

A photograph of an Orion XT10 telescope on a beach boardwalk at sunset. The telescope is in the foreground, pointing towards the ocean. The sun is low on the horizon, creating a bright reflection on the water and a golden glow in the sky. A metal railing and a folding chair are also visible on the boardwalk.

Orion XT10 Telescope Upgrades

Mercury Transit
May 9th, 2016
24th Street Boardwalk, Virginia Beach, VA

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If you have any questions let me know.

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Upgrade Your Dobsonian Bearings

If you only do one upgrade to your dobsonian telescope, this is the one. I am still using my original Teflon pads and I have yet to use another telescope that moves as smooth as mine now. After dealing with stiction for over a year I decided to upgrade my telescope and add laminate to the bearings. I made this document to help anyone else that decides to do the same thing. I took some of the pictures after I had completed the process. That is why the laminate is in the photos during the disassembly. The laminate I used was suggested to me by Kent Blackwell and without a doubt it is as good as “ebony star”. If you don’t know what ebony star is its a laminate that is no longer available but is coveted by amateur astronomers.

Materials:

Home Depot

4 ft. x 8 ft. White .090 FRP Wall Board

Model # MFTF12IXA480009600

Internet #100389836

Store SKU #121586

Store SO SKU #404572

\$33.45 / each



Weldwood 3 fl. oz. Original Contact Cement

Model # 00107

Internet #100195615

Store SKU #629937

\$4.97 /each



4 ½ in. - 7 in. Stainless-Steel Clamp (Hose Clamp)

Model # 104

Store SKU # 49371

\$2.08 / each



(2) 3/32 in. x ¼ in. Rivet



Tools:

Rivet Gun

Drill

¼ in drill bit

¾ in. drill bit

1 ½ in. hole saw

Wiss W12L 12 in. Lightweight Aluminum Handle Snips

Ruler

4mm Allen Wrench

(2) 16mm wrenches or equivalent

(2) QUICK-GRIP Wood clamps

#2 Phillips screwdriver

Chalk or Sharpie

Instructions:

First thing to do **before disassembly** of the telescope is to make a mark on the altitude bearings where the seams of the laminate will meet. You want this spot to be in an area that will NOT engage the Teflon bearings. Use a piece of chalk or a sharpie to mark this spot. On my telescope this happened to line up with the word Orion on the altitude bearings.



Illustration 1: Mark the altitude bearing

Azimuth Bearing:

Using the hand snips cut the enough material to cover the base of the telescope. Leave enough overlap of laminate to ensure that the Teflon pads on the azimuth bearing will make full contact. I left an extra 2 inches all the way around. Remove the azimuth bearing on the telescope by unbolting the center pivot bolt.

Using the two 16mm wrenches unscrew the two bottom pieces and set aside the bottom piece that is in the shape of a triangle. Ensure that the plastic bushing in the circular base piece is comes out with the bolt. If not use the bolt to gently push it out of the board. Remove the six screws next to remove the circular base plate. Lay the laminate over a piece of scrap wood and place the circular base piece on the laminate ensuring that its centered. Use the wood clamps and attach the laminate and the base plate together to ensure that all the holes line up when done. Using a drill and the $\frac{1}{4}$ in. bit drill down through the center hole and the six screw holes through the laminate. After drilling the pilot holes remove the clamps and the circular base plate and drill out the holes with the $\frac{3}{4}$ in. drill bit on the scrap wood.

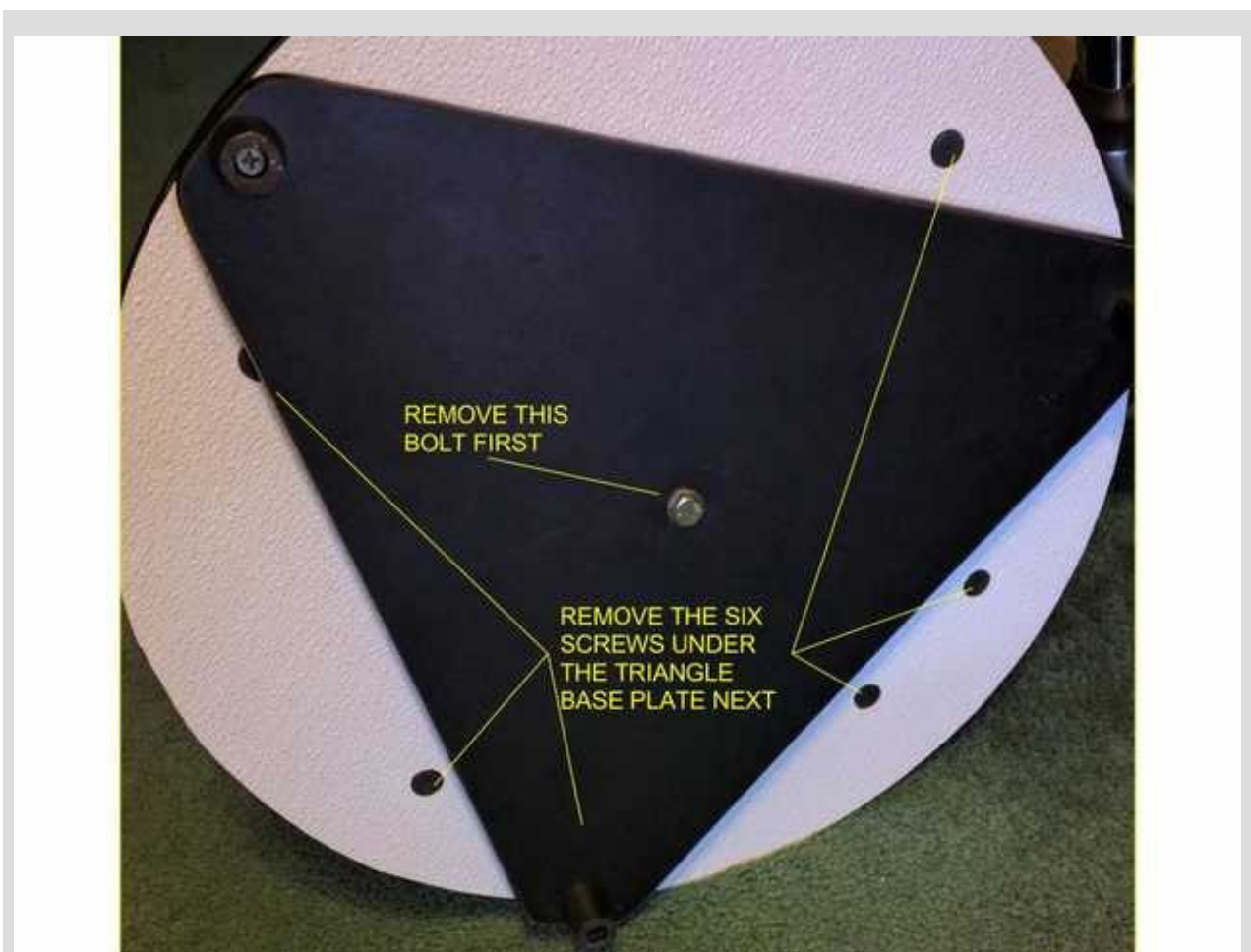


Illustration 2: Remove base mounting bolts and screws

Altitude Bearing:

The only way to reach the nuts holding the altitude bearings on the tube assembly is to remove the primary mirror. Lay the telescope tube on its side.



The mirror will fall unless it is supported in the next step.

If you have a helper have them raise the front of the tube off the ground to keep the mirror in place when you remove the bolts. If you are working alone you must support the mirror with one hand while removing the bolts with the other.

I don't know how critical this step is for a Dobsonian telescope but I prefer to error on the side of caution. Using chalk or a sharpie mark the mirror, the primary mirror holder, and the telescope tube with alignment marks to facilitate reassembly.

Unscrew the collimation and locking bolts from the bottom of the mirror while supporting the primary mirror assembly.

NOTE:

It's a good idea to never tighten the locking bolts since you can inadvertently break the mirror. Mine are just there so I don't lose them. They are NOT ever tightened down.



Illustration 3: Remove collimation and locking bolts

Now would be a good time to clean your primary mirror if it needs it. I won't cover those steps here since its covered online in many places. Here is mine drying after a through soaking. Set the mirror somewhere where it will be safe.



Illustration 4: Primary mirror drying

While you are waiting for the adhesive to dry in the later steps you can clean the mirror and the tube assembly. Use a lint free cloth dust the inside of the tube assembly. Be very careful to avoid bumping the secondary mirror.



Illustration 5: Dusty tube assembly

Using a #2 Phillips screwdriver remove the Phillips screws and the altitude bearing from the tube assembly. Remove the washers and bolts from inside the tube assembly and set aside for reassembly.



Illustration 6: Remove the azimuth screws

Cut strips of laminate that are the width of the bearing surface and long enough that the ends will overlap when its wrapped around the bearing. I used a heat gun to warm the laminate up before I wrapped it around the bearings. The reason I did this is that the laminate will bend easier around it without cracking. Wrap the laminate around the bearing and trim it so there is a slight gap where the ends meet (a little less than an 1/8 in.). I then held the laminate in place with the hose clamps and let it cool for about 15 minutes. When I remove the hose clamps the laminate now had a curve in it and most importantly no cracks.

Apply the contact cement to both the altitude bearing and the laminate. Set it aside for 15 minutes for the adhesive to setup. After the adhesive is ready I placed one end of the laminate on the bearing at where I made my mark and wrapped the laminate around the bearing the rest of the way. I then placed the hose clamp on the bearing and left it for at least a couple of hours. Because the bend of the bearings are sharp the contact cement alone will not be sufficient to hold the laminate on the bearing. I had to get creative.



Illustration 7: Contact cement on bearing



Illustration 8: Contact cement on laminate



Illustration 9: Hose clamp on bearing

After trial and error I decided to use my rivet gun to hold the laminate down at the ends. Position the laminate in such a way that the ends are located on the bearing where they will not engage the pads on the telescope during normal motion of the tube (See illustration 1). Using your drill and the ¼ in. drill bit you drill a hole near the end of the laminate. Leave about ½ in. to an inch from the hole to the end of the laminate.



Triple check before drilling

Before drilling the hole look at the inside of the bearing to make sure your not drilling into a support structure of the bearing. This will determine where you drill the holes more than anything else.

As soon as you remove the hose clamp the cement will start to separate so have your drill, rivets, and location of the hole ready to go. Once the rivets are in the laminate will stay in place. Now you can reassemble the altitude bearings back on the telescope.



Illustration 10: Completed altitude bearing

Primary Mirror Assembly:

Reassembly the mirror assembly using the alignment marks you made earlier. Don't tighten the screws down all of the way on the mirror clip screws. There should be a slight gap so the screws don't effect the collimation of the scope. A dab of nail polish or Loc-Tite at the end of the bolt will keep it in place.



Illustration 11: Mirror clips

For the rest of the assembly reverse the steps from the previous pages.

I don't have firsthand experience with Ebony Star so I can't compare the two materials. There is no question though that the control of this telescope has greatly improved with this upgrade. Good luck with yours.



Illustration 12: Reassembled telescope

Rope Carrying Handles

Home Depot
3/8 in. x 50 ft. Twisted Nylon Rope Coquette
Model # 32-002
Internet #205326923
\$14.96 /each



Use the twisted style of rope and braid it back on itself. Don't get smaller than 3/8 in. since the rope will cut into your hand.



Illustration 13: Rope handle right side



Illustration 14: Rope handle left side

Mechanical Collimation

Materials:

- Painters Tape
- Old flexible CD case or equivalent piece of plastic
- Steel Washer (Match the diameter to the Secondary Mirror shaft)
- Isopropyl Alcohol
- Q-tips
- 1 Long zip-tie
- Sheet of paper
- Semi-rigid piece of cardboard or heavy duty envelope
- 2x4 about 2 feet long
- 5 Nails around 3 inches in length
- Paper hole reinforcements

Tools:

- #2 Phillips screwdriver
- 2.5mm Allen Wrench
- 2mm Allen Wrench
- Sharpie
- Pencil sharpened at a steep angle
- Razor blade / utility knife
- Cheshire Eyepiece
- Laser Collimator
- Hammer
- Level
- Ruler or tape measure

Focuser Assembly

When I removed the primary mirror to install the laminate I knew that I would have to collimate the telescope afterwards. At that point I decided to remove the secondary mirror and focuser assembly as well to clean and inspect them. My focuser assembly had started to stick when the dial was rotated. This probably has to do with its quality but I decided to take it apart to see if I could fix it. Turns out I could. The fix was in removing the “locking plate” shown below. The plastic that locks against the rod for the focuser knob and the rod itself had dirt on it that was causing the focuser to not function correctly.

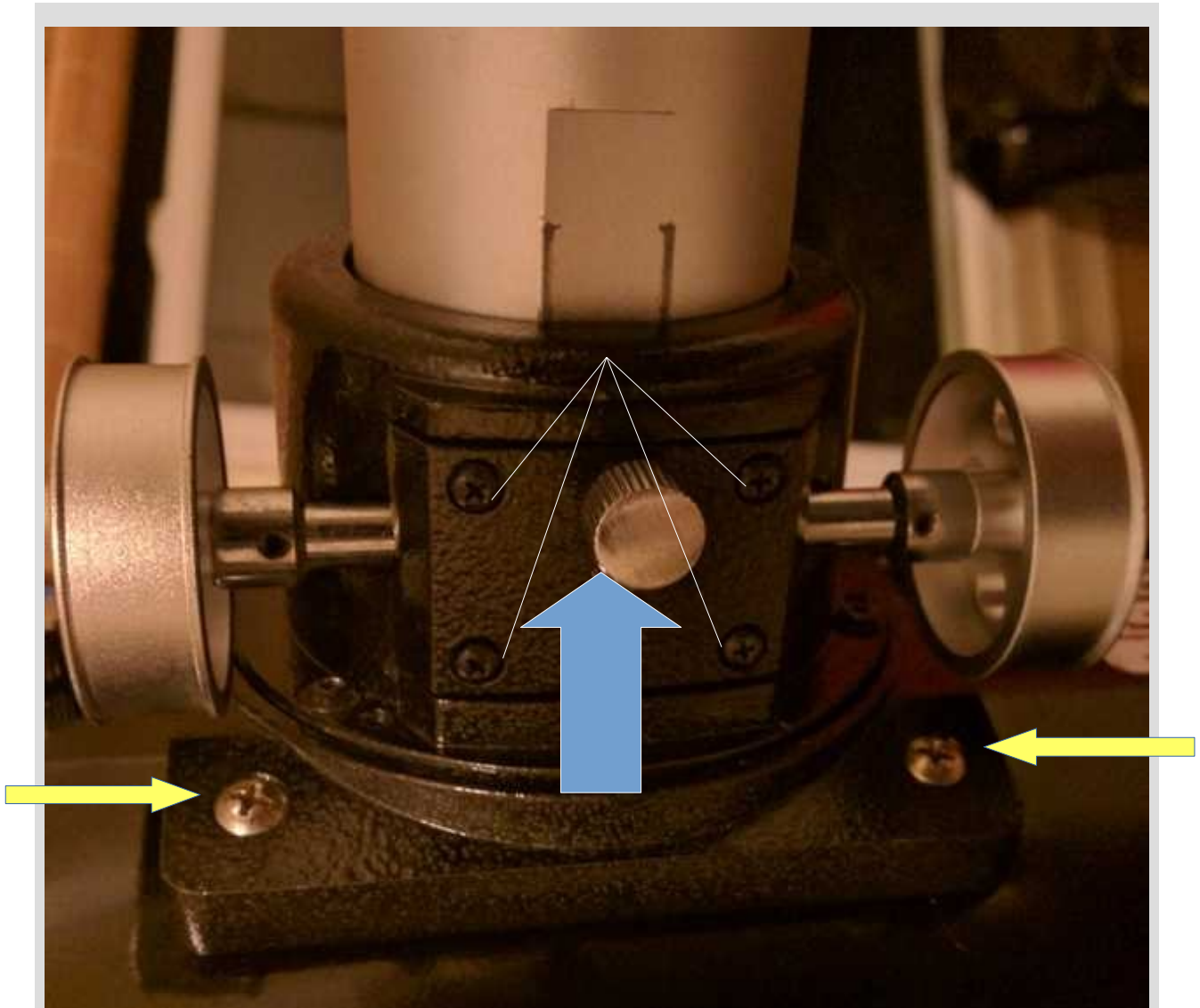


Illustration 15: Focuser Assembly



When working on the telescope ALWAYS keep it in a horizontal position.

When you drop the Allen wrench or screwdriver or nut, you don't want those items to hit the primary mirror so keep the telescope horizontal.

- Remove the focuser from the tube assembly by removing the 4 screws (2 are shown in the picture with the yellow arrows).
- Remove the 4 screws holding the tension plate on the focuser. (White lines)
- Under this plate is a piece of plastic that will clamp down against the focuser knob when tightened. Mine needed to be cleaned. The plastic and the focuser knob had some dirt on them. I used isopropyl alcohol and q-tips to clean it all.
- I removed every screw and cleaned every surface inside and out with the isopropyl alcohol.
- I set the parts aside to let them air dry. Then I reassembled everything and check the operation of the focuser.

Secondary Mirror



Support the secondary mirror at the base

Removing the knobs can allow the secondary mirror to “flop” against the inside of the tube.

While supporting the secondary mirror with one hand unscrew the 4 knobs holding the vanes in place at the end of the tube assembly.



Illustration 16: Secondary Mirror Knob



Illustration 17: Primary Mirror Knobs

I used some blue painters tape to mark all of the knobs on the telescope. This is an important step for later when the actual collimation takes place. If you prefer you can use a sharpie instead. The point of marking them is so you can count the turns when adjusting the mirrors later.

Disassemble the secondary mirror by backing out the 3 Allen screws until they are flush with the housing. Then you can unscrew the middle Phillips screw. Don't forget to support the mirror while doing this.

This next step only has to be done one time so take your time and do it carefully. Lay out the sheet of paper and CAREFULLY place the mirror on it face down. Don't let the mirror move while its on the sheet of paper. Use the pencil you sharpened to trace the mirror outline. By sharpening it to the steep angle you will be able to trace the whole mirror. When done tracing lift the mirror straight up off the paper and set it aside somewhere safe. Cut out the mirror shape from the paper and fold it in half.

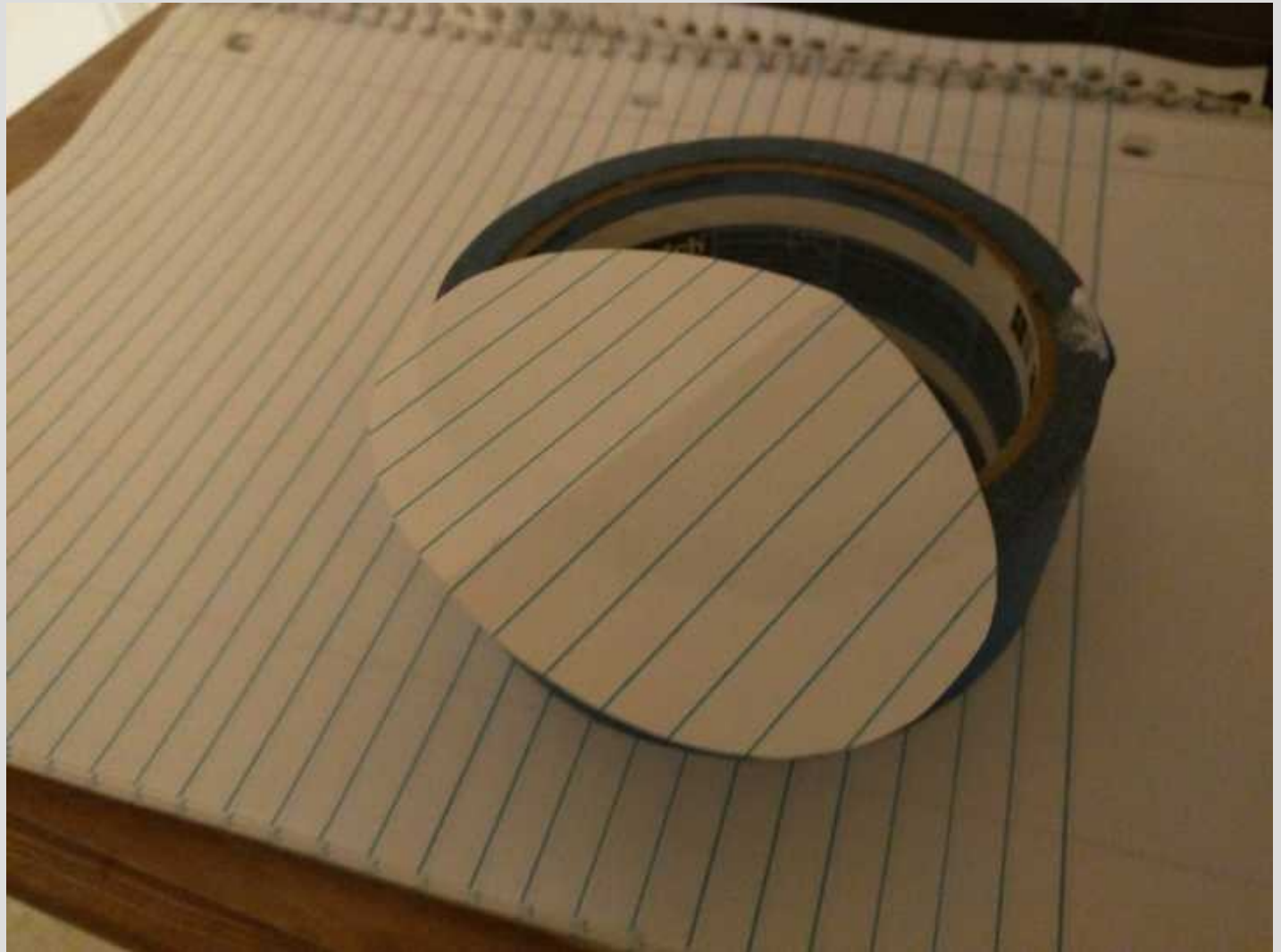


Illustration 18: Secondary Mirror Template

CAREFULLY lay the folded sheet of paper back on the mirror surface and mark on the both sides of the mirror where the fold is at. Remove the paper from the mirror and breathe again. Once you can breathe again you should use the sharpie or a piece of tape to permanently mark the center of your secondary mirror. Now you have the exact center of your secondary mirror marked.

Tweak for Secondary Mirror

You may notice that the secondary mirror does not always move as expected when adjusting the 3 Allen screws. This is caused by wear on the surface of the secondary mirror where the Allen screws touch it. To fix this problem or prevent it from happening you can insert a steel washer with a piece of plastic between it and the secondary mirror. I used a piece of plastic from an old CD case (the flexible kind).



Illustration 19: CD Case

I haven't purchased the replacement thumb screws for the secondary mirror yet but there is a link below for Bob's Knobs which sells them. After adjusting this with an Allen wrench I would recommend buying them for two reasons. One you don't need to keep a 2mm Allen wrench with you and two if you don't need a tool to adjust the secondary mirror that is one less thing you can accidentally drop on your primary mirror.



Illustration 20: Reassembled Secondary Mirror

Check Laser Collimator for Calibration

There are different jigs you can make to mount the laser and check for collimation but the easiest I found is using 5 nails and a 2x4. I stole the idea from Starks Labs (link below).



Illustration 21: Laser Collimator Jig

Now lay the 2x4 on a flat surface and put the laser in the cradle as shown below. Tweak the nails to get level and shine the light at least 10 feet away. Put a piece of the painters tape on the mark and rotate the laser in a circle while watching where the dot shines.



Illustration 22: Laser in Jig

You can turn the Allen screws on the laser to adjust the beam as needed. On mine they were hidden under the label and there is three of them.



Illustration 23: Laser Collimator Allen Screw

Calculate center of focuser assembly and reinstall

Measure from the end of the tube assembly to the center of the focuser assembly. Then make a mark on the inside of the tube assembly where that corresponds to. A Paper Hole Reinforcement is the best to use for this. If you have a laser collimator AND its calibrated you can use it to make the mark after you put the focuser assembly back in. Once the mark is made verify that the center of the focuser and the mark are exactly the same distance using a ruler or tape measure. Reinstall the focuser assembly.



Illustration 24: Center of focuser

Reinstall the secondary mirror

Tighten the thumb screws for the secondary mirror down equally. In other words all of the thumb screws will be 5 full turns or 4 full turns. When you are finished the thumb screws will be firm but not overly tightened. Use the plastic zip tie with the tape mark to center the secondary mirror.



Illustration 25: Center secondary with plastic zip tie

Align secondary mirror

With the focuser in still you can now use the plastic zip tie to measure the exact placement of the secondary mirror. Basically you will add a piece of tape to towards the end of the zip tie and carefully insert it through the focuser opening by the secondary mirror. Use the end of the zip tie to hold it in the twelve o'clock position and adjust the focuser to raise and lower the tape mark to line up with the center of the secondary mirror. By checking both sides of the secondary mirror you will ensure that the mirror is perfectly lined up with the focuser opening.

Use the video link below for a more detailed explanation.



Illustration 26: Align secondary with zip tie

Now you can use your Cheshire lens, collimation cap, and laser to finish up the collimation. If you are going to purchase a Cheshire I recommend getting one that is long and can slide the whole length of the lens. The one I purchased turned out to NOT be an ideal choice because of the feature pointed out in the picture below In the end I made it work but I do not recommend getting this brand unless they change the design. Here is the information for the one I purchased:

Astromania 1.25Inch Metal Collimating Cheshire Eyepiece without Laser for Newtonian Reflector Telescope - Long Version
ASIN B01DEVX61Q
Item model number SKU_AM_MCEL1



Illustration 27: Astromania Cheshire Eyepiece



Illustration 28: Beveled Edge You Don't Want

References:

A to Z Collimating of Your Telescope
Bobs Knobs Secondary Mirror Replacement Screws
Squaring up that cheap laser collimator

<https://youtu.be/n97dn-nGGlo>
<http://bobsknobs.com/Newt/page42/OrionXT.html>
<http://www.stark-labs.com/craig/lcc/lcc.html>

Just Flock It

I drove to fabric stores and I researched many different websites online to try to determine what was the best material to use for my telescope. Save yourself the time and buy either the flocking from ScopeStuff or the flockboard from Protostar. I choose ScopeStuff because the price was lower although I am positive that using the Protostar flockboard would have been much easier. Having said that the installation of the flocking wasn't hard as much as it was tedious. A FYI for you is that one sheet of the flocking from ScopeStuff is NOT enough material to cover the entire inside of a 10" Newtonian.

Materials:

- ScopeStuff flocking 23.5"x47"
- Isopropyl Alcohol
- Lint free cloth
- 1 Long zip-tie
- Sheet of paper
- Semi-rigid piece of cardboard or heavy duty envelope
- 2x4 about 2 feet long
- 5 Nails around 3 inches in length
- Paper hole reinforcement label

Tools:

- #2 Phillips screwdriver
- 2mm Allen Wrench
- Sharpie
- Razor blade / utility knife
- Level
- Ruler
- Patience

References:

http://www.scopestuff.com/ss_flok.htm
<http://www.protostar.biz/flock.htm>

First get your flocking material. ScopeStuff is about \$30 and Protostar will run around \$100.



Illustration 29: ScopeStuff flocking invoice

The customary before pictures:



Illustration 30: Before flocking the tube



Illustration 31: Before flocking the focuser

Since I decided that I wasn't going to flock the whole inside of the tube I needed to know where the critical areas to flock were. Fortunately I found some help online that answered those questions:

<http://www.deepskywatch.com/images/articles/critical-area.png>

<http://www.washedoutastronomy.com/washedoutastronomy.com/sites/washedoutastronomy.com/files/EyepieceTubeViewLarge/index.png>

Flocking these areas of the telescope should eliminate 99% of the stray light which was enough for me.

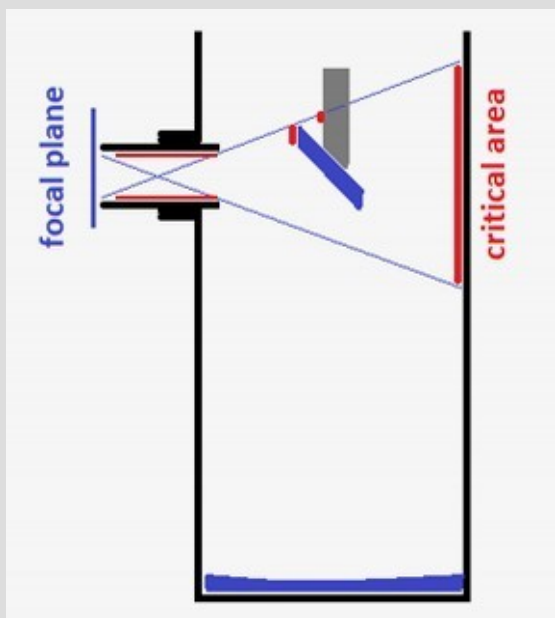


Illustration 32: Critical areas for flocking 1

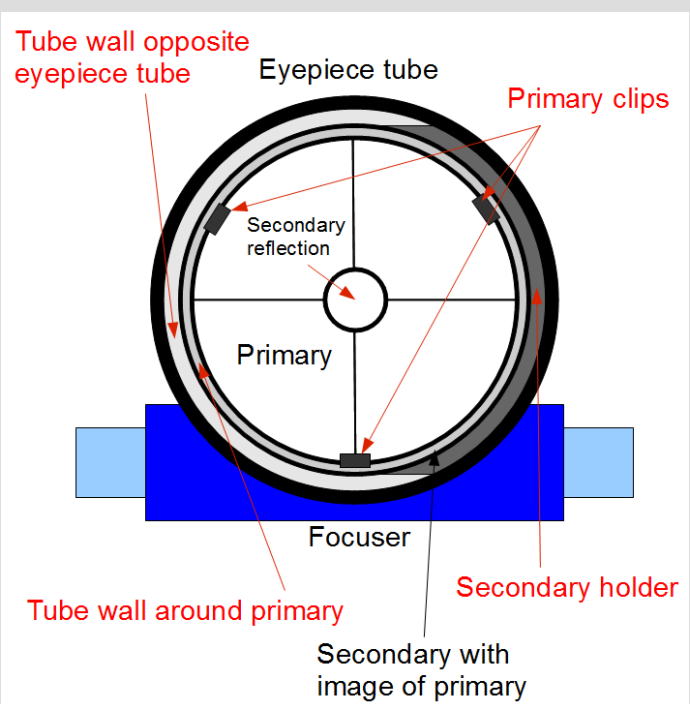


Illustration 33: Critical areas for flocking 2

Even though the first image did not mention flocking around the primary mirror I had 23.5"x47" of flocking material and decided to use it all on this telescope. To ensure that I covered the critical areas I utilized the dimensions that ScopeStuff sent me. I used the width of my level to determine the width of each strip of flocking. I then cut those strips in half to use around the primary mirror. For the front of the telescope I just used the full length of 23.5".



Illustration 34: Cut the flocking

Remove the primary mirror, secondary mirror, and focuser assembly from the telescope and set aside in a safe place.



Illustration 35: Disassemble the telescope

Measure the primary mirror so you can determine where to install the flocking material.

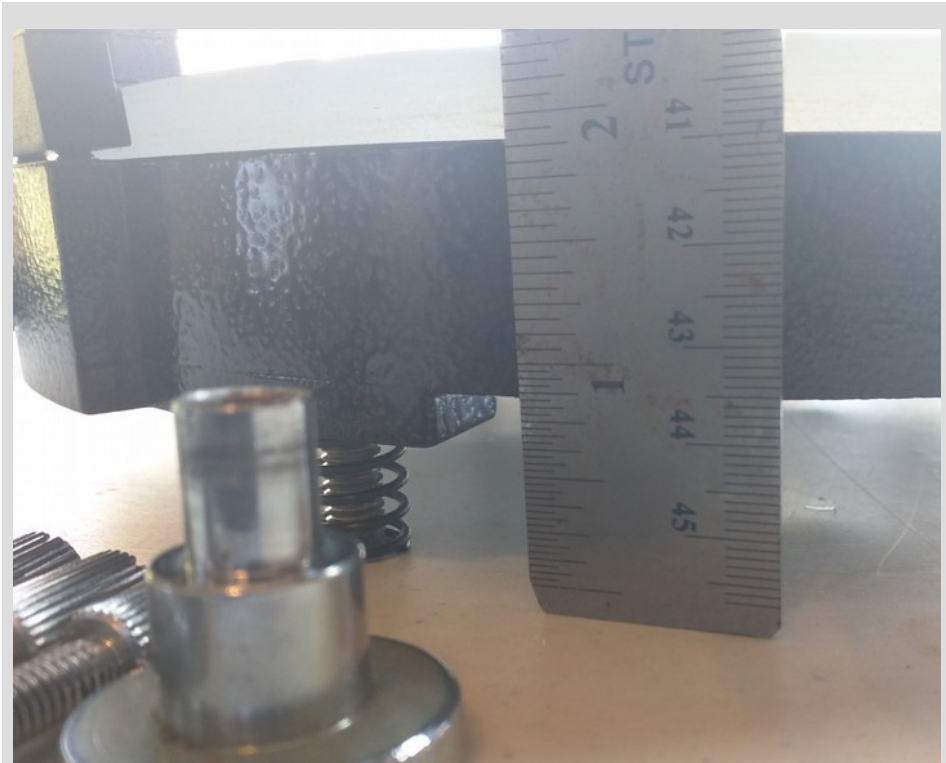


Illustration 36: Measure the primary

Place marks on the tube where the flocking will rest all the way around the tube so installation is easier.

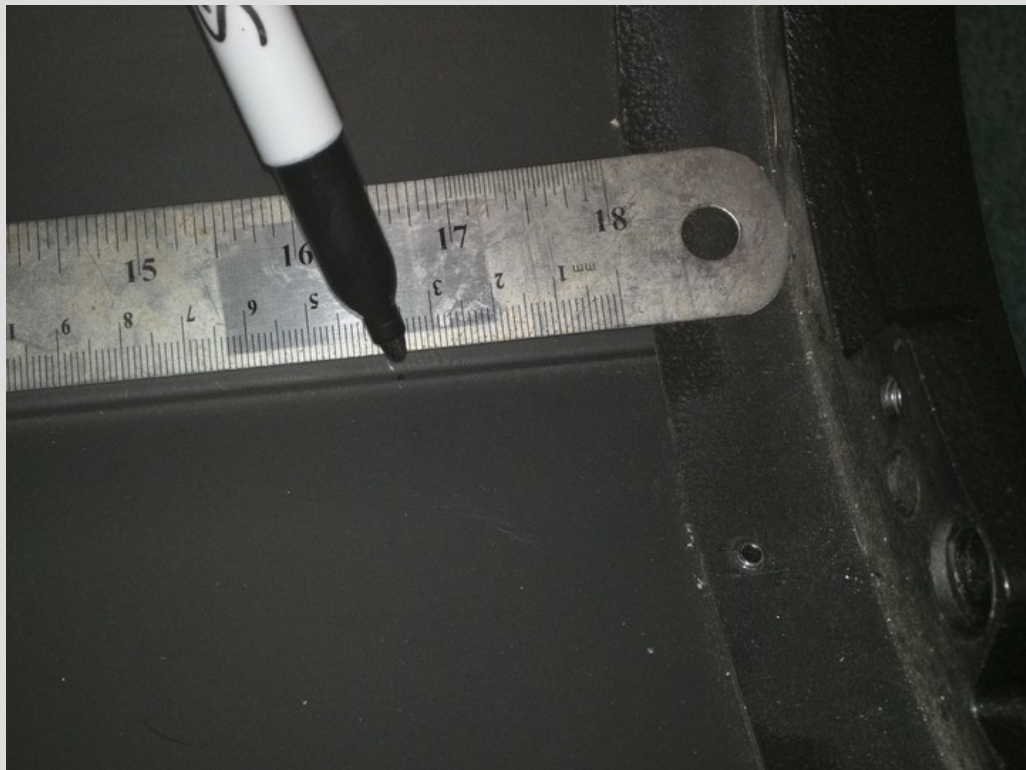


Illustration 37: Mark the tube

If you are going to put just enough material at the top of the scope then take a measurement of how far you can see down the tube from the eyepiece.



Illustration 38: Determine the length of flocking needed

I did the smaller area around the primary first because I hoped that it would be good practice when I did the longer strips for the top of the tube. I think it helped with my technique later. I think starting at the seam helped ensure that the first strip was straight and the following strips were straightish.



Illustration 39: Start flocking



Here is what the flocking looked like after doing both ends of the tube.

Illustration 40: Flocking installed

Now I did the focuser assembly. My focuser is the one that came with my scope so its not the best quality but it should give me better contrast after this. Make sure that you don't put any flocking material where it will interfere with inserting an eyepiece.

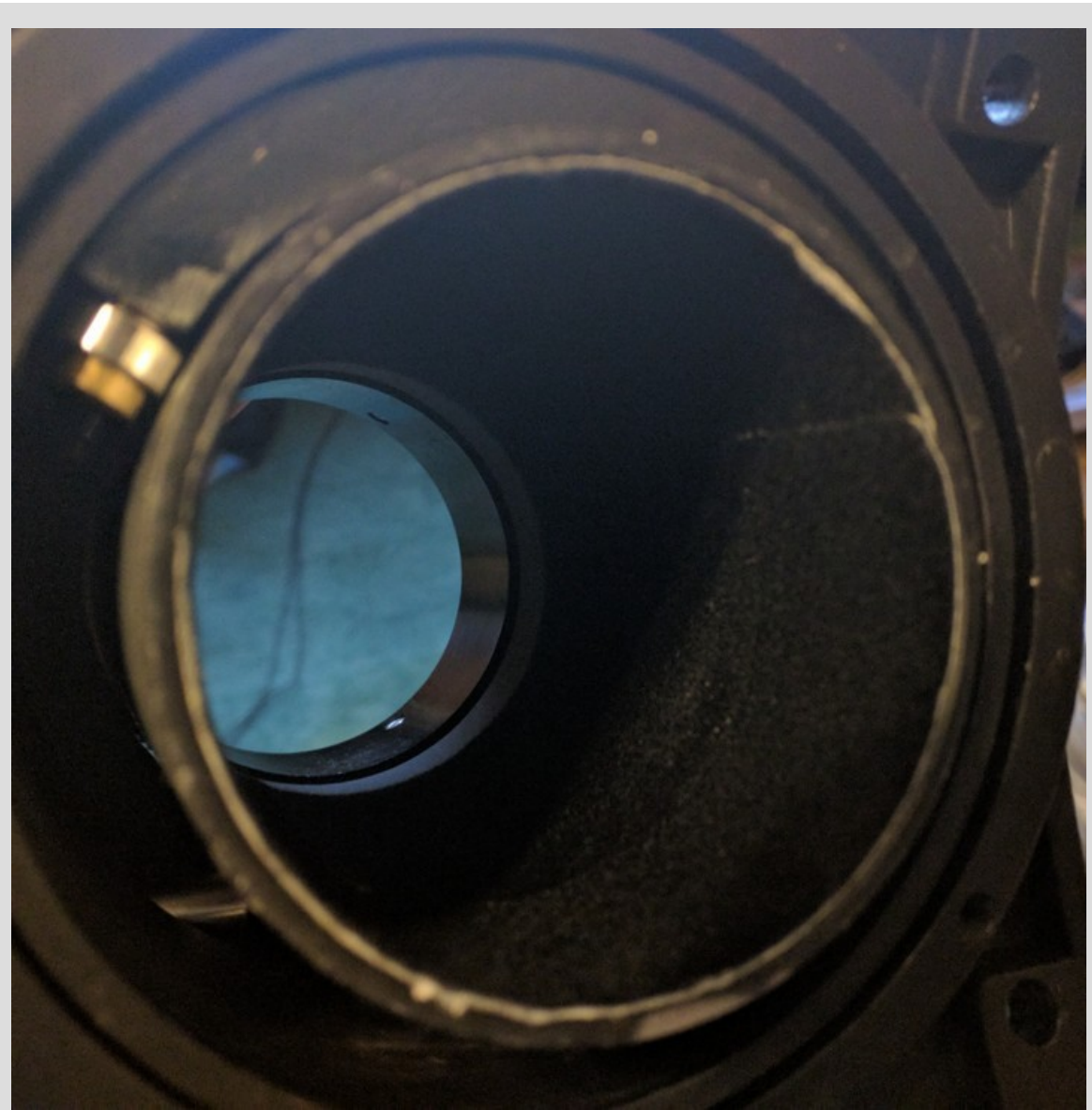


Illustration 41: Flock the focuser

Cover the leading edges of the secondary mirror with the flocking material (Blue arrows) and reassemble the telescope.

The yellow arrow is a reinforcements label affixed to the tube under the flocking. This is the bullseye for the exact center of the focuser hole. Having this allows me to ensure that the focuser is collimated with the primary and secondary mirrors.

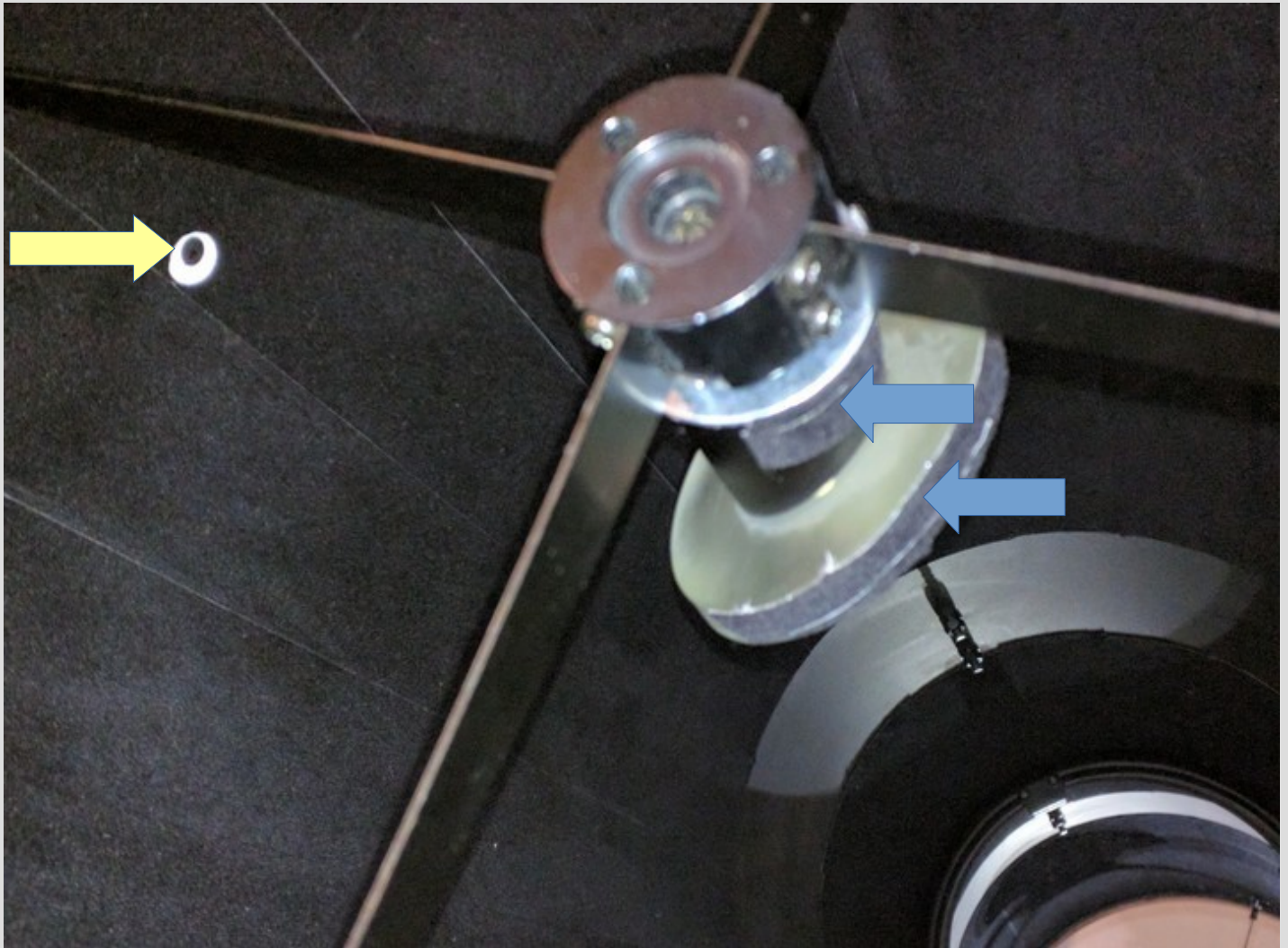


Illustration 42: Flock the secondary

Here is a final picture of the flocking after everything has been reassembled.



Illustration 43: Telescope reassembled

Only thing left to do is to collimate it now.
[Refer to this section for collimation procedure](#)

Revolution Imager Upgrades

I received a Revolution Imager camera for Christmas and finally decided to integrate it better with my dob. The Revolution Imager comes with a converted security camera, a 7 inch monitor and the battery and cables to connect the two. Two main drawbacks I found while using it are that the screen had to be placed on a tripod and because the power cord that came with the system is only about 2 feet long it is very easy to pull the tripod over while moving the scope. Another issue with the tripod is that in the dark it will ALWAYS get kicked at least once. The second issue with the Revolution Imager is that it does not record at all. This write up is how I solved both of those issues. I also wanted to mention that Orange County Telescope also offers a [DVR](#) for the Revolution Imager camera at a great price. The reason I choose to make my own is because I had most of the material already on hand.

Needed Materials:

(I payed \$14 for the parts listed below at Lowes)

(2) - 1/2-in Dia 90-Degree PVC Sch 40 Tee

(2) - 1-1/2-in Dia PVC Sch 40 Plug

(1) - 2-in Dia PVC Sch 40 Plug

(1) - 1-1/4-in x 6-ft Sch 40 PVC DWV Pipe

(1) - 4-Count 1/4-20 x 1 1/4 IN (491316) Round-Head Standard (SAE) Machine Screws



Materials already on hand:

DIY DVR

Raspberry Pi 3	\$35.00
Raspberry Pi 3 Power Cord	\$6.99
Raspberry Pi 3 64GB Micro SD card	\$19.99
Raspberry Pi 3 Case	\$2.99

CAMERA

Revolution Imager System: R2	\$ 299.99
Revolution Imager USB Video Capture Adapter	\$ 14.99

Misc Cables (RCA, Spare power cord)

Scrap Laminate flooring

Tools:

Level

Drill

3/4 in. drill bit

Phillips Screwdriver

Socket Wrench

Zip ties

Wire Strippers

Dikes

Soldering Iron

Solder

Multi-meter

At the bottom of this section are the pictures of the finished product that I came up with.

The LCD screen now rotates with the telescope and all of the wires are routed through the PVC pipe to keep them out of the way. The DVR is stored loosely under the telescope to allow easy removal.

I used Velcro to attach the battery pack is to the outside of the base. This was done to allow easy access to the on/off switch located on the battery. I cut the Y section of the power cord that came with the camera. I then soldered in a spare piece of power cord I had to allow the power to reach up the PVC tube to the screen.

I placed the connections conveniently so when I remove the camera all of the cords are left in the PVC tube for storage.

I also modified a spare RCA cable I had to allow me to send video to the LCD screen and the DVR at the same time from the input off of the camera.

Raspberry Pi Instructions

To have the Raspberry Pi act as a DVR I needed to configure it so I could interact with it remotely. The reason for this is I don't want the device recording video or pictures the entire time since it will fill up the SD card quickly. I had to come up with a method to take video or pictures without touching the telescope or the Raspberry Pi. I decided to configure the Pi's wifi to act as an access point that I could connect to it with my phone. Then when I wanted to capture images or video I would simply run a command to do that. For the time being I am using the command line but in the future I will create a static web page with simple buttons on it that will accomplish this task. So lets get to it.

First you need to download the latest version of Raspbian from [here](#) and install it on your Micro SD card for the Pi. I use Linux at home so if you are using Windows modify these directions for that operating system.

Insert the SD card into your system and type `df -h` to find out where the card is mounted

`df -h`

Filesystem	Size	Used	Avail	Use%	Mounted on
udev	3.9G	0	3.9G	0%	/dev
tmpfs	799M	20M	779M	3%	/run
/dev/sdb1	451G	240G	188G	57%	/
tmpfs	3.9G	20M	3.9G	1%	/dev/shm
tmpfs	5.0M	4.0K	5.0M	1%	/run/lock
tmpfs	3.9G	0	3.9G	0%	/sys/fs/cgroup
/dev/sdc1	1.8T	1.2T	583G	67%	/mnt/86ed6181-905a-4747-8d2d-550cb03be9da
192.168.1.220:/	71G	8.7G	59G	13%	/nfs
/dev/sdd	64G	0	64G		
tmpfs	799M	76K	799M	1%	/run/user/1000
tmpfs	799M	16K	799M	1%	/run/user/108
192.168.1.220:/2tb	1.8T	443G	1.3T	26%	/nfs/2tb

Illustration 44: `df -h` Output

By looking for the size of the SD card I can tell where the system has mounted my card which in this case is `/dev/sdd`

NOTE: Change the command below for your system.

Now use the DD method to copy the operating system to the SD card.

```
sudo dd if=2017-04-10-raspbian-jessie.img of=/dev/sdd bs=4096
```

This will take a few minutes as the operating system is copied to the SD card.

Once that is completed its time to power up the Pi. Insert the card into the Pi and plug in the necessary peripherals so you can interact with it for the first run. Then plug in the power. The Pi will power up and automatically expand the OS for the size of the card on the first run. Then it will reboot. Once it was loaded you want to customize the configuration of the Pi.

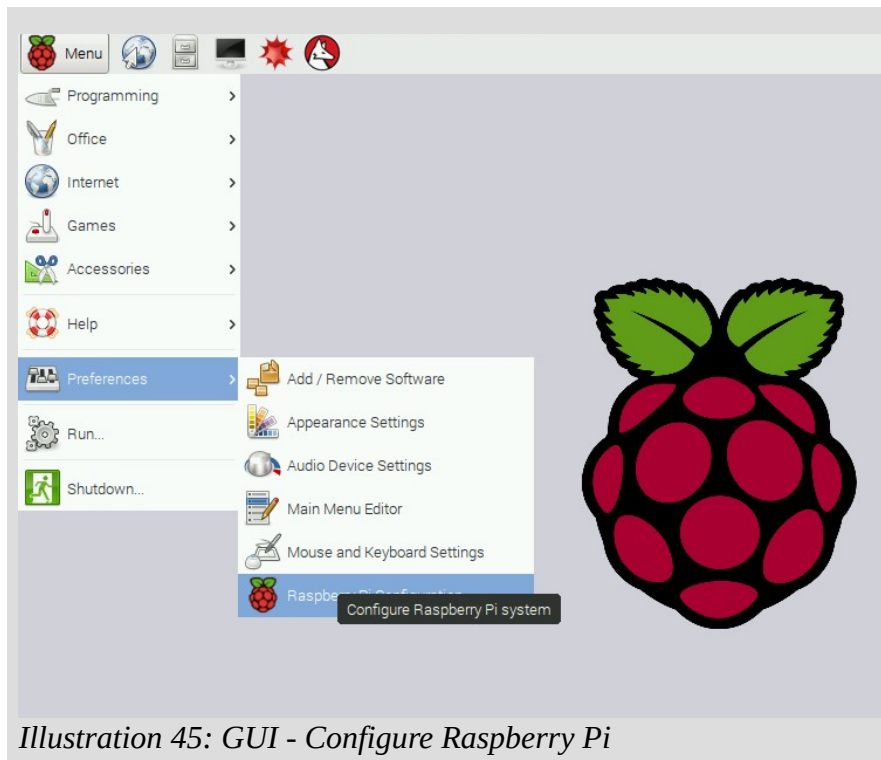


Illustration 45: GUI - Configure Raspberry Pi

The items you want to modify are:

- FIRST Change the keyboard to US so it works.
- Change the default password (by default its raspberry)
- Change the timezone and location
- Enable the SSH and the VNC servers on the Pi.

NOTE: To change the configuration of the Pi through SSH enter the following command.

```
sudo raspi-config
```

Open the terminal and find out the IP address that the Pi is using. Write it down for later.

```
ifconfig
```

```
pi@raspberrypi ~ $ ifconfig -a
eth0      Link encap:Ethernet  HWaddr b8:27:eb:f1:45:81
          inet addr:10.0.1.63  Bcast:10.0.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:112 errors:0 dropped:0 overruns:0 frame:0
          TX packets:85 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:10773 (10.5 KiB)  TX bytes:12163 (11.8 KiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

wlan0     Link encap:Ethernet  HWaddr 00:e0:4c:09:3b:f8
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

pi@raspberrypi ~ $
```

Illustration 46: ifconfig Output

At this point you can shutdown the Pi and use your regular computer to configure it.

```
sudo shutdown -h now
```

Plug the Pi in to a spare Ethernet port and turn it back on.

Now we will SSH into the Pi to finish configuring it. Use the IP you wrote down from the last step.

```
ssh pi@<YOUR IP ADDRESS>
```

Enter the password you created earlier. You should now be logged into the Pi.

First thing you want to do at this point is to update the software on the Pi. This will probably take about 10 minutes so go get a snack.

```
sudo apt-get update
sudo apt-get upgrade
```

Raspberry Pi Access Point

The instructions below are summarized from the [Adafruit website](#). They are a great resource to learn about coding and have many tutorials for the Pi. They also sell the Raspberry Pi and its necessary components.

Next up we install the software onto the Pi that will act as the 'hostap' (host access point) You need Internet access for this step so make sure that Ethernet connection is up!

```
sudo apt-get install hostapd isc-dhcp-server
```

Also install a iptables manager.

```
sudo apt-get install iptables-persistent
```

You'll get two 'config' screens, say Yes to both

Set up DHCP server

Next we will edit **/etc/dhcp/dhcpd.conf**, a file that sets up our DHCP server - this allows wifi connections to automatically get IP addresses, DNS, etc.

Run this command to edit the file

```
sudo nano /etc/dhcp/dhcpd.conf
```

Find the lines that say

```
option domain-name "example.org";
```

```
option domain-name-servers ns1.example.org, ns2.example.org;
```

and change them to add a # in the beginning so they say

```
#option domain-name "example.org";
```

```
#option domain-name-servers ns1.example.org, ns2.example.org;
```

Find the lines that say

```
# If this DHCP server is the official DHCP server for the local# network, the authoritative directive should be uncommented.
```

```
#authoritative;
```

and remove the # so it says

```
# If this DHCP server is the official DHCP server for the local# network, the authoritative directive should be uncommented.
```

```
authoritative;
```

Then scroll down to the bottom and add the following lines

```
subnet 192.168.42.0 netmask 255.255.255.0 {  
    range 192.168.42.10 192.168.42.50;  
    option broadcast-address 192.168.42.255;  
    option routers 192.168.42.1;  
    default-lease-time 600;  
    max-lease-time 7200;  
    option domain-name "local";  
    option domain-name-servers 8.8.8.8, 8.8.4.4;  
}
```

Save the file by typing in **Control-X** then **Y** then **return**

Enter

```
sudo nano /etc/default/isc-dhcp-server
```

and scroll down to **INTERFACES=""** and update it to say **INTERFACES="wlan0"**

Or whatever the name of your wifi adapter is!

Close and save the file

Set up wlan0 for static IP

If you happen to have wlan0 active because you set it up, run

```
sudo ifdown wlan0
```

There's no harm in running it if you're not sure

Next we will set up the **wlan0** connection to be static and incoming.

```
sudo nano /etc/network/interfaces
```

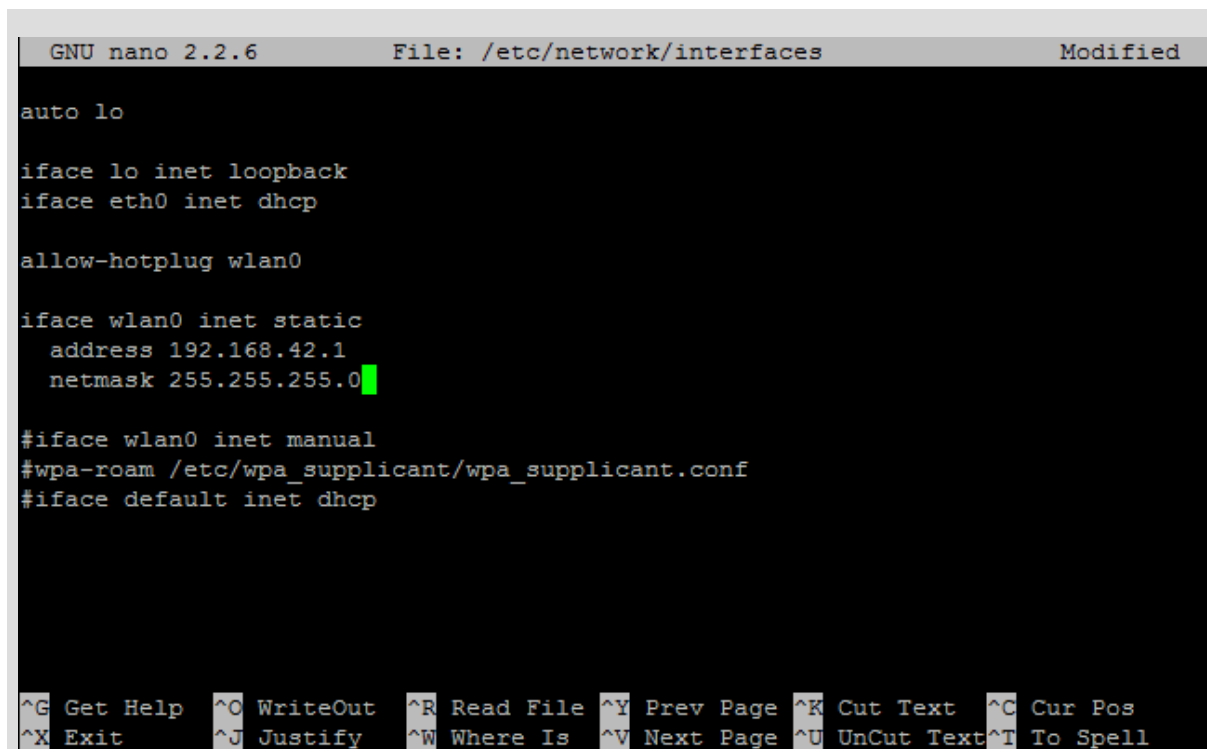
Find the line **auto wlan0** and add a **#** in front of the line, and in front of every line afterwards. If you don't have that line, just make sure it looks like the screen-shot below in the end! Basically just remove any old **wlan0** configuration settings, we'll be changing them up

Depending on your existing setup/distribution there might be more or less text and it may vary a little bit

Add the lines

```
iface wlan0 inet static
    address 192.168.42.1
    netmask 255.255.255.0
```

After **allow-hotplug wlan0** - see below for an example of what it should look like. Any other lines afterwards should have a **#** in front to disable them



```
GNU nano 2.2.6      File: /etc/network/interfaces      Modified

auto lo

iface lo inet loopback
iface eth0 inet dhcp

allow-hotplug wlan0

iface wlan0 inet static
    address 192.168.42.1
    netmask 255.255.255.0

#iface wlan0 inet manual
#wpa-roam /etc/wpa_supplicant/wpa_supplicant.conf
#iface default inet dhcp

^G Get Help  ^O WriteOut  ^R Read File ^Y Prev Page ^K Cut Text  ^C Cur Pos
^X Exit      ^J Justify   ^W Where Is  ^V Next Page ^U UnCut Text ^T To Spell
```

Illustration 47: Configure /etc/network/interfaces

Save the file (Control-X Y)

Assign a static IP address to the wifi adapter by running

```
sudo ifconfig wlan0 192.168.42.1
```

Configure Access Point

Now we can configure the access point details. We will set up a password-protected network so only people with the password can connect.

Create a new file by running

```
sudo nano /etc/hostapd/hostapd.conf
```

Paste the following in, you can change the text after **ssid=** to another name, that will be the network broadcast name. The password can be changed with the text after **wpa_passphrase=**

```
interface=wlan0
driver=rtl871xdrv
ssid=Pi_AP
country_code=US
hw_mode=g
channel=6
macaddr_acl=0
auth_algs=1
ignore_broadcast_ssid=0
wpa=2
wpa_passphrase=Raspberry
wpa_key_mgmt=WPA-PSK
wpa_pairwise=CCMP
wpa_group_rekey=86400
ieee80211n=1
wme_enabled=1
```

If you are not using the Adafruit wifi adapters, you may have to change the **driver=rtl871xdrv** to say **driver=nl80211** or something

If you are using the Raspberry Pi 3's internal WiFi adapter, comment out the `driver=rtl871xdrv` line altogether.

Save as usual. Make sure each line has no extra spaces or tabs at the end or beginning - this file is pretty picky!

Now we will tell the Pi where to find this configuration file.

```
sudo nano /etc/default/hostapd
```

Find the line **#DAEMON_CONF=""** and edit it so it says **DAEMON_CONF="/etc/hostapd/hostapd.conf"**

Don't forget to remove the **#** in front to activate it!

```
GNU nano 2.2.6      File: /etc/default/hostapd

# Defaults for hostapd initscript
#
# See /usr/share/doc/hostapd/README.Debian for information about alternative
# methods of managing hostapd.
#
# Uncomment and set DAEMON_CONF to the absolute path of a hostapd configuration
# file and hostapd will be started during system boot. An example configuration
# file can be found at /usr/share/doc/hostapd/examples/hostapd.conf.gz
#
DAEMON_CONF="/etc/hostapd/hostapd.conf"

# Additional daemon options to be appended to hostapd command:-
#
#   -d   show more debug messages (-dd for even more)
#   -K   include key data in debug messages
#   -t   include timestamps in some debug messages
#
# Note that -B (daemon mode) and -P (pidfile) options are automatically
# configured by the init.d script and must not be added to DAEMON_OPTS.
[ Read 21 lines ]
^G Get Help  ^O WriteOut  ^R Read File ^Y Prev Page ^K Cut Text  ^C Cur Pos
^X Exit      ^J Justify   ^W Where Is ^V Next Page ^U UnCut Text ^T To Spell
```

Illustration 48: Configure /etc/default/hostapd

Then save the file

Also change the hostapd file

```
sudo nano /etc/init.d/hostapd
```

and find the line

```
DAEMON_CONF=
```

and change it to

```
DAEMON_CONF=/etc/hostapd/hostapd.conf
```

Configure Network Address Translation

Setting up NAT will allow multiple clients to connect to the WiFi and have all the data 'tunneled' through the single Ethernet IP. (But you should do it even if only one client is going to connect)

```
sudo nano /etc/sysctl.conf
```

Scroll to the bottom and add

```
net.ipv4.ip_forward=1
```

on a new line. Save the file. This will start IP forwarding on boot up

Also run

```
sudo sh -c "echo 1 > /proc/sys/net/ipv4/ip_forward"
```

to activate it immediately

Run the following commands to create the network translation between the ethernet port **eth0** and the wifi port **wlan0**

```
sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
```

```
sudo iptables -A FORWARD -i eth0 -o wlan0 -m state --state RELATED,ESTABLISHED -j ACCEPT
```

```
sudo iptables -A FORWARD -i wlan0 -o eth0 -j ACCEPT
```

You can check to see whats in the tables with

```
sudo iptables -t nat -S
```

```
sudo iptables -S
```

To make this happen on reboot (so you don't have to type it every time) run

```
sudo sh -c "iptables-save > /etc/iptables/rules.v4"
```

The **iptables-persistent** tool you installed at the beginning will automatically reload the configuration on boot for you.

Update hostapd (maybe)

If you are running Raspberry pi kernel 4.4.13-v7+ or greater (check your kernel version with **uname -a**), you do not need to do this step.

If you are using the Raspberry Pi 3 built-in WiFi or are not using RTL8192-like WiFi adapter, then skip this step!

Before we can run the access point software, we have to update it to a version that supports the WiFi adapter.

First get the new version by typing in

```
wget http://adafruit-download.s3.amazonaws.com/adafruit_hostapd_14128.zip
```

to download the new version (check the next section for how to compile your own updated **hostapd**) then

```
unzip adafruit_hostapd_14128.zip
```

to uncompress it. Move the old version out of the way with

```
sudo mv /usr/sbin/hostapd /usr/sbin/hostapd.ORIG
```

And move the new version back with

```
sudo mv hostapd /usr/sbin
```

set it up so its valid to run with

```
sudo chown root:root /usr/sbin/hostapd
```

```
sudo chmod 755 /usr/sbin/hostapd
```

First test!

Finally we can test the access point host!

```
sudo /usr/sbin/hostapd /etc/hostapd/hostapd.conf
```

To manually run **hostapd** with our configuration file. You should see it set up and use **wlan0** then you can check with another wifi computer that you see your SSID show up. If so, you have successfully set up the access point.

If you get this warning

```
Configuration file: /etc/hostapd/hostapd.conf
```

```
Line 2: invalid/unknown driver 'rtl871xdrv'
```

```
1 errors found in configuration file '/etc/hostapd/hostapd.conf'
```

```
Failed to set up interface with /etc/hostapd/hostapd.conf
```

```
Failed to initialize interface
```

It could mean that either you are not using a RTL871Xdrv WiFi adapter (e.g. Pi 3 internal wifi) and should comment out the `driver=rtl871xdrv` line in the hostapd config **OR** you are using that chipset and you need to download our recompiled **hostapd** binary

If it does work, you should get something like this:

```

pi@raspberrypi ~ $ sudo mv /usr/sbin/hostapd /usr/sbin/hostapd.Orig
pi@raspberrypi ~ $ sudo mv hostapd /usr/sbin
pi@raspberrypi ~ $ sudo chmod 755 /usr/sbin/hostapd
pi@raspberrypi ~ $ sudo /usr/sbin/hostapd /etc/hostapd/hostapd.conf
Configuration file: /etc/hostapd/hostapd.conf
drv->ifindex=3
l2_sock_recv==l2_sock_xmit=0x0x1fb638
+rtl871x_sta_deauth_ops, ff:ff:ff:ff:ff:ff is deauth, reason=2
rtl871x_set_key_ops
rtl871x_set_key_ops
rtl871x_set_key_ops
rtl871x_set_key_ops
Using interface wlan0 with hwaddr 00:e0:4c:09:3b:f8 and ssid 'Pi_AP'
rtl871x_set_wps_assoc_resp_ie
rtl871x_set_wps_beacon_ie
rtl871x_set_wps_probe_resp_ie
rtl871x_set_key_ops
rtl871x_set_beacon_ops
rtl871x_set_hidden_ssid_ops

```

Illustration 49: Testing Access Point Host

```

pi@raspberrypi:~$ sudo /usr/sbin/hostapd /etc/hostapd/hostapd.conf
Configuration file: /etc/hostapd/hostapd.conf
Failed to create interface mon.wlan0: -95 (Operation not supported)
wlan0: interface state UNINITIALIZED->COUNTRY_UPDATE
wlan0: Could not connect to kernel driver
Using interface wlan0 with hwaddr b8:27:eb:83:b3:29 and ssid "Pi_AP"
wlan0: interface state COUNTRY_UPDATE->ENABLED
wlan0: AP-ENABLED

```

Illustration 50: AP-ENABLED

By searching for a new wireless connection on your computer now you should see the access point that you created with the Raspberry Pi.

You can try connecting and disconnecting from the Pi_AP with the password you set before (probably **Raspberry** if you copied our hostapd config), debug text will display on the Pi console but you won't be able to connect through to the Ethernet connection yet.

Cancel the test by typing **Control-C** in the Pi console to get back to the Pi command line

Removing WPA-Supplicant

Depending on your distro, you may need to remove WPASupplicant. Do so by running this command:

```
sudo mv /usr/share/dbus-1/system-services/fi.epitest.hostap.WPASupplicant.service ~/
```

and then rebooting (**sudo reboot**) and retrying running **hostapd**

Finishing up the AP!

OK now that we know it works, time to set it up as a 'daemon' - a program that will start when the Pi boots.

Run the following commands

```
sudo service hostapd start
```

```
sudo service isc-dhcp-server start
```

You can always check the status of the host AP server and the DHCP server with

```
sudo service hostapd status
```

or

```
sudo service isc-dhcp-server status
```

To start the daemon services. Verify that they both start successfully (no 'failure' or 'errors')

Then to make it so it runs every time on boot

```
sudo update-rc.d hostapd enable
```

```
sudo update-rc.d isc-dhcp-server enable
```

Install ffmpeg

To capture the video input from the camera I decided to use ffmpeg. There are two choices you have if you want to use ffmpeg. You can compile it yourself or you can download a pre-compiled file. I choose the later because I trusted the source. Its up to you.

Here is the precompiled deb file:

```
wget https://github.com/ccrisan/motioneye/wiki/precompiled/ffmpeg_3.1.1-1_armhf.deb
```

Once the package is downloaded you want to install it.

```
dpkg -i ffmpeg_3.1.1-1_armhf.deb
```

Install Terminal App for Android

To interact with the Raspberry Pi using my phone you need an app that can connect to it using SSH. I choose the Termius package for this only because its permissions are not too intrusive and I liked the features that come with the app. You can download it from the Google Play Store.

Termius - SSH & Telnet Client

Using your phone ssh into the Raspberry Pi using the same command as before except with the new IP address.

```
ssh pi@192.168.42.1
```

After you enter the password you can now enter the command to capture video from the camera to the hard drive of the Raspberry Pi. The command below will capture 50 secs of video. It will also name the file to the current date and time.

```
ffmpeg -f video4linux2 -s 640x480 -i /dev/video0 -vframes 1500 $(date +%Y-%m-%d-%H-%M-%S)%03d.mp4
```

To capture 100 images instead of video use the following command.

```
ffmpeg -f video4linux2 -s 640x480 -i /dev/video0 -vf drawtext="fontfile=/usr/share/fonts/truetype/dejavu/DejaVuSansMono.ttf:text='{localtime: %T}':x=20:y=20:fontcolor=white" -vframes 100 $(date +%Y-%m-%d-%H-%M-%S)%03d.jpg
```

Now for the pictures.

Camera Pictures



Illustration 51: Completed Camera Setup



Illustration 52: Completed Camera Setup View 2



Illustration 53: Camera Battery

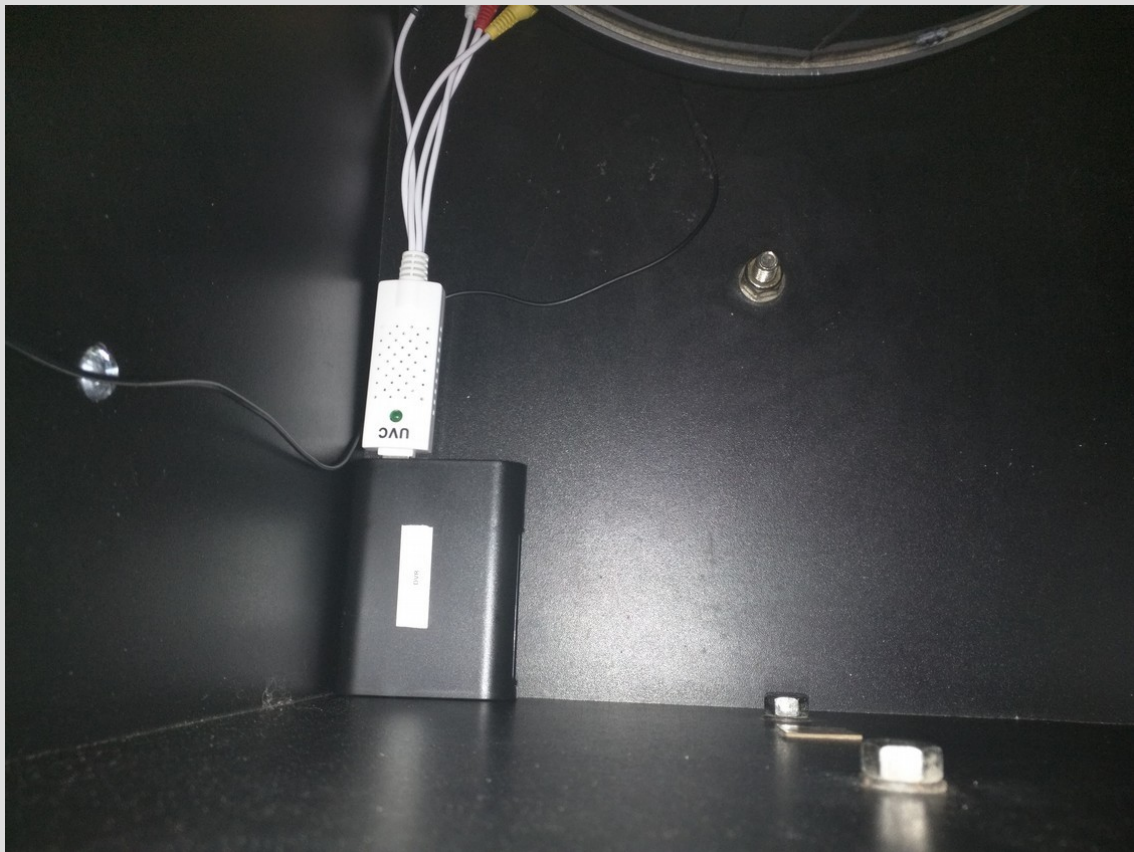


Illustration 54: Raspberry Pi DVR



Illustration 55: Raspberry Pi DVR View 2



Illustration 56: Camera Control



Illustration 57: LCD Screen Wiring



Illustration 58: LCD Mounting Hardware

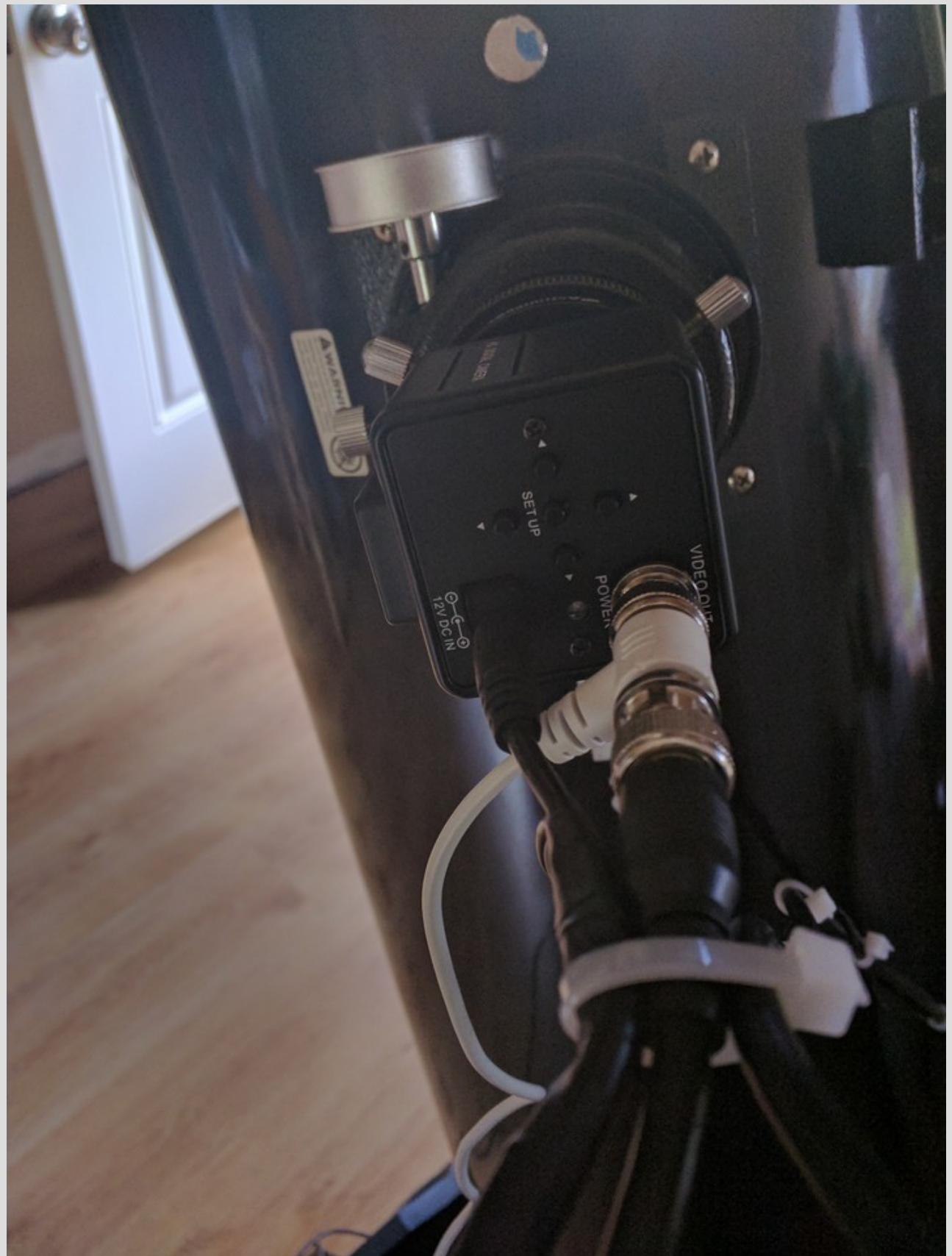


Illustration 59: Cord Relief for Camera



Illustration 60: Cord Storage for Camera and LCD

Dew Heaters and Fan

Back in April 2017 the club had a solar filter and dew heater workshop. I assembled the dew heaters using Chuck Jagow's instructions and inserted them in the shrink wrap but didn't do anything else after that. I decided to finish this project over the last couple of weeks.

Needed Materials:

Schumacher Electric 1,200-Amp Car Battery Jump Starter - \$129.00
Item # 595192
Model # XP2260
Dew Heater Strips parts (purchased in bulk through club) – less than \$40.00
330 Ohm resistors - 60?
Shrink wrap
Door trim foam
RCA connectors
Wire

Materials already on hand:

Misc Cables
RCA
Spare cigarette power cord
Wall wart
120 mm computer fan

Tools:

Drill
Various drill bits
Velcro (10 inches)
Wire Strippers
Dikes
Soldering Iron
Solder
Multi-meter

Re-check Dew Heater Strips

First I ensured that the resistors wiring was still good using my multimeter. I also disassembled the connectors to add a piece of insulation between the hot and ground points to help prevent any accidental campfires on my telescope. The insulation I used was two sided tape for poster board cut to fit.

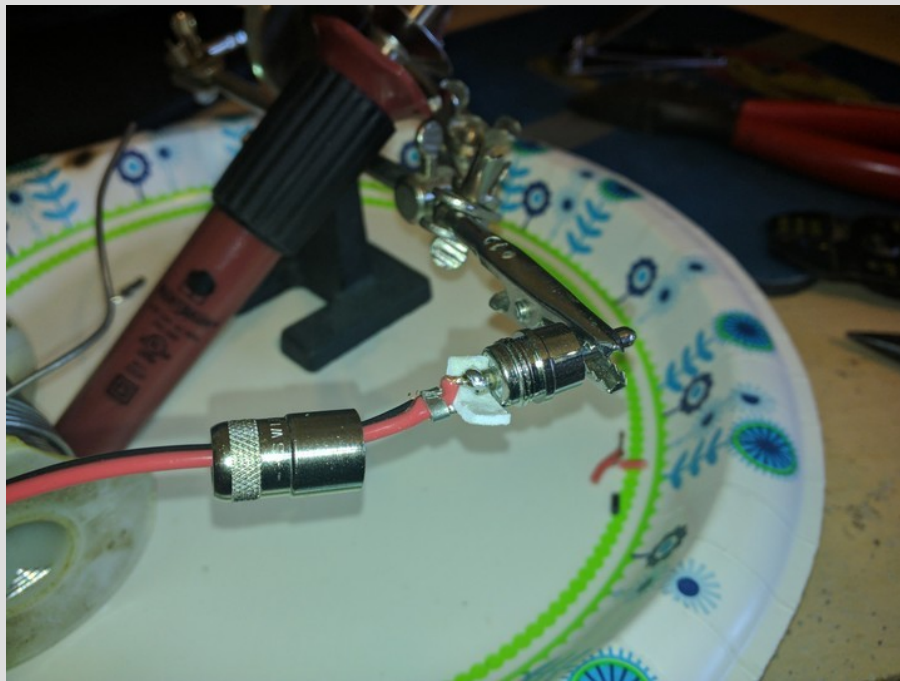


Illustration 61: Dew heater strip RCA connector

Then I wrapped the dew strips around a large PCV pipe fitting I had (about 2 inch) and used an inexpensive heat gun to shrink the dew heater shrink wraps.



Illustration 62: Heater strips after shrink wrapping

Convert Video Switch Box

Then I dug through my large bin of electronics parts to find a old video switch box that I knew was in there somewhere.



Illustration 63: Video switch box

Since there was so many RCA inputs on the box and it is about 8 inches long I didn't want to use the whole thing. I removed the circuit board from inside and de-soldered one bank of RCA connectors on it.

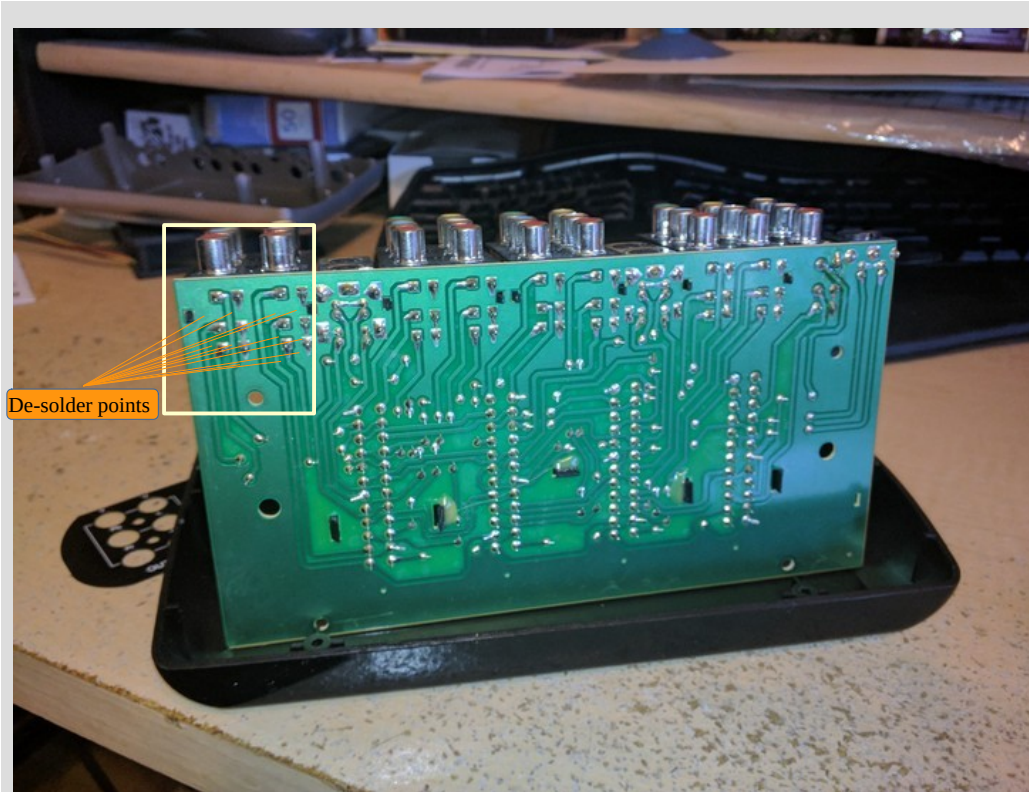


Illustration 64: Video switch box circuit board

Construct RCA Connector Assembly

I determined the RCA connector that had the easiest access to it and run wires from it to each other RCA connector and soldered them on. Then I placed the same insulation material from before between the rows to help prevent shorting again. The insulating material was placed after this photo.



Illustration 65: RCA connector internal assembly

Then I went back to my trusty electronics bin to find an old wall wart that wasn't being used for anything. I made sure that the rough dimensions were large enough to hold the RCA connector I had made in the previous step. I carefully broke it open to remove the transformer and circuit board inside. Once that was done I used a hack saw to remove the plug. Then traced a pattern of the RCA connectors and using it as a template I attached it to the top of the wall wart and drilled out the holes for the RCA connectors. Its best to do this in steps using various sizes of drill bits. Start with a very small bit to ensure that you're at dead center before drilling the holes and work your way up to the size you need. I ended up using a piece of a wood shim to ensure that the RCA connector maintained a tight fit in the box. I used some quick drying glue to reseal the box and then burned the markings for the holes so I know which one goes to what. Below is a close up of the front and back of the wall wart to help explain.



Illustration 66: RCA Connector Front



Illustration 67: RCA connector back

Custom Power Cord

Back to the trust electronics bin to find an old cigarette outlet power cord. The outlet cord I picked has a fuse built into the plug so in the event of a short I have some protection. I had an old RCA cable assembly that I removed the red cable from and soldered that to the other end of the cigarette cord. Resistance check was satisfactory so I wrapped everything up with electricians tape.



Illustration 68: RCA power adapter

Below are all of the dew heater strips and the RCA connector box.



Illustration 69: Complete dew heater assembly

I decided to place the RCA connector box inside the cradle to hopefully prevent any accidental bumps to it. The wiring to it was wrapped with Velcro in various places so the cord can be easily attached to the telescope or removed when not in use. (See last picture)

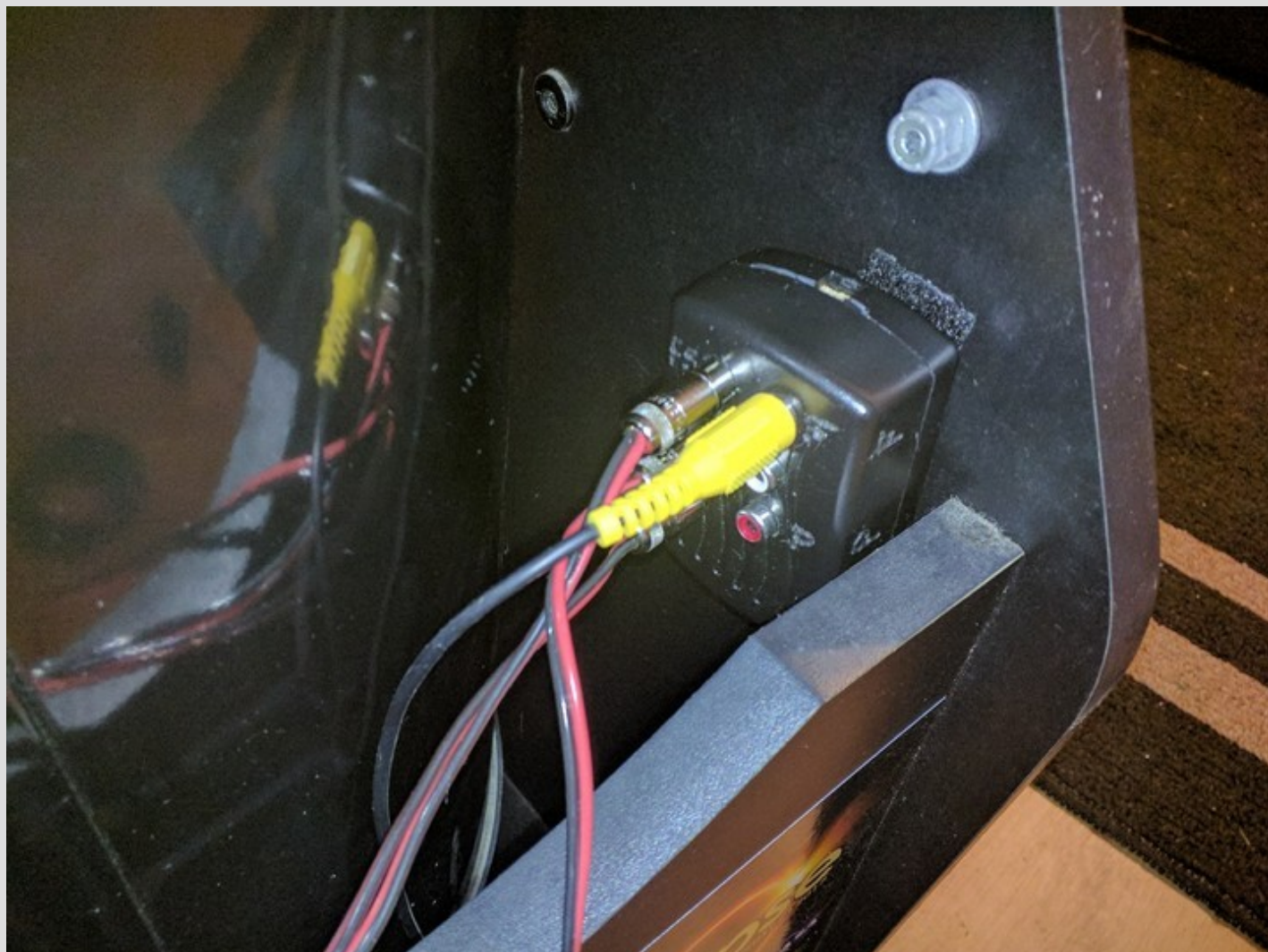


Illustration 70: RCA connector box mounted

I purchased this power pack at Lowes when I made my DVR for the camera shown above in another tutorial. It has two 12v outlets that I can use for the dew heater assembly.



Illustration 71: Power pack

Time to power it up. Fingers were crossed and my breath was held.



Illustration 72: Dew heaters installed

SUCCESS!!!

Fan Assembly

Last thing I wanted to plug into the new RCA connector box was a fan to help cool the mirror. I had a low speed 120mm fan already and poster board. I carefully cut a piece of poster board to fit the MOST of the opening at the bottom of the telescope. Then I cut an opening in it for air flow based on where the fan actually sits since it will not be centered perfectly at the bottom of the scope. The reason it won't be centered is because you're only using three attachment points to hold a square. It's close though. I used three of my daughter's hair scrunchies to secure the fan to the locking screws near the mirror. The wiring for the fan was connected to the yellow RCA cable I had not used from earlier. The benefit of using scrunchies to hold the fan is that they absorb the vibration of the motor and it's not transferred into the telescope assembly. I choose to not use a controller to determine the voltage for the heaters because from what I've read it isn't necessary. If the setup drains the battery too quickly or gets too hot then I'll make one of those too. Everything is working correctly now but there were missteps on the way. I'll update this document when I add the last heater which is for the secondary mirror.



Illustration 73: Cooling Fan

Integrated Solar Filter

In 2016 the club hosted a solar filter and dew heater workshop at Jim Tallman's home. The solar filter worked great but there was some issues. The biggest problem that I encountered was the stability of the solar filter on the telescope especially when there was wind or someone bumped it while viewing through Sun through the eyepiece. During the solar eclipse in August of 2017 I actually got dehydrated by constantly attending to the telescope while guests lined up to view the eclipse. Also the poster board is a temporary material. No matter how much you baby it the material wears out over time and becomes damaged, usually during transport. For these reasons I decided to integrate the solar filter in my existing cover for my Orion 10" telescope.



Illustration 74: First Solar Filter Design

Needed Materials:

3-in PVC Cleanout Plug - \$1.99

3-in PVC Cleanout Adapter - \$3.79

3-in PVC Test Cap - \$0.80

3-in PVC Coupling - \$1.66



Materials already on hand:

Black Spray Paint
Solar Filter Material
Painters Tape

Tools:

Drill
Hole Saw
Jig Saw
Razor Blade
Sharpie

Use the PVC Test Cap to mark on your telescope cover with the Sharpie an outline of the material you need to remove for the solar filter. Make sure you plan so the solar filter will not interfere with the secondary mirror. I used the hole saw to make the first hole in the cover and then used my jig saw to trace around the edge on the hole. Remember it is better to remove less material at first and cut it away as needed afterwards because once its gone its gone. If you have a 3" hole saw you can just use that to make the hole. Clean all of the plastic bits from cutting on the cover and your work area. You don't want them falling down your telescope onto the mirror afterwards.

Take the PVC Test Cap and remove the raised inside edge of it. When you are done you should have just the outer ring and it will look like a large 3" washer.

Place the PVC Test Cap "washer" on your solar filter material while it is still protected in the plastic cover. Using the razor blade cut the solar filter material around the outside edge of the "washer".

Now you want to paint the INSIDE of all the PVC parts and both sides of the newly created "washer" with the black spray paint. I used a flat black. I let this dry overnight.

Assembly the parts in this order:

1. PVC Coupling
2. Solar Filter Material
3. PVC "Washer" (slide the washer up the PVC Coupling upside down so it pinches the solar filter material in-between the two.)
4. Telescope Cover
5. Cleanout Adapter
6. Cleanout Plug

I used a vice to slowly compress the fittings together. You can use a rubber mallet and a hard surface to do the same thing. Just make sure that when you are done that the solar filter material is still where you want it.

I covered all the parts of the telescope cover with painters tape to protect from overspray and painted the rest of the solar filter at this point. Make sure you use light coats and let it dry in-between them.



Illustration 75: Solar Filter with Cap



Illustration 76: Solar Filter Inside

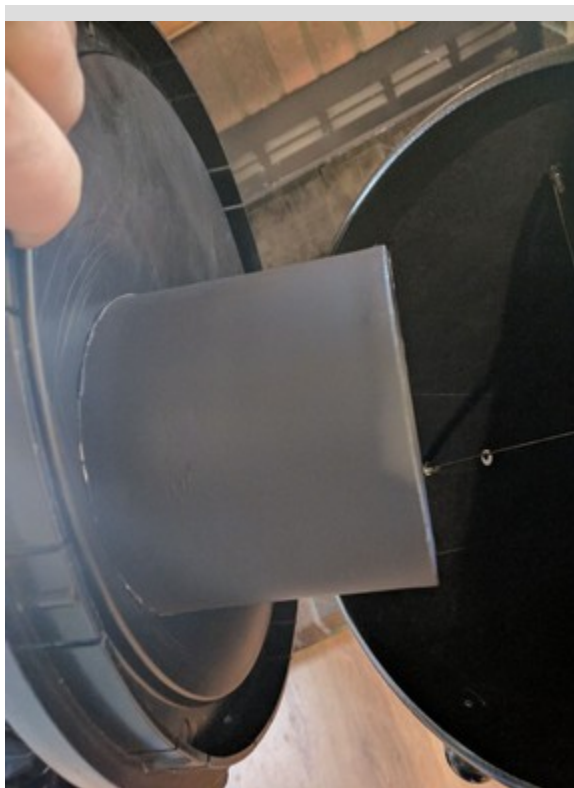


Illustration 77: Solar Filter Bottom

