Turning a Multi-Axis box
by Thom Sturgill

To turn an offset or multi-axis box, careful layout is helpful. To do the layout you will need a drawing compass, pencil, and ruler. A piece of stiff paper with a straight edge is also helpful.

First, choose some stock that will provide a reasonable sized box. I chose a piece about six inches long that would yield a 3" diameter. I turn by first mounting the blank between centers, rounding the blank, and creating tenons on both ends. Create the largest tenon that you can use. These will be used to grip the box while turning the cavity in the top and base and while fitting the top for either a friction or loose fit. A larger tenon will interfere less with the layout.

Once the tenons are turned, but before the top is separated, some layout needs to be done. Using the lathe's indexing ability, if available, is the easiest method. You need to layout points for the offset turning. I will diagram three points, but you can do four or more using the same techniques.

For a three sided box, layout points on the ends so that you get three points on one end and three matching points on the other end that are rotated 30 degrees from the other end if a spiral design is desired. Larger angles can be used, but I recommend starting at 30 degrees.

To mark out a three sided box on a Jet or Powermatic lathe using the 12 internal indexing holes, mark the first space on one end by locking the indexing pin in place and using the tool rest. Now unlock and rotate to the next hole, mark the next space on the other end being careful not to change the tool rest height. Skip the following two index holes. Repeat this pattern until all six key points are marked. To layout a four sided box, only skip one hole, and don't skip any holes if you want a six-sided box.

Remove the blank from the lathe and use the center points from the turning, and a straight edge to extend these marks to the center. Mark numbers beside each line near the edge. Make sure that the numbers on each end match up with the other end. This will help you correctly align the centers later.

Now draw a circle on each end. I use about 3/4” radius for a 3” box. Use the compass point to indent the six points where the circles meet the radial lines drawn in the previous step. These are the points that your centers will be set into.

Now set your compass point on one of these intersections and set the compass opening so that the pencil just touches the opposite radial lines at the circumference. Draw the arc between the points and repeat until all arcs are drawn on both ends of the blank. These arcs outline the final shape that you will turn to and will now allow you to set the size of the cavity. The amount of arch created can be varied by changing the diameter of the inner circle and testing the layout on paper is a good idea.
Using the compass, mark an arc from the center to a point just inside the previous arcs. Space it to allow the desired minimum wall thickness. Measure the distance from this arc to the outside of the box. This is the depth to which you will need to cut a groove around the box to separate the lid, and indicates the size of the hollowed area.

The following images illustrate the layout lines to this point.
Now is the time to separate the top. Gripping the base in a chuck by the tenon, use a parting tool to make a groove where the top will separate. This groove should be 1/4” to 3/8” wide initially. Now using a narrow parting tool start separating the lid by leaving a very small raised portion on the base. This raised area will show the diameter that you want to hollow to. A raised area on the lid will form the lip that goes inside the bottom. This can be reversed if you prefer, but will yield a smaller interior.

Hollow the base and fit the lid while the base is mounted in the chuck, then hollow the lid to the desired depth, remove it from the chuck and remount the centers. Fit the lid to the base and mount the unit between centers carefully lining up the grain. Now use a piece of stiff paper held between matching points and draw the spiral lines. This provides a set of lines delimiting the wood to be removed for each face. Mount the box so that the points labeled “1” are both held on a center and the lines are aligned. Tighten the tail-stock being sure to prevent slippage.

Turn the first face to the lines and sand completely. The box will not be remounted in this position, so be careful, use a sanding block and go through the grits.

Move to the next set of points (labeled “2”) and repeat, and do the same for any remaining center points.

To remove the tenons, I carefully mount my chuck jaws to the inside of the bottom and outside of the lip on the top. Pad them with the self-stick craft foam to prevent marring. Use very little jaw pressure and take small cuts using the tail-stock as long as possible. Other chucking techniques can also be used of course, such as jamb chucks or vacuum chucks.