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Iconantidiptic Meridian

«Il Nuovo Cimento»
Journal of Physics, Chemistry and their applications
in Medicine, Pharmaceuticals and Industrial Arts
Volume I - 1855
(p. 44-50)

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Dent's Dipleidoscope has been much praised for the simplicity and precision with which it helps us to identify the instant of the passage of the sun at the meridian. I saw this ingenious instrument for the first time in August of 1844 while visiting the famous Enke in Berlin, and in examining its construction - which consists of two plane mirrors inclined one against the other and covered with a sheet of glass with faces parallel so as to form a triangular prism, empty inside - I remembered an idea I had had years before of a double image telescope to be used on a transit instrument and described in the Acts of the Italian Society dei Quaranta. However I noted immediately that the meridian of the famous watchmaker of London could be more solidly and advantageously constructed with a single isosceles glass prism. The thought of using a glass prism had also been considered by the illustrious Prussian Astronomer, but since the position which he had planned to give the prism was different from that which I planned, he had already realized, through a simple calculation, that his plan would not have rendered a precise result.

In that same year the Meeting of Scientists was held in Milan and there I mentioned the principle of my prism meridian, giving myself time to explain it in more detail in another occasion. Ten years have gone by and this instrument is little known. I therefore believe that, even if very late, the description which I am about to offer can guide some optician or mechanic to construct it and thus provide anyone who may need it an easy way to regulate clocks and chronometers with great precision which can be improved upon only by using costly instruments such as those the astronomers use.

My little instrument, which I call iconantidiptic meridian (*table I. fig. 2*) is formed by an isosceles triangular glass prism ABCDE with right angle in E. On the side of the right angle it fits into a brass niche of about half of its size and it is firmly fixed there with cement. The jutting base of the niche is fixed with two screws over the oblique section of the metal cylinder GG along which the collar H which supports arm I can rise or descend. A small achromatic telescope L rotates on a horizontal pin attached to this arm.

Since the optical axis of the telescope is next to and parallel with the plane of the large face of the prism, ABCD, a segment of the objective remains covered by the prism opposite. Thus the light arriving from any faraway object arrives in two different ways to the objective: a part of it passes directly, and the other passes after having encountered an internal reflection on the large face of the prism. For this reason two images of the object are produced in the telescope, but opposed to each other in such a way that if one image moves from right to left, the other moves from left to right.

So if the reflecting face of the prism is appropriately situated on the plane of the meridian and the telescope is turned towards the sun when it is nearing the time of its passage, two symmetrical images of the sun can be seen. They move towards and go over each other and then move off in separate directions. The moment of the overlapping of the two disks would in this case be true midday, which as you know can be determined with greater precision by taking into account the instants of contact of the edges of the sun when they attach and detach during the observation.

To facilitate the stable and exact positioning of the meridian, the end of cylinder G is fitted onto a large circular base M, which rotates over a sturdy metal plane N, and it can be attached to the same with two screws P. In the centre of the underlying plane there is a huge screw with a large head with which it can be bolted, for example, onto a trunk of a column or on a windowsill, turning the other three screws Q at the same time as needed to bring the metal plane to a horizontal position.

The horizontality of plane N consequently brings face ABCD of the prism to a vertical position, and I will shortly explain how this can take place. The only other thing that remains to be done is to rotate cylinder G onto its base until the reflecting plane coincides with the meridian, and this can be easily obtained by using the time indicated by a good chronometer. Once the instrument has been fixed for the first time in this way, it can be further corrected as needed in the following days.

I said that the horizontality of base M leads consequently to the verticality of the reflecting plane of the prism because this condition has to be satisfied by the maker while constructing the meridian. To verify it, one only has to suspend a plumb line a few meters away in the direction of plane ABCD and look at it with the telescope or with the eye placed near the corner BD. If this line, seen at the same time directly and by reflection, presents the two images as coincident or parallel, this will be a clear sign that the large face of the prism is in a vertical position. Because if, on the other hand, the two images of the plumb line were inclined one upon the other, this would indicate the prism’s obliqueness, which can be resolved using very thin metal strips placed on the base, or better, by filing away the minimum quantity of metal from the support plane until a perfect rectification of the instrument is obtained.

The most favourable inclination to give to the elliptical section of cylinder G would be that determined by the height of the pole in the country where the meridian will be placed, and which would cause the corners of the prism to be parallel to the earth’s axis. In this position prisms of a sizeable length can be employed; they could not be used if placed vertically over a horizontal section of the cylinder, since in that case they would not offer enough width to the telescope to observe the sun from one solstice to another.

But the telescope, as mentioned above, moves as well with the ring or collar H. Thanks to the large movement a fairly short prism can transmit the rays of the sun at its greatest distances north and south of the equator to the objective lens. To effect this the telescope simply needs to be placed higher in the winter and lower in the summer. Moving the telescope does not disturb the rectified position of the meridian, which depends only on the immobility of the reflecting plane of the prism.

To make the telescope arm rise or fall one has to unscrew button R, which opens the collar. This operation may take away the parallelism that has to approximately exist between the optical axis and the meridian plane: but it can be easily put back into the right place given that the two solar disks overlap in the middle of the ocular field only when the requested condition is fulfilled. A small difference in parallelism, which anyway would not cause a noticeable error in the result, would cause one to see the two solar disks overlapping outside the middle of the ocular field, and if the difference were great, only one disk would be seen, which would not answer to the aim of knowing midday.

Comparing the construction of the Dipleidoscope with that of the iconantidiptic meridian, I believe that the latter is preferable for many reasons, principally for the greater illumination with which objects are seen in it. In the Dipleidoscope the two mirror reflections weaken the incident light less than the loss which this light suffers for the single reflection over its sheet of glass, and since the two images have to be equally illuminated, this condition is obtained by bringing the telescope laterally until it has received as much light from the mirrors as is reflected from the plane glass towards the entire aperture of the objective lens. Now it is known that a plane glass with parallel faces with an incidence of 45 degrees (the average position which the telescope is presumed to have) leads to a loss of $\frac{9}{10}$ of the light emanated by the object, and for this reason the two images which are formed in the Dipleidoscope each contain only one tenth of the light which it receives.

In the reflection of the prism of the iconantidiptic meridian there is a loss of light as well, but it is much less, not reaching $\frac{1}{5}$. For this slight decrease here, too, one must present the objective in front of the prism in a way that the relationship of the corresponding segment to the segment which receives the light is 5 : 4, and this in order to render the two images of an equal intensity, each of which will contain $\frac{4}{9}$ of the incident rays. One can therefore see how it is very nearly true that using the same telescope or two equal telescopes the clarity of the images deriving from the Dipleidoscope is in a $\frac{1}{10} : \frac{4}{9}$ relationship to the clarity of the images coming from the new meridian, which is to say that the latter are almost four times and a half more luminous.

This abundance of splendour not only extends the use of the iconantidiptic meridian to the transit meridian of a greater number of stars which in the other would be invisible, but it is also very useful in the transit of the sun, projecting its two disks over a white plane instead of observing them in the telescope with a helioscope. The images brought into the darkened room in this way are well-defined and large enough to be able to recognize spots and to determine their difference of right ascension and declination relative to the centre of the sun with a great deal of precision. What is more, with the projection of the images many spectators can assist in the meridian passage, and by comparing the respective observations realize that the differences of the results ordinarily agree within the limits of some tenth of a second.

Stability is also an advantage of the meridian I have described. If the prism is solidly set with mastic in its niche, it constitutes a single sturdy and symmetrical body with the cylindrical support; even the great differences of temperature from winter to summer do not disturb its position, and I have many years experience during which an iconantidiptic meridian which I mounted at the observatory of the Museum has conserved its first rectification. It is presumable that a similar immobility could not be maintained by the Dipleidoscope, especially if it were constructed in a large size, since the adjustment of its mirrors, carried out with pressure screws, can be noticeably disturbed by variations of hot and cold.

As for duration or conservation it cannot be doubted that the glass prism will be less easily bothered by air and humidity than is the layer of tin of the two reflection mirrors: and it must be noted that the heat develops vapours inside the Dipleidoscope which deposit little by little on the surface of the mirrors and on the second surface of the glass plane, as I have seen happen, so that the reflected image is misty and badly defined. In this circumstance one has to take the Dipleidoscope apart in order to clean the internal surfaces of the glasses; this inconvenience, which requires one to rectify the instrument anew, will never occur with the prismatic construction.

I cannot fail to mention that should one wish to observe the passage of the circumpolar stars, the iconantidiptic meridian can be used without altering its fixed position. The telescope has only to be turned to the part opposite the prism, that is, instead of the objective lens remaining against corner AC, it should be brought against corner BD, so that the vision is done in an inverse way. Then placing a small basin of mercury on the northern side, and turning the telescope towards it, the passage of the circumpolar stars will be seen by reflection in the artificial horizon without very much loss of light, since the mercury reflects it for more than three fourths of its totality.

Lastly, it will not be out of place to mention here that a glass isosceles prism mounted conveniently in front of the fissure of a meridian as is made in tall closed buildings, such as churches, would render the observation of midday more exact, with great savings, because the introduction of the two solar disks moving in opposite directions would make tracing the horizontal line on the floor superfluous.