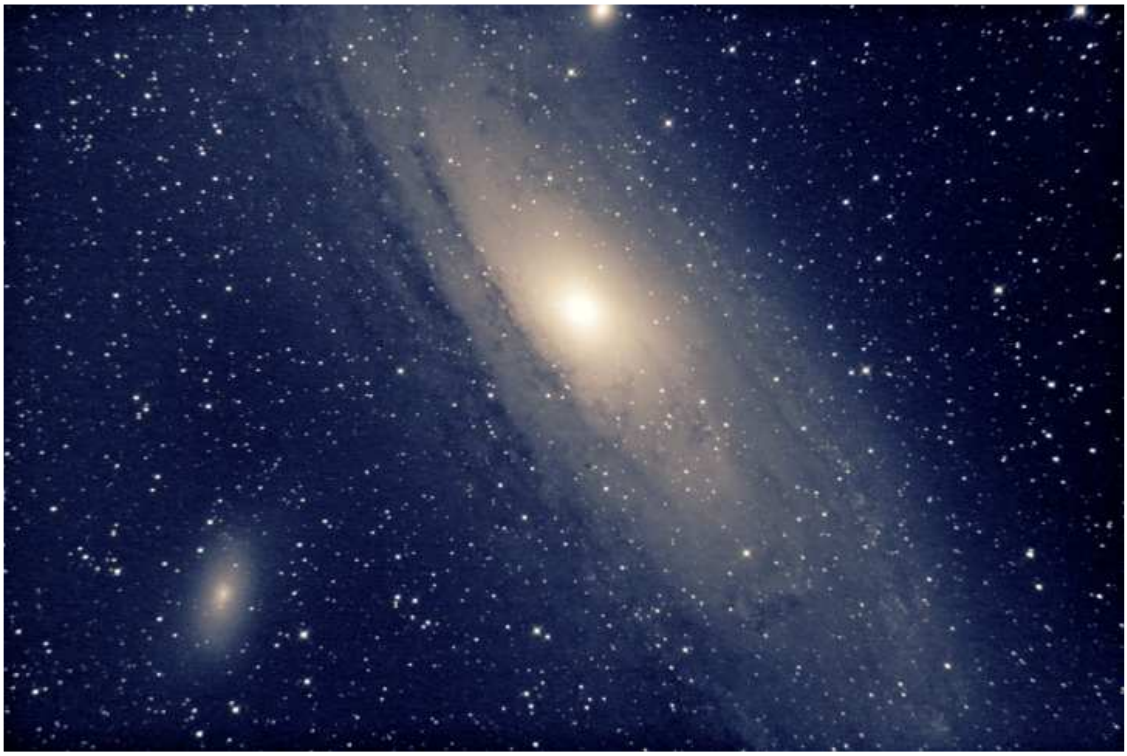
Making A Mirror Grinding Tool
By Allen Malsburry

The average person would never think, “I can make my own telescope.” Most amateur astronomers believe, “I can buy a better telescope than I can build.” Neither is actually correct.

For many decades now, amateur astronomers have been building their own telescopes. In the good old days, building your own telescope was the only way to get an affordable large aperture telescope. Back in the day, owning your own 10” telescope was huge. Today, with the low-cost imported telescopes, making your own telescope may not save you any money, but you definitely can build your own telescope, and almost any homemade telescope will have higher quality optics than the imported equivalent scope you can buy.

The image below was taken using my first homemade 6” mirror. Even though this was my first mirror, its optical quality is two to three times better than the average mirror found in an imported telescope of the same size.



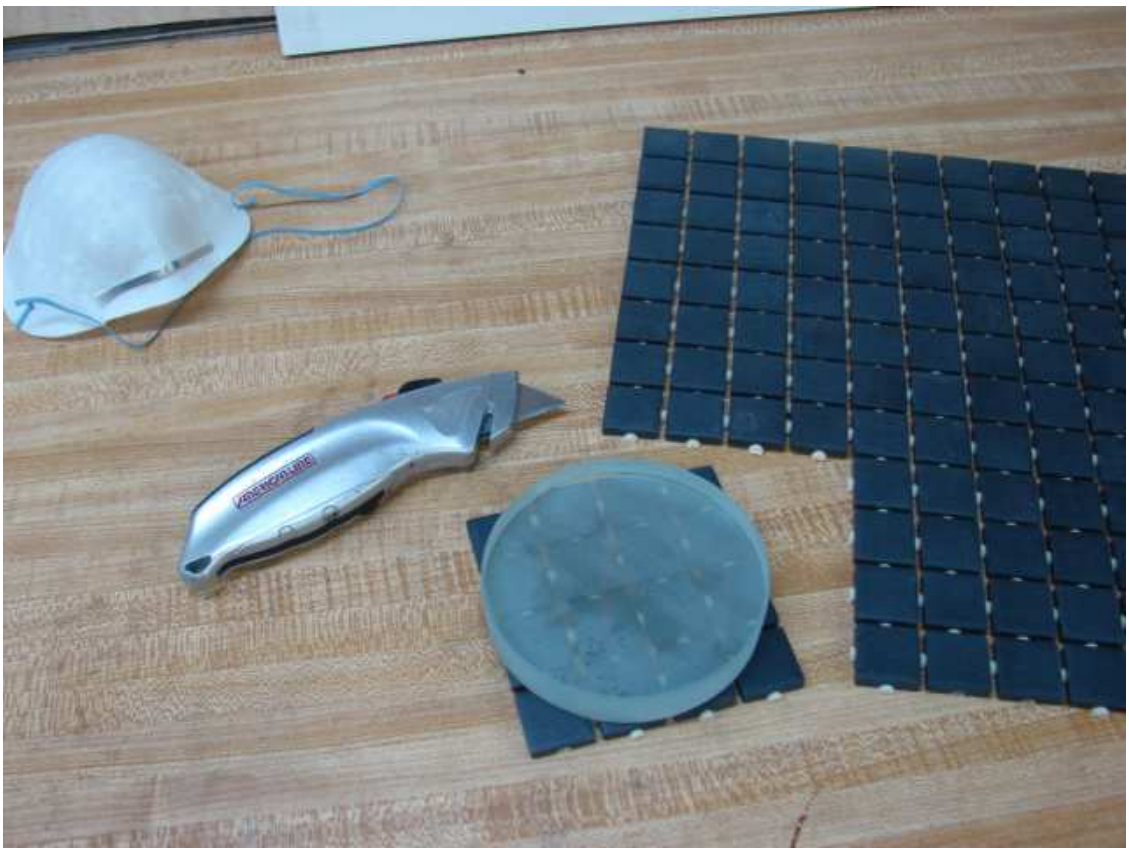
Most amateur telescope makers (ATMs) build a Newtonian telescope, a design named for its inventor, Sir Isaac Newton. The heart of the Newtonian telescope is its primary mirror. Most Newtonian primary mirrors have either a spherical or a parabolic shaped concave face. Unlike most other mirrors in your home, the mirror coating of a Newtonian mirror is actually applied to the front face of the glass, not the back. The light collected by the Newtonian primary mirror does not pass through any glass until it reaches the eyepiece. It simply reflects off the curved concave mirror face which focuses all the light collected to a point known as the "focal point" of the mirror. If you want to learn more about Newtonian telescopes the internet is replete with information about all types of telescopes.

Typically, the primary mirror is made of glass. Pyrex is commonly used for the primary mirror because of its thermal stability, but for small mirrors, plate glass will work fine too. Telescope mirrors are relatively thick. The concave shaped face is made by repeatedly rubbing the primary glass blank over another blank called the "tool". The tool is equal in diameter to the primary. To grind away the unwanted glass from the glass blank and form the primary's concave shape, grit and water are placed between the "tool" and the primary face. Once the target depth of the concave shape is reached, finer and finer grinding grits are used to slowly smooth out the new concave shape and to remove the scratches and pits left behind by the previous coarser grit. For a small mirror, it is common to use at least six different grades of grits before moving on to the polishing operation.

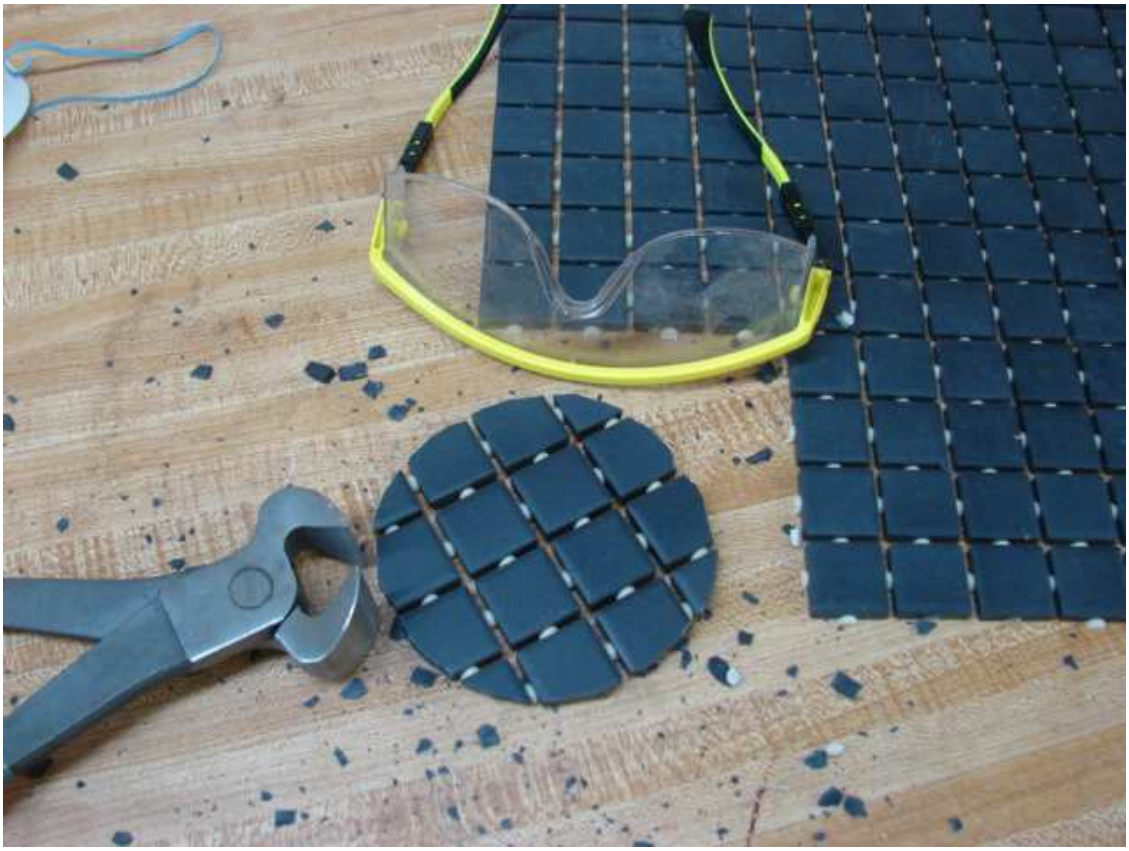
In years past, it was common to use two pieces of glass, one for the primary and one for the tool. After the concave mirror was made, the glass "tool" was scrapped. Today, because glass is expensive, we make the "tool" using less expensive materials.

Here is how to make the grinding tool.

1. Trace the outline of the blank on a section of 3/4" tiles with a marker. Pick out a flat face tile like the tile shown in the photo. Most sheets of tile have a back webbing to hold them in a sheet. Cut the tile backing material with a utility knife removing the section you want for your grinding tool face.



2. Trim the tile to that line using a tile nip. Wear safety glasses because the pieces fly in all directions when you nip off the corners.



3. Make a form/dam that fits tightly around the outside of the blank. This can be made from a section of vertical blinds or a short length of aluminum flashing that goes around the circumference of the blank at least one and a half times. Use tape to keep the form from unrolling. The form should extend above the face of the blank at least the thickness of the blank.

4. Lay the blank on a level surface, face up.
5. Cover the face of the blank with plastic wrap to keep dental plaster off it.
6. Push the form down over the blank. Mark the depth you want your tile tool to be on the inside of the form. (I make my tools about the same thickness as the glass blank.)
7. Place the trimmed tile section face down on the blank.

8. You are now ready to pour dental plaster.
9. Dental plaster is like any other plaster. A little water goes a long way.

10. Pour a portion of the plaster into the mold onto the back side of the tile. Work it into the spaces between the tiles making sure the tile stays in contact with blank. I wear deposable gloves during the mixing and pouring. It just saves time cleaning the hands later.

11. Pour more plaster to the desired thickness and smooth the top. Walk away for at least 20 minutes. Dental Plaster sets in less than 30 minutes. The surface of the plaster will begin to look dry and will be hard to the touch.

12. Remove the tape around the form allowing the form to unroll. Remove the form. The plaster is very weak at this point. Handle it with care.

13. Smooth of the edges (gently) with an abrasive block. The plaster should be fairly soft. I used a wood block wrapped with some plastic door screening to wear away the soft plastic for this step.

14. There may be a very thin film of plaster over some the tile faces, this will grind off in the first few grinding sessions. Let the tool dry/harden overnight.

During the grinding process, only the depth of the concave surface is measured. Good grinding technique will produce a spherical shape, therefore the only important property needing measurement is the depth of the concave surface at the center of the mirror. The easiest way to do this is by placing a stiff metallic straight edge across the mirror face center spanning edge to edge. You then measure the gap between the straight edge and the mirror face at the center with a set of feeler gauges. You can also use a “spherometer” which is a device that can measure the radius of curvature (ROC) of the concave surface. You must measure often when “hogging” out the center of the blank. A very common mistake is to overshoot on the concave depth. If you do this it will take at least five times as long to recover that depth as it took to dig the hole in the middle of the mirror. As you transition from "hogging" to your normal 1/3 Center over Center (CoC) strokes you need only measure once every ten minutes. After you have completed the first 3 or 4 grits, the depth of the concave surface will not change much and really does not need to be measured that often.

Before you start grinding, you should visit the Stellafane mirror making site. They have lots of information about preparing your glass blank for grinding:

http://stellafane.org/tm/atm/grind/bevel.html

The following link gives info about how to “hog out” the center of the mirror blank using the tool you just finished:

http://stellafane.org/tm/atm/grind/rough.html

They have short videos for each of the two different strokes you will need to compete grinding your mirror:

http://stellafane.org/tm/atm/mirror-refs/strokes.html#The Chordal Stroke

The site contains many other suggestions you should consider before you start.

http://stellafane.org/tm/atm/index.html

After fine grinding is complete, the mirror must be polished. It is during polishing that you “figure” the mirror by using a different polishing stroke to change the mirror’s spherical polished shape into a parabolic polished shape . See a related tutorial nearby titled, “Making A Mirror Polishing And Figuring Tool”.