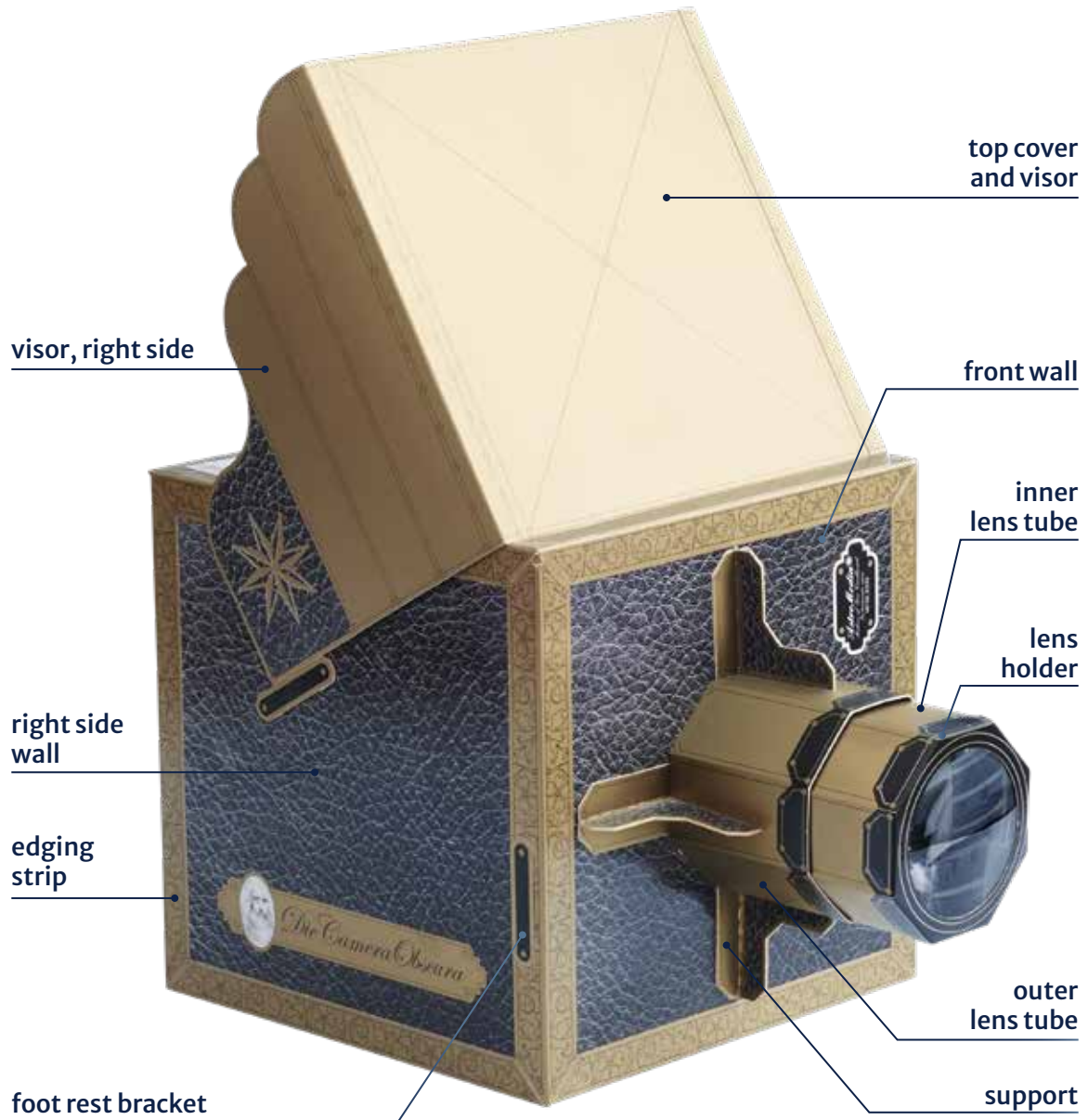
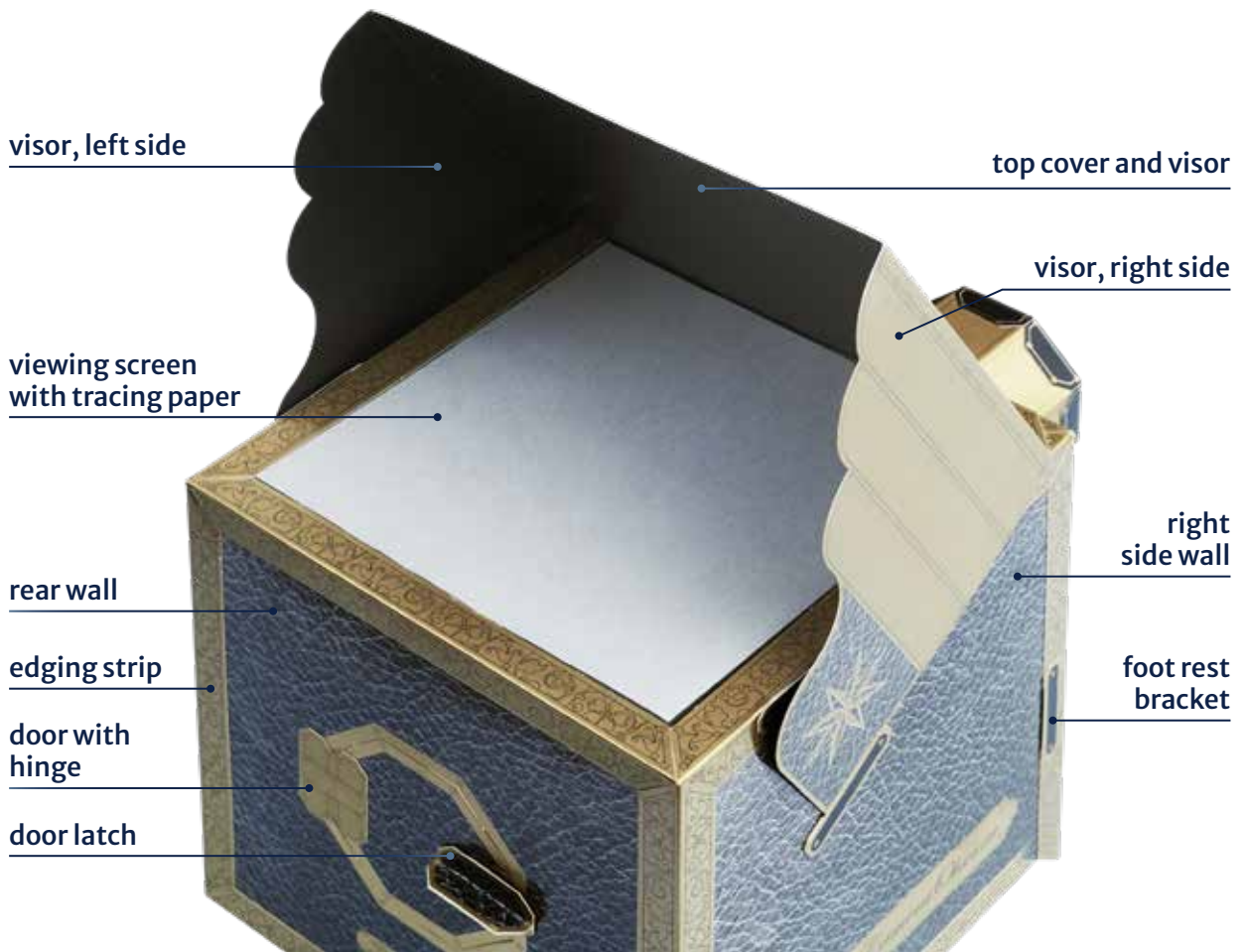


# The Camera Obscura



AstroMedia 



Contents of this kit

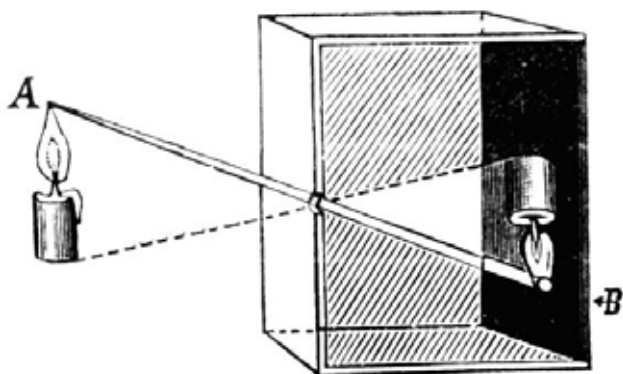
# The Camera Obscura

## The Mother of all Cameras

The principle of the camera obscura (dark room), the forerunner of all our photographic and video devices, is amazingly simple: in a darkened room, a small hole in a wall creates an upside-down image of the outside world on the opposite wall.

The picture isn't very bright because the small amount of light that comes through the hole is spread over the entire wall, but once your eyes adjust to the darkness, the picture magically becomes visible. The camera obscura can be a whole room or just a box where the projection screen is replaced by a transparent screen so that the image can be viewed from the outside (see sketch).

One might assume that even prehistoric people observed that a small hole in the curtain in front of the cave opening projects the landscape into the interior. The camera obscura would therefore be the oldest optical device known to mankind.



Aristotle (384–332 BC) was the first to study it scientifically and Leonardo da Vinci discovered that it copies the optical principle of our eyes (and the ones of most vertebrates). In fact, the image on the retina of the eye is upside down! That we see it the right way up is due to corrective action in our brain. The pinhole camera, as the camera obscura is also called when it does not use a lens, is subject to two laws:

1. The further away the projection screen is from the pinhole, the larger and dimmer the image will be.
2. The larger the pinhole, the brighter the image will be, but also the more blurred it gets.

This severely restricted the possible uses of the camera obscura, e.g. to the observation of very bright objects such as the Sun during solar eclipses. The problem was not solved until the 16th century, when for the first time ground glass lenses replaced the simple pinhole. They admitted more light and made it possible to sharpen (focus) the image.

But a focusing camera obscura has a different disadvantage: the lens cannot focus on objects at different distances at the same time. It has to be pulled out to focus on close objects and pushed in for objects that are further away. A pinhole camera, on the other hand, focuses on all points of the image equally.

In 1686, Johann Zahn constructed the first camera obscura which, with the help of a mirror, allowed the observed picture to be traced with a pen on a screen. As a result, it became popular with painters, who could use it to easily determine the perspective for their paintings.

The almost photorealistic views of Dresden by the Venetian painter Canaletto from around 1750 are well known. He used a focusing camera obscura to create them. This AstroMedia kit works exactly like the camera he used. In 1826 photography was born when the Frenchman Nicéphore Niépce shortened the imaging process by capturing the picture directly on a light-sensitive plate.

The camera obscura lives on today in the millions of photo and video cameras and, of course, in the miniature cameras of mobile phones.

However, there are still real camera obscuras in operation at some tourist attractions (e.g. on the Royal Mile in Edinburgh): a large, darkened room in which the outside world is projected onto a table via a mirror in the roof and so can be viewed by entire groups at the same time.

### This kit contains:

- 4 die-cut sheets of cardboard, 0.65 mm thick
- 4 die-cut sheets of cardboard, 0.4 mm thick
- 1 acrylic glass lens Ø 62 mm, focal length +275 mm
- 1 acrylic glass mirror, 188.5 x 188.5 x 2 mm
- 1 clear viewing screen made of transparent hard plastic, 190 x 190 mm
- 1 optional diaphragm to cut out
- 3 pieces of tracing paper, 160 x 160 mm
- 1 title page and these building instructions

A detailed photographic instruction by Michael Monscheuer can be found here:

[astromedia.de/pdf/COB-E\\_Camera\\_Obscura\\_BB.pdf](http://astromedia.de/pdf/COB-E_Camera_Obscura_BB.pdf)





### What you need for assembly:

- Normal all-purpose glue containing solvents, e.g. UHU, Evo-Stick Impact, B&Q all-purpose glue. **Do not use water-based all-purpose glue or white glue**, they soften the cardboard, warp it and do not adhere well to plastic parts and the varnished cardboard surfaces. Solvent-based all-purpose glue also dries much faster.
- Double sided sticky tape for the plane mirror. Some solvent based glues can damage its reflective coating.
- A small piece of sandpaper (medium to fine) to roughen the edges of the screen to help the glue stick to the plastic surface. The craft files from AstroMedia (order No 400.SBF) are also very practical for this.
- A sharp craft knife, e.g. the AstroMedia craft knife (order No 401.MES), or a narrow-tipped scalpel to cut the thin holding tabs of the pre-punched parts.
- A cutting board or mat, made from hardboard, plastic, or wood. Self-healing cutting mats are ideal, as the material re-closes after each cut.

### Not absolutely necessary, but helpful:

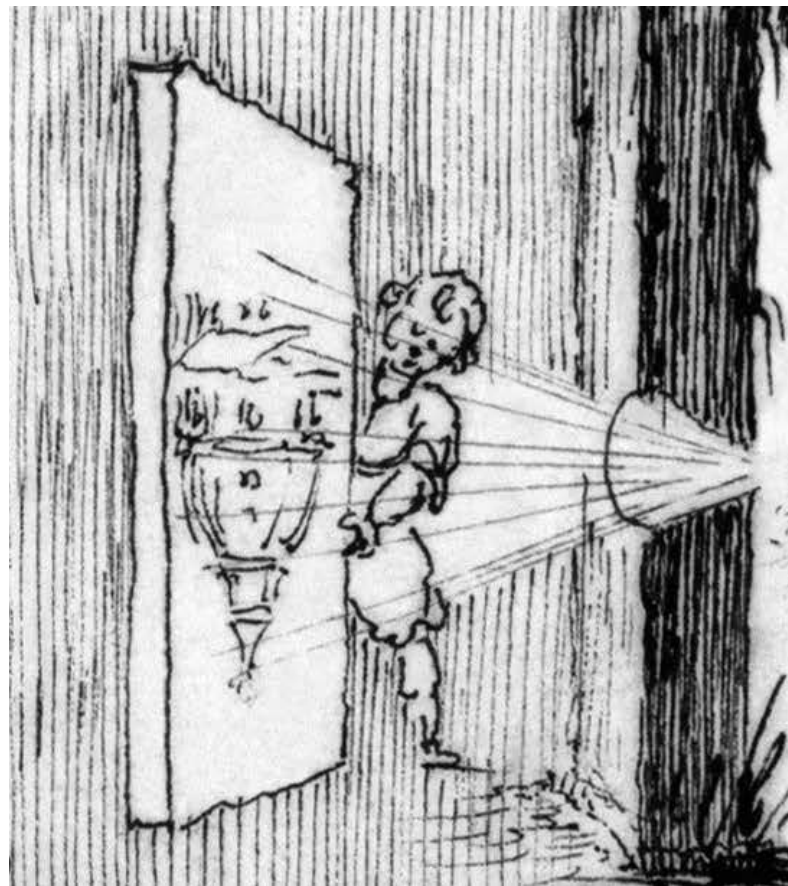
- For perfectionists: a black and a golden pen to colour the white edges of the cardboard.

## Please Read Before Commencing:

### Tips for successful assembly

**1** The building instructions are divided into 32 small steps with detailed descriptions. At first glance, this looks like a lot of text and a lot of steps, but it makes assembly easier and faster because each step is small and easier to understand. Please read each step from the beginning to the end before commencing and allow yourself about 3 hours for the construction (depending on experience). The more care you take, the better your camera obscura will work and look.

**2** Each part has its own name and part number, consisting of a letter and a number, printed in a convenient place on the front or back. The letters denotes the chapter the part belongs to, the numbers denote the order of construction. Only remove the parts from the cardboard as you need them.



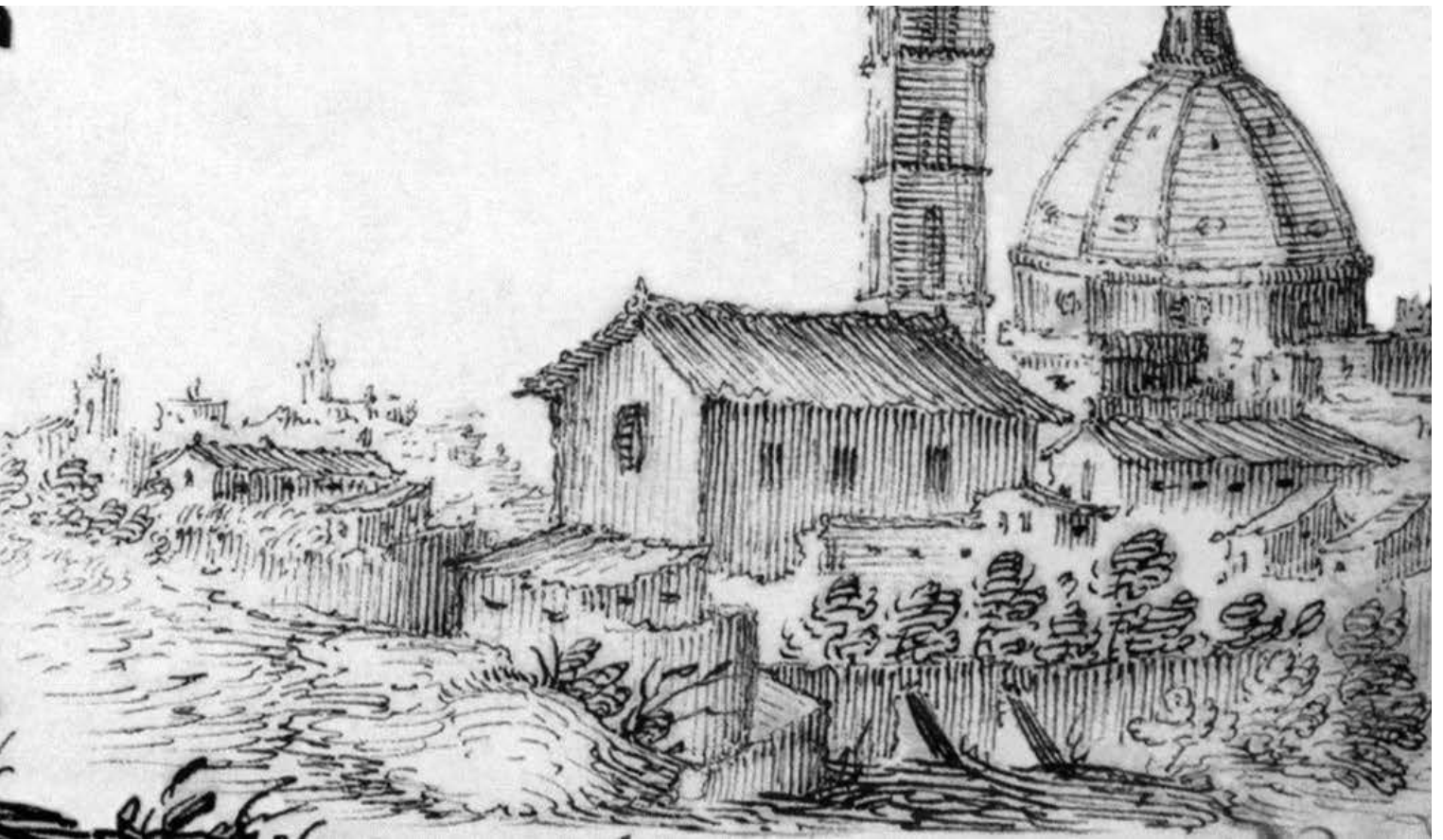
**3** The places where something is to be glued are marked by grey areas. Please note that these glueing areas are usually a bit narrower and shorter than the part that is to be stuck on. This ensures that the grey areas will be completely covered. On each glueing area is a symbol that indicates which part is to be glued there.

**4** We recommend that you do not tear the parts out of the cardboard sheet, but cut through the thin connecting tabs with a knife to make sure that the edges are completely smooth.

**5** All folding lines are prepared by groves or perforations. If they are to be bent 'forwards', you have to fold them towards you when looking at the printed side of the part. If they are to be bent 'backwards', you need to fold them away from you. You get a straighter fold if you position the folding line over a sharp edge.

### A. The Front Wall and the Side Walls

*The walls, base, and viewing window of the camera obscura form a cube-shaped housing measuring 190 x 190 x 190 mm. Walls and base are made of strong cardboard, the other parts with visible folded edges are made of more flexible cardboard.*



**Important:** “Front” is where the camera obscura has its lens, “back” is where its back wall with the small door is located. “Left” and “right” then follow automatically. The observer stands behind the camera obscura and points the lens towards the object whose image is to be captured.

**Step 1** Detach the front wall [A1, sheet 1], the left side wall [A2, sheet 3], and the right side wall [A3, sheet 4] from the cardboard sheets. Also detach the octagonal base panel [C5] from the front wall, you will need it in section C. The small disc in the base panel [C5] should not be removed because although it is punched during the production process it is not needed. Fold all glue tabs backwards along the perforations, i.e. towards the black back.

**Tip:** This is how to fold the 0.65 mm thick cardboard neatly: Place the part on a board or similar with a sharp edge so that the perforated fold line is lying on the edge and bend the glue tab downwards. Then fold it all the way over and smooth the fold with your thumbnail or a folding tool.

**Step 2** All three parts have one edge with a glue tab that is bevelled on both sides. These edges face upwards; the transparent viewing window will later be glued onto them. Place the front wall [A1] in front of you with this tab facing upwards, the black inside towards you. Set up the left side wall [A2] at right angles to it on the left so that its beveled glue tab

is also facing upwards. The black areas of the two parts then point inwards, the gold-printed areas outwards (Fig. 1). Check that the rectangular slanted glue area with the 5 arrows on the inside of the left side wall has its lower end near the front wall. Glue the front panel in this position to the side glue tab of the left side panel.

**Important:** Before drying, press the bottom and side edges onto your work surface to ensure that they are level and straight.

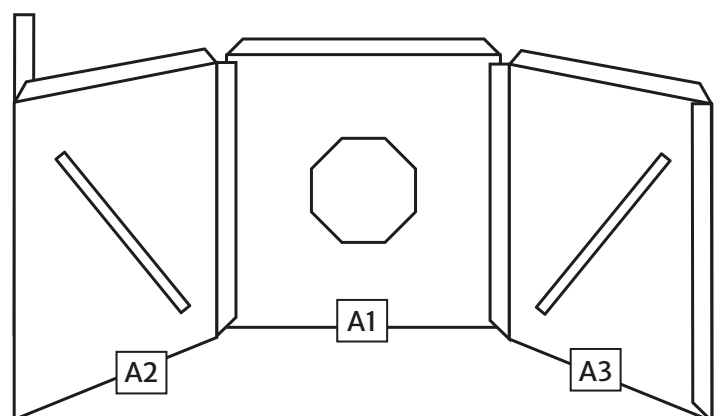


Fig. 1: Front and side walls

**Step 3** Fold the 3 glue tabs of the right side wall [A3, sheet 2] backwards as well and glue the right edge of the front wall to the glue tab in the same way. Now the three walls form part of a box with the base, back wall, and lid missing.

## B. The Outer Lens Tube

The outer lens tube serves as a guide for the inner lens tube, which will be built in Section D. The inner lens tube can be moved back and forth inside the outer lens tube so that the objective lens can be focused on objects at different distances.

**Step 4** Remove the outer lens tube [B1, sheet 5] from the cardboard and fold all 8 long groove lines backwards. When you butt the edges of the two half-segments at the ends of the piece of cardboard together, a short octagonal tube is created that is black on the inside. The small glue tabs marked in grey are the foot tabs with which the tube will be attached to the inside of the front wall. They all need to be folded forwards towards the gold printed side. In order to turn the folded piece of cardboard into a stable octagonal tube, you need the connecting piece [B2, sheet 7]. Glue it to the outside of one half segment so that it sticks out exactly half way, then glue it to the the other half. This works particularly well if you press the tube flat, so that both edges are pushed against each other without a gap. Make sure there is about a millimetre of space between the connecting piece and the foot tabs.

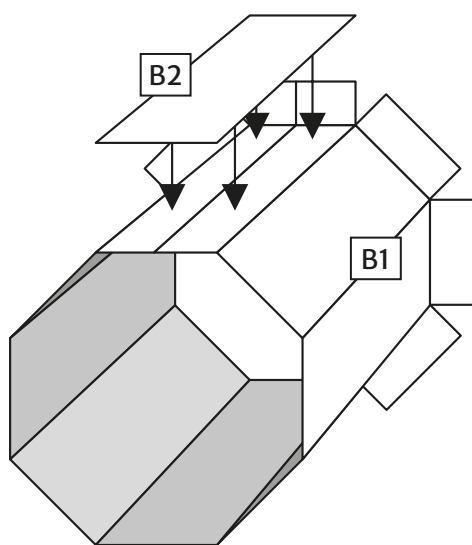


Fig. 2: Outer lens tube

**Step 5** Hold the outer lens tube horizontally and turn it so that the side with the connecting piece is facing downwards. Slide the foot tabs through the octagonal opening in the front panel from the outside and glue them to the glue marks located around the opening.

**Tip:** Press the inside of the front wall onto your work surface to push the foot tabs in place.

**Step 6** Fold the grooved lines of the edge reinforcement [B3, sheet 5] backwards and glue it onto the glue marks around the opening of the outer lens tube. The seam where the ends of the edge reinforcement meet should be at the bottom of the outer lens tube.

**Step 7** Four supports are required to stabilise the connection between the outer lens tube and the front wall. Fold the foot tabs of the 8 support parts [B4 to B11, sheets 1 to 4] forwards and glue each two of them back to back to form four angled supports with two foot tabs on one edge. As a test, first place one of the supports with its foot tabs on one of the glue marks on the outside of the front wall and push it against the outer lens tube. The edge of the support without tabs butts against the wall of the tube. Apply glue to the foot tabs and to the blunt edge and glue the support in this position. Glue the other three supports in place the same way. The lower support is glued to the connecting piece that holds the outer lens tube together.

**Step 8** Fold the two mirror mounts [A4 and A5, sheet 6] backwards at right angles. This creates two angled strips that are black on the inside and grey on the outside. Glue the mirror holders onto the two glue marks located on the inside of the left and right side walls.

**Important:** The folded edges must be exactly flush with the edge of the glue marking to which the arrows are pointing. The mirror itself will be installed in Section E-2.



### C. The Base Panel

The base panel has glue tabs on all four sides. It consists of four trapezoidal parts and the octagon detached from the front wall. These five parts are glued together on the back with eight connecting pieces (Fig. 3). On the side facing the inside of the housing, all parts are black, including the connecting pieces.

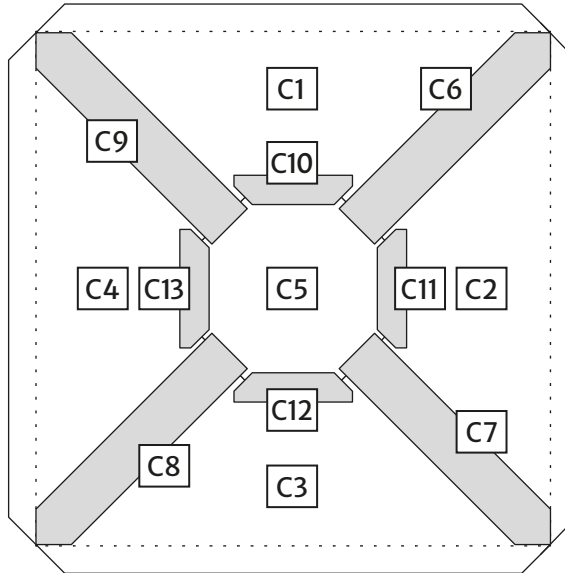


Fig. 3: Base panel

**Step 9** Remove the base panels 1 to 4 [C1 to C4, sheets 1 to 4] from the cardboard, as well as the large connecting pieces 1 to 4 [C6 to C9, sheets 1 and 2] and the small connecting pieces 5 to 8 [C10 to C13, sheets 1 to 4]. The octagonal central base panel [C5] was left over from Step 1. Fold the long glue tab on floor panels 1 to 4 backwards.

**Step 10** First place two of the trapezoidal base plates with the black side facing upwards on your work surface so that the sloping edges meet and half an octagon is formed in what is going to be the centre. Glue one of the larger connecting pieces over the joint. The pointed end of the connecting piece points to the corner and the blunt end protrudes a little into the area of the octagon. Make sure that the edges of the base plates meet without a gap and that the black side of the connecting piece is facing upwards.

**Step 11** Place the octagonal base plate [C5] with the black side facing up in the gap provided so that one of the narrower glue marks is under the protruding end of the connecting piece and all edges butt together without gap. Glue the part to the connecting piece. Now attach the other base panels in the same

way using the large connecting pieces and finally glue the small connecting pieces to the remaining free edges of the octagon (see Fig. 3).

**Step 12** Check that the space where you can write your name and the year of manufacture faces the direction you want (towards the front or back of the camera obscura). Fold the glue tabs of the base plate backwards again and push them between the two side walls of the housing until they touch the front wall. Then glue the bottom panel to the front wall. Push the front wall onto the work surface so that the base is flush with its bottom edge. As a test, push the two side walls against the base and check that the base sits exactly in the middle. Then glue the side walls to the glue tabs on the base panel.

**Step 13** Detach the round centre cover [C14, sheet 7] from the cardboard. The ring between parts D3 and C14 is not needed and can be discarded. Glue the cover onto the outside of the octagonal centre section of the base panel. This covers the small round disc that was not removed.

### D. The Inner Lens Tube

The inner lens tube has a slightly smaller diameter than the outer one and houses the objective lens.

**Step 14** Fold all groove lines of the inner lens tube [D1, sheet 5] backwards. Again, an octagonal tube, black on the inside, is formed with the two half segments touching. Connect the two half segments on their inside with the connecting piece [D2, sheet 5]. Make sure that the edges of the half segments butt against each other without a gap and that the black surface of the connecting piece faces towards the inside of the tube.

**Step 15** Remove the lens holder [D3, sheet 7] from the cardboard and fold all 8 glue tabs backwards. The enclosed acrylic glass lens is used as the objective lens. It has one curved side that points towards the object, the other side is flat and faces towards the inside of the camera obscura. Handle the lens by the edges only and, if necessary, wipe fingerprints off with a soft cloth (don't use tissue paper, as it scratches the surface). Place the lens holder with the black inside facing up on your work surface or, even better, on top of a small cup and try the lens on it with the curved side facing down. Remove the lens again and coat the lens holder with glue around the hole to a width of about 3mm. Check that no threads of glue have formed across the opening, then carefully place the lens on top and centre it. Leave to dry completely.

**Step 16** Place the lens holder on the end of the inner lens tube with the glue marks and glue its tabs to the tube. After drying, check that the inner tube can be pushed back and forth inside the outer tube. Then put it aside so that the lens is not damaged during the rest of the assembly. **Tip:** *If, despite all caution, you have a mishap with the lens, you can order a new one from AstroMediaShop.co.uk (OptiMedia lens no. 10, article No. 314.OM10).*

## E1. The Door and the Rear Wall

*In the rear wall is a small door that can be locked with a rotating bar so that pencils and rolled-up sheets of transparent paper can be stored in the space below the mirror. First the door is assembled, then the door is mounted in the rear wall and the rear wall is fitted to the housing.*

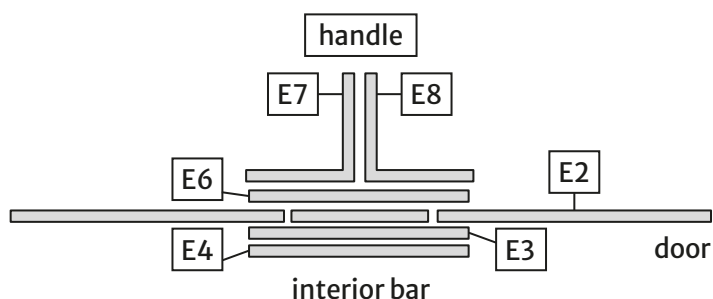


Fig. 4: Cross-section rotating bar

**Step 17** Glue the two parts of the interior bar [E3 and E4, sheet 7] with their grey sides back to back, accurately aligned at the edges (Fig. 4 shows a cross-section of the bar and door).

**Step 18** Remove the small disc-shaped bar shaft [E5] from the door [E2, sheet 2]. Glue the shaft onto the grey glue marking of the interior bar so that it sits in the centre of the semi-circle forming the end of the inner bar. Leave to dry well.

**Step 19** Fold the two door handle parts [E7 and E8, sheet 7] forwards and glue one half of each back to back. Then glue the resulting handle with the other two halves onto the grey back of the bar [E6, sheet 7].

**Step 20** Detach the door [E2, sheet 2] from the rear wall and lay it black side down onto your work surface. Place the inner bar under the door so that the disc-shaped bar shaft snaps into its hole in the door from below. Rotate it a bit so that the axle can grind into its bearing a little, then turn it so that the visible part protrudes at right angles from the door. Put a small amount of glue on the shaft and stick the door bar with its glue mark onto it. It points in exactly the same direction as the inner bar, but is slightly shorter than this. This is intentional to make it easier to close. Allow the glue to dry thoroughly and then carefully move the latch back and forth until it can be rotated around fully.

**Step 21** Lay the rear wall [E1, sheet 2] black side down onto your work surface and put the door in the doorway. The bar is turned all the way to the left so that it does not protrude over the door. Fold the door hinge [E9, sheet 7] forward once and then flat again and glue it onto the glue marks located on the door and door frame. The fold should lie exactly on the die-cut line. After drying, check the door functions (opening, locking).

**Step 22** Fold the glue tab of the rear wall backwards and again fold the three glue tabs of the side walls and floor, to which the rear wall is glued. Open the door latch and push the door partly through the door opening. This way the door handle does not get in the way when the rear wall is placed on the work surface to be pressed. Glue the rear wall to the glue tabs on the base panel and side walls. Its own glue tab is pointing upwards, just like those on the other housing walls. Again, make sure that all edges are flush with the other walls. To dry, lay the case on its back and put a light weigh on it, e.g. a book.

*The housing is now complete, except for the top cover. It will gain its stability in the next step, when the mirror is fitted inside and the viewing window is fitted to the top.*



## E2. The Mirror and the Viewing Screen

*Without a mirror, the image would fall onto the back wall of the housing and would be upside-down. Reflecting the image upwards at right angles with a mirror results in an upright mirror image. The viewing window alone does not display the image because the light goes straight through it. But when a piece of semi-transparent paper (tracing paper) is placed on top, the image appears.*

**Step 23** As a test, place the mirror with the protective foil facing upwards into the housing from above so that its side edges are flush with the two mirror supports. Its upper edge is pretty close to the future cover, the distance between the lower edge and the base panel is significantly larger. Refold the mirror supports so that they are perpendicular to the side walls and glue the mirror in place. Push the side walls together lightly and make sure the top opening of the case is square before the glue sets. This can be checked easily with the help of the transparent viewing screen, by placing it temporarily in its future position on top of the glue tabs. Allow to dry thoroughly and then remove the protective film from the mirror.

**Step 24** Using a craft file or sandpaper, roughen all four edges of the viewing screen to a width of about 1 cm on both sides, so that the glue adheres better to the plastic. If you don't have sandpaper, you can scratch the edges with a sharp object, but be careful not to scuff or scratch the viewing area. Then fold the glue tabs of the housing again so that they are horizontal. Glue the viewing screen onto the housing and check that it does not protrude on any side. Weigh the screen down while the glue sets, e.g. with a book.

## F. The Edging Strips

*The 12 edging strips cover the glued edges of the housing and increase its stability. Four of them [F7, F8, F10 and F11] have punched cut-outs that will later accommodate the footrests of the visor. The places to which they are to be glued are indicated by the accordingly shaped glue markings. The edging strip [F9] has a glue mark on its outside. It is used to attach the top cover, which also serves as part of the visor.*

**Step 25** Fold all edging strips 1 to 12 [F1 to 12, sheets 5, 6 and 8] sharply backwards. Make sure the fold goes precisely through the pointed ends. Glue the edging strips [F1 to F4] to the four edges of the base panel, then the edging strips [F5 and F6] to the two vertical edges on the right and left of the rear wall. Their pointed ends should touch without gaps and their tips meet at the corners of the housing.

**Step 26** Glue the edging strip [F7] to the edge formed by the front wall and the left side wall in such a way that the half-oval cut-out is positioned at the bottom of the left side wall, as indicated by the glue marking. Then glue the edging strip [F8] to the front right edge of the housing accordingly.

**Step 27** Next, glue the edging strip that has the grey glue marking [F9] onto the upper front edge of the housing above the lens. The half with the glue marking is glued onto the viewing screen. Then glue the edging strip [F10] to the upper left edge of the housing. The punched cut-out should be on the back of the left side wall, towards the back wall, as the glue marking indicates. Correspondingly, the edging strip [F11] is glued onto the edge of the housing at the top right. The last strip [F12] then fills the last free space at the top back.

## G. The Top Cover and Visor

To make the image on the tracing paper easier to see, the top of the Camera Obscura can be shaded by a visor. The top cover acts as the front of the visor. The side visor parts have foot rests that can be slid into brackets at different heights.

**Step 28** Fold the glue tab on the top cover [G1, sheet 6] forwards and then glue this tab to the marked spot located at the top of the front edge strip. Make sure that the cover sits in the middle of the housing and is flush with the edges of the housing when it is closed.

**Step 29** Fold the glue tab on the right side of the visor [G2, sheet 7] backwards and glue the grey surface of the foot rest 1 [G3, sheet 7] to the marked spot on the black back of the side part of the visor (Fig. 5). The foot rest should be flush with one edge of the visor side part and on the other side the gold printed semicircular end protrudes beyond the edge. Then glue the right visor part with its tab onto the right hand edge of the top cover. At the rear it should be flush with the end of the top cover. At the front it just reaches the bend of the cover's hinge.

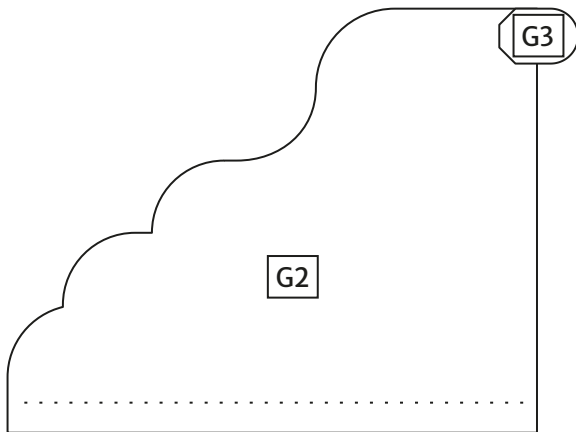


Fig. 5: Visor side part with foot rest

**Step 30** Glue foot rest 2 [G5, sheet 7] to the left side of the visor [G4, sheet 7] in the same way and then glue it to the left edge of the top cover.

**Step 31** If you now open and close the lid, you will see that the foot rests on the sides of the visor fit into the cut-outs in the edging strips. To enable them to latch in those positions, brackets are glued over the cutouts. Glue the 4 foot rest brackets 1 to 4 [G6 to G9, sheet 5] over the cut-outs in the front and the top edging strips so that they are flush with the edges of the edging strips. This creates pockets in which the foot rests can be inserted and the lid can be secured either closed or open at right angles.

**Step 32** To enable the top cover to be secured in a 60° position, two further brackets are provided for the foot rests. They are glued at an angle onto the side walls. Glue the four bracket feet [G10+11 and G13+14, sheet 3 and 4] under the ends of the foot rest brackets [G12 and G15, sheet 7] and then glue these onto the angled glue markings on the right and left side wall. Before the glue sets, check that the foot rests of the visor fit neatly into place.

### Congratulations!

Your camera obscura is now complete. Place a sheet of tracing paper on the viewing screen and it's ready to use.

## Tips for using the camera obscura:

**Tip 1** Make sure that the subject is well lit and that the camera obscura itself, especially the tracing paper screen, is in the shade or in the dark.

**Tip 2** You can see the picture more clearly by covering yourself and the screen with a dark cloth or a piece of clothing.

**Tip 3** If the inner lens tube moves too easily, you can glue some strips of (black) paper into the outer tube to make the fit tighter.

**Tip 4** Unwanted reflections, which cannot be avoided despite the black inner walls, can be greatly reduced with the additional diaphragm provided. Cut it out of the cardboard and fold the eight tabs backwards. Push the diaphragm, octagon first, into the open end of the inner lens tube, opposite the lens, until the tabs are flush with the edge of the tube. You can secure it in this position with a few drops of glue or, if you want to experiment with other diaphragm sizes, just leave it loose.

**Tip 5** The lens has a large aperture and with a focal ratio of 4.8 a high light intensity. The focal ratio or f-number is calculated by dividing the focal length of 275mm by the 57mm lens diameter. A trade-off for the bright picture is the low depth of field, i.e. only objects that are at a similar distance are imaged sharply. By moving the lens in or out you can adjust the camera to different distances. You can increase the depth of field by reducing the lens aperture with a diaphragm made from dark cardboard. The smaller the diaphragm, the larger the depth of field and the dimmer the image will be.

**Tip 6** The lens cannot be pulled out far enough for very close objects. However, you can get around this with a makeshift extension made of black paper, which you fold into a suitable octagonal tube and insert between the inner and outer lens tubes.

## Photo prints of your drawings

The camera obscura is not suitable for direct exposure of photographic paper, but you can make very impressive photographic prints from pencil drawings you made on the tracing paper. There is a simple method without having to use a darkroom or chemical developers. Take a sheet of AstroMedia's Solar Photo Paper (article No. 411.FSP) and place the front side of the sketch, which is mirror-inverted, on the photo paper when exposing. When developing (with normal tap water!), a white negative appears on a dark blue background, now showing a right-sided image.

## The Camera Obscura as a pinhole camera

Your Camera Obscura can also be turned into a pinhole camera. To do this, remove the inner tube with the lens and cover the outer tube with dark paper, in which you have pierced a hole.

Start with a small hole (approx. 1 to 2 mm), which you can then gradually enlarge. Cover yourself and the screen as lightproof as possible with a dark cloth and allow your eyes to adjust to the darkness. Unlike those obtained with the lens, the images you see have a continuous depth of field – which is the great advantage of pinhole cameras. However, the picture is also much darker. The bigger the hole, the brighter, but also the blurrier the image becomes.



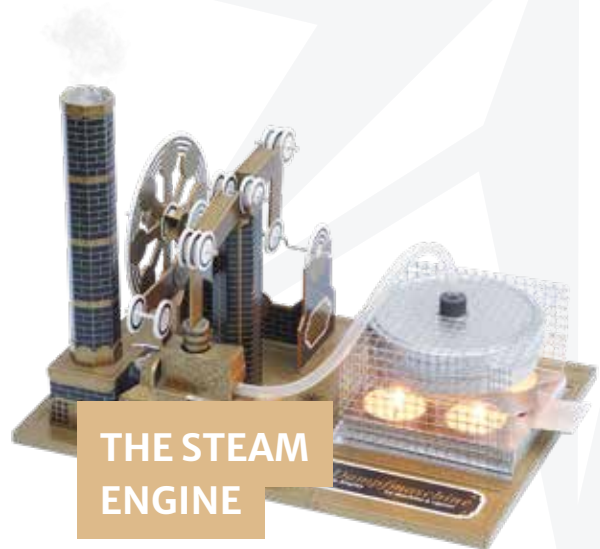
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