The Dent Dipleidoscope And The Iconantidiptic Meridian

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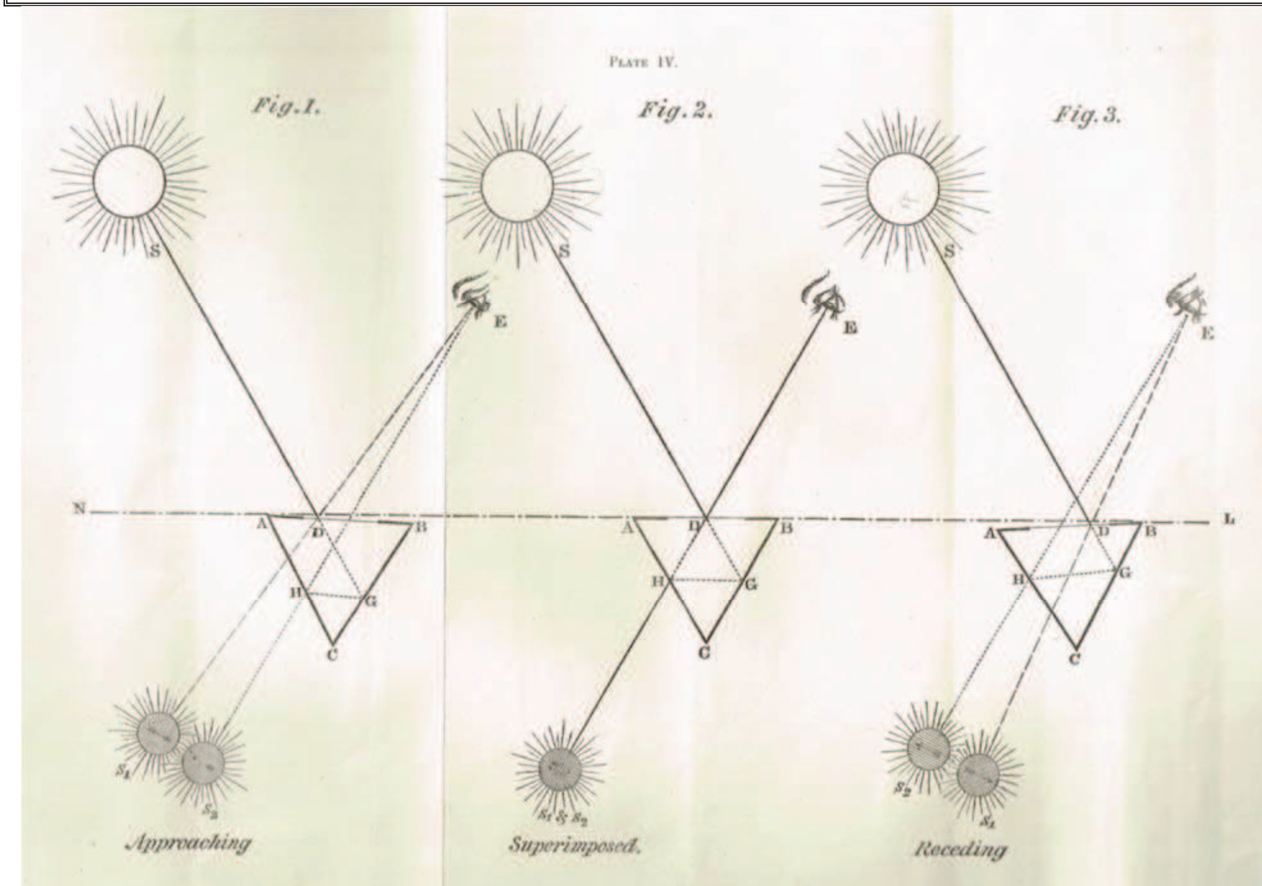

Fig. 1 Principle of Operation of the Dent Dipleidoscope - Manual of 1875 New Edition

The Dent dipleidoscope is an optical instrument which can produce two images of a celestial body (Fig.1). As the body moves, the two images move in opposite directions and become coincident when the celestial body transits the meridian. The reason for the invention of the dipleidoscope was the need to precisely determine the timing of the meridian transit of celestial bodies for an affordable price when compared to that of the transit telescopes favored by astronomers.

The original 1778 concept for such a device is attributed by Italian astronomer Giovanni Battista Amici to French astronomer Edme-Sébastien Jeaurat (Ref.1). Amici named the instrument the "iconantidiptic meridian". According to Amici, all attempts at implementation failed because it was difficult to produce the two images with the same magnification and to combine them adequately using lens optics.

In 1821 Amici published his novel idea of using an isosceles glass prism for the generation of the second image in a telescope (Ref.1) but he didn't mention having implemented it. His concept was addressed to astronomers who probably preferred the precision of the transit telescope and at that time there was no urgent need for people to synchronize their watches. A description of his idea will be presented later on as we get to the historical period when he actually implemented it.

The railroads connection

The railroads were introduced in England, Continental Europe and North America during the first half of the 19th century. As the networks of rail lines started expanding it became important to synchronize operations both for making compatible the timetables of the different railroad companies and in order to avoid accidents. For the same reason the railroad companies were also instrumental in the creation of the time zones in the United States. Since the development of telegraph networks lacked behind that of the railroads, several systems of watch synchronizing were adopted in different countries. American railroad companies required the engineers to have their pocket watches periodically verified by a certified watchmaker who used a marine chronometer as a reference which he in turn took to a telegraph station to calibrate periodically. The French depended on their great tradition in gnomonics to set their pocket watches and had a vertical sundial with an analemma at each railroad station. Station chiefs were instructed what time correction to apply corresponding to their local longitude offset. This method was used as late as the year 1900.

The development of the Dent dipleidoscope

The British were also considering the use of sun transit for this purpose. Edward John Dent, a London instrument maker, was working in the 1830s on "a device using shadows" (what are these called? I forget!) that would allow people to set their watches based on the transit of the sun but he concluded it would not be accurate enough. He was approached by a lawyer named J.M.Bloxam who had the idea of using an equilateral glass prism for detecting the transit of the sun at noon. They formed a partnership and in 1843 Dent was issued a patent for a device they called the dipleidoscope which in Greek means "double image viewer". The device is extensively described in the literature and on the net (Ref.2 & 5). A very nice *pdf* presentation, courtesy of Larry McDavid, is included in this issue as a digital bonus.

The glass prism proposed by Bloxam had the disadvantage of higher cost as well as the fact that the surface reflected beam was an order of magnitude more intense than the internally double-reflected one. The principle of the Dent dipleidoscope is pictured in Fig.1. One image of the sun is produced through an external reflection on the surface of a colored glass window, while the second image is produced after internal reflections on two mirrors. These three components define an equilateral prism. The internally reflected beam is much more intense than the surface reflected beam, so the colored glass filter attenuates it and the two beams become comparable in intensity and are of different colors. The difference of one reflection causes the two images to move in opposite directions. As we'll see, the Amici device produced the inversion of image direction also due to a difference of one reflection. The product was a success because, unlike Amici's proposed device, it met a real need at the right time. Production of the Dent dipleidoscope started in 1843 and continued for some 25 years (Ref.4). The advent of telegraphic, telephone and radio time signals made dipleidoscopes redundant.

Various implementations of the Dent Dipleidoscope

As can be seen from the middle drawing of Fig.1, at coincidence, the incoming beam from the celestial body has to arrive from a direction parallel to the AC mirror, while the two resulting beams exit the dipleidoscope in a direction parallel to the BC mirror. When the incoming beam has a downward direction relative to an imaginary plane perpendicular to the prism edges, it will also exit the device at the same downward angle. The same happens for an upward direction. Since the dipleidoscope is mostly meant to observe the sun, we have a range of +/- 23.4 deg. of declination relative to the equatorial plane to be concerned with. The dipleidoscope will operate correctly if a line parallel to the edges and sides of the prism (that we can call its axis) will be coplanar with the local meridian. In order to keep the length of the device as short as possible, the extreme incidence angles at the solstices must be kept equal which will happen when the axis of the device is parallel to the NS axis of the Earth.

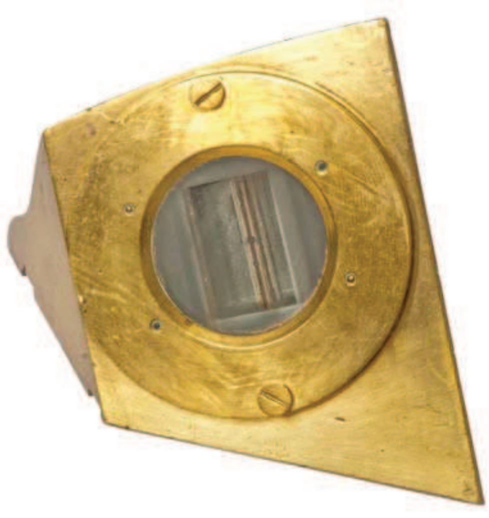

Fig. 2a Dent Dipleidoscope

Originally, the dipleidoscope was manufactured for specific latitudes, its base had to be on a horizontal surface and it was rotated with the prism axis in the meridian plane (Fig.2a).

More sophisticated models could be adjusted for latitude so the axis of the prism remained aligned with the NS axis of the earth, while the device could be rotated around the axis and the transit of a different meridian could be selected in order to set the watch at a chosen time rather than solar noon (Fig.2b). A magnetic compass was added for alignment and a telescope allowed better precision *but was not essential for operation*.

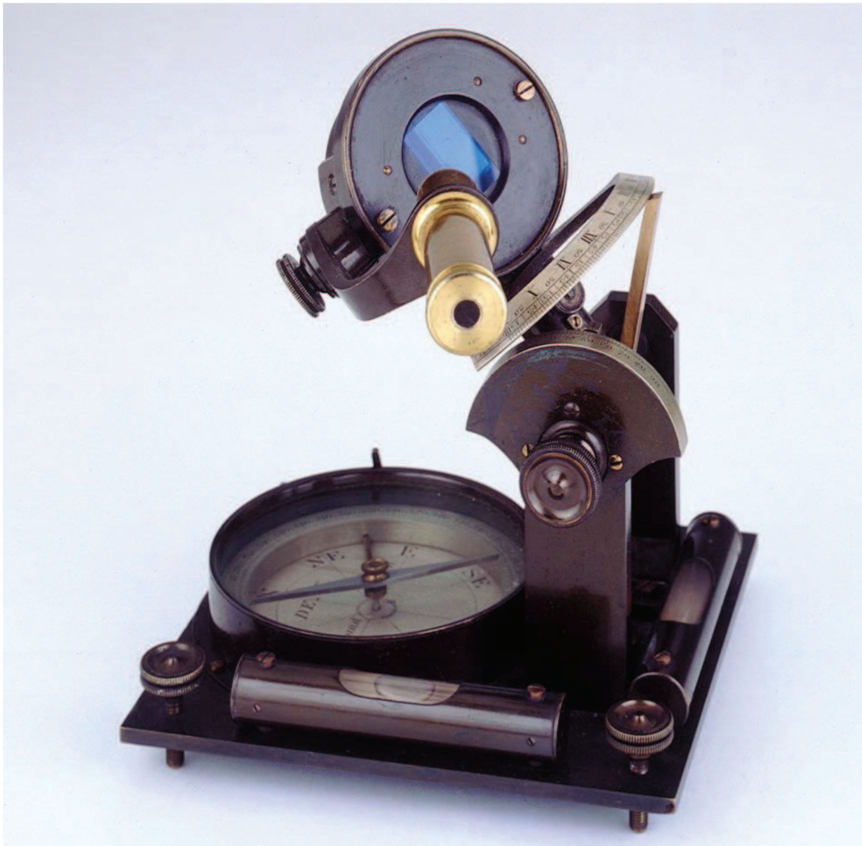

Fig. 2b Dent Dipleidoscope Credit: National Maritime Museum, Greenwich, London

The reason a telescope was not a must is that the two image wavefronts were superimposed and the lens of the human eye did the focusing on the retina. An original implementation of the dipleidoscope allowed, through the addition of a lens, the projection of 2″ diameter images on a screen (Fig.2c, Ref.7). This device used a mirror coated with a film of sulphide of lead instead of using a colored filter in order to match the beam intensities.

Fig. 2c A Projection Dipleidoscope

Giovanni Amici evaluates the Dent dipleidoscope

In 1844 while visiting the astronomer Johann Franz Enke in Berlin, Amici had the opportunity to see the Dent dipleidoscope (Ref.3) and recalled he had described a similar concept in an 1821 article (Ref.1). His concept relied on the use of an isosceles prism that intercepted part of the light going into a telescope. The intercepted light suffered two refractions and an internal reflection as shown in Fig.3 the prism acting

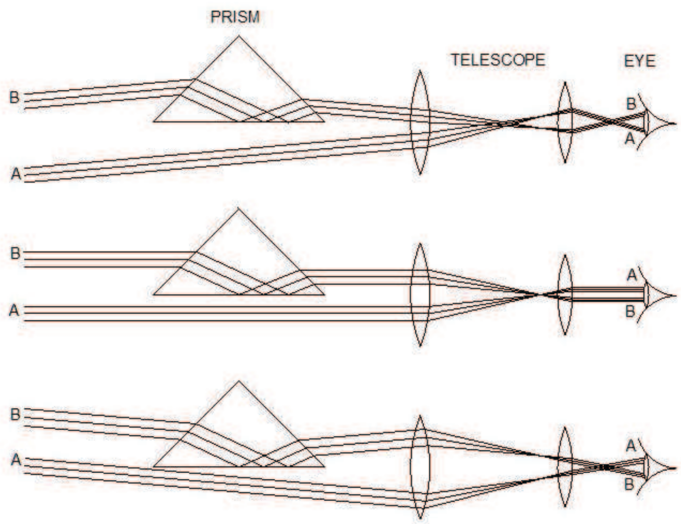

Fig. 3 Principle of operation of the Amici "iconantidiptic meridian"

as a mirror parallel to the telescope axis (Ref.6). As in the Dent device, one beam has one reflection more than the other.

Amici suggested his device as a separate unit that could be attached to a telescope and be removed as needed.

This is how Amici described his own concept in his paper of 1855 (Ref.3a & 3b):

"Since the optical axis of the telescope is next to and parallel with the plane of the large face of the prism, _____a segment of the objective remains covered by the prism opposite. Thus the light coming 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."

The 1855 paper mentions just one unit he had built and compared its advantages relative to the Dent device. One comment he made was that his device had a higher light throughput, but since the dipleidoscope was intended to observe the sun transit through a filter, this was a moot point. He was again thinking of astronomical applications when at that time the public was interested in setting their watches by the sun.

Amici missed a very important point: his device couldn't be used without a telescope to combine the two images, while Dent's dipleidoscope could be watched either directly or with an optional telescope. The reason for the difference is that the Dent unit outputs wavefronts that are superimposed and all one needs to do is to intercept the beam with the eye's pupil, while Amici's unit outputs two spatially separate sets of wavefronts that need to be combined in a telescope before reaching the eye (Fig.3).

Fig. 4 Amici's iconantidiptic meridian (Credit: Museo Galileo, Florence)

Some of Amici's "iconantidiptic meridians" can be found in museums. There is one at The National Observatory of Athens, Greece, made by Georg Simeon Ploessel, an optical instrument maker from Vienna. Another one (Fig.4) is at The Museo Galileo in Florence, Italy.

So, who invented the dipleidoscope?

Perhaps this is asking the wrong question. However, if the question is: *Who first proposed the concept of a feasible and affordable meridian transit device with applications in astronomy?*, then the answer is obvious, Italian astronomer Giovanni Battista Amici. But, if the question is: *Who was first to invent and deliver a meridian transit device, for people to synchronize their activities?*, then the answer is just as obvious: two Englishmen, James Mackenzie Bloxam and Edward John Dent.

And finally a hypothetical question: *If the Dent dipleidoscope hadn't been invented, might Amici ever had thought of producing a device to help people catch the train on time?* We'll never know....

References:

Ref.1 – Gio. Battista Amici, "Memorie di Matematica e di Fisica della Società Italiana delle Scienze", Vol. XIX (1821) pp.113-120

Ref.2 - A Description of the Dipleidoscope or Double-reflecting Meridian and Altitude Instrument by Edward J. Dent, Eighth Edition, 1867

https://books.google.com/books?id=9QlbAAAAQAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Ref.3a - Giovanni Battista Amici, Iconantidiptic Meridian, «Il Nuovo Cimento» Journal of Physics, Chemistry and their applications in Medicine, Pharmaceuticals and Industrial Arts, Volume I – 1855, (p. 44-50). http://gbamici.sns.it/eng/pdf/Iconantidiptic%20Meridian.pdf

Ref.3b - http://gbamici.sns.it/eng/strumenti/iconantidiptica.htm (contains the drawing mentioned in Ref.3a)

Ref.4 - https://en.wikipedia.org/wiki/Edward_John_Dent

Ref.5 - http://www.oasi.org.uk/Telescopes/Dipleidoscope/Dipleidoscope.php

Ref.6 – E. Hecht & A. Zajac: Optics p.153 (describes the astronomical telescope with infinite conjugates)

Ref.7 - Sir Howard Grubb: A New Form of Dipleidoscope - The Scientific Proceedings of the Royal Dublin Society, pp.140-142. (This reference courtesy of Fred Sawyer)

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