.39	-4 51.33	
	δ Leonis.	W.	12 46.88	-0.02	-0.01	+0.23	-0.02	-0.07	46.99	07 55.49	.50	
	σ Leonis.	W.	19 59.94	-0.02		+0.43	-0.02	-0.07	60.26	15 08.62	.64	
	λ Draconis.	W.	29 23.12	-0.05		-1.44	-0.05	-0.20	21.38	24 29.87	.51	
	γ Leonis.	E.	35 51.08	-0.02		+0.28	-0.01	-0.07	51.42	31 00.02	.40	
	β Draconis.	E.	40 51.38	-0.04		-0.64	-0.03	-0.18	50.91	35 59.43	.48	
	β Leonis.	E.	47 59.28	-0.02	+0.01	+0.17	-0.01	-0.07	59.52	43 07.96	.56	
	β Virginis.	E.	11 49 29.78	-0.02	+0.01	+0.26	-0.01	-0.07	30.11	11 44 38.60	-4 51.51	
Apr. 27	α Ursæ Majoris.	W.	11 01 24.32	-0.04	-0.01	-0.48	-0.19	-0.19	23.41	10 56 32.63	-4 50.78	
	χ Leonis.	W.	03 51.98	-0.02	-0.01	+0.24	-0.09	-0.09	52.01	59 01.21	.80	
	δ Leonis.	W.	12 46.36	-0.02		+0.13	-0.10	-0.10	46.27	11 07 55.48	.79	
	λ Draconis.	E.	29 21.62	-0.05		-0.97	-0.20	-0.26	20.66	24 29.83	.83	
	χ Ursæ Majoris.	E.	44 45.62	-0.02	+0.01	-0.20	-0.12	-0.14	45.43	39 54.73	.70	
	β Leonis.	E.	11 47 58.58	-0.02	+0.01	+0.21	-0.07	-0.09	58.80	11 43 07.96	-4 50.84	

UNITED STATES COAST AND GEODETIC SURVEY.

Tokio, Japan.—Time observations—Continued.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
1883.			h. m. s.							m. s.	
May 1	ν Urse Majoris.	W.	11 17 01.02	-0.02	-0.03	+0.03	+0.12	-0.05	1.07	11 12 11.90	-4 49.17
	ι Leonis.	W.	22 40.88	-0.02	-0.03	+0.27	+0.09	-0.04	41.15	17 51.83	.32
	λ Draconis.	W.	11 29 19.96	-0.05	-0.03	-1.07	+0.24	-0.12	18.93	11 24 29.66	.27
	τ Bootis.	E.	13 46 33.88	-0.02	+0.02	+0.15	+0.03	+0.04	34.10	13 41 44.86	.24
	η Bootis.	E.	13 53 58.62	-0.02	+0.02	+0.14	+0.03	+0.04	58.83	13 49 09.56	.27
	α Draconis.	E.	14 06 06.02	-0.04	+0.02	-0.53	+0.07	+0.09	5.63	14 01 16.39	.24
	α Bootis.	E.	14 15 11.26	-0.02	+0.03	+0.13	+0.03	+0.04	11.47	14 10 22.22	-4 49.25

[Instrumental corrections, Tokio transit.]					[Corrections and daily rate sidereal chron., Negus No. 1539.]			
Date.	Azimuth.		Level.		Coll.	T ₀	ΔT	Daily rate.
	West.	East.	West.	East.				
1883.								
April 24	s.	s.	s.	s.	s.	13 26	-4 52.80	+0.684
26	+0.88	+0.60	-0.08	-0.09	-0.07	11 25	51.49	+0.702
27	+0.49	+0.59	-0.10	-0.08	-0.09	11 21	50.79	+0.379
May 1	+0.65	+0.45	+0.10	+0.03	-0.04	12 46	-4 49.25	

[Comparisons with clock.]				[Number of vibrations of R. S. clock in mean solar day.]		
Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.	Date.	Set.	86636.554 -(r - 365)
1883.						
April 24	13 42.47	11 23.45	+ 314.982	1883.	I-VII	86320.71
26	11 27.11	8 58.10	+ 315.233	26	VIII	.59
27	11 24.45	8 50.30	+ 315.428	27	IX-XI	.46
May 1	11 46.00	8 50.40	+ 315.428	27	XII	.36
	14 09.06	11 13.15		Apr. 27-May 1	XIV-XXVIII	.26

UNITED STATES COAST AND GEODETIC SURVEY

Tokio, Japan.—Pendulum No. 4

[$d = 0.75$ inch]

Tokio, Japan.—Pendulum No. (

[$d=0.75$ in.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock:	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.			Corrected number of vibrations in mean solar day.		
									Arc.	Pressure.	Temperature to 58°.41			
1883. April 26	IX	M.	1	12 06 31.10	1.08	59.25	30.00	85995.40	+ .15	+ .75	+ .09	85996.39		
			39	17 42 52.80	.12	58.80	30.12							
	X		1	17 48 36.30	1.10	58.20	30.12		+ .15	+ .80	- .38	6.55		
			41	23 43 18.30	.12	56.90	30.25							
	XI		1	23 49 33.88	1.15	56.90	30.25		+ .15	+ .80	- .38	6.71		
			2	23 58 25.83										
	XII		40	+ 5 35 30.80	.12	58.20	30.29		+ .17	+ .83	- .38	6.78		
			1	5 40 54.50	1.10	58.35	30.30							
			41	11 35 31.20	.11	58.45	30.36							
	XIII	P.	1	11 45 03.90	1.05	58.45	30.35							
27	XIV		41	17 39 54.50	.12	58.50	30.28	85996.61	+ .14	+ .83	+ .03	6.91		
			1	17 45 55.30	1.08	58.45	30.27							
	XV		41	23 40 45.00	.11	58.50	30.15		+ .15	+ .79	+ .03	6.87		
			1	23 47 04.90	1.10	58.50	30.13							
	XVI		2	23 55 57.50										
28			41	5 41 48.20	.12	59.00	29.95		+ .15	+ .74	+ .15	6.84		
			1	5 55 06.50	1.07	59.00	29.94							
			40	11 40 54.80	.12	59.90	29.75							
												Mean of M. and P.		

UNITED STATES COAST AND GEODETIC SURVEY.

Tokio, Japan.—Pendulum No. 11.

[d=0.75 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.		Corrected number of vibrations in mean solar day.	Means.
									Arc.	Pressure.		
1883.												
April 28	XVII	M.		h. m. s. 1 12 22 31.10	Inches. 0.92	60.90	29.70					
	XVIII			34 18 10 08.20	.11	-60.80	29.73	86047.11	+ .11	+ .60	+ .34	86048.16
28	XIX			32 23 44 02.20	.14	61.00	29.87	7.14	+ .15	+ .62	+ .36	8.27
29	XX			34 5 38 38.40	.13	61.70	29.80	7.00	+ .16	+ .62	+ .57	8.35
30	XXVII			34 11 33 36.40	.12	62.20	29.89	6.86	+ .12	+ .61	+ .90	8.49
May 1				1 23 36 24.88	1.18	57.05	29.91					
May 1	XXVIII			34 5 25 30.90	.14	56.90	29.99	8.27	+ .19	+ .74	+ 1.40	7.80
April 29	XXI	P.		1 5 31 53.00	1.17	57.00	30.01					
	XXII			34 11 21 11.00	.14	57.50	30.16	8.42	+ .18	+ .78	+ 1.28	8.10
29	XXIII			1 11 43 52.50	1.10	62.55	29.90	5.95	+ .16	+ .63	+ 1.03	7.77
	XXIV			35 17 40 31.00	.12	62.20	29.94					
30	XXIV			1 17 46 50.00	1.11	62.25	29.95	5.99	+ .16	+ .65	+ .75	7.55
29	XXV			34 23 33 02.33	.13	61.25	29.96					
	XXV			1 33 39 10.00	1.14	61.45	29.96	6.38	+ .17	+ .66	+ .41	7.62
30	XXVI			34 8 25 51.60	.13	60.55	29.87					
	XXVI			1 5 31 51.75	1.14	60.55	29.87	5.42	+ .17	+ .65	+ .02	7.25
				2 5 42 19.50								
				34 11 18 38.60	.14	59.55	29.82	6.45	+ .17	+ .65	+ .02	7.25
				1 11 24 25.25	1.13	59.50	29.81					
				34 17 32 44.75	.13	58.15	29.84	6.84	+ .17	+ .67	+ .57	7.11
				1 17 38 02.50	1.14	58.15	29.85					
				34 23 25 32.80	.13	57.10	29.92	7.02	+ .17	+ .71	+ 1.11	6.79

SAN FRANCISCO, CAL.

At San Francisco the pendulum station was selected by Prof. George Davidson, Assistant Coast and Geodetic Survey. This station is located in the middle of Octavia street (not yet an open street), just north of Clay street. A space is inclosed by a high board fence, within which were three wooden buildings, none of which could be used for pendulum observations. Another wooden building, 10 by 20 feet, and divided into two rooms, was therefore erected. The north room was lined with heavy wrapping paper. In this room the pendulum apparatus was mounted upon a brick pier. During the pendulum observations the whole building was covered with canvas. This was the best that could be done under the circumstances, and it proved very unsatisfactory, the fluctuations of temperature being too great. Soon after the observations were begun Professor Pritchett was detached from the party, and I was assisted by E. F. Dickins, Assistant Coast and Geodetic Survey, who volunteered his services.

The geographical position of the station is latitude 37° 47' 22" N., longitude 8° 09' 42.7" W.; height, 375 feet.

UNITED STATES COAST AND GEODETIC SURVEY.

San Francisco, Cal.—Time observations.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	T
1883.											
June 20	ζ Virginis.	E.	13 29 35.50	-0.02	-0.01	0.00	-0.17	+0.16	35.46	13 28 46.54	-48.92
	m Virginis.	E.	36 20.00	-0.02	-0.01	0.01	-0.15	+0.16	19.97	35 31.12	.85
	η Bootis.	E.	49 58.30	-0.02	-0.01	0.00	-0.21	+0.17	58.23	49 09.33	.90
	a Draconis.	E.	14 02 04.16	-0.03		+ 0.01	-0.48	+0.41	04.07	14 01 15.18	.99
	ι Virginis.	W.	10 44.80	-0.02		+ 0.02	-0.08	-0.16	44.52	08 55.71	.81
	109 Virginis.	W.	41 12.22	-0.02		+ 0.01	-0.09	-0.16	11.94	40 22.99	.95
	β Ursæ Minoris.	W.	51 55.24	-0.07	+ 0.02	+ 0.05	-0.32	-0.60	54.32	51 05.44	.88
	ψ Bootis.	W.	15 00 17.82	-0.02	+ 0.02	+ 0.00	-0.12	-0.18	17.52	14 59 28.61	48.91
June 21	ζ Virginis.	W.	13 29 35.16	-0.02	+ 0.02	+ 0.06	-0.11	-0.11	34.97	13 28 46.53	-48.44
	η Ursæ Majoris.	W.	43 46.52	-0.02	-0.01	+ 0.01	-0.12	-0.17	46.19	42 57.81	.38
	τ Virginis.	W.	56 32.82	-0.02		+ 0.01	-0.06	-0.11	32.65	55 44.28	.36
	a Draconis.	W.	14 02 04.06	-0.03		+ 0.03	-0.17	-0.28	03.55	14 01 15.14	.41
	λ Bootis.	E.	12 46.82	-0.02		+ 0.01	-0.14	-0.16	46.81	11 58.31	.50
	5 Ursæ Minoris.	E.	28 37.22	-0.08	+ 0.01	+ 0.15	-0.32	-0.46	37.14	27 48.75	.39
	μ Virginis.	E.	37 45.00	-0.02	+ 0.01	+ 0.04	-0.07	+ 0.11	45.07	36 56.76	.31
	109 Virginis.	E.	41 11.38	-0.02	+ 0.01	+ 0.03	-0.08	+ 0.11	11.43	40 22.98	48.45
June 22	ζ Ursæ Minoris.	E.	14 28 26.64	-0.08	-0.01	+ 8.85	+ 0.11	+ 0.67	38.18	14 27 48.67	-47.51
	ε Bootis.	E.	40 43.32	-0.02	-0.01	+ 0.04	+ 0.18	+ 0.83	39 55.27	.56	
	P. XIV. 221.	E.	51 33.38	-0.02		+ 1.39	+ 0.03	+ 0.17	34.17	50 44.72	.45
	δ Bootis.	W.	15 11 37.69	-0.02		+ 0.31	+ 0.24	+ 0.19	37.41	15 10 49.81	.60
	γ Ursæ Minoris.	W.	21 37.97	-0.06	+ 0.01	+ 7.21	+ 0.53	+ 0.52	45.14	20 57.60	.54
	a Coronæ Borealis.	W.	30 35.11	-0.02	+ 0.01	+ 0.82	+ 0.22	+ 0.18	34.32	29 46.88	-47.44
June 23	d Bootis.	W.	14 05 53.52	-0.02	-0.01	+ 0.74	+ 0.33	+ 0.04	53.04	14 05 06.23	-46.81
	4 Ursæ Minoris.	W.	09 56.49	-0.09		+ 9.97	+ 1.12	+ 0.19	67.30	09 20.32	46.98
	λ Bootis.	W.	12 44.37	-0.02		+ 0.71	+ 0.44	-0.06	45.44	11 58.27	47.17
	5 Ursæ Minoris.	E.	28 25.86	-0.08		+ 8.42	+ 1.19	+ 0.17	35.56	27 48.61	46.95
	33 Bootis.	E.	35 17.34	-0.02	+ 0.01	+ 0.57	+ 0.51	+ 0.06	18.47	34 31.27	47.20
	e Bootis.	E.	40 42.27	-0.02	+ 0.01	+ 0.65	+ 0.40	+ 0.04	42.05	39 55.26	46.79
June 24	d Bootis.	W.	14 05 53.44	-0.02	-0.01	+ 0.87	+ 0.07	+ 0.37	52.24	14 05 06.22	-46.02
	4 Ursæ Minoris.	W.	09 56.20	-0.09		+ 11.72	+ 0.25	+ 1.60	66.48	09 20.23	.25
	λ Bootis.	W.	12 44.44	-0.02		+ 0.84	+ 0.10	-0.48	44.88	11 58.25	.63
	5 Ursæ Minoris.	E.	28 22.94								

UNITED STATES COAST AND GEODETIC SURVEY.

[Constants of Transit.]							
Date.	Azimuth <i>a.</i>		Level <i>b.</i>		Coll. α_0	T_0	ΔT
	W.	E.	W.	E.			
1883.							
June 20	- 0.02	- 0.01	- 0.11	- 0.21	- 0.16	14 19	- 48.89
21	+ 0.02	+ 0.06	- 0.08	- 0.10	- 0.17	14 08	- 48.41
22	- 3.90	- 3.39	+ 0.20	+ 0.04	- 0.16	15 00	- 47.52
23	- 3.18	- 3.23	+ 0.30	+ 0.36	- 0.04	14 21	- 46.98
24	- 3.74	- 3.86	+ 0.07	+ 0.15	- 0.33	14 21	- 46.30
25	- 4.25	- 3.81	+ 0.12	+ 0.14	- 0.42	14 21	- 45.79
26	- 3.82	- 3.67	+ 0.05	+ 0.09	- 0.30	14 21	- 45.29

[Comparison of chronometer and R. S. clock.]			
Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.
1883.			
June 20-21			
20	13 02 00	6 44 21	
21	15 08 47	8 50 40	+318.175
22	14 47 35	8 24 15	+318.255
23	15 40 14	9 11 25	+317.920
24	14 48 40	8 14 45	+317.885
25	14 56 49	8 17 35	+318.123
26	14 49 30	8 05 40	+318.471
	14 49 38	7 59 50	

UNITED STATES COAST AND GEODETIC SURVEY.

San Francisco, Cal.—Pendulum No. 4.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibrations.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.	Temperature to 57°.33.	Pressure.	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.														
June 20	I	M.	1	7 18 41.88	1.04	60.40	29.55							
21	II		27	13 10 31.60	1.13	56.25	29.55	86104.88	+ .15	.60	+ .45	86106.08		
22	III		1	13 23 16.70	1.09	56.20	29.55							
23	IV		27	19 16 14.80	1.15	53.85	29.60	5.57	+ .17	.67	+ 1.06	5.35		
24	V	P.	1	19 28 29.33	1.21	54.20	29.61							
25	VI		25	0 54 09.60	1.20	58.00	29.64	5.47	+ .22	.66	+ .56	5.79		
26	VII		1	1 04 26.20	1.07	59.45	29.64							
27	VIII		26	6 42 09.80	1.13	61.15	29.62	4.52	+ .15	.58	+ 1.36	6.61		
			1	6 55 41.90	1.01	61.25	29.60							
			27	12 47 22.50	1.15	56.60	29.62	4.73	+ .15	.60	+ .73	6.21		
			1	12 55 45.10	1.01	56.60	29.62							
			27	18 48 35.70	1.14	54.15	29.66	5.41	+ .14	.68	+ .89	5.34		
			1	18 58 45.50	1.09	54.20	29.68							
			27	0 51 52.00	1.14	56.85	29.70	5.57	+ .16	.69	+ .83	5.59		
			1	1 02 36.88	1.06	57.65	29.71							
			27	6 54 21.50	1.14	60.50	29.68	4.75	+ .15	.63	+ .80	6.33		

San Francisco, Cal.—Pendulum No. 6.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibrations.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.	Temperature to 57°.67.	Pressure.	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.														
June 22	IX	M.	1	7 21 11.40	1.08	61.05	29.69							
21	X		37	12 51 04.50	1.15	56.60	29.71	86003.66	+ .16	.63	+ .51	86004.96		
22	XI		1	12 59 23.62	1.15	56.20	29.71							
23	XII		39	18 48 17.90	1.14	53.90	29.74	4.39	+ .18	.71	+ 1.16	4.12		
24	XIII	P.	1	18 56 05.40	1.09	54.05	29.75							
25	XIV		39	0 45 11.40	1.15	57.55	29.75	4.57	+ .17	.71	+ .83	4.62		
26	XV		1	0 56 28.00	1.03	59.10	29.74							
			39	6 44 22.10	1.12	62.75	29.70	3.49	+ .14	.60	+ 1.44	5.67		
			1	6 55 07.25	1.09	62.60	29.70							
			2	7 04 14.62										
			39	12 43 14.50	1.13	57.55	29.70	3.72	+ .16	.61	+ 1.07	5.56		
			1	12 49 43.60	1.02	57.40	29.70							
			39	18 39 00.67	1.12	54.80	29.71	4.77	+ .14	.68	+ .69	4.90		
			1	18 46 06.80	1.02	54.80	29.72							
			37	0 17 14.40	1.12	56.05	29.71	4.99	+ .14	.70	+ .99	4.84		
			1	0 26 08.60	1.01	56.65	29.71							
			39	6 14 49.12	1.12	61.65	29.67	4.22	+ .13	.62	+ .65	5.62		

San Francisco, Cal.—Pendulum No. 11.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.		Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
									Arc.	Pressure.			
1883.	June 24	M.	h. m. s.	Inches.	°	Inches.							
		XVII	1	6 46 34.20	1.06	63.05	29.68		+ .15	+ .59	+ .84	86057.52	
		XVIII	32	12 27 25.20	.13	58.10	29.68	86055.94	+ .15	+ .59	+ .84	86057.52	
		XIX	1	12 35 05.80	1.01	57.80	29.66		+ .13	+ .67	+ 1.04	6.94	
		XX	33	18 28 42.50	.12	55.00	29.68	7.18	+ .13	+ .67	+ 1.04	6.94	
	24	XIX	1	18 36 29.90	1.03	54.85	29.69		+ .13	+ .67	+ 1.04	6.94	
		XXI	33	0 31 04.40	.11	57.45	29.68	7.89	+ .14	+ .68	+ 1.16	7.55	
		XXII	1	0 38 50.00	.98	58.50	29.68		+ .14	+ .68	+ 1.16	7.55	
		XXII	32	6 21 39.75	.11	62.25	29.63	7.39	+ .12	+ .59	+ .75	8.85	
		XXI	P.	1	6 32 10.20	.99	62.55	29.63					86057.72
	25	XXI	2	6 43 06.30									86057.14
		XXII	33	12 23 33.00	.12	58.50	29.61	5.28	+ .13	+ .58	+ .81	8.80	
		XXII	1	12 34 09.80	.96	58.30	29.61		+ .13	+ .58	+ .81	8.80	
		XXII	33	18 26 35.00	.11	55.35	29.63	5.93	+ .12	+ .65	+ .85	5.87	
		XXIII	1	18 35 16.20	.99	55.30	29.64		+ .12	+ .65	+ .85	5.87	
	26	XXIII	33	0 28 06.00	.10	58.30	29.66	6.26	+ .12	+ .66	+ .86	6.18	
		XXIV	1	0 35 21.62	1.04	59.30	29.67		+ .12	+ .66	+ .86	6.18	
			34	6 37 42.67	.12	64.95	29.65	5.17	+ .14	+ .56	+ 1.53	7.40	

WASHINGTON, D. C., 1884.

On my return to Washington in July, 1883, I found the entire east wing of the Smithsonian Institution was being rebuilt, and it was not till March, 1884, that the pendulum room was placed at our disposal. The room is the same in which Major Herschel made his observations in 1882, but is now much better adapted to pendulum work—being less damp, and divided into two rooms so that the apparatus may be in one and the observer in the other observing through a small hole in the intervening door.

In Major Herschel's observations the R. S. clock was attached to the north wall, while in this work it was attached to the south wall. This change was necessary on account of the division of the room and the arrangement of certain steam-pipes in the north wall. Signals were received from the Naval Observatory for ten minutes, beginning at 0^h 22^m and 12^h 22^m Washington mean time, the Washington standard clock being used. These signals were recorded on the chronograph with sidereal chronometer, Frods. No. 3477. Immediately before or after these signals the chronometer was compared by coincidence of beats with the R. S. clock, and mean-time chronometers, Negus, No. 1572, and Bond & Sons, No. 196. Corrections to the Washington clock, corresponding to 0^h 26^m and 12^h 26^m, were furnished by the observatory. They all depend upon observations of transits of stars made near these times except on April 9, indicated by brackets in the table.

The geographical position of this station is, latitude 38° 53' 19".6, longitude 5° 08' 04".4; height, 33.9 feet.

Corrections to the Washington mean-time clock as furnished by the Naval Observatory.

Date.	Clock correction.	Date.	Clock correction.
1884.		1884.	
March 26, 018	+ 7°.15	April 3 ^d , 018	+ 6°.37
26 .518	+ 7 .11	3 .518	+ 6 .24
27 .018	+ 6 .98	4 .018	+ 6 .28
27 .518	+ 6 .90	4 .518	+ 6 .18
28 .018	+ 6 .98	5 .018	+ 6 .02
28 .518	+ 6 .72	5 .518	+ 6 .04
29 .018	+ 6 .61	6 .018	+ 6 .00
29 .518	+ 6 .48	6 .518	+ 5 .93
30 .018	+ 6 .66	7 .018	+ 5 .81
30 .518	+ 6 .83	7 .518	+ 5 .59
31 .018	+ 7 .01	8 .018	+ 5 .62
31 .518	+ 6 .92	8 .518	+ 5 .55
April 1 .018	+ 6 .86	9 .018	[+ 5 .34]
1 .518	+ 6 .76	9 .518	[+ 5 .13]
2 .018	+ 6 .64	10 .018	+ 4 .92
2 .518	+ 6 .51	10 .518	+ 4 .76

Comparison of Washington mean-time clock with sidereal chronometer, Frods. No. 3477.

Date.	Time by W. M. T. clock.	Time by chron.	Correction to W. M. T. clock.	Correction to Frods. 3477.	Rate of Frods. 3477 per sid. minute.
1884.					
March 26	h. m.	h. m. s.			
	0 22	0 41 08.81	+ 7.15	-19 01.66	-0.1627
	12 22	12 43 06.24	7.11	20 59.13	
27	0 22	0 45 03.55	6.98	22 56.57	27
	12 22	12 47 00.91	6.90	24 54.01	27
28	0 22	0 48 58.29	6.98	26 51.31	25
	12 22	12 50 55.73	6.72	28 49.01	30
29	0 22	0 52 53.06	6.61	30 46.45	27
	12 22	12 54 50.75	6.48	32 44.27	32
30	0 22	0 56 48.63	6.66	34 41.97	30
	12 22	1 00 44.23	7.01	38 37.22	29
31	0 22	1 02 42.11	6.92	40 35.19	34
April 1	0 22	1 04 39.87	6.86	42 33.01	32
	12 22	1 06 37.60	6.76	44 30.84	32
2	0 22	1 08 35.24	6.64	46 28.60	31
	12 22	1 10 32.93	51	48 26.42	32
3	0 22	1 12 30.49	0.37	50 24.12	30
	12 22	1 14 28.22	6.24	52 21.98	32
4	0 22	1 16 25.94	6.28	54 19.66	30
	12 22	1 20 21.63	6.02	58 15.61	34
5	0 22	1 24 17.32	6.00	62 11.32	32
	12 22	1 26 15.18	5.93	64 09.25	33
6	0 22	1 28 12.94	5.81	66 07.13	33
	12 22	(*)			
7	0 22	1 32 08.68	5.62	70 03.06	34
	12 22	1 34 06.57	5.55	72 01.02	34
8	0 22	(*)			
	12 22	1 38 01.82	[5.13]	75 56.69	32
9	0 22	(*)			
	12 22	1 39 59.44	+ 4.92	77 54.52	-0.1632

* Signals from Observatory not received.

UNITED STATES COAST AND GEODETIC SURVEY.

Comparison of sidereal chronometer, Frods. No. 3477, with the R. S. clock.

Date.	Time by Frods. 3477,	Time by R. S. clock,	Correction to Frods. 3477,	Correction to R. S. clock,	S. clock per mean solar day.	Rate of R. s.	
1884.							
March 26	0 53 32	0 31 27	-19 03.67	+3 01.33	70.62		
	12 56 30	12 31 52	21 01.31	3 36.69	52		
27	0 59 31	0 32 40	22 58.98	4 12.02	21		
	12 40 19	12 10 40	24 52.92	4 46.08	70.89		
28	1 02 21	0 30 05	26 53.49	5 22.51	69.92		
	12 47 00	12 12 15	28 48.37	5 56.63	70.16		
29	1 05 24	0 28 03	30 48.49	6 32.51	56		
	13 06 52	12 26 58	32 46.23	7 07.77	70.72		
30	0 49 42	0 07 19	34 40.81	7 42.19			
31	0 51 43	0 04 15	38 35.75	8 52.25	+69.35		
April 1	1 17 32	0 24 54	42 35.11	10 02.89	82		
	13 16 38	12 21 28	44 32.47	10 37.53	56		
2	1 20 51	0 23 08	46 30.60	11 12.40	69.52		
	12 59 16	11 59 05	48 24.58	11 46.42	70.33		
3	1 30 50	0 28 00	50 27.11	12 22.89	70.07		
	13 29 07	12 23 45	52 24.37	12 57.63	69.83		
4	1 09 37	0 01 47	54 18.55	13 31.45	69.72		
5	1 30 36	0 17 15	58 17.28	15 03.72			
6	1 35 09	0 16 42	62 13.09	16 13.91	70.12		
	13 41 52	12 20 51	64 11.80	16 49.20	69.97		
7	1 16 08	23 52 40	66 05.16	17 22.84			
8	1 48 14	0 19 34	70 05.69	18 34.31	70.10		
	13 50 21	12 19 08	72 03.67	19 09.33	70.03		
9	1 32 01	11 45 49	75 54.08	20 17.92	70.15		
10	1 52 05	0 13 14	-77 56.49	+20 54.51	+70.43		

[Number of vibrations of R. S. clock pendulum in mean solar day.]

Washington mean date.	Sets.	86400 —r	Washington mean date.	Sets.	86400 —r
1884.					
March 26	I-II	86329.38	1884.	XXIII-XXIV	86330.48
	III-IV	.48	April 1	XXV-XXVI	29.67
27	V-VI	.79		XXVII-XXVIII	29.93
	VII-VIII	29.11	3	XXIX-XXX	30.17
28	IX-X	30.08		XXXI-XXXII	30.28
	XI-XII	29.84	6	XXXIII-XXXIV	29.88
29	XIII-XIV	.44		XXXV-XXXVI	30.03
	XV-XVI	29.28	7	XXXVII-XL	29.90
31	XVII-XVIII	30.65		XLI-XLII	.97
	XIX-XX	.18	8-9	XLIII-XLVI	.85
April 1	XXI-XXII	86330.44		XLVII-XLVIII	86329.57

UNITED STATES COAST AND GEODETIC SURVEY.

Washington, D. C.—Pendulum No. 4.

Date.	Face.	Number of coinci- dence.	Time of coinci- dence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibra- tions in mean solar day.	Arc.	Temperature.	Pressure.	Number of vibra- tions in mean solar day.	Mean of M. and P.	
					h. m. s.	Inches.	°	Inches.	°	Inches.	°	Inches.	
1884.													
March 26	I	M.	1 0 10 57.1	91 59.10	27.39								
	II		1 5 53 15.1	14 58.85	27.36	86110.80	+ .12	+.07	+ .14	29.86111.14			
	III		1 6 04 38.6	84 58.90	27.38								
	IV		2 6 17 48.0										
	V		2 11 47 12.5	12 58.55	27.38	0.97							
	VI		2 17 41 23.8	16 58.40	27.38	1.13							
	VII		2 23 36 10.0	14 58.50	27.30	1.20							
	VIII		2 23 48 41.3	1 07 58.50	27.40	1.52							
	IX	P.	2 5 31 27.9	16 58.55	27.40	1.52							
	X		2 5 41 33.6	.97 58.60	27.40	1.58							
	XI		2 17 38 00.8	1.06 58.00	27.40	0.86							
	XII		2 11 42 38.0	.15 57.65	27.50	0.72							
	XIII		2 17 34 16.5	.15 57.65	27.50	0.72							
	XIV		2 17 44 12.0	1.10 57.60	27.51	0.77							
	XV		2 23 52 00.1	.14 58.10	27.54								
	XVI		1 0 03 56.7	.99 58.25	27.58								
	XVII		2 5 45 32.1	.16 58.75	27.59	0.41							
	XVIII		1 5 57 10.1	1.04 59.00	27.60	28							
	XIX		1 11 52 01.3	.14 58.55	27.61	0.49							
	X		1 12 00 53.0	1.02 58.55	27.60								
	XI		2 17 42 47.3	.14 58.15	27.59	0.45							
	XII		1 17 53 41.7	1.01 58.10	27.58								
	XIII		2 23 48 21.3	.13 57.45	27.56	0.52							
	XIV		2 23 52 00.1	.14 58.10	27.54	0.77							
	XV		1 0 03 56.7	.99 58.25	27.58								
	XVI		2 5 45 32.1	.16 58.75	27.59	0.41							
	XVII		1 5 57 10.1	1.04 59.00	27.60	28							
	XVIII		1 11 52 01.3	.14 58.55	27.61	0.49							
	XIX		1 12 00 53.0	1.02 58.55	27.60								
	X		2 17 42 47.3	.14 58.15	27.59	0.45							
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UNITED STATES COAST AND GEODETIC SURVEY.

Washington, D. C.—Pendulum No. 6.

[d=0.9 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.	Pressure.	Temperature to 55° 12'	Corrected number of vibrations in mean solar day.	Mean of M and P.
			h. m. s.	Inches.	°	Inches.		Arc.					Means.
1884.													
Mar. 31	XVII	M.	123 39 10.8	1.06	55.50	27.17							
			223 48 12.0										
			41 5 40 34.9	.12	55.80	27.10	86012.15	.15	-.07 + .23	86012.46			
	XVIII		1 5 49 08.0	1.10	55.85	27.19							
			40 11 41 29.7	.12	55.75	27.21							
	XIX		1 11 48 49.8	1.15	55.80	27.22							
			39 17 32 09.5	.15	55.50	27.22							
	XX		1 17 42 08.2	1.10	55.50	27.22							
April 1			42 23 52 34.1	.12	55.15	27.22							
	XXI		1 23 59 40.8	1.05	55.15	27.26							
			55 8 07 30.4	.06	55.20	27.28							
	XXII		1 8 16 38.2	.97	55.25	27.29							
			20 12 02 20.6	.26	55.30	27.29							
	XXIII		1 12 11 22.1	1.01	55.30	27.30							
			37 17 36 38.5	.14	55.20	27.32							
	XXIV		1 17 45 08.9	1.05	55.25	27.33							
			39 23 28 29.2	.14	55.10	27.33							
2	XXV	P.	1 23 58 24.8	1.04	55.50	27.15							
			39 5 42 32.3	.12	55.55	27.16							
	XXVI		1 5 50 06.6	1.07	55.05	27.16							
			39 11 34 28.7	.12	55.35	27.16							
	XXVII		1 11 41 44.2	1.01	55.30	27.17							
			40 17 35 22.4	.12	55.10	27.17							
	XXVIII		1 17 42 39.7	1.05	55.15	27.17							
3			42 23 54 33.6	.11	54.85	27.17							
	XXIX		1 0 01 55.3	1.04	54.90	27.19							
			38 5 37 23.6	.14	55.05	27.22							
	XXX		1 5 45 04.3	1.02	55.10	27.22							
			41 11 47 40.5	.11	54.15	27.20							
	XXXI		1 11 55 47.8	1.04	54.15	27.21							
			38 17 31 14.2	.14	53.65	27.22							
	XXXII		1 17 38 54.8	1.08	53.65	27.22							
			40 23 32 25.8	.13	54.15	27.32							

UNITED STATES COAST AND GEODETIC SURVEY.

Washington, D. C.—Pendulum No. 11.

[d=0.9 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections.	Pressure.	Temperature to 55° 20'	Corrected number of vibrations in mean solar day.	Mean of M and P.
			h. m. s.	Inches.	°	Inches.		Arc.					Means.
1884.													
April 6	XXXIII	M.	1 0 28 13.2	1.06	56.80	27.08							
			33 6 14 32.8	.14	55.90	27.68	86063.99	.15	-.02 + .52	86064.64			
	XXXIV		1 6 28 11.5	.77	55.95	27.21							
			31 11 53 15.8	.12	55.70	27.69	4.31	+.09	+.01 + .28	4.69			
	XXXV		1 12 07 35.4	1.10	55.75	27.36							
			30 17 21 47.0	.17	55.15	27.75	4.42	+.17	+.05 + .11	4.75			
	XXXVI		1 17 32 08.7	1.04	55.15	27.19							
7	XXXVII		34 23 30 18.3	.12	55.20	27.77	4.89	+.14	+.03 + .01	5.05			
			1 23 39 41.7	1.02	55.30	27.24							
	XXXVIII		32 5 15 41.9	.13	55.30	27.79	4.40	+.14	+.04 + .04	4.62			
			1 5 25 32.2	1.23	55.35	27.28							
	XXXIX		35 11 33 54.6	.13	55.50	27.80	4.30	+.19	+.04 + .10	4.63			
	XL		1 11 44 00.3	1.05	55.50	27.23							
			32 17 20 01.9	.14	55.30	27.63	4.42	+.15	+.01 + .09	4.67			
			1 17 29 27.9	1.16	55.30	27.22							
	XLIV		34 23 27 14.3	.14	55.15	27.60	4.47	+.18	+.01 + .01	4.67			
8	XLI	P.	1 0 01 01.4	1.02	55.95	26.99							
			34 5 58 08.7	.13	55.15	27.22	4.06	+.14	+.08 + .16	4.28			
	XLII		1 6 06 51.1	1.00	55.15	27.34							
			33 11 53 19.6	.13	54.65	27.62	4.19	+.14	+.03 + .14	4.22			
	XLIH		1 12 06 01.4	.97	54.65	26.94							
			30 17 20 16.9	.15	54.45	27.28	4.30	+.14	+.07 + .29	4.08			
	XLIV		1 17 28 12.2	1.04	54.45	27.30							
			2 17 39 01.8				4.20	+.14	+.05 + .35	4.04			
			34 23 25 40.5	.13	54.40	27.71							
9	XLV		1 23 34 34.5	1.24	54.40	27.28							
			34 5 32 09.9	.14	54.80	27.67	4.29	+.20	+.04 + .27	4.26			
	XLVI		1 5 43 27.1	1.22	54.85	27.34							
			33 14 30 15.3	.15	55.00	27.66	4.32	+.20	+.04 + .13	4.43			
	XLVII		1 11 37 36.0	1.22	55.00	27.26							
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UNITED STATES COAST AND GEODETIC SURVEY.

Results reduced to mean temperature of sets with each pendulum and to density of air under pressure of 26 inches at temperature 32° F., and final reduction to temperature 62° F.

Station.	Number of pendulum.	Number of sets.	Temperature.	Number of vibrations in mean solar day.	Reduction to 62° F.	Number of vibrations in mean solar day at 62° F.	Geographical position.
Auckland	4	8	63.47	86102.08	+0.67	86102.75	Lat. 36° 51' 51" S. Long. 11° 39' 07" E.
	6	8	62.60	86001.84	+0.27	86002.11	Height 261 feet.
	11	9	63.56	86053.43	+0.70	86054.13	Lat. 33° 51' 41" S. Long. 10° 04' 50" E.
Sydney	4	8	68.59	86087.93	+3.00	86090.93	Lat. 1° 16' 46" N. Long. 140 feet.
	6	8	69.04	85987.21	+3.11	85990.32	Lat. 1° 16' 46" N. Long. 10° 04' 50" E.
	11	8	69.45	86038.73	+3.35	86042.08	Height 140 feet.
Singapore	4	8	81.77	86012.08	+9.05	86021.13	Lat. 35° 42" N. Long. 6° 55' 21" E.
	6	8	81.61	85911.30	+8.67	85919.97	Height 45 feet.
	11	8	82.15	85962.27	+9.07	85971.34	Lat. 37° 47' 22" N. Long. 8° 09' 42" W.
Tokio	4	8	57.82	86101.74	-1.91	86099.83	Lat. 35° 42" N. Long. 9° 19' 01" E.
	6	8	58.41	85996.76	-1.59	85995.17	Height 20 feet.
	11	12	60.09	86047.77	-0.86	86046.91	Lat. 37° 47' 22" N. Long. 137° 38' 58" E.
San Francisco	4	8	57.33	86105.91	-2.14	86103.77	Lat. 38° 58' 19" N. Long. 122° 22' 40" W.
	6	8	57.67	86005.04	-1.19	86003.13	Height 375 feet.
	11	8	58.72	86057.14	-1.48	86055.66	Lat. 38° 58' 19" N. Long. 122° 22' 40" W.
Washington	4	16	58.34	86110.98	-1.67	86109.31	Lat. 38° 58' 19" N. Long. 122° 22' 40" W.
	6	16	55.12	86012.33	-3.04	86009.29	Height 34 feet.
	11	16	55.20	86064.47	-3.06	86061.41	

Differences of pendulums.

Station.	4-6	4-11	11-6
Auckland	100.64	48.62	52.02
Sydney	100.61	48.85	51.76
Singapore	101.16	49.79	51.37
Tokio	104.66	52.92	51.74
San Francisco	100.64	48.11	52.53
Washington	100.02	47.90	52.12

UNITED STATES COAST AND GEODETIC SURVEY.

On examining these results it is found that at Tokio the vibration number of pendulum No. 4 is between three and four vibrations too great, and will have to be rejected. I can only explain this discrepancy by the supposition that some foreign material was adhering to the pendulum during these observations. Great care was always taken in wiping the pendulums before suspending them.

The vibration numbers in column 7 on page 58 may be readily reduced to any temperature and density of air and corrected for elevation of station, for comparison with other results. This is not done here, as it is deemed advisable, at present, to publish this work simply as so many additional data to those already obtained with the Kater pendulums, and to make no inference from them till similar data of Major Herschel's work in England and the United States have been received.

I have the honor to be, very respectfully, yours,

EDWIN SMITH,
Assistant Coast and Geodetic Survey,
Prof. J. E. HILGARD,
Superintendent Coast and Geodetic Survey.
H. Ex. 43—60