LX. *Obſervations of the Tranſit of* Venus *over the* Sun, *made at the Round Tower in* Windſor Caſtle, June 3, 1769. *By* Daniel Harris, *Maſter of the Royal Mathematical School in* Chriſt's Hoſpital, *and F. R. S. In a Letter to the Reverend* Nevil Maſkelyne, *B. D. F. R. S. and Aſtronomer Royal.*

SIR,

Read Dec. 21, 1769. I HAVE taken the liberty to ſend you my obſervations on the tranſit of Venus, as likewiſe thoſe made for aſcertaining the going of the clock; all which I ſhould have done laſt June, when I ſent the times of the contacts, to the end that they might, if you thought them worthy, have been communicated to the Royal Society through your hands; but, waiting for an opportunity of uſing your tranſit-inſtrument, in order to aſcertain the longitude of Windſor, which you was ſo obliging to lend me for that purpoſe, prevented; and am ſorry ſtill to ſay, that I have not once been able to make uſe of it, on account of the badneſs of the weather at the ſeveral times I took it down with me for that purpoſe. However, other methods have been

been made uſe of, and no pains ſpared for aſcertaining that material point, in which I hope I have ſucceeded, as well as in making the other neceſſary obſervations; and ſhall be happy if they meet with your approbation, and in any way tend to aſſiſt in determining the grand point in queſtion.

My ſituation for obſerving the tranſit, and making the previous obſervations, was extremely advantageous; all of which were made within hearing of the clock, which was a good regulator, fixed up in the Round Tower a fortnight before, by permiſſion of the Governor, his Grace the Duke of Montagu; who was ſo obliging, upon my worthy friend Captain Alexander Schomberg's application to him, by letter, in both our names, immediately to give his conſent, with ſtrict orders to his ſervants to take care that we were not diſturbed in making our obſervations, particularly on the day of the tranſit; which orders were moſt punctually obeyed; nobody being admitted into the Round Tower on that day but ourſelves, and two others, as aſſiſtants to watch the clock; viz. the Reverend Doctor Boſtock, Canon of Windſor, and the Reverend Mr. James Townley, Head-maſter of Merchant Taylors School; both gentlemen acquainted with the nature and uſe of aſtronomical obſervations.

The regulator was fixed truely perpendicular, and well faſtened to the wall and floor of the room where the tranſit was to be obſerved, and obſervations made on its rate of going for ſeveral preceding days, both by Captain Schomberg, an officer, well acquainted with aſtronomical obſervations, and myſelf; by which we found that it loſt at the rate of twenty

twenty ſeconds per day nearly. The greateſt part of the altitudes taken for that purpoſe, with a good Hadley's quadrant, in a ſaucer of treacle and water, covered with your glaſs roof, when neceſſary, to ſcreen it from the wind, which I found to be of great uſe, are herewith incloſed, with their correſponding times, &c. which have all been compared ſeparately, in compliance with your requeſt, both by Captain Schomberg and myſelf; and which I hope will be found to be ſatisfactory.

As to the longitude of Windſor Caſtle from Greenwich, which has ſo long engaged my attention, though I have not had an opportunity of aſcertaining it with your tranſit-inſtrument, by the method of differences of azimuths, which I have long wanted to do, yet, notwithſtanding, by a mean of ſeveral bearings of St. Paul's, taken from the corner of the terras, near the dial, with a good theodolite, and found to be N. 82° 30′ from the true meridian, and the difference of latitude between that cathedral and Windſor Caſtle 2½ geographical miles, think it may be very nearly determined; and in the following manner.

The latitude of St. Paul's, or, which is the ſame thing, of the Royal Mathematical School in Chriſt's Hoſpital, by the mean of a great number of obſervations, I make to be 51° 30′¼ N. and by a mean of ſeveral double altitudes of the Sun, taken in a ſaucer of treacle and water, ſcreened from the wind, I find the latitude of Windſor Caſtle to be 51° 28′¼ N. the difference of latitude therefore between thoſe two places is 2½ geographical miles; with which, and the bearing of St. Paul's from the Caſtle N. 82° 30′ E.

(variation

variation 20½ degrees allowed for), I make the difference of longitude between them (by Mercator) to be 30½ miles, which is equal to 2′ 2″ of time: and recollecting your mentioning to me Dury and Bell's actual Survey of London and its environs for 30 miles, as of ſome uſe for the purpoſe, I have looked over it, and find by that, that the direct diſtance between Windſor Caſtle and St. Paul's, London, is 22 ſtatute or meaſured miles: and by another Survey of the ſame kind, done by Kitchen, I find the diſtance between thoſe two places to be very nearly the ſame. Therefore, with this diſtance of 22 miles, equal to 19 geographical ones, and the difference of latitude, by obſervation, between the two places 2½ miles, I find the departure to be 18,8 miles, which gives 30,2 miles of longitude, equal to 2′ 1″ of time, agreeing within a ſecond to the former method.

The difference of longitude, or difference of meridians, therefore, between the Round Tower Windſor Caſtle, and St. Paul's, London, I think I may venture to put at 30½ miles, or 2′ 2″ of time; though I am perſuaded, if any thing, it is rather more than leſs; to which if we add the difference of longitude in time between St. Paul's and Greenwich, which is 22″½, it will give 2′ 24″½ of time for the difference of longitude between the Round Tower at Windſor Caſtle, and the Royal Obſervatory at Greenwich.

I cannot help obſerving, that the only inconvenient circumſtance, during the time of obſerving the tranſit, was the wind; which, blowing rather hard, and directly into the teleſcope, together with the ſmallneſs

of the Sun's altitude at that time, made the limb ſo very ill defined and undulating, that it is poſſible there may be an error of five or ſix ſeconds, at leaſt, in the time of the external contact: being anxious, therefore, of having the internal contact as exact as poſſible, I changed the magnifying power of my teleſcope from that of 125 times, recommended by yourſelf, to that of 55 times, the leaſt of all, which ſucceeded beyond expectation; for by this means that undulating motion of the Sun's limb was greatly reduced, though not entirely taken away, appearing much better defined than before, as did likewiſe that of the Planet Venus; inſomuch that the error, if any, in the time of the internal contact, by which I mean the completion of the thread of light formed by the Sun's circumference, cannot exceed three ſeconds. The obſerving of the two contacts with ſo different magnifying powers as that of 125 times and that of 55 times, muſt occaſion ſome difference in the times, and duration between the two contacts, to what they would have been, had they both been obſerved with the ſame magnifying power; which is to be allowed for.

Venus appeared remarkably protuberant on her upper limb, both before and at the time of her internal contact, which went gradually off ſoon after, but did not, though I earneſtly attended to it, obſerve any thing like an atmoſphere about her.

Be pleaſed, Sir, to accept of my beſt thanks for the uſe of your glaſs roof and tranſit-inſtrument, as likewiſe for your very obliging and uſeful communications, at different times, on the preſent ſubject,

ſubject, which I ſhall always have the moſt grateful ſenſe of; and am, with real eſteem,

SIR, Your much obliged,

and moſt obedient, humble ſervant,

Royal Mathematical School,
in Chriſt's Hoſpital,
Dec. 21, 1769.

Daniel Harris.

Times of the contacts of Venus with the Sun, as obſerved from the Round Tower, in Windſor Caſtle, by permiſſion of his Grace the Duke of Montagu, June 3, 1769.

Latitude 51° 28′¼ N. and longitude 2′ 24″½ in time, W. from the Royal Obſervatory at Greenwich.

	By the clock. h ′ ″	Mean time. h ′ ″
The external contact of Venus with the Sun,	7 4 30	7 06 14 p. m.
The internal contact at	7 22 38	7 24 22
Duration between the contacts, the clock being 1′ 44″ too ſlow for mean time,		0 18 08
*Venus's diameter meaſured 3 different times		0 59½

Chords meaſured parallel to the equator.

Venus's weſtern limb from the Sun's eaſtern limb, at 7h 46′ 04″ mean time	3 42½
Venus's eaſtern limb from the Sun's weſtern limb, at 7h 47′ 04″ mean time	15 16
Neareſt diſtance of Venus's lower limb from the Sun's limb, at 8h 0′ 15″, the laſt of her	2 49
The Sun's horizontal diameter (at 7h 30′)	31 42

Note, Theſe obſervations were made with a good regulator, made by Binning, of Windſor; an 18 inch reflector, made by the late ingenious Mr. Short, and a double object glaſs micrometer, made by Dollond.

* The very ſame that I made it at the tranſit, 1761.

An account of the methods uſed to aſcertain the going of a clock, fixed up in the Round Tower at Windſor Caſtle, in latitude 51° 28′¼ N. from the 30th of May to the 3d of June following, 1769.

		′	″
♂ May 30 at 4¾ p. m.	By a mean of three double altitudes of the Sun's center, the limb not being well defined, taken with a good Hadley's quadrant, made by Adams, in a ſaucer of treacle and water, ſo placed within the room as not to be diſturbed by the wind, after having worked each ſeparately, I found the clock to be 3′ 18″ too ſlow for the Sun, and 0′ 25″ too ſlow for mean time.		
☿ May 31 at 8¾ a. m.	By a mean of four double altitudes, of the Sun's upper limb, after being worked ſeparately, found the clock too ſlow for mean time	0	40
	And by a mean of 3 correſponding altitudes the ſame afternoon	0	48
♃ June 1 at 5½ p. m.	* By a mean of 4 altitudes, worked ſeparately, too ſlow	1	00
♀ June 2 at 8¾ a. m.	By 9 different altitudes of the Sun's upper limb, all worked ſeparately, and taking the mean, found the clock too ſlow	1	16¼
	And, by a mean of 3 correſponding altitudes, the ſame day	1	17
♄ June 3 at 8¼ a. m.	By the mean of two altitudes only; the weather not permitting more, made the clock too ſlow for mean time	1	26
Ditto. at 4¼ p. m.	The ſame afternoon, the weather being extremely fine, by 4 more double altitudes of the Sun's upper limb, worked ſeparately, and a mean taken, found the clock too ſlow for mean time	1	42

* Wound up the clock juſt before theſe altitudes were taken, which might affect it ſomething, although a regulator.

By

		′	″
♄ June 3 at $5^{h}\frac{1}{4}$ p. m.	By 4 more double altitudes an hour after, the weather being exceeding fine, tho' windy, which obliged me to uſe the glaſs roof, by working all of them ſingly, and taking a mean, made the clock too ſlow for mean time	1	43

By all which it appears, that the clock loſt of mean time, from the 30th of May to the 3d of June, incluſive, at the rate of $19\frac{1}{2}$ ſeconds per day; and by the laſt ſet of obſervations, at the time of the tranſit, 1 ſecond per hour.

Some of the foregoing double altitudes, with their correſponding times as ſhewn by the clock, and the reſults, are here ſubjoined.

☿ June 2 The weather very fine.

Times by clock.				Double alt. ⊙'s u. l.		Cl. too ſlow.		
	h	′	″	°	′	′	″	
At	8	25	55 a. m.	81	$06\frac{1}{2}$	3	41	Clock too ſlow for the Sun.
—		28	45	81	$58\frac{1}{2}$	3	43	
—		33	47	83	$30\frac{1}{2}$	3	49	
—		40	13	85	$19\frac{1}{2}$	3	39	
—		43	35	86	$23\frac{1}{2}$	3	49	
—		46	37	87	16	3	47	
—		54	35	89	35	3	51	
—		56	30	Ditto center		3	44	
—		58	07	D° lower limb		3	51	
						9)–	414	
By the mean of all, clock too ſlow for the Sun						3	46	
Equation of time						–2	$29\frac{3}{4}$	
Clock too ſlow for mean time						1	$16\frac{1}{4}$	

Corre-

Correſponding altitudes, taken the ſame day.

Times by cl.			Dou. alt.			h ′ ″	′ ″	
	h	′	″	°	′			
At	8	5	18	74	50 up.limb	3 47 44	1 05½	cl. too flow for m. time
	8	8	32	75	54½	3 44 01	1 20	
	8	11	44	76	53	3 40 38	1 25½	
							3)3 51	
By a mean of the three, cl. too flow for m. time							1 17	

♄ June 3 The weather very cloudy, and likely to rain.

	h	′	″		D. alt. °	′		′ ″	
At	8	15	47	a. m.	78	16	up. limb.	3 49	cl. too flow for the Sun
	8	18	17		79	02	ditto.	3 43	
Cl. too flow for the Sun, by the mean								3 46	
Equation of time								2 20	
Clock too flow for mean time.								1 26	

Again,

At	4	11	38	p. m.	67	31½	up. limb.	4 02	clock too flow for the Sun.
—		14	21		66	44		3 51	
—		16	51		65	54		4 01	
—		19	01		65	14		4 03	
								4)15 57	
By the mean, clock too flow for the Sun								3 59¼	
Equation of time								— 2 17	
Clock too flow for mean time								1 42	

Again,

Again,	Double alt.			
h ′ ″	° ′		′ ″	
At 5 11 35	48 56	up. limb.	4 01	Clock too
— 14 05	48 08½		4 01	flow for the
— 16 19	47 28		3 59	Sun.
— 18 27	46 48		3 57	
			4)15 58	
Clock too flow for the Sun			3 59½	
Equation of time			—2 16½	
Clock too flow for mean time			1 43	

LXI. *Obſer-*