Curve Generation with a sub-diameter tool.

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Starting with a flat blank, one of the more efficient ways of generating a concave curve on its surface is to use a sub-diameter tool. An ideal tool is a metal barbell weight about 50% the diameter of the mirror. Make sure you buy a weight with a raised rim round its edge; you will also see a similar rim round the hole through which the bar slides. It is best to grind away the central rim round the hole with an angle grinder.

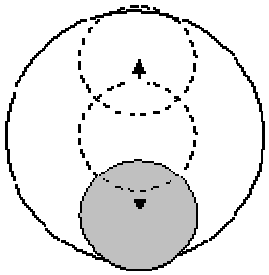
A barbell weight makes a good grinding tool, grind off the raised central region as shown on the right.

During this process the mirror is ground face up and is supported on a flat surface. The mirror should have a bevel ground on its edge about 1/8 inch wide to help prevent chips occurring, if ground away the bevel should be renewed.

Beveling the edge of the mirror blank

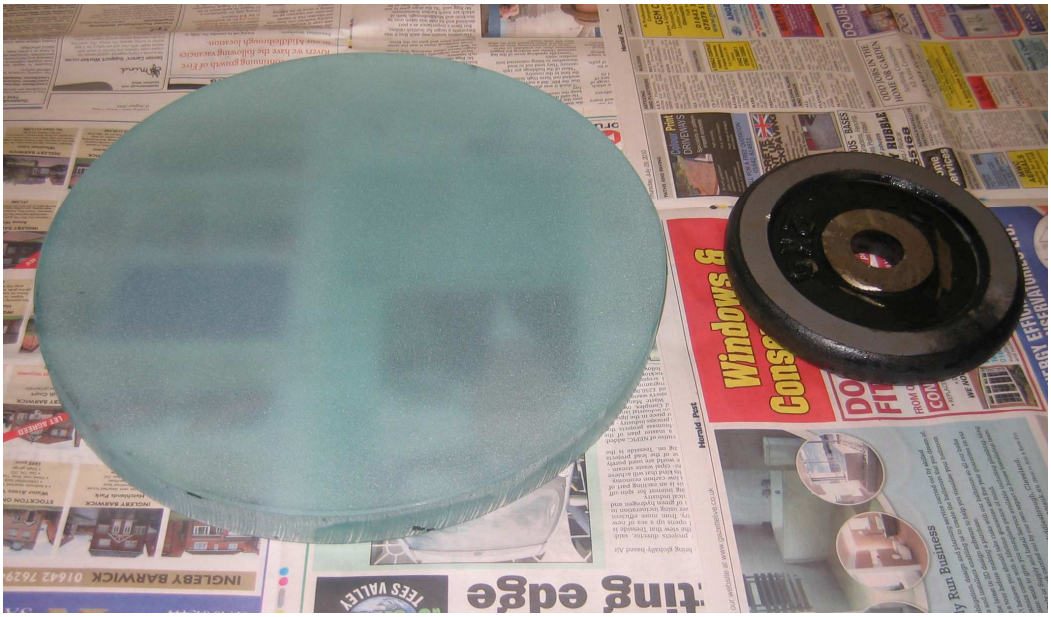
It is best to use quite a coarse abrasive for the grinding process, at least 80 grit silicon carbide is recommended, and a coarser abrasive will cut even faster. The surface of the mirror is kept wet during the grinding process. The grinding stroke involves three components all of which are undertaken simultaneously, they are:

1. The tool is pushed back and forth across the surface of the mirror with the centre of the barbell weight passing through the centre of the mirror blank. The barbell weight overhangs the edge of the mirror by about ½ inch or 12mm.
2. The barbell weight is rotated in the hands, speed is not critical one rotation per stroke is adequate.
3. Traditionally the mirror is worked on a barrel and the worker walks round the barrel at a constant rate during grinding. If the mirror is being worked on the corner of a table, the worker walks as far one way as possible then does the same in the opposite direction.



Centre through centre stroke. Using a 50% diameter tool or lap which ends with a slight overhang on each stroke. Use for example, to rough in a curve on a mirror blank. Usually results in a non spherical curve which is deeper in the centre.

For a 12 inch mirror two or three teaspoons full of abrasives and a little water will be enough to begin with, this is called a 'wet'. At the start of grinding the process will be noisy, after a few minutes the noise subsides indicating that the abrasive has been broken down; it is time for another wet. After several wets a slurry of broken down abrasive and glass dust will accumulate on the mirrors surface, this needs to be removed by washing the mirror blank and barbell weight with water. The grinding process can then continue.



The mirror and grinding tool after 2 hours work.

How Deep Does the Curve need to be?

The depth of the curve on a mirrors surface, known as the sagitta, is related to its radius of curvature (which is twice the focal length) by the following formula:

$$S=r^2/2R$$

S = sagitta, or depth of curve
r = radius of the mirror
R = Radius of curvature (twice the focal length)

For Example, to calculate the sagitta for a 12inch mirror with a focal length of 60 inches and therefore a radius of curvature of 120 inches.

$$S= 6*6/2*120$$

$$S= 0.15 \text{ inches}$$

So the depth of the curve required is 0.15 of an inch, or 1/8 of an inch.

Measuring the Sagitta.

After about 2 hours work it is worth checking on the depth of the curve, this can be done in a number of ways. Perhaps the easiest is to use a set of feeler gauges normally used by motor mechanics to set valve clearances etc. Feeler gauges consist of a number of flat metal strips of precise thickness; grouping them together enables measurements to be made that are greater than the thickest individual strip. A straight edge is placed across the middle of the mirror and the gauges are introduced under it to measure the depth of the curve. Another alternative is to use a drill bit of known diameter, this is introduced under the straight edge in order to measure the curve.

Measuring the sagitta with feeler gauges or a twist drill.

If you are not convinced that these two methods are not giving an accurate reading you can use an alternative method to check your results. Stand the mirror up on edge, taking precautions to ensure that it cannot fall over! Wet the surface of the mirror thoroughly, standing close to the mirror pick up the reflection of a bright torch. Move the torch from side to side; you will see its reflection moving in the same direction. Now, slowly move away from the mirror whilst moving the torch from side to side, you will reach a point at which the movements of the torch are seen to be reversed. This point is outside of the radius of curvature. The point at which the reflection flips from being the same to being reversed is the radius of curvature, at this point the mirrors surface is seen to be full of light when picking up the reflection of a torch. Measuring from this point to the mirrors centre gives you its radius of curvature, which is twice the focal length.

Working with a sub diameter tool tends to produce a curve that is deeper in the middle than at the edge. For this reason the curve should be

ground a little deeper than calculated as when work begins with a full sized tool the curve will even out resulting in a shallower centre.

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