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PRECISION ASTROLABE

Portuguese Navigators
and
Transoceanic Aviation

by

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The Smiths Model KSH-0205 is particularly interesting in that it incorporates a "Twilight Facility", introduced in the early 1960's. The modern successor to the sun compass designed by Bumstead for Byrd back in the mid-1920's, this Polaroid analyzer is primarily intended as an aid to polar navigation. Its incorporation in the Smiths periscopic sextant closes the circle of Western European astronomical navigation which began with the Norsemen.

The sagas of old tell of the use by the Norsemen of a *sólarstein* or "sun-stone". Scholars were long perplexed by the exact use to which these stones were put; one theory held that they were used for setting fires, like a lens. And then true serendipity put in an appearance with a vengeance.

In the 1966 number of the Danish archaeological journal *Skalk*, the archaeologist Thorkild Ramskou published an article on the art of navigation of the Norsemen. [14] He told of the sun-stone but was unable to state exactly what it was used for. He did add that it seemed to be an instrument which, in cloudy weather, could show the position of the sun ("men der synes at vaere tale om et instrument, der i overskyet vejr kunne vise, hvor solen stod").

SAS's chief navigator at its Copenhagen base, Mr. Jörgen Jensen, had a ten-year-old son who was an archaeology enthusiast and read *Skalk*. The boy told the father about the *sólarstein*, and the father instantly recognized that the sun-stone must have been identical in function with the Kollsman Sky Compass which SAS navigators used regularly when flying in high latitudes where neither di-

[14] Thorkild Ramskou, "Ret Kurs", *Skalk*, Aarhus, No. 6 (1966), 27-29.

rectional gyro nor magnetic compass functions properly. An SAS engineer, Poul Thygesen, also noted the identity in function. Both Jensen and Thygesen independently called Ramskou's attention to the Sky Compass, also known as a "twilight compass".

This instrument, developed for the U. S. Navy in 1948, depends upon the principle of the polarization of light first noted by Erasmus Bartholinus in Denmark in 1669. It is used for the determination of compass error in polar regions when the sun is near the horizon but obscured by clouds, or else lies just below the horizon as during the long twilight which often lasts for several hours if not all night. The only requirement is that the zenith be clear.

The Kollsman production model is similar in outward appearance to the Kollsman periscopic sextant. Although a quite separate instrument, it makes use of the sextant mount.

In order to determine the true heading of his aircraft, the navigator sets the lubber's line on the mount to the precomputed true azimuth of the sun, just as he would with the periscopic sextant. The problem at this point, however, resides in the fact that sight reduction tables like H. O. 214 and H. O. 249 do not provide for altitudes below a certain minimum. As the Sky Compass may on occasion be used when the sun's altitude is below that minimum, older tables such as H. O. 211 must be used to precompute the azimuth. [15] The task of precomputation is thus rendered more complicated.

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[15] H. O. 211, first published in 1931, is entitled *Dead Reckoning Altitude and Azimuth Table*. Familiarly known as "Ageton" after

The navigator next rotates the analyzer slowly to achieve a "Match" in accordance with the instructions which accompany the instrument. By so doing, he in effect analyzes the sun's rays passing overhead. He now ascertains that the Sky Compass is level by checking the position of its bubble and, finally, reads the true heading of the aircraft against the vertical line of the reticle inside the viewing piece, as with the periscopic sextant.

Although designed for the long twilights of the polar regions, the recent increase in aircraft speed has created long twilights in other regions and hence an additional employment for the Sky Compass. If a high-speed airplane flying from east to west in temperate regions enters a twilight zone, its very speed prolongs the period of twilight. As the sun is no longer visible, and stars and planets are not visible either because of the brightness of twilight or because of cloud cover, the Sky Compass proves invaluable for accurate heading checks.

The newer Smiths periscopic sextant with Twilight Facility provides the navigator with a dual-purpose instrument. When he uses the Twilight Facility, he first sets the sextant altitude at 70°.

To return to Ramskou: the Danish archaeologist naturally set about at once to look for a Scandinavian stone whose physical properties would correspond to those of the Polaroid screen in the Sky Compass. He found it in cordierite, a transparent crystal which "turned from yellow

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its designer, it is no longer available. The new H. O. 229, *Sight Reduction Tables for Marine Navigation,* will fill the gap. Indeed, because of its importance for polar navigation, the first volume to appear is actually Vol. 6 (1970), covering latitudes 75°-90° inclusive.

to dark blue whenever its natural molecular alignment was held at right angles to the plane of polarized light from the sun".

SAS extended to Ramskou the kind of courtesy TAP has extended to the present writer. He was able to experiment in a DC-8 en route from Söndre Strömfjord in Greenland (66° 58′ N, 50° 57′ W) to Copenhagen. He discovered that he could determine the azimuth of the sun to within 5° and provided one additional piece of evidence to support the thesis that the Norsemen were far more sophisticated astronomical navigators than is generally supposed. [16]

BUBBLE SEXTANTS FOR MARINE USE

Bubble sextant manufacturers have endeavored to keep the needs of marine navigators in mind, although members of this guild are far less appreciative of the manufacturers' efforts than are the air navigators.

In about 1934, Henry Hughes & Son placed on the market the "Gothic Sextant", available with a detachable "Booth Bubble Artificial Horizon Attachment". Kelvin

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[16] Thorkild Ramskou, "Solstenen", *Skalk*, No. 2 (1967), 16-17, and *Solstenen: Primitiv Navigation i Norden för Kompasset* (Copenhagen: Rhodos, 1969). See also Anon., "Navigation: Magical Stones of the Sun", *Time*, July 14, 1967.

The Polaroid Corporation in Cambridge, Massachusetts, naturally interested in Ramskou's findings, kindly provided me with an English translation of the second *Skalk* article. Sensing a connection, Mr. Howard G. Rogers, a senior research fellow and vice-president of research with Polaroid, attended my Coutinho lecture of May 18, 1969, and there displayed a piece of cordierite.