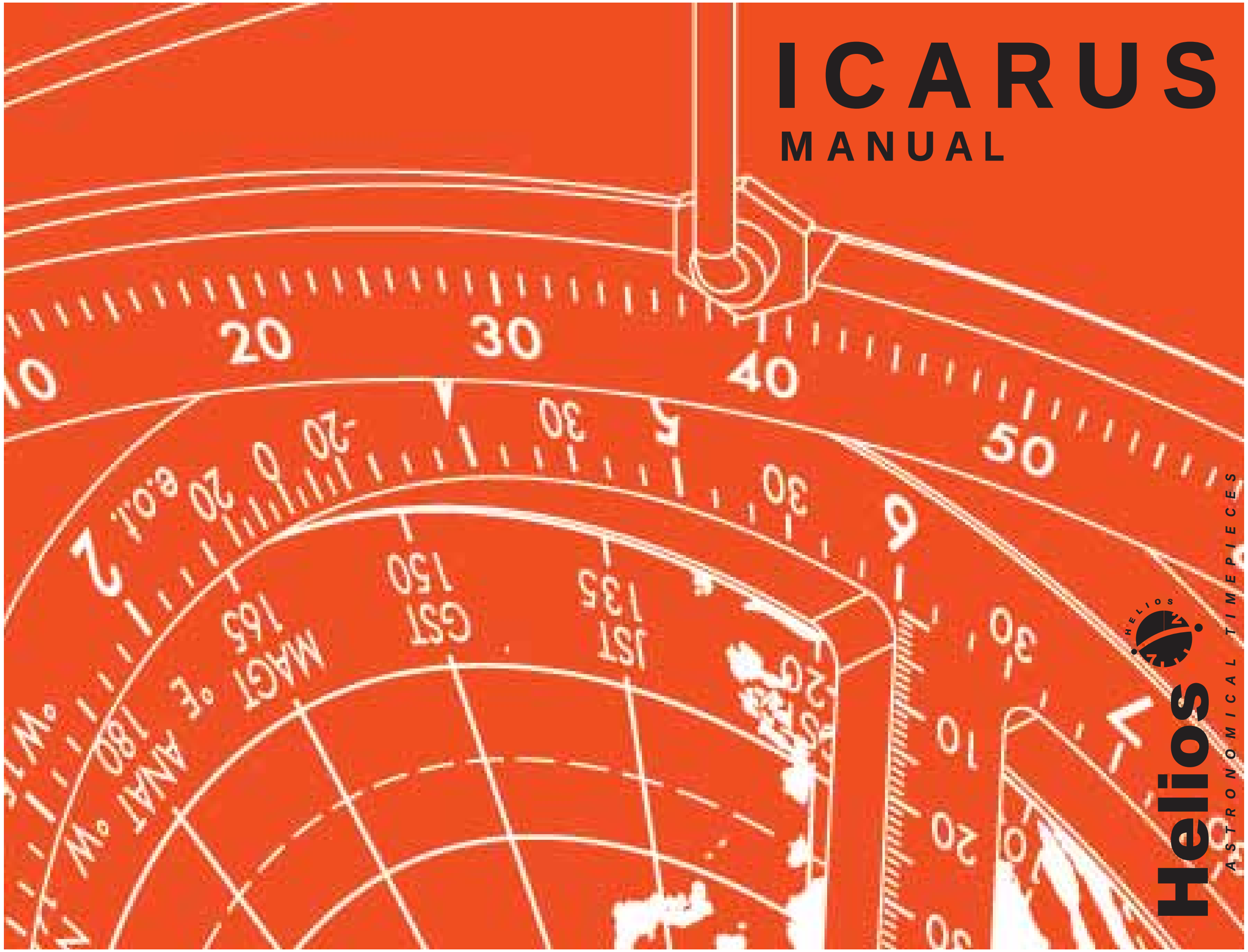
ICARUS

MANUAL



Helios

ASTRONOMICAL TIMEPIECES

1. Adjusting for your own location on the world map (page 12).

Location found on world map	*Location's geographic co-ordinates known*		*Location unknown*
Ruler on meridian arrow, turn location on world map until under edge of ruler, read off latidude for step 6, lock world map in place (figure 5).	*<15° O or <15° W*	*>15° O or >15° W*	First determine geographic co-ordinates (see Navigation section, p. 28), then continue with „Location's geographic co-ordinates known".
	Set longitude on meridian arrow and prime meridian on world map to zero marker. Lock world map in place (fig 6).	Calculate difference to nearest time zone meridian, set longitude difference on meridian arrow, chosen time zone meridian on zero marker. Lock world map in place.	

2. Setting and locking the date slider (page 15).

Loosen fastening screws on date and equation of time slider, open equator ring. Set date and tighten fastening screw for date slider (figure 7).

3. Tautening and locking the wire with the equation of time slider (page 17).

Push equation of time slider outwards, tauten wire and tighten fastening screw for equation of time slider (figure 8).

4. Setting the time zone with time scale ring (page 17).

Local apparent time (LAT)	*Local mean time (LMT)*	*Standard time (no Daylight Saving)*	*Standard time (Daylight Saving)*
12:00 hours on meridian arrow (fig. 14)	12:00 hours on meridian arrow	12:00 hours on standard meridian (figure 9)	13:00 hours on standard meridian (figure 10)

5. Reading off and setting the equation of time on the time scale ring (page 18).

Local apparent time (LAT)	*Local mean time (LMT)*	*Standard time (no Daylight Saving)*	*Standard Time (Daylight Saving)*
Equation of time not relevant.	Read equation of time from equation of time slider, subtract from 12:00 and set result on meridian arrow (see page 29).	Read equation of time from equation of time slider (on same side as date) and set value on time scale ring at 03:00 hours (figure 11).	

6. Setting the latitude slider (page 19).

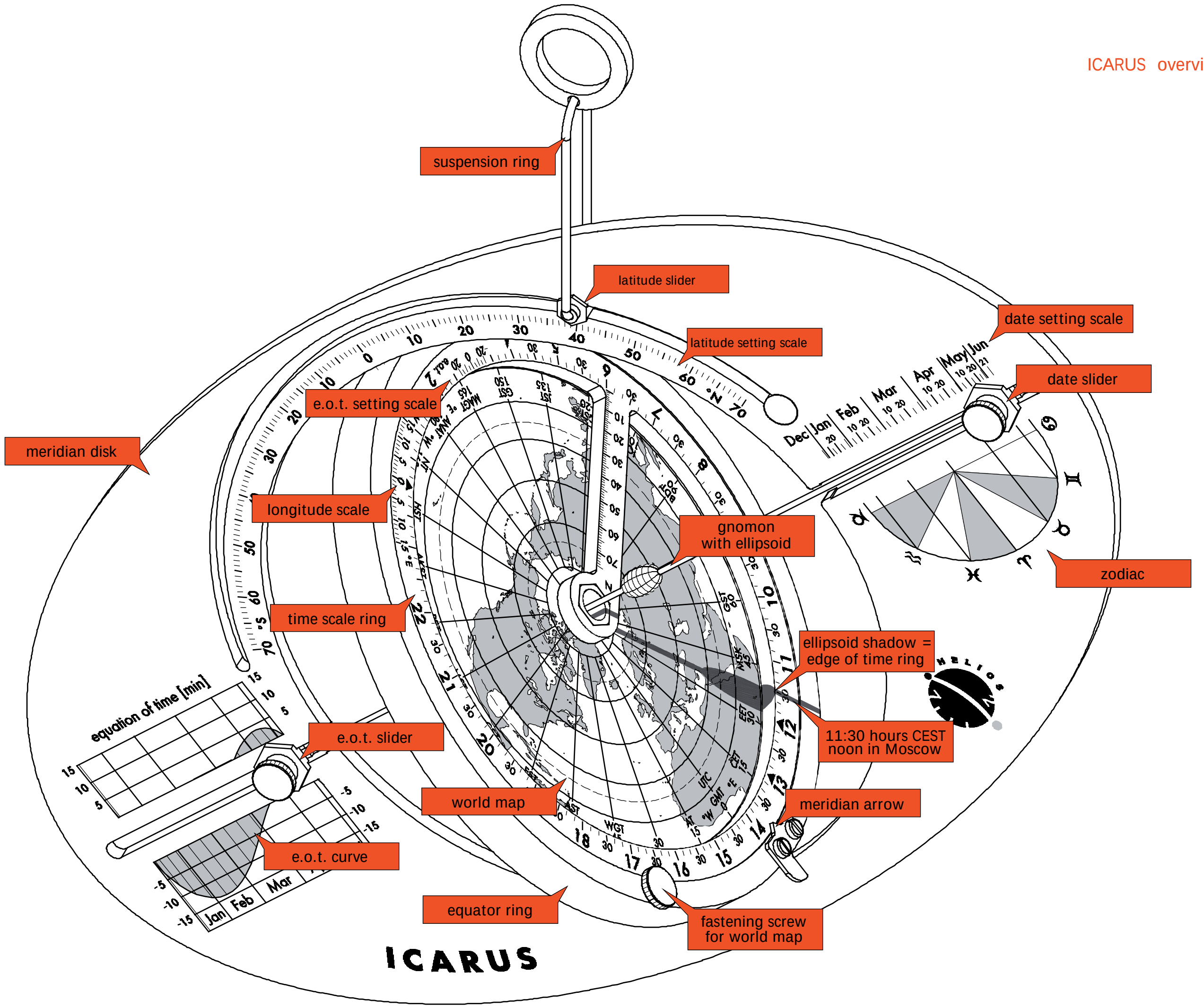
Location on northern hemisphere	*Location on southern hemisphere*
Position latitude slider on northern latitude (°N) (figure 12).	Position latitude slider on southern latitude (°S) (figure 13 below).

7. Alignment with the sun (page 19).

Spring/summer		*Autumn/winter*	
Turn yourself towards sun, suspension ring on sun side, sundial suspended freely, turn until the upper curve of the ellipsoid shadow meets the edge of the time scale ring. Read time and sun's noon position off the time scale ring (figure 12 and 13).		With your back to the sun, suspension ring on sun side, sundial suspended freely, turn until lower curve of ellipsoid shadow meets the edge of the time scale ring. Read off time and sun's noon position (figure 13).	
Afternoon time in morning	*Morning time in afternoon*	*Time of day not clear*	*Time matches time of day*
Incorrect position! Rotate to west until other position reached.	Incorrect position! Rotate to east until other position reached.	Read time again after a short while and check if time gets later. If not, other position is correct.	Time reading correct!

Table 3: Seven steps for setting the ICARUS

ICARUS overview



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Contents

ICARUS – the sundial in your pocket

Almost 5000 years have passed since the measurement of time first began. The first sundial was a "shadow stick" stuck vertically into the ground. The time of day could be calculated from the length of the shadow. The 16th to the 18th century is known as the "golden age of the sundial", local time as measured by sundials was the official time of civil life. Mechanical clocks, at that time inaccurate and expensive, were set according to the sundials. Even then, portable sundials which could be used when travelling were particularly popular.

With your new ICARUS you now own the first pocket sundial, with which you can read our modern time, which runs at even intervals and is valid for standardised time zones. The sundial includes an integrated world map with an equal-area projection of the northern and southern hemispheres. The 24 time zones are displayed, so that you can set the sundial to Central European Time and for any other time zone in the world. But you can also read local apparent time, original sundial time, off the ICARUS.

The ICARUS can be used at any position on Earth between 70° S and 70° N. It can easily be adjusted to the geographic co-ordinates for your own location.

As a result of the Earth's rotation, the Sun moves tirelessly from east to west, the location at which the Sun reaches its highest point at noon, changes continuously. The sundial displays the Sun's path around the globe. The ICARUS is not only a useful instrument for time measurement, it is also a model of our world, which we can use to actually understand time from a cosmic perspective.

This manual will serve as a guide in helping you to use this instrument effectively. The first section explains the most important facts about measuring time with a sundial. In the second section, we explain the steps from setting and adjusting the sundial to the first time reading and in the third section we explain in detail the information which you can read off the ICARUS. The appendix contains instructions on calculating the geographic co-ordinates and time zone tables. In the envelope you will find an overview of the ICARUS and a table with the steps for setting the sundial.

Measuring time via the Sun

Perhaps you have already asked yourself, why the sundial which you have just discovered on a church tower does not display the same time as that on your wrist-watch? The answer is, the Sun displays a different time, i.e. local apparent time. This is nature's time, determined by the Sun's path and valid for the place at which the church is located. When the Sun has reached its highest point and is exactly in the south, the sundial displays 12:00 hours, it is local apparent noon. If we follow this event over several days, we will notice that this happens at totally different times. The time from noon to noon is evidently not always 24 hours, the solar day is sometimes shorter, sometimes longer. The differences cumulate and result in the fact that, during the year, the sundial may be 17 minutes fast and 15 minutes slow compared to the average. There are two explanations for this phenomenon.

Firstly, the Earth moves on an elliptical path around the Sun and is faster when near the Sun than when at a distance. Secondly, the apparent Sun moves along the ecliptic which is at an angle of 23.45° to the celestial equator (figure 3). Only that part of the Sun's path in the direction of the celestial equator is relevant for time measurement. This part is also constantly changing throughout the year.

As we can see from this, local apparent time (LAT) is irregular time and is therefore inappropriate for time measurement with mechanical clocks. For this reason, local mean time (LMT) was introduced in the 18th century for large towns. This assumes a fictitious Sun which moves towards the celestial equator evenly and includes all location within the same longitude. The difference between apparent and mean time is called the

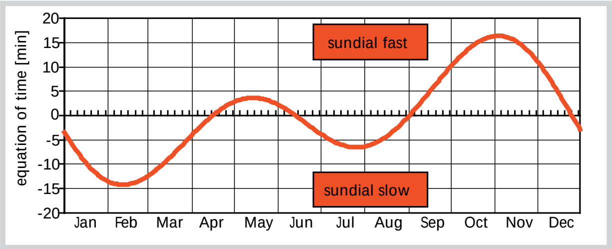

Figure 1: Equation of time

equation of time. Figure 1 shows how the equation of time changes during the year. The ICARUS has a scale at 03:00 hours, with which you can set the equation of time so that you can read off the locally valid standard time, e.g. Central European Time.

Time zones

The invention of the railway during the industrial revolution in the 19th century made it possible to travel long distance. The resulting need for a national rail timetable led to a further standardisation in time: the introduction of standard time, valid for specific time zones, by international agreement in 1884. The time zones are one hour apart, exactly the amount of time which the Sun takes to move 15 degrees in longitude across the Earth. On the ICARUS, the prime meridian through Greenwich in London, which is the basis of Coordinated Universal Time (UTC), and the meridians to the east and west at a distance of 15° are visible as representative time zones.

The standard time valid for most countries in Europe is Central European Time (CET). This is defined as the local mean time at longitude 15° E and is one hour ahead of Coordinated Universal Time. To read off CET, 12:00 hours is set on the time zone meridian and the equation of time is set on the scale at 3:00 hours. Central European Daylight Saving Time (CEST) is one hour ahead of CET, so 13:00 hours is then set at 15° E.

Ecliptic – the apparent path of the Sun

Our Earth rotates around its axis daily and orbits the Sun once a year. The Earth's axis is tilted to 23.45° to the vertical at the level of the Earth's orbit. During the Earth's orbit around the Sun its direction to the Sun changes constantly, but the Earth's axis remains consistently pointing towards the Polar Star (figure 2). This is the reason why the Sun – as seen from the Earth – moves up and down between the tropics on its annual migration, resulting in the seasons as we know them. The apparent path of the Sun is called the ecliptic and the angle of the Sun to the equator the declination. Along the ecliptic, the Sun moves daily in front of the constellations on average 1° towards the east, the declination assumes values between -23.45° and +23.45°. The apparent migration towards the west, of which we are more clearly aware, arises from the Earth's rotation upon its axis.

If the Sun's light did not outshine the constellations, we would be able to follow in which of them it is currently located. The constellations which the Sun passes through during a year are the constellations of the zodiac. About 2000 years ago, the signs of the zodiac were derived from these constellations. Each zodiac sign is one of twelve 30° segments along the elliptic path. The first sign of the zodiac, Aries, begins at the vernal point and encompasses the ecliptic length from 0° to 30°, Taurus then follows from 30° to 60° and so on (figure 3).

The zodiac signs no longer correspond with the zodiac constellations, since as a result of a slow drift of the Earth's axis (precession), the vernal point moves around the ecliptic once every 26000 years. Today, the vernal point is located in Pisces, in antiquity it was still in Aries.

The zodiac signs have retained their importance in sundial construction to this day, since they precisely mark the Sun's yearly path, for example the beginning of the four seasons.

At the winter solstice on December 21st, the Sun is in the southern tropics (declination = -23,45°), the tropic of Capri-

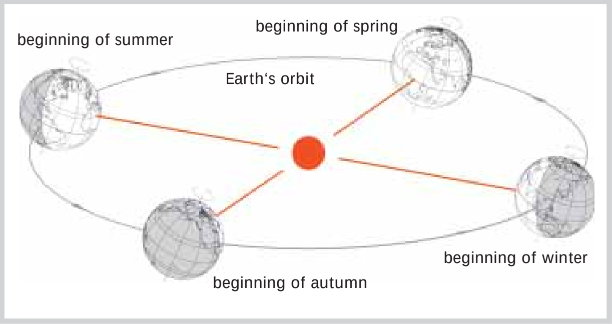

Figure 2: Earth's migration around the Sun

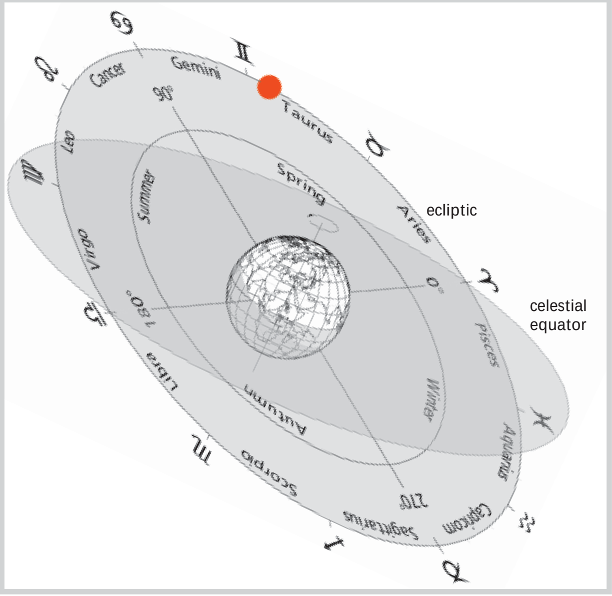

Figure 3: Ecliptic - Sun's apparent path along the zodiac

corn. Seen from the northern half of the Earth, it is taking its lowest daily path across the horizon. The complete northern Polar Circle remains in darkness throughout this day. In comparison, the southern Polar Circle experiences polar day (no night). From this day onwards the Sun moves upwards and follows a higher path each day, we speak of the ascending Sun.

At the beginning of spring (first point of Aries) on March 21st, the Sun crosses the equator (declination = 0°). Day and night are of equal length. From this day onwards, the Sun does not set in the North Pole for six months, during this time the South Pole remains in darkness. On June 21st at the summer solstice, the complete northern Polar Circle is lit up all day, the Sun reaches the northern tropics (tropic of Cancer, declination = +23,45°), in the northern hemisphere it reaches its highest daily path.

From this date onwards, the Sun moves downwards and will cross the equator on 23rd September in a southerly direction. It is now equinox again, the Sun is entering the zodiac sign of Libra and autumn is beginning in the northern hemisphere. On 21st December, winter starts and the seasonal cycle recommences from the beginning.

The signs of the zodiac are illustrated on the ICARUS. From the day's date you can ascertain the position on the ecliptic.

Adjusting the ICARUS

The ICARUS is a precision instrument which displays the time and the noon position of the Sun. Once you are used to adjusting it, you can set the time exactly. The following instructions describe the procedure for time measurement in detail using a specific example. As soon as you are familiar with this procedure, you can use the table enclosed in the envelope, which contain a summary of all the steps required for all adjustment options.

Seven steps

In order to adjust the ICARUS correctly, you have to know two things: the date and where you are in the world at this point in time.

You can set up the ICARUS in seven steps:

1. Adjusting for your own location on the world map.
2. Setting and locking the date slider.
3. Taughtening and locking the wire with the equation of time slider.
4. Setting the time zone with the time scale ring.
5. Read off the equation of time and set the time scale ring.
6. Setting the latitude slider.
7. Alignment with the Sun.

Now you can read off the time and the Sun's noon position.

Below you can find a detailed description using a specific example.

1. Adjusting for your own location on the world map

The aim of this step is to ensure that the meridian line goes through your own location on the world map (figure 4). Once the sundial has been correctly aligned, this imaginary line runs exactly in a north-south direction. The meridian line runs parallel to the meridian disk and is marked by the meridian arrow.

There are two ways of bringing your own location on the world map into congruence with the meridian line:

Firstly: You do not know the geographic co-ordinates for your location, but you know where you are on the world map. For example, you are currently on holiday in Majorca. You find the island in the northern hemisphere in the Mediterranean. First, you loosen the fastening screw above and below the equator ring and turn the world map until Majorca is congruent with the meridian line. To do this more accurately, you can turn the ruler with the latitude scale to the meridian arrow. You should orientate yourself on the 06:00 hours marker line (on the southern hemisphere it is the 18:00 hours marker line). Now you turn the world map until the Balearic island is positioned below the edge of the ruler (figure 5) and lock the setting by holding the world map with one hand and tightening the fastening screws with the other. You can now read off the geographical latitude for Majorca, which you will require for step 6, setting the latitude.

Secondly: You know the geographic co-ordinates for your location (you will find tips on ascertaining the co-ordinates in the appendix). You can then use the longitude scale at 00:00 hours to adjust the world map (figure 6). Majorca is located at 3° E (east of Greenwich). First you turn the time scale ring until 3° E on the longitudinal scale is positioned on the meridian arrow, then you turn the world map until the zero marker triangle is set at 0° longitude. Now you hold the world map in place and tighten the fastening screw above and below.

The 0° longitude which runs through Greenwich and is called the prime meridian, is the origin of longitudinal measurement.

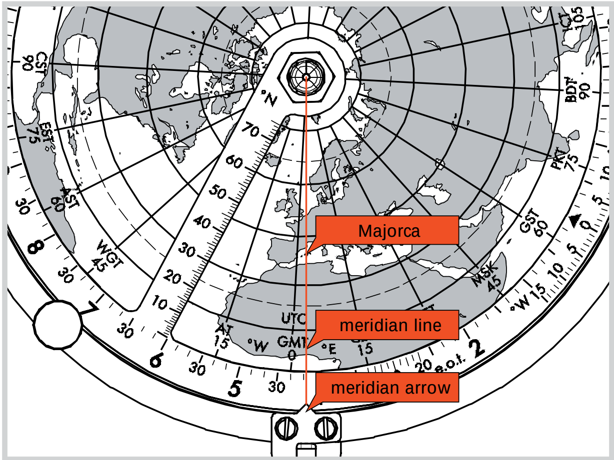

Figure 4: Setting the location in relation to the meridian line

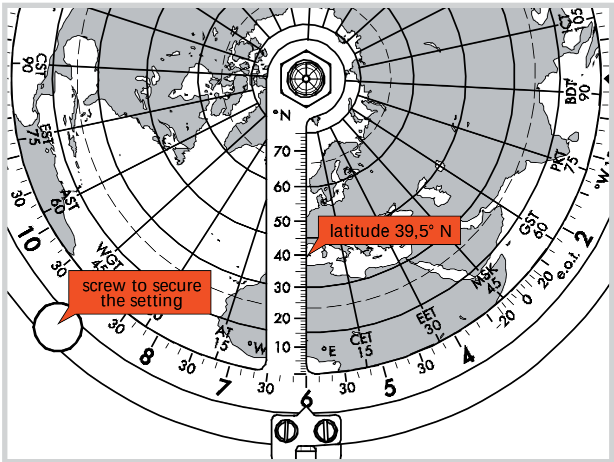

Figure 5: Using the ruler

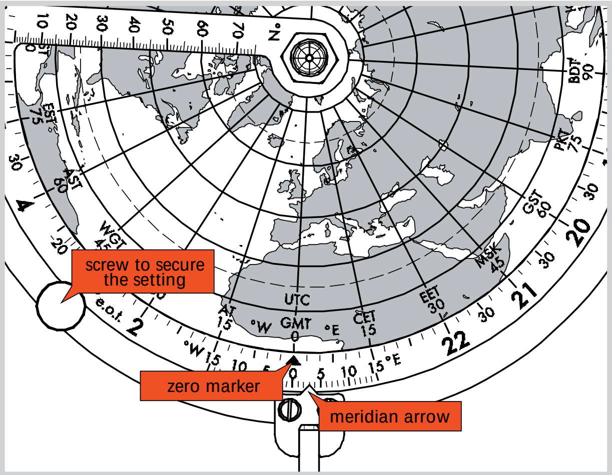

Figure 6: Setting the location using the longitude scale

As long as your location is no further than 15° east or west of Greenwich, you can simply use the longitudinal scale as described in the Majorca example. If you are more than 15° east or west of Greenwich, you should first calculate the difference to the longitude (time zone meridian) which is nearest to you from Greenwich. Example: Miami in Florida (USA) is 80° west of Greenwich, the nearest time zone meridian in the direction of Greenwich is 75° W, Miami is located 5° west of here. So you first set 5° W on the meridian arrow and then the time zone meridian 75° W on the zero marker, then Miami is located exactly on the meridian line. The procedure is exactly the same for the southern hemisphere. Sydney (Australia) is located at 151° E, in this case 1° E is set on the meridian arrow and the time zone meridian 150° E positioned on the zero marker.

As a final step, the location setting is always locked in position using the fastening screws, since you only need to change this when you travel to a new location. The location setting is completely independent of the time zone for which you wish to ascertain the time. This takes place in step 4.

Please note: The fastening screws only lock the world map in place to avoid unintentional slippage, the time scale ring can still be rotated. The easiest way to rotate the time scale ring is by pulling the upper and lower ruler simultaneously.

If you know neither your location on the world map nor the co-ordinates of your location, you can use the ICARUS to determine these. To do so, please read the section *Navigation* on page 27.

2. Setting and locking the date slider

You can set the date on the date setting scale provided on the meridian disk (figure 7). The Sun moves up and down between the tropics (solstices) during the year. On the northern hemisphere, it takes a higher path each day in the winter and spring and the days become longer, this is called the ascending Sun. During this time period, we use the scale from 21st December to 21st June. For the descending Sun, the scale on the other side of the meridian disk should be used, which runs in the opposite direction and is valid from 21st June to 21st December. On the southern hemisphere, the up and down movement of the Sun runs the other way around but the date scale can be used in exactly the same way.

Check that the fastening screws for the equation of time slider and the date slider are loosened, so that these are easily moved. Open the equator ring until the stoppers hit on the meridian disk. Now push the date slider to today's date and tighten the fastening screw for the date slider. Figure 7 shows the setting for May 15th.

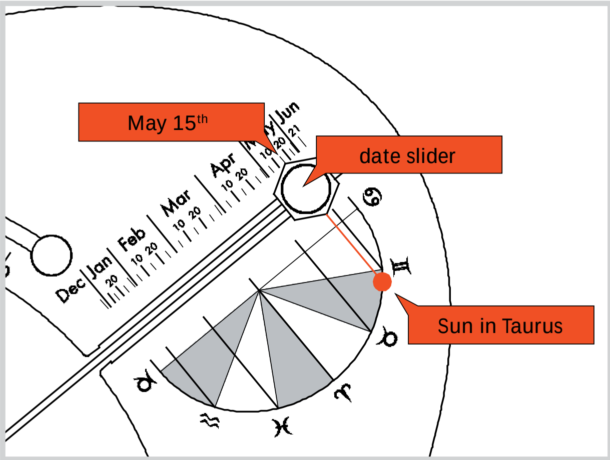

Figure 7: Setting the date

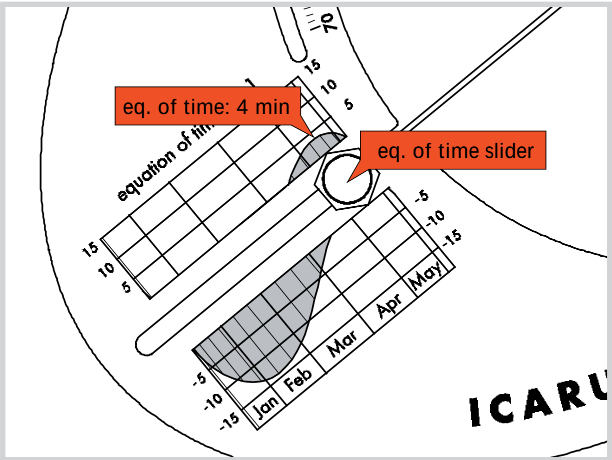

Figure 8: Equation of time slider and equation of time diagram

3. Tautening and locking the wire with the equation of time slider

Now push the equation of time slider outwards until the wire is taut (figure 8). Hold the wire taut with one hand while clamping the slider by tightening the fastening screw with the other. The equation of time slider is now positioned at the correct location for today's date on the equation of time diagram, which we will use in step 5.

4. Setting the time zone with the time scale ring

To read the time zone off the ICARUS, position the setting for 12:00 hours on the time zone meridian. In Majorca, Central European Time is used. CET is read on the time zone merid-

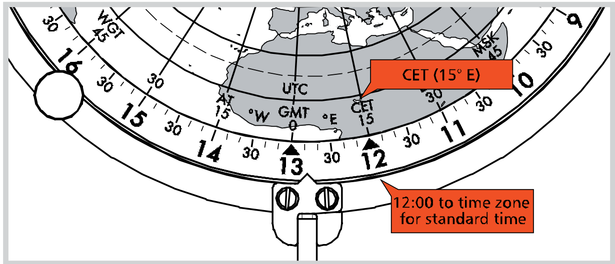

Figure 9: Setting the standard time

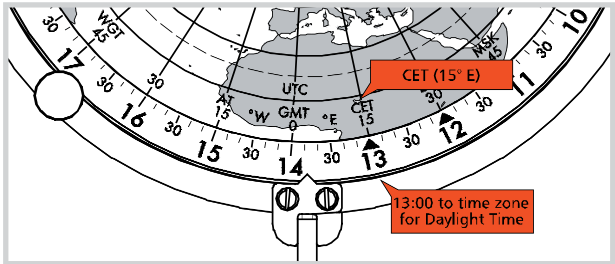

Figure 10: Setting the Daylight Saving Time (Summer Time)

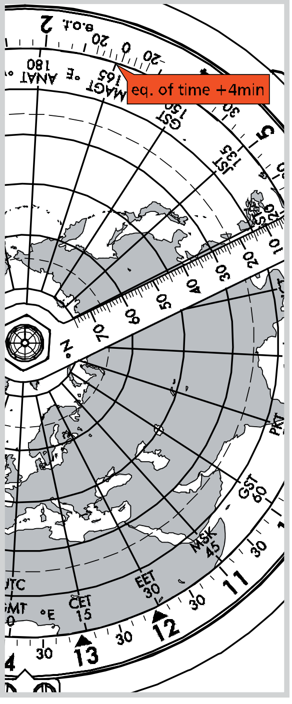

Fig. 11: Setting equation of time

ian 15° E, so you should turn the time scale ring until 12:00 hours is positioned on longitude 15° E (figure 9). In many countries around the world, Daylight Saving Time (Summer Time) is introduced in the summer months, this is one hour in advance of the normal standard time. In Majorca, Daylight Saving Time (Summer Time) is normally valid between the last Sunday in March and the last Sunday in October. During this period, you should set 13:00 hours for Daylight Saving Time (Summer Time) on the time zone meridian (figure 10).

5. Reading off and setting the equation of time on the time scale ring

Similarly to the date scale, the annual equation of time curve is divided between the two sides of the meridian disk, according to the ascending and descending movement of the apparent Sun. On the same side, on which you have just set the date, you can read off the equation of time in minutes from the diagram. For May 15th, the result will be +4 min.

Set the value you have read on the time scale ring (figure 11). The scale is at 03:00 hours, on the time zone meridian at this position, set the equation of time (in this example +4 min).

***Please note*:** The time zone meridian, on which you rotate the equation of time value, results arbitrarily from setting the time zone in step 4, longitude and time zone are of no importance here. The time difference has the same effect on all 24 time zone meridians.

6. Setting the latitude slider

The angle of the gnomon to the horizontal is defined by the geographical latitude. You can set the latitude for your current location using the latitude slider adjusting mechanism. When doing so, please take into account on which hemisphere (north or south) you are located. In the Majorca example, set 39,5° N, see figure 12.

7. Alignment with the Sun

Now the preparations for time measurement have been completed and you can align the sundial with the Sun. In the middle of the wire is an egg-like shape in ellipsoid form. In spring and summer, as illustrated in our example on May 15th, the ellipsoid is located above the equator ring, always above that side of the world map where you are located. In the case of Majorca, this is over the northern hemisphere.

Hold the ICARUS on its suspension ring, so that it hangs freely and both the side of the meridian disk with the greater part of circular latitude groove and the suspension ring pointing towards the Sun. Turn towards the Sun. Now turn the freely suspended sundial towards the west if it is morning and towards the east if it is afternoon. Then follow the shadow which the wire and the ellipsoid throw onto the world map. Turn the ICARUS until the top curve of the shadow thrown by the ellipsoid corresponds with the upper edge of the time scale ring's inner surface (see figure 12). The wire shadow now shows you the time and noon position of the Sun. In our example, this is 11:30 hours CEST (Central European Summer Time) and it is noon in Moscow.

If you use the ICARUS in the autumn or winter month, the ellipsoid will be located below the equator. In this case, turn your back to the Sun and hold the sundial above your head, so

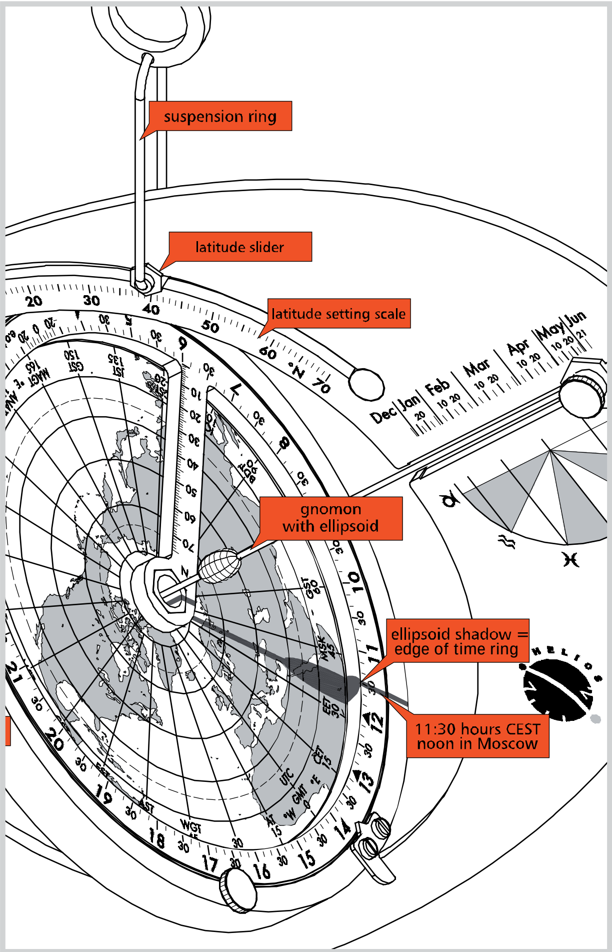

Figure 12: ICARUS ready for use

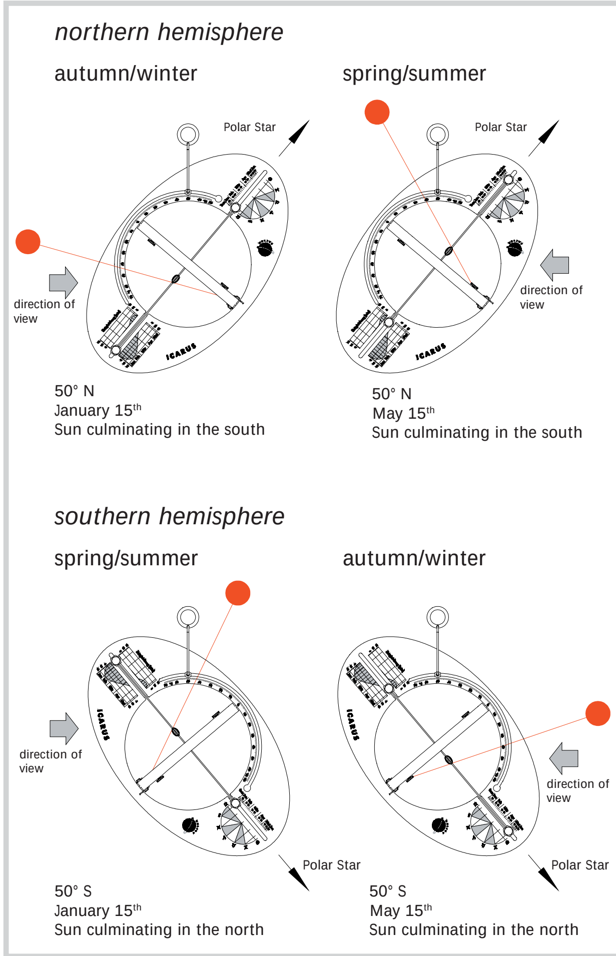

Figure 13: ICARUS in use for the southern and northern hemisphere

that you are looking at the lower part of the world map. Now proceed as before, except that in this case the lower curve of the ellipsoid corresponds with the edge of the time scale ring.

If you are using the ICARUS in the southern hemisphere, the alignment works in exactly the same way. The latitude slider is set to the relevant southern latitude and the southern part of world map is at the top. The polar star to which the gnomon points will not be visible at night either, since it is situated behind the Earth. Figure 13 shows possible scenarios in the northern and southern hemispheres.

At the equinoxes on 20th/21st March (first point of Aries) and on 22nd/23rd September (first point of Libra), the ellipsoid is positioned exactly above the equator. Since it is then completely sunk in the central passage of the world map and does not project either above or below, the ellipsoid does not create a shadow. In this case, the sundial is correctly aligned when the shadow of the ruler corresponds with the inner surface of the time scale ring. Shortly before you reach this position, you can read the time from the shadow of the wire. The actual time is in fact slightly later in the morning and slightly earlier in the afternoon.

Please note: You can always place the ICARUS in two positions, in which the curve of the ellipsoid's shadow and the inner surface of the time scale ring correspond as described above. Only one of these positions is correct. The Sun rises in the morning, reaches its highest point at noon and sets in the evening. This means that the Sun's daily path to the meridian line is symmetrical, the Sun reaches the same altitude above the horizon twice per day (see figure 15). Normally you will know whether it is morning or afternoon at a particular moment in time, so that you can estimate whether the given time is correct. But 1-2 hours before and after the Sun's daily culmination, noon, is reached, it is not always so easy to recognise this. In the latter case, you can read the time in the desired position for a second time a few minutes later. If it is now earlier, i.e. time has moved backwards, then the other position is obviously correct.

ICARUS – universal timekeeper and navigator

Now that you know how to adjust the ICARUS, this section describes in more detail the sundial's various functions and the information you can read from it.

Universal timekeeper

The time which rules our lives is the civil time as legally specified in each country. Normally, this is a standard time, i.e. it will differ from Coordinated Universal Time (UTC) in complete hours. Central European Time is a standard time, valid as civil time in various countries within Europe. On the ICARUS' world map, CET is marked at the time zone meridian 15° E. Most of the other 24 time zones are marked by a representative time zone on the northern and southern hemisphere. The meaning of the time zone abbreviations and the relevant standard meridians can be found in the appendix in tables 1 and 2.

The ICARUS is an universal timekeeper and offers you the opportunity to read off any standard time in the world. Normally you will be interested in the time for the country in which you are currently located. But, particularly when you are travelling, you may want to know the time at home. Or you intend to call a colleague in a distant country and want to know if he will still be in the office at this time. In our example from figure 12, your location is Majorca and it is exactly 11:30 CEST, now find out what time it is in New York. In New York they live according to Eastern Standard Time (EST), which is measured at time zone meridian 75° W. On May 15th it is also Daylight Time in New York, so you can set the sundial to 13:00 hours at 75° W (EST) and set the equation of time to +4min. Now you can read off Eastern Daylight Time (EDT) in Majorca, it is 5:30 hours EDT.

Local apparent time

Of course, you can also set the local apparent time (LAT) of your location with the ICARUS. The LAT is determined directly by the Sun. It is 12:00 hours local apparent time when the Sun has reached its daily high point (culmination) at noon and passes through the local meridian. So on our sundial we bring 12:00 hours in line with the meridian line, by turning the time scale ring until the meridian arrow points to 12:00 hours (figure 14). It will stay here all year round, a date-dependent correction such as the equation of time does not exist for the display of local apparent time.

This „natural“ time reproduces for you daily the Sun's natural path (see figure 15). During the morning (ante meridiem = a.m.), the Sun steadily climbs in the sky until it has culminated at 12:00 hours LAT. This event is called local apparent noon. Now the Sun is positioned exactly in the direction of the ICARUS' meridian disk and the gnomon's shadow disappears for a short time. Then the Sun lowers, it is afternoon (post meridiem = p.m.).

While local apparent time is related to the local meridian, standard time is always measured by a specified meridian. The implications of this can be easily seen using our Majorca example (figure 12). The ICARUS, set to Central European Summer Time, shows us that on May 15th, the Sun reaches local apparent noon at 13:44 hours.

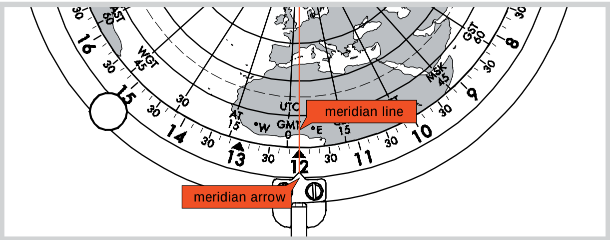

Figure 14: Setting the local apparent time (LAT)

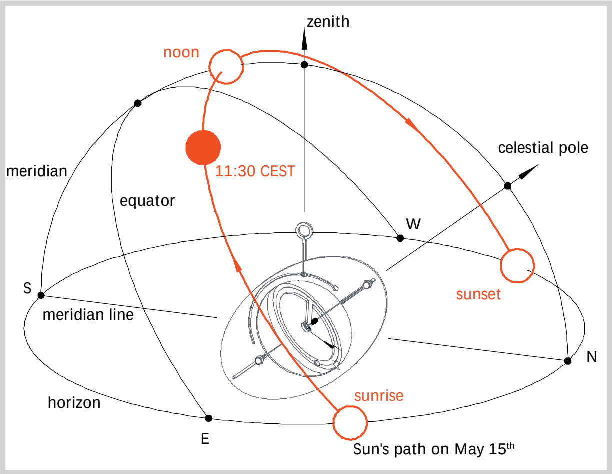

Figure 15: Sun's path on May 15th

If we are looking for the best time to go sunbathing on the beach, we would do better to orientate ourselves on local apparent time.

The time difference of CEST compared to LAT consists of the local time difference, the equation of time and the Daylight Saving Time (Summer Time) difference. The local time difference is the time which the apparent Sun needs from the CET time zone meridian (15° E) to the local meridian. The Sun can move 15 degrees in longitude in one hour, so it needs 48 minutes for the 12° which Majorca is situated west of 15° E. The equation of time on May 15th consists of +4 min, this means that local apparent time is 4 minutes ahead of local mean time (LMT), on this day noon occurs 4 minutes earlier than on average during the year (see figure 1). So the equation of time is subtracted. Finally, the Daylight Saving Time (Summer Time) difference of one hour is added, resulting in a total difference of 1 hour 44 minutes, which is the time which CEST is ahead of LAT in Majorca on May 15th.

The Sun's migration around the Earth

Just as in Majorca, noon occurs at every place on Earth once per day. This event takes place at that longitude at which you can currently see the shadow line on the ICARUS' world map. At all other places located on the longitude, the Sun is reaching its daily culmination. On the northern hemisphere it is then located exactly in the south, on the southern hemisphere in the north. In the tropical zone between the tropics it assumes both directions depending on the season and reaches its zenith at noon on one day of the year.

In our example on May 15th at 11:30 hours CEST (see figure 12), the Sun is positioned 36°35' east of Greenwich at noon. If you were situated 60 km west of Moscow at this moment, the Sun would just be culminating in the south. At the same time you could observe the passage of the Sun across the meridian at Nairobi in Kenya in the north.

A cosmic model of the world

We use the Sun's ascent and descent on its daily path to align the ICARUS in a north-south direction. The ellipsoid's shadow is not in the correct position until the sundial's co-ordinate system has been brought into alignment with the equator's co-ordinate system by turning the ICARUS on its vertical axis (see figure 15). This means that once the alignment has been carried out, the sundial's equator ring is parallel to the equator, the meridian disk displays a north-south direction. The gnomon points towards the celestial pole (the Polar Star is close by) and is therefore automatically aligned parallel to the Earth's axis. Since the Sun seems to revolve daily around this axis in the sky, it also revolves around the ICARUS' gnomon. As a result of the enormous distance to the Sun, it makes no difference that we are located on the Earth's surface with the ICARUS and not at the Earth's centre. Consequently, the shadow moves just like the Sun at 15° per hour, from time zone to time zone, across the world map and the time scale ring of the ICARUS.

The Sun's declination, that is the angle of elevation to the equator level, hardly alters during the day, so that the shadow of the ellipsoid always migrates along the edge of the time scale ring. During the year, the declination assumes values of between -23.45° and +23.45°, by using the date scale the ellipsoid is moved to the position relevant for the declination (see figure 7 on page 16).

By enabling a correspondence between the co-ordinate systems of the sundial and the Earth, it will be possible for us to follow the Sun's migration and the phenomena associated with this on the ICARUS, as they occur in the world.

Solar compass

The ICARUS can be used as a compass, since we now know that the meridian disk points exactly south after being aligned with the Sun. One advantage when compared with a magnetic compass, which is aligned with the Earth's magnetic field, is that you do not need to take any magnetic declination into account and that iron objects have no influence on the reading. On the other hand, the ICARUS can only be used as a compass in good weather, since it is a sundial, which by nature „only counts the good hours", as a well-known sundial saying tells us.

Navigation

Knowing the geographic latitude and longitude of your own location is a pre-requisite for determining time with the sundial. If you do not have this knowledge, you can establish the co-ordinates with the ICARUS. However, you should be familiar with the principles of time measurement with the ICARUS in order to properly understand the following description.

In establishing co-ordinates, we proceed exactly as we would in celestial navigation and use local apparent noon, when the Sun is at its highest, to read the *geographic latitude*. Since we don’t know the exact time, we start the reading before noon. First we set the date, positioning the time scale ring at local apparent time, that is at 12:00 hours under the meridian arrow. We can’t adjust the world map, since we do not yet know our location. Now we carry out the first latitude approach: we push the latitude slider to 70° N or 70° S and rotate the ICARUS until the shadow of the wire is positioned at 11:00 hours. If we now rotate the sundial so that the shadow of the ellipsoid migrates towards the meridian line, the shadow will approach, but normally not reach the top edge of the time scale ring. We now set the latitude slider to a lower latitude (e.g. 65°) and repeat the process. Now the shadow will have become closer to the time scale ring. We now set successively shorter latitudes until the ellipsoid shadow has reached the top edge of the time scale ring in the meridian line.

Please note: The ellipsoid is hidden by the meridian disk when it is pointing directly at the Sun. Since we are observing exactly this position, you must watch the ellipsoid shadow just before it disappears behind the meridian disk or just after it reappears. The „imaginary“ position of the shadow in the meridian line lies slightly above this.

If we carry out the latitude approach again after a few minutes have elapsed, we discover that in the meantime the latitude we noted has again been reduced because the Sun’s height has increased. Carry out this latitude approach continually at regular intervals, until you will discover that the latitude determined has reached a minimum and then slowly starts to increase. The Sun has now surpassed its highest and traversed the meridian. The latitude reading in the meridian, i.e. the lowest value, is the required geographical latitude for the location. Now set this latitude and you can read local apparent time off the ICARUS, it should be just after 12:00 noon.

The *geographical longitude* cannot be established merely from observing the Sun. For this reason, ascertaining the longitude when on high seas was a problem up even as recently as the 18th century. Only when accurate mechanical clocks had been invented, which were not affected by variations in temperature

or the ships movement, were seafarers able to determine their own longitude from the difference between their local time and the local time „imported“ from their home port.

If we know the mean time at the prime meridian in Greenwich and calculate the difference to the mean local time read off the ICARUS, we can determine the geographical longitude, since we know that the Sun moves 15° in one hour. For 1° it takes 4 minutes.

The mean local time at the prime meridian is Universal time (UT), which for our purposes we can consider as the equivalent of Coordinated Universal Time (UTC). The standard time which you read on your wristwatch differs from UTC in complete hours (see tables 1 and 2). During official Daylight Saving Time (Summer Time), we add 1 hour.

To determine Local Mean Time at our own location, we subtract the equation of time from 12:00 hours (taking care with the algebraic sign – plus or minus!) and set the resulting time at the meridian arrow. If we do not want to calculate, we can rotate 12:00 hours on the meridian arrow and then align the world map with any time zone meridian at 12:00 hours. Using this trick, we can set the equation of time at 03:00 hours using the technique we have learned (see figure 10).

An example of determining the longitude: On May 15th we set 11:56 hours (12:00 hours - 4 min equation of time) on the meridian arrow and read off for example 14:00 hours LMT. Our wristwatch displays 15:48 hours CEST.

CEST = UTC + 2 h → UTC = CEST - 2 h

So it is 13:48 UTC. We calculate the difference between LMT and UTC:

LMT - UTC = 14:00 - 13:48 = +12 min

If there is a plus sign, this is the time which the Sun takes from our location to the prime meridian, we are currently east of Greenwich. If there is a minus sign, the Sun migrates from the prime meridian to our location during this time, we are currently west of the prime meridian.

In the example, we determine:

12 min / 4 min = 3° eastern longitude

Please note: While we can only take the latitude reading at local apparent noon, this is not necessary for the longitude reading, since with the ICARUS we can read LMT all day long, as long as we know the latitude. On the contrary, it is more accurate to determine the longitude at least one hour before or after local apparent noon.

The zodiac signs

The zodiac scale is printed opposite the date scale. Using this, you can immediately identify where in the zodiac the Sun is currently situated. The symbol of the appropriate zodiac sign is always located at the Sun's entry point, which moves along the ecliptic in an anti-clockwise direction. On May 15th, the Sun is still in the zodiac sign of Taurus (see figure 3 and 7), 5-6 days later it will enter the zodiac sign of Gemini.

Conversely, you can also use the zodiac sign to set the date slider, for example by setting the date slider to Aries on 20th/21st March at the beginning of spring.

Transport

The ICARUS can be folded for transport and can be carried attached to your belt in the bag provided. First loosen the fastening screws for the date slider and the equation of time slider, position the ellipsoid into the central opening of the equator ring and fold the equator ring. Then re-tighten the screws. Please ensure that the wire does not become caught up in the guiding slots of the slider.

Support

If you have questions on the correct use of your sundial, you can reach us at the following contact address:

HELIOS (EK)
Begasweg 3
65195 Wiesbaden
Fon: +49 - (0)611 - 18 51 106
Fax: +49 - (0)611 - 59 83 29
E-mail: info@heliosuhren.de
Internet: www.heliosuhren.de

We are always grateful for your tips and helpful suggestions.

We wish you lots of enjoyment with your ICARUS on many sunny days.

Appendix

Determining the geographical co-ordinates

You need to be aware of the geographical latitude and longitude to set up your location on the ICARUS. There are various options for finding out this information:

> The geographic co-ordinates are noted around the edge of topological maps or ordnance survey maps, so that you can read off the co-ordinates for the installed location.

> If you have a navigation system (GPS) in your car, you can use this to precisely define the co-ordinates.

> Internet: at the Internet address http://earth.google.com/ you can download Google Earth free of charge. Using this program, you can fly over a virtual Earth consisting of satellite photos and determine the co-ordinates for any place on Earth.

World time zones

In the following tables 1 and 2 you will find the time zone abbreviations displayed on the ICARUS world map and their meaning. The longitude and time difference relative to UTC are listed and information on whether the standard time also has a Daylight Saving Time (Summer Time) variant (+1 h).

If you are not sure to which time zone the civil time in your country belongs, we recommend that you visit the Internet address http://www.worldtimezone.com. Here you will find the time difference relative to UTC and the information, whether a provision for Daylight Saving Time (Summer Time) exists.

long.	*abbrev.*	*northern hemisphere time zones*	*rel. UTC*	*Dayl. Time*
180°W			-12 h	
165°W	NT	Nome Time	-11 h	no
150°W	HST	Hawaii Standard Time	-10 h	no
135°W	AKST	Alaska Standard Time	-9 h	yes
120°W	PST	Pacific Standard Time	-8 h	yes
105°W	MST	Mountain Standard Time	-7 h	yes
90°W	CST	Central Standard Time	-6 h	yes
75°W	EST	Eastern Standard Time	-5 h	yes
60°W	AST	Atlantic Standard Time	-4 h	yes
45°W	WGT	Western Greenland Time	-3 h	yes
30°W			-2 h	
15°W	AT	Azores Time	-1 h	yes
0°	GMT	Greenwich Mean Time	0 h	yes
15°E	CET	Central European Time	+1 h	yes
30°E	EET	Eastern European Time	+2 h	yes
45°E	MSK	Moscow Time	+3 h	yes
60°E	GST	Gulf Standard Time	+4 h	yes
75°E	PKT	Pakistan Time	+5 h	no
90°E	BDT	Bangladesh Time	+6 h	no
105°E	ICT	Indochina Time	+7 h	no
120°E	CST	China Standard Time	+8 h	no
135°E	JST	Japan Standard Time	+9 h	no
150°E	GST	Guam Standard Time	+10 h	no
165°E	MAGT	Magadan Standard Time	+11 h	yes
180°E	ANAT	Anadyr Time	+12 h	yes

Long.	Abbrev.	southern hemisphere time zones	rel. UTC	Dayl. Time
180°W			-12 h	
165°W	WST	West Samoa Time	-11 h	no
150°W	TAHT	Tahiti Time	-10 h	no
135°W	GAMT	Gambier Time	-9 h	no
120°W	PST	Pitcairn Standard Time	-8 h	no
105°W			-7 h	
90°W	GALT	Galapagos Time	-6 h	no
75°W	PET	Peru Time	-5 h	no
60°W	BOT	Bolivia Time	-4 h	no
45°W	BRT	Brazil Time	-3 h	yes
30°W	GST	South Georgia Time	-2 h	no
15°W			-1 h	
0°	UTC	Coordinated Universal Time	0 h	
15°E	WAT	West Africa Time	+1 h	no
30°E	CAT	Central Africa Time	+2 h	no
45°E	EAT	East Africa Time	+3 h	no
60°E	MUT	Mauritius Time	+4 h	no
75°E			+5 h	
90°E	MAWT	Mawson Time (Antarctica)	+6 h	no
105°E	WIT	West Indonesia Time	+7 h	no
120°E	AWST	West Australian Standard Time	+8 h	no
135°E	EIT	East Indonesia Time	+9 h	no
150°E	AEST	Australian Eastern Standard Time	+10 h	yes
165°E	NCT	New Caledonia Time	+11 h	no
180°E	NZST	New Zealand Standard Time	+12 h	yes

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