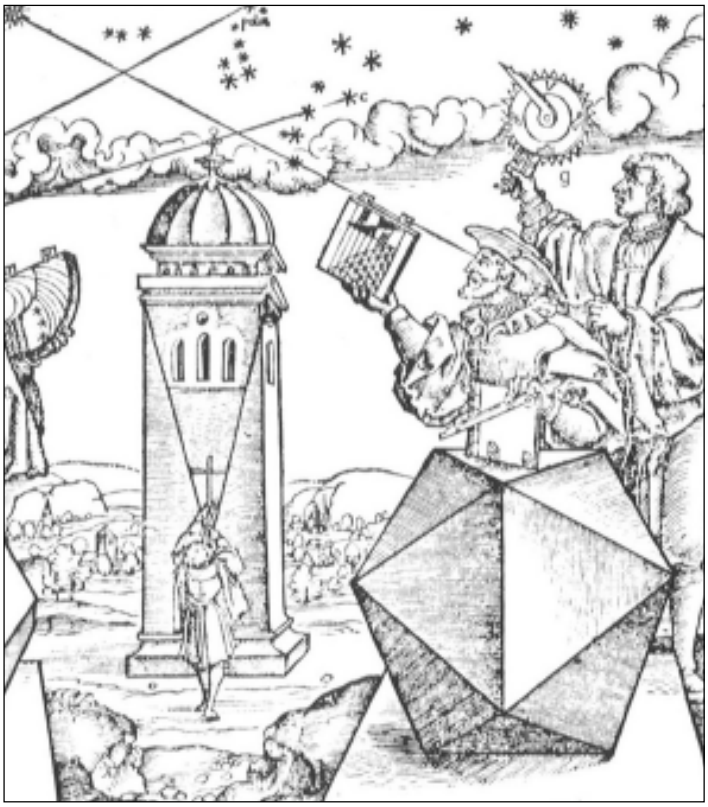
The Stardial



Shepherds,hunters and members of other trades who regularly performed their work at night time have always been able to read the time according to the position of the stars. Towards the end of the Middle Ages resourceful astronomers and makers of instruments invented the stardial, also called Nocturnal or Nocturlabium and first mentioned in 1295, for serving the ignorant town dweller or the impatient soldier being on night-watch. This sophisticated instrument makes us of the fact that the constellation Big Dipper orbits the Pole Star once in 23 hours and 56 minutes as if it were the pointer of a huge clock. Due to the difference of 4 minutes compared with an entire day the stardial is set to the current date prior to reading. Then it displays with amazing accuracy the true local time. How this happens you will read at the end of these assembly instructions.

The old instrument-makers liked to combine the stardials with a second instrument attached at the rear side, for example a sundial or, as it is the case here, with an astrolabe.

The mariner's astrolabe was usually made from heavy brass so it would not sway in the wind so easily and could take simple measurings of the elevation angle of sun and stars. From this again important conclusions could be made about the present position on the sea. In the 17th century this was a widespread instrument, it was for example part of the standard equipment of all ships of the Dutch East India Company.

Nevertheless only a few of these stardials and astrolabes have survived and they consequently are among the precious treasures of large museums.

Instructions for assembly

Before starting work please read every section completely. The assembly is not difficult, because all parts are pre-cut / die-cut for exact fitting. (to punch: rather used for holes only.)

You need a sharp knife for the assembly, in order to remove the punched parts neatly from the cardboard, possibly some fine emery paper and a good all-purpose glue. An all-purpose glue containing solvent is better suitable than a so-called solvent-free glue on water base, because it does not make the carton wavy.

Each part is marked with a piece part number ([A1], [A2], [B1], [B2] etc.) as well as its name (in German language). The letter of the piece part number is the same within a subassembly. Always only remove the parts from the cardboard which you require at that moment or otherwise write down the number of the part on the rear side.

To each of the parts with a piece part number of thin printed cardboard belongs a corresponding part with identical contour of thick non-printed cardboard. These parts are identified as "counterparts" in the assembly instructions. A few parts of thick cardboard are not required, they had however to be included in the cutting process for technical reasons.

Content of this kit:

2 die-cut cardboards, 0,4 mm thick, printed.
2 die-cut cardboards, 1 mm thick, non-printed

The parts for the stardial

Step 1: Remove the date disk [A1] from the printed cardboard plate and remove the axle [A2] from the centre. The small round little disk in the centre of the axle is removed so that a hole isopened.

Step 2: Remove the white counterpart to the date disk from the thick cardboard plate, remove here also the axle from the centre and clearthe hole in the centre. Now glue the date disk [A1] as well as the axle [A2] on their white counterparts. Pay attention to the fact that the edges at the outside and at the holes are flush. Then write down the piece part numbers [A1] and [A2] at the rear sides of both parts.

Step 3: Remove the hour disk [B1] carefully from the cardboard making sure the indentations (teeth) at the edge are not be damaged. Remove the axle [B2] as at step 1 and clear the hole in the centre.

Step 4: Remove the white counter pieces from the thick cardboard plate, glue the hour disk [B1] and the axle [B2] exactly flush to their counterparts and write the piece part number on the axle [B2].

Step 5: Glue the indented hour disk [B1] onto the date disk [A1]. Please observe that the indentations are placed exactly onto the indentations of the white glueing area and that the holes are placed in the centre of both parts above each other. Ehen correctly aligned the edge of the 18h indentation points to 5th of June.

Step 6: Remove the punched cardboard part from the reading window of the star pointer [C1]as well as the axle [C2] in its centre and open its small hole . Glue the star pointer [C1] and the axle [C2] to their counterparts of thick cardboard. Write the piece-part numbers on their rear sides.

Step 7: Glue the reinforcement of the star pointer [C3] to the rear side of the star pointer. The counterpart of thick cardboard is not required. When glueing the parts onto each other the edges at the end and at the sides of the pointer must be flush.

Step 8: Remove the covering disk [D1] from the cardboard plate and the small cardboard piece from the hole in its centre. Glue it on its counterpart of thick cardboard and write the piece-part number on its rear side.

Step 9: Remove the handle-reinforcement [E1] from the cardboard and clear the hole for the suspension. Glue the handle-reinforcement onto its counterpart of white cardboard and write the piece-part number on the rear side.

Step 10: Remove the handle [E2] from the cardboard. Clear the hole for the suspension and the window for reading the date and glue the handle on its counterpart of thick cardboard. Write the piece-part number on its rear side.

The parts for the mariner's astrolabe

Step 11: Remove the astrolabe disk [F1] and the axle [F2] from their sheet, clear the hole in the axle and glue both parts on their counterparts of thickcardboard. Write the piece-part numbers on the rear sides.

Step 12: Glue the handle reinforcement [E1] with its rear side on the rear side of the astrolabe disk [F1] so, that the edges and the hole of the handle reinforcements are exactly flush with the edges and the hole of the astrolabe suspension.

Step 13: Remove the alidade [G1] and the axle [G2] from the cardboard and remove the remaining cardboard from both pre-cut rectangles of the alidade as well as from the small hole in the axle. Glue the alidade [G1] and the axle [G2] onto their counterparts of thick cardboard and write the piece-part numbers on their rear sides.

Step 14: Remove the two feet of the sighting device [H1] and [H2] from the cardboard, then remove the cardboard from the pre-cut rectangles and glue both parts on their counterparts of thick cardboard.

Step 15: Glue the feet of the sighting device [H1] and [H2] onto both ends of the alidade in such a manner that the cut out rectangles and the curved edges at the left top are exactly flush with the rectangle and the curved edge of the alidade.

Step 16: Remove the two halves of sighting device [J1] and [J2] from the cardboard and clear the small hole. Remove one of the two counterparts from the thick cardboard and glue the halves of the sighting device onto both its sides. Pay attention that the steps in the lower edge are placed exactly on top of each other. The other counterpart is not required.

Step 17: Remove the reinforcements of the sighting device [J3] and [J4] from the cardboard and glue them onto their counterparts of thick cardboard. Then glue one of the two reinforcements of the sighting device onto each side of the sighting device [J1/J2]. Please observe that the steps in the lower edges of the three parts are placed exactly on top of each other.

Step 18: Proceed with the two other halves of the sighting device [J5] and [J6] as in step 16. Here, too, the other counterpart is not required.

Step 19: Proceed with the two reinforcements of the sighting device [J7] and [J8] as in step 17 and glue them onto both sides of the sighting device [J5/J6].

Step 20: Remove the covering disk [L3] from the cardboard and clear the hole in the centre. Glue ist onto its counterpart of thick cardboard and write the piece-part number on the rear side.

The assembly of the stardial and astrolabe

Step 21: Glue all axles made so far [A2], [B2], [C2], [F2] and [G2] on top of each other to form one cylindrical axle block. Then remove axle [K2], situated in the interior of the sliding disk [K1], of thin cardboard and glue it also to the block. The counterpart of thick carton is not required. Please pay attention that the outer edges and the holes of all disks are situated exactly on top of each other. Check whether the axle block can be inserted and turned in the star pointer, the date disk, the astrolabe disk and the alidade ; carefully grind off projecting edges by means of fine emery paper. The axle block has now exactly the height of all parts which shall rotate around it.
Step 22: Glue the axle block onto the unprinted side of the covering disk [D1] and here also make sure the holes in the centre are situated exactly on top of each other.
Step 23: Place the axle block with the covering disk down onto your working surface and push all parts prepared so far onto the axle block in this sequence without using glue:
a) Star pointer [C1]: printed side down, glued-on pointer reinforcement up.
b) Sliding disk [K1]: only the thin cardboard disk, printed side down. – The thick counterpart is not required.
c) Date disk [A1]: glued-on hour disk down, white side up.
d) Astrolabe disk [F1]: glued-on handle reinforcement down, astrolabe disk up.
e) Alidade [G1]: white side down, glued-on feet of sighting device up.
Step 24: When all parts are placed tightly on top of each other, the end of the axle block has to be flush with the surface of the alidade. Check whether all parts can be rotated around the joint axle independently from each other. A slight resistance is eased off by frequent use. If necessary, the axle or the axle hole of one part has to be carefully refinished by means of emery paper.
Step 25: Glue the covering disk [L3] onto the axle block where it projects from the alidade. Carefully pay attention that no glue enters between the covering disk and the axle and between the axle and the alidade.
Step 26: Turn over the astrolabe, so that the stardial comes to be at the top. Glue the handle [E2] onto the white glueing area of the handle reinforcement in such a manner that the curved edges and the hole for the suspension come to be situated on top of each other. Hereby the handle also projects above the date disk and the set date appears in its reading window.
Step 27: Turn over the stardial again so that the astrolabe comes to be on top. Glue one of the sighting devices reinforced at both sides to each end of the alidade in such a manner that the bevelled pegs at the lower side are glued into the cut-out rectangles of the alidade. The hole in the sighting devices then are situated exactly above the reading edge of the alidade.
The stardial and the mariner's astrolabe are now completed. Congratulations to this high quality cardboard instrument!

Five simple steps for reading the time from the stars at night

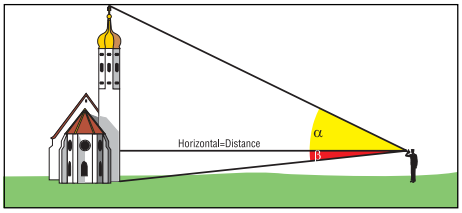
1. Turn the date disk until today's date is shown in the reading window of the handle above the arrow mark.
2. Look for the constellation of the Big Dipper and from there for the Pole Star. You find it when you extend the distance of the both rear stars of the Dipper box (= the two bright stars in the figure on the star pointer) 5½ times in direction of the box opening (on the star dial this corresponds to the direction towards the axle).
3. Hold the stardial with half-bent arm handle pointing vertically downwards and take aim at the Polar Star through the hole in the axle.
4. Turn the star pointer until its straight edge is parallel to both rear stars of the Dipper box. The Big Dipper on the stardial stands now like the one in the sky.
5. Read the true local time in the reading window of the stardial. You can however also make out the time by touching the long and short teeth on the hour disk, just as with all ancient stardials, whose owners only rarely had a light source available during night time. The somewhat longer teeth represent the full hours, the shorter ones the half hours, indicatiing the time which stands in the direction of the axle underneath the tooth. Consequently the valid indentation is always the one whose time appears at that moment in the reading window of the star pointer, and the latter always releases with its outer edge the matching tooth at that moment. For easier orientation the teeth for 18, 24 and 6 o'clock are shaped somewhat differently than the ones of the other full hours by their larger length and width. Therefore you can also start with the 18 o'clock tooth and then count the teeth of the hours that have passed since 18 o'clock.

Remark: The stardial does not indicate the civil time which we know as Central European Time or Summer Time, but the true local time determined by the course of the sun. According to this solar time it is 12 o'clock noon when the sun is standing exactly in the south, respectively midnight when it has reached its lowest point under the horizon. This occurs earlier in places further east and later in places further west, alsoeven if the citizens in these locations live according to the same uniform zone time. For example in Warsaw (Poland) the sun is one hour and 16 minutes earlier in the south than in Barcelona (Spain) although both cities belong to the Central European Time zone. The instructions for the Astro-Media kit *The digital sundial* provide a detailed description of the differences between true local time and zone time as well as instructions how to calculate it.

Four simple steps for measuring the elevation of the sun and stars by means of the mariner's astrolabe

1. In order to measure elevation angles the astrolabe has to be suspended at a cord pulled through the hole in the handle. For this you have to first balance the asymmetrically shaped star pointer by adjusting its reading edge to the small golden marking which is situated at the lower left on the astrolabe scale between 66° and 67°. This is howway you can check whether the astrolabe is really vertically suspended: Simply Hold a simple plumb line, composed of a thread and a small weight, in front of the suspended astrolabe. The thread has to run via both the 90° markings and the centre of the axle.
2. To measure the angle between a horizontal line and the tip of a mountain orand a building or also a star, hold the astrolabe by the cord at eye heightlevel and shift the alidade until you can see the point you are aiming at through both holes of the sighting device at the same time.
3. To measure the elevation of the sun, let the astrolabe hang lower and shift the alidade until a sun beam simultaneously falls through both holes, for example onto the palm of your hand . **Important: Never aim directly into the sun; this can cause permanent damage to your eyes!**
4. Read the angle at the ends of the alidade on the scale.

Here are some examples about what can be followed from the elevation angle:



1. When I know the distance to the tip of a building and the angle between the horizontal line and and the line connecting the stardial and the tip of the building, I can mathematically or graphically determine the height of the building.

2. When I know the elevation of the Pole Star, I also know my geographical latitude width, because both are (almost) the same. This measurement was of great importance for the sailor in the past.
3. When the sun is at its highest elevation, it is true noon. With this measurement it was not only possible to readjust the hourglasses onboard in the past, but to determine the geographic latitude as by means of the Pole Star: All you had to do was to look up to a tablethe angle between the sun and the celestial equator at this day and it was very simple to determine the geographical latitude from this. These measurements were perfected by means of the Hadley sextant invented some hundred years later.

A more detailed description of how to navigate with the determination of the elevation of sun at noon can be found in the instructions for the Astromedia* kit *"The Sextant"*.