



Multi-Sided Boxes – Straight, Sloping, and Twisted

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Caution:

Always use safety glasses or a full face shield when turning anything on a lathe.

Introduction.

Off-Center and twisted turnings are very easy once you have the initial layout using a little bit of geometry. You need to understand the following geometry 1. identify the parts of a circle 2. how to bisect a line with a compass 3. how to find the center of a circle using three points and 4. how to divide the circumference of a circle into equal parts. Once you have understood the geometry it is straight forward to mark up and turn multiple-sided boxes.

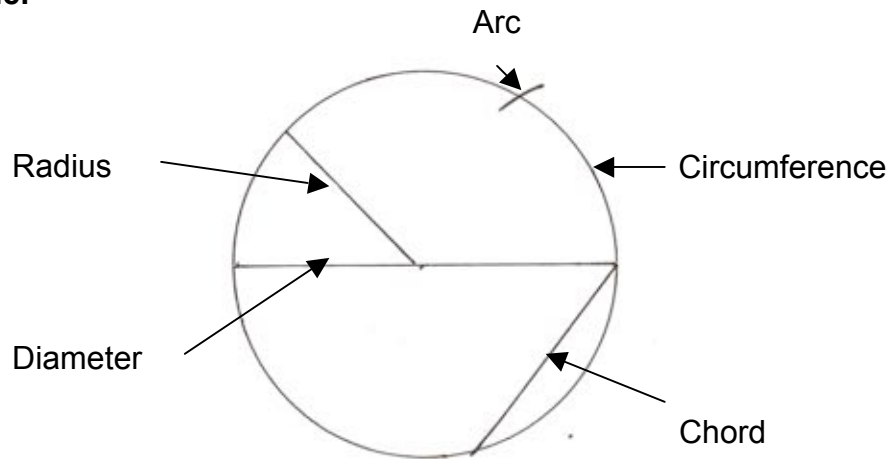
Section 1 - Basic Geometry.**1.1 Parts of a circle.**

Figure 1.1

Arc: a curved line that is part of the circumference of a circle

Radius: distance from the center of a circle to any point on the circle.

Diameter: the longest distance from one end of a circle to the other.

Circumference: the distance around the circle.

Chord: a line segment joining two points on a curve.

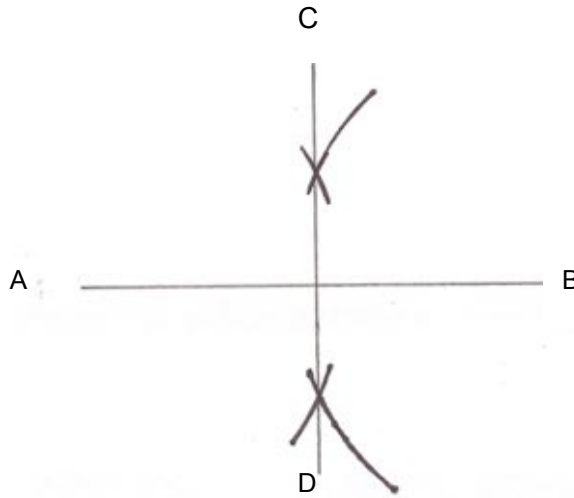
1.2 How to bisect a line with a compass.

Figure 1.2

Draw a line AB as in Figure 1.2 above. Set the compass to a measurement, which is greater than half the length of the line AB. Draw a couple of arcs with the point of the compass at one end A then the other B. The arcs will meet at two points C and D. Join these points with a straight line and you will find that the line bisects line AB, and cuts across the center of the original line at 90 degrees. This method will be used when marking a 2 and 4 sided box.

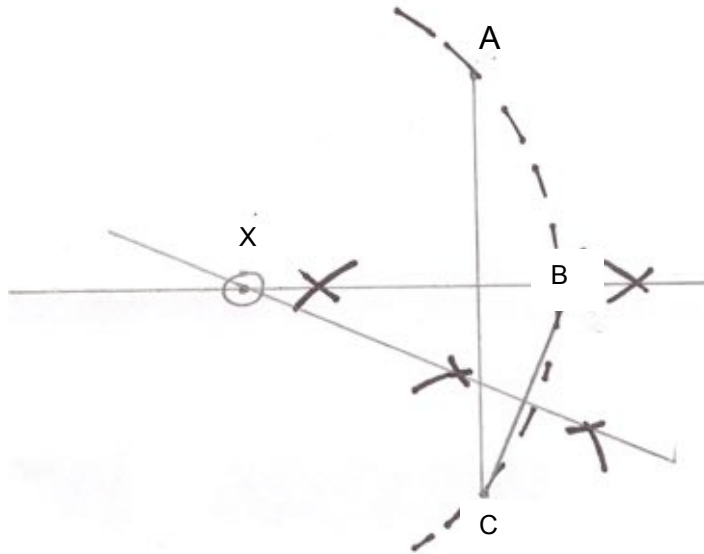
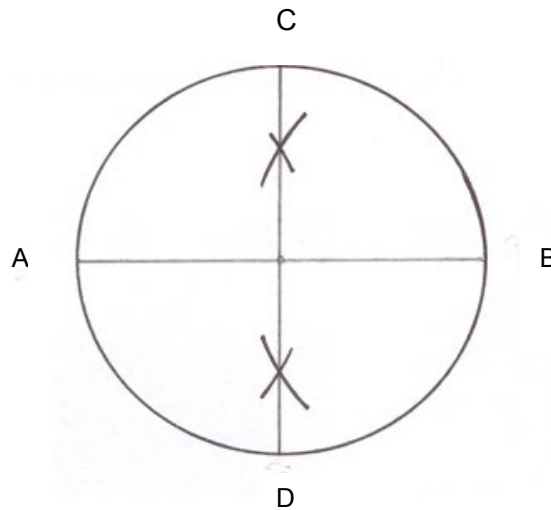
1.3 How to find the center of a circle from three points.

Figure 1.3

As in Figure 1.3 above draw three points A, B, and C that will be on the circumference of a circle. Connect points A and C with a straight line. This represents the first chord of a circle. Bisect the line AC using the method described in Section 1.2 above and join the arcs with a straight line. Connect points B and C with a straight line. This represents the second chord of a circle. Bisect the line BC using the method described in Section 1.2 above and join the second arcs with a straight line. Where the two lines interconnect is the center of the circle that puts the three points A, B and C on its circumference. This method will be used when marking a 2 sided box.

1.4 How to divide the circumference of a circle into equal parts.**1.4.1 To divide a circle into four equal parts.****Figure 1.4.**

As in Figure 1.4 above draw a circle with a diameter through the center of the circle AB that will touch the circumference of the circle. Bisect the line AB using the method described in Section 1.2 above to construct a line CD that will bisect line AB, and also touch the circumference of the circle. The circle is now divided by four points A, B, C, and D. This method will be used when marking a 4 sided box.

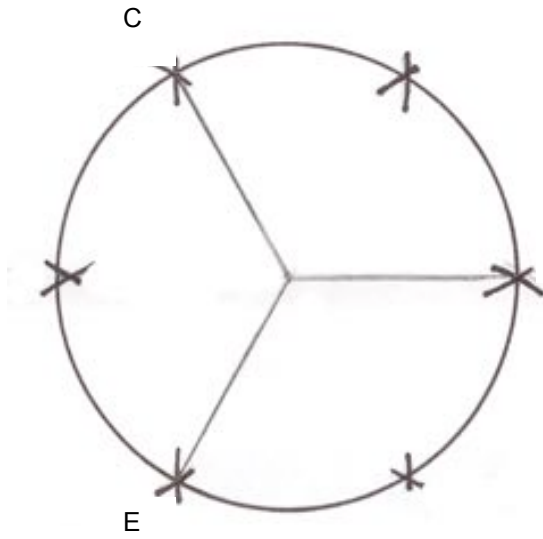
1.4.2 To divide a circle into three or six equal parts.

Figure 1.5

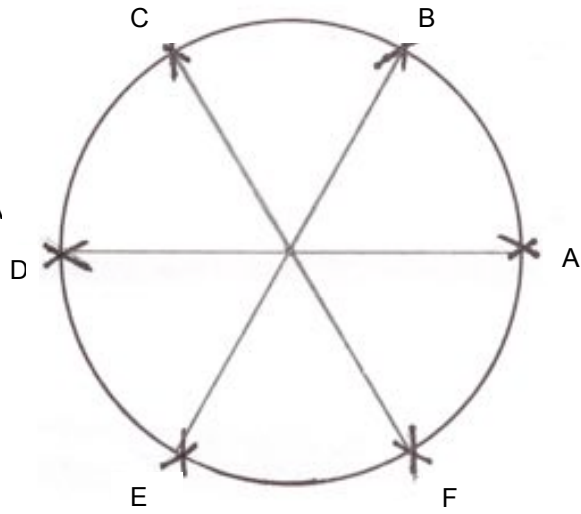


Figure 1.6

For both Figures 1.5 and 1.6 draw a circle. Set the compass to the radius of the circle. Pick point A on the circumference of the circle to strike an arc on the circle called B. Using that arc B strike a second arc C and so on until you have six arcs A, B, C, D, E and F marked around the circumference. As in Figure 1.5 a line connecting every other arc A, C, and E will divide the circle into thirds. As in Figure 1.6 a line connecting the center of the circle to any of these points A, B, C, D, and F will divide the circle into six equal sections. This method will be used when marking a 3 and 6 sided box.

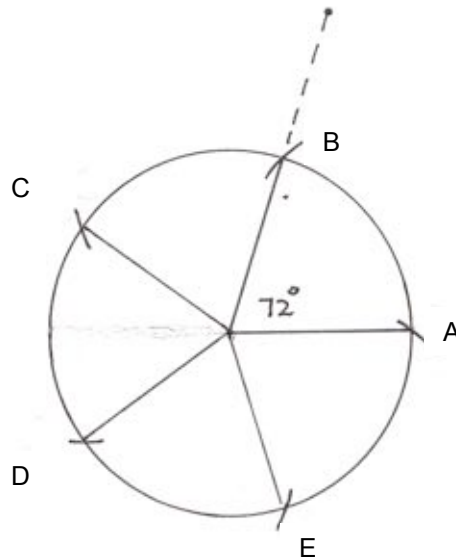
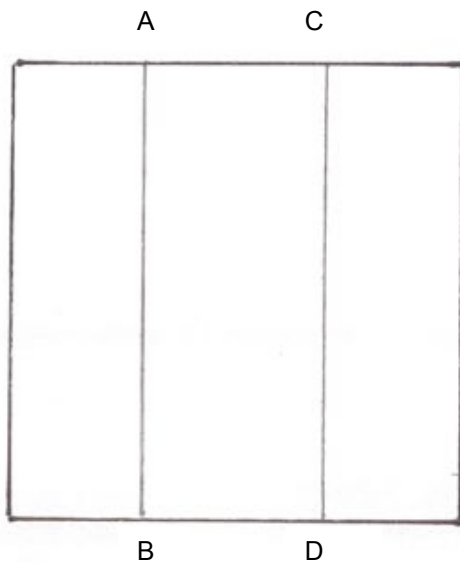
1.4.3 To divide a circle into five equal parts.

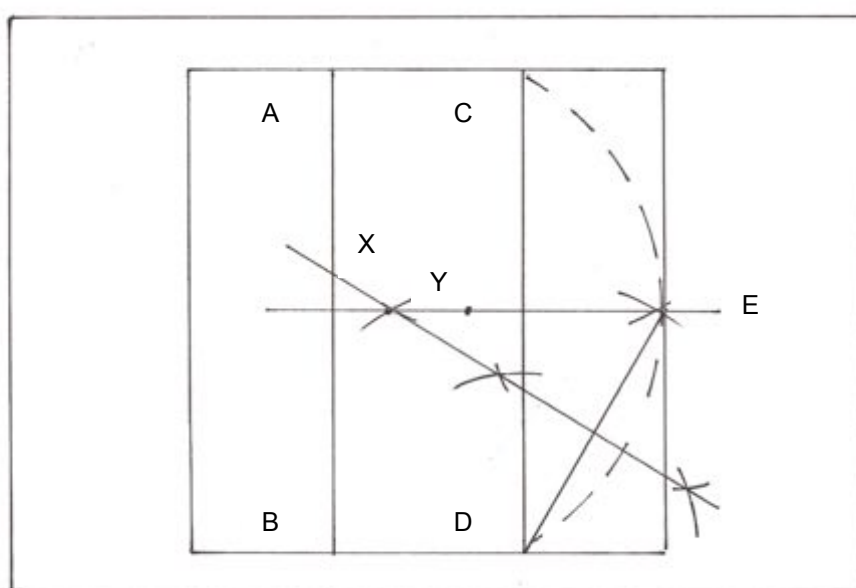
Figure 1.7

As in Figure 1.7 above the easiest way to divide the circle into five sections is first to draw a circle and mark the center point. Draw a line from the center point to the outside of the circle and mark the intersection as A.

Place a protractor on the line aligning the center point of the wood with the center mark on the protractor base. Mark the circle at 72 degrees and join the mark with the center point. Where the line intersects the circle mark the point as B. With a compass measure the distance between A and B. Place the compass point on B and strike another arc until you have five arcs on the circle. Name these arcs as A, B, C, D, and E. This method will be used when marking a 5 sided box.

Section 2 – Marking Multiple Sided Boxes**2.1 Two Sided Box.****Figure 2.1a**

Select a suitable piece of dry hardwood (suggest $2\frac{3}{4}$ " square by 4" long) that has square ends and mark the center points at the top and bottom of the wood. Using the diagram in Figure 2.1a above as a guide draw two parallel lines AB and CD across the top. These lines can be placed anywhere, but each should be the same distance from the side edge.

**Figure 2.1b - Template**

Because the arcs used to bisect the lines are off the face of the wood it is recommended to develop a template using card stock and transfer the points for the lathe drive and tail stock centers. On the template as in Figure 2.1b above mark the size of the dry hardwood (suggest 2 3/4" square) and the two parallel lines AB and CD.

Using the method described in Section 1.2 above bisect the line CD (first chord) and connect the arcs together using a straight rule.

Connect points E and D (second chord) and again bisect the line as in Section 1.2 above. Connect the arcs using a straight rule. Mark an X where the first bisect line and this second line interconnect. This is the first of four turning centers. Using X, draw an arc through C and D. The circumference should also be close to the line denoting the edge of the wood at E.

For the other side repeat the same process for line AB to get the second turning center. Mark this center as Y. Alternatively, you can measure where point X is from the side and bottom of the wood to determine where point Y should be. Using Y, draw an arc through A and B. The circumference should match the other side.

Marking the wood.

Select a suitable piece of dry hardwood (suggest 2 3/4" square by 4" long) that has square ends. Find the center mark by drawing diagonals from the corners of the box. Place the template on the top of the wood and draw the two parallel lines and indent points X and Y in the wood. Using point X draw an arc through C and D. Using point Y draw an arc through A and B.

Bottom of the wood.

Continue points A and C down one side of the wood, and B and D on the other side. On the bottom of the wood connect these points. It will look exactly like the top. Using the template mark X as the third drive point, Y as the fourth drive point, and mark the center of the wood. Ensure both X and Y are opposite to the X and Y on the top. Using X, draw an arc through C and D. From Y, draw an arc through A and B.

Turning the box.

Carefully reinforce the center point and all drive points with a sharp point to make it easier to mount on the lathe.

Place drive point X on the top of the wood in the lathe drive center, and drive point X on the bottom of the wood in the tailstock. Remove the wood with a spindle or roughing gouge using the arcs at each end of the wood as a guide. Repeat using drive point Y.

Use the instructions in Section 4 (page 18) to complete the box.

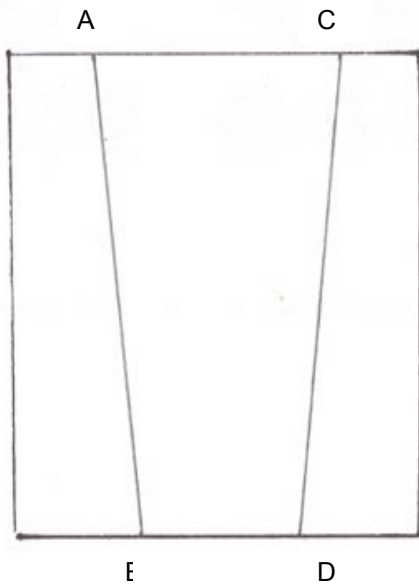
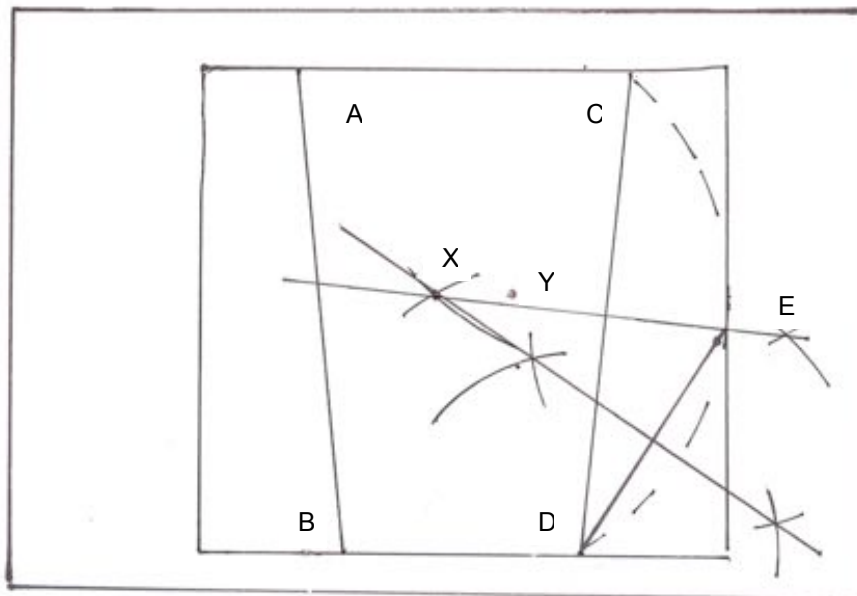
2.1.1 Alternative design.

Figure 2.1.1a



Instead of two parallel lines, as seen in the first example (Figure 2.1a), use two lines that slope towards one another. The process to determine the four drive points is exactly the same as described above.

**Figure 2.1.1b - Template**

2.2 Three Sided Box.

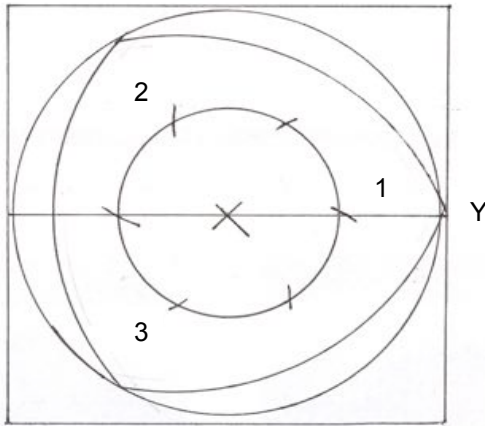


Figure 2.2



Top of the box

Select a suitable piece of dry hardwood (suggest $2\frac{3}{4}$ " square by 4" long) that has square ends and mark the center points at the top and bottom of the wood. As in Figure 2.2 above use a compass to draw a circle to the maximum size of the wood, then draw a smaller circle on the same center. Draw a line from one side of the box X to the other side Y that goes through the center mark.

Set the compass to the radius of the circle and starting where the line goes through the inner circle 1 strike a second arc and so on until you have six arcs on the circle. Three of these are your drive points, so name them clearly as 1, 2, and 3 to avoid confusion later. Ensure drive point 1 is on the same side as Y on the outside of the wood.

Adjust the compass and draw an arc using each of the three drive points inside the larger circle. The intended three-sided shape should lie within the larger circle.

Bottom of the box

Using point Y on the outside of the box, continue the line down the side of the wood and across the center point on the bottom of the wood. Repeat the same process as above, and name and mark these drive points as 1, 2, and 3 to correspond with the same position of the drive points on the top of the box. Using each drive point draw an arc inside the larger circle.

Turning the box.

Carefully reinforce the center point and all drive points with a sharp point to make it easier to mount on the lathe.

Mount the blank on the true center and reduce to a cylinder using a spindle roughing gouge. The completed cylinder should be turned down to the diameter of the large circle. Mark each of the 3 sides along the cylinder with a pencil to help you get a straight edge.

Remount the cylinder placing drive point 1 on the top of the wood in the lathe drive center, and drive point 1 on the bottom of the wood in the tailstock. Turn the cylinder

down level with the first arc at each end of the cylinder using the pencil line to get a straight edge. The three sides will be parallel. Repeat this process using drive points 2 and 3. Use the instructions in Section 4 (page 18) to complete the box.

2.2.1 Alternative design 1 – sloping sides.



Figure 2.2.1

The process is the same as described in Section 2.2 above except the circle on the bottom is smaller than the top. The three sides will slope in and make the bottom of the box smaller as in Figure 2.2.1 above.

2.2.2 Alternative design 2 – twisted box.



Figure 2.2.2

The process is the same as in Section 2.2 above except drive points A, B, and C on the bottom of the box do not correspond to the top. They are moved slightly in one direction to give a twisted look as in Figure 2.2.2.

2.2.3 Alternative design 2 – twisted box with sloping sides.



Figure 2.2.3

The process is the same as in Section 2.2 above except 1. the circle is smaller on the bottom of the box, and 2. the drive points A, B, and C on the bottom of the box do not correspond to the top. They are moved slightly in one direction to give the sides a sloping and twisted look as in Figure 2.2.3 above.

2.3 Four Sided Box. C

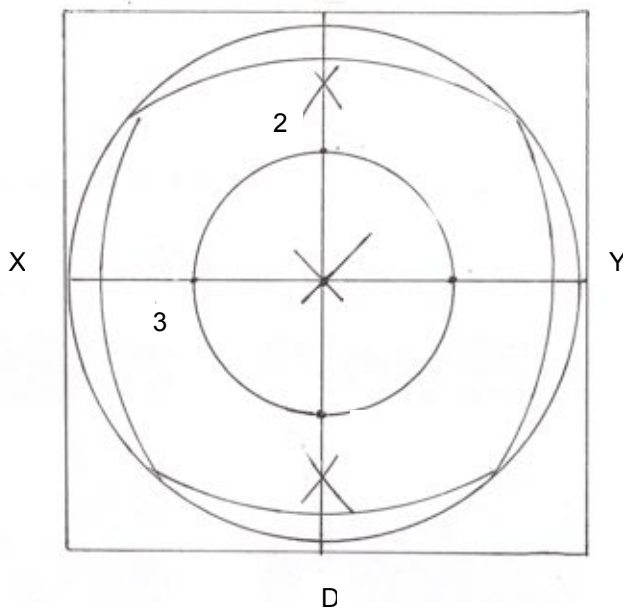


Figure 2.3

Top of the box



Select a suitable piece of dry hardwood (suggest 2 ¾" square by 4" long) that has square ends and mark the center points at the top and bottom of the wood. As in Figure 2.3 above use a compass to draw a circle to the maximum size of the wood then draw a smaller circle on the same center. Draw a line from one side of the box X to the other side Y that goes through the center mark. Bisect line XY as described in Section 1.2 above and name the new bisect line as CD. Where the inner circle intersects the straight lines are the location of the four drive points. Mark these drive points as 1, 2, 3 and 4 to avoid confusion later. Ensure drive point 1 is on the same side as Y on the outside of the wood.

Adjust the compass and draw an arc using each of the four drive points inside the larger circle. The intended four-sided shape should lie within the larger circle.

Bottom of the box

Using point Y on the outside of the box, continue the line down the side of the wood and across the center point on the bottom of the wood. Repeat the same process as above, and name and mark these drive points as 1, 2, 3, and 4 to correspond with the same position as the drive points on the top of the box. Using each drive point draw an arc inside the larger circle.

Turning the box.

Carefully reinforce the center point and all drive points with a sharp point to make it easier to mount on the lathe.

Refer to Section 4 (page 18), that describes in detail, how to complete the four sided box.

2.4 Five Sided Box.

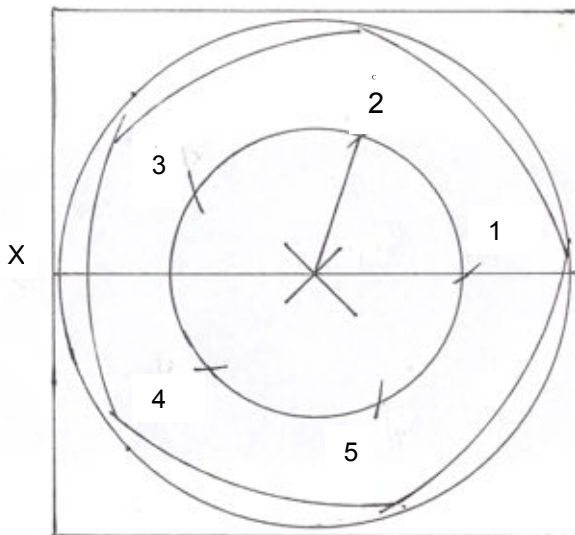


Figure 2.4



Top of the box

Select a suitable piece of dry hardwood (suggest 2 ¾" square by 4" long) that has square ends and mark the center points at the top and bottom of the wood. As in Figure 2.4 above use a compass to draw a circle to the maximum size of the wood then draw a smaller circle on the same center. Draw a line from one side of the box X to the other side Y that goes through the center mark. At the point where the line goes through the circle mark the intersection as 1.

Place a protractor on the line XY aligning the center point of the wood with the center mark of the protractor base. Mark the wood at 72 degrees and join the mark with the center point. Where the line intersects the circle mark the point as 2. With a compass measure the distance between 1 and 2. Place the compass point on 2 and strike another arc until you have five arcs on the circle. These five arcs are your drive points, so name them clearly as 1, 2, 3, 4, and 5 to avoid confusion later.

Adjust the compass and draw an arc using each of the five drive points inside the larger circle. The intended five-sided shape should lie within the larger circle.

Bottom of the box

Using point Y on the outside of the box, continue the line down the side of the wood and across the center point on the bottom of the wood. Repeat the same process as above, and name and mark these drive points as 1, 2, 3, 4, and 5, to correspond with the same position of the drive points on the top of the box. Using each drive point draw an arc inside the larger circle.

Turning the box.

Carefully reinforce the center point and all drive points with a sharp point to make it easier to mount on the lathe.

Mount the blank on the true center and reduce to a cylinder using a spindle roughing gouge. The completed cylinder should be turned down to the diameter of the large circle. Mark each of the 5 sides along the cylinder with a pencil to help you get a straight edge.

Remount the wood placing drive point 1 on the top of the wood in the lathe drive center, and drive point 1 on the bottom of the wood in the tailstock.

Turn the cylinder down level with the first arc at each end of the cylinder using the pencil line to get a straight edge. Repeat this process using drive points 2, 3, 4, and 5. The five sides will be parallel.

Use the instructions in Section 4 (page 18) to complete the box.

2.5 Six Sided Box.

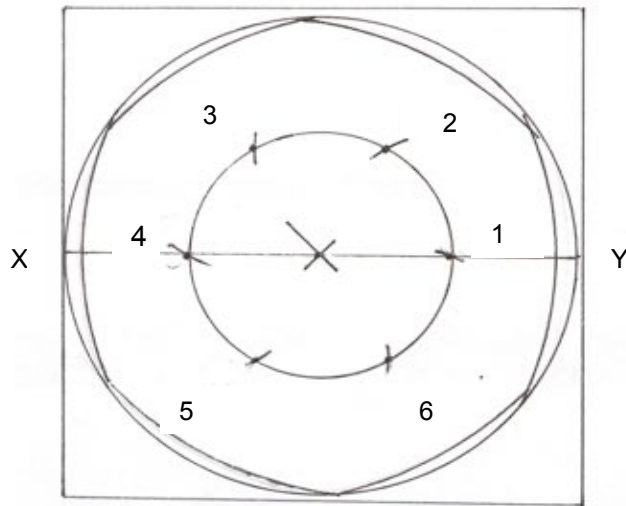


Figure 2.5



Top of the box

Select a suitable piece of dry hardwood (suggest $2\frac{3}{4}$ " square by 4" long) that has square ends and mark the center points at the top and bottom of the wood. As in Figure 2.5 above use a compass to draw a circle to the maximum size of the wood then draw a smaller circle on the same center. Draw a line from one side of the box X to the other side Y that goes through the center mark.

Set the compass to the radius of the circle and starting where the line goes through the inner circle 1 strike a second arc and so on until you have six arcs on the circle. These six arcs are your drive points, so name them clearly as 1, 2, 3, 4, 5, and 6 to avoid confusion later. Ensure drive point 1 is on the same side as Y on the outside of the wood.

Adjust the compass and draw an arc using each of the six drive points inside the larger circle. The intended six-sided shape should lie within the larger circle.

Bottom of the box

Using point Y on the outside of the box, continue the line down the side of the wood and across the center point on the bottom of the wood. Repeat the same process as above, and name and mark these drive points as 1, 2, 3, 4, 5, and 6 to correspond with the same position of the drive points on the top of the box. Using each drive point draw an arc inside the larger circle.

Turning the box.

Carefully reinforce the center point and all drive points with a sharp point to make it easier to mount on the lathe.

Mount the blank on the true center and reduce to a cylinder using a spindle roughing gouge. The completed cylinder should be turned down to the diameter of the large circle. Mark each of the 6 sides along the cylinder with a pencil to help you get a straight edge.

Remount the wood placing drive point 1 on the top of the wood in the lathe drive center, and drive point 1 on the bottom of the wood in the tailstock.

Turn the cylinder down level with the first arc at each end of the cylinder using the pencil line to get a straight edge. Repeat this process using drive points 2, 3, 4, 5, and 6. The six sides will be parallel.

Use the instructions in Section 4 (page 18) to complete the box.

Section 3 – Turning Hints and Tips

Please read the following before you start turning. It will be helpful.

1. Use a safety drive in your headstock; it has no sharp edges to grab the wood. With this drive, if you have a catch, the turning will stop immediately and will less likely to fly off.



2. Use a metal file to smooth the surface of the tool rest. There should be no nicks in the surface.
3. Carefully mark and reinforce the two center points and all drive points with a sharp point to make it easier to mount on the lathe.
4. Each time you change drive points 1. reduce the lathe speed and 2. ensure there is sufficient clearance between the wood and the tool rest. Rotate the turning each time before starting the lathe.
5. Also, ensure the tailstock and tailstock drive is locked tight. Increase the speed of the lathe slowly, and rotate the wood as fast as you are comfortable with, and the lathe is not vibrating.
6. Tool rest height:
 - a. When using a scraper the tool rest should be a mid-level and the tool handle should be slightly higher than the cutting end.
 - b. When cutting the lid flange the tool rest should be slightly higher than mid-level. This will ensure a straighter cut.
 - c. When using a spindle gouge the tool rest should be about $\frac{1}{4}$ " lower than mid-level.
7. Except for the 2-sided box mount the blank on the true center and reduce to a cylinder using a spindle roughing gouge. The completed cylinder should be turned down to the diameter of the large circle.
8. Use a pencil mark along the cylinder to define each side of the box and use the pencil line to get a straight edge when turning.
9. The tool rest must be parallel to the edge of the wood. For a sloping box the tool rest should be parallel with the intended slope.
10. Stop the lathe frequently to ensure you do not go past the circle and arcs at both ends of the cylinder.
11. Publications recommended:

Richard Raffan – ‘Turning Boxes With Richard Raffan’ 2002

Chris Stott – Turned Boxes 50 designs 2002

Section 4 - Turning a Four Sided Box

Note: You can turn a box two ways. In the first method the outside of the box is turned first, and then the inside is hollowed out. This method is described below.

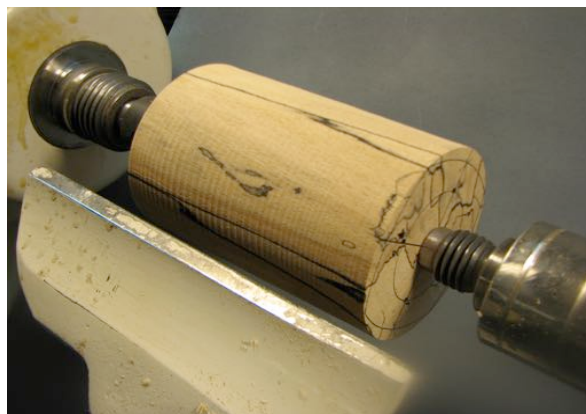
The second method hollows the inside first and then the outside of the box is turned. You need to ensure, when hollowing the inside of the box, the diameter is small enough that there is sufficient wood to complete the outside of the box. Also, you will need to mark the four sides at each end of the box again as they will be removed by the tenon.

Try both ways and select a method you are comfortable with.

- a. Mark the blank as described in Section 2.3 above.



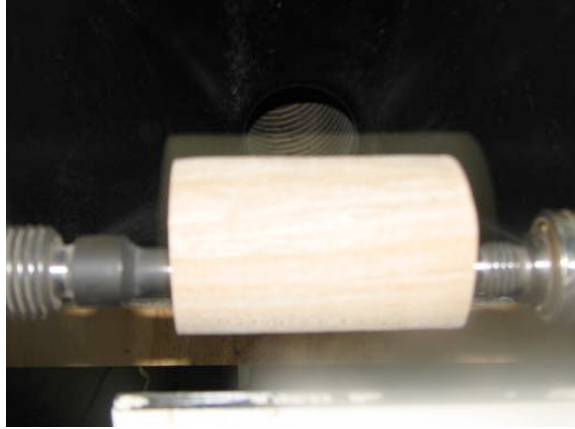
- b. Mount the blank on the true center and reduce to a cylinder using a spindle roughing gouge. The completed cylinder should be turned down to the diameter of the large circle. Ensure the tailstock and the tailstock drive is locked tight. At each of the 4 corners pencil a line from one end to the other. This will help in defining each edge.



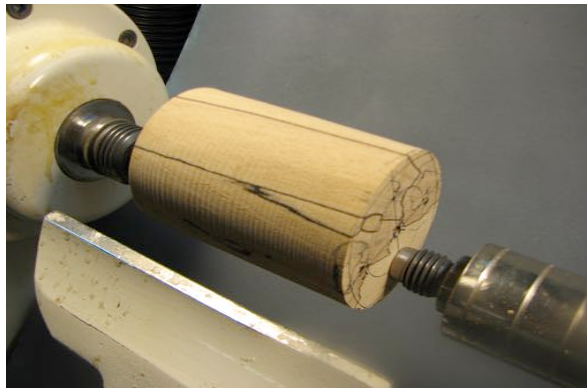
- c. Remount the cylinder placing drive point 1 on the top of the wood in the lathe drive center, and drive point 1 on the bottom of the wood in the tailstock. Ensure the tailstock and the tailstock drive is locked tight. Ensure there is sufficient clearance

with the tool rest. Rotate the wood as fast as you are comfortable with and the lathe is not vibrating.

- d. **HINT** - Place a dark board or cardboard behind the wood so that you can see the edge you are turning. This will help to ensure straight edges.



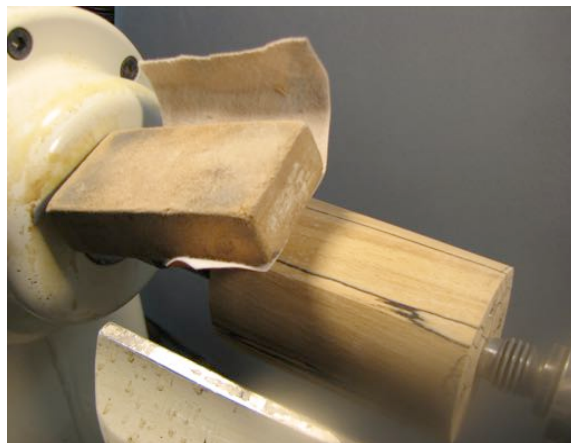
- e. Turn the cylinder down level with the first arc at each end of the cylinder using the pencil line to get a straighter edge as possible.



- f. Repeat this process using drive points 2, 3 and 4. The four sides will be parallel. **HINT** - Stop the lathe frequently to ensure you do not go past the arcs at both ends of the cylinder.



- g. **HINT** – If necessary, use a disc sander very lightly to make the edges sharper, and hand sand.



Separate lid from base.

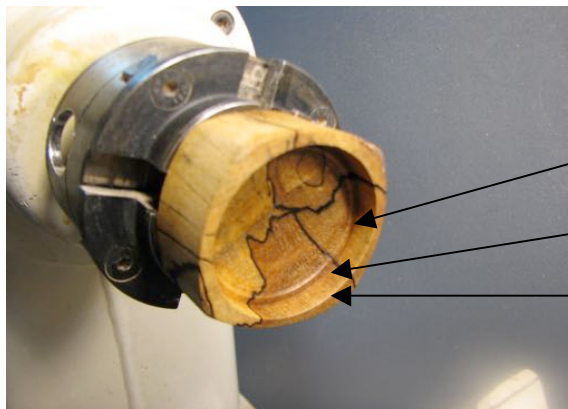
- h. Remount the box between centers and, using a parting tool, form a spigot at each end to suit your chuck jaws.



- i. Separate the lid from the body using a thin parting tool. Make the cut slightly wider than the blade to avoid the blade grabbing. You can finish off with a small saw.

Completing the lid.

- j. Start by mounting the lid in the chuck ensuring the shoulders of the spigot are firm against the chuck jaws.
- k. Roughly hollow the lid using a small gouge or a scraper. Cut the lid flange at about $\frac{1}{4}$ " in depth. This is the portion of the lid that fits over the base flange. The flange must be a cylinder, which means the sides must be parallel. Use a square-end scraper to cut the flange, and internal spring calipers to check the sides are parallel. The tool rest must be at center height, or slightly above. Finish turning the inside of the lid using a round nose scraper or spindle gouge leaving a small shoulder between the flange and the inside of the lid. Decorate the inside of the lid, if you wish.



Shoulder

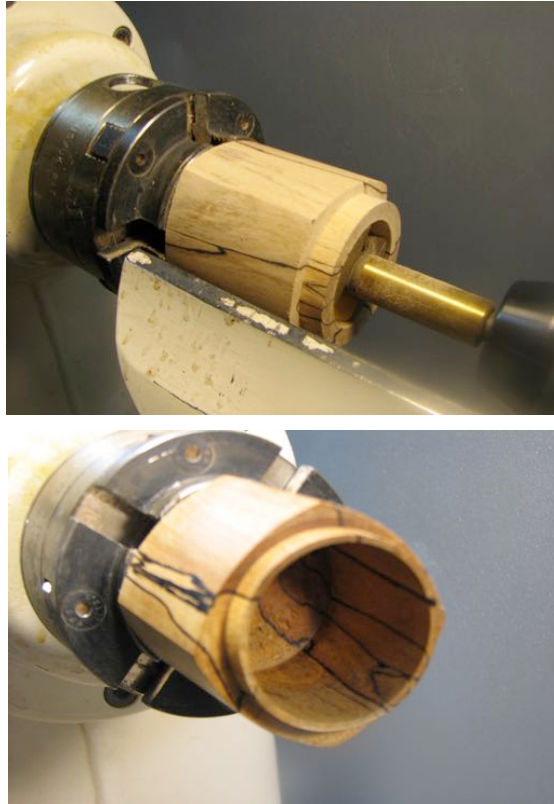
Flange should have parallel sides

Rim is chamfered on the inside of the rim

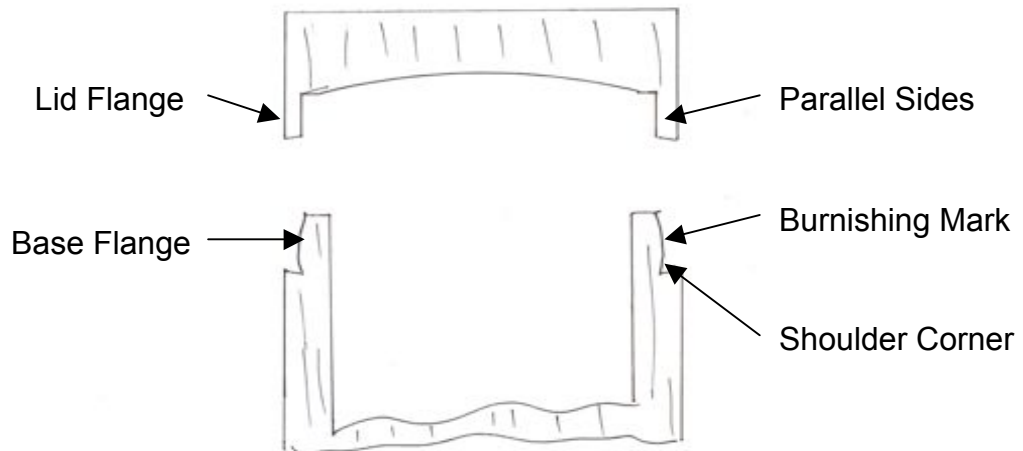
- l. To ensure the rim fits flat on the base flange shoulder, chamfer the rim so that the inner lip is lower than the outer. It is best to use a skew chisel flat on the tool rest
- m. Sand and polish the inside of the lid. Remove the lid from the chuck.

Completing the base.

- n. Remount the base section on the chuck and establish the approximate diameter of the base flange. The flange should be close to the same depth as the lid and be tapered by about $\frac{1}{16}$ ". The lid should just fit over the end of the flange. Hold the lid lightly to the flange so you get a slight burnish. Do not fit the lid now.
- o. Remove the bulk of the inside of the base. The easiest way is to use a sawtooth cutter to remove the majority of the bulk, and finish with a box scraper. Mark the sawtooth cutter shank with tape so that you stop at the depth you need. Finish the walls to about $\frac{1}{4}$ ", and sand the inside to finish.



p. Fitting the lid for a suction fit.



q. Step 1 - True the base flange from 1/16" taper to a barely discernable taper of about 1 degree and hold the lid over the end to get another fresh burnish mark. Where the lid burnishes it fits.

Step 2 – Use a skew chisel on its side for a light scrape, taking very little shavings off the rim near the shoulder corner.

Step 3 – Reduce the diameter of the burnish mark until the lid fits on tightly. There should be a popping sound when the lid is removed.

Step 4 – Extend the base flange to the required depth and chamfer the base flange shoulder so the rim is the highest point.



- r. Refit the base and push the lid fully home. Use tissue if the lid is a fraction loose.
- s. If necessary, using the revolving center for support, remove the spigot and slightly dome the top. Finally, hand sand the piece at this stage.

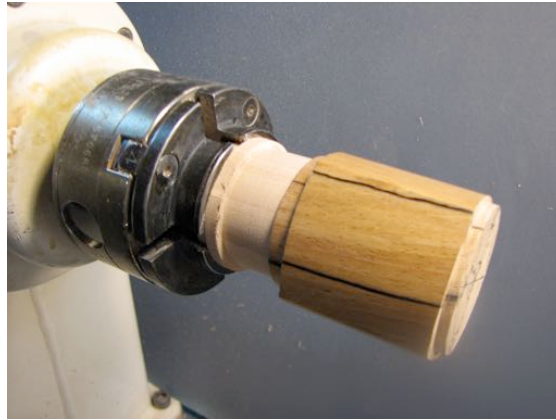
Add insert to lid.

- t. To add an insert into the lid first create an appropriately sized flat-bottomed rebate (approx. 1”) with a parting tool. Turn a piece of other wood to the size of the rebate with a slightly wedge shape. Glue in position and again slightly dome the top. Sand and polish to finish.



Completing the base.

- u. Secure the inside of the base in a chuck, or make a tenon out of a waste block, to enable the bottom spigot to be removed.



- v. Using a small gouge, slightly dish the underside of the base and finally sand to finish.



The Completed Box

