Lines of the Past: Rediscovering Renaissance Etching Techniques

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Figure 1Engraver and the Etcher Bosse

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Definition of Etching and Its History

Acid etching is a process of metal decoration through the removal of mass using a resist to create a pattern of design into the metal where it is exposed. Etching began to appear on armor, blades, and sword hilts in the mid-15th century, primarily around what is now Germany and Austria and from there it spread throughout Europe. These designs found on armor and weaponry eventually evolved into etching plates for printing. This became a new medium for reproducing art easily and inexpensively.

Intaglio etching and relief are the most common styles of etching used for armor and weaponry. Intaglio etching is the process of etching utilizing a stylus to carve a design into the resist, exposing the design into the metal for the acid to remove, leaving a deep recess to show the pattern. Etching in relief is removing all but the lines, like a stamp, to create recessed pockets which can be filled with paint or glass enamel. It was not uncommon for armor to have both etching and engraving on its surface. (Bannes, 1984)

Etching became popular because it was much less intensive to create than engraving. It did not require the practiced jeweler's skills or special tools required to create designs in the metal. If you could draw a design on paper, you could transfer it to the resist coated metal. Then inscribe the design into the resist. The acid did the work of carving the design into the metal and patterns could be used many times. It was common for etching designs to be shared with other artisans, and because etching was not controlled by a guild, it was accessible to anyone. (Jenkins, Orenstein, & Spira, 2019)

Some northern Italian swords from the second half of the fifteenth century feature a complex etched decoration. These were often gilded and combined with embossing and bluing to create an intricate decoration. (Kraus, 2011)

In order to create a pattern or design to be etched into metal, it had to be treated with a ground or resist. During the 1500s ground was considered to be a compound of three components wax, oil varnish, or oil paint. These could be combined with additives like rosin and asphaltium to make the ground stronger. This resist protected the metal from the acid. The design was drawn over the ground and then portions of it removed by scratching with a needle to expose the metal underneath or painted into a pattern by brush. The portions of the design covered by the ground or resist, would protect the metal in these areas. The removed areas would be bitten by the acid creating the image or pattern. Oil paint could be brushed on in detail as it is placed onto the metal with more control than wax or varnish but requires more time to dry. Wax would be melted and brushed or rolled on with a brayer as it quickly cooled to a hard resist but was sensitive to warm temperatures. Oil Varnish was also applied with a brush and then heated until smoke rose

from the varnish. After the varnish cooled it became a hard coating over the metal. It was not temperature sensitive but could not be controlled as easily as the oil paint. Once the ground is cured, the design would be scratched away with a sharpened tool.

Etching artists would often share patterns for designs among their community. This was not only allowed but encouraged since there were no etching guilds at this time. Daniel Hopfer, one of the earliest attributed armor etchers, created a series of etching prints drawn on paper in order to share with other artists and craftsmen to use in their own works. These could be traced onto a transfer paper in reverse and these were put onto the metal as a mirrored image and then scratched in either Intaglio or Relief. Hopfer and his contemporaries drew an ornamentation style that frequently contained florals, dolphins, and various hybrid creatures. Often the etchings of armor were spread out over the body in sections. The chest and back being broad and less concave provided excellent real estate for beautiful imagery. The lines of the arms, legs and edges of armor were often etched with inscriptions and decorative motifs. By the 1460s, blades in Italy, Germany and Spain were often etched with inscriptions and many hilts began to be etched with designs bearing coat of arms, religious figures, symmetrical patterns, leafy vines, flowers, or simple diagonal lines. (Jenkins, Orenstein, & Spira, 2019)

Acid for etching was often called Mordant in the 15th century. It consisted of Nitric acid made from saltpeter, or Hydrochloric acid, or a solution of copper and salt dissolved in strong vinegar. There are many different biting acids used for different metals like brass or copper. For the purpose of armor and swords these three mordants were the most frequently used sources of corrosion for iron. Some recipes were quite exotic in their makeup. Thet required ingredients such as urine from a goat or prepubescent child.

Some examples of acid recipes from the 15th century are thus:

“Take 2 parts of verdigris and one part of common salt and grind both in a mortar and add strong vinegar.” (Smith, 1968)

Or “Take two parts vitriol, and one-third part of Sal ammoniac and grind both on a stone slab with urine. This mixture must be used cold, and the work must be kept in a cellar for four or five hours.” (Smith, 1968)

Mordants were sometimes formed into a paste with charcoal, Sal ammoniac, and vinegar. It was then coated onto the surface of the metal that was painted with a resist such as red lead pigment and linseed oil. Depending on the strength of the acid, the metal would be exposed to the mordant for a few minutes to several hours. Stronger acids required less time, but they required a stronger resist. The longer the time the surface was exposed to the acid, the deeper the etch would become. Great care was needed to balance the time and

acidity of the mordant to get consistent etchings and sharp lines with minimal degradation of patterns. (Smith, 1968)

Hypothesis

The experiment planned is to use three distinct types of resists with the same acid solution of copper sulfate and salt in water to create a design to compare and contrast the results at three different lengths of time in the acid bath. The first type of resist is an Oil based paint comprised of a natural pigment (yellow ochre) with linseed oil. The second type of resist is a wax resin hard ball ground. I made this ball ground resist from scratch[1]. The third type of resist is a stand oil.

My hypothesis is that the oil paint resist would be the most effective providing cleanest lines and overall endurance. The hard ball ground would provide median results, and the stand oil would prove to be the most ineffective resist to the acid both in clearness of lines and overall endurance.

Materials

In addition to some of the resist materials, I also crafted the scribing tools used to remove the resist and expose the pattern to the acid[2].

In the 15th century wax was commonly used as a ground for etching and could be mixed with different chemicals. Other grounds included oil pigments, hard grounds, and soft grounds like stand oil. Each type of ground has their own strengths and weaknesses. Oil pigments are versatile and can be applied on with a brush, allowing it to reach small crevasses and hard to reach areas. Hard grounds only need to be heated to be applied and do well to coat flat surfaces. Stand oil can withstand higher acid content. It is for these reasons, as well their availability, that I chose to use these resists in my experiment.

- Resist A: Oil Paint Linseed oil and pigment. Traditionally a lead pigment such as lead white (2PbCO3*Pb(OH)2) or massicot (YellowPbO) would have been used. (Jenkins, Orenstein, & Spira, 2019). I chose to use oil paint that is a premade version of an equivalent recipe. I used Ochre, which is a pigment that would have been available during the 15th century, rather than lead white due to the toxic nature of lead. (Thompson, 1956).

[1] See Appendix A
[2] See Appendix B

- Resist B: Hard Ball. I made my own Hard ball Ground from wax, asphaltium, and pine rosin. (Untracht, 1975) For more information on the process used to create this ground see appendix A.

- Resist C: Boiled Linseed Oil (Stand Oil Varnish). Linseed oil that is heated to 300 C. for 30 minutes up to 2 hrs. Once cooled it becomes thick and tacky. This must be done in a vacuum to keep the oil from combustion and avoid harmful gases. (Jenkins, Orenstein, & Spira, 2019). I chose to purchase stand oil which is readily available at most art stores for use in oil painting. I did not have the ability to create my own, as making a vacuum, which is necessary to negate the toxic fumes released during the process, is exceedingly difficult and 300 degrees Celsius is a difficult temperature to maintain for the necessary time.

The Acid bath I used is a one-to-one ratio of Copper Sulfate and Salt in water. This chemical compound is a safe water table method that I find to be the best way to acid etch. While other acids may be faster, they can be dangerous to use. Nitric acids and Hydrochloric acids can create toxic fumes and damage the skin. They also must be disposed of extremely carefully to prevent pollution. To my reasoning, the speed of etching is not worth the risk of hurting myself or damaging the environment. (Non-Toxic Etching, n.d.)

Experiment

Step 1 Application

Resist A. The oil paint was applied with a brush in a thin layer. It applied well, and after using a softer brush it applied much smoother producing less brush strokes.



Resist B. The ball ground was heated and then rolled with a brayer. It was much more difficult to finesse into the hard-to-reach places and was difficult to work with while hot. The brayer is designed to work on flat plates. It would have been easier to apply with a brush or melting the compound or applying directly to the warm metal.




Resist C. The stand oil was applied with a brush, in a thin layer. This resist was the simplest to apply and coated like honey. It did drip quite a lot while applying and its clear nature made it difficult to ensure that it was applied with even coverage.



All of these new processes require patience and practice to become adept at using these resists.

Step 2 Curing

All of the pieces were placed on a custom-made stand and placed in a warm dry place to cure.

- Day 7:
    - Resist A: was not cured and the pigment would remove when touched.
    - Resist B: Was ready almost immediately after application.
    - Resist C: Was still tacky and dripping and needed more days to cure.
- 14 days:
    - Resist A: Had some extra time to cure. It was no longer tacky to the touch and pigment was not coming off when touched.
    - Resist B: No change as it was ready almost immediately after application.
    - Resist C: Was a little tackey to the touch and no longer dripping.
- 21 days:
    - Resist A was fully dry and cured.
    - Resist B was fully dry.
    - Resist C was still slightly tacky, that is likely expected due to the nature of the substance. It did not move or transfer when touched.

Step 3 Application of design on the resist

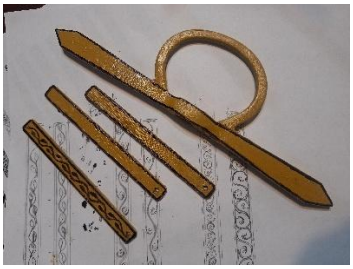
Figure 2 Daniel Hopfer armor samples 1, 2, 3

Early armorers like Daniel Hopfer created templates and patterns that contained motifs with foliage, mythical creatures, religious imagery, and stories of heroes on paper which were shared among the etching community. This helped to create a standard for etching and encouraged other craftsmen to attempt this art. These designs are not always symmetrical but can be modified to follow the shape of the piece it is etched upon. Often these designs were drawn on paper in reverse, traced onto a transfer paper, and then retraced onto the resist on the metal to be etched. This was not always done this way; however, craftsmen could draw freehand directly on the resist. This allowed for embellishment and creative expression. (Jenkins, Orenstein, & Spira, 2019)

The patterns I used for this experiment were ones I created myself in the style of those found on Italian armor during the 16th century. They are comprised of foliage, sweeping lines, and repeating patterns.

I attempted to use the Rembrandt pencils as this was closer to the implement used in the 16th century. They would not adhere to the metal, or the resist. Instead, I used a fine point marking pen. This worked satisfactory enough to get a decent design on all the Resists.

Resist A: I was able to clearly draw and see the pattern over the pigmented surface, and it accepted the ink well with little smudging of the pattern.



Resist B: Was more of a challenge as there was little contrast between the ink and the resist. It accepted the ink well with no smudging of the pattern. The resist soaked up the ink very quickly and I went through several pens.

Resist C: Needed two passes to ensure the ink was visible enough to see the pattern. This may have been because the ink was getting low in the pen.

Step 4 Exposing the pattern by removing the resist

TA sgraffito method was used to remove the resist revealing the metal which will expose it to the acid to create the pattern. This technique uses a tool to scratch through the layers of ground revealing the material underneath. This was one of the common methods used during the Renaissance. (Jenkins, Orenstein, & Spira, 2019)

For this step it was important to use the correct tools to ensure that the pattern was able to be exposed accurately and with the correct level of detail. After researching several sources and styles of tools used both for armor and print plate etching in the 15th and 16th centuries, I created a set of tools for this purpose[3].

Scraping the design to expose the metal was an exercise in patience. It took significant time to painstakingly scratch the design, into all the pieces.

Resist A scratched smoothly with some chipping from the surface using small movements. I had to be careful not to scratch too much away from the resist at a time. If I tried to remove too much at once, it would chip additional pieces I did not want. The style of pattern etching used was relief. This operates using negative space to show the pattern leaving the designed raised after the etch.

[3] See appendix B.




Resist B scratched off smoothly and did not chip off like the oil paint. Small movements were still required in order to control the detail of the resist removal. I used a lamp to see the contrast between the dark brown of the resist and the black ink. The style of pattern etching used was relief. This operates using negative space to show the pattern leaving the designed raised after the etch.




Resist C was the most challenging. The resist dried extremely clear and was difficult to see, so I decided to only scratch the lines themselves in the style of intaglio. This proved to be a good decision, as I could clearly see where the design had been scratched away to reveal the metal and provided a way to show the two different ways of etching.




Step 5 Preparing the acid bath

The Acid bath I use is a one-to-one ratio of Copper Sulfate and Salt in water. This is a water table safe method that I find to be the best way to acid etch due to the fact that it is less toxic both to the environment and myself. It reduces the speed of the process, but the speed of etching is not worth the risk of hurting myself or damaging the environment.

I use half a cup of copper sulfate, a half cup of Kosher Salt, and 2 to 2.5 gallons of water. The temperature of the water does change the efficiency of the acid. Warm water works better than cold. Warm water can also damage your resist. If your resist or ground is temperature sensitive, wax based or can melt in any way, it is much safer to use cold water.

Before getting started, always remember to wear eye protection. Rubber gloves are encouraged, but this acid is moderately easy on skin as long as hands are washed well with soap immediately after contact with the acid.

I like to collect all my tools and pieces before beginning to etch. I use a pair of plastic-coated tongs, a soft 1-inch paintbrush, a small brush to get into tight areas, eye protection glasses, disposable rubber gloves, liquid dish soap, olive or mineral oil, and a toothbrush for the final acid stop.

Always add your ingredients before adding water. It lessens the chance of accidental splashing occurring. Make certain to etch in a well-ventilated area and always clean up your workspace between each interval. Acid can eat many different substances and not maintaining your workspace can necessitate replacement of tools and surfaces if not cared for properly.

In a nonmetal nonporous container that will only ever be used for acid etching, add the copper sulfate and kosher salt and allow the ingredients to mix. I like to start the process with warm water to help the crystalized particles to dissolve into the water. The liquid will become a very pretty teal color when the ingredients are fully emulsified. Add the metal to be etched to the acid and arrange to have all of the pieces to have their own space and not come into contact with each other. Try to maintain the temperature of the acid so that the rate of decay does not fluctuate. Room temperature works very well for etching metal.

Step 6 Putting the Metal in the Acid

I often will string pieces on wire or place a rock in the center of the bath for pieces to lean up against to keep them from falling to a horizontal placement or stacking on top of each other. Each piece must have as much exposure as possible to the acid.

I put one of each design for A, B, and C on a piece of wire twisted between each bar to keep them from sliding together in the vat of acid. I made three of these so that I could pull them out of the acid at each of the two-hour periods to remove the residue and allow the process to continue efficiently. The three sword hilts were placed at the bottom of the acid bath so they could stand up vertically. I placed the string of bars at each end of the acid bath and one in the center so that they were completely covered by the acid.

Once all of the pieces were submerged into the acid I left it alone for intervals of two hours. At two hours, I removed all the pieces and began to brush off the residue of the acid affecting the metal. It will look like rust colored muck. The first set, I brushed a little too hard on the hilt for resist A. Due to the resist being damaged, I had to remove it from the vat. I was much more careful with the remaining hilts and pieces to brush with more care with

the cleaning of the residue. I placed two of the strings of bars back into the acid at each end and the remaining two hilts into the vat, for another two hours.

The removed pieces were coated liberally with dish soap and brushed vigorously with a toothbrush being very careful to get into the fissures and hard to reach areas. Much of the resist will be removed at this point but you may also need to use a terpenoid to remove the remaining resist or heat up the piece to remove resists like hard ball ground. The chemical nature of the dish soap causes the acid to neutralize, which stops the etching process.

Much of the resist came off during the cleaning. This revealed the beautiful patterns etched into the metal. At two hours, it was not a deep etch, but you could clearly see the difference in all three pieces. A, B, and C all worked well, as resists for the two-hour period. The design is clearly seen and remained intact for all three pieces. The hilt had to be removed because of the resist failing from brushing too hard to remove the sludge created by the acid. The design is clearly visible if not as deep as I would have preferred.

After a total of four hours, I removed all of the pieces from the acid bath and began to clean the residue off only using water from the sink. I did not attempt to brush off the residue with a brush, and I used low pressure from the faucet. I decided at this point to remove the hilt for resist B to show what a four hour etch would look like since we had removed the hilt for resist A at two hours. Then, I replaced the remaining string of bars and hilt C into the vat of acid for another two hours.

Once again with the pieces removed from the acid at four hours, with a toothbrush, I removed any residual acid from the pieces with dish soap to stop the etching process. All three pieces survived again with some slight degradation from resist B.

Two hours later, at the six-hour mark, I removed the final pieces from the acid bath. I scrubbed all of these pieces with dish soap to remove any of the acid and much of the resist came off again with a simple scrubbing with a toothbrush.





Resist A held up remarkably well throughout all six hours of the acid bath. Resist B held up well to four hours of the acid bath and then began to degrade just a bit. Resist C remained intact after six hours with no degradation. Most of the resist did rub off during the cleaning, however, after six hours.

Step 7 Finishing the pieces

At this point the edges can be cleaned up or detailed with a Dremel or file. I usually give the pieces a good once over with some 100 or 200 grit sandpaper and coat each piece with some mineral or olive oil. The sandpaper smooths the overall appearance, and the oil will protect the metal from corrosion and give a natural shine. A blackening solution can also be used to further add contrast to the pattern.

All three resists performed well in the acid bath and created beautiful designs in the metal. I was happy with the results of each of the resists. A, B, and C survived the acid with good results, although each of them had their own pros and cons.

Findings

Resist A applied smoothly, but it took a long time to cure and be ready for the design. Inking the pattern to the resist was clearly visible and had minimal smudging of the ink. The design scratched smoothly, and allowed for great detail, but I had to be careful not to remove too much material at once or it caused flaking. Once the metal was placed into the acid, I had to be very careful not to remove the resist while removing the residue. This resist maintained clean lines and held up well to the acid and survived all six hours with no degradation other than my own error with the hilt.

Resist B was a challenge to apply as it had to be done while the metal was relatively hot. It would be much easier to apply if the surfaces were flat. It was the fastest to cure and was ready as soon as it cooled down. The design was difficult to see as there was very little contrast between the ink and the resist. Scratching the design into the resist was not difficult as it did not tend to chip like resist A. Creating fine lines close together was possible because the resist cut cleanly using a sharp tool. The resist stood up to the acid a little better than resist A initially but after four hours, it began to show wear and. At six hours the pattern showed further signs of wear.

Resist C was the simplest to apply, but took the longest to cure. It was the most difficult to add the design to as it required a lot of ink and the most difficult to scratch into the metal due to its clear nature. The decision to scratch the design in Intaglio made it much easier to see the pattern rather than doing relief. Resist C withstood the acid better than the others and was able to stay in the acid longer without any degradation. The only downside to resist C is that its finish was transparent. This made it difficult to see the thickness of certain areas where it may have been applied a little thin during application. After some experimentation, I noticed that if you held the cured piece over a candle, the finish turns a golden honey color and the texture became harder. Next time I use this as a resist I will employ this method.

Conclusion and next steps

Experiments A, B, and C survived the six hours of etching. The design patterns are defined and clearly discernable. My hypothesis that Resist A would provide the best overall functionality and ease of use was found to be inconsistent with the results. I found that Resist C was the most versatile and consistent resist of the three experiments.

Resist A was the simplest to apply but needed two weeks to cure. It was satisfactory in drawing and scribing the pattern with a small amount of flaking but proved to be fragile in the acid. Special care to keep the resist from washing away had to be considered.

Resist B was the most difficult to apply but needed only a few minutes to cure. The necessity of heat made application cumbersome and spotty. The rounded shapes and hard to reach areas were a problem for the brayer. Drawing and scribing was a challenge as the dark color of the Hard ball ground left little contrast to the ink used. I would have liked to have used white or silver ink to give better contrast for the drawing, and will likely do that when using in the future. Resist B did not flake like the oil paint and stood up to the acid as well as Resist A but did start to degrade after four hours.

Resist C was fairly simple to apply but dripped constantly and was difficult to make certain all areas were evenly covered. It took over three weeks to cure. The transparent nature of the stand oil made it difficult to see the removal of the resist and required a different style of etching to make it viable for the experiment. I decided to etch this resist in Intaglio so that only the lines were scribed away. Resist C worked better in the acid bath due to its thicker coating and better adhesion to the metal. It did not flake, fade, or degrade in the acid. Overall, Resist C performed better than resists A and B in the acid bath and provided the best etch. It took the longest to cure and would have been difficult to scribe with the relief method but worked extremely well for intaglio.

The next time I try these three resists for etching purposes, I will play to each of their strengths. I plan to etch some flat steel and brass plates in the future; I will use the Hard ball ground for this as it gives a nice even coat on flat surfaces and is ready to use almost immediately. I will be making a dagger hilt this spring and will use oil paint for this as it can get into the tight areas where the metal bends and joins together. I will use the stand oil for etching blades where transparency will be an excellent advantage to be able to see the placement of the etching on the blade. I will further experiment with holding a flame under the stand oil to give it a golden hue that will be easier to see as it is scribed.

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Appendix A Making Hard Ball Ground

Hard ball Ground was the most commonly used resist for etching during the 15th century and is still used today with nearly the same formula. Cellini's treatise contains a formula that is one of the earliest recorded for the use of etching. The ingredients for hard ball ground are asphaltium, wax and rosin. It was a simple formula with easily accessible ingredients that creates a durable etching resist for metal. I used this formula as a basis for creating my own hard Ball ground. (Jenkins, Orenstein, & Spira, 2019) (Cellini) (Untracht, 1975)

My experiment for making hard ground for etching was a success, and I learned a lot of interesting things while doing it.

1. Weight versus volume is very different. The amount of substance can be highly different depending on the weight of the actual ingredient.
2. Cheesecloths come in layers, count carefully!

The original formula by Cellini calls for 2 parts Beeswax, 2 parts asphaltium, and 1 part pine rosin, by weight. I used 30 grams of beeswax, 30 grams of asphaltium, and 15 grams of finely ground to a powder, pine rosin.

This made slightly more than 3 gumball sized hard ground balls.

Using a double boiler, I melted the wax until it was fully dissolved.

Mixing continuously, I added in the asphaltium a little bit at a time, making sure it was thoroughly combined before adding more. It is important to fully melt the wax before adding the asphaltium to ensure a smooth mixture. Be careful full to fully incorporate the mixture before adding more.



Once these two ingredients were combined, I added the pine rosin in one go. As soon as this was added, it begins to take on a tar-like consistency.


I Ladled and pressed the mixture through 2 layers of cheesecloth with a spoon, into icy water to remove any unincorporated pieces and cool the mixture to allow it to be handled and shaped. As a note, ice water made it hard too quickly.


As it cooled, I rolled it quickly with firm pressure between my hands to form it into a ball. If the pine rosin was ground fine enough, using cheesecloth may not have been necessary. To clean up excess material, I used turpentine to de-amalgamate.

Appendix B Handmade Sgraffito Tools

This picture contains many of the different tools for etching and engraving used during the 15th and 16th centuries. Specifically, the scribing needles silver points and etching needles (shown as numbers 14-17). These were used to open the lines in the ground to create the pattern to be etched. The needles vary in thickness and shape and were sharply pointed. Sometimes for a broader needle the tip was sharpened in an oval, or flat like a chisel. This allowed for variations in width of the lines by holding the point at varying angles. (Hind, 1963)

Figure 3Engraving and Etching tools (Hind, 1963)

These Scraping tools were often made of iron or copper pieces inserted into a small penlike handle made of wood or simply left as a rod of metal as in a silverpoint. If no handle was attached they were often twisted or shaped to be easier to grasp. It was held between the index finger and the thumb as you would a pencil. The point must be smooth so it can move around the piece without catching, and not so sharp as to cut into the metal to be etched. Often the tools would have a chuck that could have multiple points to be interchangeable and able to be resharpened. (Leaf, 1976)

Creating the designs on metal for my etching pieces required some specific tools for removing materials to expose the pattern. To reveal the design, I needed to peel back the resist using tools similar to chisels and scribing needles. I had purchased some dental tools, but they were too small and fine for the purposes I had in mind for this project, so I decided to make my own tools.

I knew I would need a small flat scraping tool to work the wider areas of space that needed to be removed, a rounded oval tool to handle varying sizes of cuts and be able to follow curved sweeping lines, and a fine pointed tool to make fine lines.

I began with a small half inch dowel and cut it into 3 pieces and drilled a 1/4-inch hole in the center of the end of the dowels. I cut sections of metal round stock and glued them into the holes and shaped the ends into a flat, oval, and fine point using my belt sander. Once I had the shapes I wanted, I decided to make the wood a more ergonomic shape to hold. I shaped each tool on the belt sander and rounded the end. When I was happy with the shape, I coated the wood with olive oil to seal the wood and make it more comfortable to hold.

As I began to use these new tools, I realized that I needed to have an even finer point and a smaller pen-like shape to hold for making cleaner lines in the materials. For this I used some ¼ inch dowel and drilled a hole in the center of the end of the dowel. I glued some metal 1/8 round stock and sharpened the ends. I made one about an inch long, and the other short like a pen. I rounded both ends of the dowel and these worked excellently for getting into the intricate details of the project.

These were not difficult to make and were more efficient and effective than the dental tools I had purchased. They did not become dull like the dental tools did. The larger diameter of

the metal I used allowed my tools to retain their points and edges with less need to sharpen them requiring only once to refine one of the edges of the flat tool and the longer of the smaller point tools.

Appendix C Extant examples

This is an example of etching from Daniel Hopfer who was a noted printmaker and armorer. This curias was made in Germany around 1510 to 1520 (Cuirass and Tassets , n.d.)

This German Jousting Sallet is etched with conjoined Initials L&M for King Louis II of Hungary and his wife Maria of Austria. Likely made around 1525. (Jousting Sallet (Rennhut) Made for Louis II (1506–1526), King of Hungary and Bohemia, n.d.)

This Italian armor is decorated with etched and gilt decoration depicts the Virgin and Child in its center with ST Paul and St George created in Milan Italy,1510. (Elements of an Italian Light-Cavalry Armor, n.d.)

This is an etched rapier from the Dresden Museum from 1575. It is part of the Electors of Saxony collection. The hilt is covered in etched silver plates affixed by silver rivets. The blade is also etched to halfway down the blade toward the tip. (Rapier, n.d.)

This Italian Rapier hilt is deeply etched and the Blade is etched across the entirety of the blade with a calendar with names and dates. (Sword with Calendar blade, n.d.)

This is an Italian shield from around 1585-90. It is etched and gilt with Romanesque women and winding scrollwork. Created in Italy. (Shield, n.d.)

This Gorget possibly belonged to the King of Spain, Phillip II. Etched and gilt with lines of scrollwork and flowers with the lines following the shape of the gorget. German design 1550 (Gorget possibly from an Armor of Philip II, King of Spain, n.d.)