Star finder

Operating instructions

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1. APPLICATION

The star map is the simplest means for seeking and determining stars or constellations. Each star map is, however, valid for a certain geographic latitude or, depending on the degree of accuracy required, for a smaller or wider range of geographic latitudes only.

The star finder is a means applicable in every geographic latitude — both in the northern and in the southern hemisphere of our earth. Apart from representing the astronomic coordinate systems in a three-dimensional and illustrative manner it also shows their mathematical correlations for any observational place on earth. Its star detector allows both to find out the name of an unknown star observed and to pre-set a measuring instrument (sextant, compass, theodolite) for searching for a stellar body.

Besides this, a three-dimensional illustration of the daily circulation of the fixed stars visible in any geographic latitude, the differences in the orbit of the sun during the four seasons, the times of rising and setting of the constellations shown on the star globe, times and heights of culmination as well as other important data of the orbits of stellar bodies is possible.

2. EQUIPMENT

1 star finder
1 carrying box
2 adjusting pins
1 box key

3. Technical data

STAR GLOBE

diameter	170 mm
celestial equator scale interval of graduation in degrees scale interval of graduation in hours	 1° 5 min
celestial meridian scale interval	1°
ecliptic scale interval of graduation in degrees scale interval of graduation in dates	 1° 1 day
angular distance of meridians	15° (1 h)
angular distance of altitude circle	10°

BASE FRAME

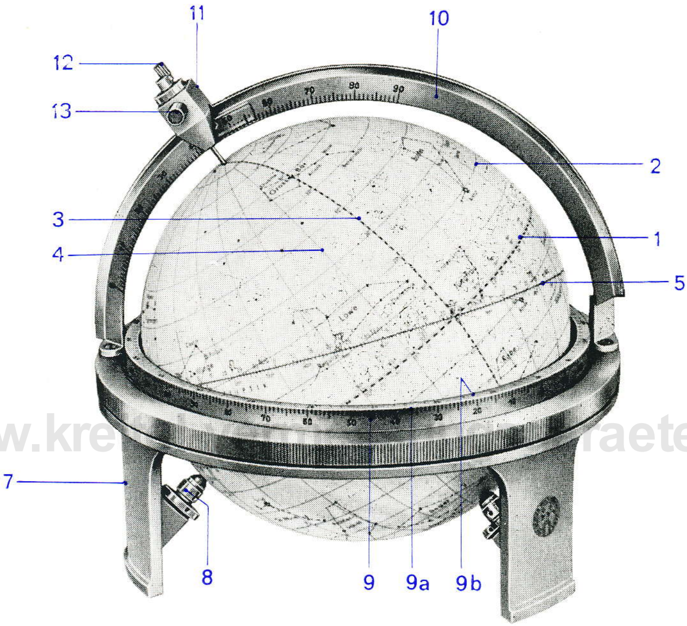
horizontal circle, diameter scale interval of graduation in degrees scale interval of graduation in hours	174 mm 1° 10 min
vertical circle, diameter scale interval of graduation in degrees (0° to 90°)	188 mm 1°

DIMENSIONS

star finder, diameter height	214 mm 210 mm
box	260 x 260 x 235 mm
weight star finder box	2,2 kg 2,5 kg

4. Description of the star finder

Figure 1: STAR FINDER, full-view illustration



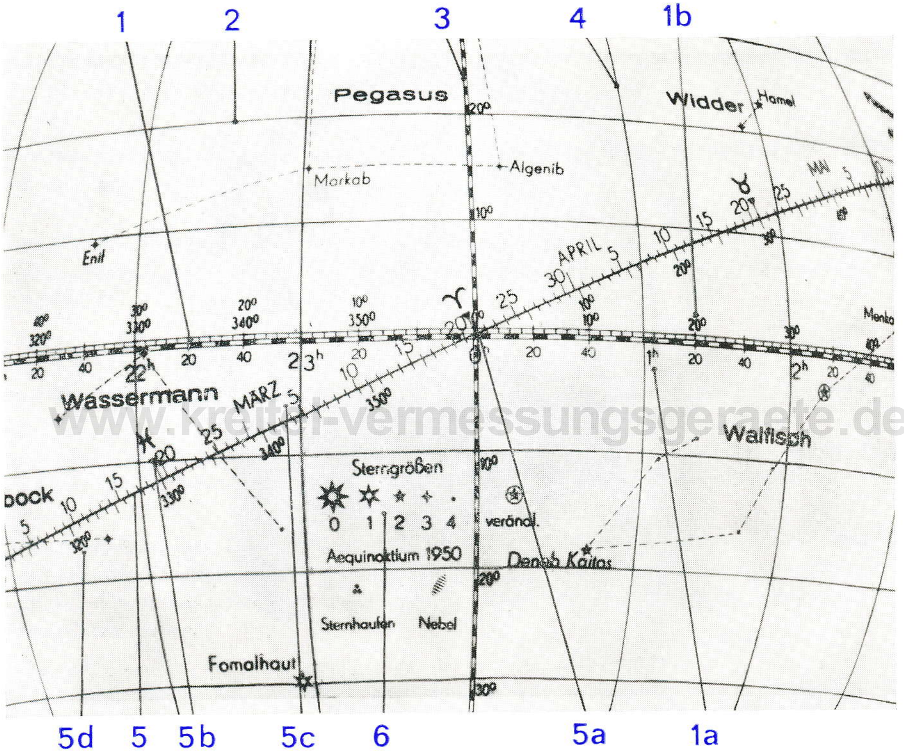
on the star globe

1 celestial equator
2 elevation circles (horizontal circles)
3 celestial meridian with degree scale
4 hour circles (circles of declination)
5 ecliptic

support

7 tripod
8 ball bearing for the star globe
9 horizontal circle
9a azimuth scale (meridian scale)
9b hour scale
10 vertical semicircle (elevation circle) with degree scale
11 pole holder
12 knurled screw for the clamping of the pole holder on the vertical semicircle
13 knurled screw for the clamping of the centering pin

Figure 2: Section of the star map of the star globe



1 celestial equator
1a hour scale
1b degree scale
2 elevation circles (horizontal circles)
3 celestial meridian with degree scale
4 hour circles (circles of declination)
5 ecliptic
5a first point of Aries or vernal equinox
5b triangular indices for the demarcation of the zodiacal signs
5c date scale
5d degree scale
6 star signatures

The star finder consists of the star globe with the base frame and the vertical circle with star detector and pole holder, resp.

4. 1. The **star globe** bears the star map with the fixed stars after the equinox of 1950 indicated in the Nautical Year Book of the Marine Hydrographic Service of the GDR. The position of the stellar bodies is cartographically correctly reproduced and also contains some weaker stars for complementing the constellations and facilitating the discovery of certain stellar bodies in the sky. Furthermore, the star map comprises a table of signatures for the stellar magnitudes and for the variable stars. It is covered with a network of hour or vertical circles (4) and altitude or horizontal circles (2). The hour-circles, extending over the north and south pole, have a scale interval of 15° (1 hour). The altitude circles, whose biggest one is the equator, spread in a north-south distance of 10°.

Three especially traced great circles are the following:

the celestial equator	(1)
the celestial meridian	(3)
the ecliptic	(5)

The **celestial equator** (1) is the great circle having every-where the same distance from the north and south pole (90°). It is graduated in hours from 0h to 24h in scale intervals of 5 minutes (1a) and in degrees from 0° to 360° in scale intervals of 1° (1b). The graduation starts in the first point of Aries or vernal point ♈ (5a) and continues in the anti-clockwise direction. By request of certain experts, an additional graduation from 0° to 180° in the opposite direction was attached.

The celestial meridian (3) is perpendicular to the equator in the vernal point ♈ and. the autumnal point (♎). It is graduated from 0° to 90° in scale intervals of 1° (3) on both sides of the equator to the north and the south pole.

The **ecliptic** (5) represents the apparent orbit of the sun. It is a great circle which is inclined by 23°27' with respect to the equator and intersects it in the vernal and the autumnal points. The upper side of the ecliptic bears a graduation in dates (5c). Triangular marks (5b) for demarcating the 12 zodiacal signs are provided in equal distances. The lower side has – starting from the first point of Aries – a graduation (5d) that proceeds from left to right like the date graduation.

4. 2. The **base frame** consists of the tripod (7) for supporting the globe, and of the **horizontal circle** (9) which represents the real horizon and is equipped with an azimuth graduation (9a) and an hour graduation (9b) in the clockwise direction. The azimuth graduation has a scale interval of 1°, the hour graduation one of 10 minutes.

Classified into cardinal points,

0°	= 0h	represents the north,
90°	= 6h	represents the east,
180°	= 12h	represents the south, and
270°	= 18h	represents the west

on the graduations of the horizontal circle.

The **vertical semicircle** or altitude circle (10) is rotatably mounted on the horizontal circle, the former also having a graduation from 0° to 90°.
For setting the geographic latitude φ of the observational place and/or the latitude of the stellar body, a slidable **pole holder** (11) is fixed on the vertical semicircle.
The spring-loaded centring pin of the pole holder also serves as a star detector. Pole holder and centring pin may be clamped by a knurled screw (12 and 13) each.

The globe rests, polydimensionally rotatable, at 3 points on a ball bearing (8).

Remark

Because of the thickness of the locating pin (2 mm), the altitude circle (10) is set on the horizontal circle (9) with a distance of 1 mm from the dividing edge of the altitude circle, and the data are read on the horizontal circle with a star distance of 1 mm above the upper edge of the horizontal circle.

5. Handling

5. 1. GENERAL

5.1.1. Setting the star globe according to the observational place

When your observational place is situated in the north, then the north pole of the star globe must coincide with the zero of the horizontal circle. When your observational place is in the south, then the same applies to the south pole.

To begin with, set the rotatable vertical semicircle with respect to the north-south direction in such a way that its graduation is above 0° (north) of the horizontal circle. As the pole latitude is equal to the geographic latitude φ of the observational place, shift the pole holder on the vertical semicircle so that its index mark coincides with the respective latitude φ, and fix it in this position (knurled screw 12).

When setting the north (south) latitude φ, turn the star globe with the effect that the north (south) pole is lifted in such a way that the spring-loaded locating pin of the pole holder may be pressed into the pole bore and clamped with the knurled screw (13).

5.1.2. Daily revolution of the starry sky visible from the observational place

When turning the star globe set according to item 5.1.1. in the east-west direction, then one gets — considered from the centre of the ball — an exact image of the daily revolution of the starry sky above the horizon (9) at the observational place.

A stellar body rises when it becomes visible above the eastern half of the horizon during this rotation; it sets when it disappears below the western half of the horizon.

The time of rising and setting coincides with the hour reading on the hour graduation (9b) of the horizon (9).

5.1.3. Three-dimensional representation of the solar orbit in the change of the seasons

Marking the sun's position on the ecliptic for a certain date, one may, according to item 5.1.2., watch the daily sun's orbit for the geographic latitude set.

For determining the solar latitude at noon, turn the star globe until the solar position marking reaches the undivided southern half of the altitude circle. Having loosened the knurled screws (12) and (13), turn the divided northern half of the altitude circle to 12h, or 180°, of the horizontal circle without changing the position of the star globe, set the locating pin by shifting the star detector to the solar position marked, and read the solar latitude on the latitude circle from the index mark of the star detector.

Accordingly, the solar latitude may also be approximately determined for any other time of the day.

Example 1: $\varphi = 54°$ N

	June 21	December 21
sunrise	3.20	8.40
sunset	20.30	15.20
solar latitude at noon	+ 60°	+ 14°

In the same way, the different solar arcs in extreme geographic latitudes may be illustrated.

Example 2:

			June 21	December 21
Singapoure	$\varphi = 2°$ N		June 21	December 21
		sunrise	4.30	7.30
		sunset	19.30	16.30
		solar latitude at noon	+ 111°	+ 65°
Leningrad	$\varphi = 60°$ N		June 21	December 21
		sunrise	2.20	9.10
		sunset	21.30	14.40
		solar latitude at noon	+ 53°	+ 8°
Murmansk	$\varphi = 69°$ N		June 21	December 21
		sunrise sunset	Sun remains in his deepest position at 24^h by approx. 2° above the horizon (polar summer)	Sun remains in his highest position at 12^h below the horizon (polar night)
		solar latitude at noon	+ 45°	

Remark:

Because of the small scale of the star map, the above times are covered with an average uncertainty of ± 20 minutes.

5.1.4. Determination of the Greenwich Mean Time (G.M.T.) from the standard time (S.T.)

The working out of the practical examples was based on the Greenwich hour angle introduced in the Nautical Year Book of the GDR on January 1, 1953. All values were expressed in degrees so that conversions from length into time units are not necessary any longer.

As, for practical reasons, coherent economic areas of the earth are treated as unitary time zones, the conversion of the respective standard times (S.T.) into a Greenwich Mean Time or universal time (U.T.) is necessary.

The geographic longitude of the observational place (λ) is known. Observing according to the standard time (S.T.), one founds the Greenwich Mean Time (G.M.T.) on eastern longitude by subtracting the time difference (T.D.) from the S.T.; and on western longitude by adding the time difference to the S.T.

$$\text{G.M.T.} = \text{S.T.} \begin{matrix} - \text{T.D. east} \\ + \text{T.D. west} \end{matrix}$$

Example 3:

Observed on	λ = 35° 12' east at
ST. of observation	= $6^h\ 30^m$
Time difference T.D.	= - $2^h\ 00^m$
G.M.T. of observation	= $4^h\ 30^m$

Example 4:

Observed on	λ = 14° 27' west at
ST. of observation	= $19^h\ 20^m$
Time difference T.D.	= + $1^h\ 00^m$
G.M.T. of observation	= $20^h\ 20^m$

5.1.5. Determination of the local hour angle of the first point of Aries or vernal point (L.H.A. ♈)

According to the Greenwich Mean Time, find the Greenwich hour angle of the first point of Aries or vernal point (G.H.A. ♈) for the day of observation in the Nautical Year Book.

The following known relation is valid:
Local hour angle of the vernal point
= Greenwich hour angle + eastern longitude of the observational place
= Greenwich hour angle − western longitude of the observational place

$$\text{L.H.A.}\,♈ = \text{G.H.A.}\,♈ \begin{matrix} + \lambda \text{ east} \\ - \lambda \text{ west} \end{matrix}$$

Example 5:

Observed on January 12, 1953
at S.T. = $6^h\ 30^m$ on φ = 54° N and λ = 35° 12' 0
Determine the local hour angle ♈ ?

S.T. of observation	= $6^h\ 30^m$
Time difference T.D. between S.T. and G.M.T.	= $-2^h\ 00^m$
G.M.T. of observation on January 12, 1953	= $4^h\ 30^m$

For January 12, 1953, one finds in the Nautical Year Book 1953:

G.H.A. ♈ for 4^h G.M.T.	=	171°	21.3'
for 30^m	= +	7°	31.3'
G.H.A. ♈ for $4^h\ 30^m$ G.M.T.	=	178°	52.6'
eastern longitude λ east	= +	35°	12.0'
L.H.A. ♈ for $4^h\ 30^m$ G.M.T.	=	214°	4.6'

Example 6:

Observed on January 12, 1953
at S.T. = $19^h\ 20^m$ on $\varphi = 54°$ N and $\lambda = 14°\ 27'$ W
Determine the local hour angle ♈ ?

S.T. of observation	$= 19^h\ 20^m$
Time difference T.D. between S.T. and G.M.T.	$= +1^h\ 00^m$
G.M.T. of observation on January 12, 1953	$= 20^h\ 20^m$

For January 12, 1953, one finds in the Nautical Year Book 1953:

G.H.A.♈ for 20^h G.M.T.	=	52°	0.7'
for 20^m (table)	= +	5°	0.8'
G.H.A.♈ for $20^h\ 20^m$ G.M.T.	=	57°	1.5'
western longitude λ west	= −	14°	27.0'
L.H.A.♈ for $20^h\ 20^m$ G.M.T.	=	42°	34.5'

5. 2. Determination of the name of a star the azimuth and altitude of which were measured

The geographic longitude and altitude of the observational place are approximately known and can, if need be, exactly enough be read from a topographic map. Altitude and azimuth of the unknown stellar body were measured.

The **altitude** can be measured with a clinometer, a box compass suitable for inclination measurements or, of course, with a theodolite; the **azimuth** (from north over east) can be measured with a normal prismatic or sports compass, a box compass or a theodolite.

5.2.1. Setting of the star globe with respect to the geographic latitude of the observational place according to item 5.1.1.

5.2.2. **Setting of the local hour angle calculated according to item 5.1.5.**

Turn the star globe around the axis of the celestial sphere (pole holder remains engaged) until the number of the celestial equator, indicated in degrees and calculated as L.H.A. ♈ coincides with the vertical semicircle (undivided southern half). For setting, use the continuous numbering from 0° to 360° on the celestial equator. Now you have an exact mirror image of the celestial sphere on the star finder at the time and for the place of observation.

5.2.3. **Searching for the observed stellar body on the star globe**

After loosening the knurled screw (13), the spring-loaded locating pin releases the pole bore, and the vertical semicircle may be turned on the base frame without changing the position of the star globe relative to the horizontal circle.

Set the divided side of the vertical semicircle to the observed azimuth on the graduation of the horizontal circle and the pole holder to the observed altitude. Read the name of the respective unknown stellar body from below the locating pin.

Example 7:

Approximated observational place	φ = 50° 54' N, λ = 13° 20' 0	
standard time of observation	S.T. = 21^h 25^m on January 10, 1953	
observation: a) altitude = 43°	azimuth = 155°	
b) altitude = 17°	azimuth = 28°	
S.T. of observation		21^h 25^m
time difference between T.D. and G.M.T.		— 1^h 00^m
G.M.T. of observation on January 10, 1953		20^h 25^m
G.H.A.♈ for 20^h G.M.T.	(Nautical Year Book)	50° 2.4'
for 25^m	(tables of the Nautical Year Book)	+ 6° 16.0'

G.H.A.♈ for $20^h\ 25^m$ G.M.T.	56°	18.4'
eastern longitude	+ 13°	20.0'
L.H.A.♈ for place and time of observation	69°	38.4'

stellar body observad a) Beteigeuze

stellar body observad b) Benetnasch

Excample 8:

Approximated observational place	φ = 38° 45' N, λ = 29° 32' W
standard time of observation	S.T. = $7^h\ 15^m$ on January 10 1953
observation: a) altitude = 25.5°	azimuth = 266°
b) altitude = 25°	azimuth = 50°

S.T. of observation			$7^h\ 15^m$
time difference between T.D. and G.M.T.			+ $2^h\ 00^m$
G.M.T. of observation on January 10, 1953			$9^h\ 15^m$
G.H.A.♈ for 9^h G.M.T.	(Nautical Year Book)	244°	35.3'
for 15^m	(tables of the Nautical Year Book)	+ 3°	45.6'
G.H.A.♈ for $9^h\ 15^m$ G.M.T.		248°	20.9'
western longitude		− 29°	32.0'
L.H.A. ♈ for place and time of observation		218°	48.9'

stellar body observad a) Regulus

stellar body observad b) Deneb

5. 3. Searching for a star specified by name in the starry sky

The geographic longitude and latitude of the observational place are approximately known like in item 5.2. Now find out the azimuth and altitude of the stellar body known by its name and search for it in the starry sky.

5.3.1. Set the star globe to the geographic latitude φ of the observational place according to item 5.1.1. again.

5.3.2. After having found out the time of observation and the geographic longitude λ of the observational place, calculate the L.H.A. ♈ in exactly the same way as described in item 5.1.5.

5.3.3. Setting the star globe to the time of observation is done again by setting the L.H.A. ♈ below the undivided southern half of the vertical semicircle as described in item 5.2.2.

5.3.4. Now look on the star globe for the stellar body to be searched for in the sky which – if visible at the time of observation – will be found above the horizontal circle.

5.3.5. After loosening the knurled screw (13) on the pole holder, the spring-loaded locating pin releases the pole bore in the star globe, and the vertical semicircle can be turned on the base frame without changing the position of the star globe relative to the horizontal circle.

5.3.6. By turning the vertical semicircle and shifting the star detector on its graduation the spring-loaded locating pin is set relative to the stellar body. Then the altitude of the stellar body can be read from the vertical semicircle and its azimuth from the horizontal circle.

6. Adjustment

Adjustment of the star finder is done in the manufacturer's workshop before supply. Normally, readjustments are not necessary. In case the bearing balls have become heavily rotatable due to unsuitable storage and contamination, the ease of rotation of the star globe into all directions will be affected. Although the star map was covered with a permanent protective coating, damages to the representation may occur.

If the cleaning of the balls with a clean dry piece of cloth is not effective in the assembled state of the device any more, take the star globe out of the base frame after having removed the altitude circle. Then, the seat of the balls will be easily accessible for cleaning in the dry state. If necessary, add some talcum to the piece of cloth when turning the balls. Under no circumstances use grease or oil because this must cause a contamination of the star globe.

Should it be indispensable to take out the ball bearings, set the pole holder to 90° after reassembling the altitude circle and engage the pole bore. Then, adjust the ball bearings with the adjusting pins contained in the box in such a way that the bottom side of the celestial equator is on all sides half an equator width (1 mm) above the upper edge of the horizon. After completing the adjustment, retighten the clamping rings by retaining the bearings with the adjusting pins.

7. Handling and maintenance

Besides the protection against dust, the star finder does not require any special measurements of maintenance. All parts are protected against corrosion.

During longer periods of non-use, the unit should be stored in the box and protectet against dust.

Do not grease or oil the balls.

For storage in the box, loosen the knurled screw (13) and take the locating pin out of the pole bore, also loosen the knurled screw (12) and push the pole holder (11) into its lower position (nearly 0°) on the altitude circle.

When inserting the unit in the box, take care that the altitude circle nearly coincides with one of the box diagonals.

In consideration of the further development of the device, we reserve the right to make alterations in the figures and the text.

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