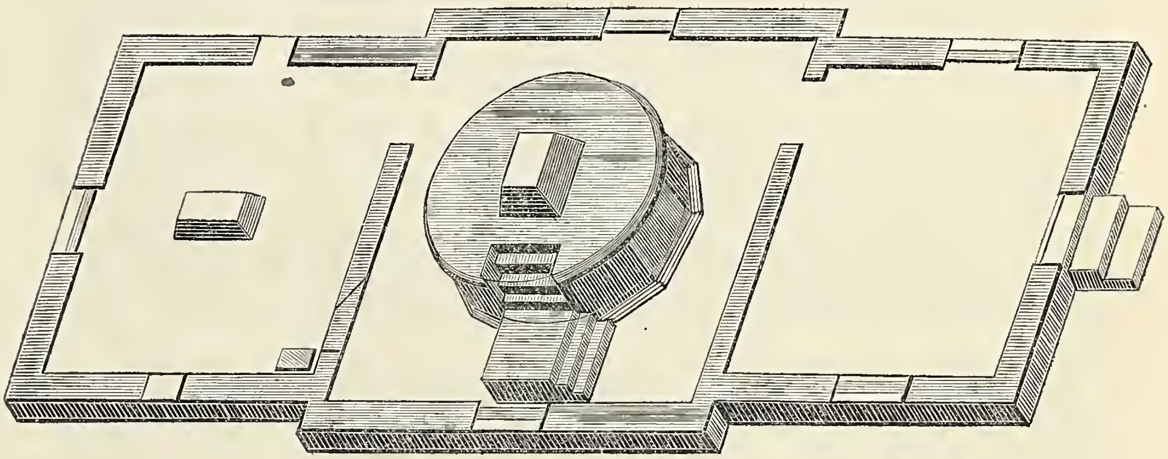
ARTICLE IV.

Astronomical Observations made at Hudson Observatory, Latitude 41° 14′ 37″ *North, and Longitude* 5*h.* 25*m.* 42*s. West; with some Account of the Building and Instruments. By Elias Loomis, Professor of Mathematics and Natural Philosophy in Western Reserve College, Hudson, Ohio. Read October* 4, 1839.

HUDSON OBSERVATORY comprises a central room and two wings. Externally, its entire length is thirty-seven feet, and the breadth of the centre sixteen feet. The foundations are of hewn sand-stone, and the walls, which are of



brick, are one foot in thickness. The transit room is represented upon the left hand in the annexed figure. It is ten feet by twelve upon the inside, and seven and a half feet high, having a flat roof covered with tin. In its centre is a pier of fine sand-stone. Its top is twenty-seven inches by thirteen, and rises twenty-four inches above the floor. It has a slope of one inch to the foot, and descends about six feet below the surface of the earth. It is entirely detached from the building, and the floor is no where in contact with it. The openings for the transit are fifteen inches wide; the side openings being closed by solid wooden shutters, and a single trap-door covers the entire top. This covering is such as effectually to exclude the most violent rain. The transit commands an unobstructed meridian from ninety degrees zenith distance on the south, to eighty-nine degrees on the north.

The central room of the observatory is occupied by the equatorial, and is fourteen feet square upon the inside. In its centre is raised a circular platform, ten feet in diameter and four feet high, upon whose circumference rest twelve small cherry columns, which help to sustain the dome. The dome is a hemisphere of nine feet internal diameter. It rests upon ten wheels of lignum vitæ, five inches in diameter, placed equidistant from each other, running in a grooved channel, and set in a wooden ring, consisting of five arcs, joined by hinges, to allow greater freedom of motion to the wheels. The dome has an opening fifteen inches wide, reaching from the base to eight inches past the zenith, closed by three doors, the top one closing last, and the joints being so secured as effectually to exclude the rain. The whole is covered with tin, and a single person can readily revolve it by hand. The top of the equatorial pin is twenty inches by thirty, and rises three feet six inches above the platform. Its slope is one inch to the foot, and it descends six feet below the surface of the ground. It is of the same material with the transit pier, and, like that, is also entirely detached from the building.

The right hand room in the above figure, which is the west room, contains no instruments, but is provided with a stove, and serves as a convenient ante-room.

The instruments of the observatory are a transit circle, an equatorial telescope, and a clock. The transit circle was made by Simms, of London, in 1837. It has a telescope of thirty inches focal length, with a very superior object glass, whose clear aperture is 2.7 inches. This is supported by broad cones, forming an axis of eighteen inches in length. The pivots are of steel, and rest on brass y's. It is supported by a heavy cast iron frame, which rests upon the pier, and is secured immoveably to it by stout screws entering brass sockets, which are leaded to the stone. In the focus of the telescope are five vertical equidistant spider lines, besides the micrometer, and they are crossed by five horizontal ones. There are three eye-pieces, one of them being a diagonal eye-piece, which I almost exclusively employ; and they may be slid back and forth so as to be brought opposite either of the vertical wires. The object end has a cap pierced with two apertures. The level for securing the horizontality of the axis is a *rider* of seventeen inches length, and is accompanied by a small bubble at right angles. My observations make the value of the division of the level 1″.278. I have two meridian marks, one to the north and the other to the south; the former distant about sixty rods, and the latter nearly a mile. The circle is eighteen inches diameter, with six radii, and is firmly connected with another of equal size, but not graduated, separated by an interval of three and a half inches, and between the two is the telescope. The graduation of the circle is on platina to five minutes; and there are three reading microscopes, each measuring single seconds. These microscopes are of the kind called Troughton's reading microscope, and are represented in Pearson's Practical Astronomy, Plate XI., Fig. 9. They are screwed upon a stout brass circle attached to the frame, and may be set to any part of the limb. Microscope A, which carries the pointer, I have set to indicate the polar point; microscope B at 120° north polar distance; and C at 240°. To the frame which sustains the microscopes is permanently attached a delicate spirit level, pointing north and south.

The equatorial telescope, made also by Simms, is five and a half feet focal length, with an object glass of 3.8 inches clear aperture. It has six celestial eye-pieces, with magnifying powers from 20 to 400; a terrestrial eye-piece; an eye-piece with five parallel spider lines, crossed by as many others at right angles; and a position micrometer, represented in Pearson, Plate XI., Figs. 1, 2, 3. A lamp, suspended from the side of the tube, illumines the field of view, when it is necessary to use the micrometer by night. The frame of the equatorial is of cast iron, secured immoveably to the pin by screws entering sockets leaded into the stone. It was made for the latitude of the observatory, and the polar axis admits but a slight motion in altitude and azimuth, by means of screws at its lower extremity. The right ascension circle is twelve inches diameter graduated to single minutes, and reads by two verniers to single seconds of time. A tangent screw, with a long handle, gives a slow motion, and enables an observer to keep an object readily in the field of view. The declination circle is also twelve inches in diameter, graduated to ten minutes, and reads by two verniers to ten seconds of arc.

The clock was made by Molineux, of London. It has a mercurial pendulum, the cistern for the mercury being of glass, and the cylinder is terminated by a steel point, which indicates the arc of vibration upon a fixed scale. It loses no time in winding, an operation which I perform every Monday morning. It is regulated to sidereal time, and its rate is tolerably uniform. It is suspended by a stout iron hook, which was inserted in the north wall of the transit room as the building was erecting, and which passes through the oak back of the clock case. It is rendered steady by two screws, which pass through the back of the case, near the bottom, and enter a timber inserted in the brick wall. The case does not touch the floor. An opening in the side wall, between the transit and equatorial rooms, allows the clock dial to be easily seen from the platform of the dome, and thus one clock is made to serve two instruments.

The instruments were first placed in the observatory, September 8th, 1838, and I at once applied myself diligently to their adjustment. Having verified the line of collimation of the transit and levelled the axis, the telescope was brought into the plane of the meridian approximately by high and low stars, and, subsequently, by repeated observations of Polaris, both above and below the pole. In noting the transits of Polaris, I do not attempt, by a single observation, to estimate the time when the star is bisected by a wire. The uncertainty of such an observation I have found to amount to several seconds. The star, in approaching a wire, appears to make an indentation upon it; and, also, itself suffers a partial eclipse. After passing the wire, the indentation appears upon the other side; and the deficiency, also, appears upon the other side of the star. When the light of the star is faint, as when the sun is several hours above the horizon, the star is entirely occulted for three or four seconds. At such times I note the instants of the star's disappearance, and of its reappearance; the mean I consider the instant of the star's passage over that wire. At other times I note the two instants when the star makes equal indentations upon the two sides of the wire, or suffers an equal loss of brilliancy, taking the mean of the two observations. For all transit observations, I take a second from the clock a short interval before the transit over the first wire, and preserve the counting by listening to the beats. Having recorded the observation for the first wire, I look again at the clock, and so on for each of the five wires. The equatorial intervals of the wires in their orders for stars above the pole were found to be 18*s*.456; 18*s*.419; 18*s*.180; 18*s*.374. The reduction to the central wire is, consequently, 0*s*.112 × secant of declination; positive above the pole, and negative below.

The pendulum of the clock, as it came from the maker, was found to be over-compensated. At three different times a portion of the mercury has been removed, namely: about two ounces, Nov. 30th, 1838; three ounces, Feb. 12th, 1839; and five ounces, March 5th, 1839. At each of these dates the rate of the clock was, of course, changed. I am of opinion that the pendulum is still over-compensated, though in a very slight degree. The column of mercury is now 6.3 inches high. Since March 5th the clock has not been stopped, nor the pendulum touched. The inequalities of the clock's rate, as shown in the accompanying list of moon-culminating stars, are to be ascribed to imperfect compensation; to a change in the adjustment of the pendulum; to errors of observation, the rate having commonly been determined from a small number of stars, and to other causes of a more uncertain character. Fortunately, from the nature of the observations, the results deduced from them cannot be greatly affected by the small uncertainty in the clock's rate.

I. *Latitude of Hudson Observatory.*

For the determination of my latitude, I have made repeated observations of the pole star, near the meridian, both directly and by reflection from the surface of mercury. The three microscopes were read at each observation; the observations were reduced to the meridian by the usual method, and corrected for refraction by Bessel's Tables. The mean latitude deduced from sixteen culminations, nine below, and seven above the pole, allowing each culmination a weight proportioned to the number of reflected observations, is 41° 14′ 33″.7. This is the mean of all the observations I have made, and supposes them all entitled to equal confidence, which is far from being the case. In the first observations the reflected image was quite indistinct, owing chiefly to the mercury being placed too near the telescope; and I have reason to believe that the latitude deduced from them is too small. In the later observations, the mercury was removed about thirty inches from the object-glass of the telescope, and the reflected observations were then found to accord quite as well as the direct observations. The direct and reflected observations were made alternately, from ten to sixteen at a culmination, and with the following result:

Upper culmination, August	8, ...	41° 14′ 39″·8
" "	10, ...	36 ·7
" "	13, ...	36 ·8
" "	14, ...	37 ·8
" "	15, ...	40 ·8
" "	17, ...	36 ·6
Mean of these six culminations,	. . . . .	41 14 38 ·1

The latitude deduced from the upper culmination of δ Ursae Minoris, August 13th, is 41° 14′ 35″.1; August 17th, 41° 14′ 36″.2. Mean latitude by δ Ursae Minoris, 41° 14′ 35″.7. Mean of observations on α ard δ Ursae Minoris, 41° 14′ 37″.5.

In order to determine the error of the readings of the microscopes, the following observations were made August 12th. The object was to ascertain if five revolutions of the micrometer exactly measure the interval between two divisions upon the limb. The numbers below give the excess of each microscope, for a reading of five minutes, for the north polar distances contained in the first column, being the points employed for the observations of Polaris.

North Polar Distance.	A.	B.	C.	Mean.
358° 25′—30′	— 1″·3	+ 1″·0	+ 2″·9	+ 0″·87
1 30 —35	— 1 ·7	+ 1 ·2	+ 4 ·7	+ 1 ·40
275 55 —60	— 1 ·9	— 0 ·2	+ 5 ·8	+ 1 ·23
279 0 — 5	— 1 .3	+ 0 .4	+ 3 ·8	+ 0 ·97

The numbers in the last column furnish the correction to be subtracted from the micrometer reading when this amounts to five minutes. A proportional part is to be taken for any other reading. This correction, although affecting the latitude by only a fraction of a second, has, nevertheless, been applied to all the observations. I assume, then, for the latitude of Hudson Observatory, 41° 14′ 37″, and think that future observations cannot vary much from this result.

II. *Observed Transits of the Moon and Moon Culminating Stars, at Hudson Observatory.*

It is hoped these observations may furnish the means of determining the longitude of the Observatory with some precision. At present I assume this element to be 5*h.* 25*m.* 42*s.* west from Greenwich. The table will sufficiently explain itself. The stars observed are generally those indicated by the Nautical Almanac. In only two or three instances is there a deviation from this rule.

No.	Date.	Star.	No. Wires Obs.	Meridian Transit.	Clock's Rate.
	1838.			*h. m. s.*	*s.*
	Sep. 27	φ Sagittarii	2	18 35 34·74	+ 0·03
		σ Sagittarii	5	18 45 15·95	
1		Moon 1 L.	5	19 20 5·99	
		h² Sagittarii	5	19 26 53·60	
	29	ψ Capricorni	5	20 36 33·25	— 0·20
		η Capricorni	5	20 55 13·76	
2		Moon 1 L.	5	21 22 25·82	
		γ Capricorni	5	21 31 10·00	
		δ Capricorni	5	21 38 9·00	
	Oct. 1	σ Aquarii	5	22 22 7·00	+ 2·67
		λ Aquarii	5	22 44 12.66	
3		Moon 1 L.	5	23 16 50.16	
		κ' Piscium	3	23 18 40·76	
	27	γ Capricorni	3	21 30 58·45	— 1·39
4		Moon 1 L.	5	21 54 46·82	
	Nov. 13	α Virginis	3	13 16 9·56	— 1·25
5		Moon 2 L.	5	13 18 47·02	
	29	ν Arietis	5	2 28 47·57	— 1·37
6		Moon 1 L.	5	3 2 39·41	
	1839.				
	Jan. 23	ε Arietis	5	2 49 12·20	+ 0·01
7		Moon 1 L.	5	3 17 55·05	
		η Tauri	5	3 37 7·79	
		A' Tauri	5	3 54 22·77	
	24	η Tauri	5	3 37 5·59	— 1·62
		A' Tauri	5	3 54 21·73	
8		Moon 1 L.	5	4 19 0·49	
		τ Tauri	5	4 31 45·87	
		ι Tauri	5	4 52 39·11	
9	Feb. 19	Moon 1 L.	5	3 0 21·26	— 1·23
		α Tauri	5	4 26 37·56	
	21	υ' Tauri	5	4 16 34·31	— 1·21
		τ Tauri	3	4 32 28·74	
10		Moon 1 L.	5	5 3 48·69	
		C Tauri	5	5 43 6·49	
	Mar. 22	κ Aurigæ	3	6 5 22·23	+ 0·34
11		Moon 1 L.	5	6 50 28·78	

No.	Date.	Star.	No. Wires Obs.	Meridian Transit.	Clock's Rate.
				h. m. s.	*s.*
		δ Geminorum	5	7 10 45·96	
		α² Geminorum	5	7 24 35·15	
	Mar. 23	δ Geminorum	5	7 10 45·94	— 0·21
		α² Geminorum	5	7 24 34·63	
12		Moon 1 L.	5	7 50 2·50	
		6 Cancri	5	7 53 53 22	
		θ Cancri	5	8 22 40·66	
	24	ε Hydræ	5	8 38 30·62	— 0·21
13		Moon 1 L.	5	8 45 14·78	
		ξ Cancri	4	9 0 22·08	
	25	ξ Cancri	5	9 0 21.33	— 0·48
		q Cancri	5	9 10 15·26	
14		Moon 1 L.	5	9 36 11·14	
		ν Leonis	5	9 49 49·24	
		η Leonis	5	9 58 48·74	
	27	l Leonis	5	10 41 3·16	— 0·01
15		Moon 1 L.	5	11 8 27·28	
		σ Leonis	5	11 13 5·82	
		υ Leonis	5	11 28 58·36	
16	Apr. 18	Moon 1 L.	5	6 26 54·31	— 0·68
		ε Geminorum	5	6 34 15·87	
17	19	Moon 1 L.	5	7 29 32·63	— 0·55
		β Geminorum	5	7 35 41·67	
		ε Leonis	5	9 36 57·41	
	20	β Geminorum	5	7 35 41·11	— 0·51
18		Moon 1 L.	5	8 27 19·67	
		δ Cancri	5	8 35 45·88	
		ξ Cancri	5	9 0 20·15	
	21	δ Cancri	4	8 35 45·34	— 0.61
		ξ Cancri	5	9 0 19·31	
19		Moon 1 L.	5	9 20 8·66	
		λ Leonis	5	9 22 45·27	
		ψ Leonis	5	9 35 11·24	
	23	γ Leonis	5	10 11 19·48	+ 0·04
20		Moon 1 L.	5	10 54 16·36	
	24	χ Leonis	5	10 56 56·72	+ 0·04

No.	Date.	Star.	No. Wires Obs.	Meridian Transit.	Clock's Rate.
	1839.			h. m. s.	s.
	Apr. 24	τ Leonis	5	11 19 53·58	
21		Moon 1 L.	5	11 37 53·84	
		β Virginis	5	11 42 32·96	
		ο Virginis	5	11 57 14·78	
	25	β Virginis	5	11 42 31·76	— 0·48
		ο Virginis	5	11 57 14·50	
22		Moon 1 L.	5	12 20 47·18	
		γ′ Virginis	5	12 33 44·80	
		ψ Virginis	5	12 46 13·48	
	26	γ′ Virginis	5	12 33 44·12	— 0·61
		ψ Virginis	5	12 46 12·94	
23		Moon 1 L.	5	13 4 3·50	
		α Virginis	5	13 16 57·24	
	27	α Virginis	4	13 16 56·72	— 0·52
24		Moon 1 L.	5	13 48 43·38	
		λ Virginis	5	14 10 38·28	
	May 3	φ Sagittarii	5	18 35 50·47	+ 0·04
		σ Sagittarii	5	18 45 31·39	
25		Moon 2 L.	5	19 14 6·81	
		h² Sagittarii	5	19 27 8·29	
26	5	Moon 2 L.	5	21 7 42·83	— 0·46
		β Aquarii	5	21 23 16·84	
		δ Capricorni	4	21 38 21·01	
	25	κ Virginis	5	13 41 22·46	+ 0·10
27		Moon 1 L.	5	14 19 27·16	
		α² Libræ	5	14 42 13·10	
	26	α² Libræ	3	14 42 13·71	+ 0·35
28		Moon 1 L.	3	15 8 32·69	
29	June 20	Moon 1 L.	4	13 16 41·23	+ 0·87
		α Virginis	2	13 17 5·08	
	22	λ Virginis	5	14 10 48·94	+ 0·84
30		Moon 1 L.	5	14 50 7·45	
		20 Libræ	5	14 55 3·59	
		ι Libræ	5	15 3 27·28	
	24	σ Scorpii	5	16 11 51·93	+ 0·84
		α Scorpii	5	16 19 58·45	
31		Moon 1 L.	5	16 36 21·31	
		A Ophiuchi	5	17 5 53·13	
	25	A Ophiuchi	5	17 5 55·37	+ 1·54
32		Moon 1 L.	5	17 34 13·33	
		p Sagittarii	5	17 37 54·31	
		γ² Sagittarii	5	17 55 55·61	
	29	ψ Capricorni	5	20 37 3·51	+ 0·61
		ο Capricorni	5	20 57 23·82	
33		Moon 2 L.	5	21 28 3·44	
		δ Capricorni	5	21 28 38·98	
		ι Aquarii	5	21 58 15·46	
	July 1	λ Aquarii	5	22 44 42·82	+ 0·84
34		Moon 2 L.	5	23 11 45·66	
		κ′ Piscium	2	23 19 10·63	
	4	β Arietis	5	1 46 15·96	+ 0·24
35		Moon 2 L.	4	1 47 49·96	
		α Arietis	5	1 58 37·07	
36	17	Moon 1 L.	5	12 58 52·92	+ 0·02
		α Virginis	5	13 17 19·76	
	18	α Virginis	5	13 17 18·66	— 0·84

No.	Date.	Star.	No. Wires Obs.	Meridian Transit.	Clock's Rate.
	1839.			h. m. s.	s.
37		Moon 1 L.	5	13 43 42·36	
38	July 19	Moon 1 L.	5	14 30 35·26	+ 0·24
		α² Libræ	5	14 42 33·60	
		20 Libræ	2	14 55 15·14	
	22	α Scorpii	5	16 20 9·07	+ 0·24
		τ Scorpii	5	16 26 29·01	
39		Moon 1 L.	5	17 10 29·87	
		θ Ophiuchi	5	17 12 44·63	
		p Sagittarii	5	17 38 3·15	
40	23	Moon 1 L.	5	18 9 40·99	+ 0·53
		λ Sagittarii	5	18 18 40·05	
		σ Sagittarii	4	18 45 55·56	
	24	λ Sagittarii	4	18 18 40·00	— 0·21
		σ Sagittarii	5	18 45 54·63	
41		Moon 1 L.	5	19 9 43·19	
		χ′ Sagittarii	5	19 16 6·67	
		h² Sagittarii	5	19 27 32·31	
	25	χ′ Sagittarii	5	19 16 6·91	+ 0·28
		h² Sagittarii	5	19 27 32·81	
42		Moon 1 L.	5	20 8 52·49	
		π Capricorni	5	20 18 44·26	
		ψ Capricorni	5	20 37 11·65	
	28	θ Aquarii	4	22 8 58·31	+ 0·25
		σ Aquarii	5	22 22 45·38	
43		Moon 2 L.	5	22 55 8·38	
		φ Aquarii	5	23 6 36·90	
		κ′ Piscium	4	23 19 18·32	
	31	δ Piscium	5	0 40 58·48	— 0·24
44		Moon 2 L.	5	1 31 10·60	
		ο Piscium	5	1 37 31·72	
		β Arietis	4	1 46 23·40	
45	Aug. 2	Moon 2 L.	5	3 26 48·49	— 0·17
		η Tauri	5	3 38 32·31	
	20	γ² Sagittarii	5	17 56 0·08	— 0·16
		δ Sagittarii	5	18 11 13·63	
46		Moon 1 L.	5	18 42 46·39	
		σ Sagittarii	5	18 45 49·07	
		τ Sagittarii	5	18 57 25·39	
	21	τ Sagittarii	5	18 57 24·96	— 0·43
47		Moon 1 L.	5	19 42 17·41	
		c Sagittarii	5	19 53 17·55	
		σ Capricorni	5	20 10 38·11	
	22	c Sagittarii	5	19 53 17·27	— 0·54
		σ Capricorni	5	20 10 37·30	
48		Moon 1 L.	5	20 40 31·75	
		η Capricorni	5	20 55 45·82	
		s Capricorni	5	21 7 21·50	
	23	η Capricorni	5	20 55 45·62	— 0·27
		s Capricorni	5	21 7 21·16	
49		Moon 1 L.	5	21 36 44·72	
		δ Capricorni	5	21 38 40·22	
		ι Aquarii	5	21 58 15·84	
	25	λ Aquarii	5	22 44 43·70	— 0·29
50		Moon 2 L.	5	23 26 8·32	
		λ Piscium	5	23 34 20·70	
		q Piscium	5	23 54 5·00	

III. *Observed Occultations of the Sun and Fixed Stars at Hudson Observatory.*

No.	Date.	Star.	Immersion. Sidereal Time.	Emersion. Sidereal Time.	Remarks.
	1838.		h. m. s.	h. m. s.	
1	Sep. 18	Sun	14 27 26·70		Good observation.
2	Nov. 13	α Virginis	11 3 51·66		Good observation.
	1839.				
3	Apr. 19	c Geminorum	9 7 17·37	10 15 28·57	Immersion good; Emersion 1*s*. or 2*s*. late.
4	" 20	γ Cancri	12 0 9·36	12 48 5·16	Immersion, good observation.
5	July 6	b Peiadum		22 55 1·34	
6	" 6	d "	22 31 9·34	23 21 11·83	
7	" 6	η Tauri	23 1 1·34		Uncertain.