

XI. *Astronomical Observations made at Chislehurst in Kent, by the Reverend Francis Wollaston, F. R. S.*

Received November 12, 1772.

Read Dec. 17, 1772. **I** the last year did myself the honour to deliver to this Society, an account of the going of an astronomical clock with a wooden pendulum, for the year preceding; together with such observations as I had made in this place; the latitude of which is  $51^{\circ} 24' 33''$  North, and its longitude  $4^{\circ} 39' = 18'',6$  in time, East of the Royal Observatory at Greenwich. As that account seemed not wholly unacceptable, I have now continued it down to the present time: omitting however the series of transits; which I gave in the former paper, merely to shew the exactness with which they might be taken with a very small instrument, beyond what I had expected to find.

The rate of the clock deduced from the observations of this last year, will not be found so uniform as the foregoing. To what cause to ascribe it, I am not certain. I think not to heat: perhaps to the great drought of the summer. However, its acceleration or retardation was not desultory, but suf-

K<sub>2</sub>                      ficient

ficient to be depended upon for any intermediate time. The clock was cleaned in November ; and when set up again, lost, between the 18th and 28th, at the rate of 7'',8 per day. The regulator was then altered, and clock set, and from that time never meddled with.

My observatory (if it deserves that name) is a room up two pair of stairs, in a square compact brick house, pretty much exposed indeed to wind, from our high situation. The face of the clock turns due East. I have set down the *throwing-out* of the pendulum, as judged by the eye, on a scale behind it divided only to every 10 minutes ; and therefore some of the variations may only be errors in judgment. How far a clock so situated may be affected by any motion of the house in windy weather, deserves consideration. I do not however perceive that it is, either in the *rate* or *throwing-out*.

1771.	Clock + too fast — too flow for mean fol. time.		Gain + or Loss —	Num- ber of days.	Rate per day.	Throwing out on the	
						South side.	North side.
		' "	"		"	o '	o '
Nov. 29	Clock	— 0,6	— 17,3	17	— 1,02	I 42	I 45
Dec. 16	—	17,9	— 12,1	14	— 0,86	I 43	I 46
30	—	30,0	— 8,0	14	— 0,57	I 43	I 45
1772.							
Jan. 13	—	38,0	— 6,9	22	— 0,31	I 43	I 46
Feb. 4	—	44,9	— 9,5	11	— 0,86	I 44	I 46
15	—	54,0	— 8,9	17	— 0,52	I 42	I 44
Mar. 3	—	1 2,9	— 2,8	32	— 0,09	I 42	I 44
April 4	—	1 5,7	+ 2,0	9	+ 0,22	I 42	I 44
13	—	1 3,7	+ 48,3	19	+ 2,54	I 38	I 40
May 2	—	15,4	+ 42,8	11	+ 3,89	I 43	I 45
13	+	27,4	+ 43,8	10	+ 4,38	I 42	I 44
23	+	1 11,2	+ 41,8	9	+ 4,66	I 42	I 44
June 1	+	1 53,0	+ 61,1	14	+ 5,08	I 43	I 45
15	+	2 54,1	+ 54,8	18	+ 6,38	I 43	I 45
July 3	+	4 48,9	+ 50,5	7	+ 7,21	I 43	I 45
10	+	5 39,4	+ 81,1	11	+ 7,37	I 43	I 45
21	+	7 0,5	+ 78,3	10	+ 7,83	I 43	I 45
31	+	8 18,8	+ 58,1	8	+ 7,26	I 48	I 50
Aug. 8	+	9 16,9	+ 60,0	9	+ 6,44	I 47	I 49
17	+	10 16,9	+ 72,9	11	+ 6,63	I 47	I 49
28	+	11 29,8	+ 52,8	10	+ 5,28	I 44	I 47
Sept. 7	+	12 22,6	+ 31,3	8	+ 3,91	I 46	I 48
15	+	12 53,9	+ 22,0	6	+ 3,33		
21	+	13 15,9	+ 37,1	10	+ 3,71	I 48	I 50
Oct. 1	+	13 53,0	+ 27,6	9	+ 3,06		
10	+	14 20,6	+ 20,0	9	+ 2,22		
19	+	14 40,6	+ 32,4	14	+ 2,31	I 44	I 48
Nov. 2	+	15 13,0					

I have

I have this year kept a register of the Thermometer and Barometer ; the highest and lowest state of which, as I observed them in each month, I will here subjoin. I do not find that they have any reference to the rate of the clock ; but they may serve for comparison with other places. The Thermometer A was made by Mr. Nairne ; and hangs without doors, near a window, up one pair of stairs, on the North side of my house ; with a skreen to keep off the morning sun in summer, but no building near it. The three first columns shew its state at eight o'clock in the morning, two in the afternoon, and eleven at night. The fourth column gives the Thermometer B, in the observatory, near the face of the clock, at nine in the morning. The fifth shews the Barometer ; which being portable, I cannot be certain that its scale is exactly placed ; though I believe it is right. It is kept in a room on the ground floor.

		Thermometer A.			B.	Baro-
1771.		H. 8. Mat.	H. 2. P. M.	H. 11. P. M.	H. 9. Mat.	meter.
Dec.	Highest	52	50	53	52	30,05
	Lowest	34	35	33	36	28,58
1772.						
Jan.	Highest	49	52	49	50	30,09
	Lowest	22	30	21	29	28,63
Feb.	Highest	50	47	48	50	29,92
	Lowest	25	32	24	32	28,79
Mar.	Highest	51	56	46	50	29,78
	Lowest	27,5	31	27	30	28,79
April	Highest	51	59	50	52	30,04
	Lowest	31	38	31	36	29,19
May	Highest	63	70	53	58	30,20
	Lowest	42	47	33	44	29,35
June	Highest	73	82	68	73	30,12
	Lowest	53	57	49	56	29,50
July	Highest	70	76,5	63	68	30,10
	Lowest	55	61	49,5	58	29,16
Aug.	Highest	73	75	67	70	30,08
	Lowest	52	62	50	60	29,23
Sept.	Highest	66	72	66,5	70	29,96
	Lowest	48	58	46	45	28,82
Oct.	Highest	60	66	59	62	30,11
	Lowest	44	52	43	51	28,88

### Eclipse of the Sun, ☉ October 25, 1772.

App.time.		
h	'	"
20	31	12
		The first impression that I perceived. But I had looked for it on the Western instead of the Eastern edge, owing to a mistake in the Almanac; so that the Eclipse was now about its greatest obscuration. A remarkable protuberance on that part of the Moon's limb.
20	36	34
		End of the Eclipse. Observed with a $3\frac{1}{2}$ feet Achromatic Telescope, magnifying 150 times.



Eclipses of Jupiter's satellites. Observed with the same telescope, magnifying 100 times.

1772.	App. time.			
	h	'	"	
♂ July 11.	11	22	34	First sat. im. Good.
♂ 27.	9	38	2	First sat. im. Vapours.
♂ 29.	10	29	59	Second sat. im. Cloudy and doubtful.
♂ Aug. 3.	11	32	48	First sat. im. Good.
♂ 22.	9	38	35	Third sat. em. Hazy.
♂ 23.	10	35	19	Second sat. em. Doubtful. Flying clouds.
♀ 28.	8	28	14	First sat. em. Very doubtful.
♂ Sept. 27.	10	53	35	First sat. em. Doubtful.
♂ Oct. 4.	9	57	14	Third sat. em. Good.
	12	50	41	First sat. em. Good.
♂ 13.	9	17	13.5	First sat. em. Good.
♂ 20.	11	14	32	First sat. em. Doubtful.

Occultations of Jupiter's satellites, and transits over his disc, and conjunctions of the satellites, and appearances of his belts. Observed with the same telescope, magnifying 150 times.

1772.	App. time.			
	h	'	"	
♀ Aug. 7.	10	44	40	Second sat. on the limb of ♃, in its egress from his disc.
♂ 11.	10	55	50	First sat. in contact with ♃'s limb.
	11	1	40	——— Total ingress on the disc. The shadow precedes the sat. but very little.
♂ 12.	9	30	0	Appearance of ♃'s belts, as in Tab. III. Fig. I.
	10	45	0	Southern belt completed.
♂ 13.	10	15	0	Appearance of ♃'s belts, as in Fig. II.
♀ 21.	9	13	8	Conjunction of first and second sat.
♂ 29.	9	2	0	Third sat. seemingly in contact with the limb.
	9	13	0	——— Occult.
♂ 30.	9	45	0	Second sat. partly covered by the limb.
	9	48	40	——— Occult.

1772.	App. time.	
	h / "	
D Sept. 7.	9 38 0	Appearance of $\mathcal{U}$ , with the shadow of the fourth fat. central. The fat. itself not visible. Fig. III.
	11 10 0	The Southern belt equally advanced with the shadow.
b 12.	8 39 20	Appearance of $\mathcal{U}$ , and shadow of the first fat. central, Fig. IV. The shadow much smaller than that of the fourth.
	9 24 30	Southern belt advanced half way.
	9 29 0	Sat. now off the disc, and shadow still on; about equidistant from the limb.
	9 40 46	Shadow going off, in contact with the limb.
3 15.	7 27 0	Appearance of $\mathcal{U}$ , as in Fig. V.
	8 22 20	Southern belt complete, and dark spot ( $\omega$ ) in the large belt, central.
	8 27 20	Second fat. on the limb.
	8 30 20	———— Total ingress on the disc.
	10 41 0	Shadow advanced about $\frac{1}{3}$ on the disc: not very visible: preceded by another dark round spot, smaller; I know not what. Fig. VI.
2 16.	8 36 0	Shadow of the third fat. about its own diameter from $\mathcal{U}$ 's limb. Well defined.
	9 19 0	Third fat. quite off the disc. The shadow was then advanced about $\frac{1}{3}$ .
	9 33 0	Southern belt reduced to about $\frac{1}{3}$ . The shadow advanced about $\frac{2}{3}$ . Fig. VII.
	9 49 0	Shadow central.
	11 2 30	Shadow advanced about $\frac{4}{5}$ . Southern belt then scarce visible on the East side.
	11 35 0	Shadow either gone off, or not visible on the limb. Southern belt now come on $\frac{1}{4}$ or more. Vide Fig. VIII.
b 15.	8 43 30	First fat. seemingly in contact with $\mathcal{U}$ 's limb.
	8 52 0	———— Total ingress.
	9 7 40	Conjunction of second and third fat.
	9 32 0	Shadow of first fat. half entered.
	9 35 30	———— totally entered.
	10 58 0	———— advanced about $\frac{2}{3}$ .
	1 1 0	First fat. on the limb.
	11 4 30	———— external contact. Vide Fig. IX. Shadow very small, but well defined.



1772.	App. time.			
	h	'	"	
☉ Sept. 27.	7	37	30	First sat. in contact.
		7	42 0	——— occult.
♃ Oct. 1.	8	9	26	Conjunction of third and fourth sat.
		8	14 45	Second sat. in contact.
		8	20 0 ::	——— occult.
☉	4	9	27 40	First sat. in contact.
		9	32 30	——— occult.
♂	5.	8	29 45	First sat. in contact, just gone off the limb. The shadow at that time about $\frac{2}{3}$ .
♂	20.	7	40 15	First sat. in contact.
		7	44 20	——— occult.

These last observations are not to be depended upon, within several seconds; and yet, if pursued regularly, might have their use. I was led into making them from what M. Messier transmitted to this Society, in a former paper, Vol. LIX. N° LXIV. Indeed the hint he there gave, concerning the superiority of achromatic telescopes above all others for these purposes, induced me to procure one from Mr. Dollond, of his last construction, with a triple object-glass; which, I believe, is excellent in its kind: at least, it has fully answered the highest expectation I had formed of them.

The drawings shew how Jupiter appeared to me at different times. The broad belt across the middle, I cannot tell what to make of; sometimes it appears as a combination of several smaller ones; but usually clouded, or waved, in the middle, with its edges in general darkest; perhaps from their opposition to the contiguous parts, which are always much brighter than the rest of the planet. There have been two places in that belt particularly dark (especially that

marked  $\alpha$ , Fig. V.), which I have seen latterly, whenever that side of  $\gamma$  has been turned towards us; though I did not perceive them August 12, when I took Fig. I. The Northern belt, I believe, is continued uniformly round the planet; the Southern one reaches little above half way. They are both of them darker, I think, than the general complexion of the largest. There is beyond each of these, a light part, not equally bright with those zones near the middle; and from thence a gradual shading off to the poles themselves; particularly to the North. The drawings are, as the objects appear in an astronomical telescope, and therefore inverted.

Chislehurst,  
November 10, 1772.

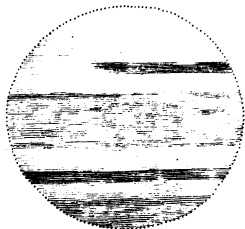
Francis Wollaston.

THE Astronomer Royal, who was present at the reading of this paper, expressed a wish that a particular account of the mechanism of the clock itself, might accompany the register of its going; as no consideration ought to be omitted which might serve to elucidate these matters.

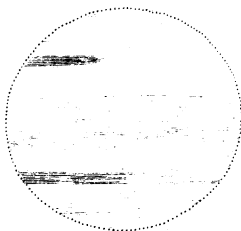
My clock is in general of the plain kind, moving in brass pivot-holes, beating dead seconds, with the common steel paletts; but of good workmanship, as being made by Mr. Holmes. The rod of the pendulum is of deal, as mentioned in a former paper; to which the ball itself (weighing about fourteen pounds) is screwed fast, there being a smaller weight underneath for a regulator. Its suspension is somewhat particular. The spring A is not hung in a slit as is usual; but is fastened to a transverse piece B, on which it rests upon the sides of the cock. The shoulders of this piece confine the pendulum from any lateral motion, as much as it would be in a slit; but it is at full liberty to hang perpendicularly under its point of suspension, without any strain on either edge of the spring above the other. The crutch is also of an unusual make. The bottom of the stem, instead of receiving the crutch-pin, is turned sideways; at right angles to itself, but parallel to the back-plate. This piece D reaches about an inch, and at the end has a smooth steady joint E (known to the workmen by the name of a socket and stud), whose axis lies horizontal. From that joint there is a return F, of equal length with the former piece; at the end of which is the crutch-pin G, nearly coinciding with the end of the stem.

This return together with the crutch-pin, if the pendulum were removed, would fall down as represented by the dotted lines *f*, *g*. The design of this mechanism is that any friction at the crutch-pin, which in the common construction is a small sliding up and down at every oscillation, is hereby converted into a smaller circular motion in a smooth pivot-hole. Both these, I understand, are contrivances of the late Mr. Henry Hindley of York: and may be seen in the regulator at Mr. Holmes's in the Strand, which is constructed in the same manner. The cock is fastened to the back-plate of the clock itself; but the clock-case is made stronger than usual, and is firmly screwed to the wall, independent on the floor.

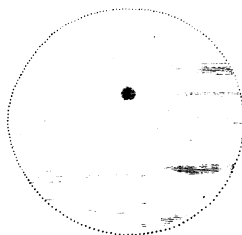
Fig. I.  
Aug. 12. 1772  
h. 9. 30. 0.



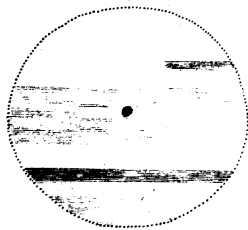
II.  
Aug. 13  
h. 10. 15. 0.



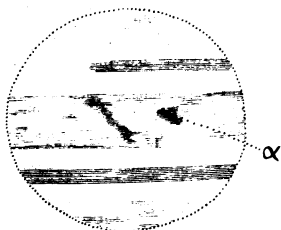
III.  
Sept. 7. h. 9. 38. 0.  
Shadow of 4<sup>th</sup> Sat.



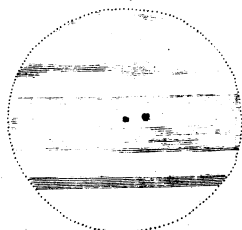
IV.  
Sept. 12. h. 8. 39. 20  
Shadow of 1<sup>st</sup> Sat.



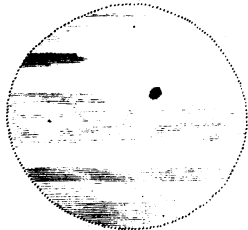
V.  
Sept. 15. h. 7. 27. 0.



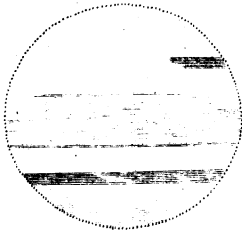
VI.  
Sept. 15. h. 10. 41. 20  
Shadow of 2<sup>d</sup> Sat.



VII.  
Sept. 16. h. 9. 33. 0  
Shadow of 3<sup>d</sup> Sat.



VIII.  
Sept. 16. h. 11. 35. 0.



IX.  
Sept. 19. h. 11. 4. 30  
1<sup>st</sup> Sat. & its Shadow.



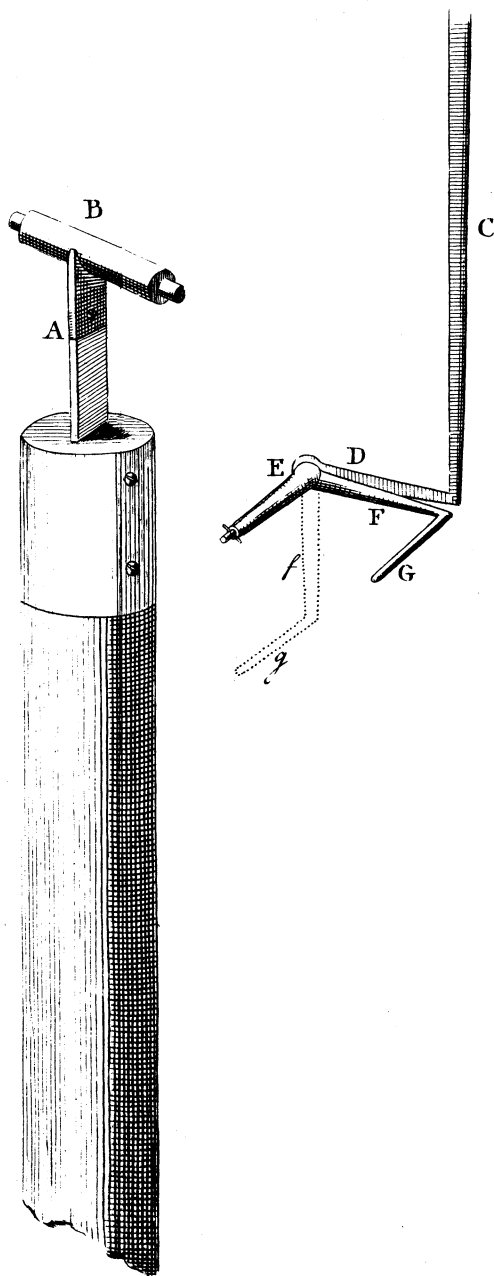


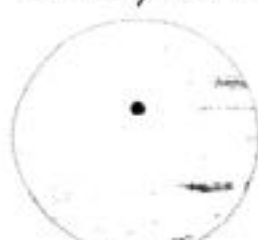
Fig. I.  
Aug. 12. 1772  
h. 9. 30. 0.



II.  
Aug. 13  
h. 10. 16. 0.



III.  
Sept. 7. h. 9. 38. 0.  
Shadow of 4<sup>th</sup> Sat.



IV.  
Sept. 12. h. 8. 39. 20  
Shadow of 1<sup>st</sup> Sat.



V.  
Sept. 15. h. 7. 27. 0.



VI.  
Sept. 15. h. 10. 41. 20  
Shadow of 2<sup>d</sup> Sat.



VII.  
Sept. 16. h. 9. 33. 0  
Shadow of 3<sup>d</sup> Sat.



VIII.  
Sept. 16. h. 11. 35. 0



IX.  
Sept. 19. h. 11. 4. 30  
1<sup>st</sup> Sat. & its Shadow.

