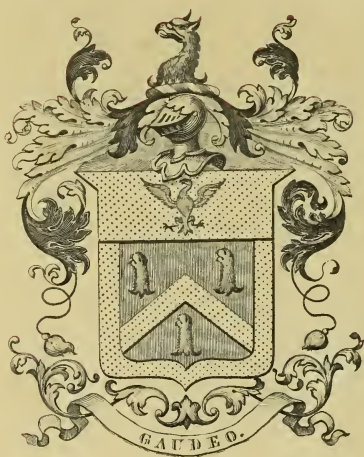
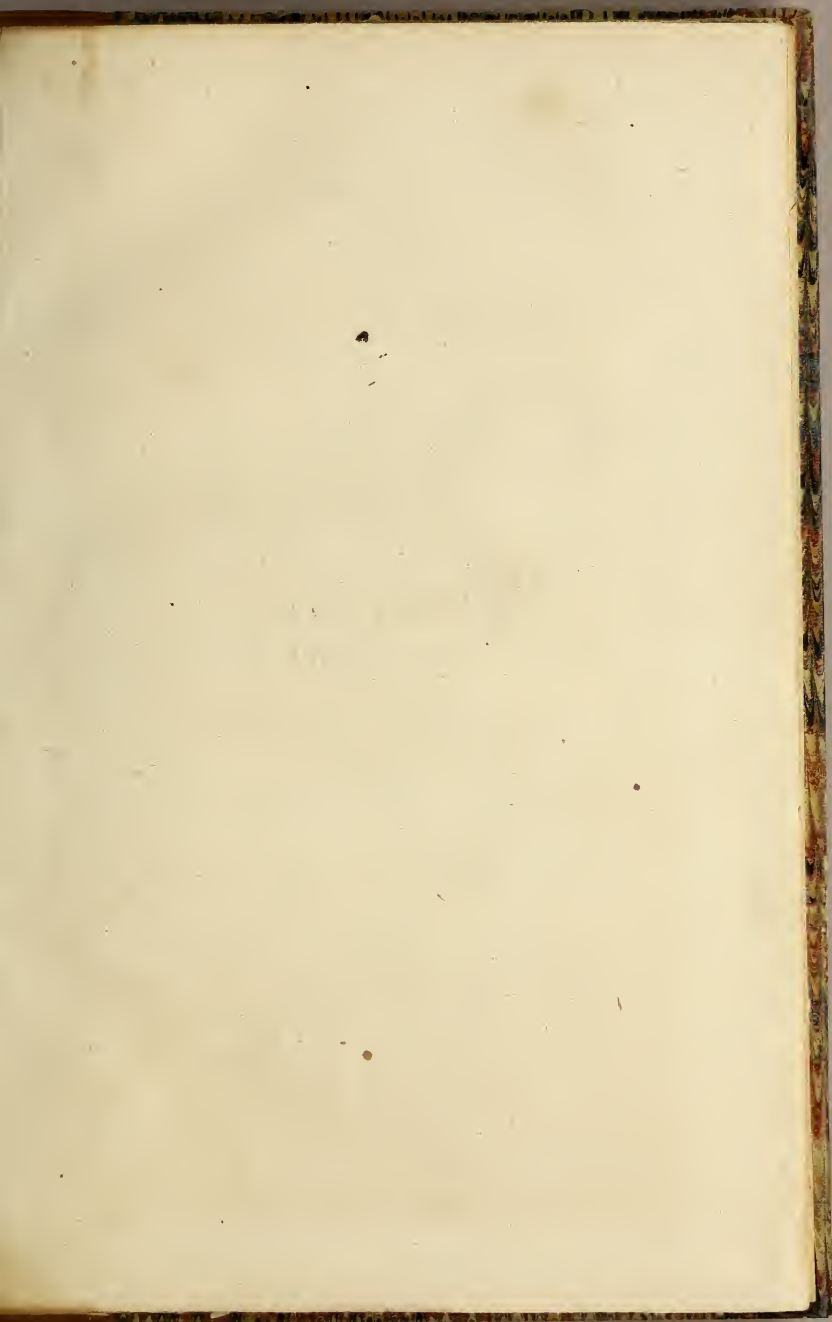
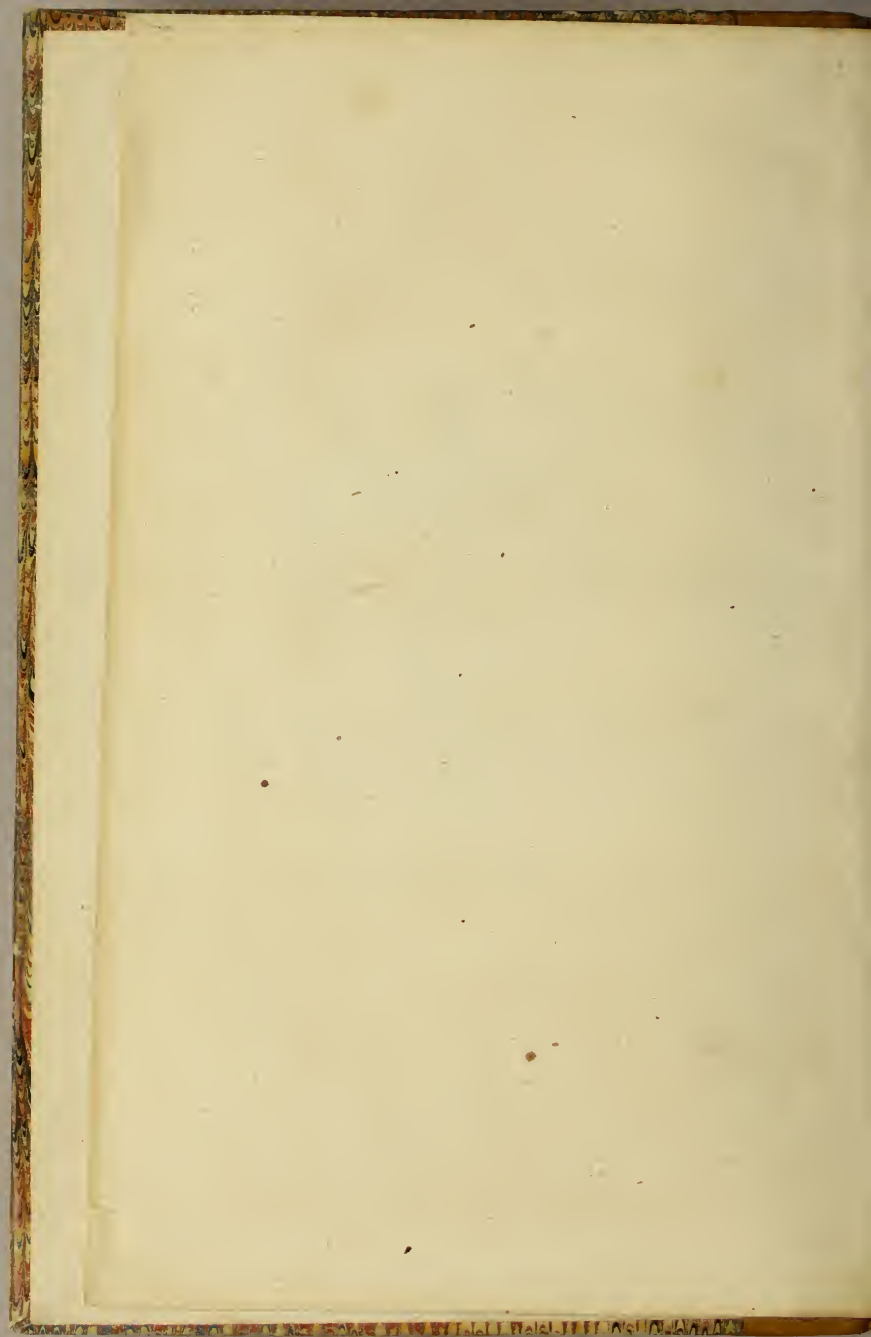






John Carter Brown.





Jos. Brown

AN

A C C O U N T

OF THE

O B S E R V A T I O N

O F

V E N U S

Upon the

S U N,

The Third Day of *June*, 1769,

AT

PROVIDENCE, in *New-England*.

With some Account of the *Use* of those *Observations*.

By *BENJAMIN WEST*.

The Course of *Nature* is the Art of GOD.

PROVIDENCE:

Printed by JOHN CARTER, at *Shakespear's Head*,
M,DCC,LXIX.

JOHN CARTER BROWN

W.C.B.

To the HONOURABLE

Stephen Hopkins,

ESQUIRE,

Member of the PHILOSOPHICAL SOCIETY
in the City of *Philadelphia*, and CHANCELLOR of
the COLLEGE in the Colony of *Rhode-Island*.

S I R,

AS your Honour was pleased to accompany, and assist us the whole time that we were preparing for the observation of the TRANSIT OF VENUS; and considering with what alacrity our work went on, when encouraged by your actuating genius; and that your Honour must be very sensible of the great pains which were taken, in order that our work might be rendered as accurate as possible; I think myself bound in duty to publish the following account of our observation under your patronage.---Much

A 2 -

might

DEDICATION.

might be said with respect to your Honour's superior abilities in mathematics and natural philosophy ; but, without flattery, these are the least of your acquirements, when compared with your profound skill in civil police, and the wise government of a people.

Your Honour very well knows, that these observations of the Transit of Venus give the solution to a problem, that is not only curious in itself, but at once opens to our view, and gives us a deeper insight into the amazing works of God.---From these observations we expect to discover the distance of the Earth, the Planets and Comets, from the Sun ; and consequently their magnitudes and quantity of matter will be known, as also their proportion of light and heat.---These things being once known, Astronomers in future will be able, from the like observations, to discover whether the Earth and Planets approach the Sun, or recede

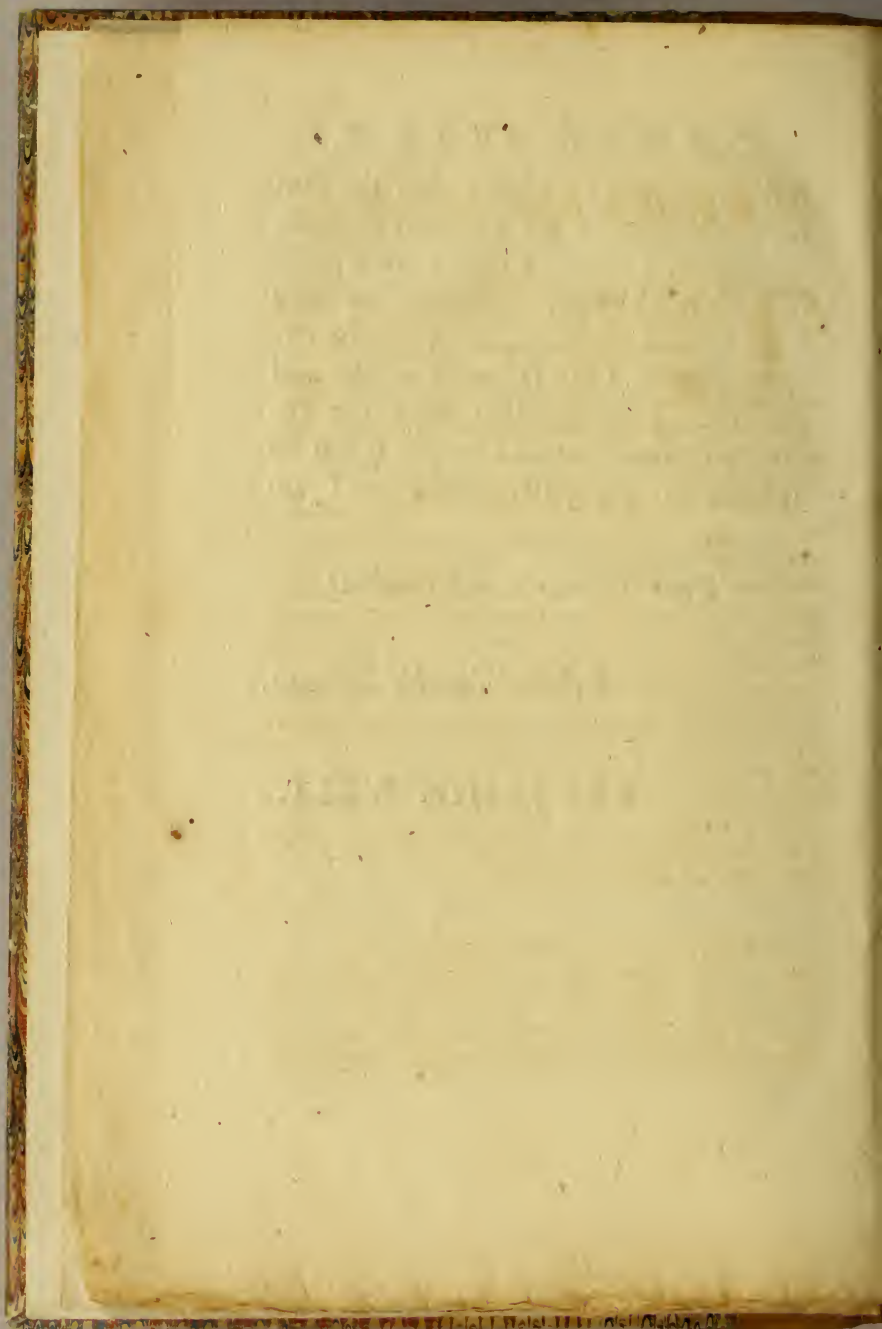
DEDICATION.

cede from him ; and whether the Sun be diminished by its constant expence of light and heat. From a knowledge of all these things, methinks we shall have such a demonstration of the existence of a GOD, who made and governs all things, that even the reformed atheist must tremble when he reflects on his past conduct.---I am

Your Honour's most obedient,

And most humble Servant,

BENJAMIN WEST.



V E N U S upon the S U N.

THE TRANSIT OF VENUS OVER THE SUN'S Disk, the third day of June, 1769, did much engage the attention of the Astronomers in all the polite nations of Europe, not barely because it was a rare phænomenon, but because the noblest problem in all the celestial science is thereby expected to be resolved; to wit, that of discovering the Sun's horizontal parallax.

Kepler*, when he had constructed his Rudolphine tables (upon the observations of Tycho Brahe, a Danish nobleman) soon saw that the planets Venus and Mercury, at their inferior conjunctions with the Sun, would sometimes appear to pass retrograde over his disk. From his tables he predicted two transits of Venus to happen, one in the year 1631, the other in 1761, in a book he published in 1629, intituled, "Advice to Astronomers." Kepler did not live to the year 1631. In 1639 a transit of Venus happened, which, according to those tables, was to be invisible, and that which he predicted to happen in 1631 was looked for at Paris, by Gassendus, but none was to be seen. All this was owing to the imperfection of Kepler's numbers.

When

* "Kepler was a native of Wittemburgh, in Germany; he flourished in the beginning of the sixteenth century; was Mathematician and Astronomer to three Emperors; was the first who discovered the elliptic orbits of the planets, and that the squares of their periodic times are as the cubes of their mean distances from the Sun, and explained the general phænomena of solar eclipses."

When our English Astronomer, Mr. Jeremiah Horrox, came upon the stage, though a youth of but 20 years of age, yet his ingenuity and strength of reason were such, that he was able from his own observations to point out the errors in Kepler's tables, and immediately set himself to work in making such other observations as enabled him greatly to correct Kepler's numbers. By these numbers, thus corrected, he predicted the before mentioned transit, which happened the 24th of November, 1639.—He expected the conjunction would be at 3 h. 57 m. P. M. with 10' south latitude. He waited with eager desire for the moment to see his prediction verified, and so extraordinary a phænomenon as that of Venus on the Sun. The day arrived, and agreeable to his expectation he saw Venus wholly entered upon the Sun at 3 h. 15 m. P. M.—The place of his observation was at Hool, about 15 miles to the northward of Liverpool. Mr. William Crabtree, of Manchester (an Astronomer, and particular friend to Mr. Horrox) was also looking for the transit, and first saw it at 3 h. 35 m; the Sun being in a cloud was the reason that he did not see it sooner. By a comparison of their observations they were found to coincide very well. This ingenious friend to Astronomy (Mr. Horrox) died the third of January; 1640-1, at the age of 25 years.

*He has taken his tow'ring flight aloft,
To mingle with his stars.*————

It seems the grand discovery which was to be made from these transits, was not intended for Mr. Horrox, but was reserved for some future genius. Accordingly we find a paper in the Philosophical Transactions, No. 348, wrote by the learned Doctor Halley,

Halley*, our late Royal Astronomer, upon this matter; wherein the Doctor shows, that by observations made of Venus on the Sun, the distance of the

* " Dr. Halley was born the 29th of November, 1656, in the parish of St. Leonard, Shoredich. He had an uncommon skill in plane and spherical trigonometry, and all the various parts of mathematics, before he was 17 years of age.—At 19 he published a geometrical method of finding the aphelia and eccentricity of the planets; the want of which before was an opprobrium to Kepler's hypothesis.—He discovered the time in which the Sun revolves on its axis by its maculæ. He was author of the geometrical method of constructing solar eclipses, by which the parallaſtic method was superseded. In the year 1676 (at 20 years of age) he was sent at the cost of the government to St. Helena, in the South Seas, with letters of recommendation from King Charles the 2d to the East-India Company, to make observations of the fixed stars about the South Pole.—In 1678 he was made Master of Arts, and chosen a Fellow of the Royal Society.—In 1684, from observation, he thought the forces of the planets towards the sun decreased as the squares of their distances inversely; but not being able to demonstrate it, he applied to Mr. NEWTON, at Cambridge, who gave him ample demonstration of the truth of what he suspected. About this time he shewed a method of finding the elevation of mountains, steeples, &c. by the barometer.—In 1686 he explained why the water in the Mediterranean Sea never rises any higher, although the current is continually setting in at the Straights mouth, besides a large supply of water from nine large rivers, and many small ones. The solution of this phenomenon gave the society so much satisfaction, that he received their orders to prosecute the enquiries.—In 1699 he set out on a voyage in a ship, of which he had the command, in order to make observations of the variation of the compass; and after traversing the Atlantic Ocean into both hemispheres, as far as the weather would admit him to go, and having touched at many coasts and islands, he arrived at England in September, 1700; and from his observations he published a general chart, shewing at one view the variation of the compass in all those seas where the English navigators were acquainted.—In 1703 he was appointed Savilian Professor of Geometry at Oxford, in room of Dr. Wal-

the Sun from the earth may be found to the five hundredth part of the whole. I shall take the liberty in this place to quote some of the Doctor's own words (as we find them translated into English in the before mentioned transactions) upon this subject.

The Doctor, after a previous introduction, saith,
 " about 40 years ago, when I was at the island of St.
 " Helena, where I was employed in observing the
 " fixed stars which surround the South Pole, I had
 " an opportunity of observing Mercury passing over
 " the Sun's disk, which I did with the greatest dili-
 " gence. I obtained most accurately, with an ex-
 " cellent tube of 24 feet, the moment in which
 Mercury,

lis, deceased, and had the degree of Doctor of Laws conferred upon him by that university.—In 1713 he was made Secretary to the Royal Society, in room of Sir Hans Sloan.—In 1717 he wrote the paper in which he shewed the method of investigating the Sun's parallax by the Transit of Venus over the Sun's disk.—Upon the death of Mr. Flamsteed, in 1719, Dr. Halley was appointed to succeed him by his Majesty King George the first.—Queen Caroline honoured him with a visit at the Royal Observatory, and being pleased with the polite reception she met with, and considering he had formerly served the crown under commission of Captain of the Navy, she obtained of his Majesty for him a grant of his half-pay for that commission during his life.—In the space of nine years (half of one plenian period) he observed the right ascension of the Moon, as she passed the meridian, 1500 times, which was a greater number of observations than were made by Flamsteed, Tycho Brahe, and Hevelius, together. When the Emperor, Peter the Great, visited England, upon discoursing with Dr. Halley on Ship-Building, the Arts and Sciences, &c. he was so well pleased with the Doctor, that he made him one of his intimate friends during his stay in England.—The Doctor died the 14th of January, 1741-2; and since his death, in 1752, were published his astronomical tables, for computing the places of the Sun, Moon, Planets, and Comets: They were supplied with precepts by Mr. Gael Morris."

“ Mercury, entering the Sun’s limb, was seen to touch
 “ it within; and, in like manner, the moment in
 “ which, at going out, he touched the Sun’s limb,
 “ making an angle of inward contact. Whence I
 “ was sure of the interval of time, in which the
 “ whole body of Mercury appeared at that time
 “ within the disk of the Sun, and that without the
 “ error of one second of time. For the thread of
 “ the solar light, intercepted between the obscure
 “ limb of the planet, and the bright limb of the
 “ Sun, slender as it was, appeared to strike the eye,
 “ and in striking the eye, the denticle made in the
 “ limb of the Sun by the entrance of Mercury
 “ vanished, as that made by his going out began
 “ as it were in a moment. When this was known,
 “ I was immediately assured, that the Sun’s paral-
 “ lax might be truly determined from this kind of
 “ observations, if only Mercury being nearer the
 “ earth should have a greater parallax from the
 “ Sun. For this difference of parallaxes is so very
 “ small, that it is always less than that of the Sun
 “ which we enquire after. Wherefore Mercury,
 “ though often to be seen within the Sun, will not
 “ be thought very proper for this business.

“ There remains therefore the Transit of Venus
 “ over the Sun’s disk; her parallax being almost
 “ four times as big as that of the Sun’s, will make
 “ very sensible differences between the spaces of time
 “ in which Venus will be seen to pass over the Sun,
 “ in the different regions of our earth. Now from
 “ these differences, if observed after a due manner,
 “ I say the parallax of the Sun may be determined
 “ within a small part of a second.” In such observa-
 “ tions, the Doctor saith, “ nothing more is necessary

“ than faithful observers, good telescopes, and
 “ common clocks, regulated to the revolutions of
 “ the heavens, and that the times be reckoned
 “ from the total ingress of Venus within the Sun’s
 “ disk, to the beginning of its egress from the
 “ same; that is, when first the opaque globe of Ve-
 “ nus begins to reach the lucid limb of the Sun;
 “ which moments, as I know by my own experi-
 “ ence, may be obtained to a second of time.”

The Doctor then proceeds to mention the transit of 1761, and to make some curious calculations thereon; represents it as a suitable opportunity for the before mentioned observations; and being fully convinced of the certainty of this method of discovering the parallax of the Sun, seriously recommended it to the Astronomers that should be then living, with all the power and elocution of an orator, not to slip so favourable an opportunity of promoting the science of Astronomy; wishing them all possible success, and that the magnitudes of the celestial orbs being then determined within more exact limits, may reward them with perpetual fame and glory.

The Doctor’s credit was too great in the astronomical world, not to be taken proper notice of; and as this learned piece of his was wrote many years before the transit of 1761, and the Astronomers since his day having had time to fully weigh and consider the matter, found his reasoning too cogent to let pass, without due notice, what he had so earnestly urged upon them.

In consequence of which we find, at the approach of the transit of 1761, the Astronomers of almost every civilized nation in Europe, emulously engaged

ged in this affair, of so much importance to science. His late Majesty, King George the second, and the French King, though in the midst of a vehement war, yet (from a sense of the utility of those observations) found time to consider of the matter, and each contributed largely towards carrying so noble a design into execution; "neither was the Empress of Russia inactive on this singular occasion."

In England, it was observed at Greenwich by the Rev. Dr. Bliss, the then Royal Astronomer; at Savile-House, in London, by the late Mr. Short, in presence of their Royal Highnesses the Duke of York, Prince William, and Prince Henry. Messieurs Ellicott and Dollond observed it at Hackney; and Mr. Canton at Spital-Square, London. It was likewise observed at Leskeard, in Cornwall, by the Rev. Mr. Richard Haydon. Abroad it was observed at Paris, in France, by Mr. De la Lande; and by Mr. Ferner, at Conflans. It was observed at Torneo, in Lapland, almost under the arctic circle, by Mr. Hellant; and this was the farthest north that observation was made. At Stockholm, the capital of Sweden, it was observed by Mr. Wargentin; and at Harnosend, in Sweden, by Mr. Gitter. In Asia observation was made at Tobolsk, the capital of Siberia, by Mr. Chapp, a French Astronomer, sent thither at the request of the Academy of Sciences at Petersburg, and under the protection of the Czarina. At Madras, or Fort St. George, in the East-Indies, it was observed by the Rev. Mr. Hirst, under direction of the East-India Company of London. Observation was also made at Calcutta, near the mouth of the Ganges,

Ganges, by Mr. William Magee; this was the farthest east. It was observed at the Cape of Good Hope, by Mr. Mason; and would have been observed at St. Helena (had not the intervention of clouds prevented) by Astronomers sent to those places, at the expence of his Majesty King George the second. It was observed nowhere farther south than at the Cape of Good-Hope. In America, it was only observed at St. John's, in Newfoundland, by JOHN WINTHROP, Esq; F. R. S. at the expence of the Massachusetts colony; and this was the farthest west.

These, and many more observations, to the number of forty odd, being collected, were submitted to Mr. Short, F. R. S. who duly examined them, and with incredible assiduity and labour solved the difficult problem; and found the Sun's parallax, on the day of the transit, to be $8''.55$; the Sun being then nearly at his greatest distance from the earth. The parallax being always in a reciprocal proportion to the distance of the Sun, it follows from thence that the parallax, when the Sun is at a mean distance, is $8''.68$ †.

By

† The horizontal parallax of the Sun being known, the distance of the Sun from the earth is found by the following proportion.

As tang. of $8''.68$	5,6241119
is to 1,	0
so is radius tang. 45°	10,0000000
to 23763 semidiameters of the earth.	4,3758881

From the latest measurements, a mean semidiameter of the earth is found to be 3957 miles. Then $23763 \times 3957 = 94030191$ miles the distance of the Sun.

By this observation of Venus passing over the Sun, a certain principle in Astronomy was settled, which Dr. Halley, from certain observations, suspected did obtain in the planetary system, which is, that the nodes in the primary planets have a slow motion in antecedentia, or contrary to the order of the signs. From whence Astronomers were ascertained that Venus would again transit the Sun's disk the third day of June, 1769. I say ascertained, because, according to the old hypothesis of the immobility of the nodes, it was doubtful; and by Dr. Halley's calculations * upon that hypothesis, the center of Venus, as she passed by the Sun, would appear to be in contact with its north limb. The Doctor said, if at the transit in 1761 the nodes should be found to go backwards, then it might be expected, that at the transit in 1769, the body of Venus would appear wholly within the orb of the Sun; and would afford a much better opportunity for investigating the Sun's parallax.—What difficulties in science are too great to be surmounted, when pursued by men of interest and understanding!

And now that nothing might be wanting to render the observations of this transit as perfect as possible, we hear that ample preparations were seasonably made, and skilful Mathematicians dispersed into those distant regions of the earth, to make observation, where the transit was attended with the most favourable circumstances. So that whatever was wanting to render the observations in 1761 complete, was now to be fully supplied. We are informed

* Philo. Transf. page 436, Lowthrop's Abridgment.

formed that several observators were sent into the South Seas, by the Royal Society in London, in order to get an observation where the whole duration of the transit was shortest; and that the Empress of Russia sent several companies into those parts of her empire, where the visible duration was of the greatest length. The King of France did likewise send observers into foreign parts; but as yet we know not to what particular places.

It remains now to give an account of the preparations that were made in PROVIDENCE, for the observation of this transit. In doing of which I shall be as particular as possible, that the reader may the better judge of the merit of our work.

When it became more generally known that there would be a Transit of Venus in 1769, and the advantages which were like to accrue to Astronomy, and consequently to Navigation and Chronology; from proper observations of it, Mr. JOSEPH BROWN*, a very respectable merchant of Providence,

* Mr. Brown is a gentleman of a solid, active genius, strongly turned to the study of mechanics and natural philosophy, which has induced him to construct and furnish himself with as curious and compleat an apparatus for electrical experiments, as any perhaps in America; and of which he well knows the use.—Reading Mr. Winthrop's account of the transit in 1761, was what first occasioned him to send for a telescope, fitted in the manner Mr. Winthrop there describes; afterwards, taking notice of the application of the American Philosophical Society to the Assembly of Pennsylvania, for an apparatus for observing the Transit of Venus, he found the orders he had sent were incomplete: He then advised with the author, as mentioned, and thereupon ordered a micrometer to be added.—Mr. Brown's expence, in this laudable undertaking, was little less than One Hundred Pounds sterling, besides near a month's time of himself and servants, in making the necessary previous experiments and preparations.

vidence, being very desirous, if possible, to obtain an observation of it, was pleased to advise with me, concerning an apparatus suitable for such an observation, and to know if we should be able to observe the transit with the necessary precision for answering the important design?

As the proposal was new, and unexpected, my answer was not direct; as it required some time to consider of it. At length I gave him my opinion concerning an apparatus proper for such an occasion; and that I thought we could observe the transit with that accuracy as would render it worthy of notice, provided we could have such an apparatus as was described. My answer gave him so much satisfaction in the matter, that he immediately sent his orders to his correspondent in London, to procure the instruments; his orders were accordingly executed with fidelity and dispatch; they arrived in Providence about one month before the transit.—Our apparatus was made by Messieurs WATKINS and SMITH, London; it consisted of a three feet reflecting telescope, with horizontal and vertical wires for taking differences of altitudes and azimuths, adjusted with spirit-levels at right angles, and a divided arch for taking altitudes; a curious helioscope, together with a micrometer of a new and elegant construction, with rack motions, and fitted to the telescope.—Such a noble disposition in Mr. BROWN for promoting useful knowledge, certainly merits the applause of the public; and, in justice to him, I must acknowledge, our work could not have been done with equal accuracy, had it not been for his skill and contrivance therein.—Besides the before mentioned instruments, we had a sextant belonging to the government,

vernment, made in Newport, by Mr. BENJAMIN KING, under the direction of JOSEPH HARRISON, Esq; now Collector of his Majesty's Customs for the port of Boston; its limb was divided to five miles, and by a vernier index to five seconds*.—We had two good clocks, one of which was made in Providence, by Mr. EDWARD SPALDING.

We had nothing to learn respecting the apparatus, excepting our new catadioptric micrometer, which, I have lately learned, is of DOLLOND's construction; not having any author by us, from which we could get the use of that curious instrument, we were obliged to have recourse to experiments.—When the micrometer was fixed upon the telescope, it was found by trial, that objects could not be seen with the same focal distance as when it was off, but were obliged to screw up the small speculum nearer to the eye; for which there is an optical reason.—From whence it was concluded, that objects should always be observed in the most distinct point of view, the same with the micrometer on as when it was off. The next thing to be done was to find the apparent diameter of an object (or the angle subtended at the eye by two objects) by this instrument. In order to this, we stretched a cord, as straight as possible, one thousand feet in length; which was measured several times over, in order to avoid

* And here we must not forget the Honourable ABRAHAM REDWOOD, Esq; of Newport, who, in order that Newport and Providence might both be supplied with a sextant, for this singular occasion, ordered one made at his own cost, for the use of the Rev. Dr. STILES.—I am sensible Mr. Redwood, for so public spirited an action, will receive the thanks of every well-wisher to science.

avoid mistake. At the end of the cord was set two circular objects, made of white paper, in a line perpendicular to the cord, and exactly ten feet apart; standing at the other end of the cord, and by opening the micrometer, we could bring the two images into an exact coincidence, or could make one of the images appear like two, and by bringing their limbs into contact, the distance of their centers was shewn on the scale, to the five hundredth part of an inch. Now from the rules of trigonometry, the angular distance of the two objects was $34^{\circ} 22' 58''$; from thence it was known, how many inches and parts of an inch were answerable to that angle. These experiments were repeated every fair day (for no other was suitable for these observations) till we could many times going find the diameter of a body to a second of a degree.—From these observations we were enabled to make a table for the micrometer, as far as the scale extended.—These experiments were carried yet farther, for, by looking at two bodies whose distance from each other was known, we could tell their distance from the place of observation, to a critical exactness; and this was proved by accurate mensuration. These were certainly very diverting experiments to an inquisitive mind!—The gentlemen who assisted us through these experiments, and likewise in the rest of our work, were the Honourable STEPHEN HOPKINS, Esq; Mr. MOSES BROWN, Dr. JABEZ BOWEN, A. M. JOSEPH NASH, Esq; and Capt. JOHN BURROUGH.

The regulation of our clocks, being of the utmost consequence in this affair, was what next commanded our attention. In this part of the work,

we endeavoured to arrive at as great a degree of certainty as the nature of the case would admit.—Several workmen, who were equal to the undertaking, were employed in laying a platform, of seasoned pine plank, as smooth and level as art could make it: This was secured from rain, or other moisture, that it might not warp when exposed to the Sun. We examined this platform three times a day (when the weather would admit of it) with a very long level, made for that purpose, in order to keep its position from altering. On the south side of the platform, and exactly perpendicular to it, we erected a stile ten feet high; this was likewise examined three times a day. We next perforated a piece of board, into which was fixed the glass of a sciopic ball, so that the center of the glass was exactly in the center of the perforation; this board was so cut, and let in at the top of the stile, that it turned upon an axis, in such a manner, that the center of the glass did not alter its position. The Sun's rays were transmitted through the lens upon the platform, where they were formed into a bright spot, and very distinctly defined. From the center of the lens was let fall a perpendicular upon the platform; from that point, as a center, was drawn a great number of concentric circles, for taking correspondent shades, in order to trace a meridian line; and, as our wishes would have it, the weather proved favourable for this work. When the line was drawn *, I found, from calculation, it reclined

* The magnetic needle, being placed on this exact meridian line, was found to differ from it $6^{\circ} \frac{1}{2}$ westward.—That our observations might be as useful as possible, notice was given beforehand to the people (whose curiosity was excited by the preparations).

reclined $3''$ in time, east of the true meridian; this error arose from the increase of the Sun's declination, between the times of forenoon and afternoon shades; this small equation of $3''$ was allowed for in regulating the clocks.

As we were willing to have every corroborating circumstance to prove our work, we made use of another method, which seems to be most approved of by all the celebrated Astronomers in Europe and America; this was the method of corresponding altitudes of the Sun, forenoon and afternoon. The sextant and reflector were both employed in this business for several days preceding the transit (and the day following) in order to ascertain the going of the clocks. In the last method (as in that of corresponding shades) the equation of time, answerable to the increase of declination, ought by no means to be neglected. Through the whole process we conducted with the utmost caution, that no errors might escape our notice. We found, upon the whole, a surprizing agreement in these two methods of regulating clocks; they were seldom found to differ a single second.—In short, as truth was the point we aimed at, nothing was omitted by which it might be obtained.

Being in this readiness, the morning of the third of June was ushered in with that serenity the business of the day required; all was calm, and not a cloud to be seen. The gentlemen concerned in the business convened very early at the place of observation,

parations) that on the day before the transit, when the Sun came on the meridian, a cannon would be fired, which being done, most of the inhabitants marked meridian lines in their windows, or on their floors.

observation, to see that every thing was in order; and at the sight of such a morning, the gladness of their hearts was visibly expressed, by a pleasant aspect upon their countenance.

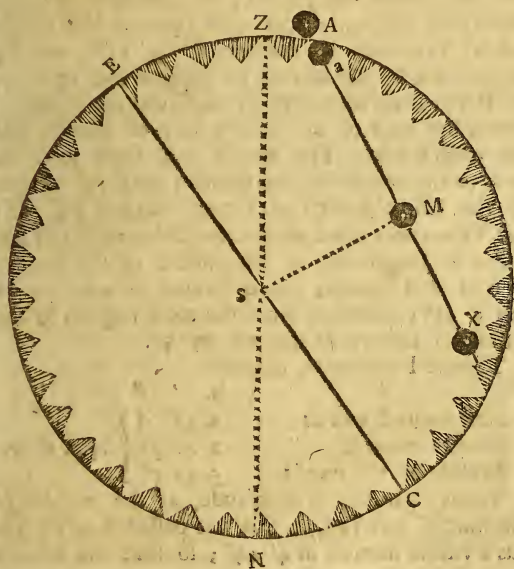
At noon we examined the going of the clocks, as the Sun passed the meridian, and found them very regular.

We began to look for the first contact of Venus with the Sun, at least 15 minutes before the time given by calculation, to get as early a sight of it as possible.—Venus was first perceived by making a dent upon the superior limb of the Sun at 2 h. 29 m. 43 sec. P. M. apparent time. But, as it is likely the exterior contacts will be given different, by different observers, they can be of but little consequence in this affair.—The greatest attention was given to the interior contact; this was at 2 h. 46 m. 35 sec. apparent time*. From a mean of a number of good observations, the apparent diameter of the Sun was $31'40''.66$, and that of Venus $58''.66$; though I could not make it myself more than $58''$, which

* At the moment of interior contact, the Sun's altitude was taken, with the sextant, by Mr. MOSES BROWN, and by the stile by Capt. JOHN BURROUGH; and both gave the time with the clocks within two seconds.—The total ingress was not so instantaneous as I did expect it would be, but the bright cusps of the Sun, as they encompassed Venus, were much more obtuse, and there seemed to be a faint junction of their limbs for at least $4''$; the moment this penumbral ligament broke, I proclaimed the time; at first I suspected the telescope was not adjusted to a proper focus; but afterwards, by looking at the solar spots, &c. I was convinced of the contrary. During the time we saw Venus upon the Sun, she appeared to be surrounded by a ring of a yellowish countenance; its width was about one tenth of the diameter of Venus. We saw nothing that might be taken for satellite.

which was the same we found it about a fortnight before the transit. The proportion of their diameters was nearly as 1 to 33. The nearest approach of their centers, at the middle of the transit, was taken with the micrometer, and found to be $10' 5''$.

The following TYPE will give the reader some idea of the appearance of Venus, at her several stages on the Sun.



In the figure, the circle Z E N C. is the disk of the Sun, and S its center; the obscure line Z S N a vertical passing through the Sun's center; E S C the

the ecliptic in its position at the middle of the transit; A a M X the orb of Venus; A is Venus at her first contact; a the interior contact; M the middle of the transit; and X her place at sunsetting.

The proportion of the distances of the Sun and Venus from the earth, at that time, was as 3,5143 to 1; then (allowing the Sun's parallax to be the same it was found the 6th of June, 1761) the parallax of Venus was $30''\text{,}04$; the difference of their parallaxes $21''\text{,}49$. The angle between the visible way of Venus and the ecliptic, $8^\circ\ 34'\ 17''$; and the angle made by the axis of the ecliptic and equator, $7^\circ\ 3'\ 7''$; their sum, $15^\circ\ 37'\ 24''$, was the angle between the axis of the visible way of Venus, and the earth's axis. The transit line, from total ingress to the middle of the transit (measured in time by the visible motion of Venus) was $2\text{ h. }55'\ 36''$; but Venus was more accelerated in her orbit (by parallax in longitude) at the middle of the transit, than at total ingress; this difference of acceleration was $1'\ 33''$; therefore from the total ingress to the middle of the transit was $2\text{ h. }54'\ 3''$.

Thence I conclude, that the

	h.	'	''
* First contact was at	2	28	0
Interior contact	2	46	35
Middle of the transit	5	40	38
	} app. time.		

Venus's parallax in longitude, at the middle of the transit, was $18''\text{,}7$; this was passed over by Venus's visible motion in $4'\ 44''$; so that the middle of

* When I calculated this transit, I supposed the longitude of our place to be much less than we have since found it by observation. — By correcting that error, the error in calculation will appear to be inconsiderable.

of the transit, as seen from the center of the earth, was at 5h. 43' 8" mean time. The true conjunction was 23' 21" before the middle of the transit, as seen from the earth's center; consequently the true conjunction was at 5h. 19' 45", mean time. At which time, the place of the Sun and planet was π 13° 27' 3"; and the geocentric latitude of Venus 10° 19', 8 north. But her heliocentric latitude was 4' 6", 51; and by the rules of spherical trigonometry, the ascending node of Venus was 1° 9' 23", 5 in consequence of the Sun; or in π 14° 36' 26", 5.

From the foregoing calculation it appears, that the mean motion of Venus is 37" forward of what it stands in Dr. HALLEY's tables, and her ascending node 2' 41".

It is probable Dr. HALLEY's solar numbers need some correction likewise; the following may not be far from truth, viz. add to Dr. HALLEY's mean motion of the Sun, for any year of the Christian æra, 25", and to the apogee 6' 18"; for each century after 1700 add 14", 666 to the mean motion, and to the apogee 3' 53"; then by making use of the Parisian* equation of the Sun's center, his place may be had within a small matter of truth.

By taking the mean of a number of observations, the latitude of our observatory was found to be 41° 50' 41" north †. The longitude was obtained by

D observing

* According to the Parisian hypothesis, the eccentricity of the earth's orb is 1680 parts, of which the mean distance of the earth from the Sun is 100,000.

† The latitude of the place being of great consequence, and the sextant and stile not giving it exactly alike, the persevering Mr. BAOWN contrived to make use of the micrometer as a lens, which he placed on his house, twenty-seven feet high, and exactly perpendicular to a center on a horizontal platform below, on which was drawn a meridian line; the Sun's image on this platform

observing the emersions of Jupiter's satellites, compared with the corresponding observations made at Cambridge, in New-England, by Mr. WINTHROP, which he was so kind as to favour us with; and for which we return him our sincere thanks.—Providence was found to be $16'$ in longitude west from Cambridge; Mr. WINTHROP has hitherto found the longitude of Cambridge to be $71^{\circ} 0'$ west from the Royal Observatory at Greenwich; so that the longitude of Providence is about $71^{\circ} 16'$ from the Royal Observatory.

It is to be hoped the Commissioners, sent abroad to observe that interesting phænomenon, were favoured with a suitable air for that purpose, as there will not be another opportunity, for making the like observations of Venus, for more than a century to come. The next transit of Venus will be in the month of December, in the year 1874, at the ascending node; and that will be succeeded by another, at the same node, in 8 years after it; then there will pass 122 years without a transit, which will bring it to the year 2004, in the month of June.

I shall now give the reader a short account of the parallax herein mentioned, and how the planets are affected thereby.

The horizontal parallax of the Sun is that angle at the Sun's center, which is included between two lines supposed to be drawn, one from the Sun's center to the center of the earth, the other from the Sun's

platform was seen to move very sensibly.—By this the latitude was finally determined. The Sun's meridian altitude, being taken for several days by this long stile, the latitudes thence found did not differ from each other more than 15 seconds.—At the time this was done, we had seen no account that a glass had been made use of, as here described; but since this went to the press, we learn from Dr. LONG's astronomy, that he found the latitude of Cambridge, in England, by the same method.

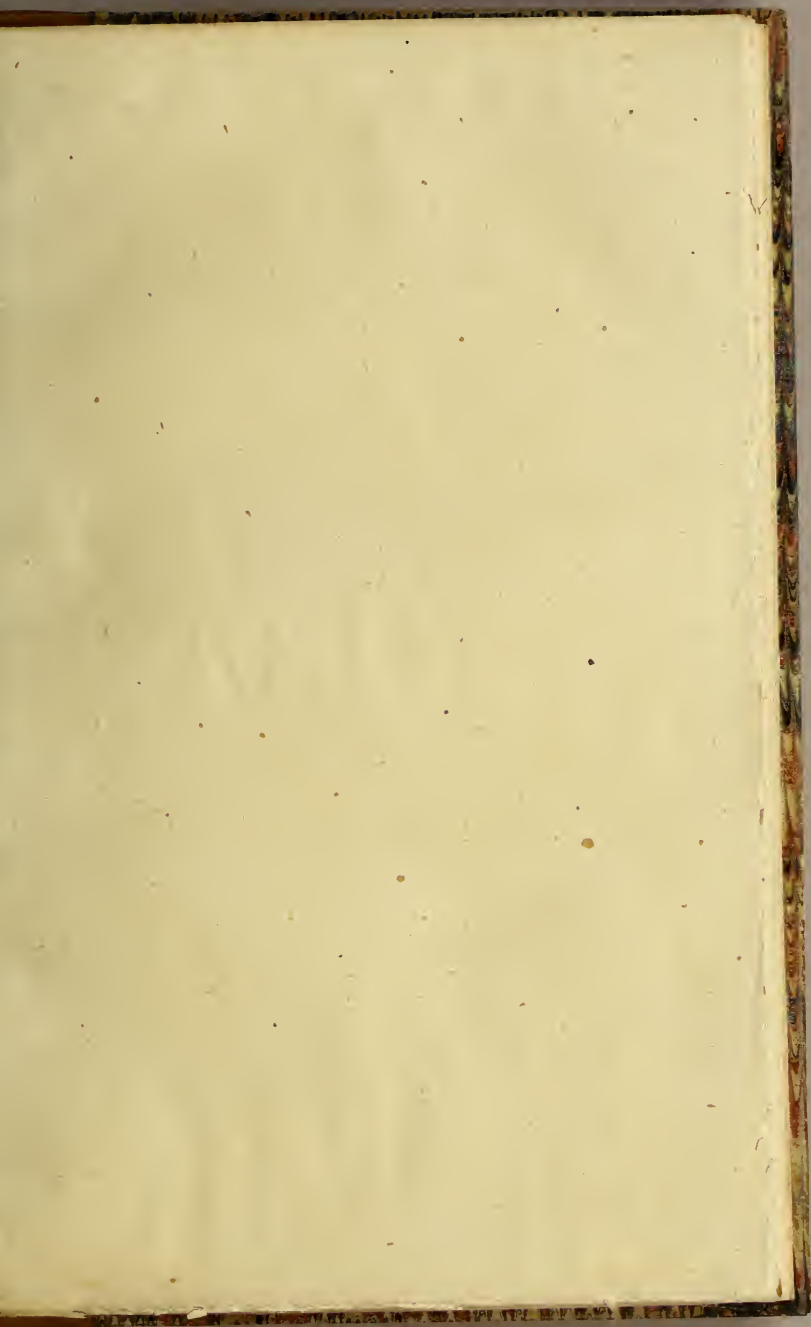
Sun's center to the surface of the earth. Or, in other words, it is the angle, under which the semi-diameter of the earth would appear to an eye, at the center of the Sun.—The way that parallax affects the Sun and Planets is, it makes them appear below their true places in the heavens, except they be in the zenith of the observer; in that case, parallax has no effect at all; and the reason is, because the observer is in that right line which joins the centers of the earth and planet. Parallax may affect the planets places several ways; as if the observer should view the planet upon a vertical, cutting the ecliptic at right angles; in this case, parallax will affect its place in respect to latitude only; but if the observer be situated in the plane of the ecliptic, it will then alter its place, in respect to longitude only; and if the planet be viewed in an oblique position, with respect to the ecliptic, parallax will affect its place both in longitude and latitude.—The horizontal parallaxes of the planets are to each other in a reciprocal proportion to their distances; that is, the planets which are nearest have the greatest parallax, and those which are most remote, the least.—Thence it follows, if two planets are viewed together, that which is nearest will appear just so much below the other, as what the difference of their parallaxes is.—The nearer a planet is to the horizon of the observer, the greater is its parallax, and in the horizon it is the greatest possible; and is then called the horizontal parallax.

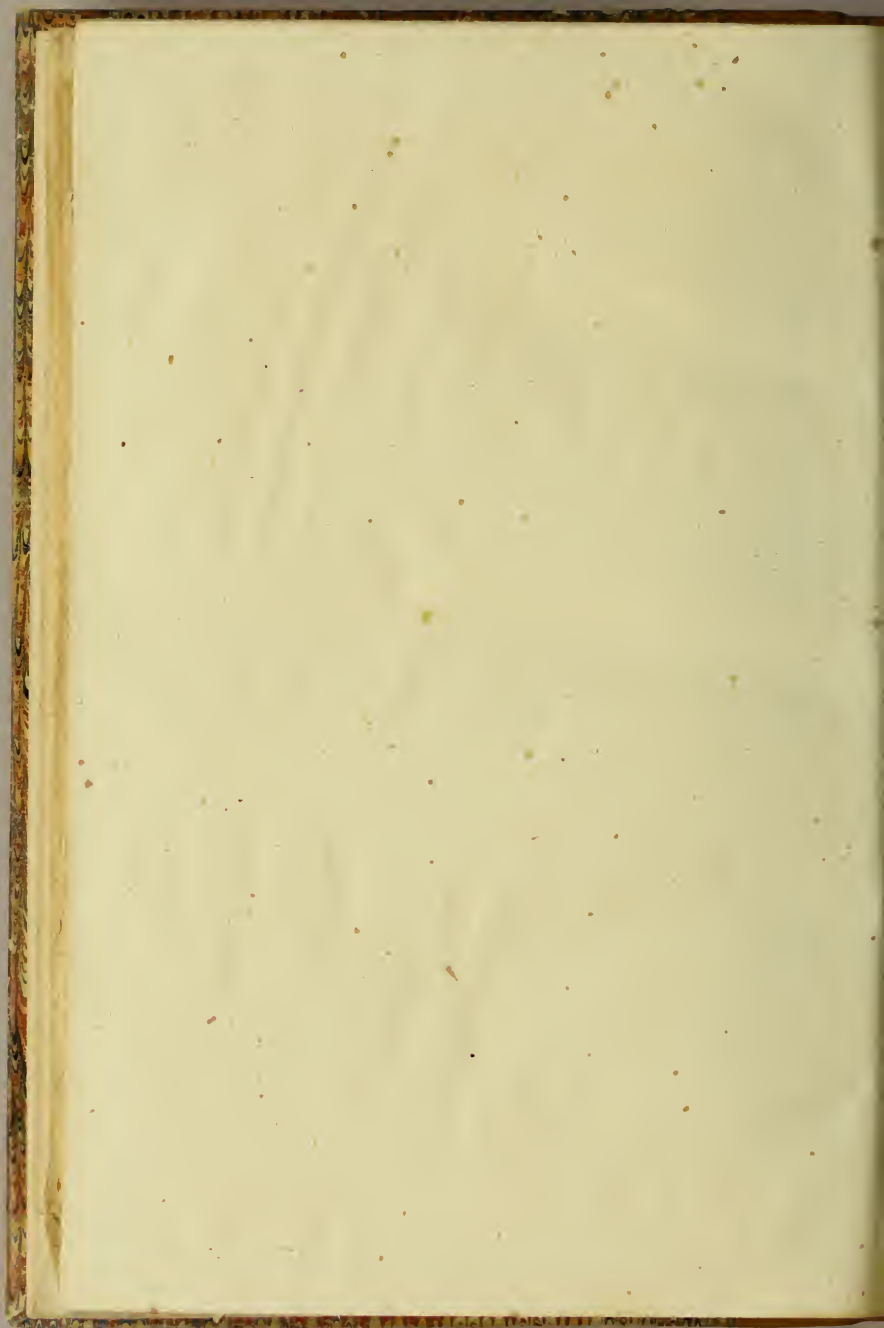
Hence comes the method of investigating the Sun's parallax, from observations of Venus on his disk. At the time of the transit, the third day of June, Venus was much nearer to the earth than the Sun was, and, of consequence, was much more affected

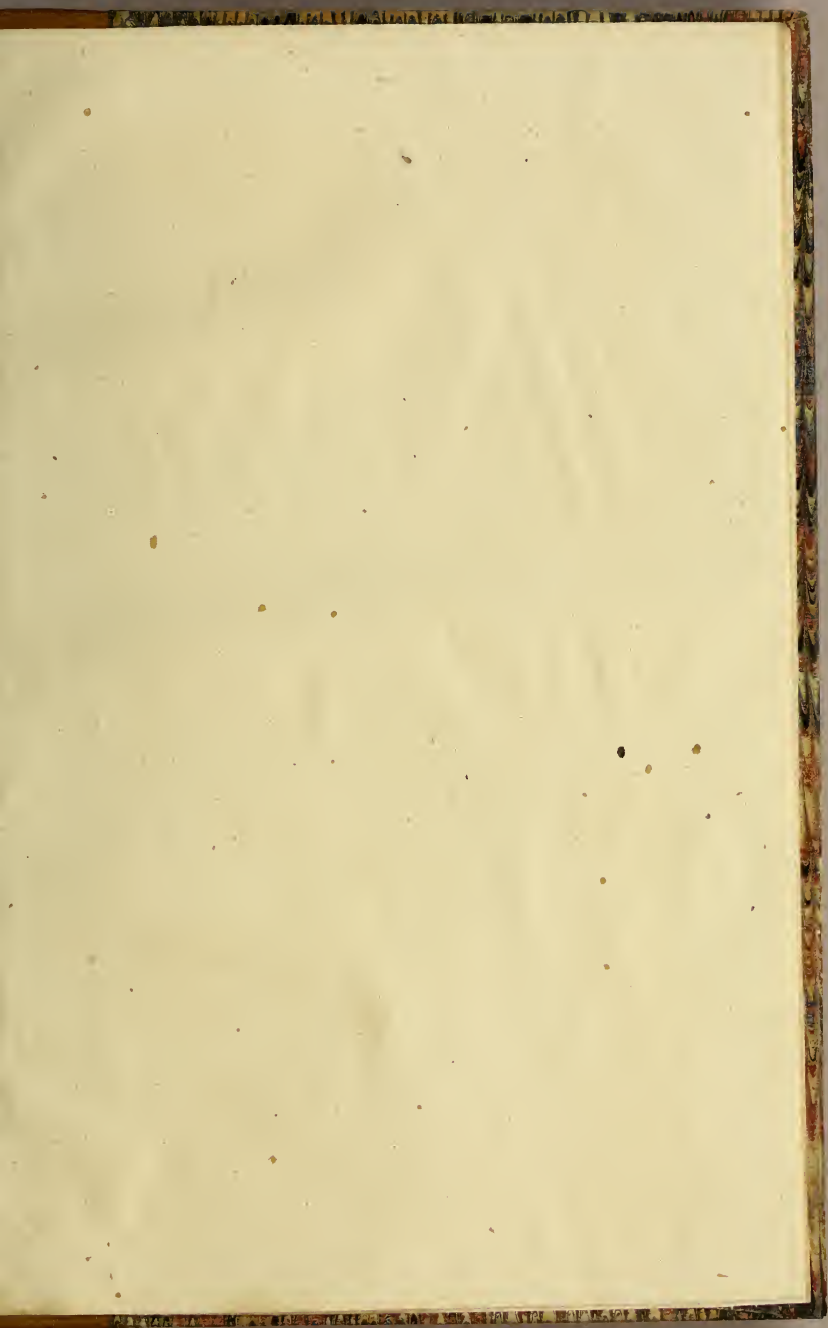
fects by parallax.—This effect was produced in a two-fold manner, in respect to us in the northern regions of our earth.—First, Venus was depressed upon the Sun, by parallax in longitude, bringing her to a conjunction with the Sun sooner to our point of view, than to a spectator at the center of the earth; in the second place, she was carried nearer to the center of the Sun, by parallax in latitude, thereby lengthening the transit-line; both which effects conspired to accelerate the time of first interior contact. Now to an observer in Great-Britain, parallax had a still greater effect, by what is said before:—That is, some minutes passed after the contact was formed to the observer there, before it was seen by us.—Now the difference of longitude, between the two places of observation, being accurately known, the effect of parallax, between the two places, is likewise known; for the difference of longitude, by these observations, will be considerably less than the true difference.

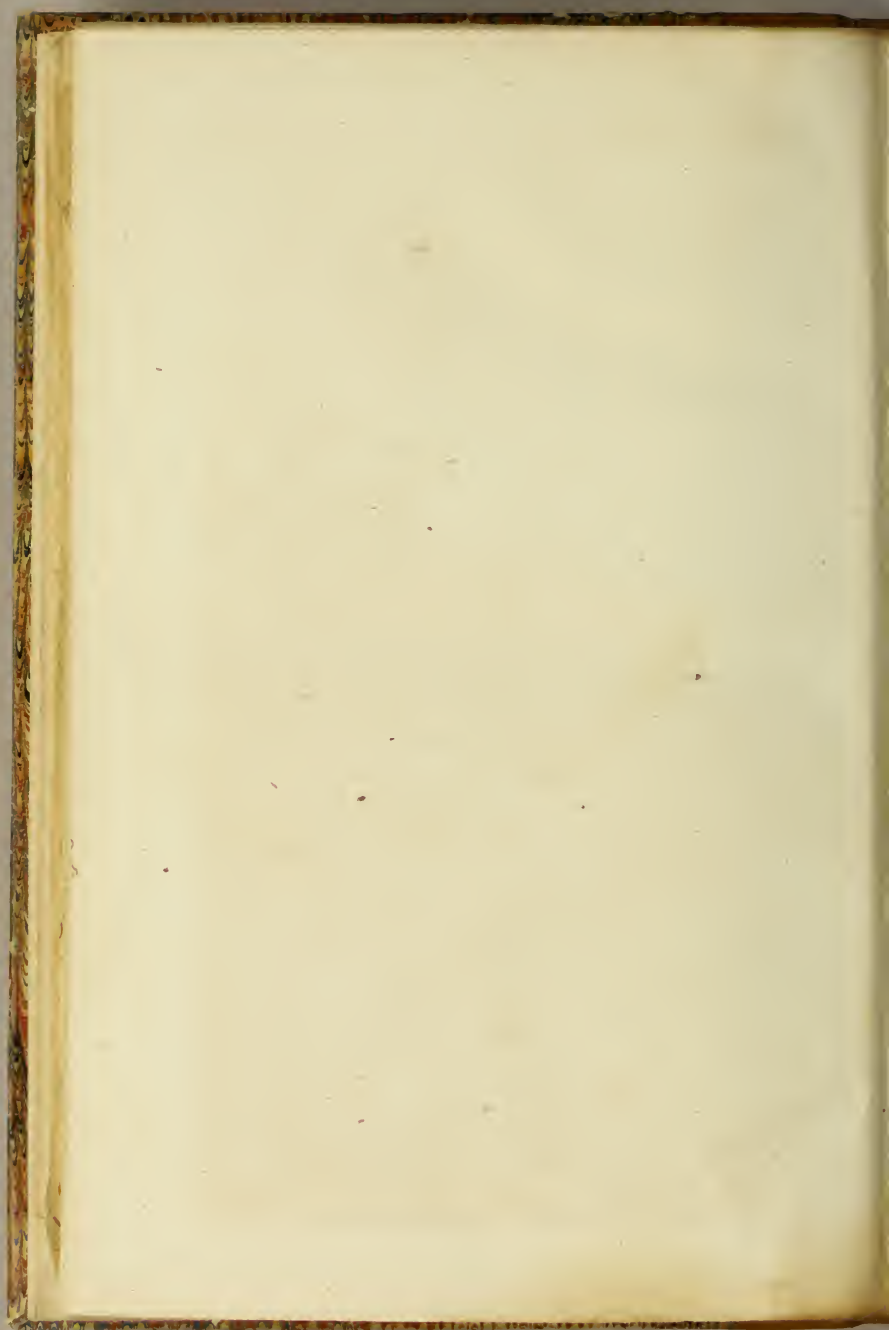
The method of calculating the Sun's parallax, from these observations, is by trial; the parallax will be supposed of that quantity, which the observations found it in 1761; hence the total effect of parallax, at each place of observation, must be computed; and if it should be the same as given by observation, it will prove the assumption to be just; but if, by observation, it should be greater or less than by calculation, the Sun's parallax will turn out to be greater or less in the same proportion.—When the Sun's parallax is known, the distance of the earth, and of all the planets, from the Sun, will be known likewise.

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