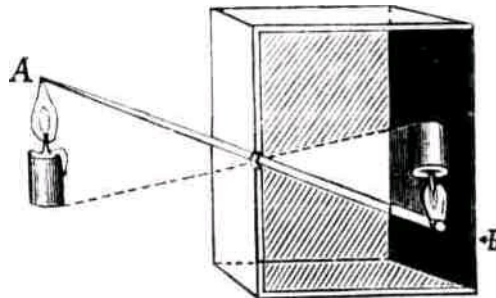




The Camera Obscura

The principle of the camera obscura (dark room), the forerunner of all our photographic and video equipment, is surprisingly simple. In a darkened room, a small hole in one wall produces an inverted image of the scene outside, on the opposite wall. The image is not very bright since the small amount of light that comes through the hole is spread over the whole wall, but when the eye has adapted to the dark, the image appears as if by magic. The room could be a whole room in a building or simply a box in which the projection wall is replaced by a matt plate so that the image can be seen from outside the box (see the sketch). We must suppose that humans in pre-history times noticed that a small hole in the curtain in front of the cave entrance would project the landscape into the cave interior. This would make the camera obscura man's oldest optical device. Aristotle (384-332 BC) was the first person to investigate this scientifically, and Leonardo da Vinci discovered that it also occurs as the optical principle in our eyes (and those of most vertebrate animals). The images on the retina of the eye are in fact upside down. We see them the right way up because of corrective action by the brain. The pinhole camera, as the camera obscura is also called when it is not using a lens, is

governed by two laws. 1. The further the projection screen is from the opening where the light enters, the larger is the image, but it is also dimmer. 2. The larger the light-entry opening, the brighter is the image, but also the less sharp.



This has greatly limited the possibilities for using it, e.g. to observing very bright objects such as the sun during eclipses. The problem was not solved until the 16th century, when for the first time ground lenses were used in place of the hole, making the image sharp ("focusing"). However, even such a focusing camera obscura has a disadvantage: The lens cannot show all objects at different distances equally sharply; it needs to be focused by pulling it out for near objects and pushing in

for distant ones. In contrast, a pinhole camera shows all points of the image equally sharp.

In 1686, Johann Zahn made the first camera obscura that, with the aid of a mirror, made it simple to draw pictures of the subjects. It subsequently became popular with painters, who could use it as an easy way to determine the correct perspective for their pictures. There are well known almost photographic paintings by the Venetian Canaletto from around 1750 (in, for example, the National Gallery in London and the Old Masters gallery in Dresden), who used a focusing camera obscura for this work. This Astro-Media kit works on exactly the same principle. Photography was born when the Frenchman Nicéphore Niépce shortened this path by capturing the image directly on a light-sensitive plate. The camera obscura lives on in the millions of still and video cameras that we have today. However, there are today still some genuine examples of the camera obscura at tourist attractions. A large darkened room in which a mirror in the roof casts the image onto a projection table where whole groups can view it.

This kit contains:

- 4 punched card sheets, 0.65 mm thick
- 4 punched card sheets, 0.35 mm thick
- 1 lens of acrylic glass \varnothing 62 mm, focal length +275 mm
- 1 mirror of acrylic glass 188.5 x 188.5 x 2 mm
- 1 viewing window of transparent hard plastic 190 x 190 mm
- 1 optional shade to cut out
- 3 blanks of tracing paper 160 x 160 mm
- 1 title sheet and these instructions

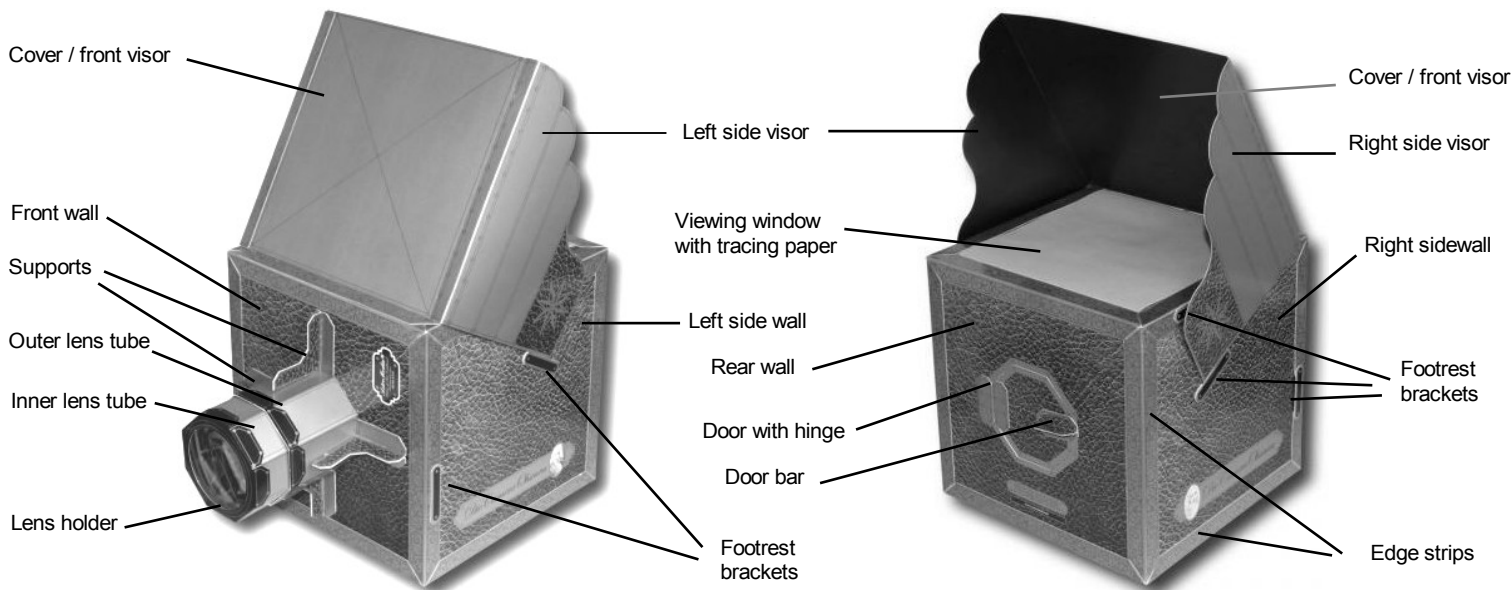
For assembling the kit you need:

- Ordinary solvent-based general-purpose adhesive, e.g. Tesa or UHU all-purpose adhesive. Do not use a solvent-free water-based or PVA adhesive; it will soften the cardboard, make it curl and adheres poorly to plastic parts and to the card surfaces protected with print varnish. Solvent-based all-purpose adhesive also sets much quicker.
- A small piece of sandpaper (medium to fine) for roughening the edges of the viewing window, to help the adhesive stick better to the plastic surface. The craft files from AstroMedia are also very useful for this (item no. 400 SBF)
- A sharp craft knife ("cutter knife", e.g. AstroMedia craft knife) or a scalpel with a fine point, for cutting the holding webs of the punched parts.
- A cutting board or mat, such as solid board (not corrugated) or plastic or wood. Self-healing cutting mats are useful, as the material re-closes after each cut.
- Not essential, but helpful for perfectionists: Gold and black felt markers for colouring the cut edges of the cardboard where necessary.

Tips for a successful construction

Please read this before you start

1. The assembly instructions have been divided into 32 small steps with comprehensive descriptions. At first sight this seems to be a lot of text and many steps, but by making everything clear, it simplifies and speeds up the process of construction. Please begin each step by reading it thoroughly and allow about 3 hours in total. The more care you take in constructing your Camera Obscura, the better it will work and the more impressive will it look.
2. The places where something will be glued are usually indicated by grey areas. Please note that these glue markings are in nearly all cases a few millimetres narrower and shorter than the part that will be glued onto them. This ensures that the marking is always covered.
3. Every item has, in a suitable place on the front or rear, its name and its part number which consists of a letter and a number. The letters in the part numbers are the same within one sub-assembly. It is best to release only those items that you need at that time.
4. It is recommended not to tear the parts out of the card sheets but to cut the holding webs cleanly with a knife, so that the edges are smooth.
5. The fold lines are prepared by pressing groove lines into the thinner card, and with perforations in the thicker card. "Fold forwards" always means towards yourself when you are looking at the gold and black printed front face of the card, and "to the rear" is away from you.



Section A

The front wall and the sides

The walls, base and viewing window of the Camera Obscura form an exactly cube-shaped housing with dimensions 190 x 190 x 190 mm. Walls and base are made of strong card, the other parts with visible fold edges are of more flexible card.

Important: "Front" is where the lens of the Camera Obscura is located, "rear" is where the rear wall with the little door is located. "left" and "right" then follow from this. The observer therefore stands behind the Camera Obscura and, together with it, looks towards the object to be captured by the lens.

Step 1: Release the front wall [A1, sheet 1], the left side wall [A2, sheet 3] and the right side wall [A3, sheet 4] from the cardboard sheet. Also release the eight-sided base panel [C5] from the front wall, but it will only be needed in the next but one section. The small disk in the base panel [C5] is not released because, for manufacturing reasons, it is only punched but not required. Bend all the glue tabs to the rear at their perforations, i.e. towards the black rear side.

Tip: The 0.65 mm thick card can be cleanly folded this way: Lay the part on a board or similar article with a sharp edge and position it so that the perforated line is on the edge, and bend the glue tab downwards. Then fold it fully and smooth it with a thumbnail or a folding stick.

Step 2: All three parts have on one edge a glue tab slanted on both sides. This edge is at the top, and the viewing window will later be glued to it. Stand the front wall [A1] with this tab at the top in front of you, the black inner face towards you, and on the left at a right-angle to it stand the left side wall [A2] so that the glue tabs bevelled on both sides are at the top. The black faces of both parts are then facing inwards, and the gold printed faces outwards (Fig. 1). Ensure that the rectangular sloping glue mark with the 5 arrows is on the inside of the left side wall with its lower end near the front wall. Stick the front wall in this position onto the side glue tab of the left side wall.

Important: Before the glue is dry, press the bottom and side edges onto your work surface to ensure that no edge protrudes or is positioned short..

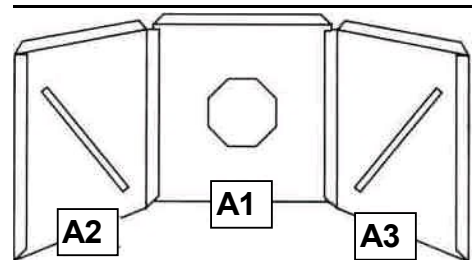


Fig. 1: Front wall and side walls

Step 3: Similarly bend the 3 glue tabs of the right side wall [A3, sheet 2] to the rear and stick the right edge of the front wall in the same way to the glue tab provided for it. Now these three walls form a kind of box with only the base, rear wall and top side missing.

Section B

The outer lens tube

The outer lens tube serves as a guide for the inner lens tube, that will not be built until Section D. The inner tube can be moved forwards and backwards inside the outer tube, in order to adjust the position of the lens for focusing objects at different distances.

Step 4: Detach the outer lens tube [B1, sheet 5] from the cardboard and bend back all eight of the scored lines. When the edges of the two half segments at the ends of the card piece press against each other, this gives a short eight-sided tube with a black interior. The small glue tabs with grey markings are the foot brackets which will be used to attach the tube inside the front wall. They are all bent forwards, outwards from the interior of the tube. To make the folded piece of card into a strong eight-sided tube, you need the connecting piece [B2, sheet 7]. Stick it on the outside on one half-segment so that exactly half of it protrudes, and then onto the other. This works particularly well if you press the tube flat with the two edges touching each other without a gap. Ensure there is about one millimetre clearance between the connecting piece and the foot brackets.

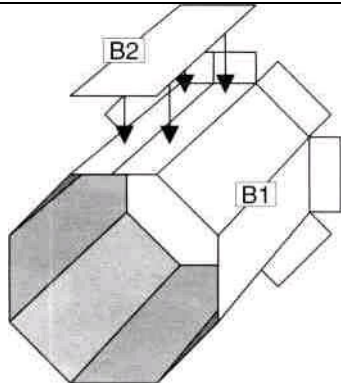


Fig. 2: Outer lens tube

Step 5: Hold the outer lens tube horizontal and turn it so that the side with the connecting piece is underneath. From the outside, push the foot brackets through the eight-sided opening in the front wall and stick them firmly onto the markings for the adhesive that are located round this opening.

Tip: Press the interior side of the front wall onto your work surface so that the foot brackets make good contact.

Step 6: Bend the edge reinforcement [B3, sheet 5] to the rear at the scored places and stick it onto the glue marking round the opening of the outer lens tube. The interface, where the ends of the edge reinforcement meet, should be at the bottom.

Step 7: To make the connection between the outer lens tube and the front wall torsionally stiff, 4 supports are required. To

do this, fold forwards the foot brackets on the 8 support pieces [B4 to B11] and stick them together in pairs to form an angled support that has two foot brackets on one of the outside edges. Initially, test by placing one of the supports with its foot brackets on one of the glue markings on the outside of the front wall, and push it into the angle between the front wall and the outer lens tube. The outer edge of the support without the tab will then abut the wall of the tube. Then apply adhesive to the foot brackets and the abutting outer edge and stick the support firmly in the position you have just tested. Then stick the other three supports at the locations provided. The lower support will then be stuck to the connecting piece that holds the lens tube together.

Step 8: Fold the two mirror supports [A4] and [A5] to the rear at a right-angle. The result will be two angled strips that are black inside and grey outside. Stick the mirror holders onto the glue markings on the inside of the left and right side walls. Important: The fold edges must be exactly on the edge of the glue marking to which the arrows point. The mirror itself is installed later, in Section E-2.

Section C

The base panel

The base panel has a glue tab on all 4 sides. It is formed from 4 trapezoidal parts and the octagon detached from the front wall. These 5 parts are glued together on their rear side by the use of 8 connecting pieces (Fig. 3). All parts, including the connecting pieces, are black on the side facing the interior of the housing.

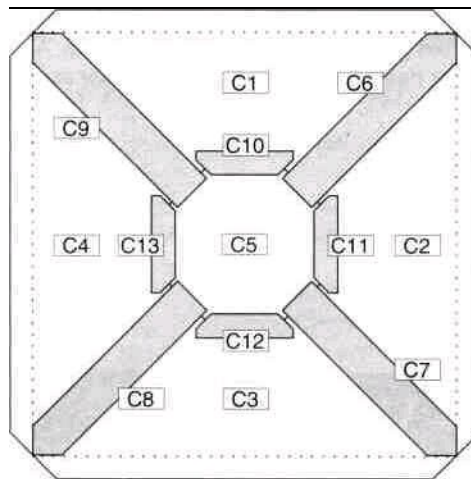


Fig. 3: Base panel

Step 9: Detach the base panels 1 to 4 [C1 to C4, sheets 1 to 4] from the card, also the larger connecting pieces 1 to 4 [C6 to C9, sheets 1 + 2] and the smaller connecting pieces 5 to 8 [C10 to C13, sheets 1 to 4]. The eight-sided central base panel 5 [C5] is already there. Bend the long glue tab on the base panels 1 to 4 to the rear.

Step 10: First place two of the trapezoidal

base panels with the black face up on the work surface so that the inclined edges touch each other and half an octagon is formed in what is going to be the centre. Stick one of the larger connecting pieces onto the join. The pointed end of the connecting piece will point to the corner and the plain end protrudes a little into the area of the octagon. Make sure that the edges of the base panels touch each other without a gap and the black face of the connecting piece is upwards.

Step 11: Place the eight-sided base panel [C5] with its black face upwards in the space provided for it, in such a way that one of the narrower glue markings is under the protruding end of the connecting piece and all edges abut each other without gaps. Glue it to fix it under the connecting piece. Then insert the other base panels in the same way with the aid of the large connecting pieces, and finally stick the small connecting pieces onto the remaining free edges of the octagon (see Fig. 3).

Step 12: Bend the glue tabs of the base panel again and push them between the two side walls of the housing until it meets the front wall. Check whether you would like to rotate it by 90° or 180° so that the area where you can write your name and the year of construction has the orientation you want, and stick the base panel with its glue tab in this position, but initially only onto the front wall. Push the front wall onto the work surface again, with the base plate not protruding at the bottom and, as a test, press the side walls so that the base is accurately centred. Then stick the side walls like this to the glue tabs of the base.

Step 13: Detach the round cover [C14, sheet 7] from the cardboard. The ring between parts D3 and C14 is waste and will not be needed. Stick the cover from the outside onto the octagonal central piece of the base panel. The small round disk, that will not be detached, is stuck with it.

Section D

The inner lens tube

The inner lens tube has a diameter a little smaller than the outer one and holds the lens at its front end.

Step 14: Bend all scored lines of the lens tube [D1, sheet 5] to the rear. This gives another eight-sided tube, black on the inside, when the two half segments meet at the ends. Join the two half segments on their interiors with the connecting piece [D2, sheet 5]. When you do this, take care that the edges of the half segments touch each other without gaps and the black surface of the connecting piece faces the interior of the tube.

Step 15: Detach the lens holder [D3, sheet 7] from the cardboard and bend back all eight of the glue tabs. The lens for this kit is

the acrylic glass lens supplied with it. It has one convex side (curved outwards), that will point to the viewed scene, and the other side is flat and faces the inside of the Camera Obscura. Take care to touch the lens only at the edge, and clean fingermarks from it if necessary with a soft cloth. Place the lens holder with the black interior upwards on your work surface or, even better, on the mouth of a small cup and, as a test, lay the lens on it with the convex side pointing down. Lift the lens off again and apply adhesive to a width of about 3 mm around the lens opening of the lens holder. Make sure there are no threads of glue across the opening. Then carefully lay the lens on it and centre it. Allow it time to dry fully.

Step 16: Place the lens holder on the end of the inner lens tube that has the glue markings, and stick its tabs onto the tube. After the adhesive has dried check that the inner tube can be easily pushed in both directions in the outer tube. Then put it aside to avoid damaging the lens during the further assembly work.

Tip: If, despite all your care, the lens suffers some damage, you can easily order another one at www.astromeridia.ch, in the OPTI Media section (part number 314.OM.10).

Section E-1

The door and the rear wall

In the rear wall there is a small door that can be secured with a rotating bar. This makes it possible to put pencils or rolled up sheets of tracing paper in the housing. First, the door will be assembled, then the door into the rear wall, and the rear wall assembled onto the housing.

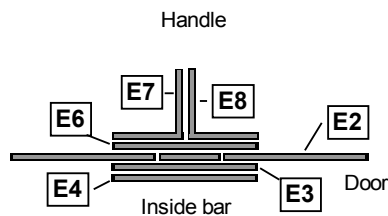


Fig. 4: Cross-section of door bar

Step 17: Stick parts 1 and 2 of the interior bar [E3 and E4, sheet 7] with their grey sides on each other accurately aligned at the edges (Fig. 4 shows a cross-section of the structure of the bar and the door).

Step 18: Detach the small disk-shaped bar shaft [E5] from the door [E2, sheet 2]. Stick the bar shaft onto the grey glue marking of the interior bar, taking care that it is in the centre of the semi-circle at the end of the inner bar. Allow it time to dry.

Step 19: Bend the handle parts 1 and 2 [E7 and E8, sheet 7] forwards and stick one half

of each of the bent parts together. Then stick the other two halves, that are bent away from each other, onto the grey rear side of the main part of the bar [E6, sheet 7].

Step 20: Detach the door [E2, sheet 2] from the card, and lay it with the black side down on your work surface. Place the interior bar under the door so that the disk-shaped bar shaft latches into its hole in the door from below. Carefully rotate it so that the shaft becomes seated into its bearing, and then rotate it so that a visible part protrudes at right angles from the door. Apply a small amount (not too much) of adhesive to the shaft and stick the bar handle with its glue marking onto it. It will then point in exactly the same direction as the interior bar but is a little shorter. This is intentional, to make the bar easier to close. Allow the adhesive time to dry and then carefully move the bar until it can be fully rotated about its axis.

Step 21: Lay the rear wall [E1, sheet 2] with the black side down on your work surface and place the door into the door opening. For this, the bar is turned fully to the left so that it does not protrude beyond the door. Bend the door hinge [E9, sheet 7] forwards once and then flat again, and stick it onto the overlapping glue marking located on the door and the door frame. The fold must be accurately on the cut line. After the adhesive has dried check the door actions (opening, locking).

Step 22: Bend the glue tab of the rear wall to the rear and once again bend the three glue tabs of the side walls and base to which the rear wall will be stuck. Open the door bar and push the door part-way through the door opening. This way, the door handle will not interfere when the rear wall is placed on the work surface to be pressed into place. Stick the rear wall onto the glue tabs of the base panel and the side walls. Its own glue tab will be facing up, like the other walls of the housing. Again, take care that no edge protrudes or is short of the correct position. Lay the housing to dry on the rear wall and put a light weight on it, e.g. a book.

The housing is now complete apart from the top cover. It will acquire its strength in the next step when the mirror is fitted inside and the viewing window is fitted as a capping.

Section E-2

The mirror and the viewing window

Without a mirror the image would fall on the rear wall of the housing and be upside down. By reflecting the image upwards through a right-angle, the mirror turns it the right way up, but it is still reversed left-to-right. The viewing window on its own does not provide a picture because it does not actually interrupt the light. This doesn't

happen until a piece of suitable transparent paper (tracing paper) is laid on it.

Step 23: First, test by placing the mirror with its protective foil from the top into the housing so that the edges of its rear side are exactly on the mirror supports. Its upper edge will then be close to the future cover; the distance from the lower edge to the base panel is significantly greater. Bend the mirror supports again so they are at right-angles to the side walls, and stick the mirror in place on them. Press the side walls lightly together while doing this, and before the adhesive dries make sure that the right-angles of the top opening of the housing are accurate. This can be checked easily with the aid of the viewing window panel by putting it temporarily into its future position at the top on the glue tabs. Allow time for the adhesive to dry and then pull the protective film from the mirror.

Step 24: Roughen all 4 edges of the viewing window on both sides and over a width of about 1 cm with the craft file or sandpaper to help the adhesive stick better to the plastic. If you have no sandpaper you can also make some scratch marks with a sharp object, but take care that no scratches or score marks appear on the viewing area of the panel. Then bend the glue tabs of the housing into a horizontal position again and stick the viewing window on them without letting it protrude over any side. Put a weight on it during drying, e.g. using a book.

Section F

The edging strips

The 12 edging strips cover the glued edges of the housing and also give it extra strength. Four of them [F7, F8, F10 and F11] have cut-outs which will later accommodate the footrests of the side panels. The places where they will be glued can be recognised by the correspondingly shaped glue markings. Only edging strip [F9] has a glue marking on its outer side. It is for fixing the top cover, that also serves as front visor.

Step 25: Bend all edging strips 1 to 12 [F1 to F12, sheets 5, 6 and 8] firmly to the rear. Take care that the fold is exactly through the pointed ends. Then first stick edging strips [F1 to F4] on the 4 edges of the base panel and edging strips [F5 and F6] on to the two vertical edges on the left and right of the rear wall. Their angled ends should meet each other without gaps if possible and the tips meet at the corners of the housing.

Step 26: Stick the edge strip [F7] on to the edge formed by the front wall and the left side wall so that the cutout is near the bottom of the left side wall, as shown by the glue marking. Then stick the edging strip

[F8] similarly on the front right edge of the housing.

Step 27: Next, stick the edge strip with the glue marking [F9] on to the top front edge of the housing above the lens, so that the half with the glue marking is on the viewing window. Then stick the edge strip [F10] on to the top left edge of the housing. The punched cutout is then at the rear on the left sidewall towards the rear wall. The glue marking makes this clear. Similarly the edge strip [F11] belongs on the top right housing edge (Note: the cutout is in this case, because of an error, too far forwards in the glue marking. It should be as far to the rear as the one on the left). The last strip [F12] then takes its place on the last free space at the top rear.

Section G

The top cover and the side visors

To make the image on the tracing paper easier to see, the top of the Camera Obscura needs to be shaded by the use of visors. The top cover acts as the front visor. The side visors have footrests that can be placed behind brackets at various heights.

Step 28: Bend the glue tab of the top cover [G1, sheet 6] forwards and then glue this

tab on to the marked place which is at the top on the front edge strip. Take care that the top cover is positioned centrally on the housing and is flush at the rear with the edge of the housing.

Step 29: Bend the glue tab of the right side visor [G2, sheet 7] to the rear and stick footrest 1 [G3, sheet 7] with its grey face on to the marked place on the black rear of the side visor (Fig. 5). So on one edge of the side visor it is flush and on the other edge the gold-printed semicircular end protrudes beyond the edge. Then stick the right visor with its tab on to the right-hand edge of the top cover so that at the rear it ends exactly where the top cover ends, and at the front it just reaches the bend of the cover's hinge.

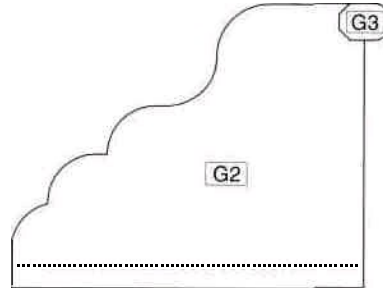


Fig. 5: Side visor with footrest

Step 30: Stick footrest 2 [G5, sheet 7] the same way to the left side visor [G4, sheet 7] and stick the latter to the left edge of the top

cover.

Step 31: Now, when you open and close the top cover, you will see that the footrests of the side visors fit into the cutouts in the edge strips. To enable them to latch in those positions, brackets need to be glued over the cutouts. Stick the 4 footrest brackets 1 to 4 [G6 to G9] over the cutouts in the front and the top edge strips so that they end flush with the edges of the edge strips. This results in pockets in which the footrests can be positioned to secure the top cover in the closed position or open at right-angles.

Step 32: To enable the top cover to be secured in a 60° position, 2 further brackets are provided for the footrests, to be stuck at an angle on the side walls. Stick the 4 bracket feet 1 to 4 [G10+11, G13+14, sheets 3 and 4] under the ends of the footrest brackets 5 and 6 [G12 and G15] and then stick these on the sloping glue markings on the right and left side wall. Before this, check that the footrests of the side visors fit neatly into place.

Congratulations! Your Camera Obscura is now finished. Place a sheet of tracing paper on the viewing window and it is ready to use.

Tips for using the Camera Obscura:

- Ensure that the subject is well lit and the Camera Obscura itself, the matt tracing paper screen in particular, is shaded or in the dark.
- You can see the image particularly well if you use a dark cloth or suitable item of clothing to shade the screen and yourself, as with the old types of camera.
- If the inner lens tube with the lens moves too easily, you can stick a few strips of paper on the interior of the outer lens tube to make it a little narrower.
- Unwanted reflections, that cannot be avoided despite the black interior walls, can be considerably reduced with the supplied lens shade. Cut it from the card and bend back the eight tabs. Push the shade with the octagon first into the open end of the inner lens tube, opposite the lens, and to the depth where the tabs are flush with the edge of the tube. You can fix the shade in this position with a few drops of adhesive or, if you want to experiment with other sizes of shade, just leave it pushed on loose.
- The lens has a large aperture and a good light-gathering capacity with an f-number of 4.8, calculated as the focal length of 275 mm divided by the 57 mm lens diameter. This also gives a small depth of field, i.e. only objects at about the same distance are in focus. By moving it, you can focus the lens on objects at different distances. The depth of field increases if you reduce the lens opening by placing a dark card with an aperture in front of it, but this also reduces the brightness of the image.
- For very close subjects the lens cannot be pulled out far enough. However, you can make a temporary extension from black paper, folded into a suitable octagonal tube and pushed between the inner and outer lens tubes.

Photographs from your drawings

This Camera Obscura is not suitable for directly exposing photographic paper, but from the pencil drawings that you make on the tracing paper, it is easy to make impressive photographic prints without a darkroom or chemical developer. For this you can use the solar photographic paper from AstroMedia (order no. 411.FSP) and, for exposing, lay the viewing side of the drawing, which is mirror-reversed, on the photographic paper. In the development (using ordinary tap water) a white negative on a dark blue background is produced, that is now the right way round.

The Camera Obscura as a pinhole camera

The 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 punch a hole. Begin with a small hole (approx. 1 to 2 mm), that you can then gradually enlarge. Put a light-tight cloth cover over yourself and the matt screen and allow time for your eyes to accommodate to the dark. The images that you can then see, unlike those obtained with the lens, have a uniform sharpness - a big advantage of pinhole cameras. The image is, however, much dimmer. The larger the hole, the brighter the image but also the less focused.