

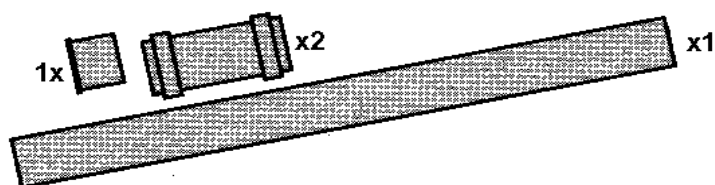
## The Plumber's Telescope

Kit for an astronomical refracting telescope with a magnification of 30 that only needs some cheap 40mm plastic pipes from your local DIY store for completion.

- Objective lens: Achromatic glass lens, 40mm diameter,  $f=450\text{mm}$
- Eyepiece: Plössl type, 15mm diameter,  $f=15\text{mm}$
- Adapter for a standard photographic tripod
- Nearly indestructible plastic pipes
- Shows Moon craters, phases of Venus, moons of Jupiter, etc. with a magnification of 30
- Easy to assemble

Shopping list for the DIY store:

- 1 piece of waste pipe, 40mm diameter, about 430mm long, preferably black, e.g. Marley (B&Q) (for the telescope tube)
- 1 push fit socket plug, 40mm (1 1/2"), e.g. Wickes SKU431912 (for the eyepiece)
- 2 push fit couplings, 40mm, preferably black, e.g. Marley WPC4BX (B&Q) (to hold the objective lens and the eyepiece)



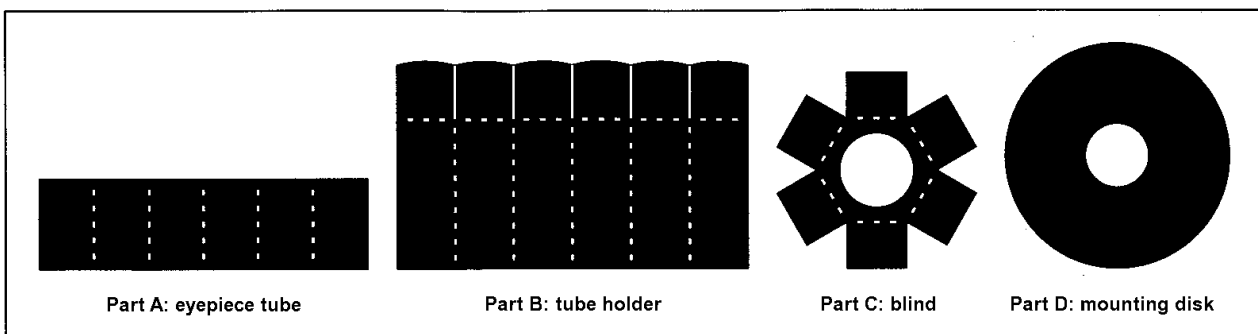
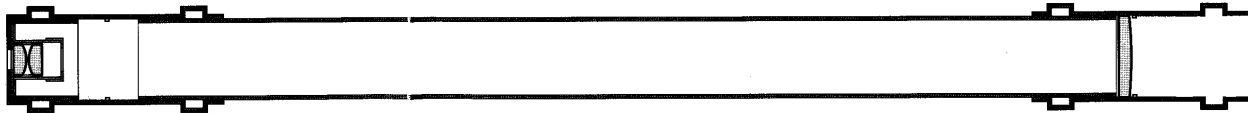
The telescope was invented in 1608 by a Dutch spectacle maker. He held a concave lens (used for short-sightedness) in front of his eye and a convex lens (for far-sightedness) towards an object. With the correct distance between the lenses he could see a magnified picture of the object. Galileo Galilei was the first person to use a telescope for science in 1609. His telescope design has the advantage of an upright picture but also the crucial disadvantage that the field of view becomes increasingly smaller with increasing magnification. This is the reason that today all astronomical refracting telescopes are built according to the design of the great mathematician and astronomer Johannes Kepler. In 1611 he described a telescope that uses two convex lenses which allows high magnifications with the field of view staying the same. The picture is upside down but that is of course no disadvantage for astronomical observations. This "Plumber's Telescope" uses Kepler's principle too but with high quality achromatic lenses of which Kepler wouldn't even have dreamt. The colour correcting properties come from the combination of two lenses with different refractivity which are cemented together to form one achromatic lens. Each of the parts on its own would have great chromatic errors, in combination though these errors cancel out.

This kit contains:

- 1 achromatic lens, 40mm diameter, 450mm focal length
- 2 achromatic lenses, 15mm diameter, 26.5mm focal length, to build a Plössl eyepiece with 15mm focal length
- 4 pre-cut pieces of black cardboard
- 1 tripod adapter
- 1 assembly instructions

What you need for completion:

- 1 piece of waste pipe, 40mm diameter, about 430mm long, preferably black, e.g. Marley/B&Q (for the telescope tube)
- 1 push fit socket plug, 40mm (1 1/2"), e.g. Wickes SKU431912 (for the eyepiece)
- 2 push fit couplings, 40mm, preferably black, e.g. Marley/B&Q (to hold the objective lens and the eyepiece)
- a small hacksaw to shorten the waste pipe to the correct length
- drill and drill bits to drill the 10mm hole of the eyepiece (you can also use a nail or a small cross headed screw driver to open the hole and then widen it with a pair of scissors).
- sticky tape (Sello tape) for the eyepiece
- strong sticky tape (gaffer / duct / insulation tape) to fit the telescope to the tripod adapter
- solvent-containing all-purpose glue (not water based)
- sharp knife (scalpel or small carpet knife)
- a piece of fine grade sandpaper to smooth the cuts



## Assembly instructions

**Please always read completely through each step before commencing.**

### A. The objective lens tube

The objective lens (or combination of lenses) is the one pointing towards the observed object, the one through which the light enters the telescope. It fits just over the end of the waste pipe and is secured in place with one of the push fit couplings.

#### Step 1:

Cut the waste pipe to  $430\text{mm} \pm 2\text{mm}$  using the hack saw. To get a nice straight line at the right length, wrap a piece of paper around the pipe and mark the line to cut with a pencil along the edge of the paper. Cut all around the line, not just straight through from one side. Smooth the edge of the pipe with sandpaper. This end of the objective lens tube will be the end holding the eyepiece. Stand the tube with the cut end down on the work surface.

### Step 2:

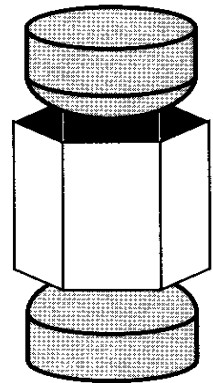
Now place the objective lens on top of the tube with the greater curved side facing upwards. Take care never to touch the surface of the lens, only handle it by its sides. From the side you can see that the lens is made from two single lenses. The thinner one of these two has to face upwards. Now carefully fit one of the couplings over the lens and push it firmly down until it holds the lens tightly in place. This finishes the construction of the objective lens tube.

### B. The eyepiece

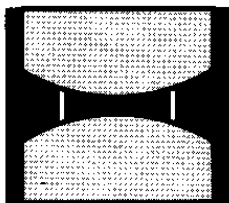
The eyepiece is the lens (or combination of lenses) through which you look with your eye. The Plössl eyepiece was invented in 1860 by the Viennese optician Simon Plössl. It is one of the best eyepieces available because it produces a fully colour corrected and sharp image with a large field of view. It is made from two identical achromatic lenses that are mounted in a short tube with their rounded sides facing each other.

### Step 3:

Remove Part A (eyepiece tube) from the black piece of cardboard. Don't tear it out, use a sharp knife or scalpel to cut the remaining bits that retain the part in the cardboard. Crease and fold Part A to form a hexagonal tube, connecting the ends with a piece of sticky tape. Put the two eyepiece lenses with their flat sides down on a clean work surface. Try fitting the tube over one of the lenses and check that it holds the lens when you pick it up. If not, bend the six sides slightly inwards. Take the lens out again. Put a small amount of all-purpose glue on all sides of the inside of the end of the tube. Distribute the glue evenly and

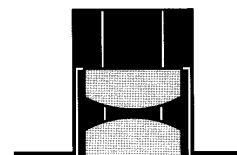
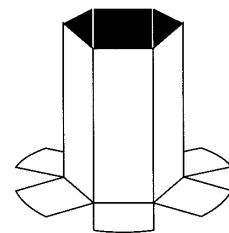


avoid any drops or glue strings. Then carefully fit the tube on the lens again so that the edges stand squarely on the work surface and the lens is glued into the tube. Do this very carefully so that no glue gets onto the lens surface. After the glue has set, glue the other lens into the opposite end of the tube, following the same procedure. Now the two curved sides of the lenses face each other inside the tube with a distance of about 1mm. With this your Plössl eyepiece is finished. It now needs a holder to fit it into the telescope.



### Step 4:

Remove Part B (tube holder) from the cardboard, again using a knife to do so. Crease and fold it to form a hexagonal tube and connect the ends with sticky tape. Fold the six tags outwards and check that the eye piece fits snugly into the holder. Put a small amount of glue evenly around the inner side of the end with the tags, again without drops or strings. Push the eyepiece into the holder from the tag side and slide it into place by pushing it onto the work surface so it is flush with the six tags.

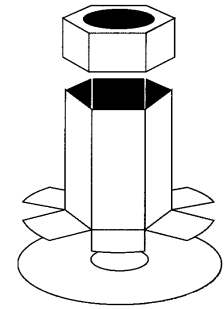


### Step 5:

Open the 11mm central hole in Part C (blind) using a sharp knife and then remove the part from the cardboard. Fold the six tags backwards and glue the part onto the end of the holder, opposite the eyepiece.

Step 6:

Open the 10mm central hole in Part D (mounting disk) using a sharp knife and then remove the part from the cardboard. Glue the eyepiece holder centrally onto the disk using the tags so that the eyepiece lens is exactly over the hole. Now the Plössl eyepiece is ready to be mounted in the eyepiece holder.



### C. The eyepiece holder

The eyepiece holder is the piece of tubing that holds the eyepiece and needs to slide on the objective lens tube for focusing. Unlike on other telescopes, the eyepiece holder slides OVER the objective lens tube.

Step 7:

Drill or file a 10mm hole into the exact centre of the socket plug. The material is quite soft, so if you don't have a drill, you can use a small cross-headed screw driver to make a hole and then enlarge it with a blade of a pair of scissors. It doesn't matter if the hole is a bit bigger than 10mm. Use the sandpaper to smooth the hole and then roughen the inside of the plug to provide a good base for the glue. Remove all dust and loose plastic bits.

Step 8:

Apply a generous amount of glue onto the disk holding the eyepiece and fit it into the socket plug so that the hole in the disk sits centrally over the hole in the plug. Again take care that no glue gets onto the surface of the lens. After the glue has set, push the plug into the second push-fit coupling. This finishes the construction of the eyepiece holder.

### D. The final assembly

Step 9:

Remove the rubber seal from the open end of the eyepiece holder. Then fit the eyepiece holder on the open end of the objective lens tube. See if you can focus on a distant object by moving it in or out. If not, you will have to shorten the objective lens tube by a few more millimetres. Since the focal length of the lenses can differ slightly and the adjustment also has to compensate for spectacles, each telescope has to be adjusted individually.

Step 10:

If the eyepiece holder moves too easily, a few strips of sticky tape can be applied to the tube to increase its diameter.

Step 11:

Lastly fit the tripod adapter to the tube with some strong sticky tape. If you want to improve the properties of your telescope, you can fit a rolled-up piece of black carton inside the objective lens tube to reduce light reflections.

**Congratulations, you finished your Plumber's Telescope!**

**We wish you good luck for your “First Light” (as astronomers call the very first use of a new telescope).**