CP- 300/U USAF Star Finder

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Introduction

Marine navigators have used the 2102-D star finder for many years as an aid to planning sights or identifying stars. The US Air Force developed a variation in the mid-1950s that incorporated a number of useful enhancements. This article highlights the main features of the CP-300/U and contrasts it to the better known 2102-D star finder. Both star finders give positions of stars included in both the American and British Almanacs and are primarily used by celestial navigators for planning sights or identifying unknown stars. CP-300/U consists of a star base with the Northern Sky on one side of the base and the Southern Sky on the other, an east-west longitude scale, and eight (8) removable discs with a grid projection at designated latitude increments of 10°.

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

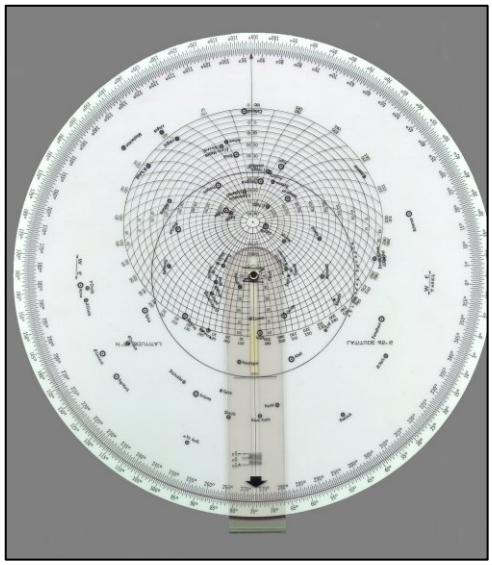
Knowing the GHA Aries and a dead reckoning latitude and longitude, this device can compute the LHA Aries and display the altitude (Hc), azimuth (Zn), SHA, Declination and LHA for a celestial body. For the celestial navigator, daily uses might include:

- predicting the altitude and azimuth (bearing) of stars for morning or evening star shots
- identifying unknown stars
- Estimating sun rise/set, civil, nautical and astronomical twilight.
- determining the time between sun/moon/Venus shots for optimal cut angles for running fixes
- time for sun, moon or Venus shots for specialty LOPs like latitude, longitude, speed or course lines.
- precomputing star-planet combinations
- precomputing daylight sights of sun / moon / Venus

In general use, the star finder is set up for an anticipated observation time. This is accomplished by setting the latitude grid overlay reference meridian to the LHA Aries on

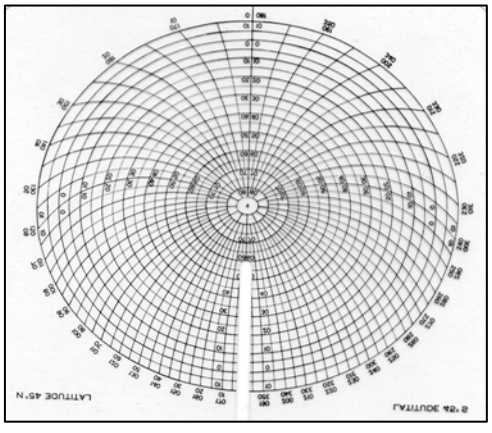
the rim scale. All bodies in the visible sky whose altitude range from -10° to 90° are located within the grid of the Altitude/Azimuth disk. Stars outside this grid are not visible at this time. An example of how to use the star finder is given later.

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. The middle wheel displays east and west longitudes 0° - 180° around its rim. This scale is printed both sides *(see Figure 2 (d))* and it's the largest wheel measuring 8 ½" diameter. The other two wheels, top and bottom, are star bases for the northern and southern celestial spheres *(see Figure 2 (a)).* They also have rim scales, the meaning of which depends on the application of the finder. Measuring 8" in diameter, their scales can be aligned adjacent to and read along with the longitude scale. The most common use of star base rim scale is to set the LHA Aries *(see detailed image Figure 2 (c)).* Each star base displays 66 navigation stars. The same set of stars is plotted on both wheels but their projection corresponds to viewpoints from the north or south hemisphere. The Celestial Equator is plotted on the star bases as well. It's labeled and graphically appears as a circle centered on the elevated pole *(see Figure 2 (e)).*

In addition to the latitude and star base wheels, the CP-300/3 includes a transparent plastic rotation arm. It's a radial pointer and doubles as a mount for slip-in altitude/azimuth disks. *See Figure 2 (b).* Disks are placed over the star base and tucked under rotation arm. A slot in the disk locks onto a key under the rotation arm. Some other features are covered later.



The CP-300/U includes eight (8) transparent removable discs with polar stereographic projections of the celestial reference grid. In effect, the grid represents the visible sky and when properly positioned over the star base, the stars that display through the grid[1] are the ones that can be seen at that time from that longitude. The grid tells you where to look for them (altitude/azimuth). 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

[1] For an explanation of the oblique azimuthal equidistant projection used for the latitude overlay grids, see Ernest Brown's "DO YOU KNOW …?" column in The Navigator's Newsletter, Issue 49 (Fall 1995).

latitudes. The north disks are only used with the north star base and visa versa. Each disk displays azimuth reference lines 0°-360° in 5° increments as well as altitude reference lines range from -10° to 90° in 5° increments. The grid system completely defines all the positions in the sky. The observer's meridian (due north and south) is indicated on the grid with reference line, one end of which has an arrow pointing 180° away from the elevated pole. For DRs in the northern hemisphere, the arrow points due south at 180°. (0° or 360° degrees for southern hemisphere DRs.)

An example

Navigators with 2102-D experience will recognize the CP-300/U's setup. The example here is a typical day's work situation. The navigator is preparing a star list for tomorrow morning's observations. He wants to know what stars will be visible at twilight and where to look for them[2]. His goal is to make a star list with their approximate altitude/azimuth angles for samples around the horizon.

A schooner is on course 333°T within the Boston Harbor In-bound Traffic Lane. They are approximately 10 nm east of Cape Cod. By daybreak, they will reach a critical turn point where the In-bound lane takes a new course of 290°T directly to Boston from the 'hook' above Provincetown[3]. The navigator estimates that they will make this turn at day break and wants to fix their position before the course change. He prepares a star list of the best bodies to shoot in the morning. Consulting the Nautical Almanac and projecting his course and speed, he determines that their DR at dawn will be Latitude 42° 05'N Longitude 69° 51'W at 10:50GMT, the time of expected Nautical Sunrise on Saturday December 7, 2002. Here are the steps:

1. Select the star base and altitude/azimuth overlay grid that corresponds to DR latitude expected at twilight. The "N" star base and overlay grid "LATITUDE 45°N" grid are selected because the DR latitude falls within it. It is inserted under the rotation arm. A slot in the disk slides around a keyway molded into the rotation arm. A quick check insures that the 45°N face is up and not 45°S which is only used with the southern star base.
2. Fine tune the grid to the DR latitude. The DR anticipate at twilight tomorrow is 42°N, not 45°N so a minor adjustment to the disk in needed. The disk can be slid in or out from under the rotation arm by +/- 5°, here is shifted -3° to more closely approximate the DR latitude. It's convenient to tape the disk and arm together to maintain the alignment when the finder is being handled.
3. Determine GHA Aries at twilight and set this angle across from 0° longitude (Greenwich) - use the daily pages of the Nautical Almanac, determine the GHA

[2] Readers interested in knowing more about star finders will benefit from David Birch's fine 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 the ***References*** section for details.

[3] NOAA charts 13009_1 or 13200_1

Aries at nautical sunrise. GHA Aries is approximately 238° 32'. GHA is measured from Greenwich, westward, to the First Point of Aires. Position the GHA Aries (238° 32' or 238.5°) of the star base across from 0° on the outer longitude wheel. The star base and longitude wheels are now in proper position to one another.

4. Align the observer's meridian to the DR longitude of sunrise. Using the rotation arm, rotate the altitude/azimuth grid so that the observer's meridian (indicated by an arrow at azimuth 180°) points to the DR longitude expected at sunrise. In this example, 70° west longitude is close enough. This step is the similar to the 2102-D however the navigator only has to work with his DR longitude and need not calculate the LHA Aries to set the wheels.

The CP-300/U is now properly set up for the sample problem. All stars within the grid are visible at dawn from the DR position, date and time given.

Interpreting the Results

Even without the planets and the moon, the navigator has many choices assuming visibility is good. Navigators often have personal preferences for the stars they will shoot. In this example, only stars with altitudes greater than 15° and less than 70° were picked. The following are some of the stars that meet these conditions. Those in bold or underlined make good combinations three-star fixes. Three planets are shown in italics.

The results shown in the Table 1 are only a sampling of the possible combinations. Although we did not plot planets on the star base, it should be noted that on this particular morning, four planets are visible. Venus and Jupiter are magnitude 1, excellent targets for sights. Mars, although of magnitude two, was so close to a very bright Venus that it offered no sight advantage and thus was not listed in the table.

Body	Alt	Az
Kochab	**50**	**021**
Vega	13	048
Alkaid	60	061
Alphecca	35	085
Arcturus	45	105
Venus	*20*	*128*
Spica	**27**	**144**
Denebola	60	156
ElNath	23	288
Alphard	34	209
Regulus	56	204
Jupiter	*56*	*225*
Procyon	30	245
Pollux	**46**	**266**
Saturn	*23*	*289*
Capella	31	305
Mirfak	18	322

Table 1 – Altitude and azimuth for selected stars resulting from the sample problem

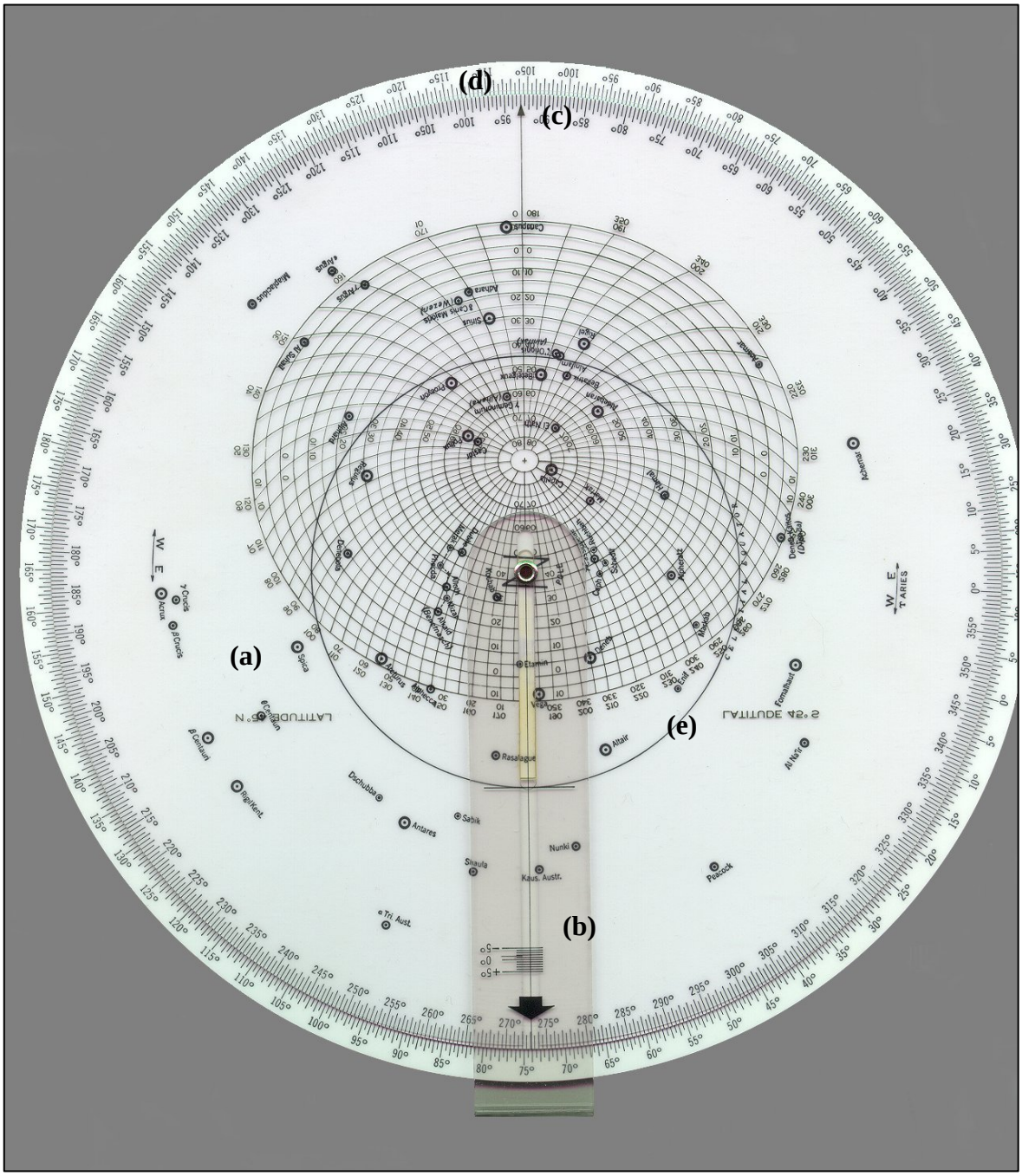
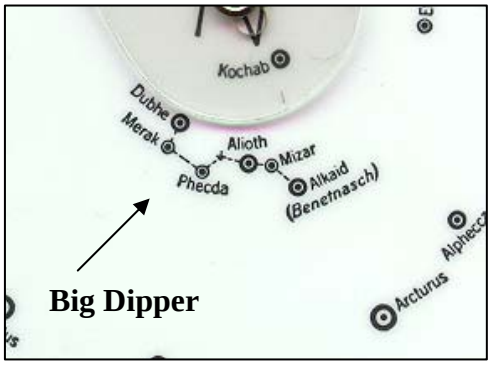


Figure 2 -- Full view of the CP-300/U USAF Star Finder. Star base is northern hemisphere side (indicated by a large "N" in the center). The altitude/azimuth disk overlay is for latitude 45° N (a). The disk latitude has been adjusted -3° to more closely approximate 42°N (b). The disk's LHA Aries is set for 93° (c). The viewer's longitude is set for 74° West (d) (home location of the author).

Features not found on 2102-D

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

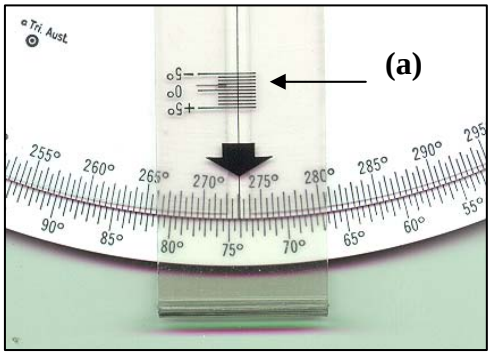
- More base stars – the CP-300/U's star base displays the same 66 stars on both the north and south bases. The 2102-D displays 57. Both star finders display a common set of 53 (see Table 2 for a listing and comparison). Stars appear to be selected on the basis of magnitude and their even distribution across the sky; 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 Big Dipper, Cassiopeia, Orion's Belt, Canis Major and the Southern Cross areas. The likely intent was to offer more choices in areas that are easily recognized.



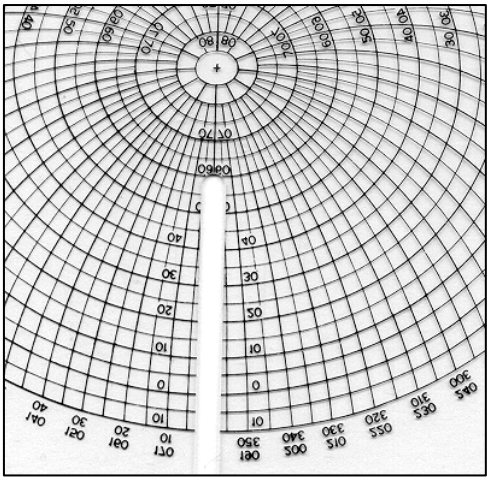
- Constellation figures - Cassiopeia and Ursa Major (Big Dipper portion) are depicted on the star base.

- Longitude Wheel – one of the most significant differences, the CP-300/U includes and extra wheel for setting the viewer's longitude. The latitude wheel is particularly useful for quickly finding the LHA Aries based on an AP or DR position. Other computations for time and hour angles are possible.

- Altitude/Azimuth grid 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°. However, a unique slot mounting allows for fine 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°. In the adjacent image, scale (a) indicates that the grid for latitude N 45° is adjusted to better fit N 42°.

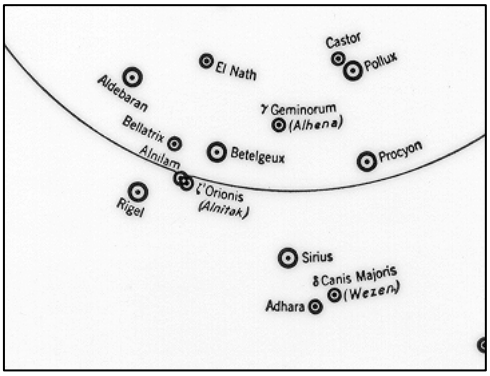


- Below the horizon altitude scales – the CP-300/U overlay disks extend the azimuth grids to -10° below the visible horizon. This is a useful addition allowing civil or nautical twilight to be estimated.



But not all CP-300/U features are improvements:

- Bayer names – unlike the 2102-D star base where common star names are used throughout, the CP-300/U uses Bayer names in some cases. For example, well know Menkent, is labeled θ Centauri, an unnecessary confusion. Some stars display both names. The result is a congested display that is somewhat difficult to read. Table 2 lists all stars displayed on both finders. The common and Bayer names are listed as they appear on the finders.



- No declination overlay – while the 2102-D provides a special overlay template to assist in adding new bodies to the star base, the CP–300/U does not. This is certainly 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. Many navigators will plot them, especially when they are bright and visible at twilight because their positions change little during a typical voyage. Plotting a new body on the CP-300/U 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 GHAs. Once located, they can be plotted in pencil on the star base. The base material is durable and withstands gentle erasures too. But nonetheless, this process is tedious compared to the overlay provided with the 2102-D.

- Terse instructions – the instruction sheet accompanying the CP-300/U is very brief and describes just a few setups. Only an experienced navigator, or one already familiar with the better documented 2102-D star finder, could understand how to use this device.

Conclusion

The CP-300/U is an enhanced version of the 2102-D star finder. Its additional complexity offers greater flexibility in locating stars and performing latitude, hour angle and time conversions. For many navigators, these benefits will outweigh its few design flaws. One can only speculate why the CP-300/U was not more widely used or made commercially available. Perhaps its additional manufacturing complexity and likely cost increase simply could not displace the venerable 2102-D star finder.

Star Name	SHA	Dec		RA	RA Hr	57	CP300	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

Table 2 – 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.

References

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