



# How to...

## MAKE A TELESCOPE – PART 2

# In detail

## Complete instructions for part 2

These instructions take you through the entire procedure of making your optical tube assembly. Print them out and all of the diagrams and use them in conjunction with the main text of the article as you go along. If you come across any snags or get stuck you can write to the author at:

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### Step 1

Mark each sheet in turn after you have decided which face of the plywood is the good one. Use a pencil; a marker pen may come through any paint or varnish you use later. Each time you mark a piece of timber, remind yourself which bit you want to keep and which bit is going to be waste.

Do not cut inside the mark, you can remove a bit of excess later, but you can't put the wood back once you've cut it. If you find it impossible to make the cuts accurately and do cut small bits off the work piece it doesn't mean total failure. It will however necessitate repair after and that means filler.

On the subject of damage, you will almost certainly have the odd notch and if you still want to varnish rather than paint the scope it would be good to fill unwanted gaps, this can be done using a sawdust and glue-water mix, mixing a third each by volume.

Always put your riggers gloves on before you start a cut, or do any work where damage to your hands is a possibility. Slowly pull the saw backwards, lightly on the edge until a groove is formed, before pushing the blade away from you. As you start the cut, use light pressure on the saw until you feel it moving smoothly.

When cutting long pieces stop about two-thirds of the way along and clamp a thin, stout support under the cut end to stop it falling away. This allows you to concentrate on supporting your end. A large unsupported piece can suddenly break off near the end of the cut, damaging the back of the board and maybe you too. As you get to the end of the cut hold the work piece firmly to stop it falling away and use short gentle strokes of the saw blade to get a nice finishing cut.

Once you're happy you can cut a straight line, cut out the Struts, Baffles, Mirror cell back plate and focuser fillet. If any cut sides

are longer or wider than they are meant to be the excess can be rasped off if it is a small amount. If, however, it is 1mm or greater use the block plane.

On the struts, notch them where they are housed in the square indents of the baffles (see positioning of baffles later).

Planing can take a bit of getting used to. The first and most important point is never plane towards your hand or body: a plane blade is razor sharp. Always support the work so that you're in control and it's not likely to slip off while you are moving the plane.

A plane's blade is designed to remove shavings off straight, grained timber, but because you're using it on plywood practise using it before taking chunks out of your beloved telescope.

To remove excess plywood with the plane (or indeed rough rasp) you need to angle it to the plywood from the front face and angle it upwards a few degrees so that it crosses the centre, missing the grains at the back of the board. This creates an angled cut from the edge to the centre known as a bevel.

Turning the board around and repeating the stroke from the other side allows you to even up the other side and a ridge is formed in the centre of the edge. By carefully removing the ridge until two very small bevels remain on each edge you remove plenty of the excess without damaging the two outer surfaces. You can finish any rough edge surfaces with the fine file afterwards.

Always plane into the board with the front edge of the plane resting on it before you move inwards, bringing the blade down gently as you proceed so it doesn't whack the side as you move in.

### Step 2

After cutting out all the pieces from the 12mm plywood, cut out the centre circles from the baffles. Find the baffles' centres by drawing diagonal lines across them from one corner to the opposite on both sides; where these two lines cross in the middle is the centre. Using a compass set at 115mm, gently press the pin side into the centre so that it just goes into the surface. Draw the 230mm diameter circles and check their dimensions across using a metal ruler.

To saw out the circle you have to get the blade into the circles to start with. Drill two 3mm holes almost touching each other just inside the circular mark, so that when drilled the outside of the hole just touches the

pencil line. Carefully drill diagonally from one hole through to the other several times to join them. Don't try turning the drill bit sideways while it is in the wood or you may break the bit. When you've removed nearly all the wood from between the holes, hold the drill square and gently move it up and down and use very gentle sideways pressure to pull the drill from one hole to the other to finish the slots.

Then clamp the baffle onto the workbench so you can access your drilled slot from above and below. With the coping saw to hand, put a blade through the slot with the points of the teeth pointing down and away from you. Attach the blade to the saw so that the handle is at the bottom and the saw is behind the blades' teeth. As you tighten up the blade make sure the two blade indicators at the ends are pointing in the same direction or the blade will not cut properly and will break more easily.

Setting the indicators to an angle of 30° from the back of the saw allows the saw to clear the corners as you go around the circle.

Cut away from yourself, making sure the blade is kept vertical. Pull down on the handle and if necessary use your other hand to guide the top of the saw. Only use gentle forward pressure on the blade or you are likely to break it. Keep the blade on the inside of the pencil circle as you go around.

Don't cut more than one piece at a time as there is the danger that the blade will distort and cause it to cut to an angle so your holes will not be even. It's very important that your circles are well cut out, as they're going to be used for the side bearings later and they must be accurate semi-circles. The other circles will be used for the mirror support plate and to make the focuser holder reinforcing ring. It would be a good idea to do a couple of practice runs on a piece of scrap ply before you start on the baffles.

Next, the 12mm indents have to be cut out from the corners of the baffles. Measure 12mm in from each side of the baffles on both corners and use a steel rule to draw the lines at the corners crossing over one another. Carefully remove the small 12mm squares using the junior hacksaw. Remember to keep the saw square from side to side and up and down. Double check the indents for size, filing away any excessive ply.

The 12mm focuser support fillet has to have its two side edges cut to a 45° bevel so that its sides are flush against the 3mm ►



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► outer ply skin when fitted, because when the 3mm ply is cut away, to form the focuser rebate, the fillet's sides support the 3mm skin that's left. Carefully cut the fillet and check its fit between two selected baffles, which will be the top one (it's best face should point outwards at the top of the tube) and the second one (with its good face going behind the first, as you look down the tube).

Using your set-square, draw two lines at 45° to one corner on each baffle just skimming past the baffle's circle edge. These lines act as guidelines when you glue the fillet into place. These lines will be installed facing each other, so one line will be on the rough side of the back of the first fillet and the second line will be on the good face of the second fillet.

You can afford to install the fillet so that its sides project slightly past the baffle edges – you can trim them later. Only do this after the skeleton is complete and the glue has had at least 12 hours to dry.

Before gluing the struts to the baffles, make a right-angled timber 'squaring stand' from some 4 x 2-inch timber scraps and clamp it to the workbench. By clamping the first baffle (with its good face towards the stand) to this known square stand, you can then measure to the remaining baffles to make sure they're all square as well.

Put a plastic carrier bag where each baffle is to be fixed to protect the workbench when gluing. The struts will glue on to the first baffle so that the ends are flush with the baffle's front face. Mark lines 262mm in from one end of all the struts; this marks the position of the second baffle. Measuring from the rear ends of the struts, mark them at 400mm for the third baffle. The last baffle fits flush to the rear struts.

The gluing needs to be done quickly so make sure you have everything to hand before starting and once you start a run, don't stop. As well as the glue have a washing-up bowl with some water in it, a rag for wiping off excess glue and a roll of 1-inch duct tape handy.

Place the first baffle up against the squaring stand with its 45° line on the top corner away from you so you can see the lines clearly when gluing the fillet in. Apply glue 12mm in from the ends and on to two adjacent sides of the two lower struts and feed them under the first baffle's indents, do the same for the top two. Put two temporary pieces of tape on them to stop them moving, then carefully place a loose, unglued baffle (not the one with the line on it) two-thirds of the way along the struts and tape it into place. Remove the temporary tape from the glued baffle and carefully position the struts so that they are square and flush with the front face of the first baffle, wipe off any

excess glue, re-tape the struts into place and leave to dry for a minimum of three hours.

When this is dry place a 350mm length of 1-inch duct tape 50mm over the face of the first baffle on the corner the 45° line is drawn on. Glue the four indents on the second baffle and feed it into the struts (with its 45° line opposing the first one) up to the 262mm marks on the struts, so that it is to the rear end side of the lines. Glue the two sides of the focusing fillet and carefully feed it between the first and second baffles so it is lying just next to the 45° line, but not covering it obviously.

While holding the fillet in place with one hand, pull the duct tape across from the first baffle to wrap around the back of the second with just enough tension that the fillet stays put. Carefully position the second baffle so that it is square to the first by ensuring the measurements from corner to corner are the same, wipe off any excess glue (being careful not to disturb the fillet's position) and tape the strut to the baffle joints. Leave it to dry for a minimum of three hours.

After this, gently glue and feed the two remaining baffles into place and tape the joints after checking they're square. Leave the skeleton on the workbench to dry for 12 hours before removing the tape.

If you find the glue has 'pooled' anywhere, causing a lump that could be in the way later, cut off any excess with the junior hacksaw but only after it has fully dried and gone from white to clear. Plane away any excess from the sides of the fillet that projects above the sides of the baffles. Use a metal rule across the two baffles to determine how much needs to be removed.

### Step 3

Cut out the 3mm sheets; they correspond with each other on the two boards so you can cut them together providing you carefully line up the boards prior to cutting. Two of the 3mm sheets are sized to fit flush with the sides of the skeleton and the other two overlap the edges of the first two which is why they are wider.

Offer the first skin up to the skeleton and align the front edge of it carefully with the front baffle – the secondary mirror end of tube. If the board overhangs the skeleton at the sides, look along its edge to see which side is the cleaner cut. Line this side up with the skeleton.

Because boards arrive square and assuming you've cut it square, it should also run flush to the edge of the skeleton; if not it shows that the skeleton's skewed. To fix the skin onto the skeleton drill a 3mm hole in one corner of the front edge of the skin, but only the depth of the 3mm plywood. The hole should be 10mm in from the front face and

6mm in from the side. Use the countersink bit to rebate the hole so the screw head is flush with the surface; don't overdo it, you can always remove the screw and countersink more later. Screw the first 12mm x 3mm screw in.

At the other end of the skeleton drill and countersink the board on the diagonally opposite corner and screw it down after pulling the skeleton to be flush with the edge of the sheet. Repeat the process with the other corner at the top end of the skeleton. If after this the skeleton bows out from the side, hold it in as you screw down the fourth corner. If a strut appears to have warped slightly (check by looking along it) pull or push it to where it should be, as you screw down.

In the event of overhang on the side check to see it is even along the whole length. If it is, at least your skeleton has even width. Now measure 6mm in from the side and mark a faint line down this side. Measure the overhang and add that to the 6mm to make your line for the other side. If the overhang varies a lot then mark it in several places along the edge where it is equidistant to the skeleton and add that value to the 6mm. This 6mm line corresponds with centres of the struts below.

Finish putting all the end screws in, then measuring in from one end of the tube assembly, mark out all the screw holes down each side at 153mm, 305mm, 458mm and 610mm. Marking across the 6mm line for each.

Don't push down hard on the struts during this stage; they are only 12mm thick and fairly fragile. When you drill, countersink and screw the skin on gently.

Carefully plane away any remaining overhang. Use a shallow blade setting and angle the plane towards the centre of the tube assembly. Remember as you reach the corners not to plane towards them, turn around and work back. Check if the baffles project out beyond the struts and don't plane beyond this.

Put the second 3mm skins on as above, allowing an extra 4mm when you come to measuring up for the side screws, so they are screwed 10mm in. All these screws need to be offset by a couple of mm or they could interfere with the first thinner boards. This is best done visually, looking down each side to ensure no screws conflict.

Once the wider boards are trimmed and everything looks correctly fitted, it is now time to glue the skin on. Remove all the screws, taking each board off one at a time and storing upright and in order (write numbers onto corresponding sheets and skeleton sides). Then glue the first board on, putting glue on all the surfaces where the ►



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► board will meet the skeleton, don't skimp on the glue as it will be holding the whole optical assembly together rigidly. Repeat for the next two sides. Stop here and allow the glue to dry.

Now you need to paint the inside surfaces matt black as well as the inside face of the final unglued board. Don't paint the outside of the front baffle. When the paint has dried, glue and screw the last board on.

### Step 4

Attach the 9mm plywood shroud at the bottom of the tube. The procedure for this is similar to attaching the 3mm skin, except you need to use four 4mm x 25mm securing screws across the boards fixing them into each baffle. You also need three additional screws along each side going into the struts between the baffles.

It is important to remember that the 9mm 'box' at the back houses the mirror cell and so the 9mm boards need to extend out from the first assembly by 60mm to provide some space for slight discrepancies in calculating the main mirror's focal length and hence the final position of the mirror cell. The positions of the baffles should be marked on the boards lightly in pencil.

Drill a 2mm pilot hole through the 9mm sheet into the skeleton for all the screw holes. After drilling these smaller holes the boards should be removed from the assembly to drill the 4mm screw clearance holes into the 3mm skin, no deeper than 3mm. Having trimmed the 9mm sides take them off and mark them as with the 3mm skin and then glue and screw them back in place.

To cut out the 45° focuser rebates is tricky: do it by clamping the tube to the bench at 45° and holding the top edge of the tube. You can also make two supports by cutting four 45° cuts in 4x2-inch timber across its deeper axis to give more support. These should be nailed or screwed onto other bits of 4x2 so that you have two 'V' shaped stands to put the tube on, pack these notches with folded cardboard if necessary to hold the tube steady. Each stand should go at each end of the tube, under the end baffles and then clamped using the baffles to clamp the tube down onto the 'V' supports and bench. Putting two long luggage straps around the tube and under the workbench will then help to hold the tube down and stop it swaying. The strap at the front will have to go at the very corner, as one of your cuts will start 30mm from that.

The first rebate cut is 30mm from the front end, coinciding with the fillet. The cut goes down towards the rear of the tube and the fillet, at 45°. The line of the rebate then goes along the fillet and then back up at 45° to the edge again. The second 45° cut starts 210mm

from the front edge. The 45° is purely an aesthetic value and doesn't affect the working of the scope and so an approximate cut will do. If you hold a saw parallel to the workbench and square to the piece and you then saw to an angle; providing you cut straight, that angle should be maintained.

Start by cutting a fine slot with the junior hacksaw, remember to keep it straight, at 45°. Having cut to where the back of the saw looks like its about to hit the ridge, stop and then move the saw towards the centre of the rebate to make a mirror cut to the first so that you cut out a 'V'. Repeat this on the other side of the rebate. Go over to using the handsaw and continue to cut down the main rebate cuts. Stop occasionally to see if you are cutting straight and to see how close you are getting towards the fillet. You don't want to cut all the way to the fillet, be sure to stop the cut 3mm or so away from it.

Using your metal ruler draw a line between the bottoms of the saw marks on each side. Use the utility knife (with your gloves on) to cut away the 3mm ply, keeping the blade parallel with the surface of the bench. Hold the knife firmly and cut through the ply using a number of cuts. The rebate's basic shape is there and now needs to be straightened out.

Carefully use the knife to carve away the remaining excess on the fillet's edge so that the cut in the ply is flush with the fillet. Then carefully file the sides of the 45° cut until they are square to the fillet going across it. As you look sideways across the 45° cut both sides should be straight and equal. Use the 120 grit sandpaper wrapped around a piece of timber long enough to span the bottom of the cut and finish the 45° faces so they are straight and free of 'dips'.

Cut two triangles to fit over the 45° cuts. The bottoms of the triangles need bevels removed for them to fit closely to the fillet. These triangle pieces should completely cover the edges of the 3mm tube plywood. Once they fit nicely glue them in. Allow to dry for four hours and then file and sand all the edges flush where necessary. Any gaps or notches should be filled later on.

### Step 5

We now move on to making the mirror cell. Having cut out the square mirror cell back plate, start by choosing an edge to be the top and make a small notch with the hacksaw in the middle on that edge. This becomes clearer when it comes to drilling out the small bolt holes. Also decide which side you want facing outwards, towards the back. Measure across the plate from top to bottom and divide this by two, then mark a centre line from side to side. Draw across the square from two corners to opposite corners

making a cross. In theory the three lines drawn should meet at the exact centre. If not the centre will lie inside the small triangle formed in the middle – double check your horizontal line measurements.

Centred on the central point, draw a circle of 85mm radius on the good side of the square back plate. Use your large plastic set square to draw two lines 60° each side of the centre line, starting from the middle of the square towards the top and bottom edges of the square.

The centres of six 40 to 45 mm diameter ventilation holes are where the 60° lines and both sides of the horizontal line meet the circle. There is also a similar diameter hole right in the middle. Now you drill them out using a hole saw and drill.

Put the back plate on a piece of scrap timber that's thicker than the distance the pilot bit sticks out of the hole saw. This avoids damaging the surface of your bench. Drill all seven holes, removing each disc off-cut from the hole saw after each hole. Use the low gear and speed to drill the holes and regularly remove the drill bit to clear the ring and drill teeth of sawdust.

The three smaller bolt holes are drilled later, using the mirror support plate as a template. Drill the four back plate retaining screw holes now though, one on each corner; centres at 15mm in from the sides. Use a 4mm drill bit and countersink the holes on the outside face.

Start the circular mirror support plate with the cross on the circle originally made from finding the centre of the baffle; this also shows the circle's centre. From this draw a circle of radius 75mm. Use only one of the two cross lines on the circle, drawing a wiggly line through or rubbing out the other line to avoid confusion. With the 60° set square, mark each side of the line from the centre to the edge, turn the circle 180° and repeat. You end up with three lines crossing each other equally dividing the circle into six.

On any given line, one side shows a centre for a small bolt where it crosses the 75mm radius circle, while the opposite side shows the centre of the larger vent hole. As you go around the circle from one line to the next you get alternating large and small hole centres. On each large hole centre draw rough 40 to 45mm circles to show where the large circles should be drilled.

Get your spare rough support timber to protect the bench, then drill out the three large circles and also a large centre circle. You now need to turn the cell around and using a 16mm flat bit with a central point, drill a 6mm deep rebate. These rebates will house the cup square bolt heads. Turn the circle back over and drill through each hole using a 6mm drill bit. We now need ►





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► to decide on which part of the circle you want at the top to correspond with the top of the back plate.

Choose one bolt hole and say this should be at the centre at the top in relation to the top of the back plate and cut a small groove on the edge; this is projected from the opposite side of the circle through the centre circle and past the small bolt hole. Carefully line up the mirror support on the top of the back plate, so that it is exactly in the middle; measure all around it if you are not sure. Make sure that the two grooves at the top on both pieces are in line and then mark through the bolt holes from the mirror support to the back plate below. Drill through the three marks on the back plate using an 8mm bit.

Sand all the rough bits off the two mirror cell pieces including inside the large holes, and paint both matt black.

When dry, put the cup square bolts through the holes in the mirror support so that their heads go into the rebates. Put small 6mm washers onto the bolts with nuts and tighten the nuts up to the plate, pulling the heads of the bolts firmly into their rebates. With the mirror support face down, feed the three springs and 6mm x 1.25-inch washers onto the bolts. Line the back plate up with the mirror support using the top indicator grooves and with its good face towards you.

Feed the plate onto the bolts making sure it is not jamming. Feed three 6mm x 1.25-inch washers onto the bolts and the three 6mm wing nuts; tighten them until just after you feel resistance on them. Take three self adhesive nylon carpet glides, make sure they are covering all the edges of the rebates and push them firmly over the tops of the bolt heads in the mirror support, and remember to paint them matt black when you come to paint the secondary mirror support.

Now for the secondary mirror. Get together your vent-hole off-cuts. Find one of the two centre discs from either the back or mirror support plates. They both have lines that radiate out in exact thirds and these can be used to drill out the adjustment screws on the spider hub.

Put four of the other vent off-cut discs together. They'll have central holes where the pilot drill of the hole saw cut through; feed a cup square bolt through this hole. Holding the discs together and lined up, put on a 6mm small washer and nut and tighten it until the bolt is tight.

Put the exposed bolt end into the drill chuck and tighten. Set the drill to a low gear and holding it down firmly on the edge of the bench turn it on. The top of the circles should be rotating towards you at the top. Using a gentle pressure on the rasp, wear away any excess until the four discs are

uniform. Then finish them (still using the drill) with the fine file. These four discs will be used for the secondary mirror holder. Take two more discs and place the spider hub top disc between them (to protect the face which many might look at later). Repeat smoothing them as above.

Take the best looking disc from the secondary holder and place it face down on a scrap of wood. Using the 16mm flat bit as before, rebate a 6mm hole into the back of the disc, making sure your gloves are on. The pilot hole from the hole-saw you used to cut out the discs originally should have been at least 8mm, if not re-drill the centre hole to 8mm so that the 6mm x 65mm cup square bolt can rotate with ease in the disc. This is important, to allow for the adjustment of the secondary mirror holder.

Glue the first three discs of the holder together so that they are lined up nicely. On the last disc with the bolt in, use the glue sparingly around the edge of the rebate so that it doesn't get in and glue the bolt solidly into place. Once dry the secondary mirror support should swivel freely on the hidden head of the bolt.

The spider's top disc (the one with the three lines) should be good face up and glued onto another disc below. Allow three hours to dry. Take the spider hub and mark the underside so that one of the three lines on the top is at 90° to one of the others. With a pencil, continue one of the lines down the side and then around the back of the hub, then use the set square to draw a perpendicular line across, which will be cut. This is to make sure one of the holes for the mirror adjustment screws is on one side of the supports and the remaining two are on the opposite side, but equally distant to the support, to prevent a clash.

To guide your saw cut, mark from the line on the back down both sides to 15mm, then carefully using the hand saw, cut a notch down to the 15mm mark for the 2mm aluminium spider legs. Use slow, precise gentle strokes, keeping the saw parallel to the bench-top and square to the hub.

Try the bar in the notch. It should be a tight fit without the danger of splitting the hub, so don't try to bang it in with a hammer. When you can push it in easily with a thumb and wiggle it out again with ease, is about the right grip. Because the saw cuts a notch between 1 and 1.5mm you will have to open out the notch, with slight angling of the saw blade to the slot's sides.

Once the notch is ready you need to drill the rebates around the central hole for the bent lips of the supports to fit in. Do this using a 3mm drill bit, making two holes very close together and near to the edge of the central hole. Mark the drill bit

with tape to a depth of 15mm. Use gentle sideways movements to open up the rebate and visually check the rebate is thoroughly cleared, repeat for the opposite side.

Measure across the tube from the corner edge of one strut to the diagonally opposite strut and add 26mm for the two, bent, screwed tails. Cut the bar to this dimension and then cut the bar exactly in half. File off all sharp edges and corners.

The ends of the supports need to be bent to fit in the rebates on the spider hub. The bends should either go clockwise or anti-clockwise, but both in the same direction so that they go away from one another when opposite.

Hold the bar very firmly in your 8-inch long-handled pliers so that 6mm is sticking out of the end. Fix the flat jawed adjustable spanner tight to the bit sticking out and bend it to about 45°. Try it out in the hub, it should fit so that no part of it obstructs the central hole and the bar should be able to fit all the way in so that its edge is just flush with the surface.

Fiddle about with the bar or the hub until it fits properly. Repeat for the other support. Make sure they don't obstruct the central hole and its 6mm bolt.

Bend the other ends of the supports to 45° but with 15mm projecting out from the pliers as you bend them with the spanner. When you are bending, if it is going off to one side more than the other, flip the bar 180° in the pliers and correct. The opposing bends should be in opposite directions like the centres.

Once happy that the bars are ready to fit in the holder, put a good dollop of glue on to the tongues and push them in, pulling outwards at the same time to make sure they don't obstruct the central hole. Work in lots more glue and wipe off any excess. Run a dampened corner of a thin cleaning cloth into the central hole to clear of glue. Before the glue can set, check the spider hub is square to both legs and that they run straight across the hub in both axis.

Look carefully at the diagram to study the arrangement of the fixing pins. They are positioned so that they avoid the adjustment screws while piercing the aluminium supports in two places from opposite sides of the spider. Before they are nailed in a pilot hole has to be drilled, which must be almost the same size as the pins to avoid splitting the hub or supports.

Take a 1mm drill bit and pass it at a very shallow angle to the sideways axis of the hub through the plywood until getting to the aluminium. Don't rush, just let the drill bit do the work, apply virtually no pressure on it (1mm bits snap very easily), it doesn't take long to go through as it is so small. ►



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► Regularly clear the holes by taking the bit in and out. After finishing each hole, pass the drill in and out several times to ensure the hole is completely clear. Fit one spider arm in and gently try to tap a pin into the hole. Keep tapping until it breaks through the aluminium. If it refuses, take the pin out and drill the hole a few more times to try and open the metal out a bit, but no sideways motions: the bit is guaranteed to snap. The pins will go in eventually, even if persistence is necessary.

With all the pins in, drill and countersink the two support screw holes at the ends of the aluminium strip using a 3 or 3.2mm bit. The spider will be screwed in with two 3mmx16mm screws. Then paint the spider hub, legs and holder.

### Step 6

Here we will construct the eyepiece holder and focuser. This consists of a holder, a 2-inch eyepiece drawtube, a 2-inch to 1.25-inch adaptor and a 1.25-inch eyepiece drawtube. The holder and 2-inch drawtube are both made using a Ryman's 450 Post Tube. The drawtube is a Post Tube cut to 90mm in length, while the holder is two pieces of tube cut to 70mm length, but then cut along their lengths and opened out, one wide enough to hold the drawtube, the other to reinforce the first.

Open the first and place over the drawtube. Measure the gap in the holder and cut a strip of the tube to fill the gap, err on the generous side so the fillet is not too small. Place a strip of foil 1-inch wide onto the drawtube and carefully slip the holder on, so you don't create any creases in the foil. Put a small bead of glue on each edge of the gap with a cotton bud and then gently fit the fillet into place with a bit more glue on the outer joint. Leave it to dry for two hours.

Remove the drawtube and its foil. Open up the second holder tube and glue onto the first. Measure the gap, cut a fillet to fit and glue this in. Wipe off any excess glue and tape around the holder just inside each edge and around the centre. Leave it to dry for four hours.

Then carefully cut three 9mm Post Tube rings, cut two to open and glue the first onto the 2-inch drawtube, then make and glue in a fillet, allow it to dry for one hour then glue on the second ring and fillet. These are the stop rings.

The adaptor is made starting with a 40mm diameter loo roll insert with layers of opened-out rolls and fillets glued on to build up to the thickness of the inside diameter of the 2-inch drawtube, which is 50mm. To achieve a good fit glue two layers of paper on at the end. Be careful when wiping any glue away between layers as cardboard and paper can

fall apart when wet. If they start to, just stop wiping them – any discrepancies will have to be dealt with later.

The adaptor's stop ring is a 9mm wide strip of cereal packet, slowly wound around the end of the adaptor to what looked a good thickness and glued in place. The 1.25-inch draw tube is started with a 100mm-long strip of cereal packet dry-rolled to get a tube shape developing, with snug overlaps inside and out. The tube is then glued and rolled while placing the 1.25-inch sleeve taken off an eyepiece into each end.

Adjust the tube bit by bit to make it parallel and when you are reasonably happy, tape the tube as above. After this first flimsy tube had dried (about 1 hour) I removed the tape and decided to put on a much longer strip. I think it provided seven or more thicknesses of the cereal packet but you basically have to keep going until you are close to a fit with the adaptor and then go over to paper again.

Once the 1.25-inch draw tube is finished and dried paint all the tubes matt black inside and out. A certain amount of sanding is required to even up the worst irregularities and a second coat of paint to cover the patches.

Next, find the centre of the focuser rebate on the tube and mark it with a spot. Place the end of the 2-inch drawtube over it and, looking down the drawtube, line it up so that it is centred with the spot in the middle. Draw around the draw tube to mark up a hole to cut in the rebate.

If you have a 56 to 58mm hole saw you can use it to cut the hole, if not you have to drill lots of 3mm holes all the way around the circle inside the pencil line and then using the diagonal drilling to join them up until you've cut out a very rough circle. Finish the hole using the rough P80 sandpaper, wrapped around a small circular object, and sand until you have made a clean even hole.

The hole must be no smaller than 56mm or bigger than 58mm because the 55mm drawtube (outside diameter) has to fit and move in it, while the 59mm holder has to glue on to the edge of that hole.

Once the hole is made, try turning the drawtube in it, it should be a loose enough fit to go in and out without jamming. If you find one or two parts of the circle touch the tube, mark them and carefully sand them away, until the tube rotates in the hole smoothly.

Now check that the face of the holder to be glued on is square by putting it down on the bench and offering the set square up to it. Rectify any high points using a piece of fine sandpaper taped to the bench and running the holder across it, until it is square. Glue the holder onto the edge of the hole, then tape from one corner of the assembly over

the top of the holder and around the opposite corner to hold it while the glue dries. Wipe away excess glue from inside the focuser rebate through the drawtube hole, and then see if the drawtube will clear the hole and go into the holder via the inside of the rebate (If it doesn't you'll need to move the holder a little until the drawtube fits). When this is done make sure you wipe any glue off the end of the draw tube and very gently from the inside of the holder again. Leave the holder to dry for 2 hours.

You need to cut a reinforcing ring to help the focuser holder be well fixed to the focuser rebate. Measure across the widest point of the holder, halve it and set the compass to that figure. Draw this onto a ply circle taken from a baffle, then draw another circle 10mm outside it.

Use two 3mm holes to make a slot on the inside of the inner circle, a fraction inside the pencil mark and cut out the inner circle, then cut out the ring. Clean up the ring with sandpaper and remove any excess from the inside of the hole until it fits over the holder, down to its base. If it is a loose fit you can pack the gap with card; pressing it into the hole using the blunt end of a kitchen knife.

Now the tube is finished, you move onto making the covers. There are no measurements on the 9mm plan because minor discrepancies in making the tube mean that the dimensions of both ends will almost certainly be unique to your scope. So measure the dimensions of both ends now and transfer those to the 9mm ply sheet.

If the tube is square and all the measurements are dead equal, draw up the squares so that they are 3mm bigger than the tube ends. If they're not, you need to mark a cover by putting the front and rear ends of the tube down on the 9mm sheet and draw around them so the pencil marks are exactly flush with the sides.

Cut out the 3mm strips for the sides of the covers. Two should be the same size as the tube ends, and two are overlapping and so 8mm longer. Put the 9mm squares good side down on the bench with plastic bags underneath them and with sparing use of glue put the two flush sides onto each. Next, glue on the overlapping sides and gently press at the bottoms of all the sides, to bed them in. Gently wipe off any excess glue and tape the corners, making sure the sides of the lids are square to each other and the lid. Leave them to dry for 6 hours.

Finish off by gluing felt onto the insides of the sides using contact adhesive, make sure the felt doesn't get any creases in it as you apply it or the extra thickness will stop the lid fitting. ☼

► Put the finishing touches to your telescope next month in part three.