Constructing a Newtonian Achromatic Refracting Telescope

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These are plans to construct a Newtonian achromatic refractor telescope with a 70-mm aperture and an 800-mm focal length (f/11). This telescope is mostly for astronomical use because the image is inverted. Even so, this telescope is very useful to observe the moon and planets, many binary stars, and brighter nebula. Under ideal atmospheric conditions you should be able to use magnifications up to 140 times before the image becomes too dim to distinguish details. Also included are plans for a 26-mm focal length Super Plossl eyepiece which, when used in the above telescope, will produce an image magnified by a factor of 30. This is also a rugged instrument that should require almost no maintenance at a very minimal price. Should it ever be in need of repair, parts are readily available, inexpensive, and easy to replace.


Homemade telescope mounted on commercial tripod

The dimensions of this telescope are dictated by the characteristics of the objective lens. This particular lens fits almost perfectly into a 3" schedule 40 pipe. Such pipes and their fittings are readily available at hardware and building supply stores. There are two main materials of which such pipes and fittings are constructed: ABS and PVC plastic. The ABS has several advantages: it is black in color, and light in weight. ABS may be more expensive, depending on your source. Either material or a mixture will do in this context since the telescope need not be watertight and is held together by screws instead of cement. Both are also very rugged. Their main use is for drain/waste/vent (DWV) plumbing in buildings. The most complicated part of this design is the focusing mechanism so let's start with the observer's end.

Step 1: One of the simplest focusing mechanisms is a draw-tube design. One can be constructed by using 1" diameter tubing about 12" in length (part 2) held in place by a short length (1" to 3") of 1-1/4 inch tubing (part 3). The focusing tube (part 2) should not be any longer that 12" if it is made of schedule 40 (thick wall) tubing or 13" if it is made of thinner PVC. If this tube is longer than the above dimensions it will interfere with the light coming from the objective lens. A little shorter, say 10", should also be good but may not accommodate some of the longest focal length eyepieces. The fit of the 1" tube in the 1-1/4" Schedule 40 tubing is not perfect (and may depend a little on the manufacturer). A little adhesive-backed felt placed in the 1-1/4" tubing should provide an excellent fit – tight enough to hold heavy eyepieces without slipping but loose enough to be moveable with a slight twist and pull or push. The felt strips (part 4) should be cut to about a half of an inch (1 cm) width and be just a little longer than the short piece of tubing. The felt strips should be applied evenly around the inside of the short tube.


Step #1

Step 2: The next step is to couple the 1-1/4" tube (part 3) to the main telescope tube (part 7), which is 3" in diameter. Unfortunately a direct coupler does not seem to be readily available but can be constructed from a 1-1/4" x 1-1/2" bushing (part 5) inserted into a 1-1/2" x 3" coupler (part 6). Insert a #4 x 3/8" sheet metal screw (part 12) through the small end of the coupler and into the bushing and 1-1/4" tube to keep them from separating. To prevent the draw-tube from unwittingly being pulled out of the telescope, you may

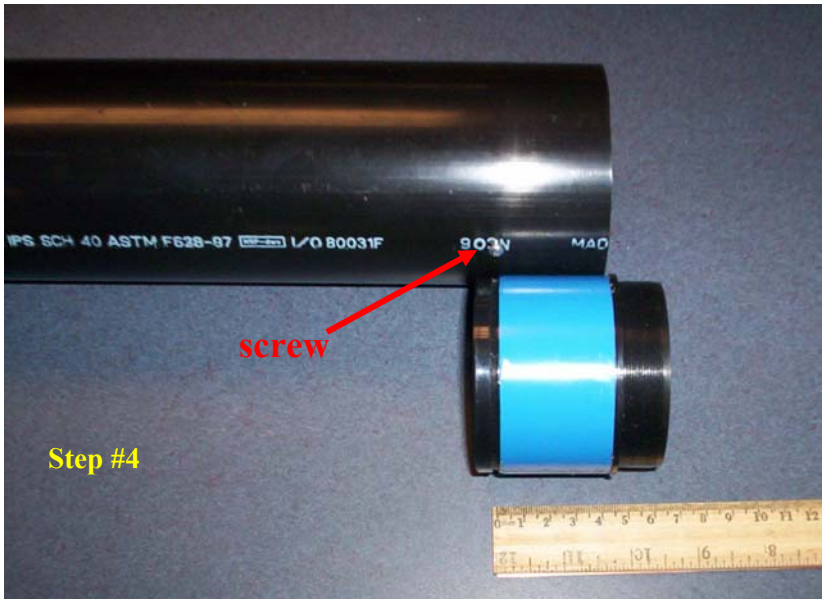

Step #2

want to place a small sheet metal screw (part 13) at the very inside edge of the 1" draw-tube.

Step 3: A 1" x 1" coupler (part 1) on the end of the focusing tube will provide a holding mechanism for an eyepiece. The coupler has an inside diameter of just over 1.25 inches which means it will also hold a standard commercial eyepiece. The coupler/eyepiece holder should be fitted with a

#6-32 x ½-inch pan-head screw (part 11) as a lock screw. Drill and tap the coupler to hold the screw. If you are going to use commercial eyepieces, insert some felt or 2-mm craft foam inside the coupler for a better fit. This could be done either permanently or temporarily as the felt and foam both come plain and with an adhesive backing. Keep a little strip of the foam with your eyepieces or the telescope for just such a purpose. This completes the focusing assembly.

Step 4: The main body of the telescope is a two-foot length of 3" diameter tubing (part 7). The objective lens (part 8) should fit snuggly in this tube. If necessary, wrap the body of the lens housing with one to three turns of 2" wide electrical tape to prevent any wobble. Insert the lens assembly into the tubing all the way to the rim on the lens housing. Lock the lens in place with one or two #4 x 3/8" sheet metal screws (part 12). Place the screws exactly 4 cm from the end of the tubing. If you are careful and a little lucky, the screw tips will come through the tubing exactly in a gap in the lens housing. This will not damage the housing itself. This will avoid any stress to the lens



housing and, should you ever need to disassemble the achromatic, the threads in the housing will not be damaged and disassembly will be easy.

Step 5: To protect the lens and provide a dew shield, place a threaded (on one end) 3" female adapter (part 9) on the lens end of the main tube. If a "toe saver" drain plug is used, the telescope can stand on its lens cap.

To complete assembly, add a garage door handle (part 14) to the top of telescope. Pick a handle that is constructed so that it is formed in a tube where you grasp it. Be careful to align it along the length of the telescope. The telescope tubes have writing imprinted along their length, which can be used to align the handle. With this type of handle and proper alignment, you will not only have a convenient way of carrying your telescope but a finder sight as well.

Step 6: On the bottom of the telescope, a threaded insert (part 15) can be added. Be sure this has a ¼"- 20 thread so that almost any camera tripod will support your telescope. Also a dimple can be added along the length of the main tube just beside the threaded insert so that the alignment pin that most tripods have will lock into you telescope. Also be careful to put the insert at the balance point of your telescope.

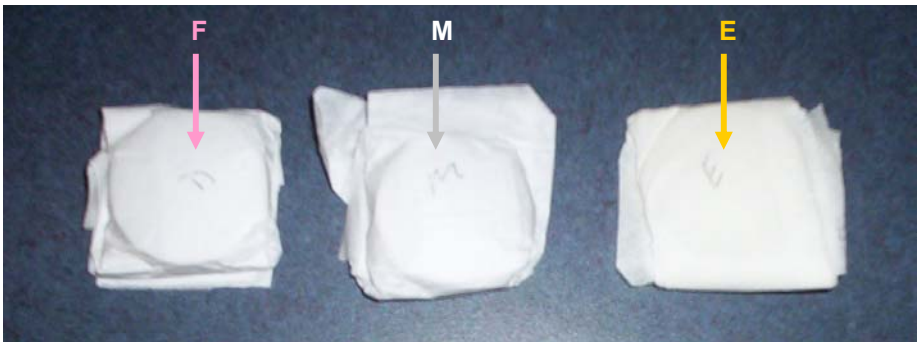
To find the balance point, fully assemble your telescope (the only thing left is to put the focusing assembly on). Place an eyepiece in the holder and focus on a distant object. Now rest the telescope on a flat level surface and move a pencil under it until the focused telescope balances on the pencil. This is where you should drill for the threaded insert. Before drilling, disassemble the focusing coupler from the main tube. This may be a bit difficult because of how tight the fittings are. Two strap wrenches will help with this process. Drill the holes, screw the ¼ -20 insert into the tube and clean out the main body. Replace the focusing assembly and lock it and the dew shield (part 9) onto the telescope body with #4x3/8" sheet metal screws (part 12).

Step 7: Every telescope needs at least one eyepiece. One good option is a super plossl design with 26 mm focal length (part 16). Surplus Shed sells such a kit for $6.50. This type of eyepiece works very well with most types of telescopes and offers a good field of view. This kit consists of three lenses, two acromats and one simple lens, usually all of the same diameter but different

thicknesses. Unfortunately the diameters will sometimes vary, depending on the source. In the case were the lenses have a diameter of 30-mm they will fit in an empty film canister (part 17).

Eyepiece Construction Using a Black Film Canister

It is important to correctly orient the lenses when installing them. The lenses will arrive wrapped in tissue marked with the letters E, F, and M; 'E' stands for eyepiece, 'F' for field, and 'M' for middle. The flat side of the eyepiece lens should be toward your eye. The middle and field lens should be positioned with the curved edged facing each other (see Image #2).



NOTE: To avoid confusion once the lenses are unwrapped, label the F and M lenses with a marker on the lens rims.

Avoid touching the lenses except on the edges. Use tissue paper or soft gloves when inserting the lenses into your eyepiece holder.

1. Cut out a hole in the middle of the bottom of your film canister about ¾" in diameter. You'll want to leave a rim to hold the eyepiece in place. This is the viewing end of your eyepiece.

2. Insert the eyepiece lens (E) from the open end of the film canister. Make sure the flat side of the lens is towards the hole at the bottom. You will need to apply a bit of pressure to get the lens to the bottom of the canister but this tight fit will work well to keep the lenses in place. (see Image #1)

Image #1:
Viewing-end of film canister with eyepiece lens inserted

3. Insert the middle lens (M) next, making sure the flat side is toward the eyepiece (see Image #2). You will need to use a pin to poke a hole in the side of the plastic film canister, above the E-lens to let the trapped air escape. Push the lens down until it is in contact with the E-lens.

4. Use a pin to poke a small hole in the side of the film canister above the M-lens. This will allow air to escape at you insert the final lens. Insert the F-lens (field lens) with the curved side facing the M-lens (see Image #2).

5. The film canister can now be inserted into the draw tube of your telescope and you are ready for viewing! When storing the eyepiece, use the film canister lid to cover the open end and store the eyepiece assembly in a plastic bag.

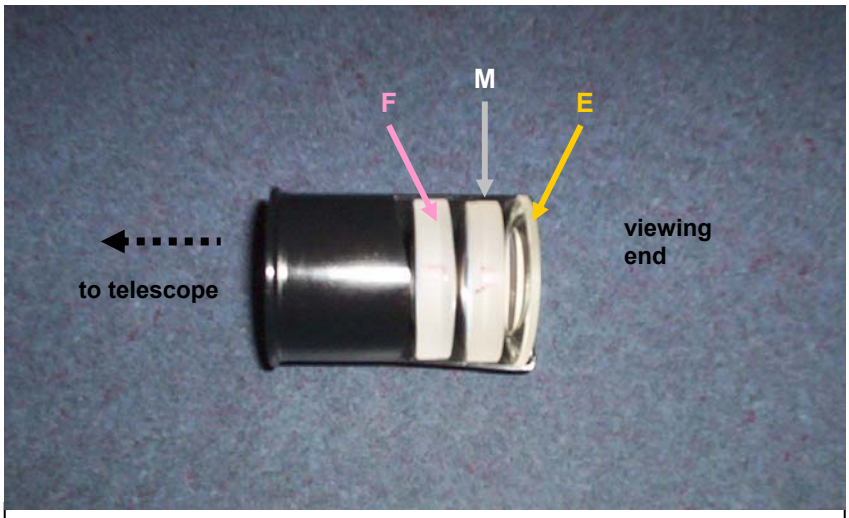


Image #2:
Film canister cut-away showing order and orientation of lenses.

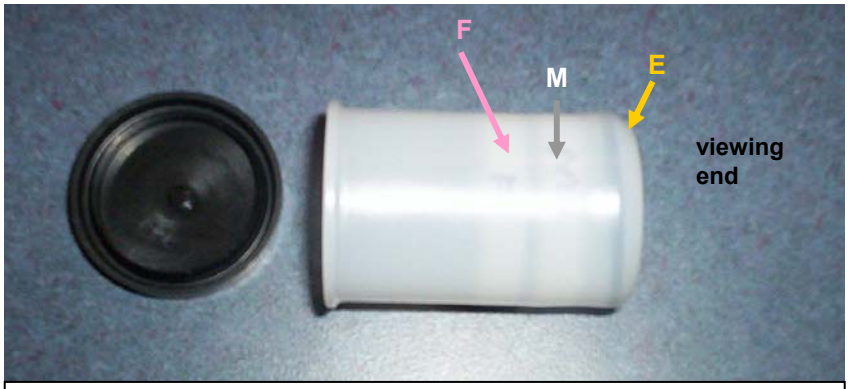


Image #3: Completed eyepiece assembly
(Note: This eyepiece assembly is shown with a white film canister for
should be made with a black

Congratulations! You now have a working telescope! Happy Observing!

Parts List:

#	Part	Supplier	Purpose	Approx. Cost
1	1”X1” coupler*	Hardware/Building Supply store	Eyepiece holder	0.49
2	1” diameter tubing of about 12 inch length*	Hardware/Building Supply store	Draw-tube for focusing	2.99/10 ft
3	1.25” diameter tubing of 2 inch length*	Hardware/Building Supply store	“Bearing” for draw-tube	3.79/10 ft
4	Felt with adhesive backing	Craft or hobby store	Provides proper fit for draw-tube bearing	
5	1.5”X1.25” bushing*	Hardware/Building Supply store	Holds draw-tube “bearing”	0.79
6	3”x1.5” couple*	Hardware/Building Supply store	Support for draw-tube focuser	3.50
7	3 “ tubing of 2 ft. length *	Hardware/Building Supply store	Telescope body	10.99/10ft
8	70mm X 800mmFL lens	Surplus Shed (L2148) (phone: 1-877-778-7758 or http://www.surplushed.com/)	Objective	$19.00
9	3” female adapter (threaded to fit plug)*	Hardware/Building Supply store	Dew shield	3.80
10	3” plug for clean out *	Hardware/Building Supply store	Lens cap	1.00
11	6-32x1/2” machine screw	Hardware/Building Supply store	Lock screw for eyepiece	
12	#4 sheet metal screw x 3/8 inch	Hardware/Building Supply store	Use to lock pieces of telescope together	
13	#4 sheet metal screw x 1/4 inch**	Hardware/Building Supply store	Use to provide stop on draw-tube	
14	Garage door handle **	Hardware/Building Supply store	Use to carry and to aim	
15	¼ - 20 insert **	Hardware/Building Supply store	Allows telescope to be mounted on camera tripod	
Eye Piece parts				
16	26mm Super Plossl Eyepiece kit	Surplus Shed (L1714)	Eyepiece lenses	$6.50
17	35 mm film canister	Photo processing center	Eyepiece lens holder	Free

* Either PVC (white) or ABS (black) material will do. The ABS has the advantage of being lighter weight and black in color. The PVC is cheaper.

** Optional Part – You will need two #10 sheet metal screw x 3/4 inch to attach the handle to the telescope body.