OBSERVATIONS OF THE TRANSIT OF VENUS: DECEMBER 5 AND 6, 1882, MADE AT THE HARVARD COLLEGE OBSERVATORY, PP. 15 - 40

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EDWARD C. PICKERING

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OBSERVATIONS

OF

THE TRANSIT OF VENUS,

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EDWARD C. PICKERING,

DIRECTOR.

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II.

OBSERVATIONS OF THE TRANSIT OF VENUS, DECEMBER 5 AND 6, 1882, MADE AT THE HARVARD COLLEGE OBSERVATORY.

By Edward C. Pickering.

Presented December 13, 1882.

The chances of cloudy weather at this Observatory early in December are large, and Cambridge was not selected by the United States Commission on the Transit of Venus as a station for observations of the phenomenon. It therefore seemed injudicious to make any extensive preparations for the occasion. The available telescopes at the Observatory, however, were employed in observing the contacts. Photometric and spectroscopic observations were also obtained with the East Equatorial, and measurements of the diameter of Venus were made with the telescope of Mr. Chandler, mounted in the West Dome, and also with the East Equatorial.

The morning of the transit was so cloudy that there seemed little prospect of observing the contacts; but the sun gradually became visible, and the clouds were thin enough at the time of ingress to allow observation of both the first and the second contacts. The first part of the afternoon was nearly clear, and the third contact was well seen. A few minutes later the sun entered a mass of thin clouds, but was still sufficiently well seen for observation of the last contact.

Arrangements had been made before the day of the transit with the Western Union Telegraph Company for the distribution of the time signals of this Observatory among those who might desire to obtain them on December 6. The clock at which these signals originate was carefully compared with the standard sidereal clock of the Observatory at frequent intervals, and also with the signals furnished by the United States Naval Observatory at Washington, which were received here by telegraph. To determine the error of the sidereal clock, observations were made with the meridian circle by Professor W. A. Rogers, the results of which are given below. Since the transit, in order to remove any doubts with regard to the error of the sidereal clock as determined by a large fixed instrument, Professor Rogers has made a special series of observations, in which he used both the meridian circle and the portable transit instrument on each of eight evenings, determining the clock error independently with each instrument. The result confirms the correctness of the form of level employed with the meridian circle, and shows that the instrument furnishes trustworthy results for the absolute as well as the relative clock error. The mean correction to be applied to the error found by the meridian circle in order to reduce it to that found by the portable transit instrument, according to these observations, is $+0^s.08$; the eight separate results are $+0^s.20$, $+0^s.06$, $+0^s.09$, $+0^s.07$, $+0^s.06$, $+0^s.11$, $+0^s.09$, $+0^s.05$, the first having a weight of one third. As the magnifying powers and the reticules used with the two instruments differ materially, the amount of the correction is not surprising.

The results for the error of the sidereal clock obtained from the observations with the meridian circle near the time of the transit are exhibited in Table I. The first two columns contain the date of the observations in mean solar days and tenths, and the sidereal time, to hundredths of an hour, for which the error was determined. The third column gives the number of stars on which each result for clock error depends. The next two columns give the amount by which the clock was slow at the time of each set of observations, and the corresponding error for noon of December 6, corrected by means of the hourly rate $+0^s.023$. The last two columns contain the values of the instrumental constants n and b (angle at pole, and inclination of axis).

TABLE I.—OBSERVED CLOCK ERRORS.

Date. 1882.	Sid. Time.	No. of Stars.	CLOCK SLOW.		n	b
			Observed.	Red. to Dec. 6.0		
Dec. 4.2	$21^h.02$	5	$+2^m\ 21^s.25$	$+2^m\ 22^s.24$	$-1^s.10$	$+0^s.77$
Dec. 4.8	12.63	4	+2 21.69	+2 22.46	−1.03	+0.77
Dec. 5.4	3.07	4	+2 22.05	+2 22.37	−1.05	+0.77
Dec. 6.2	22.05	7	+2 22.36	+2 22.24	−1.05	+0.77

The mean result for noon of December 6 is $+2^m\ 22^s.33$. Reducing this to the result to be expected from the portable transit instrument, by adding $+0^s.08$ as above, we have $+2^m\ 22^s.41$, with an hourly increase of $+0^s.023$.

On December 5, 6, and 7, at noon, the Washington signals were received at Cambridge, and compared by chronograph with our sidereal clock. The result, after allowing for the difference in longitude, was that the Washington clock was fast $0^s.6$, $0^s.4$, and $0^s.3$ on the three days respectively. The signals were promised for December 4 also, but were not received, as the lines were occupied in transmitting political news. A good example is thus afforded of the importance of depending on the local observatories for supplying the public with time.

The clock distributing the mean-time signals from the Harvard College Observatory is kept as nearly as may be $15^s.5$ fast. The time is therefore that of the meridian passing through the State House in Boston, and $4^h\ 44^m\ 15^s.5$ west of Greenwich. On the day of the transit the deviation of the Washington signals was noted, and, to avoid the confusion arising from two systems, our signals were brought to an approximate agreement with them, rather than with our own determination of the local time. Frequent comparisons were made with our sidereal clock, and showed that at December 5.8 our signals were $0^s.6$ fast; at December 6.0, $0^s.5$ fast; at December 6.3, $0^s.5$ fast; and at December 6.8, $0^s.2$ fast. Allowing for the difference of longitude, these signals therefore did not differ more than a tenth of a second from the Washington signals, but to reduce them to the true time both should be regarded as about $0^s.5$ fast. In other words, in reducing to Greenwich mean time, the longitude for the Washington and Boston signals should be taken as $5^h\ 8^m\ 11^s.7$ and $4^h\ 44^m\ 15^s.0$ respectively. Since the observed times of contact are known to be liable to variations of several seconds, these corrections in any case are small, and may be neglected without serious error, especially as it is useless to give the resulting times of contact more closely than to single seconds.

Contacts.

A statement of the results of the contact observations is given below, in Table II. The upper part of the Table contains in successive columns the names of the observers and recorders, the apertures and focal lengths of the telescopes in centimeters, their magnifying powers in diameters, and the corrections required at ingress and at egress to reduce the observed times to Cambridge mean or sidereal time according to the timepiece employed. These corrections are given in accordance with the assumption that the signals furnished by the mean-time clock give the time of a meridian $4^h\ 44^m\ 15^s.5$ west of

Greenwich. The second part of the Table gives the observed times of the four contacts, without any corrections. The third part contains the concluded Greenwich mean times of the contacts noted by each

TABLE II. — CONTACTS.

Observer.	Recorder.	Aperture in cm.	Focal Length in cm.	Power in Diameters.	Corrections of Time-piece.
E. C. Pickering	A. W. Cutler	14.5	682.5	206	$+9^s.0$, $+10^s.3$
Arthur Searle	W. A. Rogers	13.2	230	220	$-76^s.2$
O. C. Wendell	A. W. Cutler	10.2	141.4	40, 90	$+9^s.0$, $+10^s.3$
J. R. Edmands	R. G. Saunders	10.2	140	150	$+82^s.3$, $+82^s.3$
S. C. Chandler, Jr.	W. V. Brown	15.2	244	180	$-26^s.8$, $-24^s.7$
W. H. Pickering	R. G. Saunders	6.4, 10.2	71, 84	20, 110	$+82^s.3$, $+82^s.3$

Observer.	Observed Times of Contacts.			
	I.	II.	III.	IV.
E. C. P.	21^h 19^m $43^s.4$	21^h 39^m $51^s.3$	3^h 3^m $3^s.8$	3^h 23^m $10^s.0$
A. S.	. . . . .	. . . . .	20 6 23.4	20 26 28
O. C. W.	21 20 8.2	. . . . .	3 3 8.2	3 23 14.2
J. R. E.	. . . . .	14 40 1	20 3 40	20 23 40
S. C. C.	21 20 22	21 40 30	3 3 30	3 24 10
W. H. P.	. . . . .	14 40 9	20 3 33	20 24 0

Observer.	Greenwich Mean Time of Contacts.				Difference from Mean.			
	I.	II.	III.	IV.	I.	II.	III.	IV.
E. C. P.	2^h 4^m 23^s	2^h 24^m 31^s	7^h 47^m 45^s	8^h 7^m 51^s	-9^s	-12^s	$+5^s$	-1^s
A. S.	. . .	. . .	7 47 41	8 7 42	. . .	. . .	+1	−10
O. C. W.	2 4 48	. . .	7 47 49	8 7 55	+16	. . .	+9	+3
J. R. E.	. . .	2 24 50	7 47 36	8 7 33	. . .	+7	−4	−19
S. C. C.	2 4 26	2 24 34	7 47 36	8 8 16	−6	−9	−4	+24
W. H. P.	. . .	2 24 58	7 47 30	8 7 54	. . .	+15	−10	+2
Mean	2 4 32	2 24 43	7 47 40	8 7 52				

observer, obtained by adding $4^h\ 44^m\ 31^s$ to each of the Cambridge mean times. The mean result for each contact is given in the last line of the Table. At the right are given the differences of each observer's result from the mean of all.

The following notes contain, under the name of each observer, the details of his work.

E. C. Pickering.

The instrument employed was the East Equatorial. Its full aperture is 15 inches, which on this occasion was reduced to about 6 inches by a cap over the object-glass. An audible signal was given to the recorder at the time of each phenomenon noted. The recorder took the time of each signal from the chronometer, and recorded it, with any subsequent remarks by the observer. The wedge of shade glass placed between the eyepiece and the eye was of a greenish tint. In observing the first contact, the last time recorded before the appearance of the notch was $9^h\ 19^m\ 29^s.6$ by the chronometer. Venus was first seen at $9^h\ 19^m\ 44^s.2$ by the chronometer. The edge of the sun was wavy, rendering it difficult to decide whether an indentation was real. At $9^h\ 19^m\ 49^s.0$ the interval between the cusps was estimated at $9''$; two parallel lines $6''$ apart served as the unit of measure. From a reduction of this observation the time of first contact appears to be $9^h\ 19^m\ 42^s.6$; the mean of this and of the time directly observed is here assumed to be the time of the first contact, which is therefore $9^h\ 19^m\ 43^s.4$ by the chronometer. A scale in the eyepiece would allow the observer of phenomena like these to make estimates of the interval of the cusps without removing his eye from the telescope, and would accordingly afford him many of the advantages of a double-image micrometer without its disadvantages.

The images at the second contact were unusually well defined, and the contact was recorded as occurring at $9^h\ 39^m\ 51^s.3$. Eight seconds later it was clearly past.

The third contact was recorded as occurring at $3^h\ 3^m\ 3^s.8$. At $3^h\ 3^m\ 21^s.4$ the interval between the cusps was estimated as double that between the lines in the field, and consequently as $12''$. A reduction of this observation would make the time of contact $3^h\ 3^m\ 0^s.0$.

The fourth contact was recorded as occurring at $3^h\ 23^m\ 10^s.0$. At $3^h\ 23^m\ 3^s.4$ it had not occurred, at $3^h\ 23^m\ 19^s.4$ it was certainly past.

The chronometer used by the recorder, who also recorded for Mr.