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AIR NAVIGATION

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2625. Location of twilight belt.—The principles discussed in article 2624 can be used to locate the twilight belt on a polar chart, at any time, as shown in figure 2625a.

First, from the almanac, determine the GHA and declination of the sun. Locate the meridian on which the GP of the sun is situated (GHA=λW, or 360°−GHA=λE). In figure 2625a a GHA of 59° is used.

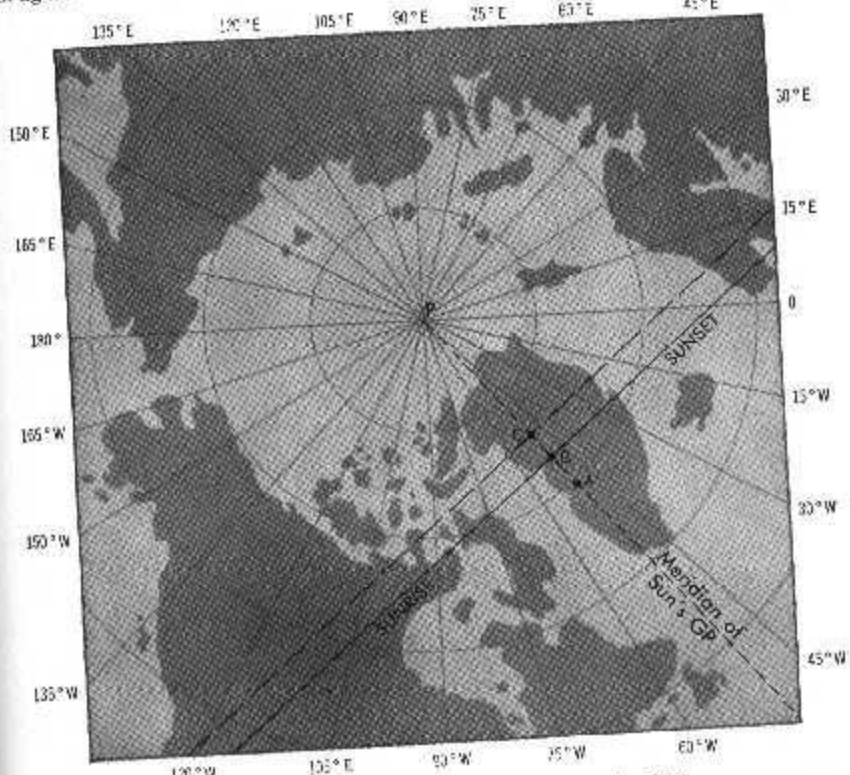

FIGURE 2625a.—Locating the twilight belt on a polar chart.

From the *pole*, measure an arc of latitude, PA, equal to the declination (20°6 S in the illustration). If the declination and pole (P) are of contrary name, measure *toward* the sun (along the meridian containing its GP); and if of the same name, measure in the opposite direction, or *away* from the sun. The point A thus located is on the great circle sunrise-sunset line.

However, because of refraction, dip, and semidiameter, the actual sunrise-sunset line is a little farther from the sun. From figure 2625b, determine the depression of the sun for flight altitude, using the left-hand curve. At 20,000 feet this value is 3°6, the amount used in the illustration. This can also be found in the "Dep. of Sun at 0

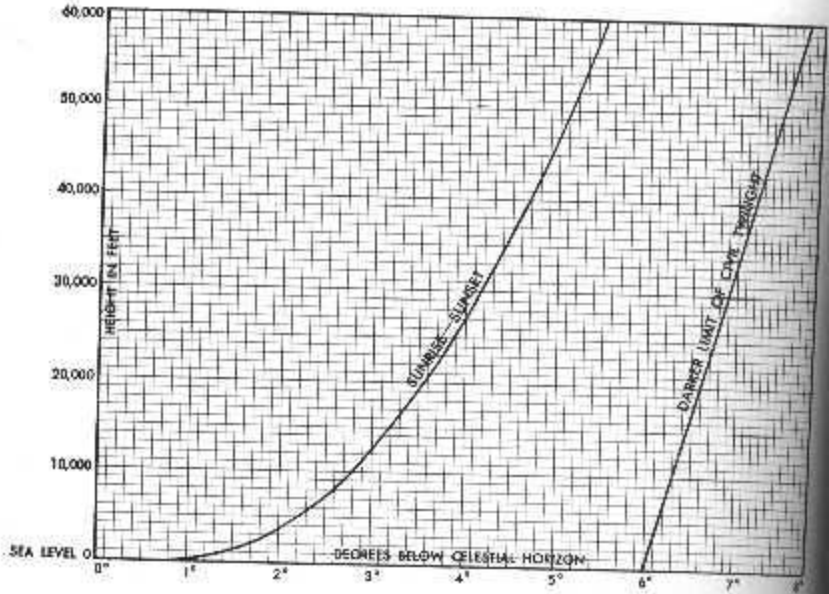

FIGURE 2625b.—Sunrise, sunset, and civil twilight at various heights.

It." column on page A52 or A53 of *The Air Almanac*. From point *A*, measure this arc (*AB*) *away* from the sun. Through the point *B*, thus located, draw a perpendicular to the meridian of the GP of the sun. This is a close approximation to the actual sunrise-sunset line at the time drawn.

Air navigators are concerned primarily with that part of twilight during which the sky is too bright for observation of stars. This is approximately between sunrise-sunset and the darker limit of civil twilight, although first magnitude stars may be visible when the sky is a little brighter. From the right-hand line of figure 2625b, determine the depression of the sun at the darker limit of civil twilight. The values, some of which are found on page A12 of *The Air Almanac*, are based upon incomplete data and may need slight revision in practice. From point *A*, measure this arc (*AC*, etc.) *away* from the sun. Through the point *C*, thus located, draw a line parallel to the sunrise-sunset line. This second line approximates the line along which the darker limit of civil twilight is occurring. Stars should be available when the aircraft is on the side of this line *away* from the sun; the sun should be available on the opposite side of the line through *B*; no bodies may be available between the lines.

2626. Twilight computer.—The twilight conditions encountered during any flight can be determined by making the diagram explained in article 2625 for intervals of perhaps 1^h during the flight. However, this entails a considerable amount of work, much of which can be avoided by drawing the two lines on a piece of transparent material placed over the chart as a template. If this template is fastened to the pole by means of a thumb tack or other pivot, the conditions at subsequent times during the flight can be determined by rotating the template 15° per hour in the direction of the apparent motion of the sun, clockwise in the arctic and counterclockwise in the antarctic.

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If the predicted DR positions of the aircraft have previously been plotted at hourly intervals, the location with respect to the twilight belt, as well as the direction of the course relative to it, can be determined for each hour of flight. Such an arrangement constitutes a polar **twilight computer,** which can be useful in flight planning, particularly in noting the effect of changing the time of takeoff or the route to avoid prolonged period in the twilight belt.

Various forms of twilight computers have been devised, all based upon this principle. One of the simplest can be made to operate with the E-10 or E-6B computer, as shown in figure 2626a. Draw, or photograph, a map of the polar regions to a size that just fits inside the compass rose of the computer. Any polar projection is suitable, but the polar gnomonic is best. Attach this overlay to a card insert, or to the slide itself so that the pole can be placed directly under the grommet of the computer, with the Greenwich meridian toward the top, as shown.

FIGURE 2626a.—The E-10 as a twilight computer.

To use this twilight computer, set N at the true index, and locate the twilight belt as indicated in article 2625, assuming the sun is over the 0° or Greenwich meridian. The sunrise-sunset and twilight lines can be drawn without a straightedge by locating points *B* and *C*, moving the slide until each is over the pole, and tracing a line along the 90° E–90° W meridian. To locate the twilight belt at any time, set 360°–GHA (in the arctic, or GHA in the antarctic) at the true index. The twilight belt is then shown in its correct position relative to the chart, with the illuminated side toward N and the dark side toward S on the compass rose.

To show the track relative to the twilight belt, plot the DR position at hourly intervals as in figure 2626b. Set the overlay for each hour of the flight, and make a pencil dot on the template, at a point directly over the DR position for the same time. Connect the successive dots, as shown in figure 2626c.

A twilight computer can be used to determine the time of rising or setting of the sun or other body, and the approximate altitude at any time. When N is placed at the true index, the rising line is to the *right*, and the setting line to the *left* in the arctic (opposite in the antarctic). To determine the time of rising or setting of any body, rotate the template until the appropriate line is over the place for which information is desired. Read 360°–GHA (GHA in the antarctic) at the true index. Enter the almanac and determine the time at which this occurs. If rising or setting of some body other than the sun is desired, the rising-setting line for that body should be drawn. A separate rising-setting line should be drawn for each body. For a star or planet, *reduce* the value taken from the left-hand curve of figure 2625b by 0°3, to eliminate the allow-

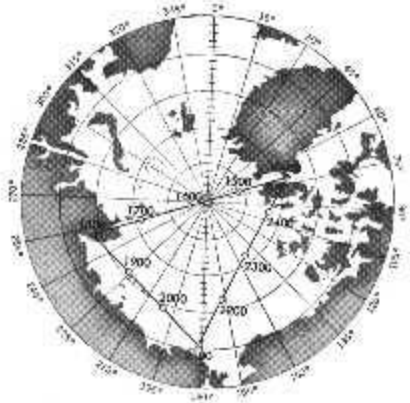

FIGURE 2626b.—A track relative to the earth.

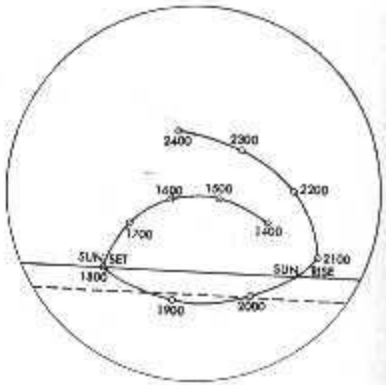

FIGURE 2626c.—Plot of track relative to twilight belt. Times indicate corresponding points in figure 2626b.

ance made for semidiameter of the sun. For the moon subtract 1°0 from the value of the left-hand curve to compensate for horizontal parallax. If the time of rising or setting in flight is desired, interpolate between the hourly entries on each side of the rising-setting line. Times of rising and setting, and duration of twilight can also be determined in the arctic by the graphs near the back of *The Air Almanac*, as explained in article 1910. Times of these phenomena determined by any method should be considered approximate only because a little change in atmospheric refraction or height of eye can have a relatively big effect on the times of the phenomena.

To determine the approximate altitude at any time, set the template for 360°—GHA (GHA in the antarctic) and measure the perpendicular distance from the position of the observer to the rising-setting line for the body, using the latitude scale. Subtract the value of the left-hand curve of figure 2625b from this measured distance to determine the altitude above the *celestial horizon* (true altitude). This does not include a correction for parallax of the moon which varies. The altitude obtained by this method is useable only when the DR position is on the same side of the rising-setting line as the body. If the DR position is on the opposite side, the body is obscured and the measured altitude is unuseable.

General

2627. Preflight planning is important to safe navigation anywhere. In polar regions, added considerations increase its value. Planning for polar flights include all the elements of planning for flights in lower latitudes, but with increased emphasis in thoroughness, and with several additional factors.

The route should be selected with care. Sometimes slight alterations will permit use of prominent check points that will serve to establish position during the flight. If the destination is a poorly-marked one without a beacon or other aid to navigation, the flight might be planned to proceed first to a prominent landmark nearby.

Because of the lack of adequate facilities for predicting the weather over relatively large portions of the polar regions, and the great distances to alternate airports in some cases, a generous fuel reserve should be provided. Since heights of the terrain are not always reliably shown on charts, it is good practice to fly above the overcast, where possible, during a flight over land.