POLARIS L Sundial

- Equatorial sundial with true-to-area world maps of the northern and southern hemispheres
- Minute-accurate display of any standard time / daylight saving time in the world (e.g. Central European Time CET/CEST)
- Sun travel around the world (noon position of the Sun)
- Year-round date display
- 22-part kit made of sturdy aircraft plywood (birch)
- Easy assembly for any location in the world
- Detailed, richly illustrated instructions
- Video instructions (tutorial) on the Internet
- Made in Germany

Equation of time
(+4 min for May 15th)

Sun travel around the world
(Sun over Irland, Portugal and Morocco at noon)

Rotatable time ring

Display of any standard time / summer / daylight saving time
(14:30 CEST)

Date display
(May 15th)

Setting the time zone
(Central European Summer Time CEST)

HELIOS (EK) • BEGASWEG 3 • D - 65195 WIESBADEN • *FON* +49 - 611 - 185 11 06 • EMAIL@HELIOS-SUNDIALS.COM

POLARIS L - Time measurement with the Sun

"But it does turn" the Italian physicist, mathematician, philosopher and astronomer Galileo Galilei is said to have murmured, when he was forced to renounce the Copernican system in his old age, standing before the Spanish Inquisition.

Since then, Galilei has been pardoned by the church and today we know without a doubt that the Earth revolves around the Sun and around its own axis, which points toward Polaris (the North Star).

The POLARIS L sundial has a gnomon, which is oriented parallel to the Earth's axis. As the Earth revolves, the Sun seems to move around the gnomon, which illustrates the position of our daylight star on the world map with its shadow.

For example, in Fig. 1 (title image), the POLARIS L shows that the Sun is positioned directly above Ireland, Portugal and West Africa, meaning that it is noon there. Simultaneously, you can read 14:30 Central European Summer Time (CEST) where the shadow falls on the time ring. This is exactly the time shown on your wristwatch and is not typical of sundials, which normally display solar time.

The „true" time from the Sun

The solar time gives us the natural course of the Sun at our location. The solar time is therefore officially called local apparent time (LAT). When the Sun reaches its highest point of the day (upper culmination) where you are, it is exactly 12 noon LAT. This time is the true midday, which actually divides the day into two halves of equal length.

You can determine this point in time using even a primitive sundial - such as a rod inserted vertically into the Earth – by observing when it casts the shortest shadow. If we now follow the true noon over several days, we will see with our wristwatch that it occurs at very different times. The time from noon to noon is obviously not always 24 hours long - the solar day is sometimes shorter and sometimes longer. This means the sundial is up to 16 minutes ahead and up to 14 minutes behind the average length of a solar day, depending on the time of year.

The reasons for the irregular sunset are the rotation of the Earth around the Sun on an ellipse (Kepler's 2nd Law) and the Earth's axis which is tilted by 23.4°.

The local apparent time (LAT) is therefore not an even time and is unsuitable for time measurement with mechanical watches. For this reason, an averaged time, the local mean time (LMT), was introduced for larger cities as early as the 18th century. The difference between local true and mean time is described by the equation of time. Figure 2 shows how the equation of time changes over the course of the year.

Time zones

The invention of the railway and telegraphy during the industrial revolution in the 19th century made long-distance travel and worldwide communication possible. Above all, the need for supraregional train schedules led to further standardization of time: the introduction of time zones by an international agreement in 1884. The time zones are each one hour apart, exactly the length of time the Sun needs for its apparent journey around the Earth for 15 degrees of longitude. On the POLARIS L, the prime meridian through Greenwich near London, to which Universal Time Coordinated UTC refers, and the time zone meridians east and west are shown at 15° intervals.

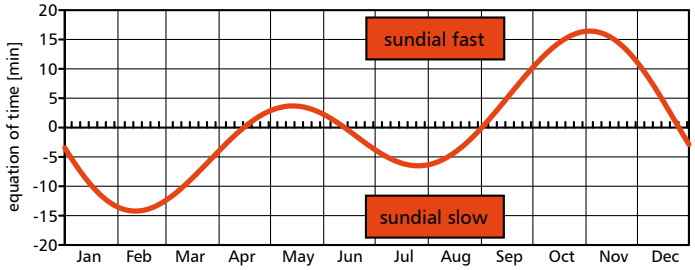

Fig. 2: The equation of time

The standard time valid in most European countries is Central European Time (CET). It is defined as the Local Mean Time (LMT) at the 15th degree of longitude east of Greenwich, where, for example, the German city of Goerlitz is located. It is one hour ahead of world time.

Seasons

Our Earth rotates daily around its axis and moves around the Sun once a year. The axis of the Earth is inclined by 23.4° relative to a line perpendicular to its orbit. Due to the movement of the Earth around the Sun, the direction towards the Sun is constantly changing, but the Earth's axis always points towards the celestial pole near the North Star (Polaris). This is the reason why the Sun, as seen from the Earth, moves back and forth between the tropics on its annual orbit and explains why we have seasons (Fig. 3).

At the winter solstice on December 21/22, the Sun is at the southern Tropic of Capricorn. Seen from the northern half of the Earth, it has its lowest orbit above the horizon. The entire northern polar circle is in darkness on this day. At the South Pole, on the other hand, Polar Day dominates. From this day on, the Sun achieves a higher orbit every day, and we speak of the ascending Sun.

At the beginning of spring (first point of Aries) on March 20/21, the Sun crosses the equator on the Spring Equinox. Day and night are of equal length. From this point on, the Sun does not set at the North Pole for half a year, and at the South Pole it is night during the same period. On June 20/21 at the summer solstice, the entire northern polar circle is illuminated all day, and the Sun reaches the northern tropic (Tropic of Cancer). In the Northern Hemisphere, the Sun reaches its highest orbit during the day.

From now on, the Sun descends again and crosses the equator in a southerly direction on September 22/23. It is again equinox (Autumn Equinox), the Sun enters the zodiac sign Libra and autumn begins in the Northern Hemisphere. On December 21/22, winter and the seasonal cycle begins anew.

The POLARIS L sundial is aligned like the Earth after configuring the location. The gnomon is parallel to the Earth's axis and the equatorial plate with the world maps is parallel to the Earth's equator. As in reality, the Sun is above the northern world map in our spring and summer and the southern world map of the POLARIS L is illuminated in winter and autumn. Accordingly, the time is read at the

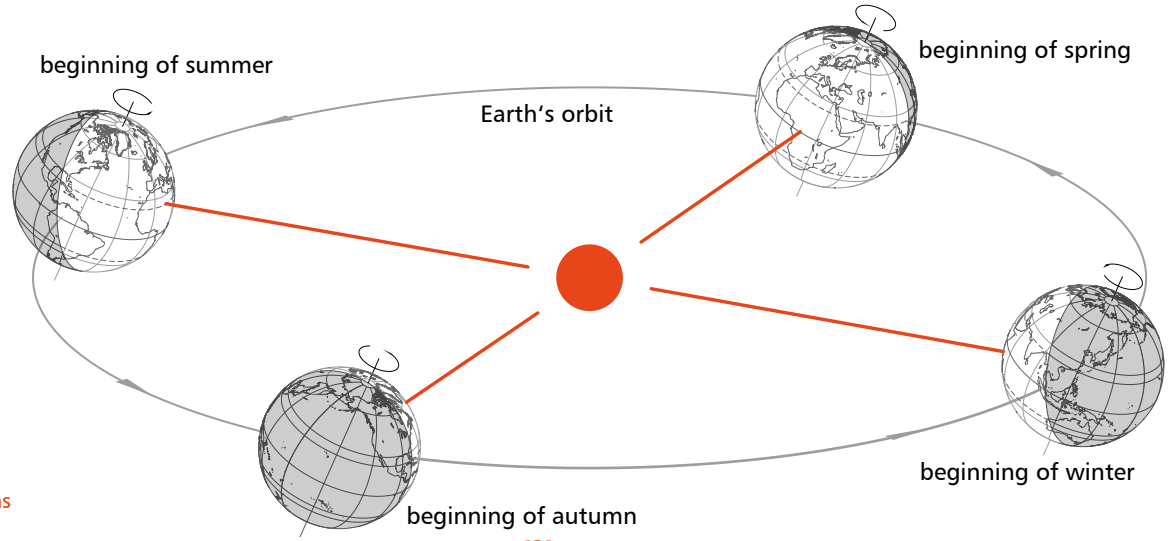

Fig. 3: The Seasons

top and bottom respectively. At the equinoxes, the sundial does not show the time for a short time.

POLARIS L - Construction manual

The „L" stands for „lignum", the Latin word for wood. We use high quality aircraft plywood made of birch, which ensures the stability and durability of the sundial. To ensure the POLARIS L functions accurately, please carefully assemble it according to the following instructions. On our homepage you will find additional video instructions (tutorial) at www.helios-sonnenuhren.de/en/polaris-l-sonnenuhr.

All you need for the assembly is a standard model construction adhesive and some sandpaper to remove the burrs, which remain when the individual parts are separated.

The POLARIS L can be set up for any location in the world between 64° S and 64° N. Since the location is irreversibly fixed during assembly, the geographical coordinates must be known before construction begins. A map or Google Earth on the Internet can help to determine them. Knowledge of the time zone is also important. Time zones are shown in Table 1 on page 7 as well as on the sundial world maps.

For demonstration purposes only, we choose Frankfurt am Main (Germany) as the location of the sundial in the following four steps. Its coordinates are 50.1° north latitude and 8.7° east longitude, and the time zone is Central European Time (CET). Please use the coordinates and time zone of your location when assembling the sundial.

1. Glue the parts on both sides

Cut the following two-sided parts out of the aircraft sheet and glue the backsides together so that the labeling is on the outside (Fig. 4):

2x stand

2x gnomon for the latitude of the location. For Frankfurt (50.1°N) choose the gnomon 45°-55° latitude (of the 4 sets provided).

2x centering pin

2x time ring supports

2x latitude slider

2. Set up the latitude slider, time ring and world map

On the stand, choose the latitude range corresponding to your location (this is the same as for the gnomon). For our example location, this is the range for 45°-55° latitude. Now set the mark of the latitude slider to the latitude of the location. For some cities, as in the case of Frankfurt (50.1°N), the latitude of the city is even marked (Fig. 5).

Now place the time ring support around the latitude slider. It is positioned in such a way that after the time ring has been glued on, the 12 noon arrow (or the 13 o'clock arrow if daylight saving is in effect) reaches the time zone meridian (in this example the CET meridian) on the world map. Depending on whether your location is to the west or east of the time zone meridian, there are three possible positions for the time ring support (Fig. 6). Select the

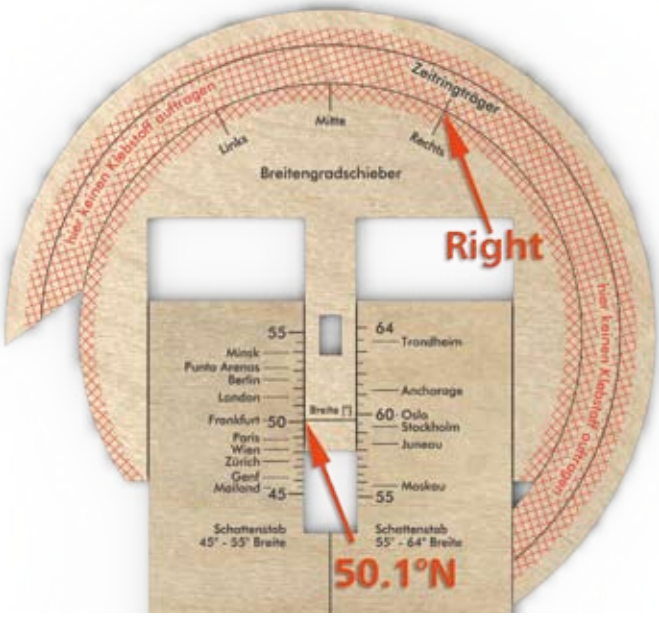

Fig. 5: The latitude slider is set to the latitude of the sundial's location (here Frankfurt 50.1°N). The time ring support is positioned to the "right".

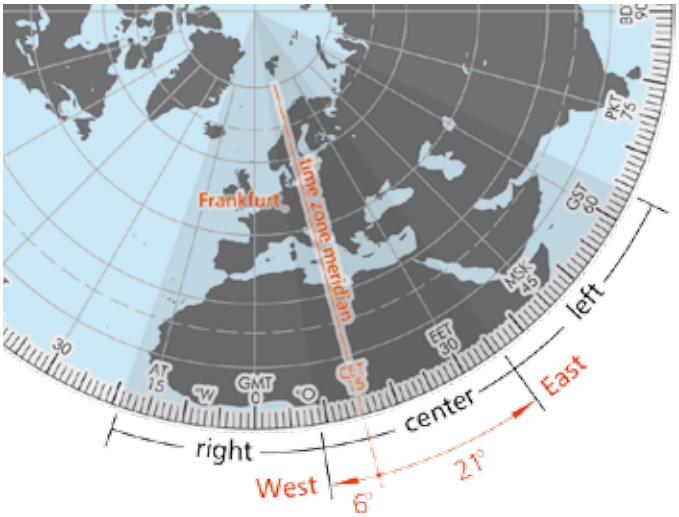

Fig. 6: The position of the time ring support in Figure 5 is based on the sundial's location relative to the time zone meridian.

"right" position if your location is more than 6° west of the time zone meridian. Select the "left" position if your location is more than 21° east of the time zone meridian. In the longitude range in between (6° west to 21° east), select the "center" position. For example, Frankfurt has a longitude of 8.7° E and is thus 6.3° west of the time zone meridian of CET (15°E). This results in the "right" time ring support position (Fig. 5).

Fig. 4: The double-sided parts (stand, gnomon, centering pin, time ring support, latitude slider) are glued with the labeling facing outwards

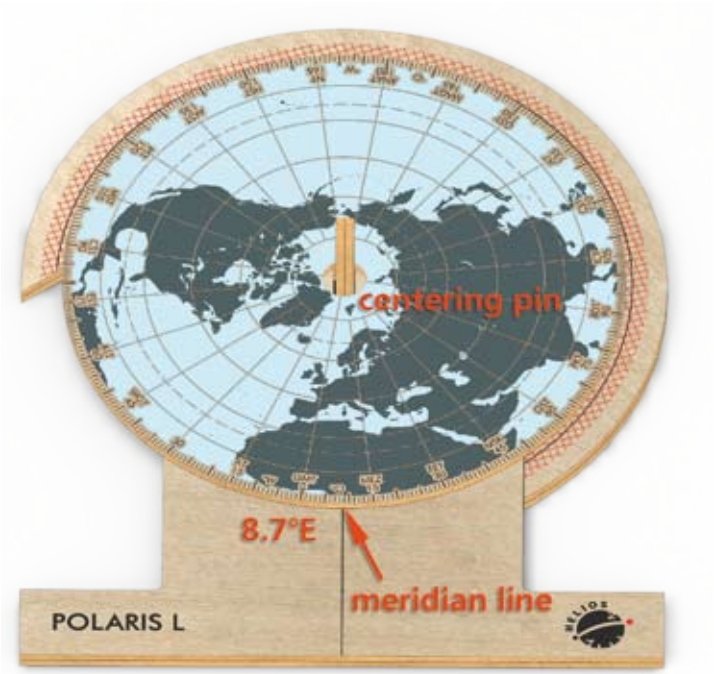

Fig. 7: The northern world map is glued according to the longitude of the location (here Frankfurt 8.7°E).

To adhere the northern world map, apply glue to the stand and the latitude slider. Avoid applying glue in the red marked area. Place the world map onto the stand/slider and insert the centering pin (Fig. 7). Now set the longitude of the location on the meridian line. 8.7°E for Frankfurt am Main. If you imagine extending the meridian line, it should pass through the location (here Frankfurt) on the world map.

Apply adhesive to the time ring support outside the red restricted zone. Now position the time ring with the 12 noon mark on the meridian line (Fig. 8). Make sure that the outer edge of the time ring is flush with that of the time ring support all the way around.

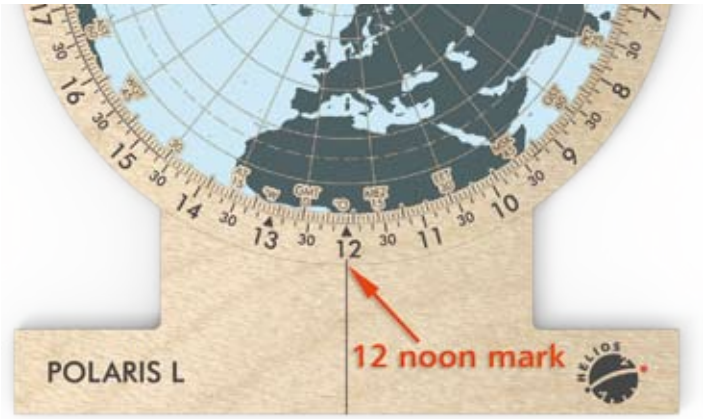

Fig. 8: The time ring is glued onto the time ring support. The 12 noon mark must be on the meridian line.

3. Set up the world map and time ring on the back

After the glue has dried for the northern side, turn the assembly around and glue on the southern world map (Fig. 9). Center it on the centering pin and set the longitude of the location (note: east and west are reversed here!) on the meridian line.

The southern time ring is once again oriented with the 12 noon mark on the meridian line (Fig. 10). It is important that the marking of the northern time ring is aligned with the meridian line when you now glue on the southern time ring. Again, make sure that no adhesive is applied in the prohibited area.

4. Install the gnomon

Insert the gnomon into the central rectangular recess from below (1st step in Fig. 11). Make sure that the date markings are upright. Check the perpendicularity of the gnomon to the world maps with a set square. Then glue the top stabilizer (2) to the northern world map by sliding it onto the upper end of the gnomon. Finally, glue the bottom stabilizer (3) to the southern world map.

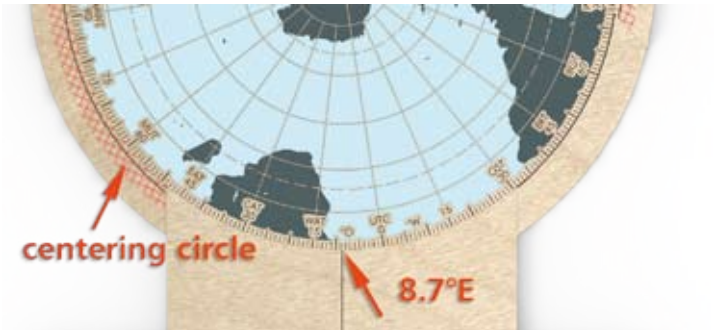

Fig. 9: The southern world map is centered using the centering pin and glued on according to the longitude (here Frankfurt 8.7°E).

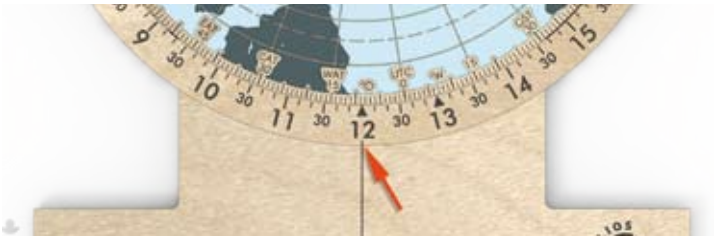

Fig. 10: The 12 noon markings of the north and south rings must be aligned with the meridian lines at the same time.

The sundial is now ready for use.

Assembly for sites in the southern hemisphere

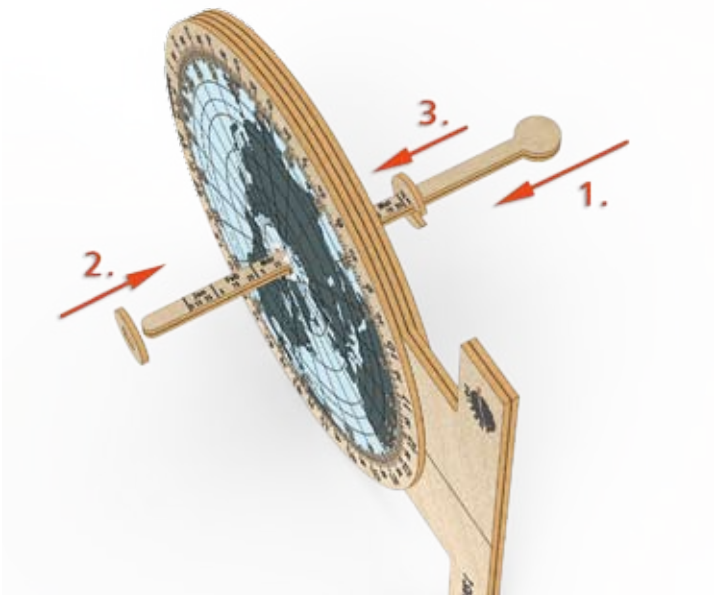

Fig. 11: The gnomon is inserted from below through the rectangular recess and fixed with the stabilizers at the top and bottom.

For locations in the southern hemisphere, the assembly procedure is analogous:

1. Start with the latitude setting and bring the time ring support into the correct position (Figures 5 and 12).

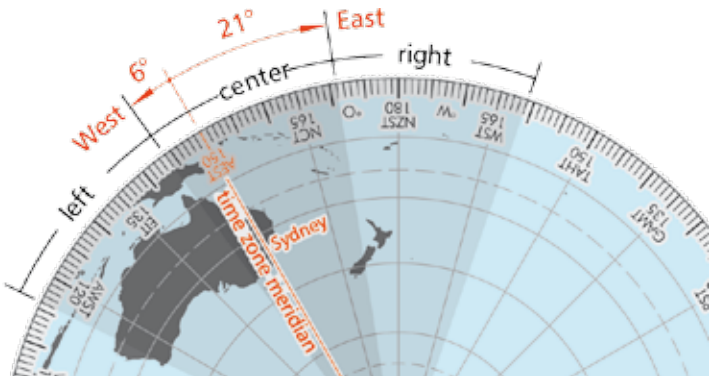

Fig.12: The position of the time ring support in the southern hemisphere is shown, using the example of Sydney and Australian Eastern Standard Time (AEST).

2. Select the „left“ position if your location is more than 6° west of the time zone meridian. Select the „right“ position if your location is more than 21° east of the time zone meridian. In the longitude range in between (6° west to 21° east) select the „center“ position. In Fig. 12 Sydney (151.2°E) is shown as an example. The city is located 1.2° east of the time zone meridian Australian Eastern Standard Time (EAST 150°E), which results in the position „center“.

3. Now install the world map South and the time ring South first, before turning the assembly over and gluing on the world map North and the time ring North.

4. Finally, insert and attach the gnomon from north to south, so that the southern world map is at the top. The gnomon then points to the southern celestial pole.

Alignment of the sundial in north-south direction

The POLARIS L displays the time zone valid for your location, so you can compare it directly with the time on your watch. Therefore, you can also set the POLARIS L according to your wristwatch in order to align in a north-south.

Time zones are shown on the world map (see Table 1 on page 7). For Frankfurt am Main, the Central European Time (CET), which refers to 15°E, is applicable.

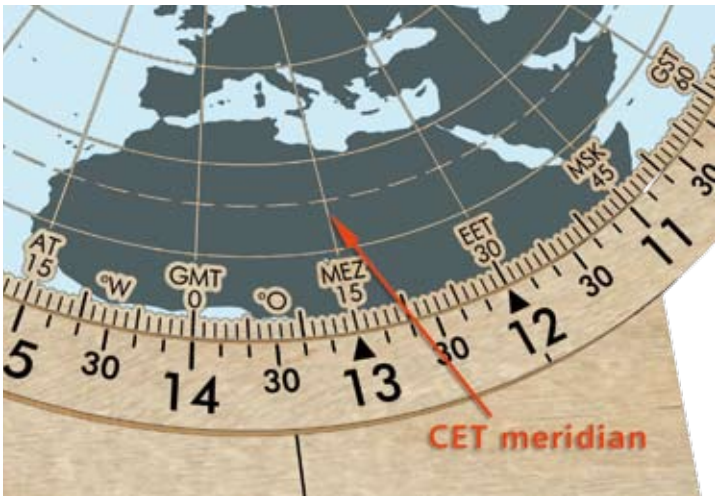

Fig. 13: Setting the time ring to Central European Summer Time (CEST)

Then, turn the time ring until the 12 noon arrow points to the time zone meridian 15°E marked „CET“. If daylight saving time (CEST) is currently in effect, use the arrow at 13 o’clock (Fig. 13).

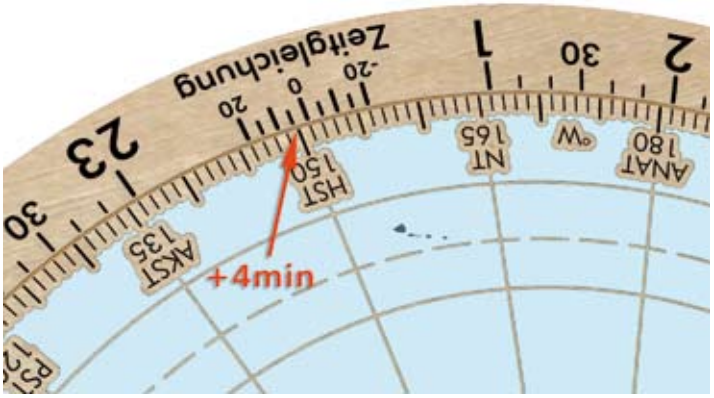

Fig. 14: Setting the equation of time for May 15th (+4 min)

The date-dependent setting of the equation of time is still missing. Recall that this has to do with the fact that the solar time is sometimes ahead and sometimes behind our average time (as indicated by, say, the wristwatch).

In our example we assume it is May 15th. For this date, Table 2 on page 7 gives a value of +4 min for the equation of time. At 0 o’clock (midnight) you will find the corresponding scale on the time ring. To set the equation of time, pay attention to the longitude at which the equation of time scale is located. For example, if you have set 13 o’clock to 15°E (Fig. 13), the equation of time scale is at longitude 150°W (Fig. 14) and shows the same +4 min we observed in Table 2.

Now everything is prepared for aligning the POLARIS L in a north-south direction. Set up the POLARIS L on a surface that is as flat as possible (like a table or ledge). Turn the sundial until the middle of the shadow shows the same time as the one on your wristwatch (Fig. 15). In spring and summer from March 20/21 to September 22/23, read the time on the northern half (top), and in

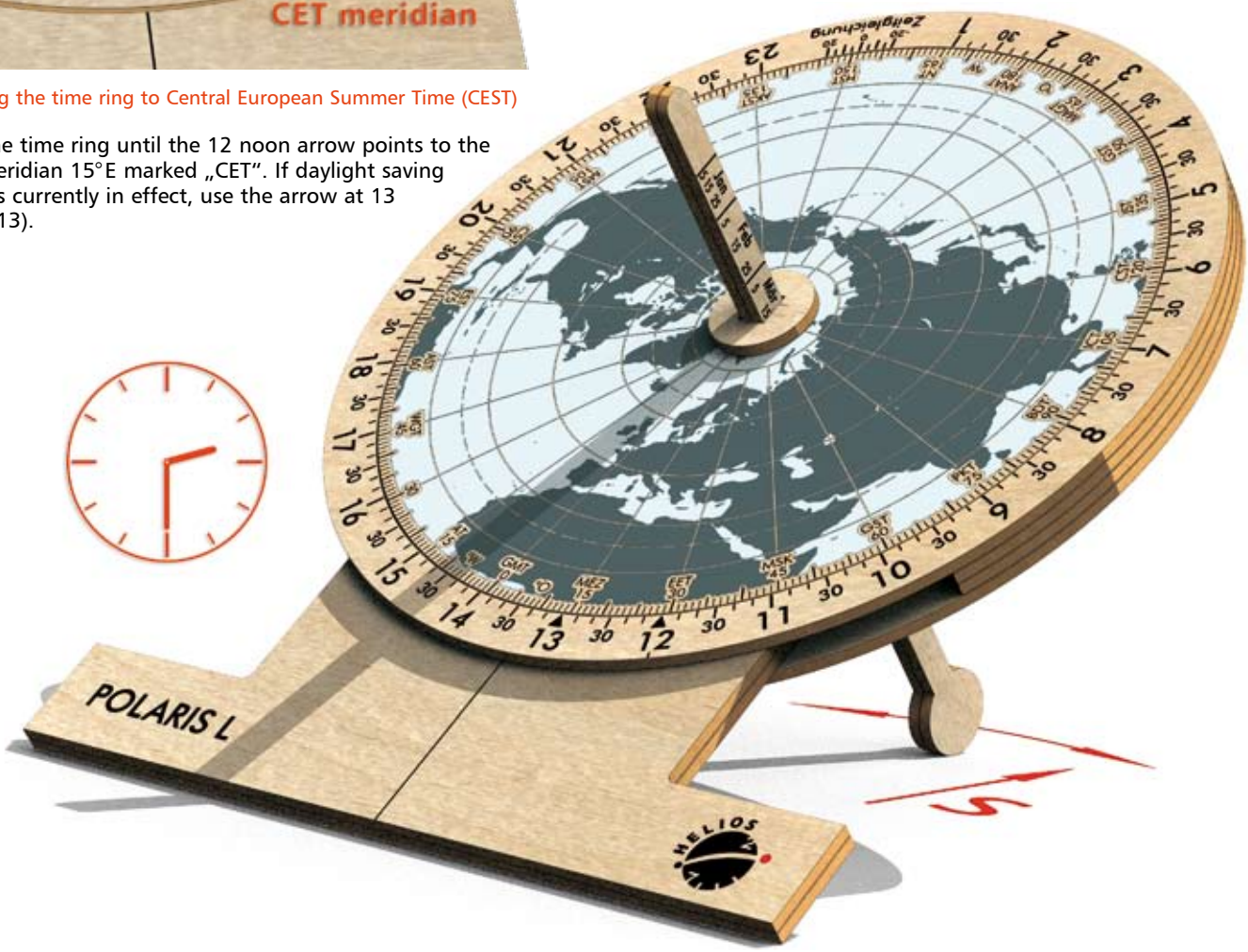

Fig. 15: Aligning the sundial in the north-south direction

Fig. 16: In autumn and winter, read the time and noon position of the Sun on the south side (below).

Fig.17: The date is read on the south side in spring and summer and on the north side in autumn and winter.

autumn and winter read the time on the southern half (bottom) (see Fig. 16). As soon as the time on the POLARIS L matches the wristwatch, the sundial is aligned and the gnomon points north towards the celestial pole near the North Star (Polaris).

POLARIS L - Reading the sundial

Now that you have set up the POLARIS L, you can read the time, the noon position of the Sun and the date all day long when the Sun is shining. This is explained in more detail.

World time clock

In the example we have set up the sundial for Central European Time. It is a zone time, which is valid as the legal time in many European countries. On the world map of the POLARIS L, the CET is shown at the time zone meridian 15° E. Most other time zone meridians are also marked with a representative time zone of the northern or southern hemispheres. The meaning of the abbreviation of the respective time zones and its time difference to world time (UTC) can be found in Table 1 on page 7.

Local apparent time - solar time

Of course you can also set the solar time on the POLARIS L, i.e. the local apparent time (LAT) of your location. The LAT is directly determined by the path of the Sun. It is 12 noon true local apparent time when the Sun reaches its daily peak (upper culmination) at noon and passes the local meridian. This causes the shadow to fall exactly on your location's longitude. This means you turn the time ring until the 12 noon mark points to the meridian line (see Fig. 8), and there it remains all year round to display the LAT. There is no date-dependent adjustment like with the equation of time. The POLARIS L always shows the true solar time directly from the Sun.

Wandering of the Sun around the world

Just like at your own location, it is true noon once a day anywhere in the world. This event takes place at the longitude where you can see the shadow line on the POLARIS L world map. At all locations on this longitude the Sun reaches its daily maximum (upper culmination). In the northern hemisphere it is then exactly in the south, and in the southern hemisphere in the north. In the tropical zone (between the Tropic of Cancer and Tropic of Capricorn) the Sun may be either north or south, depending on the season, and is at its zenith at noon on two days of the year.

In our example on May 15th at 14:30 CEST (Figures 1 and 15) the Sun is just 8.5° west of Greenwich over Ireland, Portugal and West Africa at noon. If you were at this longitude at this time, the Sun would be at its daily maximum.

Seasons and current date

In spring and summer from March 20/21 to September 22/23 the Sun moves over the northern half of the sundial, and in autumn and winter from September 22/23 to March 20/21 over the southern half (Fig. 16).

At the beginning of spring and the beginning of autumn, the Sun changes sides and the sundial does not cast a shadow for a short time!

The shadow cast by the outer edge of the time ring on the gnomon indicates the current date on the date scale. The date display is always opposite the time display. In autumn and winter, the date is read on the north side and the time on the south side. In spring and summer, the date is read on the south side (Fig. 17) and the time on the north side.

In the southern hemisphere everything is the exact opposite. The Sun's path moves from east to north (instead of south) to west (i.e. from right to left), so the time scale runs counterclockwise. The POLARIS L is illuminated in in a manner that corresponds to the conditions in the southern hemisphere: in spring and summer the upper side (southern world map) and during autumn and winter the lower side (northern world map) is illuminated.

Note that the date scale on the gnomon is only suitable for the northern hemisphere.

Terms of use

The sundial kit POLARIS L is made of multilayer glued aircraft plywood. If carefully assembled, the sundial is dimensionally stable and can withstand the Sun for a long time. However, exposure to moisture is detrimental to its service life, so we advise against exposing the sundial to the weather for long periods of time without protection.

Support

Please contact us directly if you have any questions regarding the assembly, installation and operation of the sundial. You can reach us at the following address:

HELIOS Sundials e. K.
Begasweg 3

D - 65195 Wiesbaden
Phone: +49 - (0)611 - 18 51 106
Fax: +49 - (0)611 - 59 83 29
e-mail: email@helios-sundials.com

Long.	Abbr.	Time zones nothern hemisphere	Offset
180°W			-12 h
165°W	NT	Nome Time	-11 h
150°W	HST	Hawaii Standard Time	-10 h
135°W	AKST	Alaska Standard Time	-9 h
120°W	PST	Pacific Standard Time	-8 h
105°W	MST	Mountain Standard Time	-7 h
90°W	CST	Central Standard Time	-6 h
75°W	EST	Eastern Standard Time	-5 h
60°W	AST	Atlantic Standard Time	-4 h
45°W	WGT	Western Greenland Time	-3 h
30°W			-2 h
15°W	AT	Azores Time	-1 h
0°	GMT	Greenwich Mean Time	0 h
15°E	CET	Central European Time	+1 h
30°E	EET	Eastern European Time	+2 h
45°E	MSK	Moscow Time	+3 h
60°E	GST	Gulf Standard Time	+4 h
75°E	PKT	Pakistan Time	+5 h
90°E	BDT	Bangladesh Time	+6 h
105°E	ICT	Indochina Time	+7 h
120°E	CST	China Standard Time	+8 h
135°E	JST	Japan Standard Time	+9 h
150°E	GST	Guam Standard Time	+10 h
165°E	MAGT	Magadan Standard Time	+11 h
180°E	ANAT	Anadyr Time	+12 h

Long.	Abbr.	Time zones southern hemisphere	Offset
180°W			-12 h
165°W	WST	West Samoa Time	-11 h
150°W	TAHT	Tahiti Time	-10 h
135°W	GAMT	Gambier Time	-9 h
120°W	PST	Pitcairn Standard Time	-8 h
105°W			-7 h
90°W	GALT	Galapagos Time	-6 h
75°W	PET	Peru Time	-5 h
60°W	BOT	Bolivia Time	-4 h
45°W	BRT	Brazil Time	-3 h
30°W	GST	South Georgia Time	-2 h
15°W			-1 h
0°	UTC	Universal Time Coordinated	0 h
15°E	WAT	West Africa Time	+1 h
30°E	CAT	Central Africa Time	+2 h
45°E	EAT	East Africa Time	+3 h
60°E	MUT	Mauritius Time	+4 h
75°E			+5 h
90°E	MAWT	Mawson Time	+6 h
105°E	WIT	West Indonesia Time	+7 h
120°E	AWST	Australian Western Standard Time	+8 h
135°E	EIT	East Indonesia Time	+9 h
150°E	AEST	Australian Eastern Standard Time	+10 h
165°E	NCT	New Caledonia Time	+11 h
180°E	NZST	New Zealand Standard Time	+12 h

Table 1: The time zones of the northern and southern hemispheres with their respective abbreviations and offsets (in hours) relative to UTC

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	-3	-14	-12	-4	3	2	-4	-6	0	10	16	11
5st	-5	-14	-12	-3	3	2	-5	-6	1	12	16	9
10th	-7	-14	-10	-1	4	1	-5	-5	3	13	16	7
15th	-9	-14	-9	0	4	0	-6	-5	5	14	15	5
20th	-11	-14	-8	1	4	-1	-6	-3	6	15	14	3
25th	-12	-13	-6	2	3	-3	-7	-2	8	16	13	0
30th	-13		-5	3	3	-4	-6	-1	10	16	11	-2

Table 2: Equation of time in minutes

POLARIS L

Sydney
33°51'S 151°12'E
December 25th
9:00 AEDT
Noon 150°W (Tahiti)

Berlin
52°31'N 13°24'E
May 15th
10:00 CEST
Noon 59°E (Aral Sea)

New York City
40°43'N 74°0'W
June 14th
14:00 EDT
Noon 90°W (New Orleans)