

VII. *An Account of an Improvement on the Terrestrial Globe, by Joseph Harris, Gent.*

THE Globe is justly reckoned very useful and instructive, both as a general Map, and also for explaining the first Principles of Geography, and the spherical Doctrine of Astronomy. By this Instrument it is easy to find the Length of the Days, and their Increase and Decrease, in all Places, and at all Times of the Year. But this is not usually performed in such a manner as at the same time to explain how these *Phænomena* arise from the Motion of the Earth, which is the principal thing Beginners especially should have in View: Nor can this be remedied, at least but in few Cases, as Globes are commonly fitted up; for the Axis and the horary Circle prevent the Brass Meridian from being moveable quite round in the Horizon, which it ought to be, and so indeed prevent the Globe from being universally useful, even in the common way of considering it.

It is now about Six Years since I removed this Impediment, by placing two horary Circles under the Meridian, one at each Pole. These Circles are fixed tight between two Brass Collars placed about the Axis, but so that they may be easily turned by the Hand when the Globe is at Rest; and when the Globe is turned, they are carried round with it, the Meridian serving as an Index to cut the horary Divisions. The Globe, being thus fitted, serves readily for solving of Problems in South as well as in North Latitudes,

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as also in Places near the Equator. But the chief Advantage gained by this Alteration, is, that the Globe is now adapted for solving of Problems upon the Principles of the *Pythagorean* System, or to shew how the Vicissitudes of Days and Nights, and the Alterations of their Lengths, are really made by the Motions of the Earth. To expedite this, I had the Brass Meridian at one of the Poles divided into Months and Days, according to the Sun's Declination, reckoning from the Pole. This being done, if we bring the Day of the Month to the Horizon, and rectify the Globe according to the Time of the Day, the Horizon will represent the Circle separating Light and Darkness, and the upper Half of the Globe, the illuminated Hemisphere, the Sun being in the Zenith.

While we view the Globe in this Position, we see the Situations of all Places in the illuminated Hemisphere, with respect to the Horizon, Meridian, &c. and by observing the Angles which the Meridians, cutting any Parallels of Latitude in the Horizon, make with the Brass Meridian, we have the Semidiurnal Arches of these Parallels respectively: And at the same time (if the Sun be not in the Equator) we see why the Diurnal Arches of the Parallels continually decrease from the Neighbourhood of the elevated Pole, till we come to the opposite Part of the Horizon. If we turn the Globe Easterly round its Axis, we shall see how all Places change their Positions with respect to the general Horizon, the Meridian, &c. by the Motion of the Earth round her Axis.

It yet remains to be shewed, how the annual Motion of the Earth in her Orbit, causes the Change of the Sun's Declination: This cannot be done by the Globe simply taken, but is very well shewed by the Instruments called *Orreries*: But to these their Costliness is an Objection, not mentioning others from a want of due Proportion in the things they exhibit. I had therefore an Instrument made, which consisted only of a round Trencher of Wood, a Circle of Brass upon the Face of it, and between these three Wheels of the same Dimensions and Number of Teeth: The innermost Wheel was fixed to the Wood in the Centre, the third had its Axis come through the brass Plate, round which was a brass Circle having a Socket making an Angle with it of $66\frac{1}{2}$ Degrees; in this Socket was fixed the Axis of a little Globe, having an Horizon about it, to represent the Circle separating Light from Darknes, the Sun being supposed to be in the Middle of the Instrument. While the brass Plate is turned round through the Scale of Months and Days expressed on the under Plate, the Axis of the *Terrella* is kept all the while parallel to itself, by means of the second Wheel placed between the two above-mentioned; and so the Change of the Sun's Declination, or rather, which comes to the same Purpose, the different Position of the Equatorial Axis with respect to the Circle separating Light and Darknes, is exhibited all the while the Earth is going round in her Orbit. By placing the Axis of an ivory Ball having one half blacked, upright in the middle of the Circle which carries the *Terrella*, this little Instrument will serve to explain the *Phænomena* of the Moon's *Phases*.

Having thus learned the Cause of the Sun's Change of Declination, we may now have recourse to the larger Globe, and moving it according to the different Seasons, we may observe the *Phænomena* thence arising more distinctly.

For a graduated Meridian, I had a flexible Slip of Brass divided into Degrees, which I could fix occasionally in the two Hour Circles; and upon such another Slip I had a Scale of Months, answering to the Sun's Declination, reckoning both ways from the Equator. By means of this graduated Meridian, the Globe being rectified according to the Sun's Declination, if we gently turn it round its Axis, we may presently find the Time of the Sun's rising or setting in all Places, by observing the Hour Circle, when the several Degrees of Latitudes respectively come to the Horizon.

After the same manner, if the Globe be elevated to any particular Latitude, and the Meridian having the Scale of Months be fixed in its Place, we may soon find the Time of the Sun's rising or setting in that Latitude throughout the Year, by observing the Hour Circle when the respective Days come to the Horizon. This Method is not only useful on the Account of its being expeditious, but also because it intimates, why at the same time the Days are of different Lengths in different Latitudes, and in the same Latitude at different Times of the Year.

The Globe-makers might save us the Trouble and Expence of having these graduated Slips of Brass, by dividing some Meridian, which goes over the least Land, into Degrees, which might be marked with round Dots, and every Tenth numbered. The Scale

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of Months might be engraved upon some other Meridian. It would be of Use likewise, if the Parallels and Meridians of every Degree between the Tropics be drawn in faint Lines, which I think might be done without obscuring the Map.

Parallel to the Horizon, and 18 Degrees below it, I had a Circle fixed for shewing the Limits of the Twilights: This is useful, as it shews at one View the State of the Twilights, and also why they do not lengthen or shorten, as the Days do. The Semi-circle of Position is a thin narrow Plate of Brass as usual, but made so that its Axis is moveable quite round the Horizon. I had also a narrow flexible Slip of Brass, which might be girt round the Globe in any Position, and so be made to represent any great Circle whatsoever: This occasional Circle may be instructive to Beginners on several Occasions.

If the principal Horizon be of Wood, or made so as to obscure the Globe below it, the Twilight Horizon had best have small Feet of a proper Length fixed so that it might stand in its proper Place upon the other, occasionally; then inverting the Position of the Globe, the same thing will be shewed as before.

The farther Use and Application of these Contrivances to different Projections of the Sphere, &c. will be obvious to those who are acquainted with these things; and without dwelling any longer upon this Subject, it may seem, that I have already said more than was needful in this Place. But the Globe being in every-body's Hands, and in reality a very useful, entertaining and instructive Instrument; I

thought an Attempt to render it more so, would not be altogether useleſs, or yet unworthy the Notice of the Curious.

VIII. *A new Method of improving and perfecting Catadioptrical Telescopes, by forming the Speculums of Glaſs inſtead of Metal.*
By Caleb Smith.

THE Telescope is deſervedly reckonèd one of the moſt excellent of all the Inventions of the Moderns; ſuch noble and uſeful Discoveries have been made by means of this admirable Inſtrument, and are ſtill to be expected from its further Improvement, that many of the moſt eminent Mathematicians have employed their utmoſt Skill and Industry to bring it to Perfection.

The Imperfections of Telescopes are attributed to two Cauſes; to wit, The Unſuitneſs of the Spherical Figure to which the Glaſſes are uſually ground, and the different Refrangibility of the Rays of Light.

The firſt of theſe Defects only, was known to the Writers of Dioptrics, before Sir *Iſaac Newton*; for which Reaſon (as he informs us himſelf, *Opt. Lect.* 1, 2.) they “ imagined, that Optical Inſtruments
“ might be brought to any Degree of Perfection,
“ provided they were able to communicate to the
“ Glaſſes, in grinding, what Geometrical Figure they
“ pleaſed; to which Purpoſe various Mechanical
“ Contrivances were thought of, whereby Glaſſes
“ might be ground into Hyperbolical, or even Para-
“ bolical,