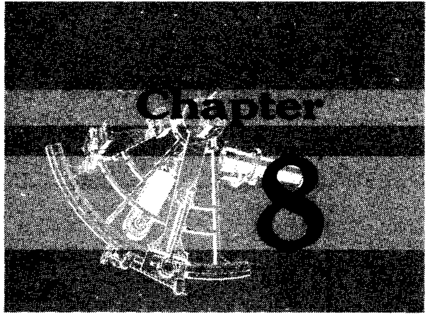
PART ONE



Celestial Precomputation

Celestial precomputation is neither new nor revolutionary. Actually, the tables necessary to do precomputation have been available since 1940, but the real need for precomputation was not present. With today's high-speed aircraft, however, the picture has changed radically. By the methods previously discussed, it is apparent that a great deal of work is accomplished after the last celestial observation is taken. The fix could easily be 10 to 20 minutes old, depending on the speed and proficiency of the navigator, at the time it is plotted on the chart. At a 600-knot groundspeed, a fix that is 15 minutes old is 150 miles behind the aircraft and is of questionable value. The need now exists to shorten the time between the last celestial observation and the final fix plotted on the chart.

Another reason why precomputation is needed in high-speed aircraft lies in the very structure of the aircraft itself. There can be no projections such as an astrodome on these aircraft. The navigator will probably be using a periscopic sextant which could easily be his only means of viewing the heavens. With the limited field of vision of the sextant, the star would be extremely difficult to find in the optics if he did not know where to look.

PRESETTING THE SEXTANT

Precomputation greatly reduces both of the problems just mentioned. By completing the majority of the computations prior to shooting, which is precomputation, the time necessary to plot the fix after the last observation is greatly reduced. Also the problem of finding the star in the optics of the sextant is simplified. The procedure for finding the star is very similar to the heading check performed with the periscopic sextant, using the true bearing method. In this case the Zn, known beforehand, is set into the sextant mount, and the Hc, which will approximate the Hs, is set into the sextant. Now, instead of sighting the body and determining the true heading, the true heading is set under the vertical crosshair and the selected body is found very close to the crosshairs in the sextant field of vision.

To avoid erroneous settings of the azimuth window and to increase speed in setting up the sextant, the relative bearing method may be used. In this method the azimuth window remains permanently at 360.0°, and the relative bearing is computed by the formula: RB = TH − Zn.

Observations Earlier than Solution Time - SIGNS AS GIVEN
Observations Later than Solution Time - SIGNS REVERSED

MOTION OF BODY CORRECTION FOR (4) FOUR MINUTES OF TIME

TRUE AZIMUTH OF BODY	LATITUDE																											TRUE AZIMUTH OF BODY
	0°	8°	16°	20°	24°	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	56°	60°	64°	68°	72°	76°	80°	84°	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	
090	+60	+59	+57	+56	+55	+53	+52	+51	+50	+49	+47	+45	+44	+43	+42	+41	+39	+37	+35	+34	+29	+27	+23	+19	+15	+11	+6	090
095	60	59	57	56	55	53	52	51	49	49	47	45	44	43	42	40	39	37	35	33	29	27	23	19	15	11	6	085
100	59	59	57	56	54	52	51	51	49	48	46	45	44	43	41	39	37	36	35	33	29	26	22	18	14	10	6	080
105	58	57	56	55	53	51	51	49	48	47	46	44	43	41	41	39	37	36	34	33	29	25	22	18	14	10	6	075
110	56	56	54	53	52	50	49	48	47	46	44	43	42	40	39	38	36	35	33	31	28	25	21	17	13	10	6	070
115	54	54	52	51	49	48	47	46	45	44	43	42	40	39	38	36	35	33	32	30	27	24	21	17	13	9	6	065
120	+52	+51	+50	+49	+48	+46	+45	+44	+43	+42	+41	+40	+39	+38	+37	+35	+33	+32	+30	+29	+25	+23	+19	+16	+12	+9	+6	060
125	49	48	47	47	45	43	42	42	41	40	39	38	36	35	34	33	31	31	29	27	24	21	18	15	12	8	5	055
130	46	45	44	43	42	41	40	40	39	37	37	35	34	33	32	31	29	28	27	26	23	20	17	14	11	8	5	050
135	43	42	41	40	39	37	36	36	35	34	33	32	32	31	29	29	27	26	25	24	21	19	16	13	10	7	4	045
140	39	38	37	36	35	34	33	33	32	31	30	29	28	28	27	26	25	24	23	22	19	17	15	12	9	7	4	040
145	35	34	33	32	32	31	29	29	28	28	27	27	25	25	24	23	23	21	20	19	17	15	13	11	8	6	4	035
150	+30	+29	+29	+28	+28	+27	+25	+25	+25	+24	+23	+23	+22	+22	+21	+20	+19	+19	+17	+17	+15	+13	+11	+9	+7	+5	+3	030
155	25	25	24	24	23	23	21	21	21	21	20	20	19	19	17	17	16	16	15	14	13	12	9	8	6	5	2	025
160	20	20	20	19	19	18	17	17	17	17	16	16	15	15	14	14	13	12	12	11	11	9	7	7	5	4	2	020
165	16	15	15	15	15	13	13	13	13	13	12	12	11	11	11	10	10	9	9	9	8	7	6	5	4	3	2	015
170	11	10	10	10	9	9	9	9	8	8	8	8	8	8	7	7	7	7	7	6	5	4	4	3	3	2	1	010
175	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	2	2	2	1	1	005
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	000
185	−5	−5	−5	−5	−5	−4	−4	−4	−4	−4	−4	−4	−4	−4	−4	−4	−4	−3	−3	−3	−3	−3	−2	−2	−2	−1	−1	355
190	11	10	10	10	9	9	9	9	8	8	8	8	8	8	7	7	7	7	7	6	5	4	4	3	3	2	1	350
195	16	15	15	15	15	13	13	13	13	13	12	12	11	11	11	10	10	9	9	9	8	7	6	5	4	3	2	345
200	20	20	20	19	19	18	17	17	17	17	16	16	15	15	14	14	13	12	12	11	11	9	7	7	5	4	2	340
205	25	25	24	24	23	23	21	21	21	21	20	20	19	19	17	17	16	16	15	14	13	12	9	8	6	5	2	335
210	−30	−29	−29	−28	−28	−27	−25	−25	−25	−24	−23	−23	−22	−22	−21	−20	−19	−19	−17	−17	−15	−13	−11	−9	−7	−5	−3	330
215	35	34	33	32	32	31	29	29	28	28	27	27	25	25	24	23	23	21	20	19	17	15	13	11	8	6	4	325
220	39	38	37	36	35	34	33	33	32	31	30	29	28	28	27	26	25	24	23	22	19	17	15	12	9	7	4	320
225	43	42	41	40	39	37	36	36	35	34	33	32	32	31	29	29	27	26	25	24	21	19	16	13	10	7	4	315
230	46	45	44	43	42	41	40	40	39	37	37	35	34	33	32	31	29	28	27	26	23	20	17	14	11	8	5	310
235	49	48	47	47	45	43	42	42	41	40	39	38	36	35	34	33	31	31	29	27	24	21	18	15	12	8	5	305
240	−52	−51	−50	−49	−48	−46	−45	−44	−43	−42	−41	−40	−39	−38	−37	−35	−33	−32	−30	−29	−25	−23	−19	−16	−12	−9	−6	300
245	54	54	52	51	49	48	47	46	45	44	43	42	40	39	38	36	35	33	32	30	27	24	21	17	13	9	6	295
250	56	56	54	53	52	50	49	48	47	46	44	43	42	40	39	38	36	35	33	31	28	25	21	17	13	10	6	290
255	58	57	56	55	53	51	51	49	48	47	46	44	43	41	41	39	37	36	34	33	29	25	22	18	14	10	6	285
260	59	59	57	56	54	52	51	51	49	48	46	45	44	43	41	39	37	36	35	33	29	26	22	18	14	10	6	280
265	60	59	57	56	55	53	52	51	49	49	47	45	44	43	42	40	39	37	35	33	29	27	23	19	15	11	6	275
270	−60	−59	−57	−56	−55	−53	−52	−51	−50	−49	−47	−45	−44	−43	−42	−41	−39	−37	−35	−34	−29	−27	−23	−19	−15	−11	−6	270

Correction for Motion of the Body

The body sought will be found at its computed altitude when its RB appears under the crosshairs.

PRECOMPUTATION TECHNIQUES

There are many acceptable methods of precomputation in general usage. However, these methods are basically either graphical, mathematical, or a combination of graphical and mathematical. The method used by the practicing navigator will largely be determined by the type and speed of the aircraft, and by the type of mission flown.

The basic principles of solution by precomputation are the same as those earlier detailed in this section. Previously discussed corrections which are used in precomputation include atmospheric and dome refraction, parallax of the moon, sextant and personal errors, coriolis and rhumb line, precession and nutation, motion of the observer, and wander. With precomputation, new corrections and terminology are introduced which include fix time, solution time, observation time, scheduled time, and motion of the body adjustment.

Fix time is the time for which the LOP's are resolved and plotted on the chart. *Solution time* is the time for which the astronomical triangle is solved. *Observation time* is the midtime of the actual observation for each celestial body. *Scheduled time* is the time for which the astronomical triangle is solved for each LOP in the graphical method. *Motion of the body correction* is used to correct for the changing altitude of the selected bodies, and can be applied either graphically or mathematically.

Motion of the Body Correction

Motion of the body correction is applied graphically by moving the assumed position eastward or westward for time. This is possible because the GHA of Aries, and consequently the subpoint of the body, moves westward at the rate of 1° of longitude per four minutes of time. In the graphical method a scheduled time of observation is given to each body. If shooting is off schedule, the following rules apply: For every minute of time that the shot is taken early, move the assumed position 15′ of longitude to the east; for every minute of time that the shot is taken late, move the assumed position 15′ of longitude to the west.

When the latitude of the assumed position and the Zn of the body are known, the motion of the body can be computed mathematically. For one minute the formula is: $15' \times \cos \text{lat} \times \sin \text{Zn}$. This correction has been computed and is shown in tabular form.

If this table is not available to the navigator, the correction may be easily determined in H.O. 249. For any stationary position (the assumed position), the LHA increases 1° every four minutes of time. Thus the Hc in H.O. 249, for an LHA 1° less than the LHA used for precomputation, is the Hc for four minutes of time earlier than the solution time. The difference between the two Hc's is the value to apply to the Hc or Hs to advance or retard the LOP for four minutes of time. If the Hc decreases, the body is setting and the sign is minus to advance the LOP if the value is applied to the Hs. If the Hc increases, the body is rising and the sign is plus to advance the LOP if the value is applied to the Hs.

The main difference between the basic methods of precomputation is the manner in which the motion of the observer and the motion of the body corrections are applied. In the graphical method, both corrections are applied graphically by movement of the assumed position or the LOP. In the mathematical method, both corrections are applied mathematically to the Hc, the Hs, or the intercept after being obtained from tables or the H.O. 249. In Volume III of this manual these two methods of precomputation are illustrated on forms, and information from them is plotted on JNU charts.

Corrections Applied to Hc

In some methods of precomputation, corrections are applied in advance to the Hc to derive an adjusted Hc (sometimes referred to as Hp). When using corrections which are normally applied to Hs, the signs of the corrections are reversed if applied to Hc. For example:

Corrections Applied to Hs

Hs	31°05′
Dome Refraction Correction	−06′
Atmosphere Refraction Correction	−01′
Sextant Correction	−05′
Ho	30°53′
Hc	30°40′
Intercept towards	13′

Corrections Applied to Hc

Hc	30°40′
Dome Refraction Correction	+06′
Atmosphere Refraction Correction	+01′
Sextant Correction	+05′
Adjusted Hc (Hp)	30°52′
Hs	31°05′
Intercept towards	13′

In both cases the intercept is 13′ 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.

Precomputing DR Positions

It is often convenient to precompute prior to takeoff all relevant data for selected DR positions en route. After determining the shooting schedule, assumed positions are chosen near the metro DR positions for computation purposes.

In flight, if the groundspeed is not as anticipated, new ETA's are obtained to the predetermined DR positions. The assumed position is moved 15′ of longitude per minute of time — east if arrival will be earlier than planned, west if later. If the time difference is more than 10 minutes, use the actual rate of Aries (15.04′/min) or refer to the *Air Almanac*.

If the planned shooting schedule is adhered to, no correction is necessary to precomputed azimuths or motion adjustments. In plotting the fix, all Zn's must be measured at the meridian nearest the adjusted assumed position.

The extent to which this method can be used varies with latitude. At latitudes above 75°, the assumed positions can be adjusted for an almost unlimited period of time. At lower latitudes, the time limitation becomes greater until in temperate latitudes adjustment of the assumed positions for an interval greater than 15 minutes will introduce significant errors into the LOP's.

B-II CELESTIAL (VAID) COMPUTER

The following examples illustrate the procedures for computing total adjustment and corrections for acceleration and wander errors on the B-II computer. The B-II is a VAID computer which has been modified with a special kit.

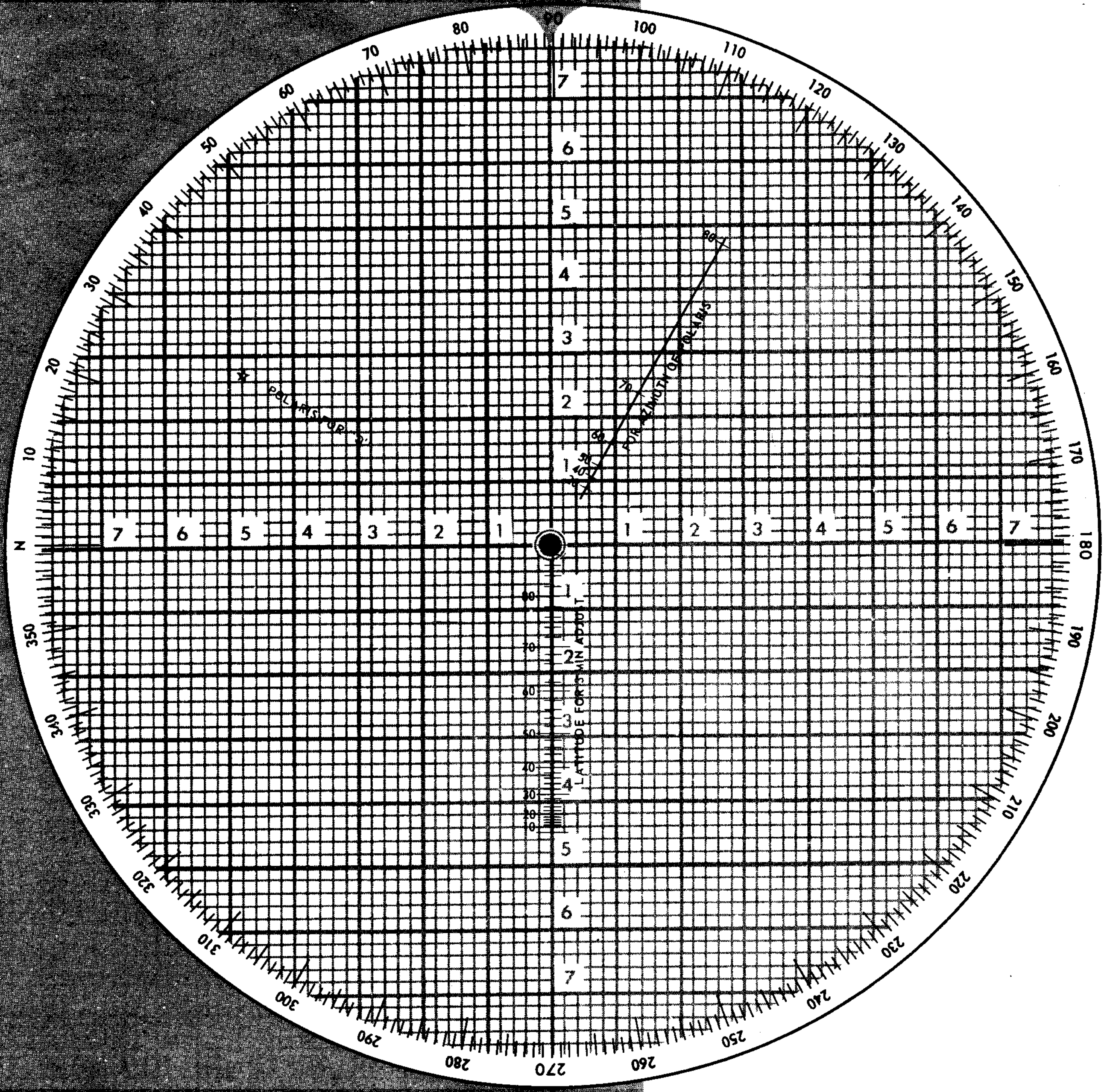
Modification of Computer

The modification of the grid side of the computer is accomplished as follows: Set 90° over the index. Mark the following values along the 270° line (down from the grommet) and label them with the corresponding latitudes.

Value	*Latitude*	*Value*	*Latitude*
45.0	0°	22.5	60°
44.4	10°	19.2	65°
42.3	20°	15.3	70°
39.0	30°	11.7	75°
34.5	40°	7.8	80°
28.8	50°	3.9	85°

These values represent the correction for three minutes of time for the motion of a body at 90° true azimuth at the various latitudes. The values for latitudes not listed may be interpolated. The modified grid side of the computer is illustrated.

No modification of the slide rule side of the computer is necessary, but a template may be added that has abbreviated instructions for a ready reference. The computer is now ready for use.



Modified
Grid Side of B-II
Computer

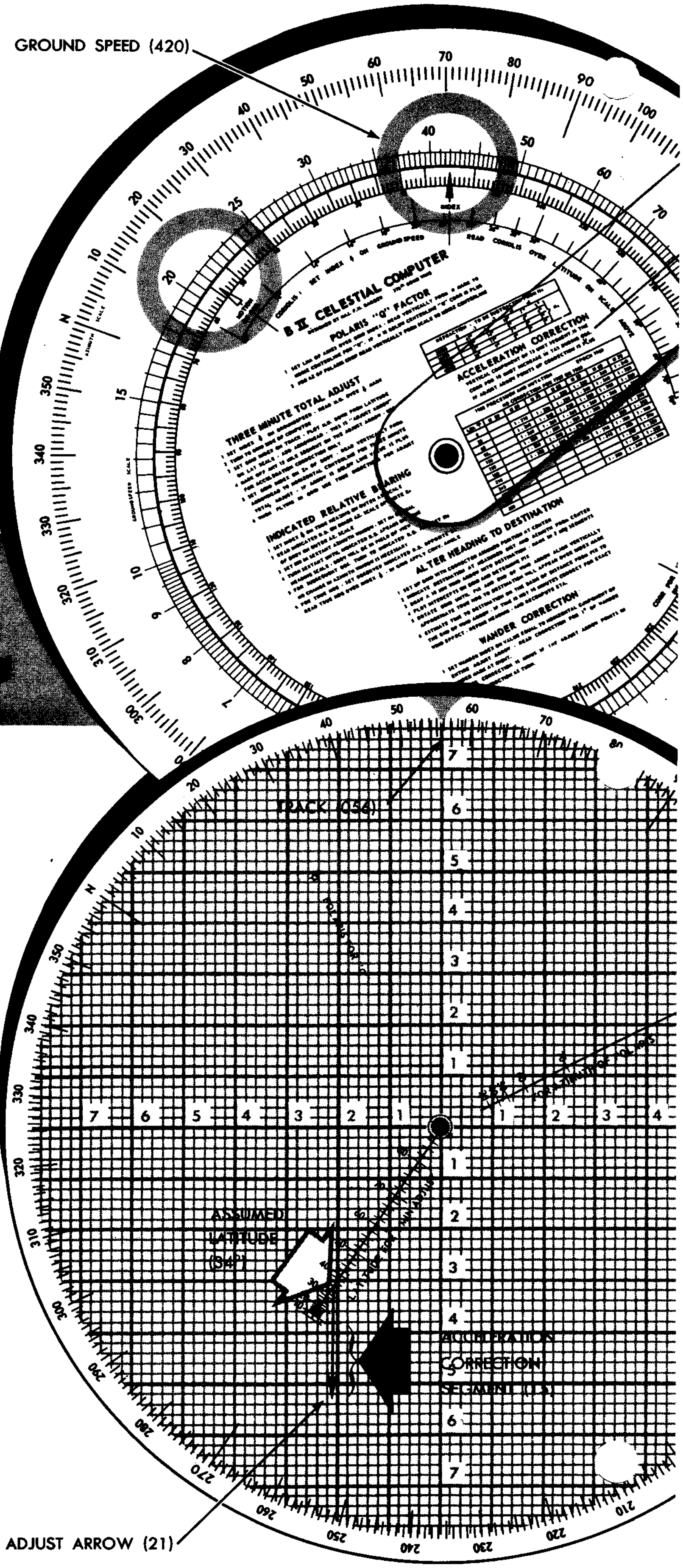
Use for Total Adjustment

The following example will demonstrate the use of the computer in precomputation.

Fix Time	0600 GMT, 31 Aug 58
DR Position	34°22′N, 97°57′W
Track	056°
GS	420 knots
PA	30,000 feet
GHAT	60°55′

Bodies to be observed:

Kochab	Hc	29°53′	Zn 342°
Alpheratz	Hc	56°53′	Zn 088°
Altair	Hc	55°23′	Zn 229°



1. First find the motion of the observer for three minutes by using the slide rule side of the computer; set groundspeed (420) over the black arrow and read motion of the observer (21) over the white arrow as shown. This value represents the motion of the observer for three minutes of the time when the body has a relative bearing of 360° or 180°.

2. On the grid side of the computer, set the track (056°) over the grid index. Plot a line downward from the assumed latitude (34°) on the latitude scale equal in length to the motion of the observer. Place an arrowhead on the end of the line. This vector, shown in the illustration, is known as the *adjust arrow*.

3. Set Zn of Kochab (342°) over grid index and read total adjustment (−6) under the arrowhead. If arrow is above the center line, the adjustment is minus if applied to the Ho. The correction is positive if the arrow is below the center line. The signs should be reversed if the observations are made after the solution time. Repeat the same procedure for Alpheratz

to find an adjustment of +55 and for Altair to find an adjustment of −49½. Note that these are total adjustments for both motion of the body and motion of the observer.

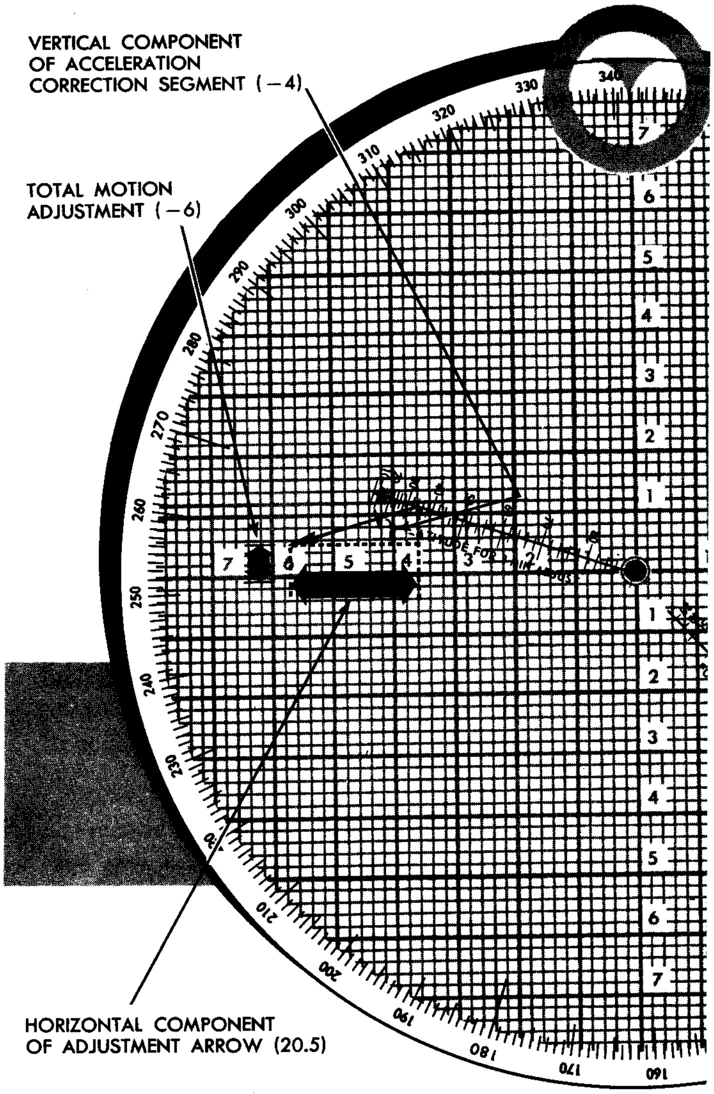
Corrections for Wander and Acceleration Errors

Correction for acceleration error may be computed at the same time as the total adjustment for each body. The wander correction is found on the slide rule side of the computer.

EXAMPLE: During the first observation, the heading increased 1° (1° right turn). At the same time, the TAS decreased four knots. The length of the observation was two minutes. During the second observation, the heading decreased 2° (2° left turn) and the TAS increased six knots. This was a two-minute observation. The third observation was of only one-minute duration; the heading increased 0.6° and the TAS was constant.

1. Mark off a 15-mile segment on the motion of the observer line on the grid side of the computer. This segment is ordinarily marked off when the line is first drawn in.

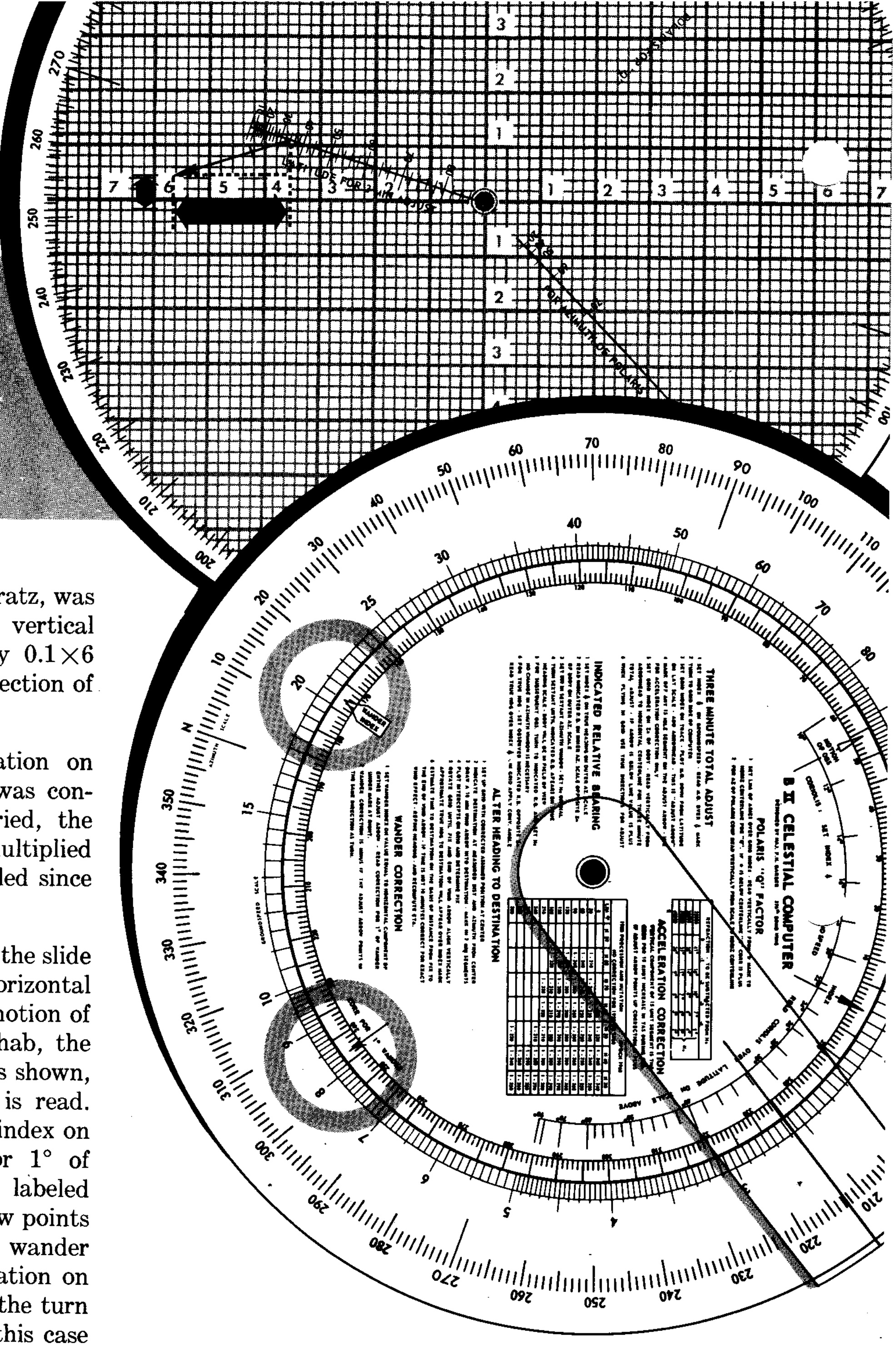
2. Set the Zn of Kochab (342°) under the grid index. The vertical component of the 15-unit segment is the acceleration for a 10-knot increase in TAS for a two-minute observation. To obtain a correction for a change of TAS other than 10 knots, multiply the computed value by 0.1× change in TAS. Double the amount of the correction if the observation is only one minute. If the adjust arrow points upward, the sign of the correction is plus. In the case of Kochab, the first observation, the correction from the computer (illustrated) is −4. This is multiplied by 0.1×4 knots (change in TAS) to obtain a correction of −1.6.



Total Motion Adjustment, Acceleration, and Wander Components for Kochab

$$\text{ACCELERATION CORRECTION} = \frac{\text{VERTICAL COMPONENT}}{10} \times \text{TAS CHANGE (KNOTS)}$$

ADJUST ARROW POINTS:	TAS:	SIGN OF ACCELERATION CORRECTION
UP	INCREASE	POSITIVE
UP	DECREASE	NEGATIVE
DOWN	INCREASE	NEGATIVE
DOWN	DECREASE	POSITIVE



Wander Correction for Kochab

3. The second observation, on Alpheratz, was a full two-minute shot. Therefore, the vertical component of $-12\frac{1}{2}$ is multiplied by 0.1×6 knots (change in TAS) to obtain a correction of -7.5.

There is no correction for acceleration on the third observation since the TAS was constant. However, if the TAS had varied, the vertical component would have been multiplied by $0.1 \times$change in TAS and then doubled since the observation lasted only one minute.

4. Wander correction is computed on the slide rule side of the computer using the horizontal component of the entire length of the motion of observer line (adjust arrow). For Kochab, the Zn (342°) is set under the grid index, as shown, and the horizontal component (20.5) is read. This value is then set over the wander index on slide rule side and the correction for 1° of wander (8.3) is read over the arrow labeled "corr for 1° wander." If the adjust arrow points in the same direction as the turn, the wander correction is minus. During the observation on Kochab the heading increased; that is, the turn was to the right. The adjust arrow in this case points to the left — the opposite direction to the turn — so the correction is plus.

5. In the same way the correction for Alpheratz is found to be +4.45 per degree of wander. The total wander was two degrees, so the wander correction is +8.9.

6. The total wander correction for the Altair shot is found to be −1.0. In this case the observation lasted only one minute, so the wander correction must be doubled to obtain a final correction of −2.0.

PRECOMPUTED WANDER CORRECTION: Wander correction may be precomputed in the following manner:

1. Determine amount and sign of error created by 1° of *right* wander error for each observation (from graph or computer).

2. Determine amount heading *should* change during observation if flying by unslaved gyro reference.

3. Note and record actual heading change to nearest 1/10 degree.

4. Compare actual change with predicted change.

5. Multiply the difference between steps 2 and 3 by value found in step 1. Reverse the sign if the wander was to the left.

Delete steps 2 and 4 if flying with a slaved reference.

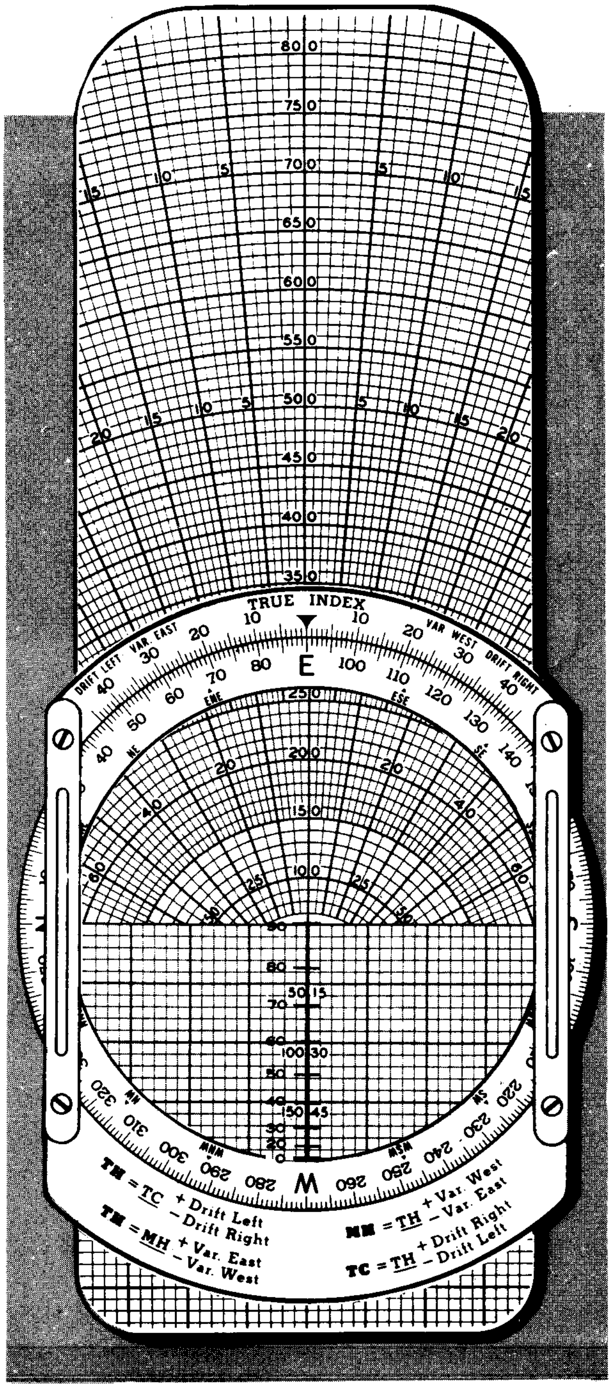
> **NOTE**
>
> Heading can change as much as a degree or more during two minutes of shooting. This is especially true at higher latitudes, when traveling more or less east or west or at high speeds.

Combined Motion on the D. R. Computer

The D. R. Computer may be used to compute combined motion adjustments in essentially the same manner as the BII. The adjustment is usually computed for three, four, or six minute time intervals. The four minute interval is explained here.

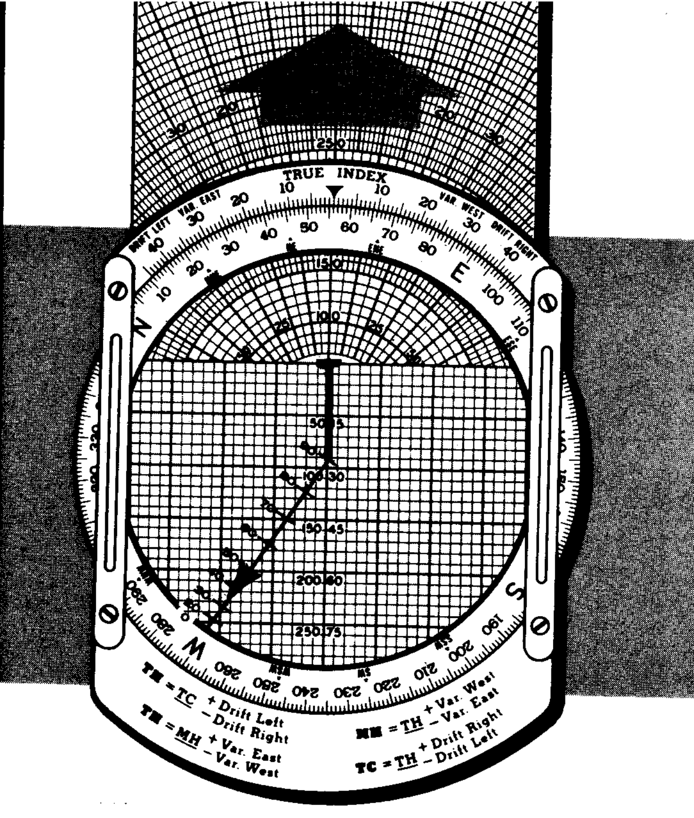
Use the vector side of the computer with the grid part of the slide. Set 90° under the index. Mark the following values along the 270° line, down from the grommet, and label them with corresponding latitudes.

Value	*Latitude*	*Value*	*Latitude*
60.0	0°	30.0	60°
56.4	20°	25.4	65°
54.4	25°	20.5	70°
52.0	30°	15.5	75°
49.1	35°	10.4	80°
46.0	40°	5.2	85°
42.4	45°	2.1	88°
38.6	50°	0.0	90°
34.4	55°		

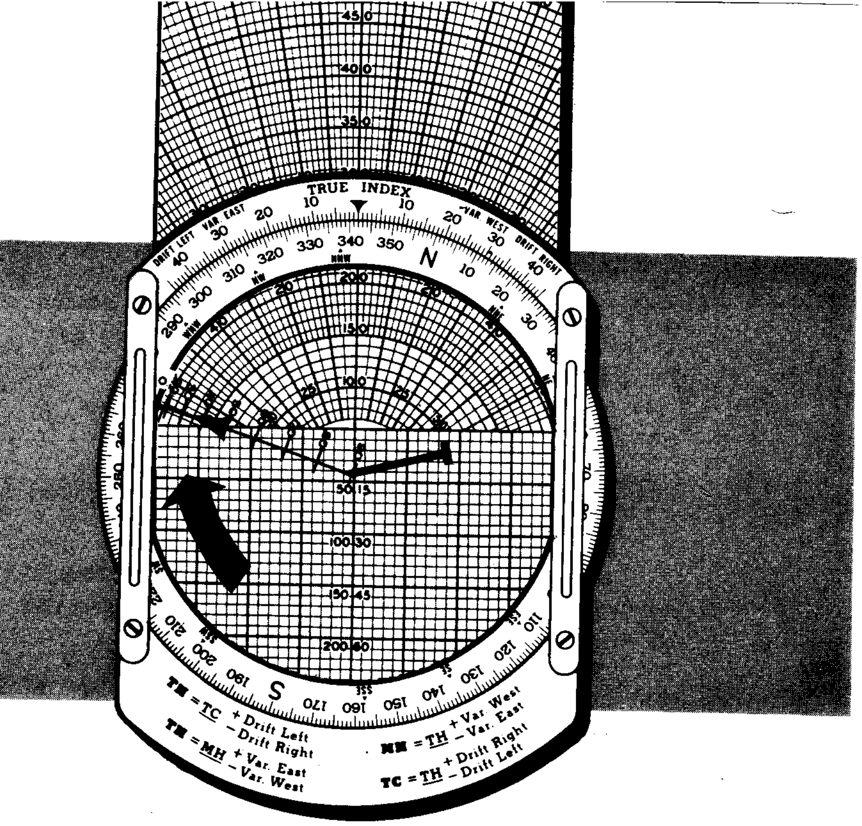


Modified D.R. Computer

These values represent the adjustment for four minutes of time for the motion of a body at 90° true azimuth at the various latitudes. The values for latitudes not listed may be interpolated. The modified grid side of the D.R. Computer is illustrated.



Plotting Motion of the Observer and Motion of the Body Vectors



Reading Four Minute Combined Motion

The following information will be used to illustrate subsequent steps:

Fix time	0600 GMT, 31 Aug 58
D. R. Position	34°22′N, 97°57′W
Track	056°
Groundspeed	420 knots
Pressure Altitude	30,000 feet
GHA ♈	60°55′

Bodies to be observed:

Kochab	HC	29°53′	Zn	342°
Alpheratz	HC	56°53′	Zn	088°
Altair	HC	55°23′	Zn	229°

1. Find the four minute motion of the observer for a body with a relative bearing of 360°. This is equal to the distance run in four minutes and may be found on the slide rule side of the computer using current groundspeed (420 knots). In this case, this distance is 28 nautical miles.

2. On the vector side of the computer, set the true track (056°) under the index. Plot a line up from the grommet the distance found in step 1 (28 nautical miles). Mark the upper end of this line as the tail, and the end at the grommet as the head, of the motion of the observer vector, as illustrated. Mark the head of the motion of the body vector by drawing an arrow at the assumed latitude (34°) on the latitude scale, as illustrated.

3. Set the Zn of Kochab under the index and move the slide until the top horizontal line of the grid is under whichever is uppermost: the head of the motion of the body vector or the tail of the motion of the observer vector (in this case, the head of the motion of the body vector). The vertical distance from the top horizontal line to the other vector end is the four minute combined motion adjustment. If the tail of the motion of the observer vector is uppermost, the sign is positive. If the head of the motion of the body vector is uppermost, the sign is negative. In this case, the four minute combined motion of Kochab is - 8, as illustrated.

4. Similarly the four minute combined motion adjustments of Alpheratz and Altair are +73½ and −65, respectively.

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 in 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 observations 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 or on the Vaid computer.

Preplotting True Azimuths (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. The procedure is set up 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, 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°.

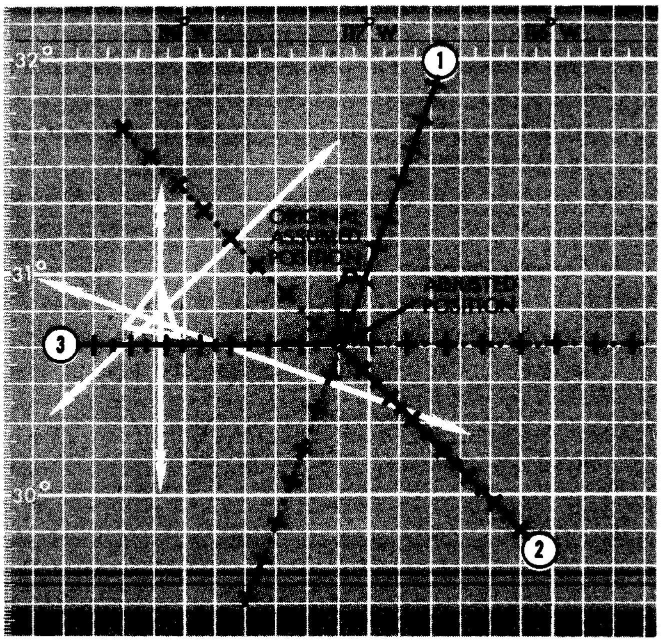
(The original assumed position of 31°N, 117°08′W has been corrected for precession/nutation and for coriolis/rhumb line error to get the corrected assumed position.)

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 or Vaid Computer

The following examples explain the procedures for plotting the fix on the DR computer. The same results can be obtained by following like procedures on the grid side of the Vaid 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.

Fix can be Plotted Quickly



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 coordinates 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 assigned 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 LOP's 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 given. 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.

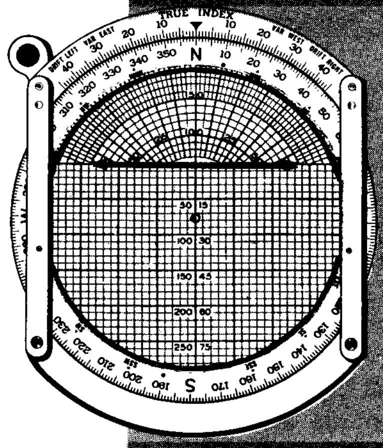
2. Place 231° under the true index and draw in the Sirius LOP, 6 nm below the grommet (6A).

3. Place 122° under the true index and draw in the Spica LOP, 21 nm below the grommet (21A).

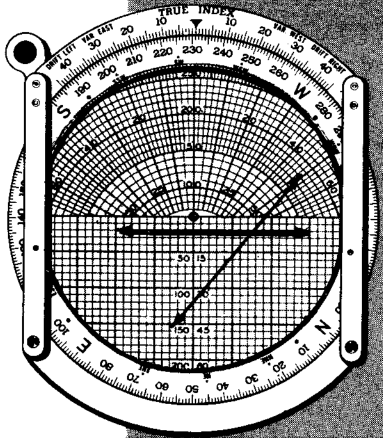
4. Place 290° under the true index and go up 3 nautical miles from the *uncorrected fix* to take care of the precession/nutation correction. Go up because the values of the precession/nutation correction indicate that the fix is to be moved 3 nautical miles in the direction of, or towards, 290°.

5. Place the track (118°) under the true index and go 10 nautical miles *to the right* from the 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.

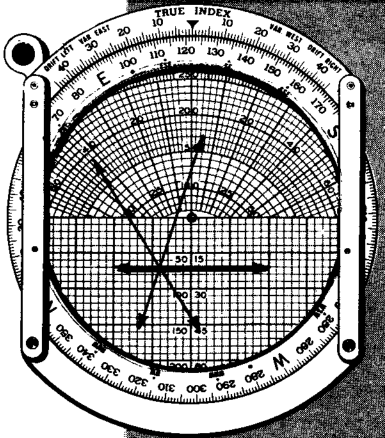
6. Place the final fix (inside the triangle) above the grommet with the zero line through the fix and the center vertical also through the fix. Read the range under the grommet and the bearing under the true index. The range is 24 nautical miles and the bearing is 310°. Hence the fix is plotted 24 nautical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



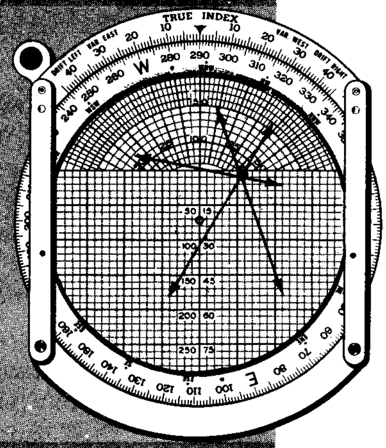
1. DRAW IN
POLARIS LOP



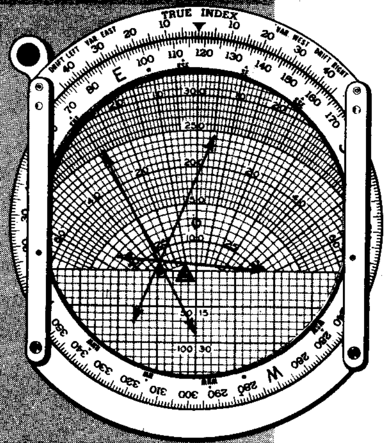
2. DRAW IN
SIRIUS LOP



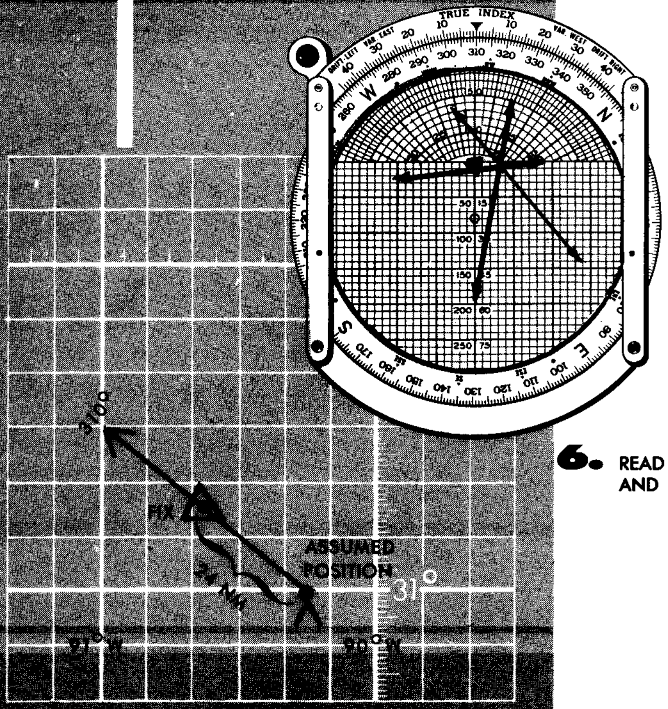
3. DRAW IN
SPICA LOP



4. PRECESSION
NUTATION
CORRECTION



5. FINAL
CORRECTED
FIX



6. READ RANGE
AND BEARING

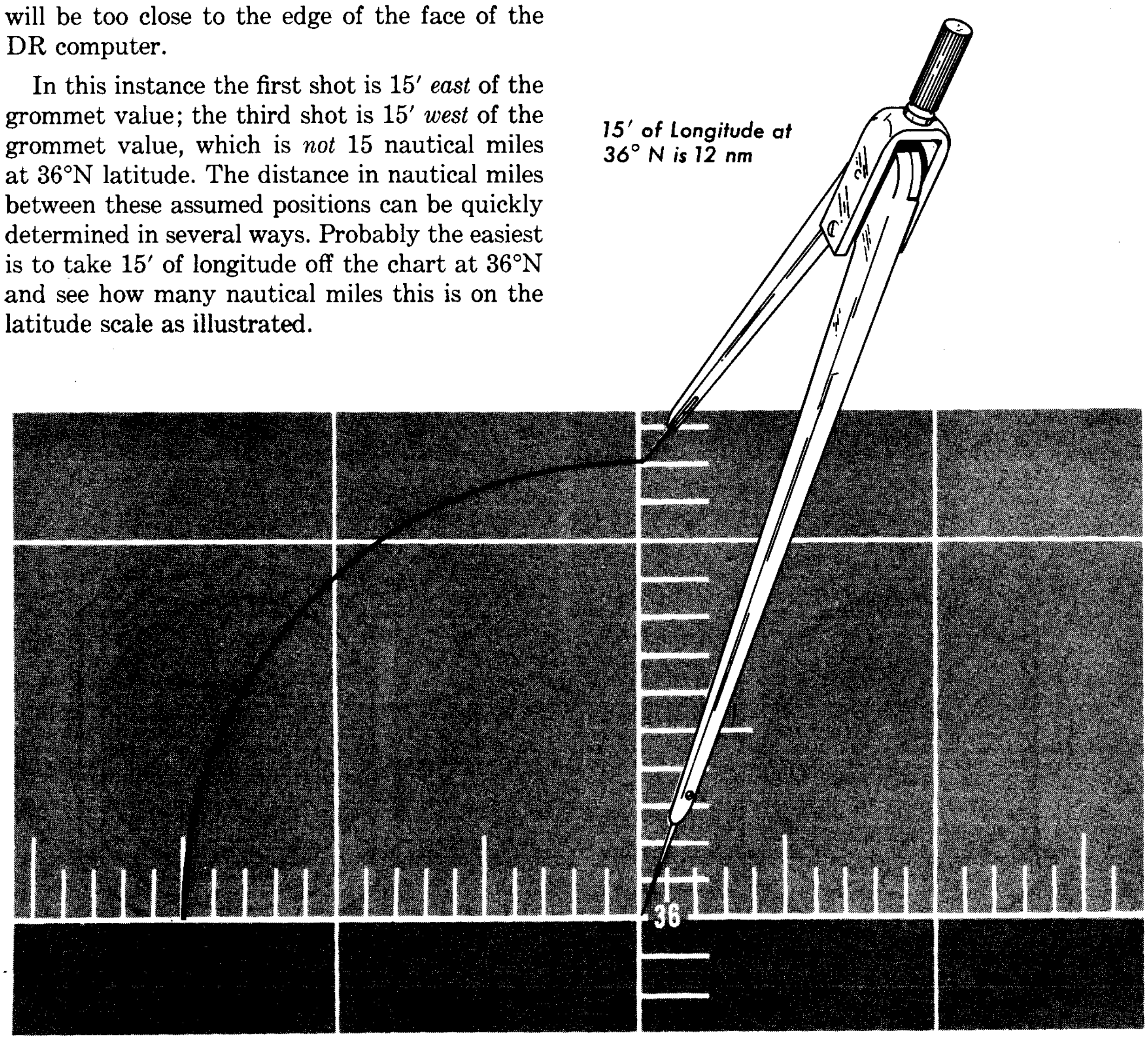
When more than one assumed position exists, a slightly different procedure must be used. In this case all the assumed positions must be plotted on the DR computer before starting. Since the grommet can only be assigned one value of latitude and longitude, it is usually assigned the value of the middle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

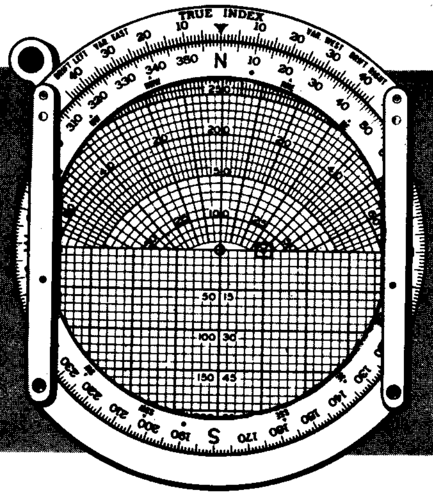
For example, all three assumed positions have the same latitude 36°00′N but the first is 119°14′W, the second 119°29′W, and the third 119°44′W. The grommet is assigned the value 36°00′N 119°29′W. This is done so that the other two assumed positions will plot on either side of the grommet and no one assumed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

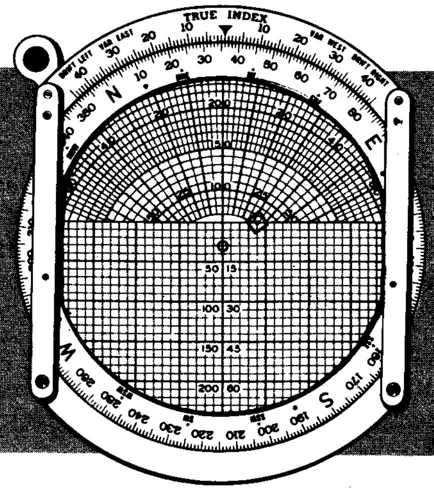
Another quick way to determine the distance is to solve it graphically on the square grid of the DR computer. Place 0° (N), at the index and make a point 15 nautical miles to the side of the grommet, using the square grid as shown in the illustration.

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 the illustration that the slide has been moved.





Mark to the Side of the Grommet



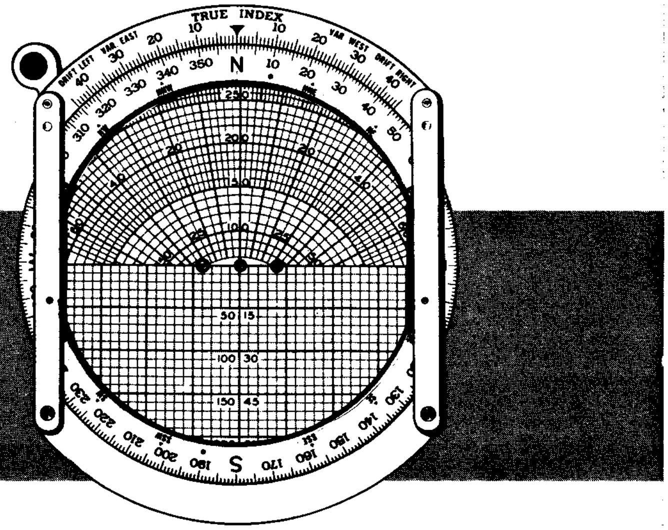
Read Horizontal Component

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 a 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.

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, including 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.

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 which 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 or Vaid computer.