In both cases the intercept is 19′ towards. This example shows that it matters little in which manner observational errors are taken into account. As long as they are applied with the proper sign, the intercept remains the same.

Limitations of Precomputation

Precomputational methods lose accuracy when the assumed position and the aircraft's actual position differ by large distances. Another limiting factor is the difference in time between the scheduled and actual observation time. The motion of the body correction is intended to correct for this difference.

The rate of change of the correction for motion of the body changes very slowly within 40° of 090° and 270° true azimuth, and the observation can be advanced or retarded for a limited period of time with little or no error. When the body is near the observer's meridian, the correction for motion of the body changes rapidly, due in part to the fast azimuth change and it is not advisable to adjust such observations for long periods of time.

Errors in altitude and azimuth creep into the solution if adjustments are made for too long an interval of time. Because of these errors, the navigator should try to keep his scheduled and actual observation times as close as possible.

SPECIAL PLOTTING TECHNIQUES

There are several plotting techniques which work especially well with celestial precomputation, although they are not restricted to this type of sight reduction. The two primary plotting techniques are preplotting the Zn's and plotting the fix on the DR computer.

Preplotting True Azimuth (Zn's)

This technique is best used when working on a constant scale chart and using some technique of precomputation that will give one assumed position. Set up the procedure on the chart by plotting (prior to observations) the assumed position and through this point, the Zn's of the bodies. When going toward the body, use a solid line or a colored pencil, and when going away from the body use a dashed line or a different colored pencil. Label each Zn as the 1st, 2nd, or 3rd as shown in figure 17-3, or use the names of the stars. If desired, distances from the assumed position can also be marked off. Suppose the corrected assumed position is 30°40′N, 117°10′W and the following Zn's were computed for the bodies:

1st Shot Zn = 020°
2nd Shot Zn = 135°
3rd Shot Zn = 270°.

(The original assumed position of 31°N, 117°08′W has been corrected for precession/nutation and for Coriolis/rhumb line error to get the corrected assumed position.)

When the first intercept is found to be 10A, second intercept 40A, and the third 50T, the fix can be plotted quickly by constructing perpendicular lines at the correct point on the respective *Zn line*. No direction or distance measurement is required after shooting—only the intercept is needed. This greatly reduces the time necessary to plot the fix. Since the dashed part of the Zn line is the away situation, it is used for the first two intercepts; while the solid or toward situation, is used for the third intercept.

Plotting Fix on DR Computer

The following examples explain the procedures for plotting the fix on the DR computer. This technique is especially favored by units flying in high-speed aircraft where plotting time must be kept to a minimum. It can be used effectively to plot a fix in any situation.

To plot the LOPs on the DR computer, the square grid portion is used exclusively. The grommet of the DR computer is the assumed position and is assigned a definite value of *both latitude and longitude*. Where the same assumed position is used for all three shots, the co-ordinates of the assumed position are the assigned values.

The Zn of the first shot is placed under the true index. If the intercept is toward, it is measured above the grommet. The LOP is then constructed by drawing a perpendicular through this point. If the intercept is away, intercept distance is measured below the grommet, and the perpendicular is constructed for the LOP.

In a Polaris shot, 360° is placed under the true index and the LOP is plotted above the grommet if the latitude determined is greater than the assigned latitude value of the grommet, and below if the Polaris latitude is less than the as-

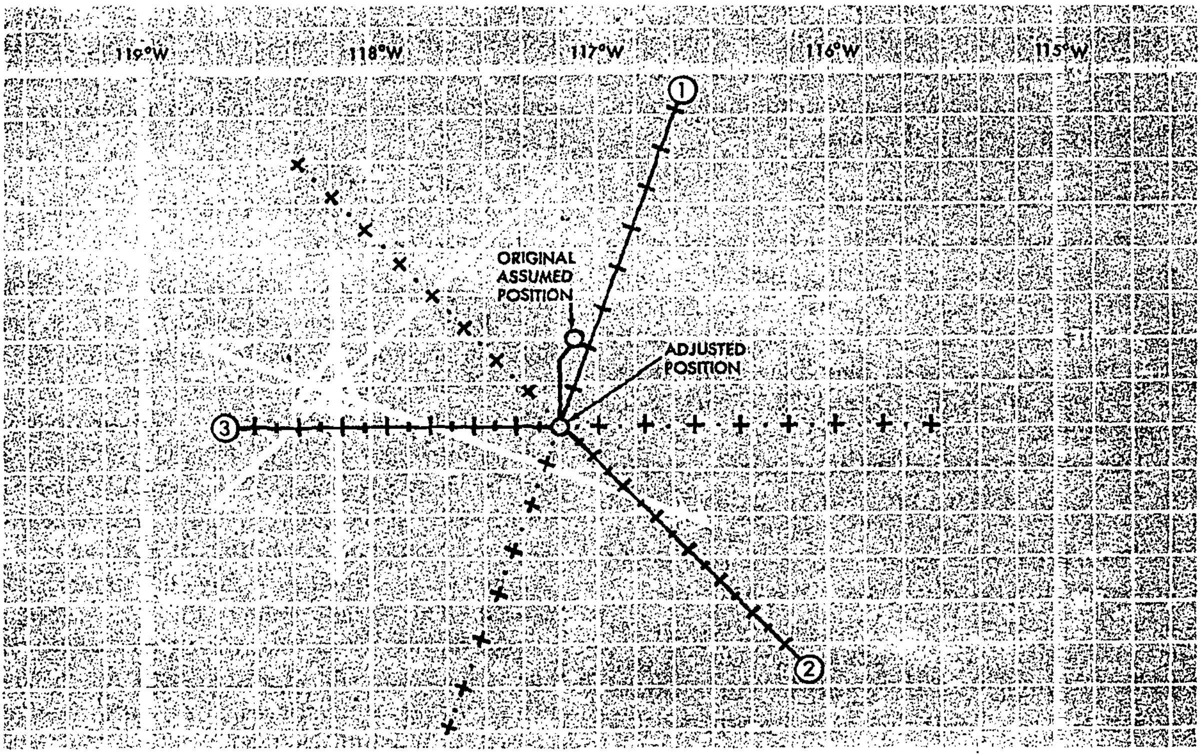


Figure 17-3. Fix Can be Plotted Quickly

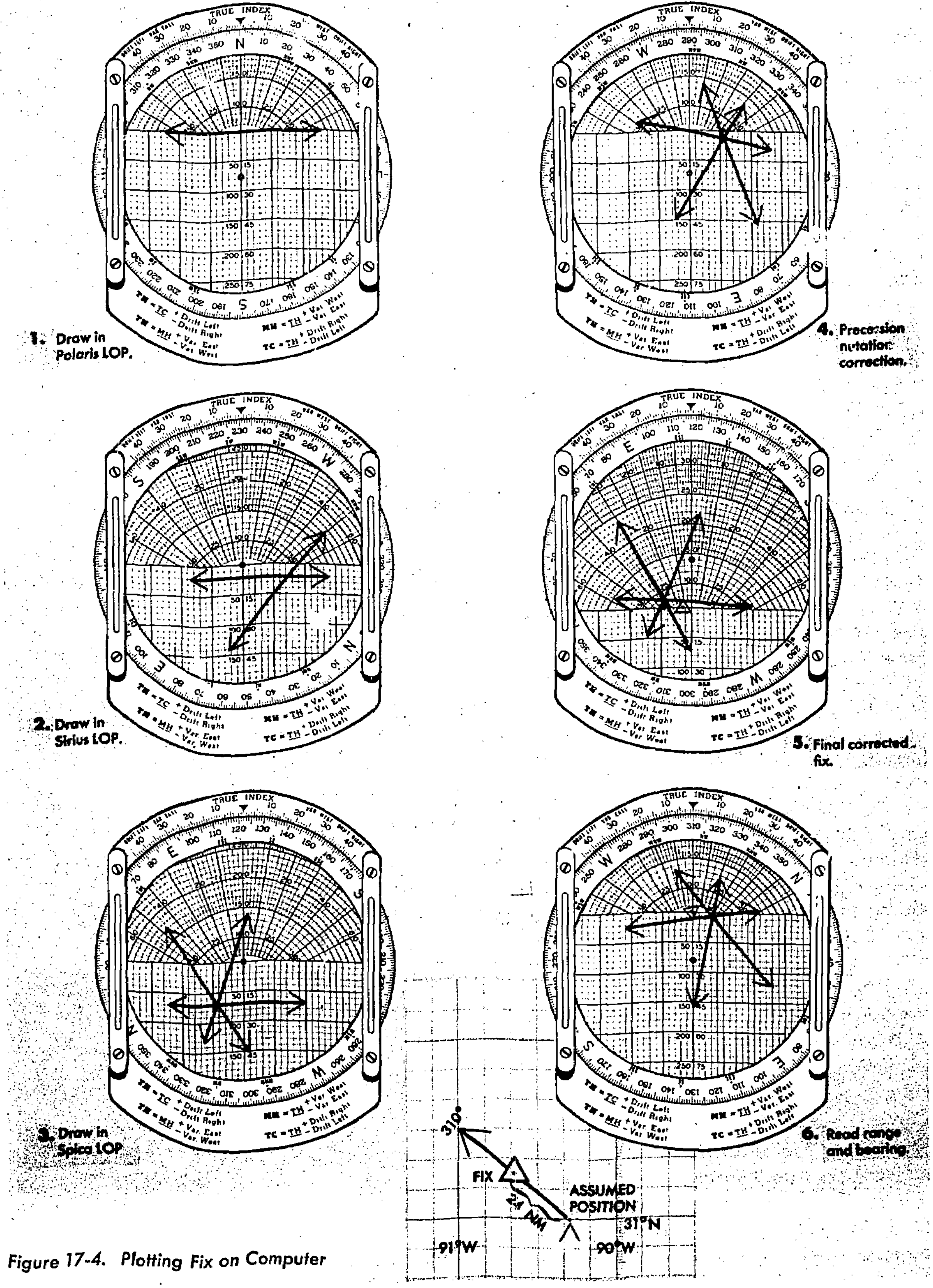
signed value of latitude. The distance above or below the grommet in the case of Polaris is the same number of nautical miles as the difference in minutes between the latitude assigned to the grommet and the Polaris latitude. This is true because one minute of latitude is one nautical mile.

The three LOPs plotted as above constitute the uncorrected fix. Precession/nutation if using Volume I of H.O. 249 and Coriolis/rhumb line correction is then applied to this uncorrected fix. The *final fix* is then placed vertically *above* the grommet to obtain the range and bearing of the fix *from* the grommet. This is also the range and bearing of the final fix from the latitude and longitude previously assigned to the grommet. The fix is plotted on the chart using this range and bearing from the latitude and longitude originally assigned to the grommet of the computer.

Sample Problem

A step-by-step procedure for a sample problem is shown in figure 17-4. The assumed position for two of the shots (moved up to a common time) is 31°00′N, 90°18′W; the other shot is on Polaris. The track is 118° and the Coriolis/rhumb line correction is 10 nautical miles to the right. Precession/nutation correction is 3NM/290°. The Polaris shot was taken first and corrected to a latitude value of 31°23′N. The second shot, Sirius, has a Zn of 231° and an intercept of 6 away. The third shot was taken on Spica; the Zn is 122° and the intercept 21 away.

1. Place 360° (N) under the true index and draw in the Polaris LOP, 23 nautical miles above the grommet.
2. Place 231° under the true index and draw in the Sirius LOP, 6 NM below the grommet (6A).
3. Place 122° under the true index and draw in the Spica LOP, 21 NM below the grommet (21A).
4. Place 290° under the true index and go up 3 nautical miles from the *uncorrected fix* to take care of the precession/nutation correction. Go up because the values of the precession/nutation correction indicate that the fix is to be moved 3 nautical miles in the direction of, or towards, 290°.
5. Place the track (118°) under the true index and go 10 nautical miles *to the right* from the



1. Draw in Polaris LOP.

2. Draw in Sirius LOP.

3. Draw in Spica LOP

4. Precession nutation correction.

5. Final corrected fix.

6. Read range and bearing.

Figure 17-4. Plotting Fix on Computer

position obtained in step 4. (If the Coriolis/rhumb line correction had been a correction left, the box would have been moved to the left.) This is the final corrected fix. Place a triangle about the point.

6. Place the final fix (inside the triangle) above the grommet with the zero line through the fix and the center vertical also through the fix. Read the range under the grommet and the bearing under the true index. The range is 24 nautical miles and the bearing is 310°. Hence the fix is plotted 24 nautical miles in the direction of 310° from 31°N, 90°18′W as shown.

When more than one assumed position exists, a slightly different procedure must be used. In this case all the assumed positions must be plotted on the DR computer before starting. Since the grommet can only be assigned one value of latitude and longitude, it is usually assigned the value of the middle assumed position.

For example, all three assumed positions have the same latitude 36°00′N but the first is 119°14′W, the second 119°29′W, and the third 119°44′W. The grommet is assigned the value 36°00′N 119°29′W. This is done so that the other two assumed positions will plot on either side of the grommet and no one assumed position will be too close to the edge of the face of the DR computer.

In this instance the first shot is 15′ *east* of the grommet value; the third shot is 15′ *west* of the grommet value, which is *not* 15 nautical miles at 36°N latitude. The distance in nautical miles between these assumed positions can be quickly determined in several ways.

- Probably the easiest way is to take 15′ of longitude off the chart at 36°N and see how many nautical miles this is on the latitude scale as illustrated in figure 17-5.

- Another quick way to determine the distance is to solve it graphically on the square grid of the DR computer. Place 0° (N), at the index and make a point 15 nautical miles to the side of the grommet, using the square grid as shown in figure 17-6A.

Next place the latitude, 36°, under the true index and read the horizontal component of the point to get the distance in nautical miles of 15′ of longitude at 36°N latitude. Again the answer is found to be about 12 nautical miles. Notice in figure 17-6B that the slide has been moved.

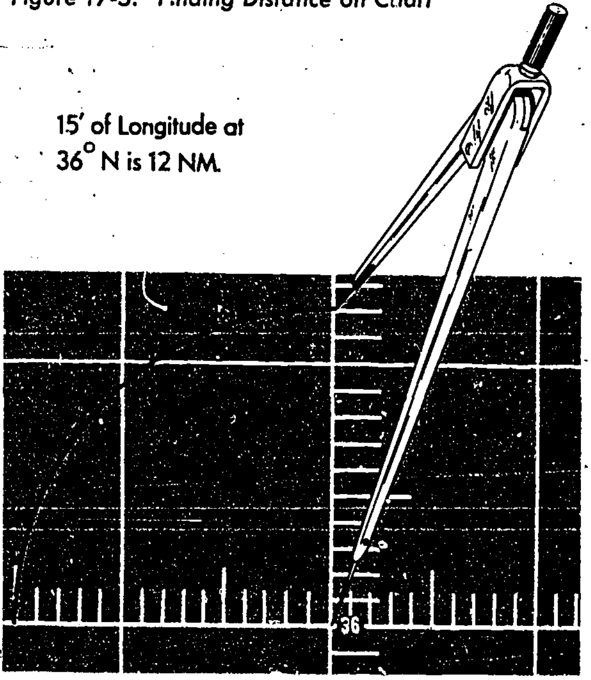
- An additional fast way to solve the distance is to use the motion of the body correction table. To find the length of one degree of longitude at any latitude, enter this table under the latitude using true azimuth of 090°. At 36° north, the length of one degree of longitude is 49 nautical miles. One degree equals 49 nautical miles, so 15′ of longitude equals 12½ nautical miles.

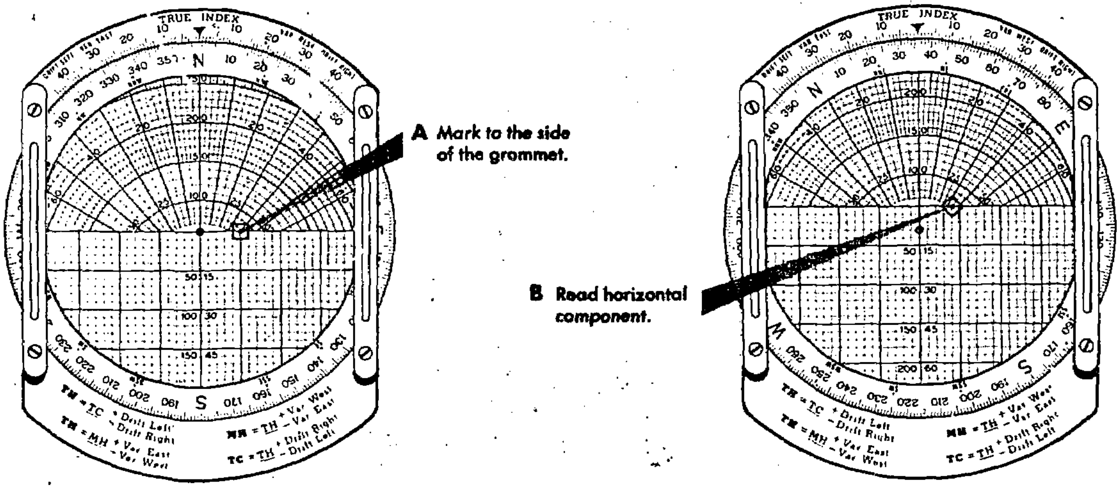
After the distance between the assumed positions has been determined, plot the other two assumed positions, circle them, and label all three as to first, second, or third shot. This is always done with 0° (N) under the true index as shown in figure 17-7.

Then plot the first LOP above or below the *number one* assumed position rather than the grommet. The second LOP is plotted above or below the grommet which is the number two assumed position. The third LOP is plotted intercept distance below or above the number three assumed position. The uncorrected fix is corrected in the usual manner, and the range and bearing obtained are from 36°N 119°29′W, the value assigned to the grommet.

If the intercepts are too large to handle in the regular manner on the DR computer, the problem may be solved by halving all the distances, includ-

Figure 17-5. Finding Distance on Chart




A *Mark to the side of the grommet.*

B *Read horizontal component.*

Figure 17-6. Finding Distance on Computer

ing the distance between the assumed positions as well as the intercept distances. All bearings remain unchanged. Do not forget to also halve the precession/nutation and Coriolis/rhumb line corrections. The final distance to the fix as read on the DR computer is doubled to give the range. The bearing is still read under the true index.

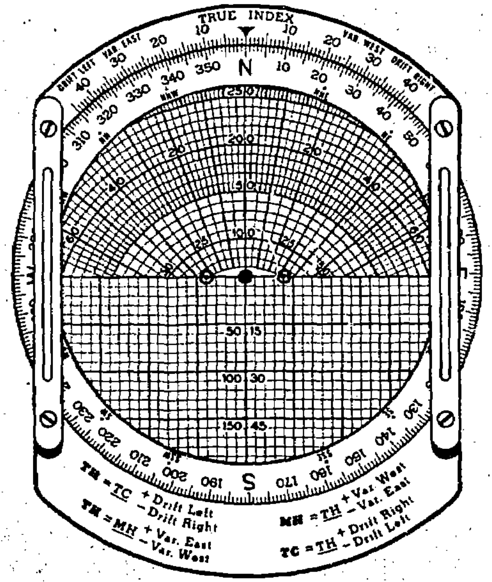


Figure 17-7. Plot Assumed Positions

SUMMARY

Celestial precomputation methods have been brought to the forefront with the advent of high-speed aircraft. The speeds at which aircraft now fly make it necessary to reduce the time between the last observation and the final fix.

The periscopic sextant may be the only means of viewing the sky. In this case, it is necessary to precompute the altitude and azimuth of a body in order to locate it.

There are two basic methods of precomputation, each with many variations. The mathematical solution, with assists from various types of computers, is favored over the graphical solution.

One of the main points to remember when precomputing is that corrections may be applied to either the Hc, Hs, or intercept. Pay particular attention to the sign of the correction. In addition to precomputation, the speed with which a fix is obtained may be increased by using special plotting techniques. The true azimuths may be preplotted, or the fix may be plotted on the DR computer.