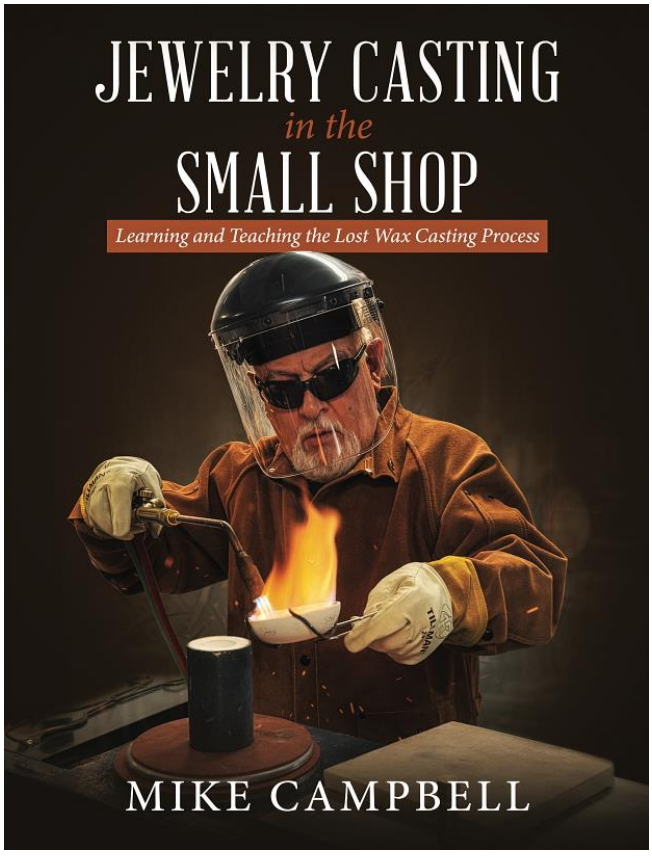

Jewelry Casting in the Small Shop is a comprehensive resource for beginners who want to learn casting and for teachers who are looking for instructional materials to enhance their jewelry curriculum.

Jewelry Casting In The Small Shop:
Learning and Teaching the Lost Wax Casting Process
By Mike Campbell

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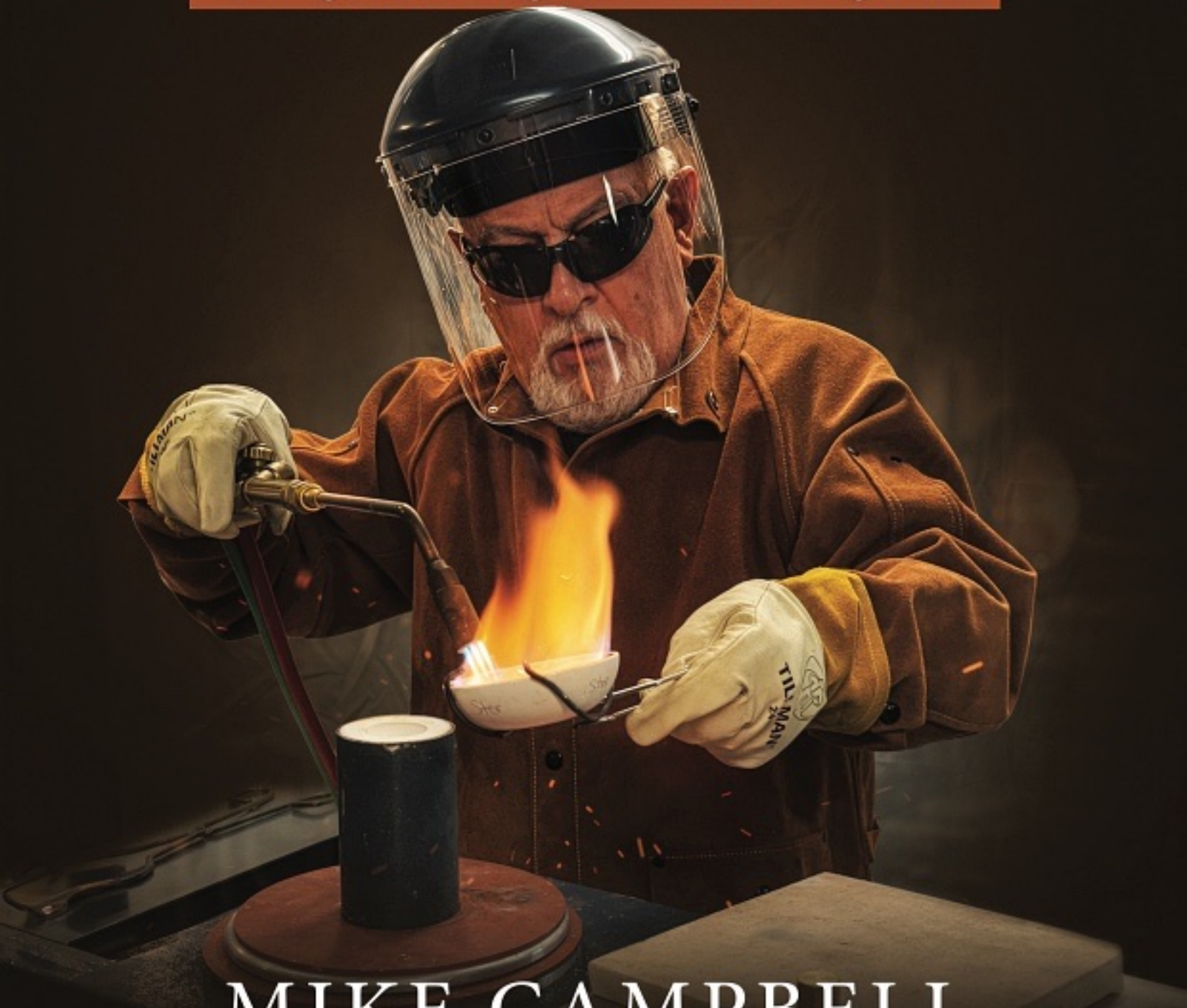
JEWELRY CASTING *in the* SMALL SHOP

Learning and Teaching the Lost Wax Casting Process



MIKE CAMPBELL

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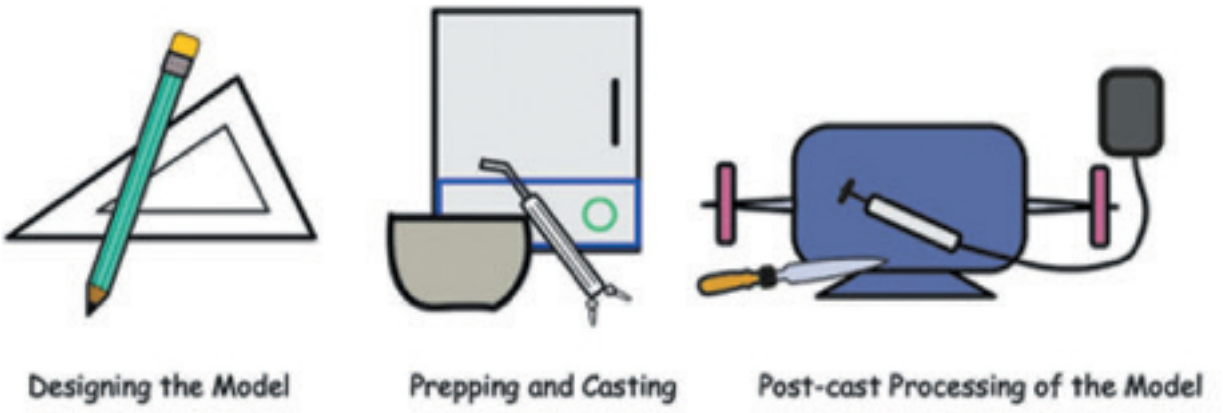
CHAPTER 1

DESIGNING THE MODEL

The Three Phases of Lost Wax Casting

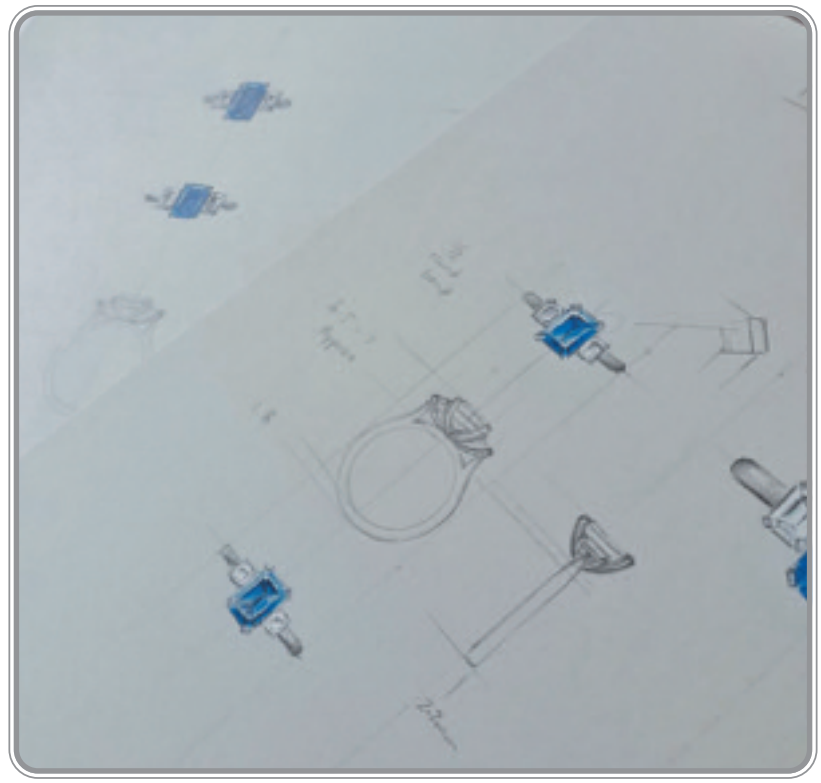
While there are seven stages in casting, there are also three distinct phases to the overall process. Each phase is a group of stages and must be completed to move on to the next phase. I have used the illustration below to help students conceptualize the lost wax casting is a lengthy process.



The first phase deals with the initial designing of the model in two ways: creating a detailed drawing on paper and then carving a three-dimensional representation of it to be used in the rest of the lost wax casting process. Both of these steps are explained in detail below.

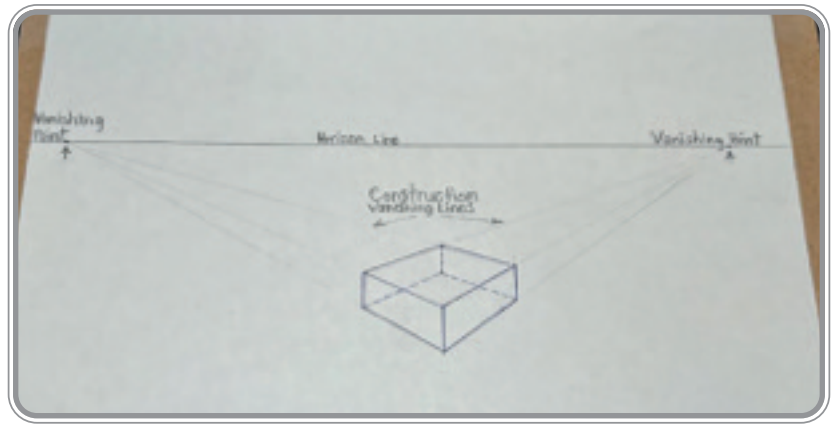
Designing the Model Two-Dimensionally: Sketching, Drawing, and Illustrating

Creating a model for casting happens in two parts. The first is drawing the design on paper, and the second is translating that design into a three-dimensional model by one of several methods. Some drawings might be just simple freehand sketches, while others are created in a more precise way using drawing instruments to aid the artist. Either way, trying to represent a three-dimensional object on paper can be challenging.



Orthographic drawing courtesy of Jennifer Rowlands

As this illustration shows, it is easy to represent the height and width of an object on paper, but it becomes more difficult to show the third dimension without a little "visual trickery." One way to accomplish showing this third dimension is by using a technique called two-point perspective drawing. This type of drawing is done using drawing tools such as a ruler, T-square, and 45-degree triangle (and sometimes other tools like drawing templates). The purpose of a perspective drawing is to show depth. Here is a simple example of a two-point perspective drawing:



Simple two-point perspective drawing showing the basic elements for creating this style of drawing. Note how the dimensions get smaller as they move toward the vanishing points.

This type of drawing technique is oftentimes confused with isometric projection or isometric illustration because both styles of drawing are used to represent three-dimensional objects. The difference is that in

two-point perspective drawing there is a horizon line, vanishing points, and vanishing lines that govern the look of the object and causes the dimensions to get smaller as the object "moves away" from the viewer into the background. An isometric illustration maintains the true measurements of the object through all three dimensions. Either of these drawing techniques are easy to learn and require only a few tools to assist you. After practicing these two types of drawing for a short time using the tools listed below, you may be surprised how quickly you will gain the confidence and skill to draw them freehand. They may not be perfectly proportioned, but anyone viewing the sketches will see the three-dimensional quality of the drawings.

Why learn to design jewelry in this way? Not all makers of jewelry start their process with a sketch or drawing, but most do. I always teach my students to make one for the following reasons. Learning how to draw in this style helps understand spatial relationship and "seeing" three dimensional objects with the mind's eye. Taking the time to create a drawing is also a great way to get the creative process going no matter how confident you feel about your sketching abilities. This is also a great entry point for students that are new to jewelry making. Metal artwork is challenging and involves many new tools for the beginner, but most students are already familiar with using a pencil and ruler, so anything that provides support while learning the bench skills and tools is a great asset. Sketching the idea of what students are making, regardless of how well it is drawn, acts as a kind of "road map" for them to follow to reach a finished product. Even a quick and dirty "napkin drawing" will help crystalize a design idea and bring it out into the real world where it can be revised and manipulated into wearable jewelry. The more detailed and accurate the design sketch is, the better. And as a teacher, a sketch, no matter how "good" it is, helps you understand what a student wants to create and provides a common frame of reference for guiding the student regarding what the next steps should be to make it a reality.

If you are a maker, there is one last point about hand illustrating jewelry: it is especially valuable to have the skills to create a visual representation of a design idea when you are working with a customer. Most customers who want a custom designed piece of jewelry h7ave only a general idea about how the piece should look; in addition, they usually struggle to explain the design they have in mind. It is up to the jewelry designer to help them focus their ideas into a detailed, specific design, and being fluent in one of these drawing styles is invaluable.

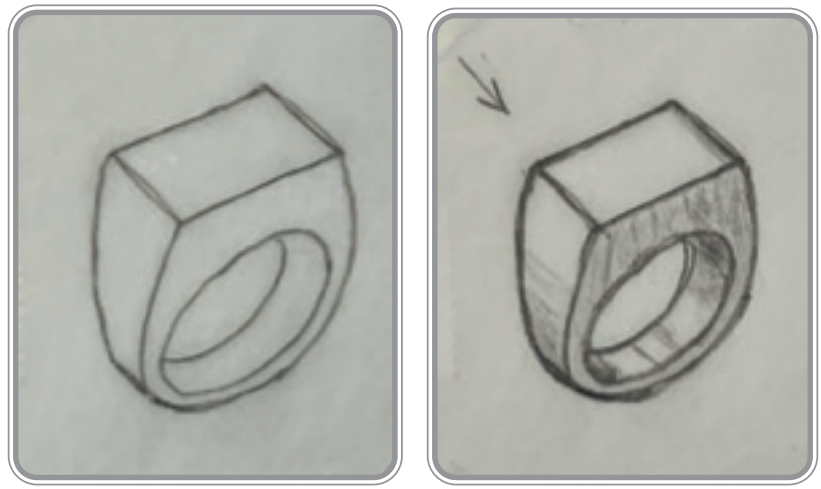
Tools and Supplies for Sketching

- #2H sharp pointed or mechanical pencil
- #4H sharp pointed or mechanical pencil
- Metric ruler
- Eraser
- Additional tools: protractor, compass, 30◦ elliptical template, and a 30/60/90 triangle
- Optional tools: T-square, isometric graph paper, drawing board

The immediate question for those who have never drawn jewelry (or who don't feel confident at all trying) is this: "How do I do it?" The list of tools needed is minimal and inexpensive. See the inset above.

One of the simplest and quickest ways to begin learning how to draw two-point perspective drawing or an isometric illustration is to find a picture of a piece of jewelry in a magazine or book and place some tracing paper over the image and trace all the lines you see through the paper. After tracing all the lines, take the tracing paper off the image, and tape it to a white sheet of paper. Now the image will appear as a sort of

"wire frame" image. Examine the original picture closely and imitate the light and dark areas on the piece by adding some shading. Below is an example of a simple signet ring done using this method.

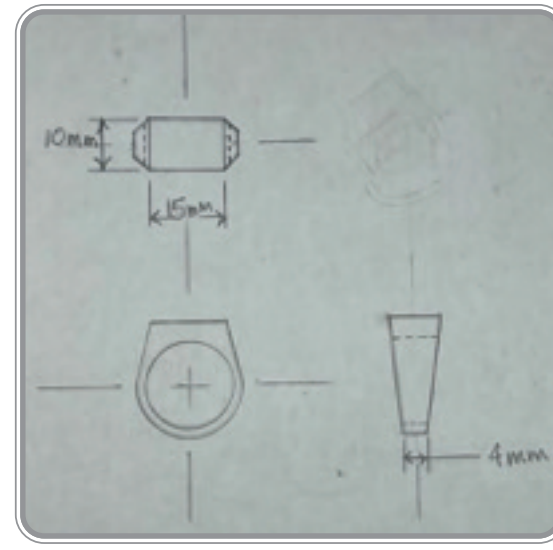


Shading adds the 3D illusion of the ring standing up off the page. The arrow indicates the direction the light is coming from.

(*Please be respectful of copyright and trademarks on the designs you trace. The purpose for doing this is to learn how to draw only.)

The tracing you make may not be a true isometric drawing (because in an isometric drawing the edges showing depth are drawn on a 30-degree angle), or a two-point perspective, but it will help you wrap your head around the process of making your sketch appear to occupy three-dimensional space in a two-dimensional drawing. After practicing this process a few times on various types of jewelry (e.g., rings, pendants, bracelets, earrings), you will be ready to take your drawing skills up a notch.

The next step to build up your drawing skills or teaching others to improve theirs is to draw an actual two-point perspective drawing or an isometric projection. "Orthographic" and "isometric" are terms sometimes used interchangeably to explain the same drawing, but technically the isometric projection is just one view in the larger multi-view orthographic projection. Learning to draw the full orthographic projection with all four views will help you (or your students or customers) to

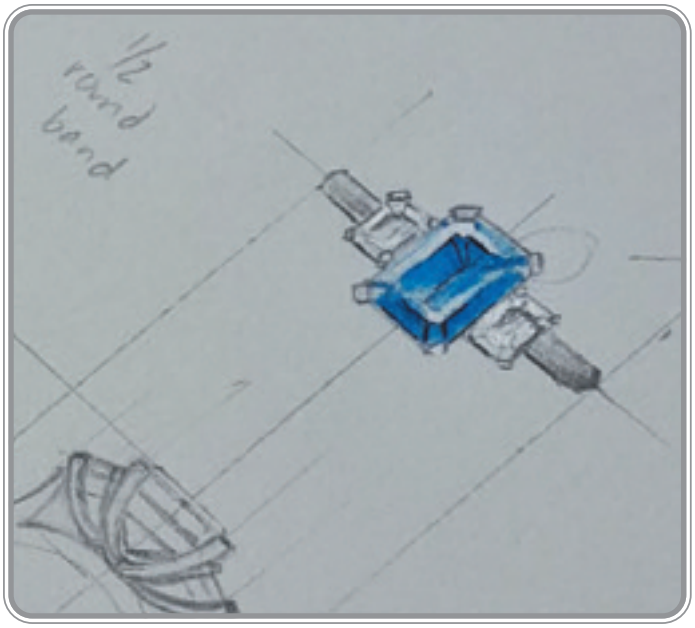


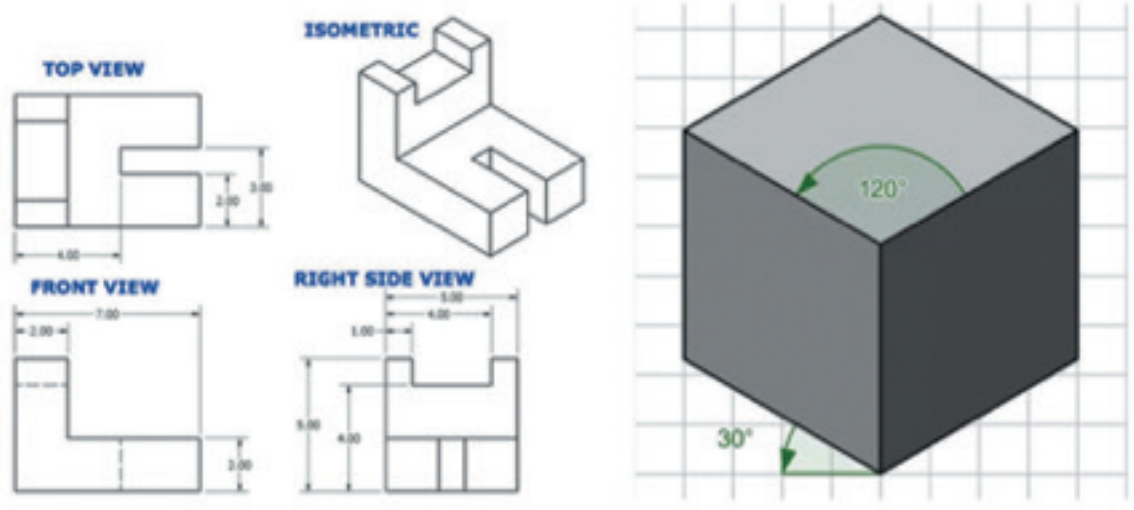
An example of an orthographic drawing. Most drawings will include dimensions, assisting the metalsmith in making the piece to the proper size and shape.

visually understand the design. The tools listed in the inset above are the bare minimum needed to draw this type of illustration. For this exercise, it isn't important that the object drawn is an actual piece of jewelry, although it can be. In fact, most teachers of this process have beginners start by drawing simple shapes: cubes, cylinders, tubes, etc. Learning how to create this type of drawing is relatively simple once the principles and guidelines are understood. As mentioned above, the

first thing to understand is that an isometric projection is drawn using vertical and horizontal lines and lines drawn at a 30-degree angle. In the example shown on the next page, the drawing on the left shows what a full orthographic illustration of a simple shape looks like, and the cube (right) is just the isometric projection seen from an elevated view; therefore, the top, left (or right) side, and front side are visible. Because there are four views that are usually shown in a full orthographic projection, any other views are included only if details on those surfaces need to be shown. These four views are top view, front view, side view (left or right), and the isometric projection. Edges not visible from one of the other views are indicated by using dotted lines, which is the way all invisible lines are indicated in this type of drawing.

Detail of Drawing by Jennifer Rowlands





Steps in Drawing an Orthographic Projection of a Ring with Center Channel

To begin the process, think of your object existing inside a glass box, and for the purpose of this example, let's use a simple signet ring. Using the drawing tools and supplies listed below, follow the step-by-step procedure below.

Orthographic Drawing Step-By-Step Procedure

Tools

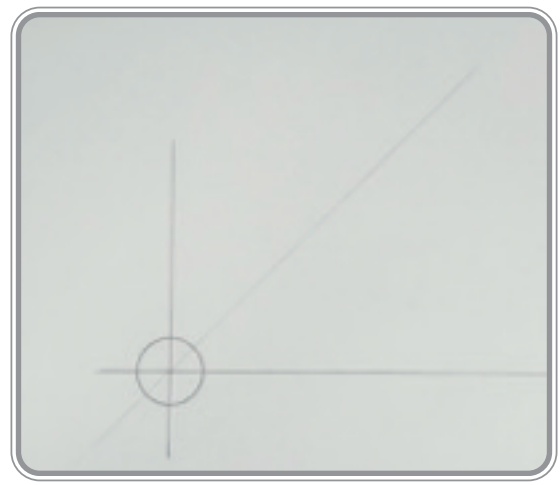
Pencils #2H and #4H
Eraser
Drawing triangles (30/60/90 and 45/90)
Compass
T-square
Ruler
Protractor (optional)
Elliptical drawing template (optional)
Drawing board

Supplies

Blank paper letter size or larger
Masking tape
Tracing paper (optional)

Step-By-Step

1. Attach a piece of blank paper to a drawing board or drawing surface (i.e., table or desk) using a T-square and masking tape on all four corners.
2. Lightly draw the vertical and horizontal center lines for the front view, using a #4 pencil, a T-square, and a drawing triangle. Extend these lines up (for the vertical) and to the right (for the horizontal) as center lines for the top and side view. See the picture below.
3. Draw a 45-degree construction line from the intersection of the center lines in the front view. Draw this line long enough to make sure the construction lines from the other views will intersect it.
4. On the center line intersection of the front view, draw a circle using a compass representing the inside diameter for the correct size of the signet ring desired. A ring size chart can be found in Appendix II.



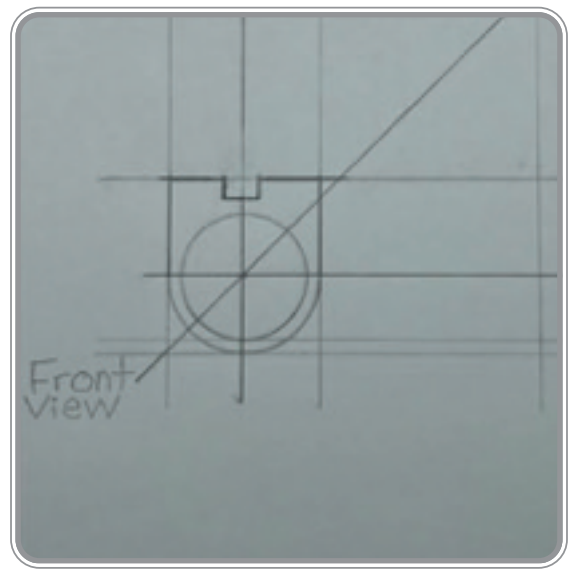
5. On the same center line intersection, draw a semi-circle as shown in the photo. This will be the shank thickness.

6. Draw construction lines vertically from the semi-circle to the top view and a construction line horizontally from the bottom of the semi-circle to the right. These lines will be used to determine the dimensions of the top and side views of the ring.

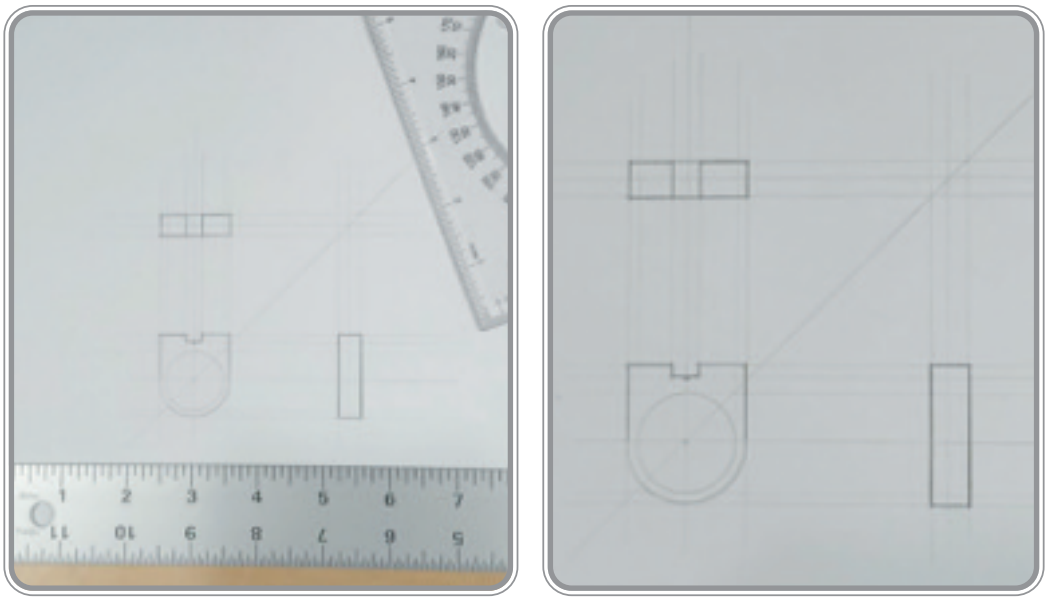
7. On the front view, determine the thickness of the top portion of the signet ring and draw a horizontal line between the two vertical construction lines. Extend this line horizontally as a construction line to the side view. This line determines the height of the side view of the ring.
8. To start drawing the top view, select a point on the vertical center construction line and make a small mark. From this point draw a horizontal construction line that intersects the 45-degree construction line and extend it beyond the intersection.
9. Draw a vertical construction line from the intersection of the top view construction line and 45-degree construction line. Steps 8 and 9 establish the center lines for the top view and the side view of the ring.

10. From the vertical center line on the front view, measure an equal distance and make two small marks on the top view horizontal construction line. These marks will indicate the width of the channel.
11. On the front view, determine the depth of the channel and make a small mark on the center line.

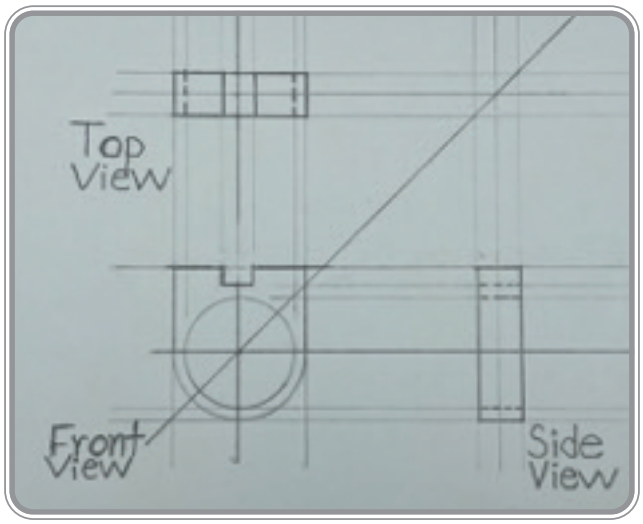
12. Using a #4 pencil, T-square, and triangle, draw the channel on the front view. The front view is now complete.



13. On the top view, determine the width of the ring by measuring from the horizontal center line an equal distance and make two small marks.
14. Draw horizontal construction lines intersecting the vertical construction lines from the front view and extending to the right to intersect the 45-degree construction line.
15. Draw vertical construction lines where the horizontal lines from the top view intersect the 45-degree construction line. These lines determine the width of the side view of the ring.
16. The outside dimensions of the top and side view may now be completed. See photo below.



17. By adding additional construction lines, the invisible lines in the top and side views may also be drawn. The three views of the signet ring are now complete.



The completed orthographic drawing without the isometric projection.

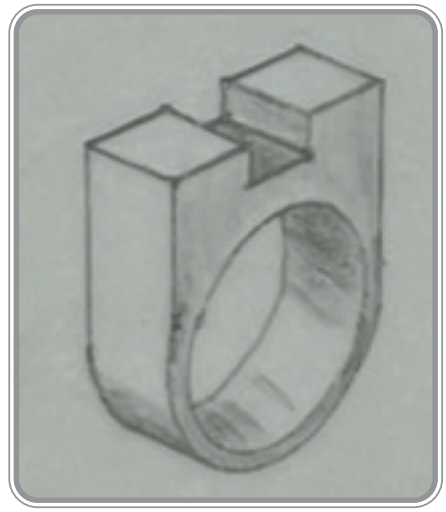
Notes for Creating the Orthographic Drawing

Before beginning, visualize in your mind what the signet ring will look like when completed.

Decide on the scale before beginning any drawing. For this exercise, a 1:1 scale is used. The pictures are enlarged to see the details of the drawing.

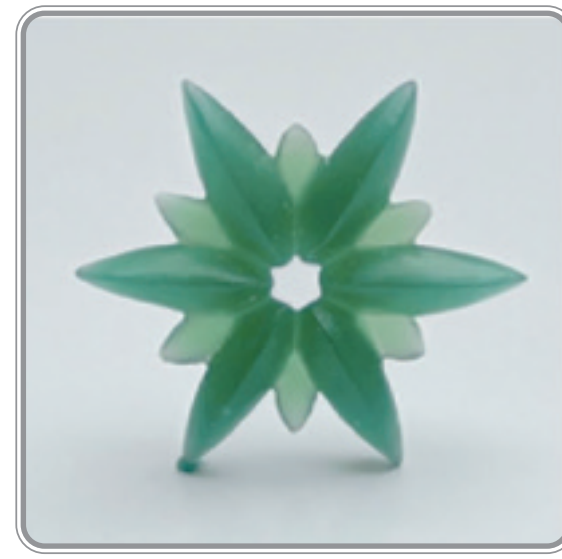
Drawing a Two-Point Perspective Drawing of the Signet Ring

If this illustration is drawn on a blank sheet of paper, then you will need to draw a very light horizon line as a reference for all the other vanishing and construction lines made to represent the object.



Signet ring drawn in isometric projection to show all three dimensions.

Wax Carving: Designing the Model Three-Dimensionally



Wax Models by Sandy Pfaff

Once a satisfactory sketch is done, a three-dimensional model is made. Making models suitable for lost wax casting can be done in several ways. The models pictured above were carved by hand. For a detailed step-by-step of hand carving a model, see the step-by-step procedure below and Project 1 in Chapter 10. Hand carving a wax model is the simplest and most frequently used method for creating a model, but there are other methods as well. Listed below are several of the other most frequently used methods with a brief explanation of each.

Wax Forming – This is another way to create a wax model by hand. The wax used for this method is soft and pliable. It can be warmed with just the heat from your hands and then bent and shaped using your fingers and a few simple tools. It can be found in sheet, wire, or block, and it can be cut very easily using a craft knife or shears. See Project 3 in Chapter 10 for an example of this method.

CNC Machining – With this method models are carved using CNC (Computer Numerical Control) milling machines controlled by a computer. Models can be made either as one of a kind or as a prototype for volume production. This method is very costly to initially set up and is usually done by large casting houses that serve the commercial jewelry industry.

CAD/CAM – Rather than a single process, this term is used to describe several different CAD (Computer Aided Drafting) and CAM (Computer Aided Manufacturing) processes. The most popular of these CAD/CAM processes for the small shop is creating a design using 3D modeling software (the CAD part) in conjunction with a 3D printer (the CAM part.) The reason this is possible is because of the greatly improved quality of 3D printing in recent years. The print resolution of these highly refined and detailed models, and the relatively affordable cost of 3D printers are the reasons for this method becoming so popular.

Casting from Nature – This term is used for casting any organic material such as plants (twigs, flowers, leaves, etc.) or insects. The advantage of this process is the fact that there is no carving of a wax model. The organic material itself is sprued onto the casting tree, invested, and burned out in the kiln or oven and then cast.

Wax Injection Molding – This process for model making has one huge advantage over the others listed. The same model can be mass produced very quickly and efficiently making it possible to do volume production of a particular design.

Since one of the main purposes of this book is to help the artisan jeweler or small shop add lost wax casting to the repertoire of skills in the most budget-friendly way possible, the only process discussed in this chapter will be wax carving by hand. The other methods are explained in more detail in Chapters 8 and 9. Let's look at the tools and supplies needed to carve a wax model before diving into the step-by-step process.

Wax Carving Tools and Supplies

Tools

Jewelry Bench – This is both a tool and a piece of furniture for doing the work of a metalsmith. It is the hub for all activities done in the studio. Because so much time is spent working at the jeweler's bench, and because people come in all sizes, this piece of equipment needs to be comfortable and ergonomically designed to suit each maker. Repetitive movements and actions place stress on the body. Doing these things with your body in an awkward position magnifies that stress and can lead to injury, which will force you off the bench until you heal or

recover body mobility and function, so choose your bench (and modify it if needed) carefully. You should be able to work at the bench in a ninety-ninety seated position – knees at 90-degree angle with both feet on the floor, and 90-degree angle on your back. Since students come in all sizes, providing an ergonomically suitable bench for an instructional setting is more of a challenge, but there are budget-friendly benches available from several jewelry supply houses. The cost for a bench will range from about $450–$650.

Sizing Rings – This tool goes by a few different names: ring sizers (or sizing rings), ring gauges, finger gauges, and it is a set of rings from size 1 to 15 (using the U.S. ring size measurement system) in half size increments (twenty-nine rings total). For makers in other parts of the world, look for a set of sizing rings from vendors near you to get a set with size designations recognized in your country. It also comes in two different widths: narrow or wide, so an accurate measurement can be determined for any ring design regardless of ring shank width. See photo in the step-by-step procedure below.

Getting the correct ring size is a subject all on its own, but two things are important to mention here. The first is this: you don't have to pay a king's ransom to get a set of sizing rings that measure ring size accurately. There are some companies selling this tool using terms like "certified" or "premium" and selling this along with a ring stick, the next tool in this list, for well over $100. A very good set of metal sizing rings can be purchased from several suppliers (see Appendix VI) for $15 to $25. The second point is this: you will want a narrow set of sizing rings and a wide set to get the right size for wider rings. The reason isn't because they will measure differently than the narrow rings on a ring stick (they won't). The reason has to do with how wider rings feel on the finger. Wider rings will trap more tissue under the ring and will "fit" tighter than narrow rings of the same size. It is also highly recommended getting sizing rings made of metal and not plastic. Metal is more durable and will not stretch like plastic will.

Ring Stick or **Ring Mandrel** –While sizing rings measure the finger the ring will be worn on, a ring stick will measure the size of the wax model or finished ring. Ring sticks are made of several different materials: plastic, wood, aluminum, or steel. For anyone who wants to acquire the tools needed to do wax carving, the best choice is to get a steel ring stick because as a basic bench tool, it can be used for more than just measuring. It can be used for forging and forming as well. While a steel ring stick will cost a little bit more than one made from other materials, it is well worth the investment because it is a lifetime tool. A typical steel ring stick will measure from 1 to 15 or 16 (depending on the vendor) in quarter-size increments and cost $30 to $50.

Dividers – There are several essential tools every metalsmith should have on their bench, and here is another example. It is an indispensable marking tool used to make wax models. This tool looks like a compass, but instead of a pencil it has two sharp points and is used for scribing or scratching lines and marks on metal or in this context, wax. Dividers can cost as much as $260, but a very serviceable divider can be purchased for $12 to $20.

Dividers are available in several styles and sizes based on their length from points to the top of the dividers.

Digital Calipers – This tool will measure in either millimeters or inches and in three different ways. Some makers choose to use digital calipers as a substitute for dividers, and they *will* work for scribing lines and laying out a design on wax or on metal, but over time the tips will wear down if used this way and the tool will not measure accurately. The cost of digital calipers varies wildly from around $36 to almost $500, but a quality caliper will run around $50. The calipers shown here are available at Gesswein for $43.50 at the time of publishing of this book.

Jeweler's Saw Frame – Also called a jewelry coping saw, this tool can be found on any metal artist's bench because it is such a versatile tool. It can be used to saw metal, plastic, wood, or wax. While there are several styles of this tool (see the pictures below) at different price points, a good quality saw frame can be purchased for about $25.

Jewelry coping saw frames are available in different sizes and styles of frames. The saw at right is the smallest frame and measures 2 ½".

Wax Sawblade (spiral or skip tooth) – There are three types of coping sawblades that are used with the jeweler's saw frame based on the type of material to cut. There are blades used for sawing metal, as well as skip tooth blades, and spiral blades that are used for sawing softer material such as wood, plastic, or wax.

Spiral Sawblade and Skip Tooth sawblade

The skip tooth and spiral sawblades are much coarser which allows the sawdust to fall free and not clog up the teeth of the blade. Saw blades come in various sizes which refers to the width of the blade. The thicker the material to cut, the thicker the blade should be. Saw blades for cutting metal have the widest range of blade sizes ranging from 8/0 (the thinnest blade) to 8 (the widest). For a fuller understanding of how to use the jeweler's saw frame and sawblades, refer to Appendix IV: Other Teaching Resources for books and videos on this topic._Wax saw blades can be purchased by the dozen for around $5 to $7 and typically will last a long time.

Wax Ring Sizer – As the name implies, this tool is used to change the size of wax ring blanks. It looks like a ring mandrel that is made of wood and is used to make the ring size larger only. The way this is done is by shaving wax from the inside of the wax blank with a blade that runs the length of the tool – except for where the handle is.

As the photo shows, there are also numbers running along the stick indicating ring size. In my experience, I haven't found these to be particularly accurate, so I have ignored them and used the ring mandrel to determine the correct size for any model. Wax ring tube from a supplier comes with a hole that measures around 4½ to 4¾. Since most rings are larger, the wax ring sizer tool makes the process of enlarging the size very easy. A wax ring sizer can be purchased for $9 to $16 from several different suppliers listed in Appendix VI. There are other tools available for increasing the ring size of a model, but for cost and ease of use it's hard to beat this tool.

There is one other point to address about sizing wax models and that is answering the obvious question: If a size smaller than 4½ is needed for a wax model, how is this accomplished? There are a few different solutions to this question. One of them involves sizing the metal ring after casting, which is the easiest for most ring designs. Another answer is to start the wax carving process not with ring tube, but with wax rod and drill a hole the right size after cutting a wax blank from the rod. There are many charts on the internet showing the inside diameter for ring sizes to help determine proper size. One other way to create a wax model the right size is to use some other type of wax rather than carving wax. (See the explanation in the supplies section below.) And the last alternative for casting rings in smaller sizes is to create a 3D print of the model which is discussed in greater detail in Chapter 8.

Metric Ruler – Most things in the jewelry industry are measured using the metric system: stones, settings, findings, etc. Fortunately, even in the U.S. where SAE measuring is still king among measuring standards, most rulers have both SAE and metric on them. Rulers also are easily found in a variety of lengths from 6 inches (15.2cm) to 24 inches (60.8cm), as well as materials: plastic, wood, stainless steel. A stainless ruler would be most durable and is inexpensive (about $3 for the 6" size).

Pro Tip for Measuring

Use a plastic ruler to wrap around large objects like round or oval stones. Mark where the ruler overlaps with a sharpie. This is great for determining the length of wire needed to build a bezel, or to equally distribute embellishments or stones around any given length.

Files –Ask any maker and they will say they don't have enough files on their bench because there are so many different types of them based on shape, size, and coarseness of cut. And the intended material to be filed – in this case wax. There are five basic shapes of files that are useful to have on a well-equipped bench. They are a flat file (also called a mill file), half round, round (sometimes called a rat-tail file), square, and triangle (also called a three-sided or a three-corner file).

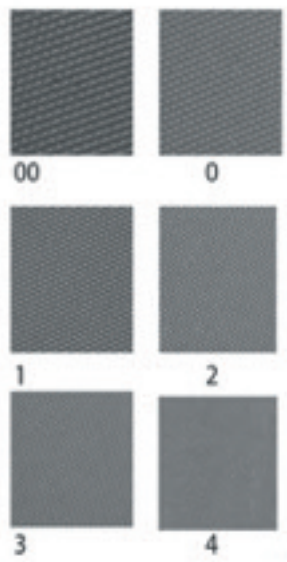
Common hand file shapes

There are also sub-categories of files that come in various shapes and sizes for more specialized work. Riffler, needle, and key files are three examples of these. In general, all these files are designed for use on metal, but they can be used for filing wax as well. For doing wax work there is even a specific half-round, double-ended file (coarse on one end and medium on the other) called a vulcanite file. The cost of files can vary greatly, but for wax work the economy version of any file – or set of files – will work well and last a long time if you use them exclusively for wax work.

Vulcanite Wax File

Above: Needle File Set (left) and Key File Set

These files also come in different coarseness of teeth typically ranging from 00 (referred to as double zero or double aught), which is the coarsest cut, to 6, the finest. The picture on the right is enlarged to show the difference. The cut of a file is indicated by a number on the tang or handle of the file, and the higher the number, the finer cut on the file. A #2 cut is a good all-around medium cut file. If a more aggressive file is needed, a #0 is a good choice, and if a finer result is needed use either a #4 or a #6 cut. The #0 cut file is a good choice for doing wax work because the softer material will not plug the teeth of the file as much. I start my own wax filing using the #0 to remove the bulk of the unwanted wax and then switch to a #2 for doing the finishing touches of the design or in some cases a #3.



Magnified view of common file coarseness for double cut files

File Cleaner (also called a **File Card**) – This tool has little metal tines and looks very much like a pet grooming brush (see photo below). It is used to clean out the shavings of material that get caught between the teeth of files. Be sure to drag the file cleaner across the face of the file at the same angle the grooves are cut into the file. This is also an inexpensive tool, costing around $8–10.

A wax card cleans any material clogged in the teeth of a file. Keeping a file clean will help the file work more efficiently and increase the useful life of the file.

Wax Carving Tools – Like files, these tools come in a variety of shapes and sizes, but unlike files, these tools are used to scrape or carve into wax to make a design. Also, like files, they can be purchased individually or in a set. The most common are sets of six or twelve tools. A good set of wax carving tools can be purchased for less than $20. There also are creative solutions such as pocketknives, craft knives, or even push gravers for use as carving tools.

Safety Tip

Wax carving tools are sharp! When carving wax, don't use sharp bladed tools for cutting; it can lead to serious injury. Use them for scraping only.

Bench Pin – Bench pins come in several styles depending on the work done on them (see the picture), but they all have the same purpose: to hold material in a stable way while it is worked on with other tools. It is the centerpiece for any maker's bench, and is secured to it either with a clap, or by inserting the tail of the pin into a slot cut into the front of the bench, or a pin holder attached to the front of the bench. Bench pins started out being made of some type of hard wood, but in more recent years, bench pins have also been made from Delrin nylon, rubber, and even metal. A bench pin will cost between $5 and $49 depending on your budget and how fancy a pin you want.

"C" clamp – A simple and inexpensive solution for holding a bench pin to a bench is this tool which can be found at any hardware store. The price will vary based on the size of the clamp's opening, but a 4" clamp will work fine and cost about $10–12.

Flexible Shaft Machine (also called a **"Flexshaft"** for short) – This is an expensive tool compared with the others listed here, but because of its versatility, it is arguably the most essential tool on any maker's bench. A flexshaft is part of my essential tool list for doing jewelry or metal artwork (see Appendix I). It is a variable speed tool with three main components: the motor, the handpiece, and the speed control mechanism (usually a foot pedal). There are literally dozens and dozens of attachments for drilling, grinding, cutting, polishing, or sanding to use with a flexshaft. So, this tool, along with the wide array of attachments, can do many metal art processes.

Refer to the section "Wax Carving Using Rotary Tools" in Chapter 8 for examples of some attachments to assist in making wax models. Is it possible to do wax carving without one? Absolutely, but it is so much easier and efficient to complete with one. An economy flexshaft will cost between $125 to $150. The Foredom SR series flexshaft shown in the picture is in the $350-plus range.

Wax Burs – This rotary tool is a great example of the value of having a flexshaft. As the photo shows, these cutting tools come in a variety of sizes and shapes, and they can really speed up the design carving process. Wax cutting burs are just like the burs used for cutting metal except the teeth are specifically designed to be coarser for work with wax, so they won't clog while carving (see the photos below). Wax burs can be purchased individually or in a set and range in price from $4 (singles) or $170 (set) depending on the number of burs in the set.

Wax burs are also an excellent choice for cutting or carving in plastic or wood. The picture above is an enlarged image of what various metal cutting burs look like. The picture below is an enlarged image showing how much more coarse wax burs are.

Wax Pen – This handy tool can be used both for the design work of wax modeling and to build sprue trees – the next stage after wax carving. The principle behind them is simple: the tip heats up so it can melt and place wax where desired. The pen tip is heated either by batteries, or with some models by plugging it into an outlet. The cost varies widely from about $20 for the battery-operated models to as much as $425 for some plug-in models. A good plug-in model can be purchased for $60-$75.

Craft Knife and **Alcohol Lamp** (if not using a wax pen) – Another cost-effective way of doing wax design work and building sprue trees is to use a craft knife (also sometimes referred to as an X-acto knife) and an alcohol lamp to

heat the blade to melt the wax. The advantage of this method is the cost of these two tools. The disadvantage is that the blade cools very quickly which means moving back and forth between the flame of the lamp and the wax you are working with. The cost of the craft knife will be between $3 to $5, and the alcohol lamp will cost about $5 to $7.

Supplies

Carving Wax – This is a type of wax that is specially formulated to carve well and to burn out cleanly in a kiln with no residue or ash. It also can be purchased in several different forms – block, tablet, rod, or tube – depending upon the type of jewelry and design desired. There are also many different colors of wax developed for different carving methods (i.e., hand carving, or use on a lathe), and you may want to try a few different colors to find which one works best for you. The cost of carving wax ranges from $7 to $30 depending on shape and size.

Sculpting Wax – This type of wax is the exact opposite of carving wax because instead of it being a hard wax, it is designed to be very soft and moldable. It can be softened just by the warmth of your hands, and model makers use this wax generally for making more organic shapes and designs as well as small sculptures. Because this wax will melt at a much lower temperature than

carving wax, care must be taken when sprueing this type of wax in preparation for investing. These strips are sold by the box for $20.

Sheet Wax – Sheet wax comes in several different colors and is also a soft wax, but not as soft as sculpting wax. There are several advantages to this wax. The first is that it comes in various gauges like sheet metal, so if a specific gauge is needed for a particular design, then it can be ordered from several suppliers from 8 to 28 gauge.

Another advantage of this softer wax is that designs can be cut out of it using a craft or razor knife making it possible to cut multiples of the same design from a sheet of wax. Finally, as a softer wax, this stuff can be bent, twisted, or curled in ways that carving wax cannot, and sculpting wax won't keep the crisp edges. This wax works great for design embellishments as well as structural elements like bezel settings or under-gallery work on pendants, rings, etc. It is also very easy to cut a ring shank to the exact width and length needed to make the right ring size. This type of wax is usually sold by the box either in a variety of gauges, or several of the same thickness and cost ranges from $14–20 per box.

Wax Wire – The consistency of this wax is very much like sheet wax so it, too, can be twisted, bent, etc., and like sheet wax it can be purchased in gauges 8 to 28 from many different suppliers. Other advantages of wax wire are that it comes in various shapes (e.g., round, half round, square, triangle, etc.), and it can be used to make sprue trees in preparation for casting.

These various types of wax can be purchased for around $7 for individual pieces to about $30 per box for assorted shapes and sizes. Refer to Appendix VI for a list of the suppliers. There are many other tools and supplies specially designed for doing wax carving, but these lists form a good basis for getting started.

Model Making in the 21st Century

With the advancement of technology, there may be no other aspect of jewelry manufacturing that has grown faster, or more broadly than jewelry design and model making for casting. Some of the more recent methods will be explained in later chapters, and while learning (and teaching) the wax carving process in the beginning can be daunting because of all these advancements, it does not have to be complicated. The process described below is a tried-and-true method and is not difficult to learn. It is possible with some patience

and practice using just the tools listed in this chapter to make some beautiful wax models of earrings, pins, pendants, rings, etc.

Carving a Wax Ring Model: Step-By-Step

The example step-by-step process for wax carving included here relates to making a wax ring model. I always start my students off by learning how to carve a ring, not because it is the easiest form to carve, but because it isn't. They start by learning how to make a wax ring because it is by far the most popular type of jewelry purchased and worn by customers. Another reason for starting with carving a ring is that it introduces all the tools used for carving a wax model. In Appendix III you will find a recipe-format teaching handout suitable for printing that lists all the tools, supplies, and a step-by-step procedure for carving a wax ring. All the other procedures in the lost wax casting process are also there.

Step 1 – Choose a wax tube shape suitable for the design planned (e.g., round center hole tube for a simple band; flat top wax for signet ring).

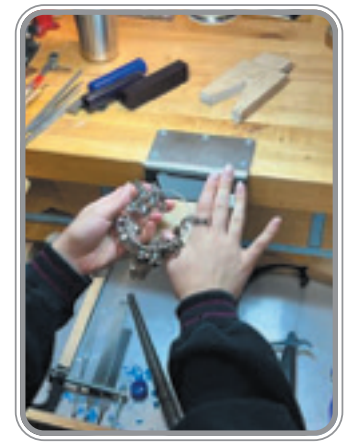
As the picture below shows there are several styles of wax ring tube that can be used based on the size of the ring to be made, and the basic ring profile from the front view. Referring to the orthographic projection discussed earlier in this chapter, the front view of the design will inform your decision on which shape ring tube to use. For example, if the ring will be a band of uniform width and thickness, then the round center hole ring tube will be the best shape to start the carving process. If the basic ring design will be a signet ring, then the best shape wax tube to begin with will be the flat top wax tube. And for a basic domed shaped ring, the off-center hole ring tube is the best choice.

The other consideration is the finished model ring size because this will determine how thick the tube wall needs to be to start the carving process. All tube wax made has a hole through the tube that measures about 4¾ +/-, so for carving a ring that is under size 7 a thinner walled wax tube can be used. For casting a ring larger than size 7-ish, you will need to use a thicker walled wax tube. The reason is that by the time you have reamed out the wax blank to the right size, you will still have enough wax material to carve the outside design of the ring. Use a thinner walled wax tube and you may not have any wax tube left at all.

This is also a good time to talk about the various colors of wax. As shown in the photo below, there are several to choose from, and there are some differences to consider based on hardness versus flexibility. Green wax is the hardest wax and least flexible. The upside of this wax: it is best used for carving very intricate designs. The downside is it breaks most easily when the design gets thin and especially when the design has open areas. Purple is medium-hard with a little more flexibility, so this wax is a good choice when you need the wax to be a bit more "forgiving" while carving thin or open areas in a design. Blue is the softest of the three colors but still suitable for general wax carving. This is a great wax for beginners. It is very good wax for carving simple bands or models that do not have fine detail in the design. There are also several other colors of wax developed for various purposes. Some are formulated to perform very well while being lathed or cut by a CNC machine but are still very good for hand carving.

Others are gold colored wax, so the model looks more like the final piece of jewelry when showing it to a customer. Different jewelry supply houses will carry different styles of wax, and all the companies listed in Appendix VI will happily answer your questions and help you choose the right one for your purpose. Ring tube will cost $8 to $12 depending on vendor and type of wax.

Step 2 – Gather the necessary tools needed from the list. The list of tools in the wax carving procedure is intended to be comprehensive, but they may not *all* be needed to complete a particular model. Knowing which tools to use comes with design plan, experience, practice, and finally, experimentation, but there are certain tools that will be used for each ring carved. For example, you will need to cut a wax blank from the wax tube so a jeweler's saw will always be used. Files are another example of tools that will always be needed for creating a model. Most makers carve their models at a jeweler's bench dedicated to doing wax work. If you only have one jeweler's bench, it is highly recommended to sweep up all the recyclable metal filings and grindings before doing any wax carving and likewise clean all the wax dust from the bench before returning to any metal work.



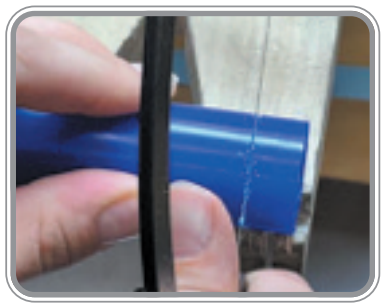
Step 3 – Measure the finger the ring will be worn on with the sizing rings set and write down the size needed. The first tool I always teach students to use is the sizing rings set because this will partially determine which wax tube to use: larger size rings (above size 7) – thick-walled ring tube, smaller size rings – thin-walled ring tube. All three styles of ring tube shown in the picture above are available in a thin-wall tube and a thick-wall tube; for this reason, and I always keep both available in my shop.

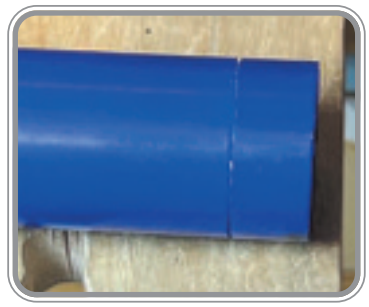
Pictures courtesy of Gesswein Tools

If you are making a wax model with a shank that is narrower, the narrow sizing set will work fine. The wider rings are used to determine an accurate size for rings with wider shanks. The reason is because wider rings will fit tighter on the finger than narrow rings of the same size. Here is a general guideline for using the wider sizing set. If the shank of the model you are making is 4mm wide or wider, then use the wide ring sizing set.

Step 4 – Using the dividers and a metric ruler, scratch a mark all the way around the ring tube just slightly wider than the width of the ring at its widest part that you want to carve. Not all rings are uniform in width all the way around; in fact, most are not, so it is important to know how wide the widest part of the ring will be. In almost every case, the widest part of the ring is the "top" where the main design is. This is an example of the importance of having a sketch of the design drawn on paper with the dimensions indicated. Marking the wax tube a little wider than the desired width of the model provides the "fudge factor" needed when filing the wax down to the final shape and dimensions.

Step 5 – Cut the ring tube on the mark with the jeweler's saw and wax sawblade (either spiral or skip-tooth) by cutting a little and turning the tube until there is a groove all the way around the tube. Continue to saw and turn the tube until the wax blank is cut from the tube.



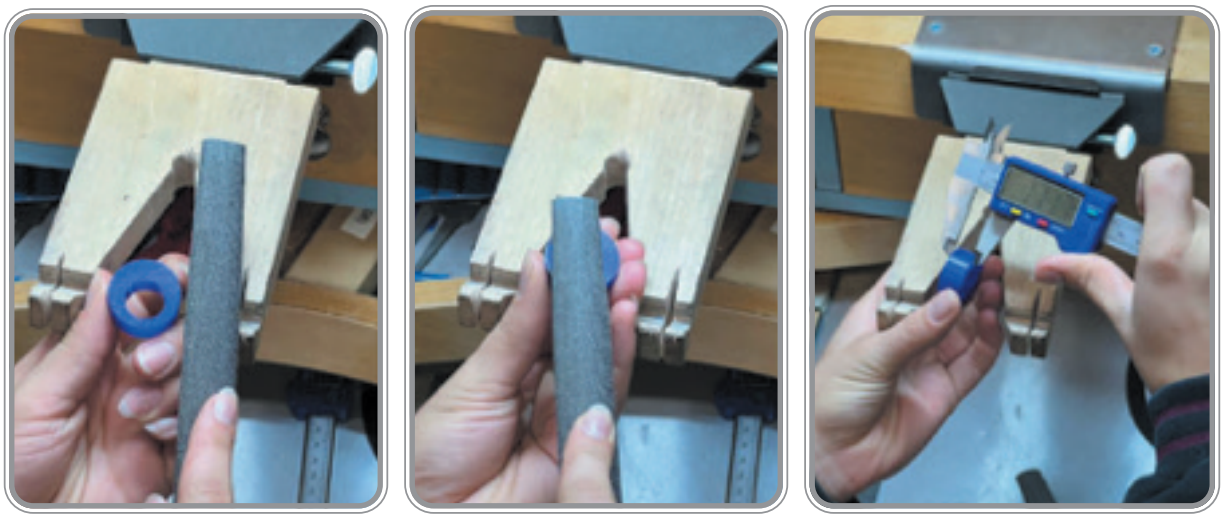


There are a couple of other ways to cut a wax blank from the tube such as using a band saw (be careful and follow all safety guidelines for using a power saw) or a miter box and manual saw specially made to hold wax tube. The tube cutting jig shown is made by Matt Wax Tools.

Following the groove on the tube with the sawblade can be a bit tricky at first, but with a little practice, the wax blank can be cut from the tube very precisely. As shown in the photos, you will want to use a sawblade with coarser teeth; this will prevent the blade from clogging with wax dust while sawing. Just like sawblades used for cutting metal, there are different sizes of spiral sawblades or skip-tooth sawblades, which will cut a narrower or wider saw kerf. A saw kerf is the groove cut by a sawblade that is the width of the teeth on the blade. The general rule of thumb is this: the thicker the material to be cut, the thicker the sawblade should be.

If done correctly, the end of the wax tube will be flush and perpendicular to the length of the tube, which means less waste or time lost in squaring up the end of the wax tube in preparing to cut another wax blank.

Step 6 – After cutting the wax blank off the tube, smooth the sides with a file to remove the saw marks and measure the blank with the calipers to make sure it is the right width to proceed with the rest of the carving. If the blank is too wide, continue filing to get the desired width.



Step 7 – Measure the wax blank on the ring mandrel to find the starting size. The leading edge of the wax blank determines the size.

Pro Tip:
Always measure the ring on both sides to make sure the hole going through the tube is parallel.

As the picture shows, the leading edge of a ring is the edge on the wide side of the ring stick. The marks on the ring stick indicate the inside diameter of a ring, or in other words, its size. Almost all ring mandrels have sizing marks on them in ¼ size increments, so the size of any ring can be very accurate. There are several different systems for sizing rings used throughout the world. To see how each system matches up refer to the table in Appendix II.

Step 8 – Once the finished model size is determined, the hole in the ring blank can be enlarged. Ream out the inside of the ring blank using the wax ring sizer until the correct size is obtained by alternating sides of the ring to keep the hole in the ring blank parallel. To ream out the inside of the wax blank, place it on the wax ring sizer, keep it perpendicular to the blade, and begin twisting the ring sizer.

As you do this, the blade will begin to shave wax from the inside of the wax blank and enlarge the hole, but because the wax ring sizer is tapered, the hole will become tapered as well. To prevent this and keep the hole in the wax model parallel and true to size, flip the wax over and shave from the other side. Continue to do this, frequently alternating sides until the leading edge of the wax blank reaches the same sizing mark on both sides of the model when measured on the ring mandrel. This is particularly important when carving a wider ring because the size can measure differently from one side of the ring to the other by as much as a half size, and that is a big difference.

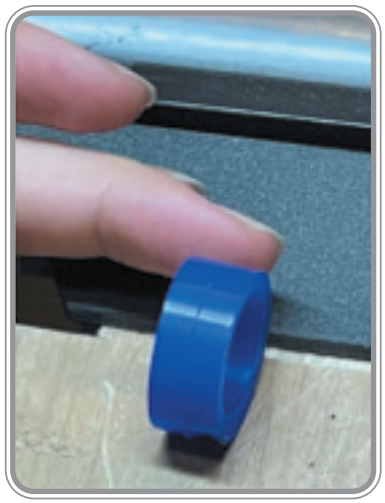
When learning this process, you may ream the hole too much and get a ring size larger than what you want. This isn't the end of the world, and it doesn't mean you will need to start over. It just means you will need to size the ring after it is cast.

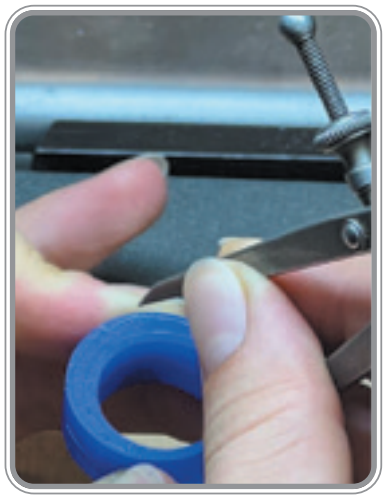
There are also other tools and methods for enlarging the ring hole in a wax blank. One method is to use a coarse round file, sometimes called a rat tail file. Hold the wax blank against a bench pin secured to a jeweler's bench or worktable and file the inside of the ring. File a few strokes then rotate the ring and file the hole in a different spot. Continue working your way around the inside of the wax blank, flipping the ring around from time-to-time filing from both sides of the wax model until the desired size is reached.

Another method involves using a flexshaft. A rotary file is one of the attachments that can be used to enlarge the hole of a ring blank. Use the rotary file on a slow speed to cut away the excess material of the ring blank by cutting and rotating the wax model a little at a time until the desired size is reached.

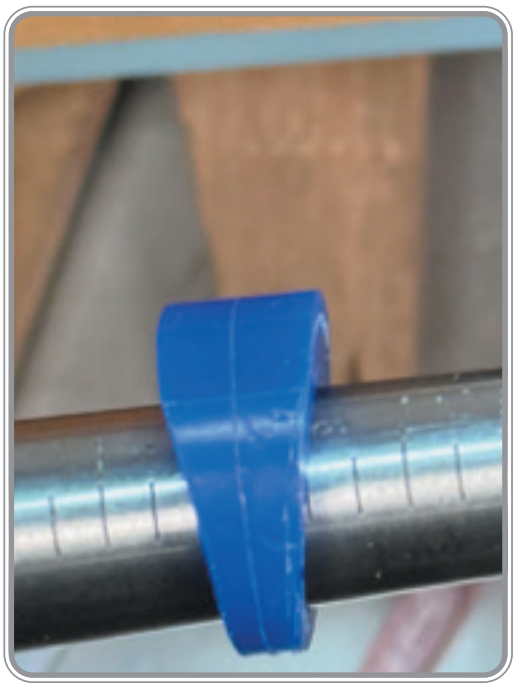
The downside with these two methods for enlarging the ring size in a wax model is keeping the hole perfectly round while reaming it to the larger size. Put the wax model on the ring stick frequently not only to measure size, but to check if the hole is still round.

Step 9 – After reaming the ring blank to the correct size, scribe a centerline around the outside of the ring and some guidelines on both sides of the blank to get the basic shape of the design you intend to make before carving the outside of the ring. This "blocking out" process is entirely dependent upon the final design of the wax model (see the example in Project 1).





Step 10 – Use a scribe or some other sharp pointed tool to scratch a basic outline of what the model will look like when complete. The purpose of the guidelines is to inform you what part of the wax blank to carve away and what part to keep as you begin to remove material.

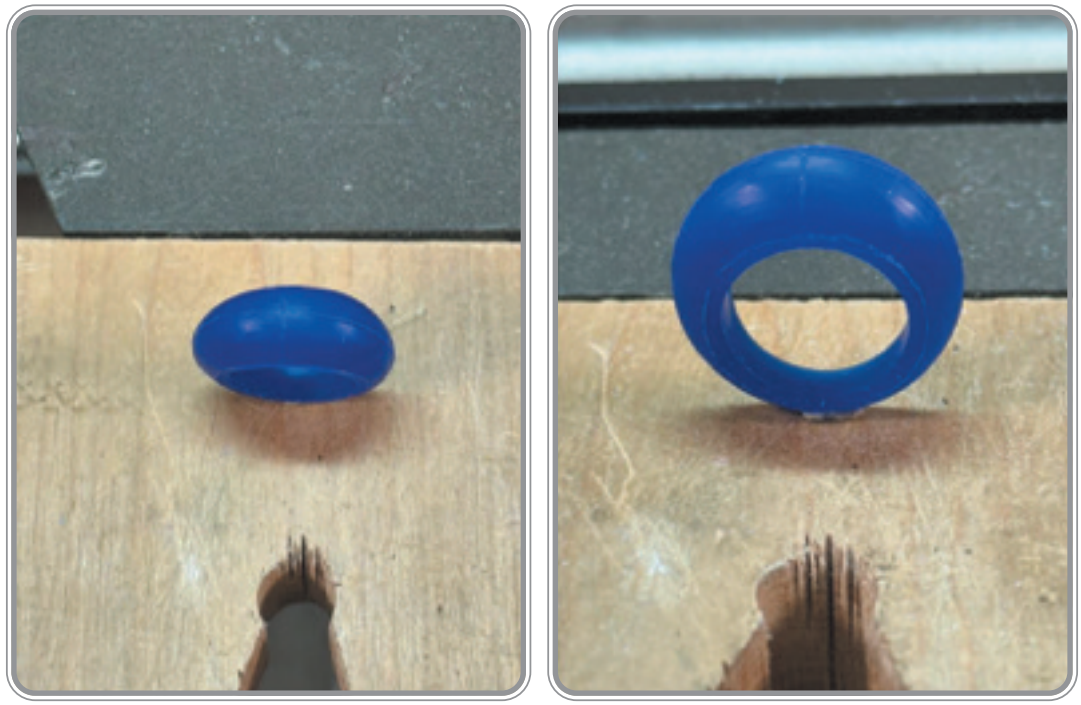


Roughing out the model.

In this view the taper on the model is filed, and on the other side the guideline running down the side of the ring is still visible. Note also the center scribe line running around the model. This is the starting point for all other guidelines.

Step 11 – Using the files, wax carving tools, and possibly the jeweler's saw or flexshaft with wax burs, begin roughing out the design by removing material from the ring blank. "Roughing out" the design means to remove the bulk of the unwanted material from the model without carving into the model in the areas you want to keep. With more practice you will get better at removing the unwanted wax and not over carving into areas where it needs to remain. When you accidentally over-carve the wax model into areas you want to keep (and you will on occasion when learning), it can easily be repaired by adding molten wax back where you cut too much off. Refer to the troubleshooting tips at the end of the chapter on how to do this process.

Step 12 –Continue to use files, scrapers, wax carving tools, or rotary tools in your flexshaft to remove excess wax and refine the design until you reach the model dimensions and finished "look" desired.

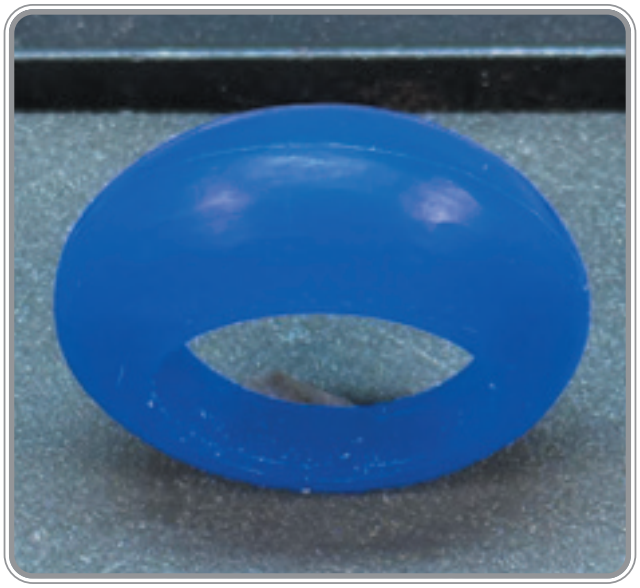


If any guidelines are filed away while roughing out the model, they can be reapplied (if needed) to do the detailed finishing design work.

Step 13 – Smooth the surface of the wax by scraping with the blade of a wax carving tool or craft knife, and do not use sandpaper. Sandpaper leaves scratches, which can cause problems during the investing stage as well as cleaning up the model after casting. Another way to smooth the surface of the model is to rub it lightly with a piece of denim or a nylon stocking. Just be careful around fragile or thin parts of the model; thin areas of a model can break with very little pressure. Yet another way that some makers use to smooth the surface is to wave the model back and forth over an alcohol flame, but again, be careful. Thin parts on the model will heat up more quickly than thicker parts, and wax tends to melt into a non-descript blob. If you try this method, be sure to hold the model using some finger cots so you don't burn your fingers. The flame is hot, but so is the molten wax and you can get a nasty burn from wax dripping on your skin. This technique for smoothing the surface on wax models is also a bit tricky, so I suggest you practice it using a piece of scrap wax before trying it on a finished wax model. There is nothing worse than investing many hours of labor to create a finished wax carving only to have it ruined right at the end of the process.

Step 14 – Inspect the model for any deep scratches or cracks/breaks. These will need to be repaired before proceeding. Any deep scratches that cannot be smoothed without thinning the wax too much should be filled with molten wax and blended into the surrounding areas of the design. You will be glad you took the time to get rid of the scratch in the wax rather than trying to deal with it in the metal after casting. Cracks and breaks can sometimes be hard to see but must be fixed before moving on to the next stages. Your wax models will be subjected to significant pressure during the next stages of the casting process, and you want them to come through in one piece – literally. Finding cracks or breaks is a very simple process. Take a high

intensity flashlight and hold the model over the light. Cracks and breaks will show up as lighter lines running through the model. Sometimes these lines are jagged and sometimes not. No cracks or breaks? You are ready to move on to the next stage. Refer to the troubleshooting section below for the procedure to fix wax models.



Finished bombe ring wax model. Note there are still some very light guidelines still on the model left for additional design work.

Troubleshooting Tips and Tricks for Wax Carving

Fixing cracks/breaks/over-carving when making a model:

Tools – wax spatula or craft knife, alcohol lamp or wax pen
Supplies– scrap wax of the same color/type as the model

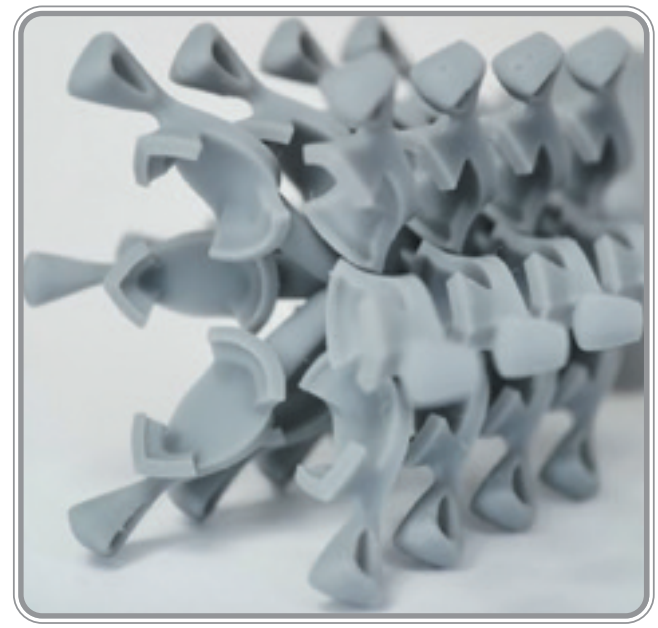
Process– Heat the tool. Touch it to the crack or break to melt the wax back together. Heat some scrap wax and place on the crack or break as needed. Carefully file the excess wax and blend into original model.

Tip: Hot wax does not stick to cold wax, so use a hot tool to partially melt into the model.

Chapter Summary

The principles presented in this chapter are intended as a good starting point for learning how to design jewelry on paper and in a three-dimensional model. An orthographic projection is a drawing that illustrates three views of an object (like a ring) showing top, front, and side as well as an isometric illustration that displays all three sides of a three-dimensional object. Today, the creation of a three-dimensional model for casting can be done in several ways, but carving a wax by hand is still the simplest method. It is done by using hand tools or rotary tools in conjunction with a flexshaft. Hard carving wax is the method most frequently used to create a model because it is the easiest to learn. While there are many tools that can be used to carve, there is a basic set of tools that are always used in this process.

Sprue tree and detail courtesy of Jonas Mackowski



CHAPTER 2

SPRUEING THE MODEL

Above: Sprue Tree on a sprue base

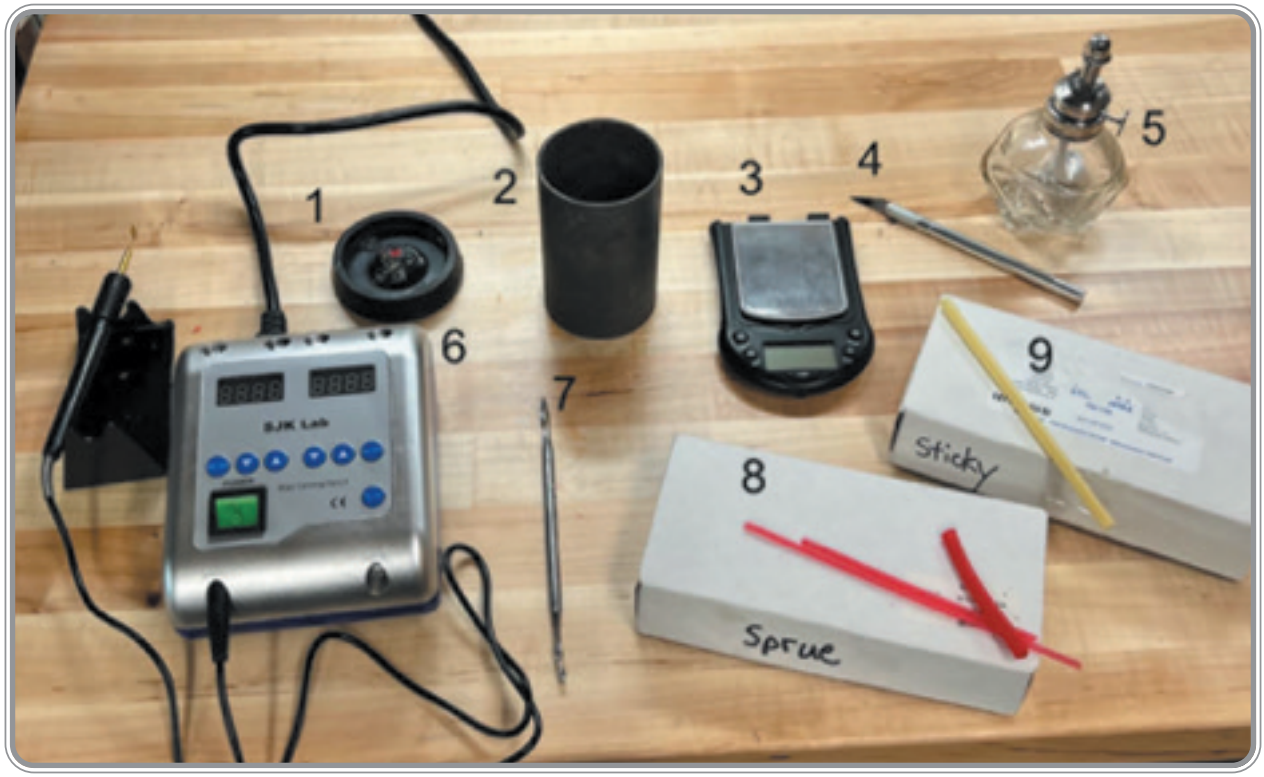
Once you have carved your model (or models), it is time to move on to Phase 2: prepping and casting of the lost wax casting process. This part is where all the magic takes place in transforming wax models into metal pieces, and the "magical transformation" begins with sprueing the model(s) before casting. In the sprueing stage the models are attached to a sprue tree, so called because when complete it looks like a miniature tree. It all starts by creating a central "trunk" with thick gauge wax wire – usually 6 or 8 gauge, then attaching the wax models to the trunk using 12-gauge wax wire. The purpose of sprueing is to create a channel for the molten metal to flow through during the casting stage. This channel is also sometimes referred to as a *gateway*, and to form it, a mold must be made that surrounds the sprue tree. This part of the process will be explained in more detail in Chapter 3: Investing the Model.

One of the keys to a successful casting, however, happens at this point in the process. It is very important that at the base the tree has one (and only one) trunk. If there is more than one opening branching off at the sprue base, once the mold is made, it could happen that molten metal won't follow (fill) all the openings. The result will be losing part of the casting tree or having some of the models only partially fill.

In my experience, the sprueing and the investment stages are the most difficult for students to grasp, and I think there are two reasons for this. both processes have many steps to follow – all of them important to do in proper sequence; and it is difficult for the newbie to see how they are connected to the overall process. Most people new to lost wax casting will ask the same questions when they see the demonstration for making the sprue tree: "Why are the wax wires attached to the models?" "Why are they all attached to the central trunk?" Once again, there is that key word in all the questions asked: "Why?" After students see the whole process completed, the why for doing each of these stages becomes clear.

When teaching this to students, I skip over "connecting the dots" of these intermediate stages and simply ask them to trust that it will all make sense when they see the entire casting process completed. I then demonstrate how to build a sprue tree, and they are given a written step-by-step of the process that they can follow for making one of their own. This tree is then used to move on to learning the investing stage. The following is the process for building a sprue tree, and as with carving a wax model there is a step-by-step procedure in Appendix III suitable for printing handouts for students to follow as they make their own sprue tree.

The Wax Sprueing Process: Tools and Supplies



As shown in the photo above, there are some new tools and supplies to learn how to use. Below is a closer look at each one, how much it costs, and any other important details about them before explaining the sprueing process.

Tools

1. Sprue Base – As the name implies this is a rubber base that the sprue tree is attached to, but it also has another purpose. The lip of the sprue base also attaches to a steel cylinder called a casting flask that will surround the sprue tree during the following stages of the casting process. Sprue bases and flasks come in different diameter sizes, so be sure to check and make sure these two tools match is size. The cost for a sprue base varies from $4 to $12 and is based on the style and size of the base.

2. Casting Flask – This tool is used to hold the investment during the burn-out stage and casting stage of lost wax casting. It is made of steel so it can withstand temperatures up to 2000°F (1093°C). Like the sprue base, the cost of a flask is determined by the size and style. There are two styles of casting flasks. The one on the left can be used in either a centrifugal caster or a vacuum caster. The one on the right is designed specifically for use with a vacuum casting machine and will be explained in Chapter 5. Casting flasks will range in cost from $7 to $30 depending on size and type.

3. Scale – Either a mechanical scale or a digital scale can be used if it will weigh objects in small enough increments with accuracy and has a maximum weighing range large enough to weigh the amount of metal needed for casting. The price of a scale varies greatly, but a good quality scale can be found in the $50 to $100 range.

4. Craft Knife – There are several different styles of craft knives that are comprised of a handle and replaceable razor blade. This type of knife is readily available in a local hardware store or craft store and can be purchased for $5 to $10.

5. Alcohol Lamp – An alcohol lamp is basically a glass jar with a screw-on lid and cotton wick that comes up through the middle. Cost for this tool ranges from $5 to $7.

Optional Equipment

6. Wax Pen – This is a great tool that can be used in place of a craft knife and an alcohol lamp. The tip of the wax pen is heated by electricity and models vary in price. Some wax pens run on batteries while others are plug-in models. The advantage of using the wax pen is that the tip will continue to remain hot as long as it is on. Purchasing a digital wax pen can be quite costly (as much as $325), but an excellent plug-in model can be purchased for around $55. While this price is more than the combined cost of a craft knife and alcohol lamp, it has the advantage of not having to constantly heat and reheat the blade of the knife to do your wax work.

This wax pen has two independently controlled pens allowing two makers to use simultaneously.

7. Wax Spatula – If wax needs to be added to a model for any reason, this optional tool will come in very handy. Use it with an alcohol lamp as an inexpensive alternative to using a wax pen for applying wax to a model where needed. A wax spatula will usually come as part of a set of wax carving tools, but it is possible to purchase one separately for about $7.

Supplies

8. Sprue Wax Wire – 8-gauge and 10-gauge for making the trunk and branches of the sprue tree. This wax is usually sold by the box for around $20.

9. Sticky Wax – As the name implies, this wax is very sticky when melted. It melts at a lower temperature than either the carving wax or the sprue wax and helps hold the sprue tree together at all the connection points. The added advantage of using sticky wax is that it strengthens all the joints on the sprue tree before the investing stage is done. Sticky wax is also sold by the box for $15 to $20.

Matches – For lighting the alcohol lamp.

Alcohol – This is the fuel for the lamp. The best alcohol is denatured alcohol that can be found in the paint department of a hardware store. This supply is available for $20 to $25 a gallon.

Optional Supplies

Scrap Carving Wax – This is handy to have available in case one of the models needs to be fixed.

Once all the tools and supplies are gathered, building the sprue tree can begin.

Sprueing Procedure Step-By-Step

A completed sprue tree. After weighing, it will be ready for investing.

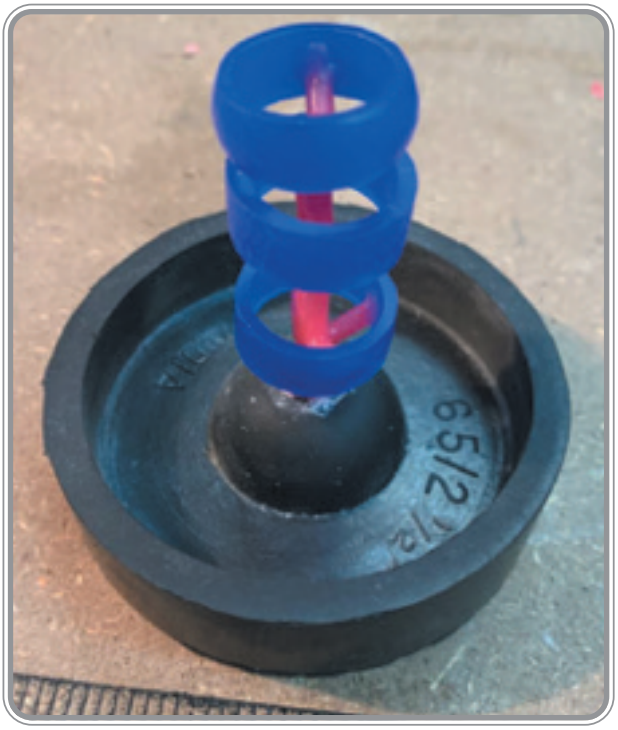
Step 1 – Inspect your wax models one more time to make sure they do not have any cracks, breaks, or air pockets in the models. It is very important to make sure the structural integrity of the models is intact because they will be exposed to significant stresses during the investing stage. These problems in the models can result in poor quality castings that will require time and labor to repair after they come out of the casting process. It is much easier to fix any potential issues now rather than deal with them in the metal. If you find any of these problems in the models, take the time to fix them before attaching them to the sprue tree. It is very difficult to fix a crack or break in a wax model once it is attached to the sprue tree, and it will be impossible to do it after the sprue tree is invested.

Step 2 – Get a piece of 8-gauge wax wire about 3 inches long, and some 12-gauge wax wire about 6 inches long. Unless you are building a tall wax tree with many models attached, 3 inches of 8-gauge wax wire will be more than enough to make the trunk of the tree. The same is true for the 12-gauge wire; 6 inches should be enough.

Step 3 - Light the alcohol lamp using a match.

[Safety alert: Use only matches to light the alcohol lamp. Do not use a butane pocket lighter! It could blow up on you.]

Step 4 - Heat the blade of the craft knife in the flame of the alcohol lamp (or using a wax pen) and melt the end of the wax wire and the jewelry piece together. Hold the wax wire and the model together until the wax resolidifies. Use the 12-gauge wax wire and attach it on the outside of the shank at the thickest part of the model. Cut the wax wire leaving about 1/2" (1 cm) attached to the model. The only exception to this guideline is when the connection point will interfere with the design on the model. In a situation like this, some creative sprueing will be necessary to avoid fixing the design work after casting which is time consuming and much more difficult in metal (see photo). Repeat this step for each model on the tree.



This is an alternative method of sprueing models to preserve any design details on the outside of a ring model.

Step 5 – Attach a 3-inch piece of the 8-gauge wax wire in the middle of the sprue base using the craft knife and the alcohol lamp to melt the end of the wax wire. This will act as the trunk of the sprue tree. There are two common styles of sprue bases. One style has a cone-shaped rise in the middle of the base, and the other has a rounded shape. Either style will work fine, and they both serve the same purpose: to form a funnel-like opening into the casting mold that will be made in the investing stage. The important thing is to get a flask and a sprue base that fit snugly together. For example, if you use a 2½-inch diameter flask, then you will want a sprue base that measures 2 ½ inches.

Step 6 – After attaching sprue wires to all the jewelry models, heat the craft knife blade in the alcohol lamp (or using a wax pen), and melt the sprue wire to the main "trunk" of the tree for each of the models. Attach them from the top of the tree down and all the way around the trunk. The models can be very close together. Just make sure they are not touching. Hold the two pieces together until the wax cools and resolidifies. Be sure the models are angled up toward the top of the sprue tree. When I teach this process, I always save the thickest/heaviest model to attach directly to the top of the central trunk of the sprue tree without using 12-gauge sprue wire because it is not needed. The easiest way to build the sprue tree is from the top down rather than from the bottom up and attaching the models as close together as possible without touching each

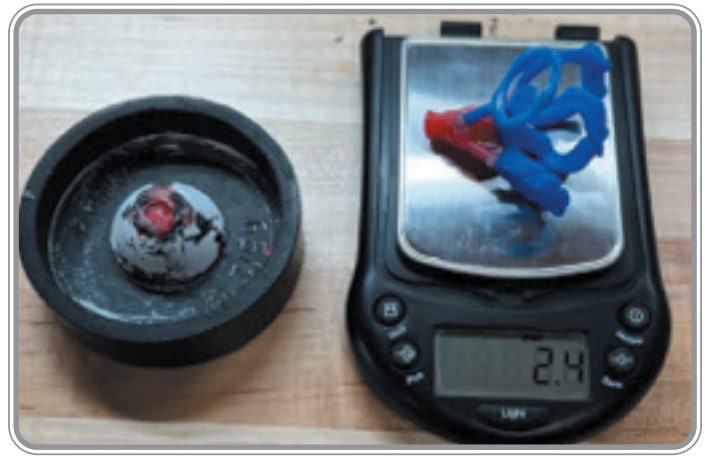
other. The shorter the sprue tree the better, so if you have a tree trunk where the models are attached only halfway down the tree, that's good. The remaining sprue trunk can be trimmed off before weighing and investing. The reason for this will be explained in the next chapter about investing. The other models are angled at about 20 to 30 degrees from vertical so there is as straight a line from the base of the sprue tree to the model as possible (refer back to the photo at the beginning of this chapter to see an example.). The reason for doing this is to provide the most direct line for the molten metal to travel during the casting stage and get from the base of the tree to the model as quickly as possible. Molten metal will cool from liquid to solid very quickly during the casting stage, so it is critical the liquid metal does not have to travel through sharp bends or narrow areas of the sprue tree any more than is necessary on its journey to fill the models.

Step 7 – Add some sticky wax to all the joints where wax parts are connected (trunk to branch and branch to model). Sticky wax melts at a lower temperature than the sprue wax, and as the name implies, it is super sticky, so it joins with the existing wax very well without melting it. This wax comes in an 8-gauge wire about 5 inches long. Heat the craft knife with the alcohol lamp, pick up some sticky wax with the hot blade, and place the molten wax on the joint (see illustration in the sprueing procedure in Appendix III). It is important to reinforce these connections so models don't break off the sprue tree during investing. In the next stage the sprue tree will be subjected to some significant vibrations, and having a wax break off during the investing stage means having to back up and redo the sprue tree. And *that* means wasting a batch of investment because it is impossible to clean the investment off the sprue tree, reattach the model, and then use the same batch of investment before it hardens. Each stage builds upon the previous stage, so to get consistently successful casting results means taking the time to tend to details like this step. Remember the mantra: Details matter!

Teaching Tips for the Classroom Instructor

- Have students work in groups of three or four.
- Each student attaches their own model to the tree. This ensures that each student learns the process.
- All members of the group participate in weighing the sprue tree and recording the information.

Step 8 – After all the models are attached securely, carefully remove the tree from the sprue base by heating the craft knife blade in the lamp (or using a wax pen) and melting through the base of the trunk right where it is attached to the sprue base. Trim off any excess length of the sprue trunk below the attached models leaving about 1 centimeter on the end and weigh the tree. This necessary and crucial step must be done to calculate how much metal will be needed to complete the casting.



Step 9 – Weigh the sprue tree on the scale. It must be done when all the models are attached to the tree, not attached to the sprue base, and *before* investing it. There must be enough metal to fill the trunk and branches of the tree as well as the models, so if only the models are weighed, there will not be enough metal, and the result will be a partially filled casting. The unit of measure used

to weigh the tree does not matter – grams, pennyweight – just be sure you use the same unit of measure when weighing the amount of metal needed for casting. This is figured out by doing a little math. Here is the equation for calculating the amount of metal needed to cast any sprue tree.

Wax Weight X Specific Gravity = Metal Weight

All matter weighs something, and all matter occupies space. When the sprue tree is invested it will occupy a certain amount of space inside the investment mold. After the wax is eliminated from the mold during the burn-out stage, there will be a cavity, or hollow area, left to fill with molten metal. The obvious question to ask is, "How much metal?" The answer is contained – in part – in the equation above. The other part of the answer is "What type of metal is being used to make the casting?" Lost wax casting can be done with all sorts of metals: aluminum, pewter, copper, brass, silver, gold, platinum. All these metals have a different specific gravity because they all have different densities. Many of my students struggle with spatial relationship, so I explain it using the following example.

Picture in your mind a cube of sugar so you have an idea of its size. Now consider a cube that is the same size, only it is made of lead. Which cube is heavier? They always get the right answer because they understand the idea of density. The same principle in being applied in our equation above for calculating the amount of metal we need to cast. The specific gravity for any type of metal can be found in the chart in Appendix II of this book.

For example, let's say we are going to do a casting in sterling silver. From the chart we find that the specific gravity of sterling is 10.4. The specific gravity of the wax is 1, so, if the sprue tree weighs 5.2 grams, we can now plug our values into the equation above.

5.2gr (Wax Weight) x 10.4 (Specific Gravity of sterling) = 54.08gr Ag (Metal Weight)

All we need to remember is whatever unit of measure we used to weigh the wax, we must use the same to weigh the metal. If you use a mechanical scale that has only one unit of measure, that works fine. If you use a digital scale, however, that can measure using multiple measuring systems, then be sure you are using the same unit of measure to weigh the wax and the metal. This may seem obvious, but I have used a digital scale in my teaching studio for years, and that mistake has been made, and things did not end well for that casting.

Step 10 – Once the tree is weighed, it can be reattached to the sprue base by heating the craft blade in the alcohol lamp (or using a wax pen) and melting the sprue tree back on the sprue base. Now would be the right time to check and make sure all the models are well attached to the branches, and all the branches are well attached to the trunk of the sprue tree.

Step 11 – With the sprue tree attached to the base, carefully attach the flask to the sprue base. Check to make sure none of the models touch the wall of the flask, and that the top of the tree is at least ½ inch (approx. 10mm) lower than the top of the flask. The sprue base needs to fit snugly around the outside of the flask like a snap-ware lid.

There are two reasons for this. If the sprue base does not fit snugly around the flask, the investment will leak out between the base and the flask during the investing process. The other reason is to get an accurate idea of how far from the end of the flask the top of the sprue tree is before filling with investment. The importance of both details will be explained more fully in the next chapter.

Casting flask and sprue base attached

Notes on the sprueing procedure:

- A wax pen may be used for any step where an alcohol lamp and craft knife are used. Just be sure the wax pen can generate enough heat to do the job; some battery-operated wax pens don't.
- Make sure the models are angled up towards the top of the tree. This makes the gateway as straight as possible for the molten metal to travel through on its way from the base of the tree to the models. Narrow areas and 90-degree bends from the trunk to the branches will slow down the metal flow and can cause it to chill back into solid form before reaching the model.

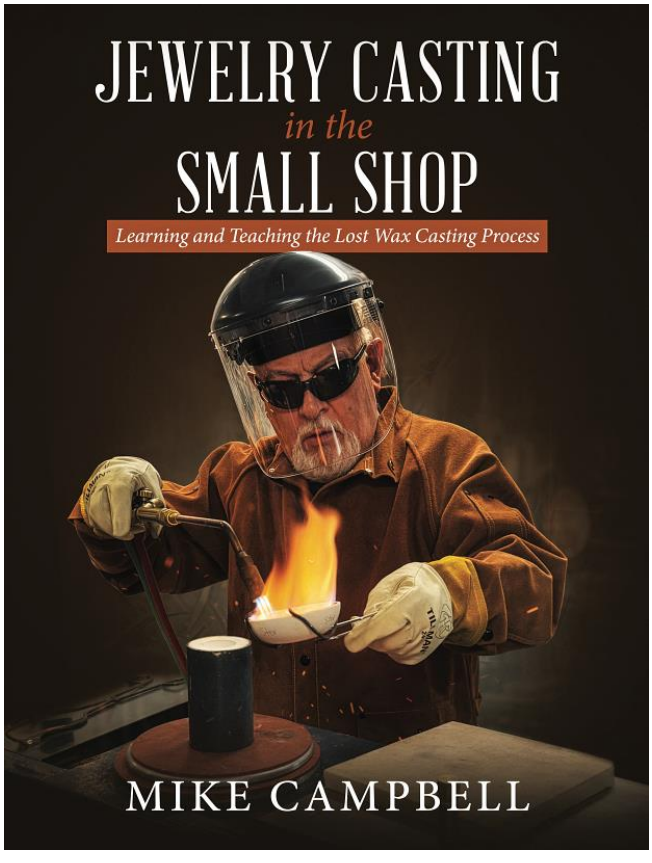
Things to be alert for:

- All joints are strengthened with sticky wax.
- Sprue tree is half an inch from the end of the flask.
- Sprue base is securely attached to the outside of the flask.
- No wax model is touching another or the side of the flask.

Chapter Summary

Sprueing is the process of attaching the models on a tree in preparation for casting. It is the first stage in the transition from wax (or other organic material) to metal. Models must be attached securely to the tree at the thickest part of the model and angling up from the base. Making the sprue tree as short as possible with all models angled up at a 20- to 30-degree angle from vertical enables the molten metal to reach the models before it resolidifies. Ring models with design work around the entire outside can be sprued from the inside to preserve the design. The sprue base and the flask must fit together snugly.

Green-blue parti sapphire in platinum
Photograph by Cheyenne Weil



Jewelry Casting in the Small Shop is a comprehensive resource for beginners who want to learn casting and for teachers who are looking for instructional materials to enhance their jewelry curriculum.

Jewelry Casting In The Small Shop:
Learning and Teaching the Lost Wax Casting Process
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