XXXV. *Some Obſervations of the Planet* Venus, *on the Diſk of the Sun,* June 6*th,* 1761; *with a preceding Account of the Method taken for verifying the Time of that Phænomenon; and certain Reaſons for an Atmoſphere about* Venus: *By* Samuel Dunn.

Read Nov. 5, 1761.

AS ſoon as I heard, that ſeveral mathematicians were to go abroad, and obſerve the tranſit of Venus over the diſk of the ſun, from foreign parts, I purpoſed to obſerve the ſame at Chelſea, and to compare my obſervation with the more accurate ones, which I expected would be made at the Royal Obſervatory at Greenwich. Suppoſing, that if my obſervation at Chelſea was made with equal care, and as good inſtruments for aſcertaining time, as the inſtruments to be uſed by the obſervers abroad, it might be uſeful, as a kind of proof, how exact the obſervations had been made abroad, where the obſervers had leſs conveniencies for aſcertaining time, than at the Royal Obſervatory.

Mr. Dollond (a member of the Society) had, ſome time before, newly ground, and fitted up for me, a Newtonian reflecting teleſcope, ſix feet in length; which ſo far exceeded expectation, that by it the Reverend Mr. Maſkelyne (who is now at St. Helena) and myſelf, had ſeveral times obſerved how long Jupiter's ſatellites dwell on the limb of Jupiter, entering on the body. And I was provided with an eight-

eight-day clock, having a ſecond-hand, an iron pendulum, and an adjuſting ſcrew at its bob.

Altitude inſtruments of wood and braſs, adjuſted by ſpirit levels, had engaged my attention; but having found ſeveral of theſe defective, by comparing their reſults with meridian altitudes, and the time by the clock; and having many times examined the clock by double altitudes of the ſun, taken with a Hadley's quadrant, having a nonius to minutes, and an artificial horizon of ſweet oil in a tea-ſaucer, I determined to depend on ſuch an inſtrument and horizón, for aſcertaining the error of the clock, and correctneſs of my meridian.

An artificial horizon of water, and even of quickſilver, I had found to be too eaſily diſturbed, and therefore had, ſome time before, introduced oil, and found it vaſtly preferable. And in taking altitudes, I always obſerve, when the ſun, or other celeſtial body, is as near the prime vertical, or eaſt and weſt azimuth, as poſſible; and generally take either five double altitudes, half a minute of time aſunder each, or three double altitudes, a minute of time aſunder, dividing the ſum by either ten or ſix, as the caſe is, for a mean ſingle altitude, correſponding to the mean time of thoſe obſervations by the clock. And in taking the ſun's tranſit acroſs the meridian, I take a mean of the times of appulſe to ſeveral parallèl and equidiſtant lines on each ſide of the meridian, and it generally gives the tranſit to leſs than a ſecond of time.

The daily tables of the ſun's declination, equation of time, &c. which I uſe, are thoſe in the ephemerides of the Abbé de la Caille; and the latitude of

 my

my place is 51° 29′ 5″ N. and 41″ of time weſt of the obſervatory at Greenwich, between the phyſic-garden and Chelſea hoſpital.

Several obſervations * for verifying the quadrant, meridian, clock, &c. made at different times of the year, were as follow; viz.

22d December 1760. Altitude ſun's upper limb on the meridian 15° 6′ 30″. Error by calculation 2″ of a degree.

26th December 1760. Altitude ſun's upper limb on the meridian 15° 12′ 15″. Error by calculation 8″ of a degree.

2d January 1761. Altitude ſun's upper limb on the meridian 15° 20′ 42″. Error by calculation 3″ of a degree.

18th February 1761. Altitude ſun's upper limb on the meridian 27° 22′ 45″. Error by calculation 4″ of a degree.

6th February 1761. Sun on the meridian, by the clock, at 12^h 14′ 35″. Error by equation table 0″ of time.

11th February 1761. morning, at 10^h 20, per clock. Altitude ſun's upper limb 20° 23′. Error of clock 0″ of time.

11th February 1761, noon, ſun on meridian, per clock, at 12^h 14′ 44″. Error by equation table 0″ of time.

11th February 1761, afternoon, at 6^h 37′ 30″ per clock. Altitude ſun's upper limb 6° 37′ 30″. Error of clock 0″ of time.

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* A great number of others were made, although not inſerted in this paper.

From

From 18th February to 11th March, the clock had gained of equal time 37″, which is near 2″ of time per day.

11th March to 10th April, the clock had gained of equal time 15″, which is near 3″ of time per day.

4th June, afternoon, at 4^h 52′ per clock. Altitude ſun's centre 27° 40′ 14″, which is near 3″ of time per day.

6th June, afternoon, at 5^h 40′ per clock. Altitude ſun's centre 24° 29′ 5″, which is near 3″ of time per day.

8th June, afternoon, at 5^h 20′ per clock. Altitude ſun's centre 23° 45′ 53″, which is near 3″ of time per day.

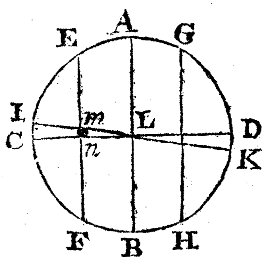
9th June, noon, ſun on the meridian, per clock, at 12^h 59′ 32″, which is near 3″ of time per day.

Theſe latter obſervations, ſhewing the gain of the clock 3″ of time per day, ſurprized me, as being contrary to my expectation; for the clock had loſt two or three ſeconds per day in winter, and therefore, I concluded it would loſe more in the ſpring and ſummer, by the lengthening of the pendulum; but it happened quite the contrary, and the cauſe thereof I could not determine.

For aſcertaining the diameter of Venus, and alſo the poſition and diſtance of the ſolar maculæ from Venus, I had cauſed to be conſtructed an inſtrument *, much like one which has been already deſcribed to the So-

* Angular micrometer.

ciety, with this addition, which was originally defigned for that inftrument; namely, EF and GH, two filver wires parallel to the diameter AB, and diftant therefrom 30° = AE = AG = BF = BH, the three parallel wires EF, AB, and GH, being fixed, whilft the moveable wires CD and IK opened to any angle, as ILC for intercepting the diameter *mn* of Venus, whilft CD was perpendicular to AB, and the planet was divided into two equal parts by the wire EF. This micrometer was placed in the eye-piece of a two feet Gregorian telefcope, which magnified 55 times, and through the field of view, of which the fun paffed in 118 feconds of time.



I had two eye-glaffes to the fix feet Newtonian * reflector; one of which, being fix tenths of an inch focus, magnified 110 times; and the other, being three tenths of an inch focus, magnified 220 times, or four times that of the Gregorian reflector. The greater of thefe two glaffes I purpofed to truft to, having often experienced its fuperiority in viewing the occultations of Jupiter's fatellites and the folar maculæ.

The idea I had formed of the internal contact was, that the planet would touch the edge of the fun in an inftant, like two drops of quickfilver meeting on a plane, and that in an inftant the black contact would appear; but in this I was deceived, the particulars of the phænomenon being as follows; viz.

* The diameter of the great fpeculum of this telefcope was fix inches.

June

June 6th, a cloudy morning, till about ſix o'clock, when the clouds began to diſſipate, but not enough to afford a plain ſight of Venus on the ſun, till more than half paſt ſeven, and the planet got nearer the limb of the ſun, than I had deſired to ſee it firſt on the diſk.

By repeated trials, the time in which the planet was paſſing from the internal to the external contact, with the wire of the micrometer was $3\frac{3}{4}$ ſeconds of time, and the angle ICL of the angular micrometer was 8°.

With the ſix feet Newtonian reflector, and its magnifying power of 110, and alſo of 220 times, I carefully examined * the ſun's diſk, to diſcover a ſatellite of Venus, but ſaw none; for I had a very clear dark glaſs next my eye, and the ſun's limb appeared moſt perfectly defined; but a very narrow wateriſh penumbra † appeared round Venus, by which its limb was not perfectly defined, and at the diſtance of about a ſixth part of Venus's diameter from its edge, was the darkeſt part of Venus's phaſis, from which to the centre, an imperfect ‡ light increaſed, and illuminated about the centre.

At $8^{h}\ 16'$ per clock, I was prepared to obſerve the internal contact; and as Venus drew nearer to the limb of the ſun, the penumbra near the limb of Venus

* After the tranſit, till two o'clock afternoon the ſame day, I continued obſerving the diſk with this teleſcope, but ſaw no ſatellite paſs over the ſun.

† This penumbra could not by any means be made to diſappear, although I tried to make it vaniſh, by altering the focus of the teleſcope a great number of times.

‡ This could not ariſe from any imperfection of the teleſcope, as the ſolar maculæ appeared ſharply defined, as through a refractor.

became

became darker, and threatened to obſcure the point of contact at the inſtant it would happen; the circumſtances of which, for each of the moments of time, are imperfectly delineated, on account of the nearneſs of the lines, but more truly deſcribed as follows; (a right line repreſenting that part of the ſun's limb near where the contact happened, and an arch the approaching limb of Venus, for each three ſeconds of time, from the loſs of the thread of light.)

A diagram, repreſenting the approach of Venus to the ſun's limb, for each three ſeconds of time. [*Vide Tab.* VII.]

In this diagram, the black ſegments repreſent Venus, and the right lines drawn nearly at contact to them, repreſent a ſmall part of the ſun's limb, as ſeen through a dark glaſs; the intermediate ſpaces white, repreſent the ſky. In words, (for each ſecond of time by the clock) thus:

	h	′	″	
At	8	16	41	No diminution of light between the limb of Venus and that of the ſun.
	8	16	42	Slight penumbra, or diminution of light, near where the contact was to be.
	8	16	43	Penumbra of a grey colour, near the ſame place.
	8	16	44	Penumbra almoſt brown, and the thread of light very narrow, and almoſt loſt.
	8	16	45	Penumbra brown, and the thread of light in the contact point indiſtinct, or loſt.
	8	16	46	Penumbra more brown, and the touch the ſmalleſt poſſible.

At

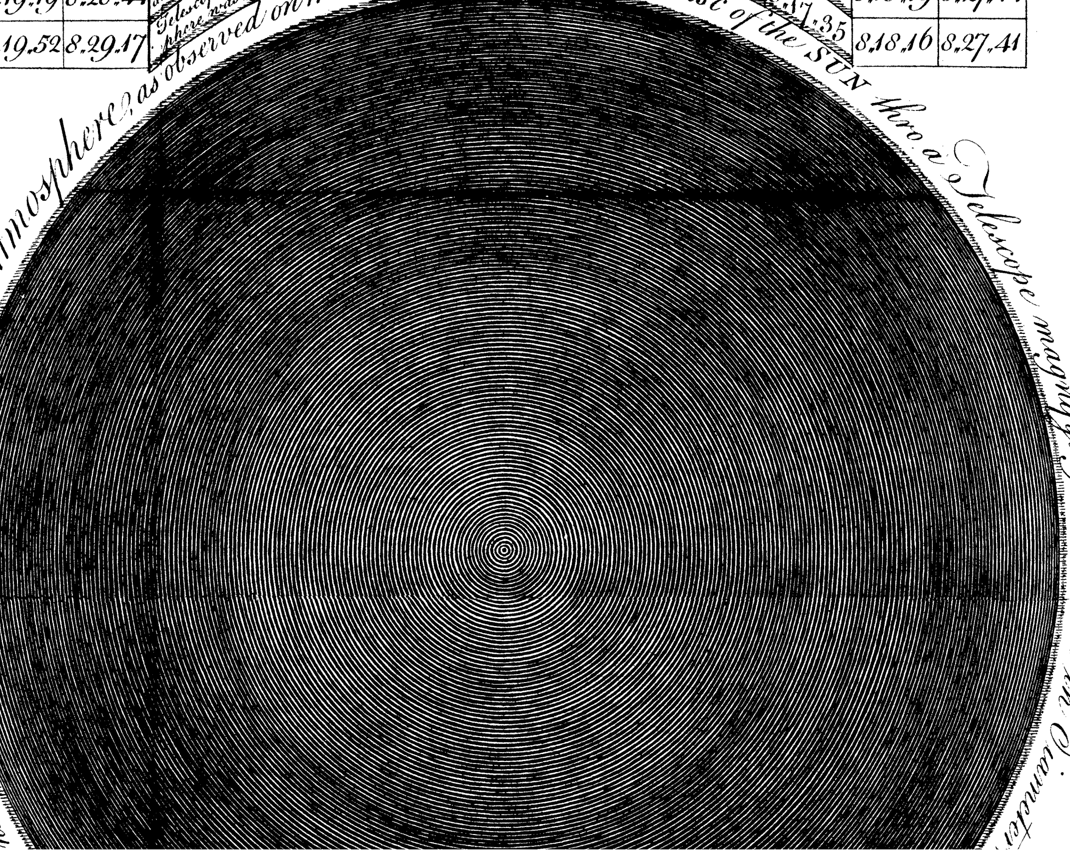
VENUS with an Atmosphere, as seen on the Face of the SUN 6th June 1761, thro' a Telescope magnifying 220 times in Diameter. Also the Approaches of the Planet toward the Sun's Limb, & the Circumstances referred to other Telescopes & to the Royal Observatory at Greenwich. By Samuel Dunn.

A Table deduced from this Observ.n shewing the apparent Time of the Contact by different Tel.s at Greenwich & at Paris. p. S.D.

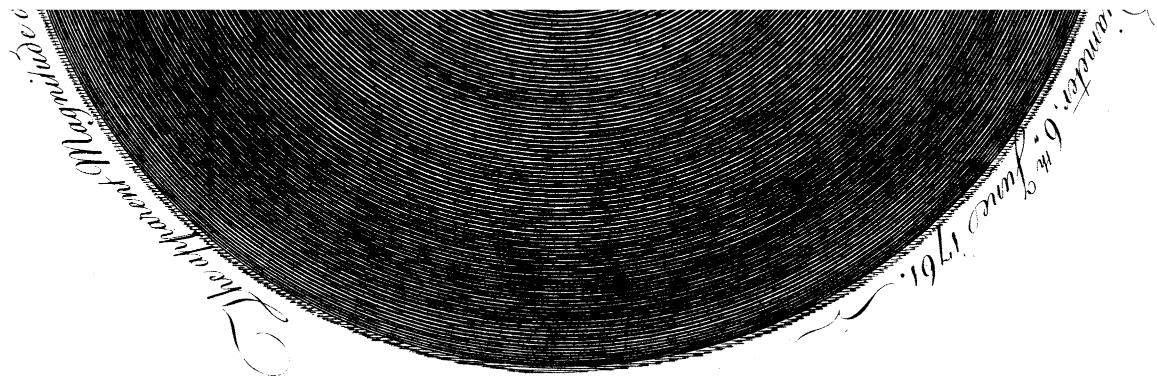
Power	Greenwich Observatory	Paris Observatory
	h ′ ″	h ′ ″
150	8.18.21	8.28.16
100	8.18.53	8.28.18
75	8.18.55	8.28.20
60	8.18.57	8.28.22
55	8.18.58	8.28.23
50	8.18.59	8.28.24
45	8.19.0	8.28.25
40	8.19.2	8.28.27
35	8.19.5	8.28.30
30	8.19.8	8.28.33
25	8.19.12	8.28.57
20	8.19.19	8.28.44
10	8.19.52	8.29.17

Approaches deduced for a Tel. of 80 times for Paris. — Paris Observatory.	Approaches deduced for a Tel. of 80 times for Greenwich. — Greenwich.	Approaches of the Planet toward the Sun's Limb, at the Internal Contact.	Time p. Clock with a Tel. of 220 Power at Chelsea.	Apparent Time with a Tel. of 220 Chelsea.	Apparent Time for Greenwich, by a Telescope of 220, by this Observation.	Apparent Time for Paris, by a Telescope of 220 Power, by this Observation.
h ′ ″ 8.28.35	h ′ ″ 8.19.10	Broader black Contact.	h ′ ″ 8.16.58	h ′ ″ 8.18.14	h ′ ″ 8.18.55	h ′ ″ 8.28.20
8.28.27	8.19.2	Broader black Contact.	8.16.55	8.18.11	8.18.52	8.28.17
8.28.19	8.18.54	Black Contact.	8.16.52	8.18.8	8.18.49	8.28.14
8.28.11	8.18.46	Brown Contact.	8.16.49	8.18.5	8.18.46	8.28.11
8.28.3	8.18.38	Grey Contact.	8.16.46	8.18.2	8.18.43	8.28.8
8.27.55	8.18.30	Atmosphere untouched.	8.16.43	8.17.59	8.18.40	8.28.5
8.27.47	8.18.22	No Loss of Light now.	8.16.40	8.17.56	8.18.37	8.28.2
8.27.39	8.18.14	No Loss of Light now.	8.16.37	8.17.53	8.18.34	8.27.59
8.27.31	8.18.6		8.16.34	8.17.50	8.18.31	8.27.56
8.27.23	8.17.58		8.16.31	8.17.47	8.18.28	8.27.53
			8.16.28	8.17.44	8.18.25	8.27.50
			8.16.25	8.17.41	8.18.22	8.27.47
			8.16.22	8.17.38	8.18.19	8.27.44
			8.16.19	8.17.35	8.18.16	8.27.41

The above Numbers denote the correspondent Approaches apparently, and therefore in different Telescopes the Atmosphere was less.



of the Planet Venus with the Atmosphere, as observed on the Disc of the SUN thro' a Telescope magnifying 220 Times in Diameter



Philos Trans. Vol. LII. TAB. VII. p. 190.

	h	′	″	
At	8	16	47	Penumbra almoſt black, and the touch a little broader.
	8	16	48	Slight black in the point of contact, and the edges a little broader.
	8	16	49	True black in the point of contact, and the edges a little broader.
	8	16	50	More ſo.
	8	16	51	More ſo.
	8	16	52	More ſo.

(8 16 50 – 8 16 52:) Here I concluded with myſelf, that obſervers would differ in their judgments about the moment of contact, ſome ſeconds of time, or that ſome would eſtimate the contact ſooner than others.

From theſe obſervations, I concluded, that the thread of light in the point of contact was ſo obſcured, as to be undiſcernible at $8^h\ 16'\ 46''$, and that true black did not ſucceed in the ſame point, till $3''$ after, namely, $8^h\ 16'\ 49''$; and from * both of theſe properties,

* As the ſix feet Newtonian teleſcope magnified four times as much as that of the two feet Gregorian teleſcope, and the vaniſhing of the thread of light, from its leaſt degree of duſkiſhneſs to a true black, was about 3 ſeconds of time by the ſix feet teleſcope, the time in which the thread of light was vaniſhing from the leaſt degree of duſkiſhneſs to a true black, by a two feet Gregorian reflector, may be ſuppoſed to have been 4 times 3 = 12 ſeconds of time; and hence an error, or rather difference, of pronunciation, but not of judgment, may have ariſen among good obſervers, if ſome eſtimated the contact by the inviſibility of the thread of light, and others by an apparent blackneſs in the point of contact, or, which is the ſame thing, the time when the planet had made the leaſt apparent dent in the ſun's limb,

perties, I concluded, that the real internal contact was at $8^h\ 16'\ 47''$ by the clock; which makes $8^h\ 16'\ 11''$ equal time, and $8^h\ 18'\ 2''$ apparent time, at Chelsea; and $8^h\ 18'\ 43''$ apparent time, at Greenwich.

Whilst Venus was on the sun's limb, no other penumbra appeared between the limb of Venus and the sun, than had appeared before on the sun's disk; and therefore, I concluded there must be an atmosphere about Venus, which, receiving weak impressions of light between the limbs of Venus and the sun, occasioned the uncertainty of ascertaining the exact instant of the internal contact, as above described; and because my Newtonian reflector shewed objects clearer than the generality of Gregorian reflectors, I concluded, that the aforegoing property was what no two feet reflector was capable of examining, the atmosphere being so narrow.

At $8^h\ 35'$ per clock, the external contact was near, and not incumbered with such a penumbra, or partial light, as the internal contact had been. At $8^h\ 35'\ 4''$, the least dent possible, quite black, appeared in the sun's limb. And at $8^h\ 35'\ 6''$, the limb was restored to its perfect form, there having been a small trembling light, between the narrow watery border of Venus and the vanishing point of contact in the sun's limb for these two seconds of time. From which the

of the same colour, through a dark glass, as the sky. This was verified by a two feet Gregorian reflector, in the contact abovementioned, and possibly may have occasioned greater differences in estimating the contact, with lesser telescopes, to no less than half a minute of time.

external

external contact at Chelsea was $8^h\ 34'\ 30''$ equal time, and $8^h\ 36'\ 21''$ apparent time; which makes $8^h\ 37'\ 2''$ apparent time at Greenwich.

From the aforegoing circumstances, it appeared to me, that the external contact was more easily to be determined than the internal one, which was contrary to what I had before expected; and because the point of contact must have appeared through such a telescope as I observed with, in its proper colour, dark or black, sooner than through a smaller magnifying power of equal light, I concluded, that, through my telescope, the internal contact was visible, sooner than through a two foot reflector, ten or twelve seconds of time.

And, considering the aforesaid penumbra, or border of partial light, surrounding Venus, as an atmosphere of that planet, with the time of its vanishing, $2\frac{1}{2}$ seconds of time; and reducing this to the diameter of Venus, with due allowance for the oblique direction over the sun's limb, the atmosphere of Venus comes out $8\frac{1}{2}$ thirds of a degree, which is nearly about $\frac{1}{430}$th part of Venus's diameter; which diameter being nearly equal to the earth's diameter, the atmosphere of Venus comes out nearly 50 geographical miles.

As these observations were made with care and attention, I have lain them before the Society only; and the more readily, as they reconcile a seeming contradiction in Mr. Short's * numbers of the internal contact;

* It having been 3 seconds of time from the instant when the thread of light between Venus and the sun became so indistinct, as not to be properly termed light, to the instant when the black

contact; and, whilst I am very certain with respect to the particulars of the external contact, cannot determine why they differ from that ingenious observer's numbers, or any other's.

Samuel Dunn.

*** When the limb of Venus was almost clear of the sun's disk, I perceived a difficulty would occur at the last contact, as the limb of the sun, and also that of Venus, which was to make the

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contact appeared through a telescope magnifying 220 times, the limits of time in which it continued in a like apparent state, by a telescope magnifying $\left\{\begin{array}{c}140\\55\end{array}\right\}$ times, may be supposed to have been $\left\{\begin{array}{c}5\\12\end{array}\right\}$ seconds of time; and as $\left\{\begin{array}{l}\text{Savile-House is } 30''\\\text{Chelsea is } - 41''\end{array}\right\}$ west of Greenwich, the black contact, by the above observation, with $\left.\begin{array}{l}\text{Mr. Short's telescope at Savile-House}\\\text{the telescope at Greenwich observatory}\end{array}\right\}$ was at $\left\{\begin{array}{l}8^h\ 18'\ 18''\\8\ \ 18\ \ 58\end{array}\right\}$ the observations at those places being $\left\{\begin{array}{l}8^h\ 18'\ 21\frac{1}{2}''\\8\ \ 19\ \ 0\end{array}\right\}$ And, for other telescopes, the limits above-mentioned may be supposed to have been nearly as in the following table.

Magnifying power.	Limits.
200 times.	3″ of time.
100	7
80	8
60	11
50	13
40	16
35	19
30	22
25	26
20	33
10	66

last

laſt dent, approached ſo near to a right line. This led me to conſider, that the ſpherical external angle of contact, by the ſix feet teleſcope, would be but an * eighth part of the ſame angle by the two feet teleſcope, the eye judging of the ſame relative diſtance in one teleſcope as in the other; and that, therefore, as the verſed ſine of the dent in the ſun's limb was but a fourth part as large in one teleſcope as the other, and the laſt contact vaniſhed in about $2\frac{1}{2}$ ſeconds of time, the laſt contact might poſſibly be eſtimated, by a two feet Gregorian teleſcope, about twice $2\frac{1}{2}$, or 5″ or 6″, ſeconds of time later than with a ſix feet Newtonian teleſcope; which allowance being made, the apparent time of the two contacts, as reduced to a Gregorian reflector, magnifying 55 times: by ſuch a teleſcope, the contacts at Greenwich obſervatory were, viz. internal contact 8^h 18′ 55″, external contact 8^h 37′ 7″. The accounts which have been publiſhed of the obſervations made at Greenwich being, internal contact 8^h 19′ 0″, external contact 8^h 37′ 9″; and the difference in each within five ſeconds of time, an error anſwering to about a 500^{th} part of the ſun's diſtance from the earth.

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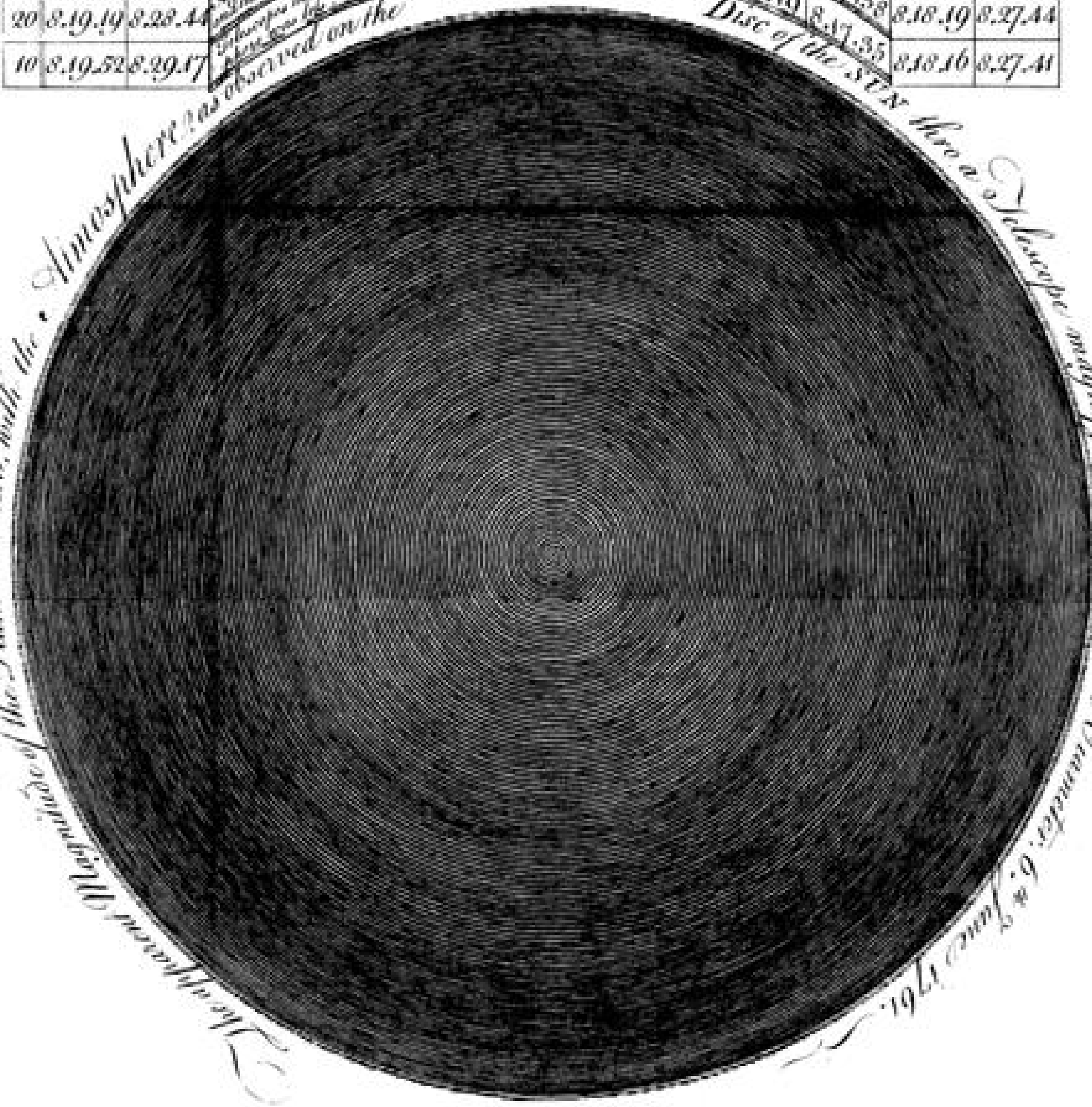
* As the ſpherical angle of contact in the limb of Venus, and alſo of the ſun, was four times as great in one teleſcope as in the other, the ſum of both is eight times; which, being diminiſhed by four times the apparent magnitude of the verſed ſine of the leaſt viſible dent in the one teleſcope, what it was in the other teleſcope, leaves the one double to that of the other.

VENUS with an Atmosphere, as seen on the Face of the **SUN** 6th June 1761, thro' a Telescope magnifying 220 times in Diameter. Also the Approaches of the planet toward the Sun's Limb, & the Circumstances referred to other Telescopes & to the Royal Observatory at Greenwich. **By Samuel Dunn.**

Power	Greenwich Observatory	Paris Observatory	Paris Observatory	Greenwich	Approaches of the planet toward the Sun's Limb, at the Internal Contact.	[illegible]	[illegible]	[illegible]	[illegible]
			8.28.35	8.19.10	Broader black Contact.	8.16.58	8.18.14	8.18.55	8.28.20
150	8.18.21	8.28.10	8.28.27	8.19. 2	Broader black Contact.	8.16.55	8.18.11	8.18.52	8.28.17
100	8.18.53	8.28.18	8.28.19	8.18.54	Black Contact.	8.16.52	8.18. 8	8.18.49	8.28.14
75	8.18.55	8.28.20	8.28.11	8.18.46	Brown Contact.	8.16.49	8.18. 5	8.18.46	8.28.11
60	8.18.57	8.28.22	8.28. 3	8.18.38	Grey Contact.	8.16.46	8.18. 2	8.18.43	8.28. 8
55	8.18.58	8.28.23	8.27.55	8.18.30	Atmosphere untouched.	8.16.43	8.17.59	8.18.40	8.28. 5
50	8.18.59	8.28.24	8.27.47	8.18.22	No Loss of Light now.	8.16.40	8.17.56	8.18.37	8.28. 2
45	8.19. 0	8.28.25	8.27.39	8.18.14	No Loss of Light now.	8.16.37	8.17.53	8.18.34	8.27.59
40	8.19. 2	8.28.27	8.27.31	8.18. 6		8.16.34	8.17.50	8.18.31	8.27.56
35	8.19. 5	8.28.30	8.27.23	8.17.58		8.16.31	8.17.47	8.18.28	8.27.53
30	8.19. 8	8.28.33	The above Numbers, &c. [illegible]			8.16.28	8.17.44	8.18.25	8.27.50
25	8.19.12	8.28.57				8.16.25	8.17.41	8.18.22	8.27.47
20	8.19.19	8.28.44				8.16.22	8.17.38	8.18.19	8.27.44
10	8.19.52	8.29.17				8.16.19	8.17.35	8.18.16	8.27.41



The apparent Magnitude of the Planet Venus with the Atmosphere, as observed on the Disc of the SUN thro' a Telescope magnifying 220 Times in Diameter: 6th June 1761.