ATM Journal 2: Getting Ready to Push Glass
By Gordon Tulloch, RASC Winnipeg

We have a couple of telescope designs in mind (as described last time) - an 8" f5 portable telescope, and an 8" f10 decidedly non-portable instrument. The common thread is that each will require an 8" mirror to be bought or made. While an 8" mirror is fairly inexpensive (approximately $200-250) we will do things the old fashioned way: grinding our own.

Mirrors can be created using a huge variety of materials, including various glasses, Pyrex, and ceramics. The criteria one must consider when looking at materials is ability to hold a figure, and thermal characteristics. For example, if you have a portable scope that you want to haul out of the house into the back yard and observe with, you will want to choose a material that will cool to the ambient temperature quickly to avoid changes in the figure of the mirror due to differing thermal zones in the mirror.

For my 8" planetary scope I've chosen to try Black Vitreous Ceramic (BVC) which is conveniently available from a Canadian company named ASM Products in Ste-Basile, PQ (pages.infinit.net/asmprod.) BVC has excellent thermal characteristics, and is softer than glass or Pyrex so grinding will be faster. An 8" blank from ASM costs $44.95US. A kit containing a BVC blank, a glass tool (used as the surface against which the mirror is ground), plus supplies for grinding and polishing a mirror is also available but although this is what I purchased originally, I suggest you not bother with the kit. We will in fact be casting a tool to use for grinding as well as a separate tool for polishing. Also, the abrasives provided by ASM are in some cases not required and in some cases of insufficient quantities (at least for inexperienced grinders). My 8" glass tool provided by ASM will in fact be ground into the 8" f5 mirror - glass isn't the best material thermally but since it's lying around anyway, I might as well make a mirror out of it!

Abrasives and other supplies must be purchased as well. I suggest purchasing the following from ASM or US companies such as www.GotGrit.com:

1 lb. Aluminum Oxide 120, 240
1/2 lb. Aluminum Oxide 500, 1000 and 2500
1/2 lb. Cerium Oxide
1/2 lb. Pitch
Spray Bottle and water (mark it H^2O, you'll feel very scientific!)
Sponges - one per abrasive grade (very important!)
Bucket
Towels

Silicon Carbide can also be used but is more aggressive than Aluminum Oxide and more suitable for glass or Pyrex rather than softer BVC.

The process of grinding a mirror is astonishingly simple, considering the result will be a surface that deviates from perfection by perhaps thousands of an inch. Generally, the tool is attached to the top of a grinding platform such as a barrel (I use a 4 sided 2x4 pier embedded in concrete in a garbage can.) The mirror is the ground against the tool using progressively finer grades of abrasives. As the grinder strokes the surfaces

together, she also periodically rotates the mirror one way, and steps in the opposite direction around the grinding platform (or in some other way causes the tool to rotate.) As the work progresses, the mirror and tool can be interchanged - Mirror On Top (MOT) will generally increase the curve of the mirror, Tool On Top (TOT) will decrease the curve. Different phases of the process will required different strokes.

Speaking of tools, in the bad old days people rubbed two pieces of glass together and then used the same piece of glass as the foundation for a polishing tool. Unfortunately, using a flat piece of glass can lead to problems with polishing, so mirror makers have almost universally moved to a channeled tool, either by grinding channels in glass tools, or more commonly casting a tile tool from some form of plaster.

To cast a plaster tool, obtain some Dental Stone from a dental supply company (Dental Plaster will also work well although not as hard as Stone - other plasters are to be avoided since they' re not waterproof). This material can be cast into a very hard tool and is waterproof so it doesn' t need to be sealed. You' ll also need some 1x1 unglazed mosaic tiles. These tiles (commonly found at Home Depot or tile specialty stores) are joined together using nylon or rubber into 12"x24" mats, which makes them perfect for creating a regular, hard grinding surface on a tool. Since the tool needs to match the face of the mirror exactly (particularly if you buy a mirror with a pre-generated curve) we cast the tool on top of the mirror. The cost for a sheet of tile as of Oct. 2002 is $6. If you have problems finding tiles, contact the author, I have a limited supply on hand.

Prepare the tiles by placing the mirror on top of the mat of tiles and tracing it' s outline onto the tiles. Try to include as many complete tiles or large sections as possible. Depending on the mirror size you can either cut the tiles using a tile nipper, or remove incomplete tiles from the mat for mirrors larger than 12". Don' t keep tiles smaller than 50% as they are prone to lift and scratch the mirror. If you do cut tiles, put a bevel on the cut tile with a carborundum stone (commonly found in the Tiles section in Home Depot) or whetstone. Clean any grease or dirt off the tiles with hot water and dish detergent.

Place the mirror face up on a flat surface. Next, cover the surface of the mirror with cooking oil to allow easy release of the tool. Cover the cooking oil with plastic cling wrap, getting as much of the air out as possible. Next place a dam around the edge of the mirror - this will hold in the plaster while it sets. The dam should be about 3" taller than the mirror thickness. You can use wax paper, aluminum foil, or other materials for dams, although I prefer to use thicker aluminum sheeting (from the car body repair section in Canadian Tire) since it' s very stiff and easy to snugly fit around the mirror. Place the tile mat face down on the surface of the plastic wrap.

Mix up some Dental Stone in a bucket, ensuring that the mixture is kept fairly wet to avoid it hardening in the bucket. When the mixture is wet but not sloppy, pour enough onto the mirror surface to create a 2" thick layer. The stone should hold it' s shape but liquefy when vibrated. Make sure to run more water into the pail and agitate to avoid the stone hardening, and never pour Dental Stone down the drain unless you' re skilled in using explosives, because that' s the only thing that will clear a drain blocked by this material! Note that the stone will harden quite quickly so work fast.

Give the mirror and dam a few taps to get rid of any bubbles and to flatten the back of the tool. Using a skewer or chopstick to press down on the tiles through the stone to make sure none have lifted (agitate to get rid of the holes left by the skewer.) Using a flat scraper, scrape the back of the stone as it hardens to ensure it is flat. When the material is dry (but not yet too hard) you can remove the dam and slide the tool off the face of the mirror. If you' ve timed it right, the tool should be quite hard, but wiping the tile face should wash away some of the stone from the face so you can deepen the channels between the tiles with a clothe or a sponge. Again, do this from the bucket to avoid getting stone into your plumbing. If the stone is too hard to deepen the channels, use a whetstone on edge to grind away stone from the channels. You now have a grinding tool! Save your dam as you' ll use the same technique later to cast a polishing tool (without the tiles).

For very detailed instructions on this process send me an email (gtulloch@shaw.ca) and I' ll send you a Word document from Richard Schwartz, who while not originating this technique has refined it greatly.

Final word: You might wish to check out “How to Make a Telescope Second Edition” by Jean Texereau published by Willmann-Bell Inc. This is the classic text for making telescopes, particularly grinding, polishing and figuring mirrors. The Winnipeg Public Library has multiple copies held at the Centennial Library, or get it from www.willmann-bell.com. We will deviate from Texereau in some ways but it' s well worthwhile to read at least the mirror making sections of this book to understand what the deviations are and why they were developed.

Next time: Rough Grinding