at the lathe by Jon Siegel

Used for architectural accents.

This "ball-on-ball" finial is 28 inches high.

The ball is a classic finial for a bed post and is known as "cannon-ball" style.

In Search of the Perfect Sphere

Most of us have memories of 10th grade geometry class. I have noticed that people either loved it or hated it. As you probably guessed, I reveled in it, and even went to summer school for advanced classes in solid geometry. I have often stated that these were the most useful courses I had in school. When I learned more about the history of mathematics and science, I became aware that geometry is the only subject in the modern curriculum that has remained unchanged for millennia. It is today essentially the same as it was as when taught in 300 BC by Euclid, who was the first to systematically state the relationship of solid shapes to planar figures such as lines and circles.

In the last article in *The Old Saw* on duplication, I mentioned that one of the most frequently asked questions is, "Do you use templates?" I wrote that I only use templates for straight lines and circles. The reason is that these elementary shapes are pure forms that must be made with care because the eye can easily detect any errors.

The ball is an elegant feature in the sequence of shapes on these furniture parts.

A sphere holds a special place in design. It is the only shape that appears the same from any point of view. Because it is the shape of the earth, spheres have been studied by geometricians for millennia.

A massive amount of information is available on how to take measurements on the surface of a sphere. For the purpose of this article however, it is only necessary to understand that a sphere is generated by a circle rotating on a diametral axis, and when a circle is drawn on a sphere, it falls into one of two categories — a great circle or a small circle. A great circle is the same diameter as the sphere and its center coincides with the center of the sphere. All longitude lines are examples of great

circles. The only latitude line which is a great circle is the equator.

The shortest distance between two points on the surface of a sphere follows the path of a great circle. This is important when plotting the course of travel over long distances. A small circle has a diameter that is less that the diameter of the sphere and this includes all latitude lines other than the equator.

There are many mechanical devices that will generate a perfect spherical shape on the lathe. They all consist of some type of pivoting arm which holds a cutting tool as it swings on a circular path across the turning. These have been used by ornamental turners for centuries as well as ivory turners who made billiard balls by the millions until this practice caused the near extinction of elephants and stimulated the invention of the first plastics — then celluloid and now phenolic — as a substitute for ivory. *I bet you knew I would bring pool into this somehow.*

Machinists still use these sphere generating devices on lathes to make ball-and-socket joints. But here I will assume that you do not have any of these gadgets, and you want to make a perfect ball with just the turning chisel held in your hand. There are three common applications of ball shapes in woodturning — ball finials, balls incorporated in the middle of a turning, and separate spheres.

Making Ball Templates

The way to make a perfect ball is to have a perfect ball template. This device serves two purposes. First it is used as a comparator while the ball is being turned. Then it is used to press the sandpaper against the turning to further refine the ball.

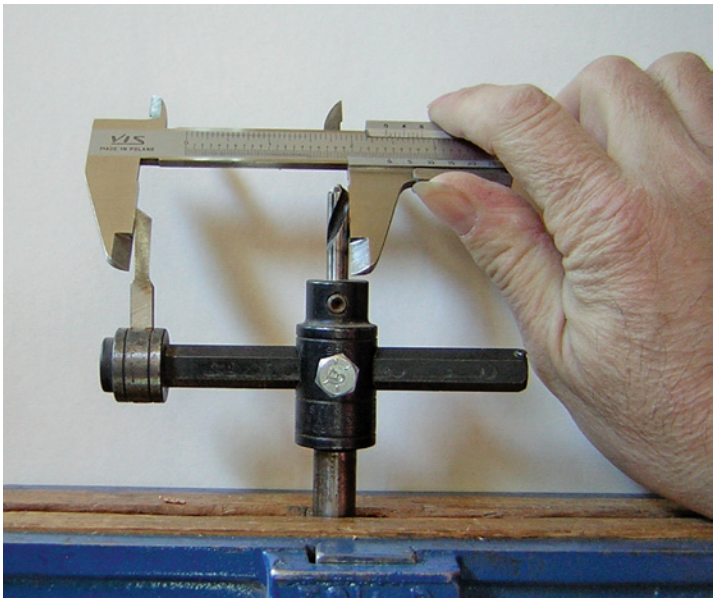
The trick to making a perfect ball template is to generate the arc with a spur bit or a circle cutter. Spur bits are the easy way to make a hole up to about two inches, but for larger sizes you will need a circle cutter. These devices are available from most woodworking tool suppliers *(Woodworker Supply #119-002 — $34)*.

Set the hole cutter carefully with a caliper. Do not forget to add ⅛″ (the radius of the pilot) to the measurement. A circle cutter MUST be used in a drill press, not a hand held drill. Use the slowest speed and be sure to clamp the plywood to the table. Do not attempt to hold the work down with your hand!

The technical name for this process is trepanning. I use ½″ baltic birch plywood for most of my ball templates, although any good grade of plywood without voids will be fine.

I use a circle cutter, because it is convenient, but if you don't have one, or the size exceeds the capacity of the tool, it is possible to make a hole of any diameter on the lathe. Simply attach the plywood to a backer on a faceplate and cut out the center, first with a parting

An assortment of ball templates.



Add 1/8 inch to the radius to obtain a caliper reading.

Use a slow speed, and clamp the work.

tool which removes a disc, and refine the hole with light scraping cuts.

After the hole is made in the plywood, use a band saw or scroll saw to cut the outline of the template. Break all the sharp edges except on the circular part. The template will subtend an arc somewhere between 90° and 140°, and this depends on the how the ball fits into the turning. Check the template against the drawing to decide what size of arc is best.

Testing & Correcting

The template is brought against the turning to indicate where the ball must be reduced. When ball shapes are incorporated into spindle turnings, either as finials or in the middle of a turning, it is important that the diameter at the widest point be exact. It should be checked with a caliper, and also, of course it must fit the template when put to the diameter.

Apply some wax to the contact surface of the template. The two photos (above to the right) viewed in alternating sequence show how it is used without having to put down either the template or the chisel. When the turning fits the template, you are ready for the sanding stage.

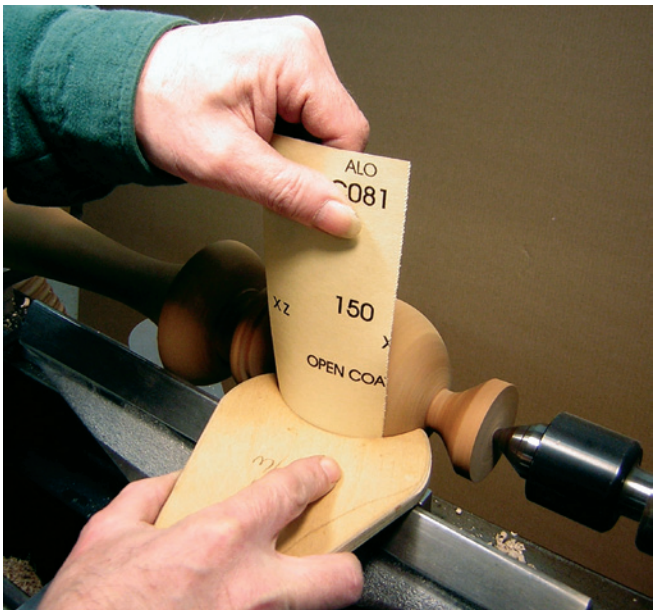
Cut strips of sandpaper the approximate width of the ball template. Set the tool rest low enough so the template will be on the center line when it is held horizontally. Use a little wax on the template and/or on the back of the sandpaper. Press the paper against the turning with the template while moving the strip up and down.

Relying on Randomness

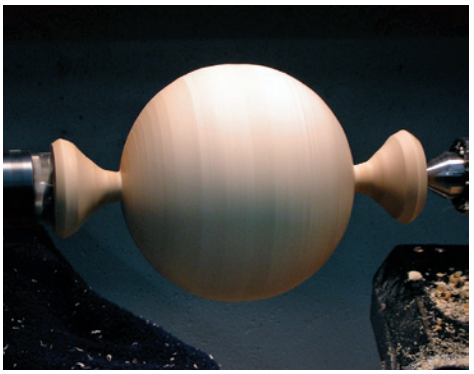
A different method may be used to make a sphere that is separate. It is possible to employ a self correcting process in random sequence to achieve great accuracy in the turning of spheres. Stone balls are ground between rotating cups on automated machines by this means. This is similar to how lenses are ground. Although wood cannot be worked this way, we can rely on randomness by altering the AXIS of the sphere a multitude of times. This is based on the principle that we began with — a sphere is the same (a circular profile) from any point of view, or any axis of rotation.

Spheres are made in two stages. The first stage is done between centers. Cut the blank slightly longer than the diameter to

Frequent checking with the template will give good results.



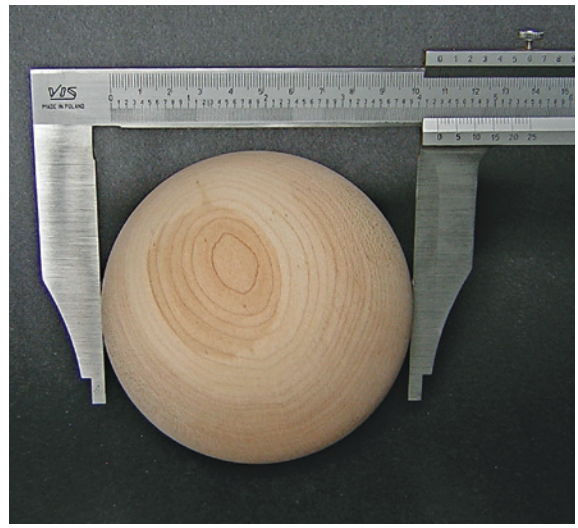
Lower the tool rest, and press the sandpaper against the ball with the template.



First step in making a sphere.

Cross section shows how the sphere seats in the cup chuck.

Final step in refining
the sphere in a cup chuck.



This 4 ¼″ sphere measures
within 0.003 inches total variation.

allow for cutting off at each end. The second step involves changing the axis of rotation multiple times to refine the sphere and correct any errors.

Many books describe the cup chuck method for refining balls (see especially Mike Darlow, *Woodturning Methods*), but invariably these authors advise jamming the ball into the chuck up to the diameter, leaving less than half of the ball available for turning. My method is different because the type of cup chuck that I use is simply a centering device, and it will not hold the ball without the aid of the tailstock. The ball seats on a circle of contact (small circle) which subtends about 120° of the ball. This type of cup chuck is very easy to make and will accommodate a reasonable variation in the size of the ball.

The leather tipped dowel holds the ball in the cup and provides flexibility to the set up, allowing the ball to seat centrally. This method gives you access to much more of the ball than does the typical jam fit chuck. The first time you place the ball in the cup chuck, put it 90° from its original axis. Remove just enough material to "true up" the surface. The second time, rotate 180° to get at the opposite end. After that, simply use random placement. Each time you true up the ball, it becomes more perfect, until finally every part of the surface runs true in every orientation. I measured the diameter of this 4¼″ ball about 20 times in random locations, and the difference between the largest and smallest measurement was 0.003″, about the size of a human hair. ■