

Received November 14, 1771.

LI. *An Account of the going of an Astronomical Clock : By the Rev. Francis Wollaston, F. R. S.*

Read Dec. 19, ^{1771.} **H**AVING heard it often lamented, that very few registers of the going of clocks have been communicated to the public; I take the liberty to lay before the Society such observations as I have made to ascertain mine; and shall be happy if my amusements can in any way be of the least service to any one.

My clock was made by Holmes. The pendulum rod is of deal, to which the ball is screwed fast; and it is adjusted by a smaller weight underneath. The clock beats dead seconds; and is fastened to a principal wall, independent of the floor. The room never has a fire in it.

The transit telescope, with which I made the observations, has an achromatic object glass, of only 14 inches focal length, and magnifies about 15 times; its transverse axis is but 12 inches long, and it is mounted on a vertical axis of 18; being designed for an equal altitude instrument likewise, and so used
I in

in some of the following observations. It is fastened to a large stone pillar, bedded on the wall of the house; and is adjusted in the meridian, to a mark 700 feet distant. I mention these particulars, because the observations shew that even so small an instrument is capable of tolerable exactness: and it is for that reason I have set down the result of all the transits I have taken for a year past; though much fewer would have sufficed for shewing the rate of the clock. The observations themselves are not here; because I would not trouble the Society with such a detail; else they should readily have had them. It can be of no service to falsify calculations, which might have been withheld; and I believe to the best of my abilities, these are done accurately. I am sure they are delivered faithfully.

The 1st and 2d columns require no explanation.

The third shews how much the clock proved to be + or too fast, — or too slow, for mean solar time upon each observation, when it came to be calculated afterwards. The marks :: or : are set down as any one appeared to me to be more or less doubtful at the time of observing. The calculations will shew which are really most to be suspected.

The fourth column shews how much the clock varied per day, when compared with the preceding observation of the same object. The small variations in these, are owing probably to errors in observing, rather than to the clock itself. I do not pretend in observing to distinguish nearer than to half a second; though the calculations are set down in decimals.

In the middle of February, when the first change was, the frost was intense; and the pendulum did not, for some days, throw-out so far by about 7' as it generally did; which was about $1^{\circ} 37'$ on one side, and $1^{\circ} 40'$ on the other. At the change in August, I observed no difference. It appears by these trials as if the clock gained in warm and lost in cooler weather: but this is not clear. It began to gain before the weather grew warm. Whether this be owing to damp, or any other causes; longer experience and abler observers may discover.

1770		Clock + too fast - too slow	Varies from mean time per day	1771		Clock + too fast - too slow	Varies pr.day
		' "	"			' "	"
♃	Nov. 1	♁ Pegafi	Cl. + 0,5	♃	Jan. 10	Rigel	Cl. -1 43,7 -2,2
		♁ Andromedæ	+ 0,5	♀	11	♁ Andromedæ	-1 44,2 -0,5
♀	2	♁ pr. eq. Alt. & Tr.	- 2,6	♁	13	♃ Pleiadum	-1 42,3 -0,8
♁	4	Fomalhaut	- 2,7	♂	22	Rigel	-1 54,9 -1,0
		♁ Pegafi	- 1,8 -0,8	♀	25	Rigel	-2 0,7 -1,9
♂	13	♁	-13,4 -1,0	♁	27	♁ Andromedæ	-2 1,3 -1,2
		♁ Pegafi	-10,0 -0,9	♀ Feb. 1		Rigel	-2 9,7 -1,3
		♁ Andromedæ	-10,5 -0,9	♁	3	♁ per equal Alt.	-2 12, :
♃	17	♁	-18,0 -1,1	♃	4	♁	-2 13,3 -1,3
		♁ Pegafi	-16,9 -1,7	♂	5	♁	-2 15,5 -2,2
		♁ Andromedæ	-16,9 -1,6	♃	7	♃ Pleiadum	-2 16,1 -1,3
♂	20	♁	-21,5 -1,2			Rigel	-2 17,5 -1,9
		♁ Pegafi	-19,6 -1,0	♃	7	Sirius	-2 19,3 :
		♁ Andromedæ	-21,2 -1,8	♃	11	♁	-2 17,0 -0,5
♃	24	♁ Pegafi	-22,5	♂	12	♁	-2 15,5 +1,5
		♁ Pegafi	-21,5 -0,5	♀	13	Sirius	-2 16,4 +0,5
♃	26	♁	-23,9	♃	14	♁	-2 15,1 +0,2
♂	27	♃ Ceti	-24,4			Rigel	-2 15,4 +0,2
♀	28	♁	-25,6 -0,5			Sirius	-2 16,6 -0,2
		♁	-25,7 -0,9	♁	17	Sirius	-2 14, +0,8
♁ Dec. 16		♁ Andromedæ	-5,1	♃	23	Rigel	-2 13,4 +0,2
♃	22	Fomalhaut	-1 6,4 -1,3	♃ Mar. 9		♁ Castor	-2 5,2
		♁ Pegafi	-1 6,3 -1,6			Procyon	-2 5,5 +1,7
♁	23	♁ Pegafi	-1 7,4 -1,1	♁	10	♁ Castor	-2 3,5 +1,2
		♁ Andromedæ	-1 6,3			Procyon	-2 4,3 +2,0
♂	25	♁ Ceti	-1 14,0	♃	11	Procyon	-2 2,3
♃	27	Rigel	-1 16,3	♀	13	♁ Orionis	-2 0,4 +1,1
		♃ Orionis	-1 15,9			♁ Castor	-2 0,2 +0,5
		♂ Orionis	-1 17,3			Procyon	-2 1,3 +0,4
		♁ Orionis	-1 17,0	♀	15	♁ Orionis	-1 59,6 +0,5
♁	30	♁ Andromedæ	-1 22,2			Sirius	-2 0,1 +0,5
		♁ Andromedæ	-1 22,0			Procyon	-2 0,5 +0,5
1771				♃	23	Sirius	-1 56,1 +0,5
♁ Jan. 6		♁ Andromedæ	-1 37,5 -2,1			Procyon	-1 56,3
		♃ Andromedæ	-1 37,5 -2,2	♁	24	♁ Hydræ	-1 55,6 +0,6
♂	8	♁ Andromedæ	-1 40,5 -2,0	♀	27	♁ per equal Alt.	-1 51,8 +1,4
		♁ Andromedæ	-1 39,3 -0,8	♃	28	♁ Hydræ	-1 50,1 +1,0
		Rigel	-1 40,4 -2,0	♃	30	♁ pr. eq. Alt. & Tr.	-1 48,8 +0,8
♀	9	♁	-1 43,3			Sirius	-1 49,8 +0,3
		♁ Andromedæ	-1 40,1 -0,8	♃ Apr. 1		♁	-1 48,2 +0,4
		♃ Andromedæ	-1 40,8 -1,1			Sirius	-1 49,4 ±0,0
		♁ Medusæ	-1 41, :	♂	2	♁	-1 48,2 +1,4
		Rigel	-1 41,5 -1,1			Sirius	-1 48,0
♃	10	♃ Andromedæ	-1 41,9 -1,1				

1771		Clock + too fast - too flow	Varies from mean time per day	1771		Clock + too fast - too flow	Varies pr.day
	"	"	"		"	"	"
♂ Apr. 2	Procyon	Cl. - 1	48,4	+ 0,8	♂ June 20	α Coronæ	Cl. + 38,4
	α Hydræ	- 1	48,3	+ 0,4	♀ 21	⊙ Coronæ	+ 39,7
♀ 3	⊙	- 1	47	+ 1,2	♀ 21	α Coronæ	+ 39,3
♀ 5	⊙	- 1	45,3	+ 0,9	♀ 21	Antares	+ 39,3
♂ 8	⊙	- 1	43,7	+ 0,5	♂ 22	⊙	+ 40,6
	Sirius	- 1	43,5	+ 0,7	♂ 25	⊙	+ 45,4
	Procyon	- 1	44,3	+ 0,7	♂ 25	Antares	+ 45,5
♂ 9	⊙	- 1	41,7	+ 2,0	♂ 25	α Ophiuchi	+ 46
	Sirius	- 1	42,4	+ 1,1	♂ 27	⊙	+ 47,75
	Procyon	- 1	42,4	+ 1,9	♂ 29	⊙	+ 51,2
♂ 11	⊙	- 1	38,5	+ 1,6		Arcturus	+ 51,0
	Sirius	- 1	39,5	+ 1,4		Antares	+ 51,6
♂ 13	⊙	- 1	37,5	+ 0,5	♂ July 2	⊙	+ 56,8
	α Hydræ	- 1	37,5	+ 1,0	♀ 3	Antares	+ 58,7
♀ 17	⊙	- 1	30,0	+ 1,9	♀ 5	⊙	+ 1 0,2
♀ 19	Regulus	- 1	26,4		♀ 5	α Ophiuchi	+ 1 30,9
♂ 20	⊙	- 1	25	+ 1,7	♂ 22	α Ophiuchi	+ 1 32,8
♂ 25	β Ω	- 1	19,4		♂ 23	β Lyræ	+ 1 34,3
♂ 27	⊙ per eq. Alt. & Tr.	- 1	16,2	+ 1,3	♂ 24	⊙	+ 1 35,1
⊙ May 5	β Ω	- 1	59,5	+ 2,0	♂ 27	⊙	+ 1 40,8
⊙ 12	β Ω	- 1	47,6	+ 1,7	♂ 29	α Lyræ	+ 1 47,7
⊙ 13	β Ω	- 1	45,4	+ 2,2	♂ Aug. 1	⊙	+ 1 52,0
♂ 16	β Ω	- 1	42,4	+ 1,0	♂ 3	α Aquilæ	+ 1 58,1
	Spica ♃	- 1	40,9		⊙ 4	α Lyræ	+ 1 59,2
♂ 18	Spica ♃	- 1	38,6	+ 1,2	♂ 4	α Aquilæ	+ 1 59
⊙ 19	Spica ♃	- 1	36,2	+ 2,4	♂ 5	⊙	+ 2 0,3
♂ 21	⊙	- 1	34,0	+ 1,8	♂ 6	α Lyræ	+ 2 1,1
	Spica ♃	- 1	33,4	+ 1,4	♂ 6	α Lyræ	+ 2 3,0
♀ 24	⊙	- 1	27,8	+ 2,0	♀ 7	⊙	+ 2 3,9
♂ 27	Spica ♃	- 1	19,8	+ 2,3	♂ 8	α Lyræ	+ 2 6,9
	Arcturus	- 1	20,9		♀ 9	⊙	+ 2 7,2
	β ♃	- 1	19,6		♂ 10	⊙	+ 2 9,0
♂ 28	Arcturus	- 1	18,3	+ 2,6	♂ 10	α Lyræ	+ 2 9,7
♀ 29	⊙	- 1	15,4	+ 2,5	♂ 15	⊙	+ 2 18,9
♂ June 1	Spica ♃	- 1	5,5	+ 2,9	♀ 16	α Aquilæ	+ 2 20,9
⊙ 2	Arcturus	- 1	3,2	+ 3,0	♂ 17	⊙	+ 2 20,3
	γ Bootis	- 1	3,0		♂ 17	α Lyræ	+ 2 21,3
♀ 5	⊙	+ 1	5,3	+ 2,9	♂ 17	α Aquilæ	+ 2 21,8
♂ 8	⊙	+ 1	13,2	+ 2,6	♂ 26	⊙	+ 2 26,1
	Spica ♃	+ 1	14,1	+ 2,8	♂ 27	⊙	+ 2 25,5
♂ 10	⊙	+ 1	18,0	+ 2,4	♂ 27	α Lyræ	+ 2 26,4
♂ 18	⊙	+ 1	35,0	+ 2,1	♂ 29	α Aquilæ	+ 2 25,7
	Antares	+ 1	36,1		♀ 30	⊙	+ 2 26,1

1771		Clock + too fast - too slow	Varies from mean time per day	1771		Clock + too fast - too slow	Varies pr.day
		' "	"			' "	"
♀ Aug. 30	δ ♀	Cl. +2	24,7	♂ Oct. 1	α ♀ 2	Cl. +2	10,7 -0,7
♃ 31	⊙	+2	24,3	♃ 2	⊙	+2	10,3 -0,8
♃ Sept. 9	α Aquilæ	:: +2	27		α Lyræ	+2	11,6 -0,5
	β Aquilæ	+2	25,5		α Aquilæ	+2	11,6 -0,6
	α ♀ 2	+2	25,5	♀ 4	⊙	+2	11,3 +0,5
	β ♀	+2	25,6		α Aquilæ	+2	11,4 -0,1
♂ 10	α ♀ 2	+2	25,4		Fomalhaut	+2	10,9 -0,4
	β ♀	+2	25,5	♃ 5	⊙ pr.equal Alt.	+2	10,9 -0,4
♃ 12	⊙	+2	25,0	♃ 10	⊙	+2	7,4 -0,7
♃ 14	⊙	:: +2	22,6		γ Aquilæ	+2	7,5 -0,5
	α Lyræ	: +2	22,8		α Aquilæ	+2	7,4 -0,7
	γ Aquilæ	: +2	22,9	♀ 11	⊙	+2	6,6 -0,8
⊙ 15	⊙ Equal Alt.	:: +2	20,4		γ Aquilæ	+2	6,6 -0,9
	α Aquilæ	+2	22,4		α Aquilæ	+2	6,8 -0,6
♃ 16	β ☿	+2	21,5	♃ 12	⊙	: +2	6,7 +0,1
	γ ♀	+2	21,1		γ Aquilæ	+2	6,3 -0,3
	Fomalhaut	+2	21,5		α Aquilæ	+2	6,4 -0,4
♂ 17	⊙ per Transit per equal Alt.	+2	20,9	♃ 14	γ Aquilæ	+2	4,6 -0,9
		+2	20,5		α Aquilæ	+2	4,3 -1,0
♃ 18	β ♀	+2	19,8		γ ♀	+2	4,6 -0,5
♃ 19	⊙ pr.eq. Alt. & Tr.	+2	19,0	♂ 15	γ ☿	+2	3,4
	γ Aquilæ	+2	18,4	♃ 16	⊙	+2	2,4 -1,0
	α Aquilæ	+2	18,7		α Lyræ	+2	2,1 -0,7
	β ♀	+2	18,7	♀ 18	⊙	: +1	59,9 -1,2
♀ 20	α Lyræ	+2	17,9	♃ 21	⊙	+1	55,3 -1,5
	α Aquilæ	+2	18,1	♀ 25	⊙	+1	47,5 -1,1
♃ 21	⊙	: +2	16,1	♃ 26	⊙	+1	46,4 -1,9
	γ Aquilæ	+2	16,3		γ Aquilæ	+1	46,5 -1,5
	α Aquilæ	+2	17,0		α Aquilæ	+1	46,7 -1,5
♃ 25	β ☿	+2	13,7	♂ 29	⊙	: +1	40,4 -2,0
	γ ♀	+2	14,1	♃ 30	γ Aquilæ	+1	39,1 -1,8
♀ 27	⊙	+2	12,0		α Aquilæ	+1	39,3 -1,8
♃ 28	⊙	+2	11,9	♃ 31	β Pegasi	+1	38,1
♃ 30	γ Pegasi	+2	11,6				
♃ Oct. 1	⊙	+2	11,1				

From these Observations it appears that the rate of the clock was as follows.

1770	Clock + too fast - too slow	Grain or Lofs	Numb. of Days	Rate per Day
	' "	"		"
Nov. 1	+ 0,5	-17,4	16	-1,1
17	- 16,9	- 8,8	11	-0,8
28	- 25,7	-40,7	24	-1,7
Dec. 22	- 1 6,4	-15,6	8	-1,9
30	- 1 22,0			
1771				
Jan. 13	- 1 45,6	-23,6	14	-1,7
Feb. 1	- 2 9,7	-24,1	19	-1,3
14	- 2 15,4	- 5,7	13	-0,4
March 9	- 2 5,5	+10,1	23	+0,4
15	- 2 0,0	+ 5,5	6	+0,9
April 1	- 1 49,4	+10,6	17	+0,6
13	- 1 37,5	+11,9	12	+1,0
May 5	- 59,5	+38,0	22	+1,7
18	- 38,6	+20,9	13	+1,6
June 1	- 5,5	+33,1	14	+2,4
18	+ 36,1	+41,6	17	+2,4
July 3	+ 58,7	+22,6	15	+1,5
21	+ 1 30,9	+32,2	18	+1,8
Aug. 3	+ 1 57,1	+26,2	13	+2,0
16	+ 2 20,9	+ 3,8	14	+0,3
30	+ 2 24,7	- 2,3	16	-0,1
Sept. 15	+ 2 22,4	-11,7	16	-0,7
Oct. 1	+ 2 10,7	- 7,3	14	-0,5
15	+ 2 3,4	-25,3	16	-1,6
31	+ 1 38,1			

I will here add a few other observations I have made since I settled in this place, the lat. of which is $51^{\circ} 24' 33''$ North, and the long. is $18,^{\circ} 5$ in time, East of the Observatory at Greenwich.

Ocultations of stars by the Moon.

1770		App. time	
Apr. 7	e Ω	Imm. 11 29 25	observed with a 12 inch reflector.
28	ζ 8	Imm. 9 51 56;	windy and doubtful; same telec.

- 1771
 ♄ June 18 The Moon's lower limb just covers a small star. The imm. on the dark part, to which the star seemed to adhere above two minutes; and, though not at all discoloured, lost a little of its brightness, but disappeared at last instantaneously, Apparent time 10 1 49
 The Em. on the light part and doubtful 10 10 46
 Observed with a $3\frac{1}{2}$ feet achrom. magnifying 100 times.
- ♄ July 23 2^h 4^m † I believe
 Imm. 10 41 36,5 certain $3\frac{1}{2}$ achrom. mag. 150
 Em. 11 43 27 :: doubtful
- ♃ Sept. 18 * ν Imm. 11 56 51 good } $3\frac{1}{2}$ achrom. mag. 150
 β ν Imm. 12 2 47 good }
 The emersions not till after the Mbon was set.

Eclipses of Jupiter's Satellites.

	1770	App. time		
♀	July 13	9 6 24	First Sat. Em.	12 In. Reflector mag. 55
♃	21	9 3 8::	Fourth Sat. Imm.	Ditto
		9 57 43::	Em.	
♁	Aug. 5	9 20 42	First Sat. Em.	Ditto
♁	28	9 43 3::	First Sat. Em. μ near δ	Ditto
♃	29	9 1 41	Second Sat. Em.	Ditto
	1771	App. time		
♃	July 22	8 46 20::	Second Sat. Em. cloudy	$3\frac{1}{2}$ Achrom. mag. 100
♃	Aug. 1	9 8 5::	Third Sat. Em. cloudy	$3\frac{1}{2}$ Achrom. mag. 100
		10 30 54::	First Sat. Em. cloudy	$3\frac{1}{2}$ Achrom. mag. 100
♃	17	8 51 9	First Sat. Em.	12 Inch Refl. mag. 35
♄	27	9 32 3	Fourth Sat. Imm. hazy	$3\frac{1}{2}$ Achrom. mag. 100
♀	30	11 3 20	Second Sat. Em.	Ditto
♃	Sept. 9	9 12 18	First Sat. Em.	Ditto
♃	16	11 11 15:	First Sat. Em. μ but $3^\circ 30'$ high	Ditto
♃	Oct. 2	9 35 56	First Sat. Em.	Ditto
♃	11	6 3 16	First Sat. Em.	Ditto
♃	26	6 14 25	Third Sat. Imm.	Ditto
		8 4 16	Second Sat. Em.	Ditto

Chiffchurst, Nov. 2,
 1771.

Francis Wollaston.