

The Camera Obscura

Pre-punched cardboard kit for a Camera Obscura with a projected image of 16cm x 16cm.
Produces an upright image for viewing and perspectively correct drawing of motifs.

Front and side visors with
3 height adjustments

Large housing
275 x 190 x 190 mm

Large acrylic objective
lens with $f = 275$ mm

Transparent screen to
hold tracing paper

High quality acrylic
mirror

Beautiful gold and black
leather print

Pre-punched multi-layer
cardboard



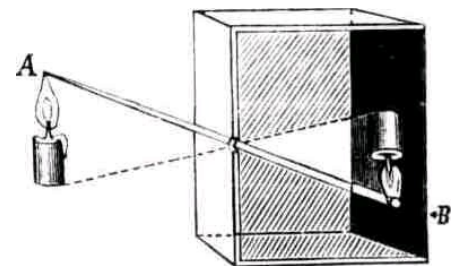
AstroMedia

Revised Version: Andreas Schröer



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 on the opposite wall of the scene outside. 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 transparent screen so that the image can be seen from outside the box (see the sketch). We can presume that even in pre-historical times people noticed that a small hole in the curtain in front of a 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. Leonardo da Vinci discovered that this is also the optical principle of our eyes (and those of most vertebrate animals). The images formed on the retina of the eye are in fact upside down. We see them the right way up because our brain turns them around again. 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 through which the light enters, the larger the image is (but it is also dimmer). 2. The larger the pinhole, the brighter is the image, but also the less sharp.



These facts have greatly limited the possibilities for using a pinhole camera, 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 pinhole, 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 sharp; 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 observed objects. 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 (for example in the National Gallery in London and the Old Masters Gallery in Dresden), who used a focusing camera obscura for this work. This AstroMedia kit works on exactly the same principle.

Photography was born when the Frenchman Nicéphore Niépce had the idea of capturing the image directly with a light-sensitive plate. So now the camera obscura lives on in the millions of still and video cameras that we have today. However, there are still some genuine examples of the camera obscura at tourist attractions (e.g. in Edinburgh). A large darkened room in which a mirror in the roof casts the image onto a projection table where whole groups can view it.

Contents:

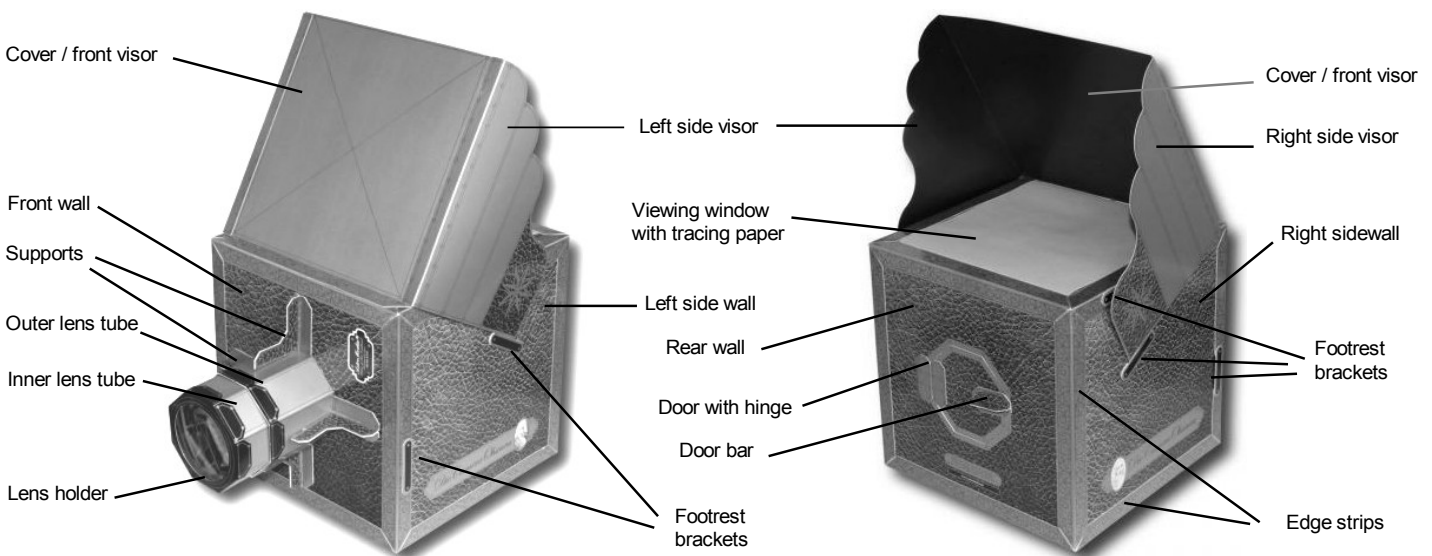
- * 4 pre-punched sheets of cardboard, 0.65 mm
- * 4 pre-punched sheets of cardboard, 0.35 mm
- * 1 acrylic lens OptiMedia 314.OM.10, 62 mm diameter, $f = 275$ mm
- * 1 acrylic mirror, 188.5 x 188.5 x 2 mm
- * 1 transparent plastic viewing screen, 190 x 190 mm
- * 1 optional blind
- * 3 pieces of tracing paper, 160 x 160 mm

You will also need for assembly:

- * Standard solvent based all purpose glue, e.g. UHU, Evo-Stik Impact, B&Q All Purpose Glue. **Do not use water-based glue:** it softens and warps the cardboard, and doesn't stick properly to the printed surfaces. Solvent based glues also dry much faster.
- * Double sided sticky tape for the plane mirror. **Some solvent based glues can damage its reflective coating.**
- * A small piece of sand paper or a file of our file set (400.SBF) to roughen the edges of the screen to make the glue stick better.
- * A sharp knife with a fine point (thin carpet knife, craft knife, 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.
- * For perfectionists: a black and a golden pen to colour the white edges of of the cardboard.

Tips for successful construction - Please read before commencing!

- * In order to ensure good results and for straightforward construction, the building instructions have been broken down into Chapters A to G, which are broken down further into smaller steps. Do not be worried by the long text - it is simpler and faster than it appears and helps to avoid mistakes. Read each step from the beginning to the end before commencing and allow yourself a few hours for the construction (depending on experience). The more care you take, the better your Camera Obscura will work and look.
- * Every part has its name and part number printed on the front or back. The part number consists of a letter and a number: the letter denotes the chapter it belongs to, the numbers denote the order of construction. The part number can be recognised by its rectangular frame, e.g. [B1]. Only remove the parts as you need them.
- * Places needing glue are marked in grey. Please keep in mind that the glueing areas are slightly smaller than the parts that will be glued to them. This ensures that grey areas will be completely covered.
- * We recommend that you do not tear the parts out of the cardboard sheet, but cut through the thin connecting tabs to make sure that the edges stay smooth. Frayed edges can be cleaned with a nail file or with our AstroMedia File Set (400.SBF).
- * 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.
- * The surface of the acrylic glass plane mirror is covered with a protective film. Only remove this after mounting the mirror.



Chapter 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 thick, strong cardboard, the other parts with visible folded edges are made of thinner material.

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

Step 1: Remove the front wall [A1, Bogen 1], the left side wall [A2, Bogen 3] and the right side wall [A3, Bogen 4] from the cardboard sheet. Also remove the eight-sided base panel [C5] from the front wall, although it will only be needed in Chapter C. The small disk in the base panel [C5]

should not be removed. It is only punched for manufacturing reasons. Fold all glue tabs backwards along their perforations, i.e. towards the black printed side.

Tip: The 0.65 mm thick cardboard can be cleanly folded this way: put the part on a wooden board or similar object with a sharp edge and position it so that the perforated line is along the edge. Then bend the glue tab downwards. Fold it over fully and smooth it with a thumbnail or the rounded back of a knife.

Step 2: All three parts have on one edge a glue tab that is slanted on both sides. This edge is 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 side towards you, and on the left at a right-angle to it stand the left side wall [A2] so that the side with the two slanted glue tabs is at the top. The black sides of both parts are then facing inwards, and the gold printed sides 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. Glue the front wall in this position onto the side glue tab of the left side wall.

Important: Before the glue hardens, push the bottom edges against your work surface to ensure that they are flush.

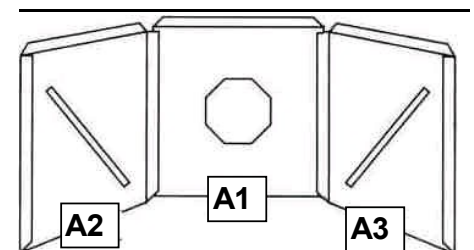


Fig. 1: Front wall and side walls

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

Chapter B

The Outer Lens Tube

The outer lens tube serves as a guide for the inner lens tube, which will be built in Chapter 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 on objects at different distances.

Step 4: Remove the outer lens tube [B1, Bogen 5] from the cardboard and fold all eight scored lines backwards. Hold the edges of the two half segments at the ends of the card piece against each other, forming 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 turn the folded piece of card into a strong eight-sided tube, you need the connecting piece [B2, Bogen 7]. Stick it onto 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.

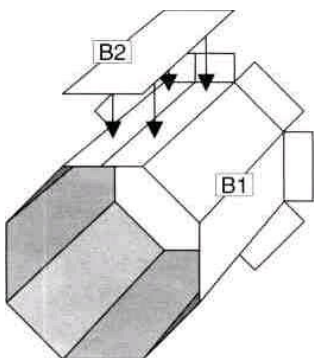


Fig. 2: Outer lens tube

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 tabs through the eight-sided opening in the front wall and glue them firmly onto the grey glue markings that are located around this opening.

Tip: Push the interior side of the front wall against your work surface so that the foot tabs make good contact.

Step 6: Fold the edge reinforcement [B3, Bogen 5] backwards along the grooved lines and glue it onto the glue marking around the opening of the outer lens tube. The ends of the edge reinforcement should be at the bottom of the outer lens tube.

Step 7: To make the connection between the outer lens tube and the front wall warp-resistant, four supports are required. Fold the foot tabs of the eight support pieces [B4 to B11, Bogen 1 to 4] forwards and glue the pieces back to back in pairs to form right-angled supports that have two foot tabs on one of the outside edges (see cover photo). Initially without glue, try out the fit by placing one of the supports with its foot tabs on one of the glue markings on the outside of the front wall, and push it into the corner between the front wall and the outer lens tube. The outer edge of the support without the tabs will then abut on the wall of the tube. Now apply adhesive to the foot brackets and the abutting outer edge and glue the support firmly in the position you have just tested. Then glue the other three supports onto their respective locations. The lower support will be glued to the connecting piece that holds the lens tube together.

Step 8: Fold the two mirror supports [A4 and A5, Bogen 6] backwards at right angles. The result will be two angled strips that are black inside and grey outside. Glue the mirror holders onto the glue markings 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 point.** The mirror itself is installed later, in Chapter E-2.

Chapter C

The Base Panel

The base panel has glue tabs on all four sides. It is formed from four trapezoidal parts [C1 to C4] and the octagon that was removed from the front wall [C5]. These five parts are glued together on their rear side with the help of eight connecting pieces (see Fig. 3). All parts, including the connecting pieces, are black on the side facing the interior of the housing.

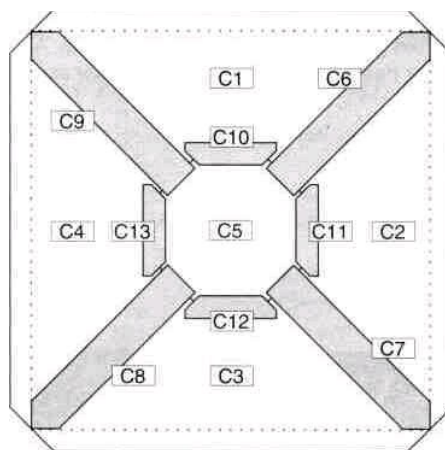


Fig. 3: Base panel

Step 9: Remove the four base panels [C1 to C4, Bogen 1 to 4] from the cardboard sheets, also the four large connecting pieces [C6 to C9, Bogen 1 and 2] and the four small connecting pieces [C10 to C13, Bogen 1 to 4]. The eight-sided central base panel [C5] was left over from Step 1. Fold the long glue tabs on the four base panels backwards.

Step 10: First place two of the trapezoidal base panels with the black side facing up on your work surface so that the inclined edges touch each other 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 should point to the corner and the straight end should protrude a little into the area of the octagon. Make sure that the edges of the base panels touch each other without a gap and that the black side of the connecting piece faces upwards.

Step 11: Put the octagonal base panel [C5] with its black side facing upwards in its space, so that one of the narrower glue markings is under the protruding end of the connecting piece and all edges abut against each other without gaps. Then glue it to the connecting piece. Now add the other base panels in the same way, using the large connecting pieces, and finally glue the small connecting pieces onto the remaining free edges of the octagon (see Fig. 3).

Step 12: Fold the glue tabs of the base panel backwards (towards the black side) once more and push them between the two side walls of the housing until the base panel meets the front wall. Check whether you would like to turn 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 glue the base panel with its glue tabs in this position, but initially only onto the front wall. Push the front wall against the work surface to make sure that the base plate is exactly flush with its bottom edge. Also push the side walls against the base panel to check that it is accurately centred. Then glue the side walls to the glue tabs of the base panel in this position.

Step 13: Remove the round cover [C14, Bogen 7] from the cardboard. The ring between parts D3 and C14 is waste and can be discarded. Glue the cover from the outside onto the octagonal central piece of the base panel. The pre-punched small disk should not be removed and is also covered.

Chapter 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: Fold all scored lines of the lens tube [D1, Bogen 5] backwards. This forms another eight-sided tube, black on the inside, with two half segments meeting at the ends. Join the two half segments on their inside with the connecting piece [D2, Bogen 5]. When you do this, take care that the edges of the half segments touch each other without a gap and that the black surface of the connecting piece faces the inside of the tube.

Step 15: Remove the lens holder [D3, Bogen 7] from the cardboard sheet and fold all eight glue tabs backwards. The acrylic glass lens supplied with this kit has one convex side (curved outwards) that should point towards the viewed scene, and a flat side that faces towards the inside of the Camera Obscura. Take care to only touch the lens at the edge, and wipe off any fingerprints with a soft cloth. Place the lens holder with the black interior upwards on your work surface or on a small cup and put the lens into it with the convex side pointing down to test the fit. Take the lens out again and apply glue to the lens holder to a width of about 3 mm around the opening. Make sure there are no threads of glue across the opening. Then carefully put the lens back inside and centre it. Allow the glue to dry fully.

Step 16: Place the lens holder on the end of the inner lens tube that has the glue markings, and glue its tabs onto the tube. After the glue has set, check that the inner tube can be easily pushed into the outer tube and moved inside it. Then put it aside to avoid damage to the lens during the rest of the assembly.

Tip: If, despite all your care, the lens is damaged, you can easily order another one at www.AstroMediaShop.co.uk in the Components section (314.OM.10).

Chapter E-1

The Door and the Rear Wall

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

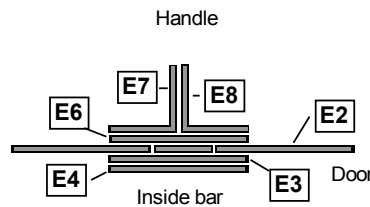


Fig. 4: Cross-section of door bar

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

Step 18: Remove the small disk-shaped bar shaft [E5] from the door [E2, Bogen 2]. Glue the bar shaft onto the grey glue marking of the interior bar, taking care that it sits in the centre of the semi-circle forming the end of the inner bar. Allow the glue to dry.

Step 19: Fold the two handle parts [E7 and E8, Bogen 7] forwards and glue one half of each back to back. Then glue the handle with the other two halves onto the grey rear side of the main part of the bar [E6, Bogen 7].

Step 20: Remove the door [E2, Bogen 2] from the cardboard sheet 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 in its bearing, and then rotate it so that its visible part protrudes at right angles from the door. Apply a small amount of glue to the shaft and stick the bar handle with its glue marking onto it. It should point in exactly the same direction as the interior bar but it is a little shorter. This is intentional, to make the door easier to close. Allow the adhesive to dry properly and then carefully move the bar until it can be fully rotated about its axis.

Step 21: Lay the rear wall [E1, Bogen 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. Fold the door hinge [E9, Bogen 7] forwards and then flat again, and glue it onto the overlapping glue marking located on the door and the door frame. The fold must be exactly flush with the cut line. After the adhesive has dried, check the door actions (opening, locking).

Step 22: Fold the glue tab of the rear wall backwards and once again fold inwards 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 partly 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. Glue 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 ones of the other walls of the housing. Again, take care that all edges are flush with the other walls. 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 to the top.

Chapter E-2

The Mirror and the Viewing Window

Without a mirror the image would fall onto 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 left and right are still reversed. The viewing window on its own does not provide a picture because the light goes right through it. But as soon as you place a piece of suitable transparent paper (tracing paper) on it, the image appears.

Warning: Some glues can damage the reflective coating of the mirror. It's a good idea to test the glue on a corner of the mirror first, or use double-sided sticky tape.

Step 23: First, test the fit by putting the mirror including its protective foil from the top into the housing so that its edges lie exactly on the mirror supports. Its upper edge will be quite close to the future top cover; the distance from the lower edge to the base panel is significantly greater. Fold the mirror supports again so that they are at right angles to the side walls, and glue the mirror in place. Press the side walls lightly together while doing this. 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 on 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 four edges of the viewing window on both sides and to a width of about 1 cm from the edges with a craft file or sandpaper to help the adhesive stick 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 are made 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 onto them without letting it protrude over any side. Put a weight on it while the glue sets, e.g. a book.

Chapter F

The Edging Strips

The twelve edging strips cover the glued edges of the housing and give it extra strength. Four of them [F7, F8, F10 and F11, Bogen 8] have cut-outs which will later accommodate the footrests of the side panels. The places they will be glued to can easily be recognised by the correspondingly shaped glue markings. Only edging strip [F9, Bogen 6] has a glue marking on its outer side. It is for fixing the top cover, that also serves as front visor.

Step 25: Fold all twelve edging strips [F1 to 12, Bogen 5, 6 and 8] firmly backwards. Take care that the folds are made exactly through the pointed ends. Then first glue edging strips [F1] to [F4] on the four edges of the base panel and edging strips [F5] and [F6] onto 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: Glue the edging strip [F7] onto 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 glue the edging strip [F8] similarly on the front right edge of the housing.

Step 27: Next, glue the edging strip with the glue marking [F9] onto the top front

edge of the housing above the lens, so that the side with the glue marking is glued to the viewing window. Then glue the edging strip [F10] onto 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 should make this clear. Similarly, the edging strip [F11] belongs on the top right housing edge (Note: due to a printing error, the cutout is indicated too far forwards on the glue marking. It should be as far to the rear as the one on the left). The last strip [F12] is glued on the last free space at the top rear of the housing.

Chapter G

The Top Cover and Side Visors

To make the image on the tracing paper easier to see, the top of the Camera Obscura needs to be shaded by 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: Fold the glue tab of the top cover [G1, Bogen 6] forwards and then glue this tab onto the marked place at the top on the front edge strip. Take care that the top cover is positioned centrally on the housing and that the rear is flush with the edge of the housing when it is closed.

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

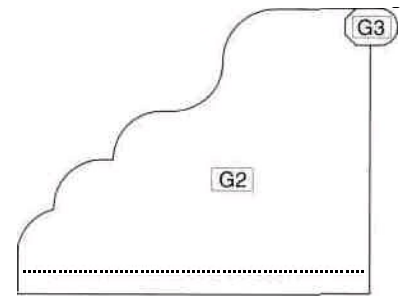


Fig. 5: Side visor with footrest

Step 30: Glue the other footrest [G5, Bogen 7] the same way to the left side visor [G4, Bogen 7] and glue the latter to the left edge of the top cover.

Step 31: When you open and close the top cover, you will see that the footrests of the side visors fit into the cutouts in the edging strips. To enable them to latch in those positions, brackets need to be glued over the cutouts. Glue the four footrest brackets [G6 to G9, Bogen 5] over the cutouts in the front and the top edging strips so that they are flush with the edges of the edging 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, two further brackets are provided for the footrests. They are glued at an angle on the side walls. Glue the four bracket feet [G10+11, G13+14, Bogen 3 and 4] under the ends of the footrest brackets [G12 and G15, Bogen 7] and then glue these on the angled glue markings on the right and left side wall. Before the glue sets, 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.

Some tips on using your Camera Obscura:

- * Make sure that the motif is well lit and the Camera Obscura is in the shade. You could also try covering yourself and the screen with a dark cloth or piece of clothing.
- * 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.
- * Although the inside of the camera is mostly black, you might still see some distracting reflections. These can be efficiently reduced with the enclosed objective blind. Cut it out and fold the eight tabs backwards. Then push it, octagonal first, into the inner lens tube until the ends of the tabs are flush with the edge of the tube. You can secure it with a little bit of glue or leave it loose, so you can experiment with other blind sizes.
- * The objective lens is quite large and has an F-number of 4.8 (focal length divided by diameter). This produces a bright image, but it also leads to a small depth of field: only objects that have the same distance to the lens are sharp. By moving the lens in or out you can adjust the camera to different distances. You can increase the depth of field by using a smaller objective blind; but that will also dim the image.
- * If the motif is very close, the lens tubes might be too short to focus the camera. In this case you can build an extension from black paper. Fold the paper into an octagonal tube that you can fit between the inner and outer lens tubes.