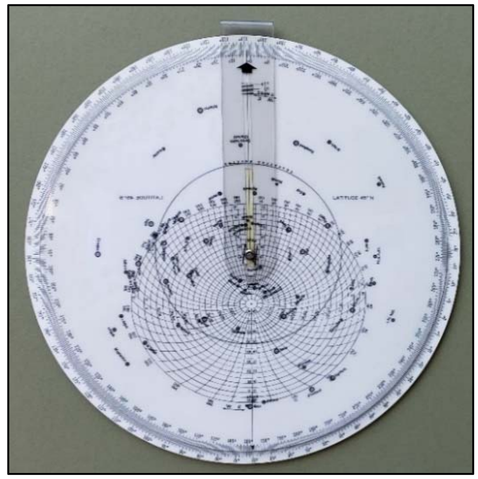
CP- 300/U USAF Star Finder

by Edward S. Popko, USPS SN

Introduction



Marine navigators have used the Rude 2102-D star finder for many years as an aid to planning sights and identifying stars. The US Air Force developed a variation in the mid-1950s that incorporated a number of enhancements. This article highlights the main features of the CP-300/U and contrasts them with the better known 2102-D star finder.[1] Both star finders give positions of stars included in the American and British Almanacs. The CP-300/U consists of a star wheel for the northern sky on one side, southern sky stars on the other and an east-west longitude wheel in-between. In addition, there are eight (8) removable altitude/azimuth discs with grid projections for north/south latitudes in increments of 10°. Both the 2102-D and CP-300/U use the polar azimuthal equidistant projection of the stars and the oblique azimuthal equidistant projection of the horizon system for the altitude/azimuth disks. See Appendix C for a technical description of these two projections. Note that stars are the mirror image as they appear in the sky like an old-fashioned star globe; you can't hold it up to the sky and use it like a planisphere.

Knowing the Greenwich Hour Angle (GHA) of Aries and dead reckoning (DR) latitude and longitude, this device displays the Local Hour Angle (LHA) Aries and the altitude (Hc) azimuth (Zn) of key navigation stars. Daily uses might include:

- predicting the altitude and azimuth of stars for morning or evening star shots
- identifying unknown stars
- estimating sun rise/set, civil, nautical and astronomical twilight.
- select stars with best lines of position for course and speed checks or fixes

In general use, the star finder is set up for an anticipated observation time, expected DR latitude/longitude and the GHA Aries at that time. This is accomplished by setting the star wheel GHA Aries to 0° on the longitude wheel and the latitude altitude/azimuth disk meridian pointer to the navigator's anticipated DR longitude. All bodies in the visible sky whose altitude range from -10° to 90° are located within the grid of the altitude/azimuth disk. Stars outside this grid are not visible at this time. An example problem, included later in the paper, details how to set up the CP-300/U and interpret the results.

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[1] This article is an updated and enlarged version first published in: "The Navigator's Newsletter", Issue #77 Fall 2002, *Foundation for the Promotion of the Art of Navigation* column entitled History of Navigation, pp 6-12.

FSN 6605-557-0778

Computer Air Navigation Celestial Azimuth
TYPE CP- 300/U
MIL- C - 277333(USAF)
QTY 1
CONTRACT NO. AF36(600)9047
ALLEGHENY PLASTICS INC. MFG/CONTRACT
MFG NO. APAF-31
III PKG 5/61

Parts

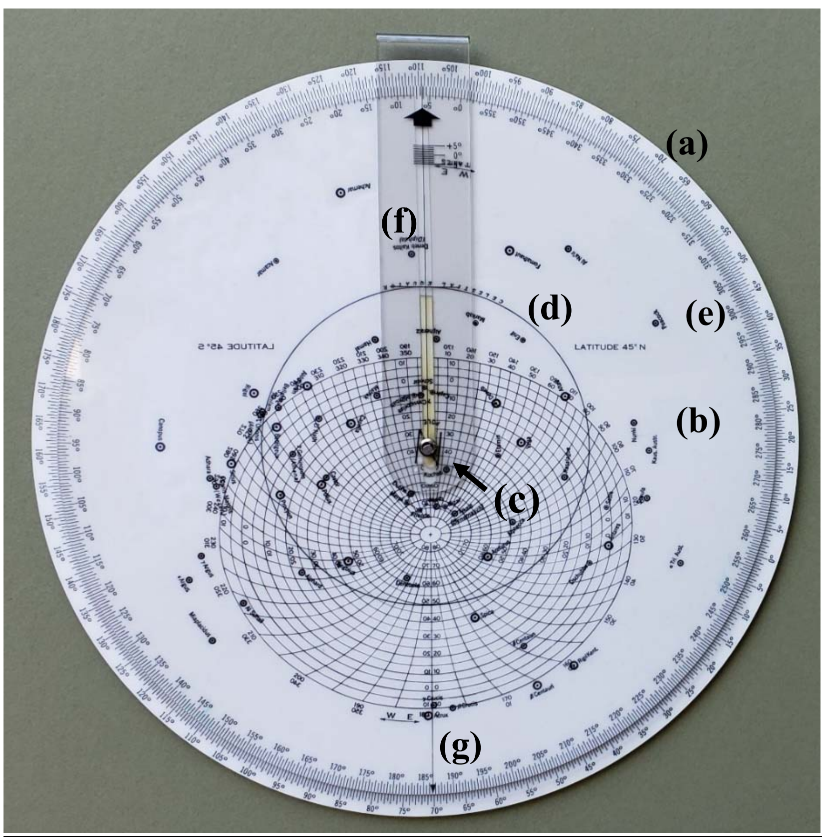
- Star base with the Northern Sky on one side of the base and the Southern Sky on the other side
- East-West Longitude Scale
- Eight (8) removable discs with grid projections on the sphere with designed latitude in increments of 10°
- Instruction set
- Plastic case

Complete CP-300/U Star Finder Kit

Design and Layout

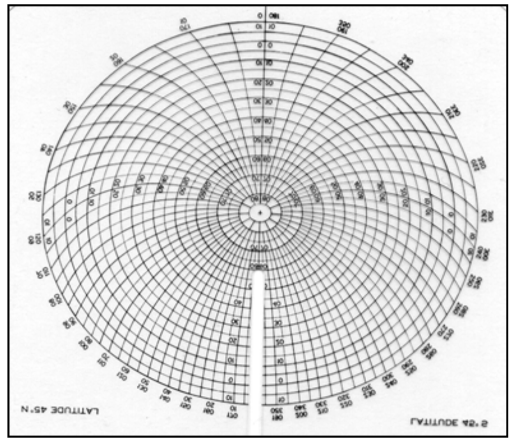
The CP-300/U's main body is a sandwich design of three thin white opaque plastic wheels with a common center pivot. Referring to the image below, the middle and largest wheel displays east and west longitudes 0° to 180° around its rim **(a)**. This scale is printed both sides; the wheel measures 8½″ in diameter. The other two wheels, top and bottom, are star bases for the northern and southern celestial spheres **(b)** identified by a large 'N' or 'S' at the center pivot **(c)**. Their rim scales are marked in hour angles; their meaning can be the GHA or LHA of Aries depending on the finder's application. They are 8″ in diameter and, in use, they are rotated to read alongside the longitude scale.

Both star wheels display the same 66 navigation stars projected from their respective north or south elevated poles. Stars are marked with circled dots; the circle's diameter indicates their relative brightness. The Celestial Equator is plotted on both star bases as well. It's labeled and graphically appears as a circle centered on the elevated pole **(d)**. The star base rim **(e)** is used to set the GHA or LHA of Aries, it reads counter clockwise 0° to 360°.



Full view of the CP-300/U USAF Star Finder. Star base is northern hemisphere side (indicated by a large "N" in the center). The altitude/azimuth disk overlay is for latitude 45°N. The disk latitude has been adjusted -5° to more closely approximate the vessel's DR latitude of 40°N. The disk's GHA Aries is set for 257°, the expected hour angle for twilight. The viewer's DR longitude is set for 70° West. These adjustments are explained step-by-step below and used in the sample problem.

In addition to the latitude and star base wheels, the CP-300/U includes a transparent plastic rotation arm **(f)**. It's a meridian pointer and doubles as a mount for slip-in latitude-specific altitude/azimuth disks. Disks are placed over the star base and tucked under the rotation arm. A slot in the disk locks onto a key under the rotation arm.



The CP-300/U kit includes eight (8) transparent removable plastic discs with oblique azimuthal equidistant projections of the horizon coordinate system altitude/azimuth grid. The grid when properly positioned over the star base, interprets the altitude/azimuth positions of the stars on the wheel below. Stars within the grid are the ones that can be seen at the latitude and time the finder is set for. The grid indicates a star's Hc and Zn angle. Each disk covers a 10° increment of terrestrial latitude starting at 5° and proceeding to 85°. Depending on which disk-face is inserted 'up', the grid represents either north or south latitudes. The north latitude faces are used only with the north star base which is indicated with a large "N" at the center pivot and vice versa. Each disk displays azimuth reference (Az) lines 0° to 360° in 5° increments as well as altitude (Hc) reference lines ranging from -10° to 90° in 5° increments.   The grid system completely defines all the positions in the sky. The observer's meridian (due north-south) is indicated with a reference line, one end of which has an arrow pointing 180° away from the elevated pole **(g)**. For DRs in the northern hemisphere, the arrow points due south at 180°. Conversely, the arrow points due north (0°) for use in the southern hemisphere. In general usage, the altitude/azimuth meridian pointer is set to the navigator's DR longitude.

An Example Problem

This example is a typical day's work situation where the navigator is preparing a star list for a round of evening twilight star shots. The list of star names and their altitude/azimuth angles will be a guide for pre-setting his sextant and recording the body's name and altitude after each shot.[2]

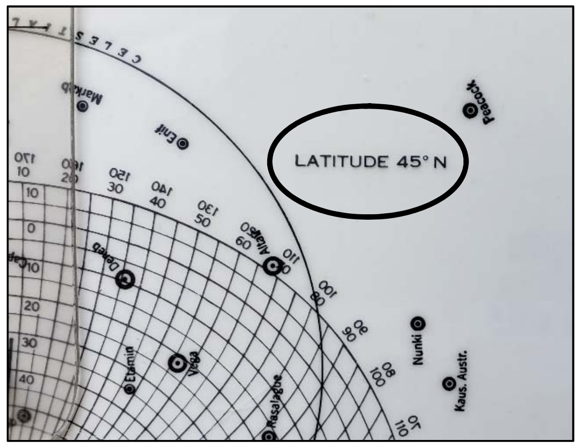
Navigators with 2102-D experience will recognize the CP-300/U's setup.

[2] Readers interested in knowing more about star finders will benefit from David Birch's manual "***The Star Finder Book – A complete Guide to the many uses of the 2102-D Star Finder".*** It's quite readable and the many examples provide an excellent refresher on time, hour angles, the Nautical Almanac and the various interpretations of the scales and reference grids on the finder. The differences between the 2102-D and CP-300/U are minimal. See ***References*** section for details.

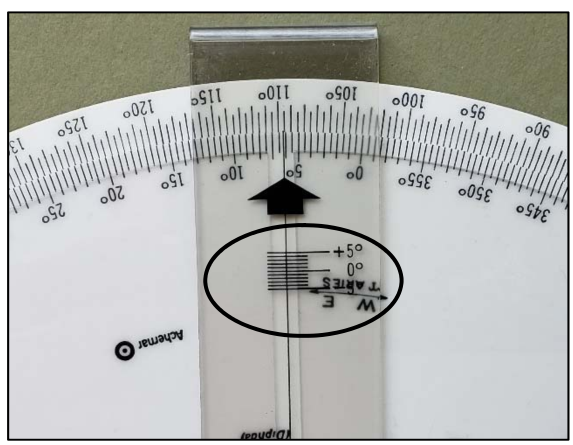
Our navigator is in the Marion-Bermuda sailboat race and sailing on a rhumb-line heading straight for Bermuda. Based on his current course and speed, he estimates his DR latitude and longitude position at sunset will be about 40°N 70°W. The Nautical Almanac gives him the estimated time of sunset. From that GMT, he determines the GHA Aries. In this example, June 15, 2017, sunset begins at approximately GMT 23:30:00 and the GHA of Aries will be 257°.

This is enough information to set the star finder wheels and altitude/azimuth disk and see what stars will be candidates for sextant sights.

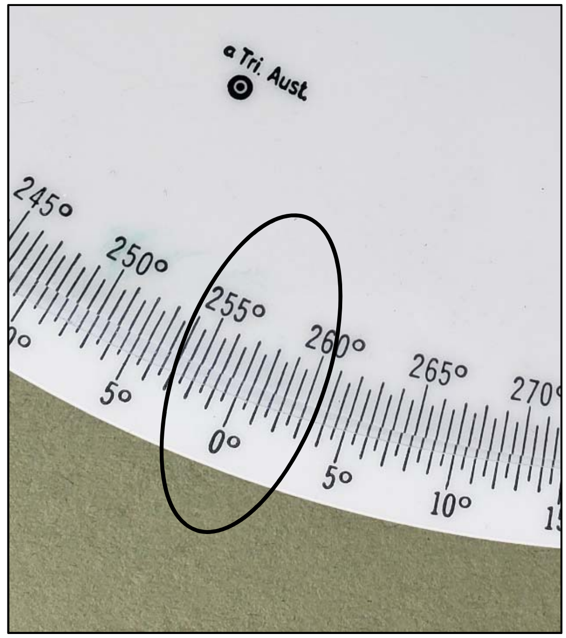
1. <u>Select the star base wheel and altitude/azimuth overlay disk closest to the expected DR latitude</u>. The "N" star base wheel and grid disk "LATITUDE 45° N" is selected because the DR latitude falls within it. It slides under the rotation arm and is held in place by a molded key. A quick check ensures that the 45°N face is up and not 45°S which is only used with the southern star base. Since our expected DR latitude is 40°N and falls in-between disks 45°N and 35°N, we could have selected the LATITUDE 35°N disk as well.



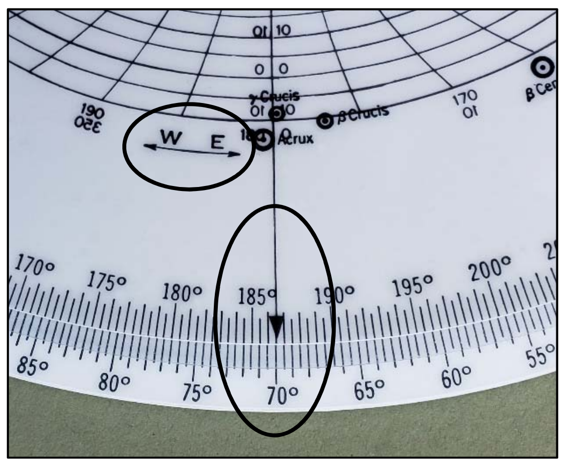
2. <u>Fine tune the grid disk to the DR latitude.</u> The DR anticipate at twilight is 40°N and not the template's 45°N. A minor adjustment positions the grid disk closer to the DR. The disk can be slid in or out from under the rotation arm by +/-5°. In our example, it's shifted -5° to more closely approximate the expected vessel's DR 40° N latitude at twilight. Had we selected the 35°N latitude disk, we could have shifted it +5° to approximate our DR 40°N latitude.



3. <u>Position the GHA Aries wheel adjacent to 0° longitude Greenwich.</u> In this example, the GHA Aries is about 257°. GHA is measured from the Greenwich meridian, westward, to the First Point of Aires. Position the GHA of Aries 257° on the star base wheel across from 0° on the outer longitude wheel. The star and longitude wheels are now in proper position to one another.



4. <u>Align the observer's Meridian Arrow to the anticipated DR longitude at twilight.</u> Use the rotation arm to rotate the altitude/azimuth disk so that the observer's Meridian Arrow points to the anticipated DR longitude on the outer longitude wheel. West longitudes are clockwise rotations from 0°, east is counter clockwise. A reminder of east/west rotation directions is printed on the star base. In this example problem, the meridian pointer is set to 70°W longitude. Note that once the altitude/azimuth disk is oriented, LHA of Aries 187° can be read above the DR longitude. This step is the similar to the 2102-D however the navigator only has to work with his DR longitude and GHA of Aries. LHA of Aries is simply the DR longitude offset to Aries.



The CP-300/U is now properly set up for the anticipated DR position, date and time. All stars within the altitude/azimuth disk are visible at twilight.[3]

[3] Some users find it convenient to tape all the disks together so that they do not inadvertently change position while the device is being handled.

Interpreting the Results

Even without the planets or the moon plotted on the star base, the navigator has many good candidates assuming sky visibility is good. Navigators often have personal preferences for favorite stars or the preferred altitudes they shoot. In this example, only bright stars with altitudes greater than 15° and less than 70° are considered.

	Body	Alt	Az
	KOCHAB	52°	15°
	ELTANIN	35°	48°
*	VEGA	22°	57°
	RASALHAG	17°	88°
	ALPHECCA	49°	94°
	ARCTURUS	58°	124°
*	SPICA	37°	162°
	DENEBOLA	63°	203°
	ALPHARD	24°	232°
	REGULUS	47°	238°
	PROCYON	14°	263°
*	POLLUX	32°	282°
	CAPELLA	17°	316°
	POLARIS	40°	360°

Table 1 – Star List

Looking at the stars within the grid and in clockwise order of azimuth, we see that quite a few meet the above criteria. *Table 1 - Star List* is just a sampling. From this twilight list, the navigator might shoot them in the ascending azimuth sequence starting with Polaris at 0° because easterly stars appear first as the sun sets in the west. Although planets and the moon were not plotted on the star base, they too would make excellent twilight bodies to shoot if they were visible. Note that the azimuths of three stars, indicated with an asterisk, make an excellent three body fix.[4]

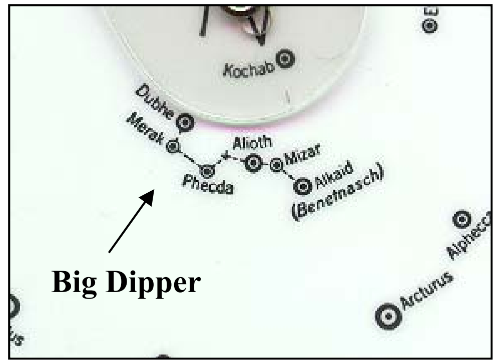
Features not Found on 2102-D

The CP-300/U is refinement of the 2102-D star finder, enhancements include:

- <u>More base stars</u> – the CP-300/U's star base displays 66 stars on both the north and south wheels. The 2102-D displays only 57. Both star finders display a common set of 53, see *Appendix A* for a side by side comparison. Stars appear to be selected on the basis of magnitude, even-distribution across the sky and within prominent constellations; not necessarily because they are among the 57 designated Navigation Stars included in the Daily Pages of the Nautical Almanac. Almost all of the additional stars are in the constellations Big Dipper, Cassiopeia, Orion's Belt, Canis Major and the Southern Cross. Perhaps the star finder's developers thought these additional stars, in easily recognized areas of the sky, would be useful.

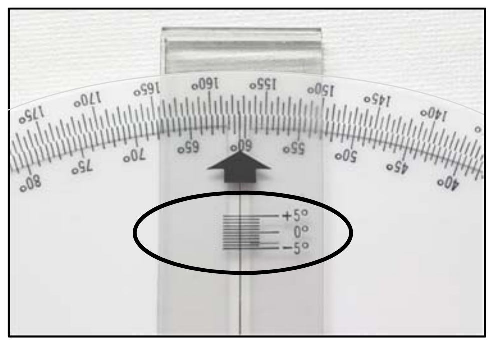
[4] *Publication Number 249 Volume 1, Sight Reduction Tables for Air Navigation (Selected Stars)*, published by the Defense Mapping Agency, is a standard reference carried by air celestial navigators. It contains the altitude and true azimuth of seven selected stars for the complete ranges of north and south latitude and hour angle of Aries. For every combination of latitude and LHA, seven of the most visible stars are listed and three are highlighted with '*' indicating they would produce the best three body fix.

- Constellation figures - Cassiopeia and Ursa Major (Big Dipper) are depicted on the star base. For those stars clustered near Polaris on the north star base, asterisms help sort out the congestion. Keep in mind that the view is reversed, as seen from the outside like an old-fashioned star globe, and not the view you would see in the sky.

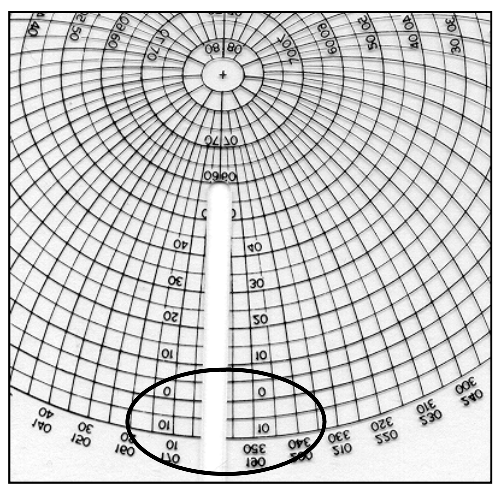


- Longitude Wheel – one of the most significant differences, the CP-300/U includes and extra wheel for setting the viewer's meridian and longitude. The longitude wheel is also useful because the LHA of Aries is displayed above the DR longitude position. Other computations for time and hour angles are possible.

- Altitude/Azimuth disk adjustment – like the 2102-D, the CP-300/U includes sky projection grids for north and south latitudes 5°, 15°, 25°, 35°, 45°, 55°, 65°, 75° and 85°. A unique disk-slot feature fine tunes latitude adjustments of +/- 5°. Thus, it's possible to set the observer's position to any desired latitude north or south from 0° to 90°. The adjacent image shows a grid adjusted -3° latitude.[5]

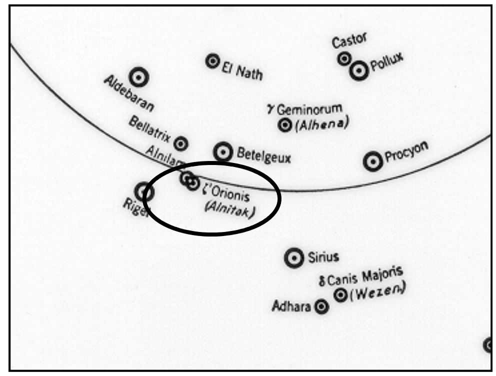


- Below the horizon altitude scales – the CP-300/U overlay disks extend the azimuth grids to -10° below the visible horizon. This is a useful addition for estimating which stars are just entering or leaving Civil and Nautical Twilights.



[5] Small disk adjustments of one or two degrees are not likely to make any measurable difference to reading a star's altitude/azimuth. Larger adjustments of three to five degrees may improve some star altitude/azimuth readings but hinder others at the same time.

Not all CP-300/U features are improvements; some can be confusing and lead to errors while others may lead to a false sense of precision the device cannot offer:



- Bayer designation – unlike the 2102-D star base where common star names are used, the CP-300/U uses Bayer designations in some cases. For example, star Alnitak is labeled ζ'Orionis, an unnecessary confusion. Some stars display both names, the result is a congested display that is somewhat difficult to read. *Appendix A* lists the stars displayed on both finders. The common and Bayer designations are listed as they appear on the finders.

- Congested starfield – The CP-300/U star wheel is smaller than the 2102-D. It's additional stars and foreshortened starfield projection area make it harder to read than the 2102-D's simpler and larger format.

- No declination overlay – while the 2102-D provides a special overlay template for adding new bodies to the star base, the CP-300/U does not.[6] This is a design shortcoming. Unlike stars that have fixed celestial positions, the sun, moon and planets are never printed on the star base because they are constantly changing against the star backdrop. Air and marine navigators often add additional bodies to the star base if they are bright and visible at twilight. With no convenient way to add new bodies, the navigator would not have added two very visible planets, Mars at altitude/azimuth 16°/288° and Jupiter at 46°/171° to the list in the twilight example problem. Adding a new body to the CP-300/U star base involves using dividers to measure off the distance between the pole (star finder center) and the Celestial Equator circle. The declination is then estimated. The rotation arm acts as a ruler for intersecting the body's RA and declination on the star base. The Nautical Almanac provides the necessary Sidereal Hour Angles. Once located, the body can be plotted in pencil on the star base. This process is tedious when compared to doing the same with the 2102-D.[7]

- Latitude adjustment – at first glance, it seems that the adjustable +/-5° altitude/azimuth disk feature would improve locational accuracy but this is hard to demonstrate. Adjustments may improve some interpretations while worsening others at the same time. The latitude adjustment feature gives a false sense of increased precision the finder simply does not have.

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[6] It may have been standard operating procedure within the Air Force to use only the sun, moon and significant bright stars in celestial navigation. The sun and moon are easy to find without the finder. But planets are constantly changing position with respect to the background stars. The additional pre-calculation and drafting skills to add them to the star base may not have been worth the time or risk of error.

[7] For someone who is not familiar with the constellations one might confuse Mars and Antares or Jupiter or Saturn with bright star they happen to be near.

- Terse instructions – the instruction sheet, *Handbook of Operating Instructions*, is a misnomer. Just two pages describe the most basic setups, see *Appendix B*. Only a navigator already familiar with the better documented 2102-D star finder, could make full use of this device.

Conclusion

The Air Force CP-300/U offers some useful enhancements over the Navy's 2102-D star finder. The addition of a longitude wheel, more stars and constellation asterisms facilitate quicker setup and interpretation.

On the other hand, the CP-300/U star base is visually congested when compared to the 2102-D and its lack of a star base overlay template for adding new bodies is a glaring shortcoming. The latitude grid-disk adjustment feature does little, if anything, to increase accuracy. Shifting the grid-disk as much as +/-5° may improve some star altitude/azimuth readings but other star readings will likely suffer at the same time.

Despite CP-200/U and 2102-D physical and set-up differences, many navigators will see that their applications and accuracy are about the same.

Some navigators speculate that the CP-300/U was simply a product of interservice rivalry – Navy vs. Air Force - and one wonders why it was not widely used or commercially available. It's likely that it's few benefits and additional manufacturing complexity, with no significant increase in accuracy but at higher cost, could not displace the venerable Rude 2102-D star finder.

Appendix A – *Stars Appearing on the CP-300/U and 2102-D*

Stars appearing on the CP-300/U and 2102-D star bases or listed in the selected 57 stars in the Nautical Almanac. Stars are listed in their ascending order of right ascension and declination, the same order printed on the star-bases.

Star Name	SHA	Dec		RA	RA Hr	57	CP-300/U	2102-D
Alpheratz	357	N	29	3	0	Y	Y	Y
Caph	357	N	59	3	0		Y	
Ankaa	353	S	42	7	0			Y
Schedar	349	N	56	11	1	Y	Y	Y
Deneb Kaitos (Diphda)	349	S	17	11	1		Y	Y
γ Cassopeia	345	N	60	15	1		Y	
Ruchbah	338	N	60	22	1		Y	
Achernar	335	S	57	25	2		Y	Y
Hamal	328	N	23	32	2	Y	Y	Y
Acamar	315	S	40	45	3	Y	Y	Y
Menkar	314	N	4	46	3	Y		Y
Mirfak	308	N	49	52	3	Y	Y	Y
Aldebaran	290	N	16	70	5		Y	Y
Rigel	281	S	8	79	5	Y	Y	Y
Capella	280	N	46	80	5	Y	Y	Y
Bellatrix	278	N	6	82	5	Y	Y	Y
El Nath	278	N	28	82	5	Y	Y	Y
Alnilam	275	S	1	85	6		Y	Y
ζ Orinois (Alnitak)	274	S	1	86	6		Y	
Betelgeuse	271	N	7	89	6	Y	Y	Y
Canopus	264	S	52	96	6	Y	Y	Y
γ Geminorum (Alhena)	260	N	16	100	7		Y	
Sirius	258	S	16	102	7	Y	Y	Y
Adhara	255	S	28	105	7		Y	Y
δ Canis Majoris (Wezen)	252	S	26	108	7		Y	
Castor	246	N	31	114	8		Y	
Procyon	245	N	5	115	8	Y	Y	Y
Pollux	243	N	28	117	8	Y	Y	Y
γ Argus	238	S	47	122	8		Y	
ε Argus	234	S	60	126	8		Y	Y Avoir
Al Suhail	222	S	43	138	9		Y	Y Suhail
Miaplacidus	221	S	69	139	9	Y	Y	Y
Alphard	218	S	8	142	9	Y	Y	Y
Regulus	207	N	11	153	10	Y	Y	Y
Dubhe	194	N	61	166	11	Y	Y	Y
Merak	194	N	56	166	11		Y	
Denebola	182	N	14	178	12	Y	Y	Y
Phecda	181	N	53	179	12		Y	
Gienah	176	S	17	184	12	Y		Y
Acrux (α Crucis)	173	S	63	187	12		Y	Y

γ Crucis (Gacrux)	172	S	57	188	13		Y	Y Gacrux
β Crucis (Mimosa)	168	S	59	192	13		Y	
Aloth	166	N	55	194	13	Y	Y	Y
Mizar	158	N	54	202	13		Y	
Spica	158	S	11	202	13	Y	Y	Y
Alkaid (Benetnasch)	153	N	49	207	14		Y	Y
β Centauri (Hadar or Agena)	148	S	60	212	14		Y	Y Hadar
θ Centauri (Menkent)	148	S	36	212	14		Y	Y Menkent
Arcturus	146	N	19	214	14	Y	Y	Y
Rigil Kent. (Toliman)	140	S	60	220	15	Y	Y	Y
Kochab	137	N	74	223	15	Y	Y	Y
Zubenelgenubi	137	S	16	223	15	Y		Y
Alphecca	126	N	26	234	16	Y	Y	Y
Dschubba	119	S	22	241	16		Y	
Antares	112	S	26	248	17	Y	Y	Y
α Tri Aust. (Atria)	107	S	69	253	17		Y	Y Atria
Sabik	102	S	15	258	17	Y	Y	Y
Rasalhague	96	N	12	264	18	Y	Y	Y
Shaula	96	S	37	264	18	Y	Y	Y
Eltanin	90	N	51	270	18	Y	Y	Y
Kaus Austr.	83	S	34	277	18	Y	Y	Y
Vega	80	N	38	280	19	Y	Y	Y
Nunki	76	S	26	284	19	Y	Y	Y
Altair	62	N	8	298	20	Y	Y	Y
Peacock	53	S	56	307	20	Y	Y	Y
Deneb	49	N	45	311	21	Y	Y	Y
Enif	33	N	9	327	22	Y	Y	Y
Al Na'ir	27	S	46	333	22	Y	Y	Y
Fomalhaut	15	S	29	345	23	Y	Y	Y
Markab	13	N	15	347	23	Y	Y	Y

Appendix B – Handbook of Operating Instructions

HANDBOOK OF OPERATING INSTRUCTIONS

FOR

COMPUTER—AIR NAVIGATION, CELESTIAL AZIMUTH

AIR FORCE TYPE CP-300/U

Prepared By

SERVICE ENGINEERING DIVISION

Electronic and Instrument Branch

Middletown Air Material Area (MANEE)

DESCRIPTION:

The CP-300/U Computer gives positions of stars included in both the American and British Almanacs, and may be used for identifying or locating stars. It consists of a star base with the Northern Sky on one side of the base and the Southern Sky on the other side of the base, an East-West Longitude Scale, eight (8) removable discs with a polar stereographic grid projection on the sphere with designed latitude in increments of 10°, a set of instructions and a plastic case.

Knowing the GHA (AIRES) and the dead reckoning latitude and longitude, you can obtain the following:

1. LHA (AIRES)
2. Z_n (Celestial Body)
3. h_c (Celestial Body)
4. SHA (Celestial Body)
5. Declination (Celestial Body)
6. LHA (Celestial Body)

Whenever any of the above terms are used in the following instructions, it is to be assumed that they have reference to a celestial body unless otherwise stated.

INSTRUCTIONS TO PLOT ADDITIONAL CELESTIAL BODIES:

Stars, Planets and the Moon are plotted by the following coordinates:

1. 360°—SHA
2. Declination

The outer edge of the North and South Pole Displays (Movable Base) are graduated in half degree increments to 360°—SHA.

1. Find SHA of stars in Air Almanac and solve for 360°—SHA.

2. For Moon and Planets, 360°—SHA = GHA (AIRES) —GHA. (If 360°—SHA is negative in value, add 360° to reverse the sign.) Since the Moon and Planets continually change apparent positions relative to the fixed stars, the positions have to be plotted for a particular time of observation. GHA (AIRES) and GHA are found in the Air Almanac.

3. Draw a line from 360°—SHA (obtained in Step 1 or 2 above) from the outer periphery of the star base to the pole.

4. Obtain the declination of the celestial body from the Air Almanac. Using dividers, measure this value on the altitude scale of any removable disc. Then lay off this distance along the 360°—SHA line using the celestial equator as a starting reference. If the Southern Sky side of the computer is being used, Southern declination will be plotted within the celestial equator circle and Northern declination outside the celestial equator circle and vice versa when the Northern Sky side is used.

5. By reversing this procedure, the declination and SHA of a plotted body may be found.

IDENTICATION OF A CELESTIAL BODY:

1. Select removable disc nearest the D.R. latitude.
2. To obtain correct latitude:
   a. With proper side up, insert removable disc under curson by aligning slot in disc with pivot.
   b. Slide disc into position over star base.
   c. Align small horizontal line on removable disc, located adjacent to center line of cursor, with 0° mark on correction scale on cursor. This is the correct position for the designated latitude on the removable disc.
   d. Add or subtract the degree marks on the cursor to the designated latitude to obtain the correct D.R. Latitude.
3. For any G.M.T., take the GHA (AIRES) from the Air Almanac and add or subtract the D.R. Longitude to find LHA (AIRES). LHA (AIRES) = GHA (AIRES)
+ E Longitude
— W Longitude. If LHA (AIRES) is negative in value, add 360° to reverse the sign. Rotate removable disc to bring the 0° to 180° Meridian Arrow to LHA (AIRES).
4. For the specified time, the arrow over the LHA (AIRES) is the observers local meridian. Stars in the visible sky whose altitude range from —10° to +90° are then located within the grid lines of the removable disc.
5. The Altitude and Azimuth of any celestial body within the grid can now be found.

EXAMPLE: Find — Altitude and Azimuth of SPICA

Given — 21 Mar 61 — D.R. Latitude 40°N
D.R. Longitude 75° 34′ W
G.M.T. $7^h 00^m 00^s$

G.M.T.	$7^h 00^m 00^s$
GHA (AIRES)	283° 34′
Long.	75° 34′W
LHA (AIRES)	208° 00′

Correct Latitude of 45°N disc to 40°. Place 0° to 180° Meridian Arrow to 208°. Read Alt. = 38° and Z_n = 190°.

6. Alternate method for finding LHA (AIRES). For any given G.M.T., place GHA (AIRES) on inner scale of star base directly over 0° on the outer scale (East-West Longitude Scale). Rotate the removable disc to bring 0° to 180° Meridian Arrow to the D.R. Longitude on the outer scale. The LHA (AIRES) will be found under the 0°-180° Meridian Arrow on the inner scale of the star base.

Appendix C – Star Wheel and Latitude Disk Projections

The CP 300/U star finder uses the same star wheel and latitude disk projection system as the Rude 2102-D. Navigation historian Ernest Brown investigated the 2102-D's star and latitude disk projections and describes them this way:[8]

> Each side of the white base plate of No. 2102-D, Star Finder and Identifier, is a polar azimuthal equidistant projection of the celestial equator (equinoctial) system of coordinates.[9] For each side, the plane of projection is tangent to the above system of coordinates on the celestial sphere at the elevated pole, north or south. For clarity most of the projection has been removed, leaving only the elevated pole, celestial equator, and short segments of the celestial meridians near the periphery. The 57 navigation stars are placed according to their coordinates of declination and right ascension. All of this is made possible by the fact that the azimuthal equidistant projection can project almost all of the sphere.
>
> Each latitude template is an oblique azimuthal equidistant projection of the horizon system of coordinates. For each template, the plane of projection is tangent to the combined coordinate systems on the celestial sphere at the elevated pole on the principal vertical circle. The display of the zenith, vertical circles and circles of equal altitude on each template is a family of altitude and azimuth curves limited to the region on the celestial sphere above the celestial horizon. The radial extension of the principal vertical circle indicates the observer's celestial meridian. Note that with this radial set at LHA of Aries on the base plate, the observer's celestial meridian is set at the right ascension, or at its proper place among the stars.

[8] Ernest Brown, "DO YOU KNOW …?", *The Navigator's Newsletter*, Issue 49 (Fall 1995), p.16.
[9] The azimuthal equidistant star projection has the useful properties that all stars on the projection are at proportionally correct distances in declination from the elevated pole, north or south, and that all stars are at the correct azimuth (Right Ascension) around the elevated pole.

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