A portable ball scope is shown mounted on a red barrel. The scope is black with a red section and a lens. It is mounted on a black frame that is attached to the barrel. The background is a wooden bench.

The \$90 Porta- **BOWL**

Plans and instructions
for an affordable, easy-to-build,
4½" f/8 ball-scope.

by Jay Scheuerle



In the sub \$100 telescope arena, small aperture refractors on shaky mounts litter the shelves of big-box stores and I'm convinced they've turned many youngsters away from astronomy before they even had a chance to learn what it was about. Since treating my nephew to one of these some years ago, I've come to believe that \$100 can go a LOT further and have since set out to find a solution that addresses every weak point in these little scopes.

The **PortaBowl** is where I eventually settled. It's a 4½" f/8 bowl-scope (a derivation of the ball-scope theme), which means the scope can essentially roll to point in any direction with no interconnected, moving parts—pure elegance! You'll find it's not that difficult to build and there's room for experimentation and personalization. I've allowed myself the assumption that the tools and fasteners necessary to build this scope are going to be part of a basic workshop, but if they aren't, they'll all be good investments. You'll find that everything can be done with hand-tools and what has to be done isn't out of the realm of an enthusiastic teenager. If you're not sure what you're doing, stick tightly to the list. If you've built a few scopes before or are handy in the woodshop, you may find some better ways of building (please let me know!), but everyone will probably want the 11" Stainless Steel Ikea bowl and the 10 lb. Walmart weight as starting points.

This build will be broken down into 4 simple sections with the parts and tools required listed under each: **1) the base and body, 2) primary mirror cell, 3) upper assembly, and 4) light management.** The adage "Measure twice, cut once" is always apropos, and though being precise is always a plus, the nature of the system is that its optics are adjustable and there is little chance that you can't adjust out any errors in the end. So, breathe easy and jump in! - **Jay Scheuerle**

Your attempting this is my reward, so please email me pics or feedback: jayscheuerle@comcast.net



Base and Body - \$22.50

Materials:

1 - 11" IKEA BLANDA BLANK stainless steel serving bowl - \$7 ((This item is not available online and I have yet to find an affordable alternative. Let me know if you do!)

1 - 10 lb. Walmart barbell weight - \$8

1 - 3' x 7/8" oak dowel - \$3.75

1 - 4' x 3/8" dowel (any kind) - \$2.50

1 - 3/4" ID PVC coupler - \$.75

2 - #4 x 1/2" round slotted screws for brace bottoms

2 - #4 x 3/4" round slotted screws for brace tops

1 - #8 x 1" flat-head screw for attaching oak dowel

epoxy

flat black spray paint

Tools: drill, small length of pipe, hammer, punch, screwdrivers, sandpaper, saw

This is the innovative heart and soul of this project. Though those terms usually apply to the optics in a system, without this inexpensive and sturdy starting point, the optics would never live up to their potential.

Let's start with the base upon which the bowl sits. No materials were listed above because many will work. What we're looking for is something that the bowl can sit in and on top of – a round ring structure on which it can move freely (plastics are good!). It should be around 6"-7" in diameter, a size which is large enough to provide stability, but small enough that its rim doesn't interfere with the optical train when the scope is near horizontal. In my example, I've used a large coffee can and the lid material works as a bearing (when cut down to a 1/4" wide ring). It's weighed down with sand on the inside to aid with stability since it's lightweight and tall. I've also used a small dog-food bowl with much success. A tiny bucket will work too. You'll probably run through a lot of materials until you find the one that gives you the best motion. It's not important to find the best base right off the bat as we're only going to be using it as a place to set the scope while we're working on it, so almost anything will work for now!

Roughen up the inside of the bowl with some coarse sandpaper to help the paint and epoxy hold better, then turn the bowl upside down and find the center (it's where all the concentric rings meet by the IKEA logo). Measure 3" down in any direction and mark this spot for where the bottom of your oak dowel is going to attach. Continue this line to the rim and then find the spot on the exact opposite side of the rim. Mark this spot on a piece of tape. Bending a ruler around the outside edge, measure 5" in either direction from this spot and make marks 1/2" down from the rim. These are the points where your braces will attach. Drill 1/8" holes for each, punching the surface first (while supporting it on the back) so that your bit won't wander. Also drill a 3/16" hole at the center pole mark, punching the surface (and supporting!) first again.

Now that we have a main hole, we need to countersink it with a dimple so that the screw that goes into the end of the dowel will be beneath the surface of the curve (we don't want it to get stuck on the lip of your base!). Find a section of strong metal pipe that's around 1/2" to 3/4" wide on the inside and clamp it in a vise facing upward (**figure 1**). Put a piece of masking tape over the end and mark the center of the pipe on here. Lay your bowl over this pipe, upside down, and line up your drill hole with the masking tape mark. Now take either a large, wide punch or a conical flat-head screw, and hammer it into this hole until a dimple is made that is deep enough for your screw head to hide (**figure 2**). Check it by inserting the screw and laying a flat edge over the dimple. If the edge clears the screw head, you're good (**figure 3**)!

You'll notice that the dimple flare on the inside will not allow your dowel to sit flat, so after drilling a 1/8" hole for your dowel screw, you'll want to take a 1/2" wide bit and widen that hole around 1/4" deep in the center (**figure 4**). Check to make sure it fits nicely around the dimple with no tipping before securely screwing it in. While you have the rod out, drill a 1/16" hole in the opposite end and cut a 45° wedge from there (starting right at the edge of the circular face) to be used as a secondary support (**figure 5**). After you have that piece, square cut the end of the main pole again.



Figure 1



Figure 2



Figure 3



Figure 4



Figure 5

Base and Body *(cont.)*

Turn the bowl right-side up and put it in its base (it will tip over if the dowel isn't vertical). Handle it gingerly at this point as the pole is not adequately supported and might bend the bowl or strip the wood if it falls over. Gently place the weight over the pole and slide it down to the bowl. Notice that the weight touches the bowl securely at the top and bottom, but clears the bowl on both sides. When we use the epoxy, we'll want to make sure that we have enough so that it's thick enough on the sides to fill in the gaps. Remove the weight and spray the inside of the bowl (where we won't be able to reach after the weight's on) flat-black. It's okay if the pole gets paint on it. After the paint dries, slide the weight back on and then rotate it in order to scrape the paint off of the bowl at the contact points. Tilt it to have it scuff all around so you can see the extent of the weight's contact. Use some sandpaper to scuff up the areas where the epoxy will fasten (**figure 6**). Take the weight off and wipe out the inside of the bowl to remove dust and paint chips. Make a large batch of extra-strong epoxy and put it on 4 spots on the rim of the weight (2 contact points and 2 sides). Make these areas around 2½" long and lay it on thick, especially on the sides. Now slide this back down the pole and properly orient your contact points. With the bowl in the base, move it so that the dowel is pointing as straight up as possible. Then move the weight so that the space between the weight and the dowel is equidistant all the way around. Hands off and let it completely dry in this position.

Once the epoxy is dry, we need to securely connect the dowel to the weight. Take the PVC coupler and taper one end of it on the outside with sandpaper or a file so that it goes from full thickness in the center down to roughly ¼" all the way around the edge. This does not have to be pretty or exact! Then cut the coupler into two cylindrical halves. Take the tapered half and cut it again so that you have two semi-circular pieces, both with tapers. Put the bowl on a folded towel on the floor and wedge these down on either side of the dowel, maintaining an even amount of space between them. Hold a small piece of wood on top of a wedge section and tap it down with a hammer. Go back and forth so that the wedges maintain even pressure. Hammer the wedges down until they can go no further (**figure 7**).

For the diagonal braces, cut two 18½" sections from the smaller dowel. You're going to need the two ½" screws to hold the braces to the bowl. I used brass ones because they contrasted nicely with the stainless, but any will work as long as their bottoms are flat. Drill ⅝" holes ½" from one end of each dowel (**figure 8**). You can round over the ends of the dowels with sandpaper if you like for a more finished look. Screw the dowels in tightly, but make sure not to strip the screws as you'll be removing them for painting and to install the mirror (**figure 9**).

The braces should naturally lean against the center pole. Line them up so that you can drill a ⅝" hole around ½" down from the top of the brace and have it pass through the center of the main pole. Do this on both sides. Use the same sort of wood-screw as you did for the bottom, but use ¾" long ones this time. Use a ⅛" drill-bit to widen the hole in the brace so that the screw's threads don't catch it. We only want the threads to catch the main pole, pulling the braces in toward it. Tighten these down with the ¾" screws and all should be sturdy (**figure 10**—ignore primary cell). You've completed the main structure! Remove the braces at this point.

You can spray-paint the inside of the bowl/weight flat black at this time. You can also use a brush, but you want oil-based paint so that it sticks to the bowl. Try to avoid getting paint on the outside of the bowl, though you should be able to clean it off with thinner or steel wool. In terms of the center pole, you shouldn't paint it at this time, except for the bottom 6" or so. Don't worry about getting paint on it, but even a single coat is going to make it harder to slide your primary unit down. You can also paint the braces at this point, but don't reattach them yet.



Figure 6



Figure 7



Figure 8



Figure 9



Figure 10

Primary Cell - \$43

Materials:

- 1 - 4 1/2" f/8 mirror set (with 1" secondary) - \$33 from meridiantelesopes.com
 - 2 - 3" x 1/4" x 20 carriage bolts - \$1.50
 - 2 - 7/8" long x 1/4" x 20 coupling nuts - \$1.50
 - 2 - 1" x 1/4" x 3/8" nylon spacers (or 4 - 1/2" tall ones) - \$3
 - 2 - 1/4" x 7/8" fender washers - \$1.50
 - 2 - 1" high, 3/8" wide, heavy-duty springs - \$1.50
 - 1 pack of 3M exterior foam mounting tape (red backing) - \$4
 - 8" x 5 1/2" x 3/4" piece of wood (a length of 1x6—which is 3/4" x 5 1/2"—or plywood is fine)
 - Same size piece of 1/8" masonite or formica (something stiff, but flexible—needs to bend)
 - 1 - #8 x 5/8" wood screw for tightening cell to pole
- wood glue

This is an easy build! First, cut off a 2" section from the end of the 1 x 6 to be sandwiched between the upper and lower layers. Use the included template (*see next page—print it out at 100%*) for both the remaining 1 x 6 and the masonite. I used finishing nails to fasten the two pieces back to back and then cut them at the same time. This makes sure your 1/4" holes line up. You can also shape the sandwiched part at this time. It's the part in the template that's shaded brown. Don't drill the larger hole at the top until after everything is assembled. After you cut these parts and sand their edges down (*figure 11*), paint them flat black as it's not so easy to get between the pieces after they're assembled. Mask off areas that will be glued later. You'll want to re-sand the sandwiched pieces after they're glued so that their curves all match, so count on repainting. When gluing, run the carriage bolts through their holes to keep the pieces aligned (*figure 12*). After the glue dries, sand the curves to match and drill the hole for the pole. You'll also want to drill a 1/8" hole at the back side of the cell unit for the screw that will hold the cell onto the pole. Repaint to finish (almost).

A word on mirrors: Though glass is durable, coatings are not. Try not to touch the surfaces and never wipe the mirrors to clean them. It takes a substantial amount of dust to hurt the views, so just cover the mirror when not in use. If you can't blow it off, don't worry about it.

Not using the springs, run the carriage bolts up and put the nylon spacers on. Put three spots of tape out towards the bolts and back pole-hole (*figure 13*). Don't remove the tape backing. Set your mirror on top of this and measure how high the mirror sits above the surface of the masonite. Add 1/16" of an inch to this measurement and cut/sand your nylon spacers down to this height. The spacers keep the washers from contacting the mirror's surface. Also fashion a small piece that will act as a lip along the back side of the mirror, between it and the pole (*figure 14*). Make sure this has the same 1/16" clearance. When gluing this piece, scuff the paint off the masonite in the area first so that the glue adheres better. With the mirror in place, mark exactly where this piece will go, leaving a small gap (just less than 1/16") all the way around the mirror between it and the spacers and the lip. Remove the mirror, glue the lip and clamp it gently. Once it dries, remove the hardware and apply final paint.

The holes in my fender washers were bigger than 1/4", so I super-glued them to the coupling nut ends. 1" fender washers have 1/4" centers, but they intrude into the primary more than I'd like. Whether you glue them or not, you should paint them all flat black (nuts and washers) now.

For assembly, start inserting the carriage bolts through the springs between the wood and masonite. Put your resized nylon spacers on. Remove the backing on the foam tape and attach the mirror (centering it between the two spacers and the wood lip), then screw on the washers and coupling nuts. Tighten the coupling nuts until the space between the masonite and the wood base is even all the way around to complete your primary cell (*figure 15*).

You can slide this down the main pole at this point until the bottom edge of the cell is around 1/4" from the bottom curve of the bowl. Center it in relation to the brace holes and put your locking screw in on the back. Paint the rest of the pole black, either with a brush or by thoroughly masking off the bottom of the scope before spraying. Attach your braces and the main unit is complete.

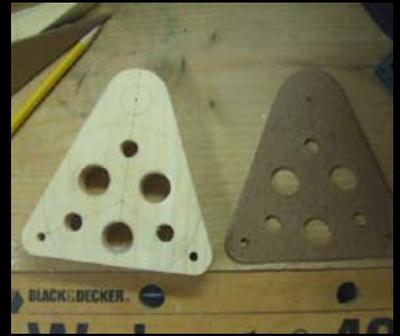


Figure 11



Figure 12



Figure 13

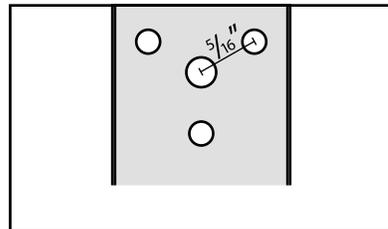
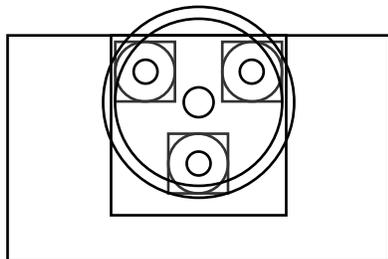
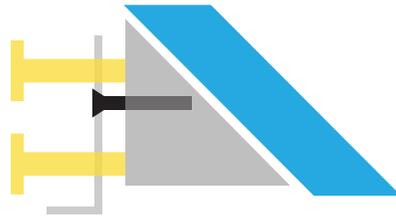
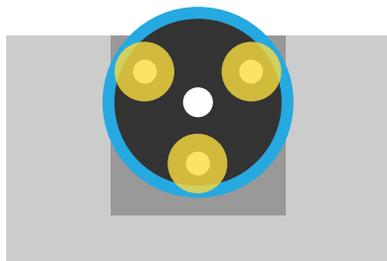
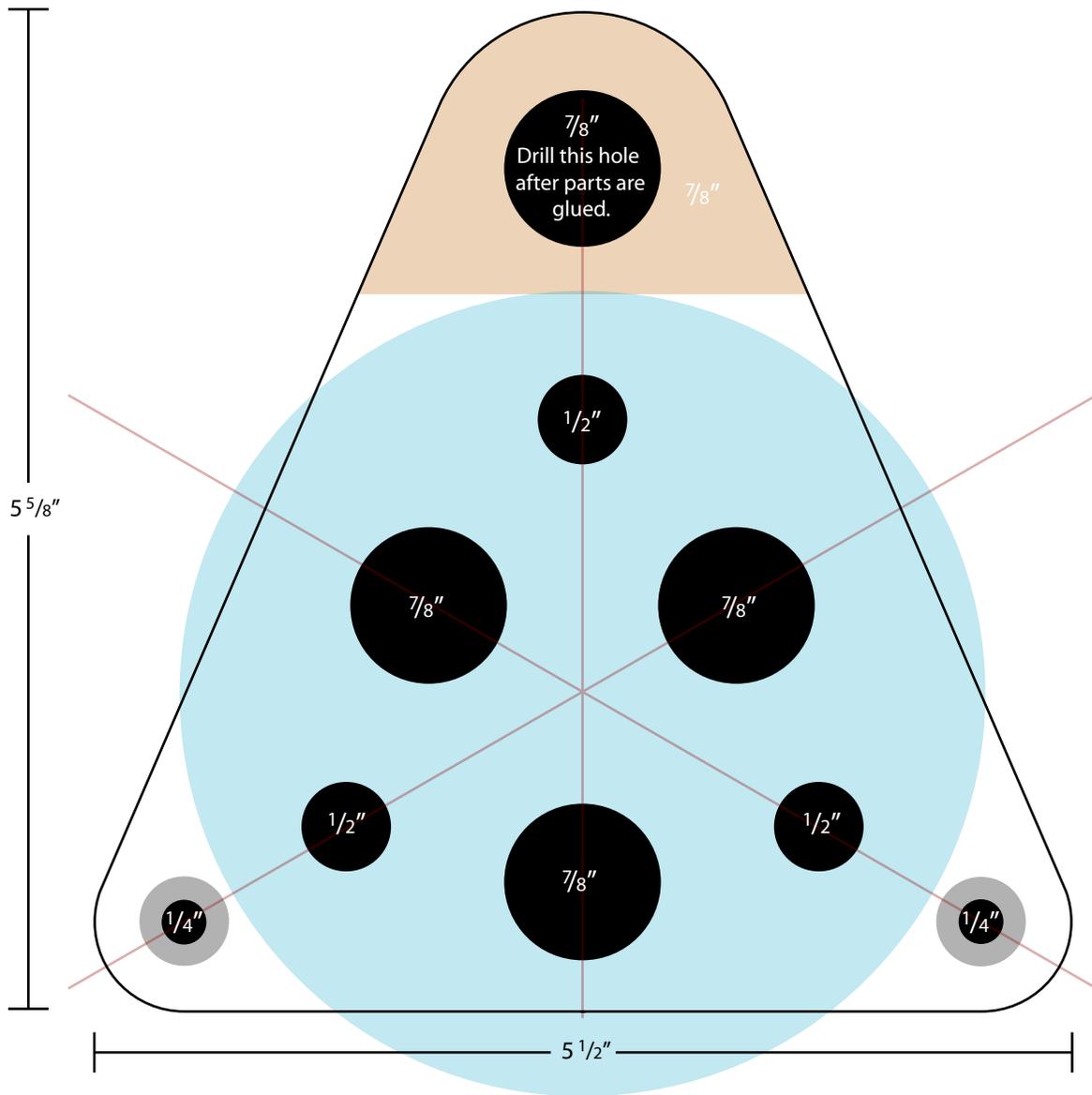


Figure 14



Figure 15

Primary Cell & Secondary Templates - 100%



Upper Optical Assembly -\$18

Materials:

- 1 - 1½" x 6" sink tailpiece (plastic) - \$2
- 1 - 1¼" extension tube (plastic) - \$2.75
- 1 - Staples iZone 12" aluminum ruler - \$3
- 3 - 8-32 x 1" brass plated lamp screws for secondary collimation - \$.75
- 2 - 2½" x ¼" x 20 flat head screws for mounting finder - \$.50
- 1 - Daisy red-dot finder - \$9
- 1 - 1¼" EP - you can find inexpensive ones at www.escience.ca or www.owlastronomy.com
- 1 - 7" long length of 2 x 4 cut down to 2" wide for focuser beam
- 4 - #6 x ½" round head screws for attaching spider to focuser beam
- 1 - #6 x ½" flat head screw for attaching secondary wedge
- 1 - #8 x 1" screw for securely affixing focuser beam to main pole

Take the 7" x 1½" x 2" piece and draw a center-line down the 2" side. Mark a spot 2" from the end. Using a 1½" hole-cutting drill-bit, go all the way through this piece. On the end of this piece, closest to this hole, mark the dead center and then drill straight through to the larger hole with a 7/8" bit (**figure 16**). Add a 1/8" hole on one side, ¾" up from the drilled end and centered, for when you want to attach this piece firmly to the pole with a wood screw. This is the basic structure for your upper end. Pick a top side where your focuser will go. The finder will go along one of the edges of the long end. Which side is a personal preference, so imagine switching from looking through the focuser to looking through the finder before you commit. The screws for the finder are angled at 45° for easiest viewing and since you'll want both of the angles to match as closely as possible, make a jig for the two holes and space them 1½" apart (**figure 17**). Put them close to the far end so that you won't bump it with your head. Drill the holes 3/16" so that you can tap them for the ¼" x 20 screws to which the finder will attach like a dovetail (**figure 18**). If the 45° holes are too difficult for you to drill, you can put them on one of the sides, but usage will be more awkward.

The focuser is a simple slip one. First, cut the threaded part off of the extension tube, leaving around 1 1/8" of the wider part remaining. This will be where you insert your EPs. It's a good idea to tap a hole in the side of this to lock in your EPs with a nylon thumbscrew, but it will work fine without one as long as your focuser never faces down. Wrap the upper 3" of the thinner part of this tube with a napkin and slide it into the tailpiece's lipped end. From this outer tube's lip, measure down 3". Cut through both tubes together at this point. Sand down all cut surfaces to remove burrs. The inside of both tubes needs to be painted flat black with an oil-based paint. Do not paint the outside of the inner tube as this needs to be as smooth as possible. When paint is dry, cut 3 - ¼" wide strips of foam tape (3" long) and run them lengthwise down the inside of the wider tube. Keep the backing on as this will act as a bearing for the focuser (**figure 19**). Carefully slide the smaller piece inside of the larger, making sure not to pull back the tape backing. Your focuser is complete.

For the spider/secondary support, we're using an aluminum ruler (see p. 9 for a simpler variation), as these are thicker than steel (which we need to hold threads) and lighter (as we want to keep the weight down). Make all your marks and drill/tap all your holes first while it's flat as this makes it much easier! There is a basic 100% layout on p. 5 with the primary cell template. Some instructions might not quite match the pictures (as I've learned the hard way) and am passing the better approaches on to you! Following the template, drill all your holes for the secondary center support (5/32") and the 3 collimation screws (9/64") (**figure 20**). These 3 will need to be tapped for the 8-32 lamp screws. You can use other screws, but these have knurled ends that allow you to use your fingers instead of tools. Socket cap screws can work too as they are easy on the fingers. The center hole is large enough for the screw to be able to tilt from side to side, but not so big that it slips through. When hack-sawing the slits, the area we're leaving uncut is ¼" wide. Don't go past this because we really don't want it any thinner. If you're not comfortable with tapping the aluminum or the following steps concerning bending the center tab, I've included a combination aluminum/wood version of the spider/secondary support at the end of this section.



Figure 16



Figure 17



Figure 18



Figure 19

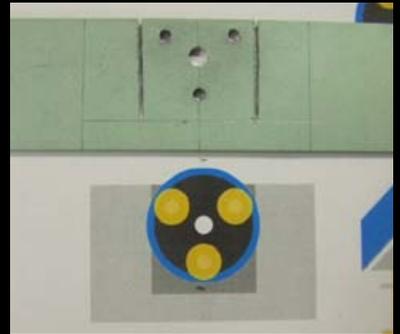


Figure 20

Upper Optical Assembly *(cont.)*

Bend your spider by centering it over your focuser beam, making sure it's running perpendicular (use a square), clamping it down tight and folding over each side (**figure 21**). You can use a mallet to sharpen the corners after bending (**figure 22**). Slide the spider down to the end so that the center tab is hanging all the way off. Take another piece of wood and lay it over the ¼" strip that's remaining on the beam and clamp it down tightly. Now bend down the tab at a sharp angle. You can use a narrow piece of wood to push against the tab and again to tap it flat with a small hammer. It's important that you get this as close to 90° as possible.

Time to attach the secondary! Using the 45° wedge you cut off in the beginning, attach the secondary to this face with the foam tape, making sure to center it. Run the center wood screw through the spider and into the wedge until there's just ¼" of space remaining. Insert your collimation screws and tighten evenly (**figure 23**). **Note: newer secondaries from Meridian have a 45° holder pre-attached. Adjust plans as necessary.**

Figure the placement of the spider relative to the focuser beam by visually centering the secondary through the focuser hole (**figure 24**). Make sure your spider is perpendicular to the beam and that both sides are the same distance from the end of the beam. The distance from the beam to the center of the mirror should be 2¼". Mark the spider for cutting off the excess material from the end of the legs and mark the beam for placement. Remove the secondary to protect it, trim the spider, clean up the edges and return it to position. You don't want screws to intrude into the focuser hole, so take care in finding safe locations for them before you drill your spider and beam (**figure 25**). Clamp the spider in place, checking all measurements and angles. Drill your smaller holes (7/64") through the spider and into the beam (**figure 26**), then drill larger ones (5/32") that only go through the spider (**figure 27**). You want your threads to clear the spider but hold onto the beam so as to hold it tight. When all holes are drilled, you are done with the construction phase! Check for fit and then move on to finishing.

Do any sanding of spider and beam, and shape the ends of the beam as you like. Paint your spider flat black. Paint the wedge and the secondary sides and back flat black, using a brush to make sure that no paint gets on the face of the mirror. Use flat black on the focuser beam as well, except for the front face. Have some fun on that side!

When all is dry, insert the wider focuser tube into the focuser hole. It should be a tight fit. Place the beam black side down on a table and push the tube down until it is hitting the table. If it's too tight to push through with your hands, place a small piece of wood over the tube and tap it with a hammer until the bottom is flush. Insert your finder screws until their heads are the same height and they are deep enough to be stable. Attach your secondary and then screw your spider to the beam. Put the finder on and insert the inner focuser tube and this end is done! You can place it on the pole to check for fit.

The next step is to trim the center pole to the correct height for your EPs. You'll have around 2" of focuser travel. If you trim the pole to a length that brings the neighbor's house into focus, you will not be able to achieve focus on the Moon, and there's no easy way to add a couple of inches back onto the pole once you've cut it off. A safe length to start with is to measure from the top of the primary cell (not the mirror face!) and mark 29" up the pole. Trim here.

At this point, we need to address aligning the optics (collimation). I suggest looking online for more detailed information, but here's a starter: 1) Looking down from the top of the scope, twist your focuser beam so that the secondary lines up with the primary (ignore the reflections). Lock it down with the screw on the side. 2) With the focuser tube pulled out as far as possible, look down it to the secondary. Make sure the secondary is centered in the tube. You can adjust it in one direction by loosening or tightening the center screw of the secondary or bending the spider to one side or the other, but if you built it correctly, you should be very close to center. 3) Adjust the secondary so that you can see the reflection of the primary mirror centered in it. Do this by rotating the secondary via the center screw and adjusting the tilt with the 3 screws (this gets easier with practice!). 4) Adjust the primary with the two coupling nuts so that the reflection of your eyeball/focuser tube is in the middle of the mirror when looking through the focuser tube. You can get more accurate results if you put a small hole in the center of a 35mm film canister (if you can find one!) or a prescription bottle and insert that into the focuser first, but you should be close enough just by eyeballing it on an f/8 scope.



Figure 21



Figure 22



Figure 23



Figure 24



Figure 25

Upper Optical Assembly *(cont.)*

Put your EP in the focuser and by pushing/pulling while twisting, try to get the moon or stars into focus. You'll likely find that it gets sharper as you push it in, but it stops before it hits focus. If that's so, remove the focuser beam, trim $\frac{1}{2}$ " off, reassemble and recollimate. Check it again and repeat until your EP comes into focus. You may find that different EPs focus at different levels, so you can trim again if necessary. The further out the focuser tube is, the more chance there is for movement and that will affect the quality of your views, so don't trim any more than you need. When you are satisfied with the pole's length, position your focuser beam correctly and tighten it down. You can also attach and adjust the finder so that it aligns with the view through the focuser.

Simpler Spider

I've included a simpler version of the spider/secondary support that doesn't involve tapping aluminum or making the more difficult tab bend in the original piece. You will need to either get a small $\frac{1}{4}$ " thick piece of wood or to cut a $\frac{1}{4}$ " thick slice off of the side of a 2x4. It's important not to have an end cut as we want the grain running across the face of the piece.

Draw a 1" circle, $\frac{1}{8}$ " from the edge of the piece and then make perpendicular lines from the edge to each side of the circle. Using the template from p. 5, mark the points within the circle for where the 4 holes will be drilled (3 collimation screws and 1 center screw). Then drill a $\frac{9}{64}$ " hole at each of these points. Using a $\frac{1}{4}$ " bit, widen the center hole, leaving around $\frac{1}{16}$ " at the bottom (**figure 28**). This allows the center screw to sit deeply and be able to tilt. You can take your 8-32 lamp screws or socket caps and tap them into the collimation holes. "Tapping" wood can simply mean screwing machine threaded screws into a smaller hole, which may take a little force to get started. You can use taps if you have them. For this version, using the socket caps or even phillips head screws might be a better idea as the wood tends to grip harder than the aluminum will. Trim out the "U" shaped piece and sand to shape. Do not round over the edges on the flat end.

You'll still be using the ruler you bent around the focuser beam, but instead of cutting a tab and bending it, you'll be fastening the wood piece to the inside edge, flush against side. Because you won't be tapping the ruler in this simpler spider, feel free to substitute a thin stainless one if an aluminum one isn't available. Mark the center of the spider along one side and then make a mark on either side of this $\frac{3}{8}$ " away. From these points, drill $\frac{7}{64}$ " holes $\frac{1}{8}$ " in from the edge. It's important that these holes are as accurate as possible. Lay this piece on a table with the side with the holes on it nearest the table face. Take your wooden piece and center it behind these holes. Either mark the wood through the holes to drill, or drill directly into the wood using the holes as a guides (**figure 29**). After the wood is drilled, you'll need to widen the holes in the spider so that the threads pass without catching. Use a $\frac{5}{32}$ " bit for that. It will be tight, but if you were careful with placing your original holes, you'll be fine. Use 2 - #6 x $\frac{1}{2}$ " round head screws (just like the ones that will be used to attach the spider to the focuser beam) to fasten these pieces together while supporting them on the tabletop (**figure 30**). From here, proceed to attaching the secondary and finding the proper position for the spider.



Figure 26



Figure 27

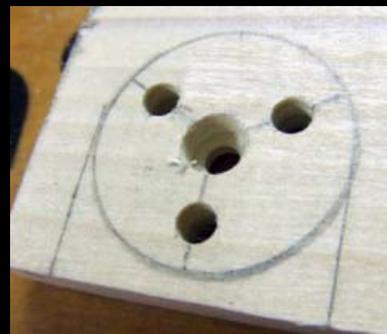


Figure 28



Figure 29



Figure 30

Light Management -\$2

Materials:

1 - 12" x 18" piece stiff black felt - \$2
an old CD or DVD
foam tape
electrical tape
flat black spray paint

Now that you have a working scope, we want to make it work better! The most obvious problem is that you can see light from behind the secondary. This kills your contrast, introduces glare, washes out your views, etc. It's unacceptable! Take the CD, place it in the corner of the felt, and use it as a template to trim out a circle of felt. Spray-paint the felt flat black on both sides, two or three coats. This not only makes the felt slightly darker, but also helps protect it from dew. Put two pieces of foam tape on the back end of the spider (*figure 31*) and fasten the felt to the face of this, taking care to center it directly behind the secondary mirror, which is offset from the spider's face (*figure 32*). Don't center it on the spider's face! A quick look through the focuser will tell you this is a valuable modification.

Take the CD and put a piece of tape over the center hole and spray paint it black on both sides to use as a cover for your primary. It will fit perfectly on top of the washers and lip on the primary cell.

We can also take the remaining felt and make a light/dew shield for the primary mirror. Using a flexible tape measure, get the distance from the edge of the bowl where the brace connects, over the top of the main pole, and down to the other brace. This is the maximum width of your shield. Trim the felt along the long edge on the side where you did the CD cut-out so that the piece is this maximum width. You can now fold this in half lengthwise, not creasing sharply, but just putting a soft bend into it. Now lay this over the pole and slide it down until it touches the top of the primary cell. Use masking tape on the felt to mark the line of the braces on either side (*figure 33*). You'll want to cut the felt so that its edge runs down the middle of each of the braces (*figure 34*). Once cut, run a length of black tape down each of these sides, taking care not to stretch the tape. Trim the ends to line up with the felt. Lay the shield back in place and fold over the tape around each of the braces (*figure 35*).

At this point, you're done! You may find yourself playing with base materials to get the best motion or adding a handle near the center of gravity to ease in carrying. If not, carry vertically by grabbing the length of pole above the braces. Don't carry it by grabbing the edge of the bowl as you might cause uneven stresses that leads to the weight pulling away from the bowl.

A word on EPs: They have an incredible price and quality range, but if you're going to start off with just a few simple ones, a 15mm Plossl will allow you to see the entire Moon and some wider fields of stars (60x). A 6.5mm Plossl will probably give you as much magnification as your scope will handle on most nights (140x) to use on planets and double stars.

For general information about telescopic astronomy and more, check out the best forum on the web at CloudyNights.com. You'll find that any questions you have will be enthusiastically answered, though you may find yourself catching something called "aperture fever."

Updates to this document will be published as necessary and will be noted at the bottom of the first page as edition numbers. They can be found at:

<http://home.comcast.net/~jayscheuerle/PortaBowl.pdf>

– or hopefully by searching for **PortaBowl Telescope**. If you've found this useful, please pass it on to anyone or group you might think will be inspired! - j

WARNING: Never use this scope to look at the sun. It will act like a magnifying glass and fry the back of your eye like an ant on the sidewalk, causing permanent damage.

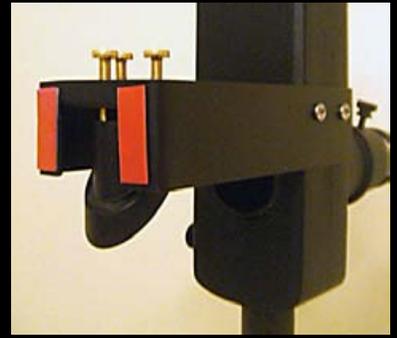


Figure 31

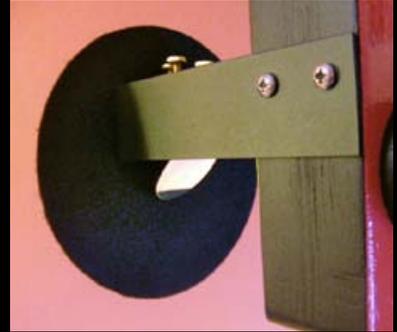


Figure 32



Figure 33



Figure 34



Figure 35

Revisions and Upgrades

With usage comes knowledge and inevitably you notice shortcomings with even the most carefully thought out projects. If it's a change in the build, it will be rectified within the plans, but I'll list minor tweaks and observations here.

- The electrical tape that holds the light shield on will eventually peel away from the felt at the edges. Black paper tape doesn't do much better. Alternative options could be long strips of foam tape, silicon adhesive or high-tack spray mount (masked to the edge of the foam), but these don't allow for easy removal. Let me know what works for you!
- The coffee can base has two problems. The first problem stems from the bowl not being perfectly hemispherical (it's flatter towards the rim), so it rocks in the base at lower altitudes. To fix this, I modified the circular bearing to contact in 3 specific points by cutting 3- .25" wide by .75" long pieces of thin cardboard, folding them over twice and setting them on the edge of the can directly above the feet (*figure 36*). The bearing rim then snaps on as usual, but will be slightly higher at these points.

The second problem is that the base can end up rocking on some surfaces. What it really needs is three feet. I tried some small pegs just inside the rim of the can, but that made it tip too easily. Instead, I made 3-6" long legs out of some 1½" wide x ¾" thick scrap (*figure 37*), screwing them into the can from above (*figure 38*). The lip on the can will give the legs enough angle so that they only rest on the tips (*figure 39*).
- Though generally well-balanced, I found that my top end was a little light when using my smaller eyepieces. I found that 1"(ID)x 2" galvanized pipe nipple, with a ring of velcro fuzz at each end (*figure 40*), will slide onto the pole with enough friction to stay put. Though I bought 1½", 2" and 2½" sections to test, the 2" (\$1.88) worked best (and I returned the other two).
- The most recent mirror package Meridian has sent out has a secondary attached to a holder (*figure 41*). This should make construction easier, but please let me know if this alters the plans otherwise.
- If the screws that the finder attaches to are not set deep enough, they can end up wobbling and eventually break the wood. I'd recommend drilling a 1½" deep hole and tapping as deep as possible.

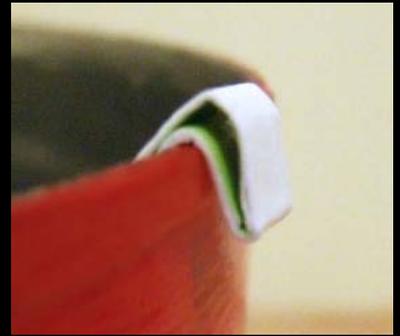


Figure 36



Figure 37



Figure 38



Figure 39

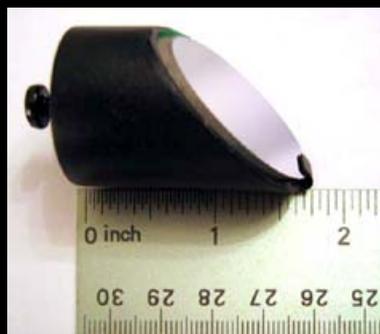


Figure 41



Figure 40