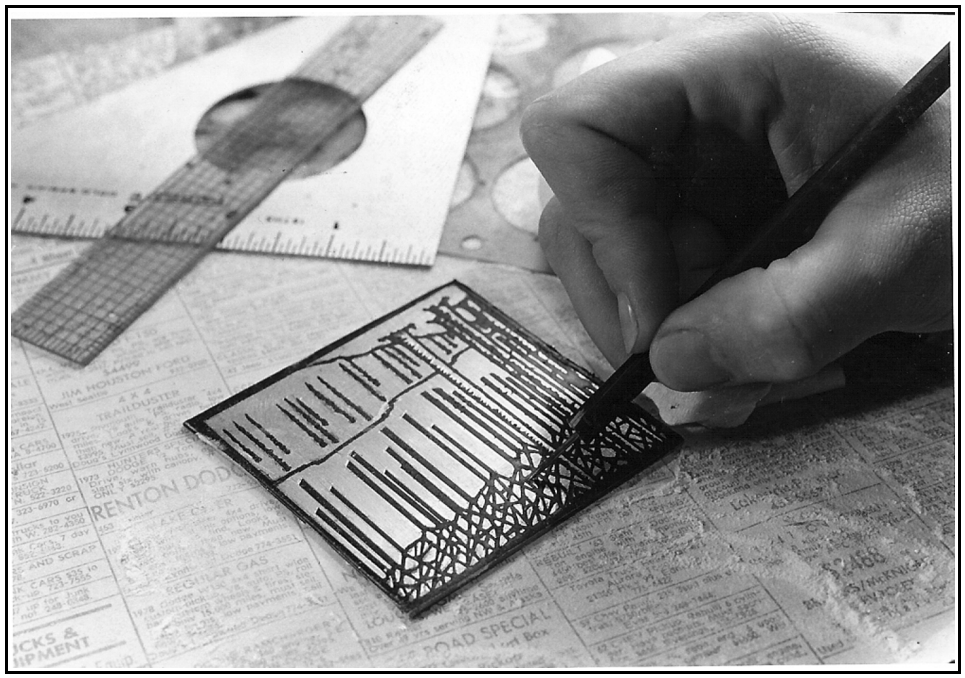
# Relief Etching for Jewelers and Enamelists

by

Coral Shaffer



Cover photo: Relief etched piece for champlevé enameling. Courtesty of J. Patrick & Judith Lull Strosahl and Coral Shaffer from A Manual of Cloisonné & Champlevé Enameling.

Title page photo: Touching up asphaltum resist. Courtesty of J. Patrick & Judith Lull Strosahl and Coral Shaffer from A Manual of Cloisonné & Champlevé Enameling.

I am grateful for the generous technical assistance from the folks at King County Hazardous waste and those from the University of Washington's Field Research and Consultation Group.

My thanks to A.J. Strosahl for lending her proof reading skills.

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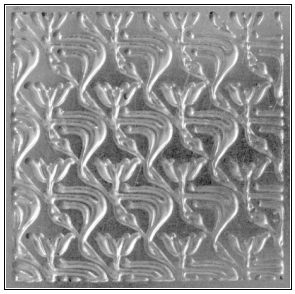
# RELIEF ETCHING FOR JEWELERS AND ENAMELISTS

Relief Etching

## INTRODUCTION

My intention in writing this book was to share with you the results I have gathered from years of experimenting with relief etching. I have tested all the formulas that are presented here. And the chemists of the University of Washington's Field Research & Consultation Group have reviewed the health and safety precautions for us.

"Relief" etching differs from "intaglio" etching. The design lines remain **raised** in relief etching and the background etches away. Whereas in the "Intaglio" technique used by printermakers the design lines are **etched away**. Metalsmiths and enamelists might use either the intaglio approach or the relief approach. There are many books written about intaglio etching. *Please see the "Sources of Information" section, pp. 51-52* and listings in your public library if you are interested in this type of etching. Jewelers can use the relief techniques covered here for making recessed areas to inlay another material such as enamel,resin, wood, or stone; to make piercing easier; to add an over all texture to the metal or to make master models for casting. Enamelists often use the relief technique as the first step in making a piece of Champlevé or Basse Taille enamel. In these pages you will find relief etching information for copper, tombac (sometimes called gilding metal or copper alloy #210 which is 95% copper and 5% zinc), fine silver, sterling silver and brass. Gold is seldom etched and will not be covered here.

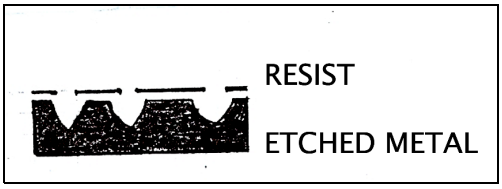


Intaglio Etching

These are the factors we should consider when evaluating etching systems: safety, cost, ease and effectiveness of process, and waste disposal. We would all like an etching system that was fast, cheap, easy, safe and gives perfect results every time. I'm sorry to tell you that I am not aware of any system that fulfills all these criteria. Often the faster the etch, the rougher the result and the more dangerous the process. However I suggest ways to safely speed up the etching process. I am dedicated to using the least toxic materials that I can find that will be effective. Therefore not every etching product will be reviewed. Many options for resists, etchants and bath processes are outlined – just skim through them and chose the ones most appropriate for you. Sources for the the materials discussed, but not commonly found, are listed in the *"Supplies & Suppliers" section pp. 45-47.*

# CHAPTER 1 PREPARATION

## Design Considerations




Etchants, the solutions used for etching, will etch sideways into your design lines as well as down into the metal. A spray bath or an electro-etching bath will minimize this undercutting. But to avoid losing your lines you need to make them somewhat wider than the width you wish to have after etching. The width required will depend on the depth of your etch. Your lines should be at least as wide as the etch will be deep. For example if you want your etch to be 1/64 inch deep, make your lines at least 1/64 inch wide. You may wish to draw a border around the outside of your design area to form a ready-made bezel. Champlevé pieces need this border to corral the enamel that will be added later. The first task is to draw a design by hand or with a computer. If your line width is at least 1/32" you will be less likely to lose lines during a deep etch.

## Preparing the Metal

The resist will bond better to a surface that is free of tarnish, dirt and grease. Oxidation (tarnish and firescale) can be removed with a pickle such as sodium bisulfate (e.g. Sparex™), a combination of vinegar and table salt or a solution of citric acid. *Recipes for these are in the "Recipes" section p. 41-42.* These last two milder pickles work better when heated in a commercial pickle pot, crock-pot or Pyrex container on a burner turned to low. Sodium bisulfate can also be heated but it is not necessary. Penny Brite™ is available from some super markets, hardware stores and enamel suppliers and is a safe, easy to use paste that removes both tarnish and grease. Putz pomade™, available from printmaking supply sources, will work in a similar fashion. Another option is to pre-etch the metal for a short time to remove any oxidation. Dirt and grease can be removed with dish soap. Scouring with an abrasive such as pumice, wet or dry sand paper or Scotch Brite™ will remove dirt, grease and oxidation at the same time. Any of these abrasive materials will also leave fine scratches that will aid with the adhesion of the resist. You will know when your metal is clean if the rinse water sheets across the surface and does not ball up (the water break test). Clean both sides and the edges of your piece of metal. Make sure the metal is rinsed and dried well after cleaning. Then try to keep the oil from your fingers off the piece.

*Personal favorites: I like to clean the metal with Penny Brite because it is non-toxic, fast-working and removes both tarnish and grease. It also has a gentle abrasive in the compound to give the metal a little "tooth". Penny Brite does not remove firescale. That must be filed off or removed with a pickle if you have annealed your metal.*

## Health and Safety

Regardless of the resist, the etchant and the resist remover you choose, use good sense. Even if the products you use do not permanently harm you they may have short-term health effects and/or stain your clothes and skin. Wear gloves when dealing with etchants. Latex gloves are the most protective – they hold up best when wet and guard against many chemicals. If you are allergic to latex try Nitrile gloves that are nearly as tough and are less likely to cause irritation. Wear goggles, especially if you do not wear glasses, to keep any etchant splashes out of your eyes. Wear an apron to protect your clothes. If you have an exhaust system, use it. Otherwise make sure you are getting fresh air – open a door or a window. Opening two will give you even better air circulation. If you can, place a fan in one of the windows to improve ventilation. Don't etch in small, enclosed spaces like closets. If you use anything with chlorine in it – hydrochloric acid, ferric chloride, salt (sodium chloride) – and you heat it, or add electricity to it, there is a potential for chlorine gas to be emitted. If you use nitrate solutions – nitric acid, ferric nitrate, silver nitrite - for electro-etching there is a potential for nitrogen oxides to be emitted. Pay attention to ventilation and keep the voltage at or below 1.5V. If you smell chlorine or nitric oxide, stop etching and make adjustments. If any etchant spills, clean up small spills with a paper towel but dump kitty litter on larger spills to contain them. Dispose of the litter as you would the etchant. Keep the etchants from contaminating the earth by taking them to a hazardous waste facility when you are ready to dispose of them. You may find different "recipes" on the Internet for treating the etchants and their sludge to make them non-toxic. The King County Hazardous Waste engineers helped me evaluate these recipes and found that it would always be best to ask permission from your local authorities. Chances are, even after the etchants and sludge have been neutralized and treated they still won't be safe to put down a drain or into the landfill. In addition, treating the waste may be dangerous for you. Many cities have Household Hazardous Waste facilities that are free for small amounts of toxic materials. If not, there are companies that will take them for a fee. *To see the relative hazard levels of the different chemicals used in etching please see the "Health & Safety" section pp. 48-49.* When you have chosen the substances that you will be using, look up each MSDS (material safety data sheet) on the Internet. There you can find specific cautions and control measures.

# CHAPTER 2 RESISTS

## Types of Resists

The resist is the material that protects selected areas of the metal from the etchant and keeps those areas from etching. When choosing a resist for relief etching we need one that will allow us to transfer our design; that will adhere well to the metal; that will hold up in the etching solution; and that will be easy to remove without damaging the metal, the environment or us. There is a wide range of possibilities here and your choice will depend upon what you want to accomplish. Do you have a very detailed design? Do you need to repeat it or is it a one-off? How deep do you need to etch? How much time do you have to make the piece? How much can you afford to spend on supplies? We do not need to be this particular for resists for the backs and edges of pieces. Some possibilities for the design-side resist are art pens, paints, sticky-back materials, screen-printed resists, copy & laser printer toners, and resist films. Edge and back-resist options include tapes, spray paint and brand name liquid resists. Please see the specifics and directions that follow. Regardless of the resist you choose you will need to clean your metal first. *See the preceding chapter.*


*"Inks"*: Pilot™ gold markers, Sharpies™, Painters™, Deco™ Color Pens, and Staedtler™ red permanent pens will all protect design lines for a short etch period in a mild etching solution such as Ferric Chloride. I have found that industrial Sharpies last a little longer than the ones from office supply stores. Of all these inks, the paint markers are the longest lasting in the etching bath. DecoColor extra fine black opaque paint markers work well without drying out.


*Stamping resists*: Rubber, foam and polymer stamps used with embossing pads and embossing powder will make a resist suitable for mild etches.

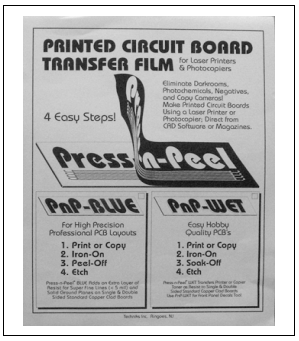

*Sticky-back materials*: Self stick materials such as graphing tape; hole reinforcements; Contac™ paper; and vinyl letters, dots and labels are available from office supply and art supply stores. These sticky back materials are quick and easy to apply but there is danger that the mordant will seep under them in longer etches. Some leave a residue on the metal. There are some specialized sticky-back materials such as anodizers' tape, plater's tape, 3-M Polyester tape #854 and EtchAll Mask™

that can be applied to the metal and cut away in the areas that you would like to be etched. *See the "Supplies and Suppliers" section pp. 45-47 for sources*.

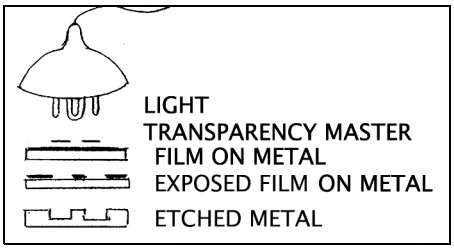

*Paint*: Any acrylic or lacquer spray paint in conjunction with a stencil can be used as a design resist.


*Asphaltum*: This tar-like substance comes as a dry powder or as a liquid. Asphaltum has been used for many years as the resist of choice and is a long lasting resist. The negative attributes of asphaltum are that it is incredibly messy, stinky and slow to dry. Asphaltum will have better holding power if you mix up some "asphaltum plus". *See the recipe p. 41.*

*Toner*: This is the toner used in copy machines and laser printers. The polymer in the toner melts when heated and acts as the resist. Ink jet printers use a different type of material that will not work as a resist. Artists have tried printing the toner onto a variety of temporary substrates including acetate (transparencies), photo paper, glossy magazine type paper and Lazertran™. With these substrates, the toner is transferred to metal and acts as the resist. However, I have not found toner alone to be an adequate resist for my purposes. *If you are interested in trying these methods please see the "Sources of Information" section pp. 51-52*. PnP™ (Press and Peel), and Pulsar Toner Transfer System™ are longer lasting toner resist systems made for printed circuit board hobbyists. These systems add another layer of resist on top of the toner. This top layer covers the pinholes in the toner and therefore makes a stronger resist. These toner transfer methods rely on a combination of heat and pressure to bond the resist to the metal. The toner acts as the adhesive, bonding the overcoat resist to the metal.




*Photosensitive Films*: Commercial etchers apply photosensitive film to both sides of a piece of metal with hot rollers that supply a combination of heat and pressure. They then use a vacuum frame to press the original against the film and expose the film with a high intensity ultraviolet light source. The technique for the studio is much less sophisticated and less costly. Dry and wet film emulsions are available in the marketplace but the dry films are easier to use and much less toxic. Puretch, Z-acryl and ImagOn are dry photosensitive films made for printmakers. UV light changes the solubility of the film, making it harder where the light hits. When the film is placed in the developer, those harder areas will remain while the rest is washed away. Because printmakers want to etch their drawn lines away and we don't, we need to make a negative of our original in order to use these resists. Micro-mark sells a Pro-Etch Photo-Etch System that includes the film and the etchant for copper but other options follow in this chapter. Films offer an exact replica of your design and stand up better to etchants than the resists previously listed. Pre-sensitized 16-gauge copper that has the emulsion already attached to the copper is also available in the marketplace. However the developer used with this is more toxic than that needed for the dry films and is considered hazardous for shipping purposes.




*Back/Edge Resist:* These are used to protect the metal on the edges and backs of your pieces where creating a pattern or design is not necessary. You could use the same resists that you have used for the design side of your piece but that is often overkill. Lacquer or acrylic based paint, electrical tape, stucco tape, plastic tape, Scotch brand "Extreme" strapping tape, Z-acryl Stop Out Resist™, Pledge™ floor finish, finger nail polish, liquid "rubber", and Lascaux Plate Backing Resist™ are all readably available and easy to use back and edge resists. The "sticky back" resists work well on strait sided pieces where they can be folded over from the back to cover the edges. They can also be used on the backs of round pieces but in these cases it is easier to use a liquid resist for the edges.

## Applying the Resist

### *Ink resists*

**1) Clean the metal**. *See Chapter 1.*

**2) Apply the design.**


Draw on the cleaned metal with marking pens as you would draw on a piece of paper. You can draw directly or transfer your design onto the metal with transfer paper. Check your lines under a good light to make sure that there aren't any pinholes in the ink coverage.

**3) Cover the back and edges with resist**. *See the "Back/edge resist" sections pp. 21-22.*

### *Stamping resist*

**1) Clean the metal**. *See Chapter 1.*


Wipe the clean metal with alcohol and dry it. Shake on some baby powder and then wipe it off. This helps remove atmospheric moisture from the metal.

**2) Stamp the metal.**

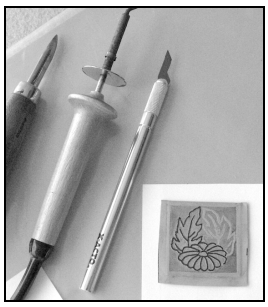
Press a rubber, foam or polymer stamp into an embossing pad and stamp the metal. You can have custom stamps of your own designs made for you. *See the "Supplies and Suppliers" section pp. 45-47.* Shake embossing powder over the stamped design. Tip off the excess embossing powder and brush off any stray grains of powder. Embossing liquid also comes in a pen body allowing you to draw your design onto the metal to sprinkle with the embossing powder without using a stamp.

**3) Melt the embossing powder.**

Heat the stamped design with a heat gun on high, on a griddle, on a tea warmer or in a toaster oven until it melts.

**4) Cover the back and edge with resist**. *See the "Back/edge resist" section pp. 21-22.*

### *Sticky-back materials*



1) **Clean the metal**. *See Chapter 1.*

**2) Shape the sticky-back material.**

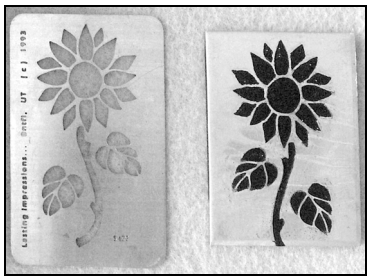
Use these materials "as is" or cut shapes out with scissors, an art knife or a stencil burner after attaching them to the metal.

**3) Affix the sticky-back material to the metal.**

Stick the sticky back material down on the metal and burnish it down with the back of a metal spoon or a steel burnisher for better adherence.

**4) Cover the edge and back with resist**. *See the "Back/edge resist" section pp. 21-22.*

*Spray paint (acrylic or lacquer)*



**1) Clean the metal**. *See Chapter 1.*

**2) Use a stencil.**

Buy a stencil or cut one out from acetate or Frisket™ paper. Attach the stencil to the metal with removable adhesive if it doesn't have a self -adhesive backing.

**3) Spray**.

Spray over the attached stencil design with the spray paint. Re-spray after the first coat dries to strengthen the resist. When the paint has dried, remove the stencil.

**4) Clean off the metal.**

Rub off any remaining adhesive on the metal with your finger.

**5) Cover the edge and back with resist**. *See the "Back/edge resist" section pp. 21-22.*

*Asphaltum for one-o-a-kind pieces*


**1) Clean the metal.** *See Chapter 1.*

**2) Transfer the design to the metal.**

Tape a piece of black transfer paper (e.g. Pro Art Transfer Paper # Pro-5270) to a piece of clean metal. Tape the design over this. Trace over the design to transfer it to the metal. Or draw free hand, directly on the metal, with a Sharpie™ marker or the like.

**3) Apply the asphaltum**.

Paint over the design lines with asphaltum and a fine point brush. Use straight asphaltum or mix up a batch of "asphaltum plus". *See the recipe on page 41.* Tip: Shake a little baby powder over the painted asphaltum to make it less sticky and shake some onto any paper or platform you are using under the piece.

**4) Touch up.**

When the asphaltum dries, you will probably need to clean up your lines with a scribe. Use a tool with a soft rounded point that will not scratch the metal but will scrape away unwanted asphaltum. A darning needle embedded in a wooden dowel or held in a

pin vice would serve the purpose. Repaint with the asphaltum if the lines are weak or you unintentionally scribed through them.

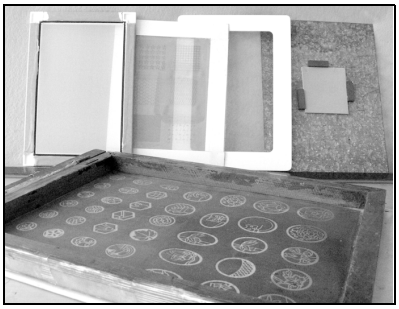
**5) Cover the edge and back with resist.** *See the "Back/edge resist" section pp. 21-22.*

### *Asphaltum for production pieces*

**1) Make a screen.**


There are many ways to make a "silk" screen. Other than the traditional way to make screens there are some newer screen materials that are faster and easier such as Riso™ screens, Dura-film™ screens, Stencilpro™ screens and Yudu™ screens. Riso screens are used with a Gocco machine. Unfortunately the original Gocco machine is no longer being manufactured. However they are often available on eBay or through other online sources. Also there are newer, more expensive models of the Gocco machine still available, as are the supplies for the original Gocco. The Yudu system is the most expensive but everything you need to make a screen is included in the kit. These products come with directions and you can see how they work and buy them on the Internet. Screens are not cost effective unless they are used 25 times or more.

**2) Make a frame for the screen.**



You will need to have a frame for the Riso, Stencilpro and Dura-film screens. You can purchase them or make your own from metal, plastic or wood strips.

**3) Make a base for the screen.**

When the screen has been framed attach it to a base. The base can be as simple as a clipboard or a piece of hard plastic or wood to clip the screen onto. Another alternative is to use a piece of steel sheet metal with magnets to hold the screen down.

**4) Screen a template.**

Lay a piece of clean white paper on the base and tape it in place. With a squeegee, pull a print through the screen with any screen printing ink and let it dry. This will give you the placement for your piece later on.

**5) Clean the metal.** *See Chapter 1.*

**6) Screen the asphaltum.**

Use asphaltum about the consistency of pudding to screen with. This should be thicker than the consistency used for hand painting. If you find it is too runny, put it outside and let it evaporate. *Try the "asphaltum plus" recipe p. 41.* Spread a mound of the asphaltum above your design and screen it on to a piece of newspaper to test the consistency. If it looks good, place your metal on the inked image on the paper on the base, lower the screen, and spread more asphaltum and print your metal. Screen-printing onto 3-D pieces is pretty much impossible although a simple cylinder would be worth a try. In this case leave the frame off of the screen and tape the flexible screen on to the cylinder. Screening and etching first on a flat piece of metal and then forming and/or fabricating the metal is the best way to get your etched design onto a 3D piece.

**7) Gently melt the asphaltum.**

After printing and drying the asphaltum, heat the screened metal lightly to help the asphaltum adhere and to flow into the spaces left by the threads of the screen and to speed up the drying process. You could use a toaster oven or a hair dryer or a 500 - 700º F. kiln. Be careful not to heat your piece too long or too hot or the lines will run.

**8) Cover the edge and back with resist.** *See the "Back/edge resist" section pp. 21-22.*

***PnP Blue – Household Iron Method***

**1) Create a design.**

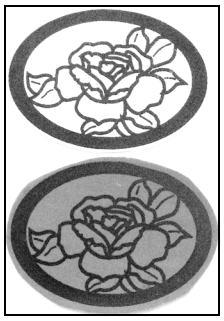
Draw a design or find a copyright-free design that is black and white only. The black areas will remain raised after etching; white areas will be etched away. You will need a positive, reverse image of your design. A "positive" simply means that the black lines of your drawing represent the raised metal lines in your etched piece. And because you will be flipping the printed PnP over during the transfer process, you will need a "reverse image" (a mirror image) of your design. A reverse image is not necessary if you do not care which way your image "faces" but is important for text. Cover the entire 8 ½" X 11" sheet with designs because it is not a good idea to send the same piece of PnP through the copier/printer more than once.

**2) Test the copies.**

When the designs are completed, experiment on regular paper with your photocopier or laser printer until you can make a dark, evenly colored impression without "graying" the white areas. If you are using a photocopier, put the original on the glass as you usually would. Make sure you know how the printer or copier handles the paper – does it go straight through or turn the paper over while printing?

**3) Clean the metal.** *See Chapter 1.*

**4) Transfer the design.**



Transfer your design to the PnP using an appropriate toner-based copy machine or laser printer. Note: the newer, very high-speed copiers are too hot and will melt the PnP. The machine you choose must also accept a thicker-than-usual paper. Usually the single sheet feed slot works best but sometimes the regular paper tray works fine. Wipe the dust off the PnP. Run the PnP Blue through the photocopier or laser printer so that the image registers on the dull side.

**5) Cut out the selected design from the sheet of PnP.**

Cut around the outside of the border of the design that you want to use. If you do not need to use all the designs now they can be saved indefinitely between clean sheets of paper after copying/printing. Just be careful not to scratch the toner.

**6) Transfer the resist to the metal**.

Set a household iron to "steam" (use no water) or whatever setting heats the iron to about 285˚F. The correct temperature depends on the toner. You may need a hotter temperature to transfer the design. Test the temperature of the iron with a thermometer. I find an oven thermometer works well. Heat does not transfer where there are steam holes. If there are any in your iron make a “bootie” out of copper tooling foil or aluminum foil to cover them. Make an "ironing pad" out of a folded towel covered with aluminum foil. Place the pad on a board or other flat surface that won't be hurt by the heat. Wipe the dust from the PnP image again. Place the cut out PnP Blue on top of the flat metal piece so that the toner image side touches the metal. Center the image. Tape the PnP in place with two small pieces of removable tape. Place this on the ironing pad so that the metal is on the top and the PnP touches the pad. Place the heated iron on top of the metal so that the solid bottom of the iron covers the entire piece. Set a timer for 3 minutes and rock the

iron back and forth while exerting a light pressure. Make sure you are reaching all the parts of the design with the heat and pressure of the iron. The ironing time needed depends on the size and thickness of your metal. The temperature must remain constant so don't use an iron with an automatic turn off. Turn the piece over (with tweezers because it's hot) and place it back on the pad, design side up. Rock and press on this side for another 3 minutes. Now go over every part of every design line, pressing with the tip of the iron for a few seconds. You should now see a darker version of your image through the clear polyester backing sheet of the PnP. Pieces larger than jewelry size will take longer to heat through.

**7) Remove the clear backing**.

Drop the whole thing (again using tweezers) in a tub of cold water to cool it off. The clear polyester backing will lift off. The image remaining on the metal should be dark, blue, solid and just as you drew it. Dry the piece. If small areas have filled up with blue resist, press a piece of packing tape over the area and lift. The unwanted parts should pull away with the tape. Note: the backing sheet that you just removed can be used as the original to photocopy onto another piece of PnP. This negative image can be used to etch a plate for roller printing.

**8) Inspect the toner lines with a magnifying glass.**

If there are pinholes in the toner or the lines are too thin in places or your border does not reach to the sides of the piece, touch up the toner with a #000 brush and a liquid resist.

**9) Cover the edge and back with resist.** *See the "Back/edge resist" section pp. 21-22.*

Note: The Pulsar Transfer System directions are the same as these except it is a 2-part system. The toner is transferred first followed by the plastic protection sheet.

***PnP Blue- electric hair straightener method*** (This method works well for jewelry size pieces.)

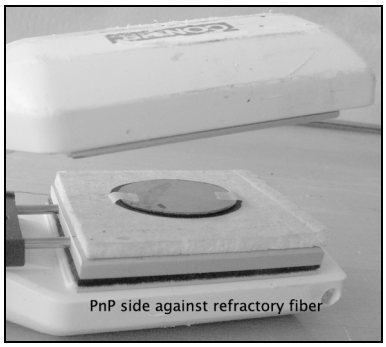
**1) Clean the metal.** *See Chapter 1.*

**2) Transfer your design to the PnP Blue as described in the previous section.**

**3) Transfer the PnP resist to the metal.**

Tape the PnP, design side down, to the metal. Lay a piece of soft, noncombustible material over the PnP. I use ¼" refractory fiber (kiln blanket). Silicon rubber sheets would also work. As would a piece of steel wool wrapped in aluminum foil.

4) Heat and Press the PnP.




Put the PnP piece between the pre-heated plates of an electric hair straightener with the PnP against the refractory fiber. Clamp this all together tightly with a hose clamp. Inexpensive straighteners have just one temperature, which probably will be the correct temperature. More expensive ones have a range of temperatures so test to see which one will work. If the hair straightener is pre-heated, 3 minutes should do it. If not you may need a longer time.

**5) Remove the clear backing.**

Remove the piece from the straightener with tweezers and drop it into a tub of cold water to cool it off. The polyester backing should lift right off. The image remaining on the metal should be dark, blue, solid and just as you drew it. Dry the piece. If small areas filled up with blue resist, press a piece of packing tape over the area and lift. The unwanted parts should pull away with the tape. Note: the backing sheet that you just removed can be used as the original to photocopy onto another piece of PnP. This image can be used to etch a plate for roller printing.

**6) Inspect the toner lines with a magnifying glass.**

If there are pinholes in the toner or the lines are too thin in places or your border does not reach to the sides of the piece, touch them up with a #000 brush and a liquid resist.

**7) Cover the edge and back with resist.** *See the "Back/edge resist" section pp. 21-22.*

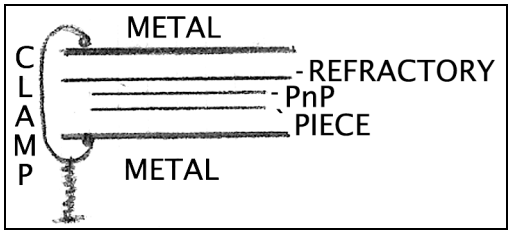
***PnP Blue – oven method*** (This method is effective with large pieces.)

**1) Clean the metal.** *See Chapter 1.*

**2) Transfer your design to the PnP Blue as described previously.**

**3) Transfer the PnP resist to the metal.**

Tape the PnP, design side down to your piece. Lay a piece of soft, noncombustible material on top of the PnP. Sandwich this between 2 pieces of flat, sturdy metal. I use ¼" refractory fiber (kiln blanket) for the noncombustible material. Silicon rubber sheets would also work. If your metal design sheet is large enough it will serve as the backing sheet. If not find another piece of metal that is the same size as your top metal sheet to use for the backing sheet.



C-clamp this “sandwich” together. Or squeeze it together with bulldog clamps or whatever will hold it tightly closed and not be harmed by the heat.

**4) Melt the toner.**

Heat the “sandwich” in a toaster oven or regular oven at ≈ 275˚F. (check the temperature with an oven thermometer) until everything has heated through. Because this amount of metal is a big “heat sink”, it may take 1/2 hour to an hour but you do not need to supervise as long as the temperature remains constant.

**5) Remove the backing.**

Remove the "sandwich", allow the metal to cool, unclamp it and pull away the polyester backing.

**6) Touch up if necessary.**

After removing the backing sheet touch up the PnP with a liquid resist.

**7) Cover the edge and back with resist.** *See the “Back/edge resist” section pp. 21-22.*

***PnP Blue – electric griddle method***

**1) Clean the metal.** *See Chapter 1.*

**2) Transfer your design to the PnP as described previously.**

**3) Transfer the PnP to the metal.**

Tape the PnP (toner side down) to the metal. Heat an electric griddle or fry pan to ≈ 275-300º. Place the metal, metal side down and PnP side up, on a paper towel on the hot griddle. Check the temperature with an oven thermometer placed on top of the piece. When the metal has reached the proper temperature, hold the piece steady with an implement - such as a wooden stick - that will not burn or transfer heat to your hand. Burnish over the top of the PnP with a preheated steel burnisher or the bowl of a metal spoon until you can see the design more distinctly through the clear PnP backing sheet.

**4) Remove the backing sheet.**

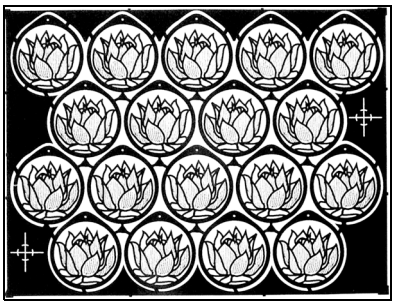
Use tweezers to drop the hot metal piece into cold water to release the backing sheet.

**5) Touch up if necessary**.

After removing the backing sheet touch up the PnP with a liquid resist.

**6) Cover the edge and back with resist.** *See the “Back/edge resist” section pp. 21-22.*

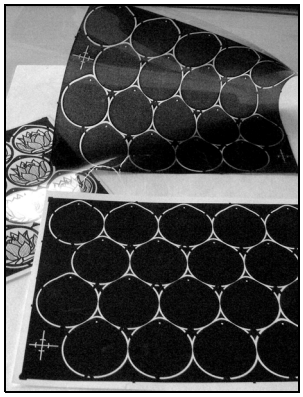
*PnP Blue for multiples*



**1) Clean the metal.** *See Chapter 1.*

**2) Draw the designs.**

Draw the designs for all the pieces on the same piece of paper and connect them all with tabs. These can be duplicates of the same design or all different designs but if they are of a similar size it will be easier. The border around each design must be slightly wider than you want because some of it will be lost in the etching. Draw a frame around the periphery of your design sheet. You can simplify the task of cutting out your small pieces after etching if you make another original for the backside of your metal. This backside original should show only the solid shapes of your pieces without any design lines plus the tabs. The top design sheet and the bottom sheet must align exactly. It is a good idea to make the back shapes slightly larger than their front counterparts because this side will etch for a longer time. Both sides should include registration marks so you can match them up later. This set up will allow you to etch out the metal between the designs except for the tabs, which will keep the pieces from falling out of the frame. The tabs can be cut through and ground off your pieces after etching.



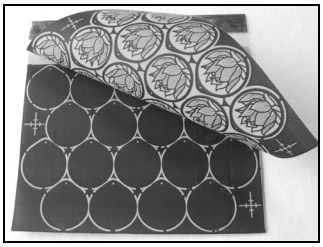
**3) Copy the front design sheet on to PnP.**

**4) Make the back sheet.**

Copy the back sheet drawing onto a transparency sheet for copiers. Flip the transparency over and copy this version onto a piece of PnP.

**5) Attach both sheets of PnP to a metal strip.**

Tape each piece of printed PnP to a separate 1" strip of clear acetate. With the help of a light box align the bottom sheet with the top sheet. With double-sided tape, affix both acetates to a metal strip of the same gauge as the metal you will be etching. Remember that the top sheet must be upside down so that it faces the piece.



**6) Adhere the PnP using the "oven method".**

Follow the directions in the "Oven Method" except cover both pieces of PnP with refractory fiber and put metal plates on both the top and bottom of this sandwich.

**7) Touch up the PnP if necessary.**

After removing the PnP backing sheets touch up the PnP with a liquid resist.

**8) Protect the edge of the design plate with a liquid resist.** *See the "Back/edge resist" section pp. 21-22.*

***Photosensitive Film – ImagOn HD*** (ImagOn has gone through several revisions since it first came out and each one has slightly different requirements. The following directions may need to be tweaked slightly.)

**1) Create a design.**

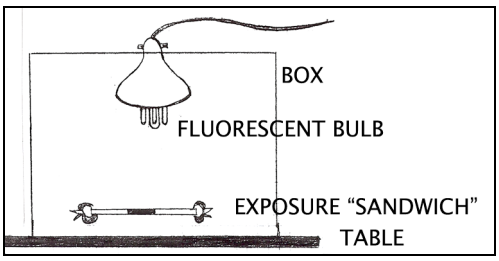

Draw, computer generate, or copy a design from a copyright-free source. This original image should be rendered in black and white only (no gray). The next step is to make a negative of your original and then transfer that to a clear transparency sheet. Make the negative with an image program on a computer, on a commercial copy machine or go to a reprographics firm. Be aware that copiers and laser printers use a different type of transparency sheet than ink jet printers. However some manufacturers make a transparency sheet that can be used with either. Transfer the negative to the appropriate transparency. I find that ink jet printers make darker copies than laser printers and good ink jet photo printers are the best for this. Reprographics firms can make the darkest images. They can also make a negative transparency from your paper original if you do not have the means to make the negative yourself. Let's call this negative on the transparency sheet the "transparency master". If you are concerned about the directionality of your design and would like it to "face" the same direction as your original, flip the original (make a mirror image) with a design program or make a transparency of your transparency by flipping it over and copying it or tell the reprographics firm what you require. This is particularly important for any text that may be included in your design. Don't just flip the original transparency over when exposing the film because the inked side of the transparency should touch the ImagOn emulsion. This is to prevent light from seeping in between the transparency master and the film. Note: If you do not want to bother with printing negatives onto acetate you can use a piece of Rubylith™, a screen making product, and cut away the background areas of your design to use as your negative.

**2) Clean a piece of metal.** *See Chapter 1.*

Use a piece of metal about 6" long and 1" wide. **This will be your test piece**. Make sure that tarnish, grease and oil have all been removed and sand it lightly with 320 wet & dry sandpaper to give it a little tooth. It is a good idea to do a test plate with every different design and every exposure set up. It takes a little time but is well worth it in order to get the best rendition of your design. If you use the same set up over time with similarly sized pieces and similar designs you should be able to use the same exposure guidelines.

**3) Set up a darkroom.**

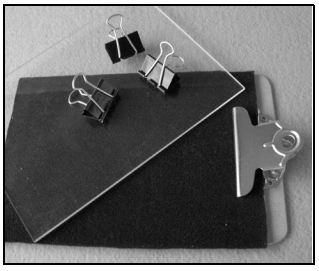
A room with subdued light will work. Cover the windows if necessary. You can use a yellow bug light bulb or the red bulbs used for photography but no fluorescent lighting to light the area.




**4) Set up an exposure unit.**

Various Ultra Violet (UV) light sources can be used to expose ImagOn including sunlight and photoflood lights. *Please see the other light options p. 43.* Sunlight is the cheapest source of UV but the strength of the rays is variable. You should do an exposure test every time you expose this way. If you can't count on sunlight or wish to work indoors or at night you can make a simple exposure box out of a cardboard box with a hole cut in the top. Through this hole suspend a silver reflector holding a compact fluorescent screw-in bulb. The higher the wattage, the faster the exposing time. I use a 45-watt (200 watt incandescent equivalent) bulb, available over the Internet. Ready-made exposure units are available if you do not wish to make your own. *See the "Supplies/Suppliers" section pp. 45-47.* The cardboard box exposure set up works well for jewelry sized pieces but larger pieces may need a series of long fluorescent tubes. The distance between the light and the piece should be 1½ times the diagonal of the piece to ensure even illumination. For instance if the piece is the size of your test piece, 6" X 1", then the diagonal is 6 $^{1}/_{16}$" and the light should hang ≈ 9 $^{3}/_{32}$" above the piece.

**5) Make an exposure "frame".**



I use a simple clipboard system to press the master transparency against the film. The clipboard base is the bottom of the "sandwich" and it is covered with a soft, black material. Use black fabric so it won't reflect light and a soft fabric like felt so you can press your original

against the film. The top of the sandwich is a piece of glass or Plexiglas cut to size. Make sure that the glass or plastic is not the kind that is treated to absorb UV radiation. Clip the whole sandwich together on all four sides.

**6) Mix the developer.**

Purchase some anhydrous sodium carbonate powder a.k.a. soda ash and washing soda. *See the "Supplies & Suppliers" section pp. 45-47.* Don't confuse this with sodium bicarbonate (baking soda). Mix 1 level tablespoon of the sodium carbonate powder in 1/4 cup of hot distilled water in a one-liter container and stir until dissolved. Then add room temperature distilled water to make a volume of 1 liter. Pour this into a flat container large enough to hold your metal test strip. Note: if your tap water has a ph of 7 you can probably use it in place of the distilled water called for in these directions.

**7) Prepare the film**.

In a darkened room trace around your test metal onto a piece of ImagOn. Cut out this piece of ImagOn slightly smaller than your tracing. Peel off the clear plastic protective backing on the film (the back of the film is the inside of the curl). You can remove it by applying a small piece of sticky tape to one of the corners of the backing layer and pulling it toward you. I repeat, peel this off or you will not be able to adhere the film to the metal! Discard the protective backing.

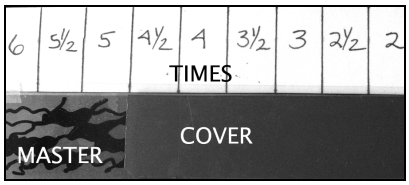
**8) Laminate the film to the test piece.**


Wipe the clean metal with rubbing alcohol and dry it. Spritz the metal liberally with distilled water (you can add a few drops of soap to the distilled water to improve the wetting of the metal if necessary). Center the ImagOn film with the emulsion side against the test piece. The emulsion side is the side you just uncovered and is the less shiny side. Spritz the top of the film with water. Start in the middle of the test piece and lightly squeegee from the center out to each corner using an "X" pattern. Then squeegee from the center out in all directions until all water and air bubbles are no longer visible. Rub over the top surface of the film using a clean absorbent rag and firm hand pressure. Ensure the edges of the film are well secured to the metal. Always rub from the center of the piece outward. Bond the film to the test piece by drying it in a ventilated oven (set between 150-200°F. for ≈ 15 min.) or set the piece down and use a hair dryer set on high or a heat gun set on low and dry the film.

**9) Test the exposure.**


Lay the printed side of your transparency master against the film on your metal test plate. You can use a commercially made gray scale exposure guide to help you determine the best exposure time. *See pages 45-47 for sources.* To use a gray scale, lay it on top of the transparency master on your test strip. Center this in your exposure frame, cover with a piece of glass or clear Plexiglas (make sure that these are not UV protected) and center the frame in the exposure box. Expose for about 10 minutes. After the test is developed you will be able to narrow down the correct exposure using the information that comes with the gray scale. In lieu of a gray scale you can make a home made testing device. Let's say you want to test exposures of from 1 to 6 minutes in ½ minute intervals. Make a timing chart divided into 12 sections and mark it "6", "5½", "5" etc. Place this timing chart on the black fabric. Lay the test piece with the adhered ImagOn on this so that you can see the minute markings. Lay your transparency master upside down over the ImagOn so it covers it completely from end to end. Cover this with the glass or Plexiglas and clip the frame together. If your transparency master is small you can skip the exposure frame and use water (for laser printed and photocopied transparencies) or Citra Solv™ (for ink jet transparencies) to hold the transparency master against the ImagOn. Spread the water or Citra Solv over the film, center the transparency master (ink side down) over the liquid and squeegee the original down to the film. For a 6" timing chart cut a 5 ½" X 1" piece of some light impervious material such as black plastic or construction paper. Put this over the top of the glass or plastic of your exposure frame if you are using one or on top of the transparency if you are not so all but the "6 minute" section is covered and protected from the light. Center the test piece etc. under the exposure box. Set a timer for 6 minutes, turn on the light and start the time and when it gets to 5½ minutes turn off the timer and the light and move the protective cover over to line up with the line between the "5" and the "5½" minute marks. Continue doing this every ½ minute until the 6 minutes have lapsed. Sunlight is stronger and therefore faster - test for shorter times.



**10) Develop the film.**

Make sure the piece is cool and then remove the layer of protective Mylar that is on top of the film with a piece of sticky tape and discard. Place the test piece face up in the developing solution and cover the tray with an opaque lid. Set a timer for 9 minutes. After 9 minutes swab it gently with a foam brush and remove the test from the developer solution (wear gloves.) Lightly rub the colored emulsion residue from the test piece under cool running water with a sponge or foam brush. The sodium carbonate developer can be discarded down normal water drains. Use new developer with each piece.

**11) Fix and harden the image.**

To stabilize the image, spray it with white vinegar. Lightly rub the vinegar into the imaged area and give it a final rinse with cold water. Dry off the test by blotting with a soft cloth. Finish drying the test in an oven or with a hairdryer as before or in the sun. Find the best timing – the part where the resist is darkest but the background is completely clear of resist. You can remove the ImagOn and use this piece of metal again or keep it for reference. *See the "Removing resist" section p. 22-23.*

**12) Laminate, expose and develop your designed piece.**

Choose the best timing from your test and follow the preceding directions for preparing your final piece. Put your transparency master, ink side down, over the laminated ImagOn in the exposure frame. After exposure remove the acetate design and you will see a ghost image of your design on the ImagOn. Develop for 9 minutes and rinse. If the emulsion in the non-image areas does not easily wash away, return the piece to the developing solution and check it every minute or so until the unwanted emulsion can be sponged away. It is easy to miss a faint coat of emulsion left on the metal background so be sure to check it in a good light. When the background is clear, fix and harden the image. See step 11.

**13) Touch up the film if necessary with a liquid resist.**

**14) Coat the edge and back with resist.** *See the "Back/edge resist" section pp. 21-22.*

These same steps can be used for the Puretch and Z-acryl films.

*Back/edge resists – sticky back materials*

**1) Clean the metal.**

Make sure the back and edges are clean. If the metal has tarnished, pickle it, rinse it and dry it.

**2) Paint the edges with a liquid resist.**

Paint the edge and a margin around the perimeter of the backside with a liquid resist. Dry the liquid resist.

**3) Cut a piece of sticky back material to cover the back.**

Stucco tape, plastic tape, duct tape, electrical tape and Contac paper™ will all serve as a back resist. Cut a piece slightly larger than your piece if the piece is straight sided. Cut a piece of sticky-back material the same size as the piece if the piece has a rounded shape.

**4) Attach the sticky-back material.**

Lay the sticky back material on the piece and smooth it out from the center. Overlap pieces if one piece is not wide enough to cover. Press it down and burnish it well. You can fold the sticky back material up the edges and over the top of a straight-sided piece if you wish to doubly protect a border around your design. Burnish these areas too.

*Back/edge resists – lacquer & acrylic spray paint*

**1) Clean the metal.**

Make sure the metal on the back and edge is clean. If you are worried that paint might spread over onto the design, cover the front temporarily with Frisket Film™ or a piece of paper cut to size and adhered with a temporary adhesive.

**2) Spray the back and edges.**

Lay the piece, design side down on newspaper. Spray the paint over the back and edges. Let the paint dry according to the directions on the can and re-spray to get a solid coat.

**3) Touch up the edges with a liquid resist if necessary.**

*Back/edge resists – Z-acryl, Pledge floor finish, liquid "rubber", and Lascaux Plate Backing Resist and finger nail polish.*

**1) Clean the metal.**

Make sure the metal on the back and edges is clean.

**2) Paint the back and edges with the liquid resist.**

Attach the front of the piece to a pedestal such as a bottle cap using a wad of removable adhesive putty (the type used to attach posters to the wall). This way you can hold your piece up and keep it steady while you apply liquid resist to the back and edges at the same time. However don't use the putty with the resist pens because the stickiness can pull the pen resist off. Larger pieces can rest on a damp sponge. Paint the liquid resists on with an artist's paintbrush or a foam brush. Or use the brush that comes in the fingernail polish bottle. If using the Pledge, add a small amount of food coloring or India ink to make it easier to see.

**3) Dry the liquid resist.**

Air dry the piece or use a fan or a hairdryer on low to speed up the drying. Too high a heat can crack or bubble the resist.

**4) Cover the back and edges again with a second thin coat and dry.**

**Removing the resist after etching**

***"Inks"*** – Citra Solv™ removes Painters™ ink, Pilot™ gold marker ink, and Deco pen ink. Lacquer thinner removes Staedtler™ red permanent ink and Sharpie™ ink.

***Stamping resists*** – Remove melted embossing powder with Citra-solv, lacquer thinner, paint thinner or acetone.

***Sticky back materials*** – Most will peel cleanly off. If sticky residue remains remove it with Goo Gone™ or the like.

***Spray paint*** – Remove with Citra-solv, paint thinner or lacquer thinner.

***Asphaltum*** – Remove with Citra Solv™, turpentine or a turpentine substitute. Or heat the piece and wipe off the melted asphaltum.

***Toner*** – PnP can be removed mechanically with steel wool or by soaking in Citra Solv™, SOYsolv 2™, lacquer thinner or acetone.

***Films*** - Soak the piece in a strong, hot sodium carbonate solution for about 15-30 minutes. *See the recipe on p. 42.* Or remove with a 50% ammonia and water solution. ImagOn film is fully biodegradable and can be disposed of along with the sodium carbonate solution into normal municipal waste systems.

***Z-Acryl and Future Floor polish*** – Soak the piece in a hot 40% sodium carbonate solution, a 50% solution of household ammonia or full strength denatured alcohol.

***Finger nail polish*** - Remove with Citra-solv, 50% ammonia solution, finger nail polish remover or acetone.

***Lascaux Plate Backing Resist*** - Remove with a strong, hot sodium carbonate solution. *see the recipe on p. 42.* Or use Lascaux Remover™, Citra Solv™ or denatured alcohol.

***Liquid "rubber"*** – Remove with mineral spirits.

*Personal favorites: I like PnP Blue toner resist for chemical etching because it is easy and precise. I like ImagOn for electro-etching because it is also precise and holds up better than PnP for this type of etching. The 3-M #854 tape is the easiest to cut tape and holds up the longest but is difficult to find in small quantities. I like Lascaux Plate Backing Resist for backs and edges because it is self-leveling, holds up well during etching and is safe to remove. If you use ImagOn with the Lascaux backing resist both can be removed with the warm sodium carbonate solution. Filter out the resist bits through a coffee filter. The filter and residue can go into the garbage and the sodium carbonate solution can go down the drain.*

Fine silver
ImagOn resist
Ferric Nitrate electrolyte
Electro-etch bath
15 minutes

Fine silver
PnP resist
Ferric Nitrate etchant
Aerated chemical bath
7 ½ hours

Copper
ImagOn resist
Sodium Bisulfate electrolyte
Electro-etch bath
8 hours

Copper
PnP resist
Ferric Chloride etchant
Heated/aerated chemical bath
3.25 hours

# CHAPTER 3 ETCHANTS

## Types of Etchants

*Acids:* Nitric acid etches copper, brass and silver but it is very exothermic which may lead to violent reactions. Even though Nitric acid provides a rapid chemical etch and holds a large amount of dissolved metal, I choose not to use it. It exudes toxic gas and attacks the resist so strongly that the result is a ragged etched line and an unhealthy atmosphere for you.
*Salts:* Ferric chloride and cupric chloride will etch copper and brass. Ferric chloride etches faster and undercuts less but cupric chloride is cleaner and does not produce as much residue. Both benefit from the addition of an acid such as citric acid to help prevent sludging. This is know as the "Edinburgh etch". Used as a chemical bath it is quite slow but results in a nice clean etch. Add heat and some form of agitation to speed up the process but keep the temperature under 70° F. Ferric nitrate will etch fine silver and sterling silver. Heat and agitation (its, not yours!) will shorten your etching time.
*Oxidizers:* Ammonium persulfate and sodium persulfate will etch copper and brass. These provide a constant etch and are clear solutions but have a short shelf life of about 2 weeks.
*Electrolytes:* Salt water, sodium bisulfate or 5% sulfuric acid can be used as the electrolyte with copper and brass. Ferric nitrate, silver nitrate or a 5% nitric acid solution can be used as the electrolyte with fine and sterling silver.

## Mixing Etching Solutions

***Ferric nitrate*** (chemical etchant and electrolyte for fine silver and sterling silver)

### 1) Make the ferric nitrate solution.

Mix ≈ 55% ferric nitrate crystals by weight into 45% distilled water by weight. This measures out to be about 10 oz. of ferric nitrate crystals added to 1 cup of hot water to dissolve. For every quart of ferric nitrate solution add 1 cup of the citric acid solution to help with the sludging. *See the recipe for citric acid on p. 41.*

### 2) Dispose of the ferric nitrate.

Contact your local hazardous waste department for instructions for proper disposal. This is considered hazardous waste. If ferric nitrate is used for electro-etching it should last indefinitely. After electro-etching filter the solution through a coffee filter and continue to re-use. Store in a glass or plastic container with a plastic screw-on lid.

***Sodium persulfate and Ammonium persulfate*** (chemical etchant for copper, gilding metal and brass)

**1) Mix up the solution.**

Mix 1 pound of sodium persulfate or ammonium persulfate into a gallon of water if you will only be removing a small amount of copper. Use 2 pounds per gallon to remove a large quantity of copper. Let this mixed solution sit 24 hours before using.

**2) Dispose of the solution.**

These solutions only have a shelf life of a few weeks after water has been added. When it comes time to dispose of them contact your local hazardous waste authority. They are considered hazardous waste.

***Ferric chloride*** (chemical etchant for copper, gilding metal and brass)

**1) Prepare the ferric chloride.**

Buy the liquid whenever possible. Mixing your own from the dry crystals is more dangerous because chlorine gas is a by-product. If you do mix your own do it outside or with good ventilation and wear protective rubber gloves, goggles and a waterproof apron. The liquid version of ferric chloride from Radio Shack is called PCB Etchant and has an addition of a very small amount of hydrochloric acid. Ferric chloride from printmaking supply sources and chemical supply sources does not have this additive but citric acid can be added. *See the recipe for citric acid and the Edinburgh Etch on p.41.* The acid serves to retard the formation of insoluble copper salts that interfere with the etching. I find that 42° Baume liquid ferric chloride etches better and goes further when diluted with 1 cup of water to every 3 cups of ferric chloride.

**2) Dispose of the ferric chloride.**

When the color of the ferric chloride changes from rusty brown to dark olive (from the etched away copper) the etching action will slow down and it is time to dispose of it. An easy way to judge the color is just to dip a strip of white paper into the bath and see what color it turns. Contact your local hazardous waste department for the instructions for the proper disposal. This is considered hazardous waste.

***Cupric chloride*** (chemical etchant for copper, gilding metal and brass)

**1) Make a cupric chloride solution.**

Mix 50 grams (1.75 oz.) Cupric chloride powder with 50 grams (1.75 oz.) table salt. Stir these into 500 milliliters (15 fluid ounces) of hot water and add 100 milliliters (3 fluid ounces) of the mixed citric acid solution. *See the recipe p. 41.*

**2) Dispose of the cupric chloride.**

Cupric chloride can be kept active longer by introducing more air after your etching is finished. Run an airline into it for a day or so. The color should change back from a green to the original blue color. You may need to add more citric acid and salt next time you etch. A source for the complete rejuvenation directions is listed in the "Sources" section of the Appendix. When it comes time to dispose of the cupric chloride, contact your local hazardous waste department for the instructions for proper disposal. This is considered hazardous waste.

***Dilute nitric acid*** *(electrolyte for fine and sterling silver)*

**1) Dilute the nitric acid.**

I suggest this option only if you have nitric acid already on hand and have experience using it. Pour 2 oz. of nitric acid ***into*** 38 oz. of distilled water. Remember this order. Think of the water molecules as the "good guys" and the nitric molecules as the "bad guys". You always want the good guys to outnumber the bad guys. "Add acid to water, just like you oughter".

**2) Dispose of the nitric acid.**

This solution can be re-used as an electrolyte many times. Filter it through a coffee filter (not one that you are using for coffee!) to get the sludge out. When you wish to dispose of the nitric acid, contact your local hazardous waste department for the proper procedure.

***Salt water*** *(electrolyte for copper, gilding metal and brass)*

**1) Mix up the salt-water electrolyte.**

Make a saturated solution of salt water by mixing non-iodized salt into warm distilled water until it starts to precipitate. Pickling salt works well as does kosher salt. You may wish to hold this solution over night, adding the salt little by little.

**2) Dispose of the salt-water mixture.**

Save the mixture and re-use it. It actually works better with copper in it (it will look like pulpy orange juice) but filter it after each use to remove the "flotsam". When the time comes to dispose of this saltwater electrolyte treat it as hazardous waste because of the copper concentration. Contact your local hazardous waste department for the proper disposal procedure.

***Sodium bisulfate*** *(electrolyte for copper, gilding metal and brass)*

**1) Mix up a sodium bisulfate solution.**

Dissolve 2.5 pounds of sodium bisulfate in 7 pints of warm water. This will make one gallon of electrolyte. To make a smaller batch add 1 cup sodium bisulfate to 1 quart warm water.

**2) Dispose of the sodium bisulfate solution.**

You can use the same solution many times but when you wish to dispose of it treat it as hazardous waste. Contact your local hazardous waste department for the proper procedure.

***Dilute sulfuric acid*** *(electrolyte for copper, gilding metal and brass)*

**1) Dilute sulfuric acid.**

I suggest this option only if you already have sulfuric acid on hand that you wish to make use of and have had experience using this acid. Pour 2 oz. of sulfuric acid ***into*** 38 ounces (1 quart + 6 oz.) of distilled water. Remember to always have more water than acid in the solution as you make it up. "Add acid to water just like you oughter".

**2) Dispose of the sulfuric acid solution.**

Re-use this solution. When it comes time to dispose of it contact your local hazardous waste department for the proper procedure.

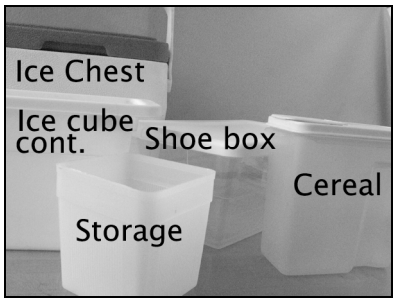
*Personal etchant favorites: For chemically etching copper and brass I prefer ferric chloride because of its low cost, availability, relative safety, high holding capacity for metal and because it results in an etch with nice clean lines. I like ferric nitrate for chemically etching silver for the same reasons though it must be purchased from a chemical supply house and not a neighborhood Radio Shack. Ferric nitrate chemical etches are slow so see the following chapter, "Baths", for ways to speed them up. For electro-etching copper I like sodium bisulfate (pickle) because it results in less precipitate than salt water, though salt water "works" just as well. I like ferric nitrate for silver electro-etching because it doesn't form precipitates and is very fast. Interestingly, copper etches faster than silver in a chemical bath but silver etches faster than copper in an electro-etching bath.*

# CHAPTER 4 BATHS

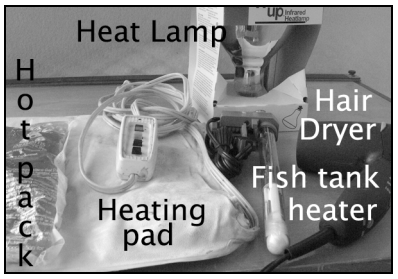
## Types of Baths

Factors other than the choice of etchant affect the speed and performance of a chemical bath. High air content, agitation and elevated temperature result in faster etch times. Also because sediments land on the etched out areas as you etch hampering further etching, you can speed up the action of every type of bath by rinsing and brushing off your piece. I use inexpensive foam brushes for this. The more often you do this, the faster the etching will go. Keep chemical baths covered to retard evaporation and keep mists away from you. Spray-etching and electro-etching result in the least undercutting. Commercial etchers spray warm etchant onto the metal while it travels along rollers. Jewelers and enamelists can use simpler, less expensive options for moving the bath.

## Setting Up the Bath

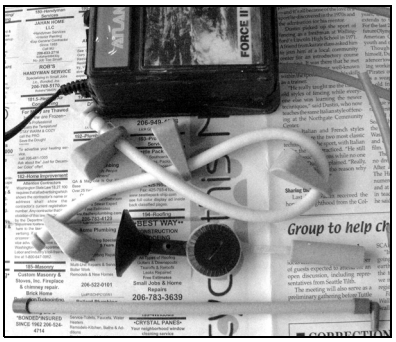



*Containers:* Do not use metal containers but many kinds of plastic and glass containers will safely hold the bath. You could use plastic storage containers such as shoe boxes, plastic ice chests, plastic cereal containers, plastic ice cube containers and Tupperware™ or other food storage containers. Or use glass containers such as Pyrex™ or Corning Ware™.




*Heating:* You can heat a bath with a fish tank heater (if the container is tall), a hair dryer, a heating pad, a heat lamp (if the container is glass), a hot plate (if the container is Pyrex), a hot pack heated in a Microwave oven or by setting the container in a hot water bath. It is important to monitor the temperature with a chemical resistant thermometer. Glass candy thermometers and fish tank thermometers are inexpensive options. If the temperature gets too hot it can cause unwanted and dangerous chemical reactions and cause the resist to deteriorate.

*Spraying*: Introduction of air helps shorten etching times. One spray option for the studio is to use a garden spray pump. This can be very messy and you must figure out a way to keep the etchant somehow contained and off of you. Try putting an upturned plastic berry basket in the bottom of a big bucket. Place the piece on the berry basket and spray down at it. Refill the spray pump every time the etching solution fills the bucket up to the level of the piece.



*Aeration*: Bubbles will introduce air and circulate the etchant. Use a fish tank pump from a tropical fish store connected to airline connected to some kind of bubble maker such as Marineland Bubble Wands™ or Elite Air Curtains™. Do not use "sand" air stones because the etchant tends to dissolve the glue that holds the grains together. You can make a home made version of a bubble wand by poking holes in plastic tubing with a hot needle or drilling holes in it with a small bit.

*Magnetic stirring*: These devices provide the fastest non-commercial chemical etches. Some magnetic stirrers combine both a stirring and a heating function. They are available through chemical supply sources and some larger jewelry supply sources.

*Rocking and vibrating:* You can build or buy a contraption for rocking the bath back and forth. *Please see the "Sources of Information" section pp. 51-52.* Even the simple motion of jiggling the bath will help circulate the etchant and help remove the sediments. You can tape your bath to the top of a fish tank pump, put the bath on a washing machine while it is washing or attach it to anything that vibrates. Please make sure that the bath will not jiggle off its platform and spill. Putting the etchant in a container and the container in an ultrasonic cleaner full of water will also serve to jiggle the bath. I find this to be the best movement option for an electro-etching bath.

*Manual movement*. If you have the time and energy you can manually move the bath by rocking the container or move the piece by swishing it through the etchant, wearing protective gloves of course. Or you can move the etchant over the piece by repeatedly stroking the piece with a foam paintbrush.

*Direct rub.* This is a technique explained on the Pulsar web site. *See p. 47 for the website address.* It involves soaking a sponge in ferric chloride or ferric nitrate and rubbing the damp sponge against the metal. This method is very effective in removing the sediments from the metal and thereby speeding up the etching process. It is, however, very hard on the resist.

*Electro-etching.* Using DC, direct current, instead of, or in addition to, an acid or salt etchant to etch your piece allows you to reuse the etchant indefinitely. Thereby cutting down on your expenses and disposal problems. The process is similar to electro-plating but works in the reverse – removing rather than adding metal to your piece. The DC current can be supplied by equipment such as rectifiers and constant current/voltage regulators or by something as simple as flashlight batteries. The speed of the etch depends on the size of the metal; the

distance between the anode and the cathode; the concentration of the electrolyte and the strength of the DC power.

### Etching Procedures

Soaking your metal in pickle to remove the tarnish before you etch will hasten the etching process. Then "flash bite" your pieces to check that all the open areas are etching. After a few minutes remove your pieces from the bath. If any of the exposed metal is still shiny it means that some resist is there even if you can't see it. You need to scrape this off before etching further.

#### *Chemical baths*

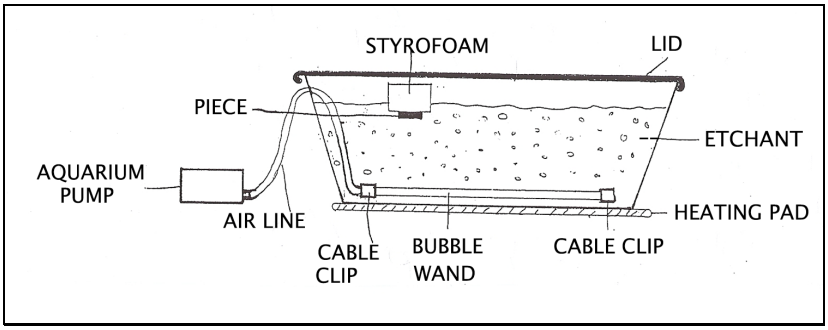
**1) Protect the metal with resist.**

Cover the front of your piece with a design resist and the back and edges with an appropriate resist. *See chapter 2 "Resists".*

**2) Prepare the bath.**

Set up a bath with the chemical, movement device and heating method of your choice. *See chapter 3 "Etchants" and chapter 4 "Setting up the bath".* Adding a few chunks of the metal you will be etching or some used etchant to the bath before you add your piece will jump start the etching action.

**3) Place the piece in the bath.**




Position your piece in the bath. You can lay the piece on the bottom of your vat or lean it against the side but the best position is upside down. I find the easiest way to accomplish this is to attach the back of your piece to a piece of Styrofoam with double-stick carpet tape. Your piece will float like a boat on the surface of the etchant and some of the grunge left on it from the etching action will fall off of the piece. If you are etching both sides of the metal, etch until the design side is the appropriate depth and then "stop it out" with a liquid resist, turn the metal over and continue etching. Or if you can hang the piece so that both sides come into contact with the etchant at one time, do that. Double-sided etching works best with moving baths, still baths may take too long and wear out the resist before the etching is completed.

**4) Check the piece as it etches.**

Check your piece as often as is comfortable. Every time you check, rinse off the piece over a separate vat while gently brushing off the front with a foam brush. The more often you do this, the faster the piece will etch.

**5) Remove the etched piece.**

When the piece has etched to the desired depth, remove it from the bath and soak it immediately in a solution of vinegar and salt (any proportions) or household ammonia or scrub with Penny Brite and an old toothbrush. This loosens the residue left behind by the etchant. Ferric chloride in particular is almost impossible to remove after it has dried onto the metal.

**6) Remove the resist and clean the piece.**

Remove the resist. *See "Removing the resist" p. 22-23.* Rinse well with water and dry.

**7) Cut multiple pieces apart.**

If you have etched multiples that are attached to each other with tabs you can clip the individual pieces out with shears now. The Xuron Micro Shear™ from Micro Mark works very well for this.

Your piece is now ready for enameling, forming, soldering, plating, adding a patina or whatever vision you have in mind.

*Direct Rub*


**1) Apply resist to the metal.**

Cover the front of your piece with a design resist and the back and edges with an appropriate resist. *See chapter 2 "Resists".* This method is fast but hard on the resist. Use a tough resist such as Imag-On for the design side.

**2) Prepare the etchant set up.**

This technique uses a sponge to hold the ferric chloride or ferric nitrate etchant. I like to use high-density foam sponges such as cosmetic sponges because the pores are smaller than those in kitchen sponges. Put on a pair of protective gloves. If your piece is large, put the piece in a tray and rub the etchant-dampened sponge over it. If the piece is small, put the sponge in a container. Plastic jar lids work nicely as the sponge container. Use some double-stick carpet tape to keep the lid from sliding around as you rub. Dampen the sponge with straight ferric chloride or ferric nitrate. Turn the small piece over and rub the design side back and forth over the sponge.

**3. Keep checking your piece.**

This method is fast. You should be able to get a pretty deep etch in 15 minutes. Check periodically to see if the etch is deep enough.

**4) Clean the etched piece.**

When the piece has etched to the required depth, soak it immediately in a solution of vinegar and salt (any proportions) or household ammonia or scrub with Penny Brite and an old toothbrush. Ferric chloride residue in particular is almost impossible to remove after it has dried onto the metal.

**5) Remove the resist and rinse the piece.**

Remove the resist. *See* "*Removing the resist" p. 22-23.* Rinse well with water and dry. Your piece is now ready for enameling, forming, soldering, plating, adding a patina or whatever vision you have in mind.

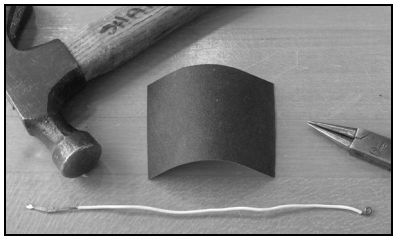
### *Electro-etching baths for single pieces*

**1) Apply resist to the piece.**

Cover the front of your piece with a design resist and the back and edges with an appropriate resist. *See chapter 2 "Resists".* You will find that electricity affects the resist differently than chemicals do. Pens will only last a few minutes before the "ink" is worn away, PnP will last a little longer but the film resists such as ImagOn have the greatest resistance in an electro-etching bath. Special tapes such as anodizers's tape plater's tape, EtchAll mask and 3M #854 Polyester Film Tape will last almost as well but require that you hand cut your design and the cut lines are not as neat as the drawn lines of ImagOn.

**2) Prepare the electro-etch bath.**

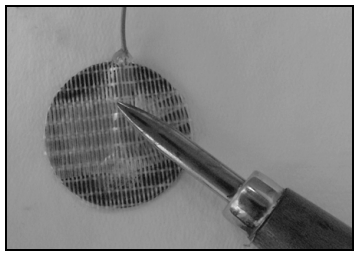
Fill a non-metallic container with the appropriate electrolyte. *See Chapter 3 "Etchants".* Square and rectangular containers are the easiest to work with. The container needs to be large enough to hold your piece (the anode) and the other electrode (the cathode) without them touching – but not much larger than that. The cathode should be as wide as your piece and tall enough to protrude out of the container. The reactions are "cleaner" if you use the same metal for your cathode and your anode (your piece).



**3) Prepare a wire to connect to the piece.**

Cut a piece of a wire, such as bell wire (the wire used for doorbell connections) about 6" long. If your piece is large, cut more than one piece and/or

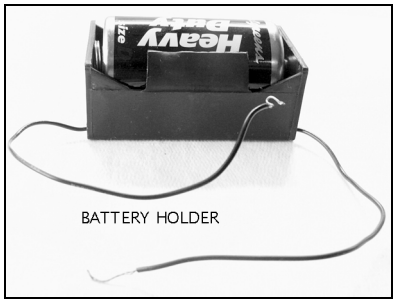
use heavier plastic coated wire. Strip about ½" of the plastic covering from both ends of the wire. Hammer one end flat and curl the other end. Sand both ends. Also sand the back of your piece where the wire will attach. Leave a bare spot in the backing resist or if you have already covered the back with a resist, scrape it away in the spot where the wire will attach.



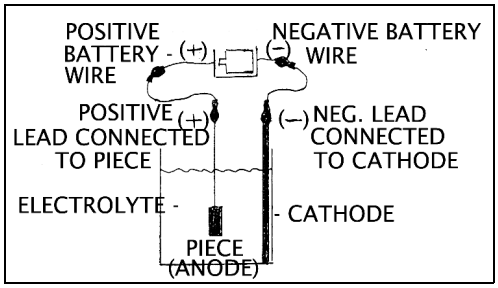
**4) Attach the wire to the piece.**

The wire can be soldered to the back of the piece with a low melting solder but I prefer to tape it in place with non-metallic duct tape or reinforced packing tape. Tape the flat end of the bell wire securely down to the bare spot on the back of your metal with a thin strip of tape. Burnish this down. Then cover the entire backside with another piece of this tape cut to fit the piece. Burnish this tape down. Fill the open space where the wire exits the piece with a drop of glue from a hot glue gun.

**5) Attach insulated jumper leads to the power source.**




A lead is a piece of wire with alligator clips on both ends. Small ones from Radio Shack work fine if a flashlight battery in a battery holder is your power source. Use one 1.5V. battery. More voltage will damage the resist and potentially release toxic gasses. If using a rectifier or constant voltage regulator keep the voltage at 1.5V or less. These come with the leads attached. The battery holder method is the cheapest and works fine for small pieces. I use the one "D" battery holder. Put a "D" battery in the holder. Attach one lead to the positive terminal of the battery holder and connect another lead to the negative terminal.

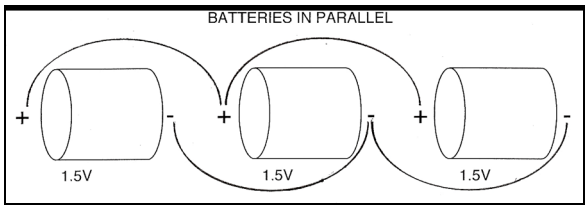



**6) Position the electrodes.**

Position the electrodes, the anode (your piece) and the cathode (a strip of the same metal), so they face each other and are parallel but do not touch. You can clip both the electrodes to opposite walls of your container with plastic clothespins but I prefer to clip the cathode to the side but suspend the piece (the anode) by its bell wire wrapped around a "stick" that spans the container. Leave the bare end of the bell wire sticking up. Use something flat that won't roll for the stick. Attach the stick to opposite walls of the container with two wads of reusable adhesive to keep it steady. You can easily move the stick and piece closer or further from the cathode to moderate the action.

### 7) Connect the leads to the anode and cathode.

Clip the free end of the negative lead to the cathode and clip the free end of the positive lead to the wire attached to your piece (the anode). If you are doing large pieces or have a large vat and your pieces are spaced further apart you may need to adjust the amperage. The larger the piece and the farther apart the anode and the cathode, the greater the resistance. Amperage and voltage are not the same thing. You can boost the amperage by moving the electrodes closer together, by using a more concentrated electrolyte, by decreasing the length of the leads, by using smaller gauge leads, and by keeping lead ends clean. Another way to increase amperage is to connect several batteries in parallel. This increases the amperage without increasing the voltage, which we do not want to do. This is easy to do with battery holders and leads. Connect all the positive terminals together and all the negative terminals together.




### 8) Test the connections.

After a few seconds you should see bubbles rising at the cathode. If not it means that something is preventing a good connection. You can test all the connections with a multimeter (a.k.a. multitester, voltmeter). The multimeter should read almost 1.5 V. The usual problem area is the connection between the bell wire and the back of the piece. If you suspect this is the problem, test it by touching the negative probe of a multimeter to the cathode and the positive probe to the metal of the piece held half way out of the electrolyte. If this proves to be the problem remove your piece, untape it and take off the bell wire. Dry off the piece. Sand the back of the piece and the end of the bell wire again and re-tape them together.

### 9) Clean off the electrodes.

You might find that lots of "debris" will form on your piece (the anode) and the cathode. Rinse and brush them both as often as you can. Otherwise the etching will slow down or cease all together. I keep a spray bottle full of water, a foam brush and an empty vat near by so that I can pull the piece and the cathode out, spray them over the empty vat, brush them off and return them to the etching vat.

### 10) Clean the etched piece.

When the piece has etched to the required depth, soak it immediately in a solution of vinegar and salt (any proportions) or household ammonia or scrub with Penny Brite and an old toothbrush to remove the etching residue.

**11) Remove the resist and rinse the piece.**

Remove the resist. *See "Removing the resist" p.22.* Rinse well with water and dry. Your piece is now ready for enameling, forming, soldering, plating, adding a patina or whatever vision you have in mind.

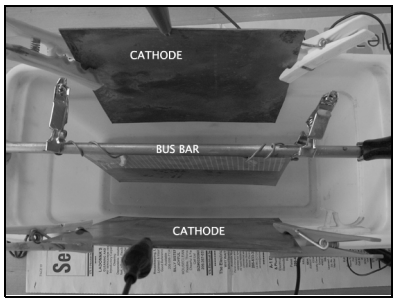
### *Electro-etching baths for multiple pieces, 2-sided etching and 3-D pieces*

**1) Apply resist to the piece.**

Cover the front of your piece with a design resist and the back and edges with an appropriate resist. *See chapter 2 "Resists".* You will find that electricity affects the resist differently than chemicals do. Pens will only last a few minutes before the "ink" is worn away, PnP will last a little longer but the film resists such as ImagOn have the greatest resistance in an electro-etching bath. Special tapes such as anodizers's tape plater's tape, EtchAll mask and 3M #854 Polyester Film Tape will last almost as well but require that you hand cut your design and the cut lines are not as neat as the drawn lines of ImagOn. If you want to electro-etch a 3-D piece you will need to use a liquid resist like asphaltum because the films and papers will not conform to a 3-D shape. Although a tape resist would work with a cylindrical shape.

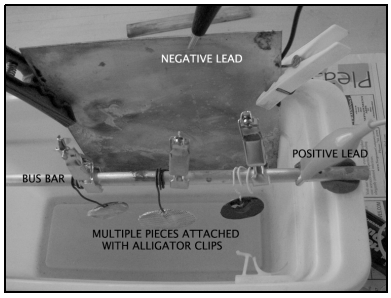
**2) Prepare the electro-etch bath.**

Fill a non-metallic container with the appropriate electrolyte. *See Chapter 3 "Etchants".* Square and rectangular containers are the easiest to work with. The container needs to be large enough to hold your piece (the anode) and the other electrode (the cathode) without them touching – but not much larger than that. The cathode should be as wide as your piece and tall enough to protrude out of the container. The reactions are "cleaner" if you use the same metal for your cathode and your anode (your piece). If you are trying to etch both sides at once you will need 2 cathodes – one in front and one behind the piece. For 3-D pieces you will need a cathode that circles the vat. Something like copper tooling foil can be easily bent to fit the vat for this purpose. To etch multiple pieces you will need a "bus bar" and alligator clips to connect your pieces to the DC power source. A bus bar is a piece of conductive metal such as copper rod which will distribute the DC power. Hang the bus bar across your vat. Hang your individual pieces or multiple-piece sheet from this by attaching the bell (or heavier) wires with alligator clips so that the bare ends of the wires have good contact with the bus bar.



### 3) Prepare a wire(s) to connect to the piece(s).

Cut a piece of a wire, such as bell wire (the wire used for doorbell connections) about 6" long for each piece. Each piece will need a separate bell wire if you are etching several separate pieces at the same time. If the multiple pieces are all on one sheet of metal you will probably need a heavier plastic coated wire and more than one attached to the back of the sheet to hold the weight. Strip about ½" of the plastic covering from both ends of the wires. Hammer one end of each flat and curl the other end. Sand both ends of each wire. Also sand the back of your piece where the wires will attach. Leave a bare spot in the backing resist or if you have already covered the back with a resist, scrape it away in the spot where the wires will attach.




### 4) Attach the wire(s) to the piece(s).

The wire(s) can be soldered to the back of the piece with a low melting solder but I prefer to tape them in place with non-metallic duct tape or reinforced packing tape. Tape the flat end of the bell wire(s) securely down to the bare spot on the back of your metal with a thin strip of tape. Burnish this down. Then cover the entire backside with another piece of this tape cut to fit the piece. Burnish this tape down. Fill the open space(s) where the wire exits the piece with a drop of glue from a hot glue gun.

### 5) Connect the cathode and anode to the power source.

Attach the positive wire from the energy source to the end of the bus bar with a jumper lead. Attach the negative lead to the cathode(s). If you are etching two sides at once you will need two negative leads. Attach one of the negative leads to the negative terminal and the other end to one of the cathodes. Clamp the jaws of the other negative lead over the alligator clip at the power source connection and the other end of this lead to the other cathode.

### 6) Test the connections.

After a few seconds you should see bubbles rising at the cathode. If not it means that something is preventing a good connection. You can test all the connections with a multimeter (a.k.a. multitester, voltmeter). The multimeter should read almost 1.5 V. The usual problem area is the connection between the bell wire and the back of the piece. If you suspect this is the problem, test it by touching the negative probe of a multimeter to the cathode and the positive probe to the metal of the piece held half way out of the electrolyte. If this proves to be the problem remove your piece,

untape it and take off the bell wire. Dry off the piece. Re-sand and re-tape.

**7) Clean off the electrodes.**

You might find that lots of "debris" will form on your piece (the anode) and the cathode. Rinse and brush them both as often as you can. Otherwise the etching will slow down or cease all together. I keep a spray bottle full of water, a foam brush and an empty vat near by so that I can pull out the piece(s) and the cathode(s), spray them over the empty vat, brush them off and return them to the etching vat.

**8) Clean the etched piece.**

When the piece has etched to the required depth, soak it immediately in a solution of vinegar and salt (any proportions) or household ammonia or scrub with Penny Brite and an old toothbrush to remove the etching residue.

**9) Remove the resist and rinse the piece.**

Remove the resist. *See "Removing the resist" p.22-23.*

Rinse well with water and dry.

**10) Separate multiples.**

Multiples attached with tabs are easily separated if you cut the tabs with something like Xeron shears.

Your piece is now ready for enameling, forming, soldering, plating, adding a patina or whatever vision you have in mind.

***Personal etching bath favorites****. When I am using a chemical bath I position my piece upside down and use bubble wands with a fish tank pump for agitation and aeration and a heating pad for heat when my studio is cold. I sometimes use a magnetic stirrer. This takes a little longer to set up but the movement and heat provided result in a faster etch. I find that both set ups do a good job. However pieces larger than about 2 inches may etch unevenly in a magnetic stirrer so watch them closely. The direct rub method is interesting and takes only about 15 minutes to get a fairly deep etch. Plus it uses very little etchant. I like the idea of electro-etching because the etchant (the electrolyte) can be re-used indefinitely making it a cheaper option and less damaging to the environment. Electro-etching silver with ferric nitrate is cheaper and many times faster than chemical etching with ferric nitrate. It is difficult to "move" an electro-etch bath because of the number of pieces already in the bath. But one way is to put the electro-etch container into an ultrasonic machine full of water. Don't heat an electro-etch bath. I choose the type of resist according to the type of bath I want to use. See some examples of bath movement on p. 44.*

## Problems with the Resist

***PnP image did not adhere or is very light***: Increase the temperature of the iron, griddle, hair straightener or toaster oven. Heat for a longer time. Test the temperature with a thermometer to make sure it is correct. Re-clean the metal.


TOO HOT !

***PnP image lines spread and/or the image shrinks***: Decrease the temperature of the iron, griddle, hair straightener or toaster oven.

***ImagOn will not stick to the metal:*** Remember to remove the clear backing sheet. Check to see that the metal is clean. Use plenty of water and squeegee carefully when adhering the film to the metal.

***ImagOn peels off when top Mylar is removed for developing:*** Be sure the film is dried sufficiently after lamination. Make sure the ImagOn film is squeegeed adequately. Make sure humidity in your work space is 60% or lower. Do not let the film overlap the metal or it is apt to peel off when you remove the top cover sheet.

***The non-image areas of ImagOn do not wash away during developing***: Check to see that the black areas of the transparency master are dense enough that light cannot filtrate. Develop for a longer time. Expose for less time. Make a stronger developing solution.

***Edges of ImagOn film do not adhere:*** Film will only adhere to a flat surface not a beveled edge of metal. Cut your film slightly smaller than the metal and don't let it overhang the metal.

***ImagOn film breaks down during developing:*** Make sure the exposure time was sufficient by testing with a grey scale or home made testing card.

***Pinholes in the resist:*** Check the resist with a magnifying glass and touch up with a liquid resist and a #000 paintbrush before etching. If using PnP as the resist, wipe all dust off the PnP sheet, the original and the copy machine glass. If using ImagOn as the resist, wipe the dust off the exposure cover, the transparency master and the ImagOn before exposing. An electrostatic dust cloth works well for this.

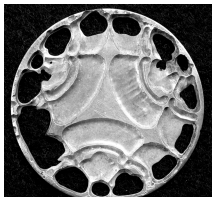
## Problems with the Etching Bath

***Flotsam collects in the electro-etching bath:*** This is often the natural result when electro-etching. Filter the bath through a coffee filter if it gets too bad. Sodium bisulfate for copper and ferric nitrate for silver make for relatively "clean" electro-etching baths.

***Electro-etching stops or slows:*** Check all the connections with a multimeter. Clean all the "gunk" off the piece (anode) and the cathode. Use a more concentrated electrolyte. Add more current by attaching several 1.5V batteries in parallel. Move the anode and cathode closer together.

***Chemical etching is too slow:*** Renew the bath. If the bath is new, dilute the bath. Add heat if the work area is cool or add movement or add both to the bath. Keep your metal piece free from etchant residue. If the metal is tarnished, pickle it to remove the oxide before etching. If using ferric chloride, add some old solution to jump-start the new bath before adding your piece.

## Problems with the Etching



Etchant too strong!

***Undercutting or lines etch away:*** Etch for a shorter time by replenishing an exhausted bath or by heating and/or agitating the bath. Use a milder etchant. Make sure your resist lines are all wider than the depth you will be etching.

***Uneven etching:*** Move the piece around in the vat. If using bubblers install them so they cover the vat evenly. The edges of a piece in an electro-etching bath will naturally etch more deeply than the middle of the metal. Pieces larger than 2" in a magnetic stirring device may etch unevenly due to the currents that are set up.

Resist too weak

***Places on the metal don't etch at all:*** There may be resist there even if you don't see it. Rub those places with isopropyl alcohol and/or scrape them off with a stylus or knife blade.

***Resist degrades:*** Reduce the etchant temperature. Dilute the etchant concentration. Shorten the etching time. Use a suitable etchant for the type of resist or choose a suitable resist for the type of etchant and the depth you need to etch.

## Problems Removing the Resist & Etching Residue

***ImagOn will not come of after etching:*** Make a stronger and/or hotter sodium carbonate resist remover solution.

***Etching Solution Residue will not rinse off:*** Immediately after etching soak the piece in a mixture of vinegar and table salt or a 50% ammonia solution. Or scrub with Penny Brite and an old toothbrush.

# AFTERW0RD

And there you have it. That is what I know about etching for jewelers and enamelists. I hope it has been useful to you. Remember that I said in the introduction that the fastest etching was not the best etching because it results in deteriorated resist and ragged design lines. Plus fast etching is more likely to release toxic chemicals into the air that you are breathing. I etch deeply for my champlevé enamel work – somewhere between 1/32" and 1/16". It is not unusual for my copper etching in ferric chloride to take 7 hours even when aerated. Etching silver in ferric nitrate takes even longer. Chemical etching with spray or a magnetic stirring device is faster but there are more costs involved with the set up. Electro-etching is somewhat faster particularly with silver. Find the method that you are most comfortable with and you will be rewarded with a deep, precisely etched piece.

"Sunflower" pin, relief-etched copper

Enameled "Sunflower" pin, gold plated Champlevé

**Mixing Chemicals**
To make a 1:4 solution of liquids mix 1 unit of liquid X to 3 units of liquid Y to make 4 units total. For example add 1 cup of water to 3 cups of liquid ferric chloride to make 4 cups of a 1:4 solution.
To mix dry and wet ingredients together weigh the dry ingredient and find the volume of the wet ingredient. For example to make a 3% solution of salt water weigh out 3 grams of salt and add enough water to make 100 ml of solution. Or weigh out 30 grams of salt plus enough water to make 1 liter to make 1 liter of solution.

*Ammonium Persulfate and Sodium Persulfate*

1 pound ammonium persulfate or sodium persulfate
1 gallon of water

Mix the persulfate into the water and let the solution sit overnight. Use 2 pounds of the persulfate to one gallon of water if you have a lot of copper to etch away.

*Asphaltum plus*

6 parts liquid asphaltum
3 parts beeswax
1 part rosin

Break the beeswax into chunks and put them in a can or jar of hot water on a hot plate. Do not use a gas stove. Be careful, this is a flammable mixture. After the beeswax has melted, add the asphaltum and stir to combine. In another container in the hot water bath, mix the rosin with a solvent composed of equal parts turpentine and rubbing alcohol. When the rosin has completely dissolved, slowly add it to the beeswax/asphaltum mixture and stir constantly until all the ingredients are completely mixed. Remove the container from the heat and as the mixture cools, stir it every few minutes to keep the rosin from settling out. When cool you may need to thin it with rubbing alcohol and turpentine to the proper consistency. Make it thinner for painting and thicker for screening. You must have very good ventilation while mixing this up.

*Citric Acid*

66.7 grams (2 1/3 oz.) citric acid powder to
.2 liters (1 cup) hot water

Gradually add the citric acid to the water until dissolved.

*Cupric Chloride*

50 grams cupric chloride powder
50 grams sodium chloride (table salt)
500 milliliters hot water
100 milliliters citric acid solution

Mix the dry ingredients together. Mix the liquid ingredients together. Add the dry to the liquid and stir to dissolve.

*Edinburgh Etch*

1 part of citric acid solution
4 parts of liquid ferric chloride or ferric nitrate

Mix the liquids together.

*Ferric Chloride (dry)* (Buy liquid ferric chloride when possible.)

13 oz. dry ferric chloride crystals

1 qt. warm water

Add the crystals to the water and stir to dissolve. When mixing from dry crystals add 1-cup salt to each quart of water for a cleaner etch in lieu of citric acid. Mixing this can be dangerous!!!! Only make this with adequate ventilation and safety equipment.

*Ferric Nitrate*

10 ounces ferric nitrate crystals

1 cup distilled water

Add the ferric nitrate to the water and stir to dissolve.

*Nitric Acid Electrolyte*

38 oz. distilled water

2 oz. nitric acid

Pour the nitric acid INTO the water and stir to mix.

*Salt Water Electrolyte*

Warm water

Sodium chloride (Kosher salt or pickling salt)

Continue adding the salt to the water while stirring until you have a saturated solution and the salt begins to precipitate out of solution.

*Salt & Vinegar Pickle*

2 cups white vinegar

4 tablespoons Kosher or uniodized salt

Stir the vinegar and salt together to dissolve the salt. There are many recipes for this pickle, almost any combination will remove firescale, tarnish and etching residue but some will take longer than others to get the job done. Heat this pickle when using it.

*Sodium Bisulfate Pickle & Electrolyte*

2.5 pounds sodium bisulfate

7 pints of warm water

Stir together to dissolve the sodium bisulfate. This will make one gallon of solution. To make a smaller batch add 1 cup sodium bisulfate to 1 quart warm water.

*Sodium Carbonate Developer*

1 level tablespoon sodium carbonate

¼ cup hot distilled water

Room temperature distilled water to make 1 liter

Dissolve the sodium carbonate in the hot water. Then add the room temperature water to make 1 liter.

*Sodium Carbonate Resist Remover*

½ cup sodium carbonate

1 liter of hot water

Mix together and use hot to remove resists. It will take 15 – 30 minutes to remove the resist. You can also use old developer solution (above) and soak a piece overnight.

*Sulfuric Acid Electrolyte*

38 oz. distilled water

2 oz. sulfuric acid

Pour the sulfuric acid INTO the water and stir to mix.

## Resist Options

***Toner transfer vehicles***: Press & Peel Blue (PnP), Pulsar transfer paper, photo paper, transparency film

***Heat sources for toner transfer***: electric hair straightener, griddle, household iron, toaster oven, electric frying pan, T-shirt press, "monocoat" iron, pouch laminator

***Photosensitive films***: ImagOn, Puretch, Z-Acryl

***Master for light sensitive films***: printed transparency film, hand cut Rubylith™

***Transparency imaging***: photo inkjet printer, color copier, reprographics companies, laser printer

***Light sources for photosensitive films***: UV light bulbs, photo lights, fluorescent black lights, grow lights, sunlight, halogen lights, (note: halogen lights are relatively inexpensive and easy to find but they are very hot and may damage the Plexiglas cover, the transparency master and/or the film)

***Pressing transparency master to film when exposing***: glass or Plexiglas clipped sandwich, water + squeegee for laser printer or copy machine original, Citra Solv™ + squeegee for ink jet originals, expose with the transparency master and film under water (the water holds the master tight against the film)

***Design Resists***: embossing powder with rubber stamp; paint pens; spray paint with stencil; sticky back shapes; asphaltum; PnP; Pulsar Toner Transfer paper; ImagOn film; Puretch film; Z-Acryl film; hand cut stucco tape, anodizer's tape, plater's tape, 3-M #854 polyester film tape or Etchall™ etchmask,

***Resist removers***: 40% soda ash for films, Z-Acryl, Lascaux Plate Backing Resist and Future Floor Finish; Citra-solv for inks, embossing powder, spray paint, asphaltum, PnP and finger nail polish; lacquer thinner or acetone for Staedtler red permanent ink, Sharpie ink, embossing powder, PnP, finger nail polish and lacquer spray paint and embossing powder; Goo Gone™ or rubbing for sticky back materials; mineral spirits for liquid rubber and asphaltum; denatured alcohol for Lascaux Plate Backing Resist, Z-Acryl and Future Floor Finish, household ammonia for Z-Acryl and Future Floor Finish

***Screen frames***: wood slats, metal window screen frames, canvas stretcher frames, ready made wood or plastic screen frames, picture frames, plastic DIU frames, sheet metal and magnets without a frame


**Making asphaltum plus**

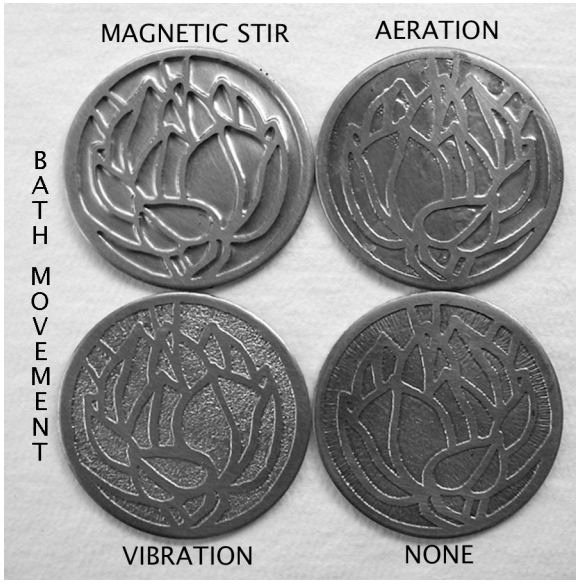
## Etchant Options

***Chemical etchants for copper***: Ferric chloride, cupric chloride, ammonium persulfate, sodium persulfate
***Chemical etchants for silver***: ferric nitrate, silver nitrate
***Electrolytes for copper***: salt water, sodium bisulfate, 5% sulfuric acid
***Electrolytes for silver***: silver nitrate, ferric nitrate, 5% nitric acid

## Bath Options

***Piece extensions for electro-etching***: bell wire (taped or soldered), plastic coated electrical wire (taped or soldered), long tab of metal as part of piece and protected with resist where it will be in the bath, a length of taped or soldered tooling foil protected with resist such as liquid rubber except on the two ends
***Heat sources for chemical baths***: heating pad, fish tank heater, light bulb, hair dryer, microwavable hot packs, hot water bottle, double boiler method (a container within a container, the outer container filled and refilled with hot water)
***Direct current***: 1.5V flash light batteries in a battery holder, a rectifier, a constant current/voltage power supply
***Bath or piece movement***: air pump bubbles, garden spray, rocking, vibrating, stroking, direct rub
**Aerator options**: holes in airline, fish tank "bubblers"

EXAMPLES OF BATH MOVEMENT/1 HOUR IN FERRIC CHLORIDE



## Supplies & Services

**Airline:** tropical fish stores, hardware stores
**Air stones:** tropical fish stores, pet stores
**Alligator clips:** Radio Shack, hardware stores, electronic supply stores
**Ammonium persulfate:** D & L Products, Inc., chemical supply houses
**Anodizer's tape:** Reactive Metals Studio
**Asphaltum:** Daniel Smith, Graphic Chemical and Ink, printmaking supply stores, Rio Grande Jewelry Supply, Thompson Enamel, Renaissance Graphic Arts
**Battery holders:** Radio Shack, Willy's Electronics
**Beeswax:** Graphic Chemical, candle-making supply stores, SSS Chemicals, Renaissance Graphic Arts
**Bell wire:** hardware stores
**Citra-solv:** health food stores, hardware stores
**Citric acid:** Thompson Enamel, Graphic Chemical, drug stores, Science Company, SSS Chemicals
**Commercial etchers a.k.a chemical etchers, chemical millers, photo etchers, and photochemical machiners:** Aculine Corp. (copper and brass) International Etching (fine and sterling silver), David Fell (shallow etches on silver)
**Constant current power supplies:** Sale Stores, electronic supply stores
**Copper and brass etchers:** Acu-Line Corp., chemical machining shops
**Cupric Chloride:** Science Company, Integra Chemical, chemical supply houses
**Dura-film screen:** Martronics Corp.
**Electrical wire:** hardware stores, electronic supply stores
**Electrodes:** Rio Grande, Science Company, D & L Products, Inc., copper and silver suppliers
**Electro-etching kits:** Sheri Haab
**Embossing pads, pens and powder:** Kmart, rubber stamp stores, craft supply stores, scrap-booking stores, stationary stores
**Etching kits:** MicroMark
**Etching machines:** Metacafe, Sheri Haab
**Etching tanks:** Daniel Smith, Graphic Chemical and Ink, Dick Blick, Circuit Specialists, Inc., Renaissance Graphic Arts, Willy's Electronics
**Etchmask:** B & B Etching Products
**Exposure units:** Dick Blick, Martronics Corp., EZ Screen Print, Circuit Specialists, Inc., Renaissance Graphic Arts, Circuit Bridge
**Exposure frames:** EZ Screen Print, Martronics, Circuit Bridge, Welsh Products
**Ferric chloride:** Radio Shack (PCB etchant), D & L Products, Inc., Fisher Scientific, Graphic Chemical and Ink, MG Chemicals, Willy's Electronics, Zacryl.com, Science Company, SSS Chemicals, Art Chemicals, Renaissance Graphic Arts, chemical supply houses
**Ferric nitrate:** Fisher Scientific, Science Co., Art Chemicals, SSS Chemicals, chemical supply houses
**Fish tank pump:** tropical fish stores, pet stores, large grocery stores
**Fluorescent bulbs:** hardware stores, fish stores, Energy Saving Products (Lights of America #2342, 42 watt compact fluorescent bulb), Sally's Beauty Supply (UV light for nails)
**Gray scales a.k.a. exposure step scale, exposure calculator, step wedge kit:** Graphic Chemical, D & L Products, Inc., Takach Press
**ImagOn:** Daniel Smith, Graphic Chemical and Ink, Enamelwork Supply Co., Takach Press, Renaissance Graphic Arts
**Jumper leads:** Radio Shack, electronic supply stores

**Lascaux Plate Backing Resist:** Graphic Chemical and Ink
**Lascaux Remover:** Graphic Chemical
**Magnetic stirrers and stir bars:** Fisher Scientific, Rio Grande Jewelry Supply, scientific supply houses, laboratory supply companies
**Multimeter:** Radio Shack, electronic supply stores
**Paint pens:** art supply stores
**PnP Blue:** Enamelwork Supply Co., Techniks, Thompson Enamel
**Penny Brite:** grocery stores, hardware stores, Enamelwork Supply Co., enameling supply companies
**Presensitized copper:** Graphic Chemical & Ink, D & L Products, Inc., Renaissance Graphic Arts
**Pulsar Toner Transfer Paper:** Pulsar (a 2-step process that works much like PnP)
**Putz Pomade:** Dick Blick, printing supply companies
**Rectifiers:** Rio Grande Jewelry Supply, jewelers supply companies, plating supply companies
**Rosin**: Graphic Chemical, printmaking supply companies
**Rubylith:** Mister Art, Silk-screening Supplies
**Safety supplies:** hardware stores, scientific supply companies, safety supply companies, Rio Grande, Art chemicals
**Screen frames:** Circuit Bridge, EZ Screen Print, Welsh Products, Northwoods Studios, Welsh Products, Graphic Chemical and Ink, Dick Blick
**Screen-printing screens:** Welsh Products, Martronics Corporation, Yuzu, EZ Screen Print, Northwoods Studios, Circuit Bridge
**Silicon rubber sheets:** McMaster-Carr
**Silver etchers:** David H. Fell & Co., International Etching
**Silver nitrate:** Salt Lake Metals, Science Company, SSS Chemicals, pottery supply companies
**Sodium bisulfate:** Enamelwork Supply, Thompson Enamel, Rio Grande, swimming pool supply companies, spa supply companies
**Sodium carbonate:** grocery stores (Arm & Hammer Washing Soda), Daniel Smith, Graphic Chemical, pottery supply stores, swimming pool suppliers, Art Chemicals
**Sodium persulfate:** D & L Products, Inc., MG Chemicals
**Stamps, polymer (custom**): Rubber Stamping Across America, Repeat Impressions
**Thermometers:** tropical fish stores, cooking stores (glass candy thermometers), scientific supply houses, plating supply companies
**3M Polyester Film Tape #854:** R.S. Hughes, Enamelwork Supply Co.
**Transfer paper:** see www.c2f.com to find retail stores in your area
**Transparency sheets:** art supply stores, office supply stores
**Yudu:** Northwoods Studios, EZ Screen Print, Welsh Products
**Z-acryl film:** Takach Press
**Z-acryl resist:** Graphic Chemical and Ink
**Xuron Micro shear:** Micromark

## Suppliers

**Acu-Line Corp.,** www.aculineetch.com, 206-634-1618, Seattle, WA
**Art Chemicals,** www.artchemicals.com, 510-637-8707
**B & B Etching Products,** www.etchall.com, 888-382-4255, Peoria AZ
**Circuit Bridge,** www.cbridge.com, 408-428-9414, San Jose CA
**Circuit Specialists, Inc.,** www.web-tronics.com, 800-528-147, Mesa AZ
**D & L Products, Inc.,** www.dalpro.net, 1-800-325-3878
**Daniel Smith,** www.danielsmith.com, 800-426-7923, Seattle WA
**David H. Fell & Co., Inc.,** www.dhfco.com, 800-822-199, City of Commerce CA
**Dick Blick,** www.dickblick.com, 800-828-4548, many locations
**Enamelwork Supply Co.,** www.enamelworksupply.com, 206-525-9271 or 800-596-3257, Seattle WA

**Energy Saving Products,** www.esplighting.com
**EZ Screen Print,** www.ezcreenprint.com, 520-423-0409, Casa Grande AZ
**Fisher Scientific,** www.fishersci.com, 412-490-8300 or 800-766-7000, Pittsburgh PA
**Graphic Chemical & Ink Co.,** www.graphicchemical.com, 630-832-6004 or 800-465-7382, Villa Park IL
**Integra Chemical Co.,** www.integrachem.com, 425-277-9244 or 800-322-6646, Renton WA
**International Etching,** www.internationaletching.com, 888-781-6800, Providence RI
**La Grand Industrial Supply,** 2620 S.W. First, Portland, OR 97207, 503-224-5800.
**MG Chemicals**, www.mgchemiicals.com, 1-800-201-8822
**Martronics Corp.**, www.etch-o-matic.com, 1-800-775-0797, Salkum WA
**McMaster-Carr,** www.mcmaster.com, 630-833-0300, Chicago IL
**Micromark,** www.micromark.com, 800-225-1066
**Mister Art**, www.misterart.com, 800-721-3015, Houston TX
**Northwoods Studios,** www.northwoodsstudios.us
**Pulsar**, www.pulsar.gs, 727-524-1500, Clearwater FL
**Reactive Metals Studio**, www.reactivemetals.com, 800-876-3434, Clarkdale AZ
**Renaissance Graphic Arts,** www.prinmaking-materials.com, 888-833-3398, Ivyland PA
**Repeat Impressions,** www.repeatimpressions.com, 207-865-3794, Freeport ME
**Rio Grande,** www.riogrande.com, 505-839-3300 or 800-545-6566, Albuquerque NM
**Rubber Stamping Across America,** www.rubberstampit.com, 585-451-8797, Victor NY
**SSS Chemical,** www.ssschemical.com, 800-862-5958, Los Angeles CA
**Sale Stores,** wwwsalestores.com
**Sally's Beauty Supply,** www.sallybeauty.com, 866-234-9442
**Salt Lake Metals,** www.saltlakemetals.com, 800-387-7008, Salt Lake City UT
**Science Company,** www.sciencecompany.com, 800-372-6726, Denver CO
**Sheri Haab,** www.sherihaab-store.com, Springville UT
**Silk-screening Supplies**, www.silkcreeningsupplies.com, 800-314-6390
**Takach Press,** www.tacachpress.com, 800-248-3460, Albuquerque NM
**Techniks,** www.techniks.com, 908-788-8837 (fax)
**Thompson Enamel,** www.thompsonenamel.com, 606-291-3800, Newport KY
**Welsh Products,** www.welshproducts.com, 800-745-3255, Benicia CA
**Willy's Electronics**, www.willyselectronics.com, 888-294-5597
**Yudu,** www.yudu.com, sold through Wal-Mart, Jo-Ann Fabrics & Crafts, Amazon.com

# APPENDIX HEALTH & SAFETY

ETCHING MATERIALS HEALTH & SAFETY HAZARD RATINGS

Note: This list contains an overview of the health and safety issues encountered with the etching materials covered in this book. It is worth your while to check the Internet for individual material safety data sheets (MSDS's). You will find more complete information there for the materials you are considering. Not all MSDS's have the same ratings for the same materials. If I found the ratings to differ, I added the additional rating in parentheses.

*Codes*

**0** = Minimal hazard (health - no significant risk to health, fire - materials will not burn, reactivity – materials are normally stable)

**1** = Slight hazard (health - irritation or minor reversible injury possible, fire – materials must be preheated before ignition will occur, reactivity – materials can become unstable at high temperature and pressures)

**2** = Moderate hazard (health - temporary or minor injury may occur, fire – materials must be moderately heated or exposed to high ambient temperatures before ignition will occur, reactivity – materials are unstable)

**3** = Serious hazard (health - major injury possible unless prompt action is taken and medical treatment given, fire – materials capable of ignition under almost all normal temperature conditions, reactivity – materials that may form explosive mixtures at normal temperature and pressure)

**4** = Severe hazard (health - life threatening, major or permanent damage may result from single or repeated overexposures, fire – flammable gases or very volatile flammable liquids, reactivity – readily capable of explosive decomposition at normal temperature and pressures)

*Materials*

**Acrylic Spray Paint:** health-2, fire-4, reactivity-0 (wear safety glasses & use general exhaust)

**Ammonia** (household)**:** health-3, fire–1, reactivity–0 (wear goggles, gloves and use local exhaust)

**Ammonium persulfate:** health–2, fire–0, reactivity–3 (wear safety glasses, gloves, an apron and a dust respirator)

**Asphaltum (liquid):** health-1(2), fire–1, reactivity–0 (wear safety glasses and gloves)

**Beeswax:** health–1, fire–1, reactivity-0 (wear safety glasses, gloves and a dust respirator)

**CitraSolv:** health–2, fire–2, reactivity–0 (wear safety glasses and gloves)

**Citric acid:** health-2, fire–1, reactivity0 (wear safety glasses, gloves and an apron)

**Cupric chloride:** health–2(3), fire-0, reactivity-0(1) (wear safety glasses, gloves and an apron, ventilate if used with heat or electricity)

**Denatured alcohol:** health–1, fire–3, reactivity–0 (wear safety glasses, gloves and a fume respirator if needed)

**Ferric chloride 41˚ Baume:** health–2(3), fire–0, reactivity–2 (wear safety glasses, gloves and an apron, ventilate if used with heat or electricity)

**Ferric nitrate (crystals):** health-1, fire-0, reactivity-0 (wear safety glasses, gloves, an apron and a dust respirator, ventilate if used with heat or electricity.)

**Lacquer thinner:** health–2, fire-3, reactivity-0 (wear splash goggles, protective gloves and use good ventilation)

**Liquid rubber (Plasti Dip™):** health-2, fire-4, reactivity-0 (wear impervious gloves)

**Nitric acid:** health-3(4), fire-0, reactivity-2(3) (wear splash goggles, gloves, an apron and a vapor respirator)

**Paint thinner**: health-1, fire-2(3), reactivity-0 (wear splash goggles, protective gloves and use good ventilation)
**Putz Pomade**: health-1, fire-1, reactivity-0 (wear safety glasses and gloves)
**Rosin**: health-1, fire-1, reactivity-0 (wear goggles, gloves and use local exhaust)
**Silver nitrate**: health-2(3), fire-0, reactivity-0(3) (wear safety glasses, gloves, an apron and a dust respirator, ventilate if used with heat or electricity)
**Sodium bisulfate**: health-1(3), fire-0, reactivity-0(1) (wear safety glasses, gloves and a dust respirator when mixing)
**Sodium carbonate**: health-1(2), fire-0(1), reactivity 1(2) (wear safety glasses and gloves)
**Sodium chloride (salt)**: health-0, fire-0, reactivity-0 (no safety equipment necessary, ventilate if used with heat or electricity)
**Sodium persulfate**: health-2(3), fire=0(1), reactivity 2(3) (wear safety glasses, gloves, an apron and a dust respirator)
**Sulfuric acid**: health-3(4), fire-0, reactivity-2 (wear splash goggles, gloves, an apron and a vapor respirator)
**Turpentine**: health-2, fire-3, reactivity-0 (wear splash goggles, gloves and a vapor respirator)

# APPENDIX COMPARISONS

## CONSIDERATIONS FOR CHOOSING RESISTS

**Hazard Progression for Design Resists (from least to most harmful)**
Sticky Back Material ➔ Imag-On ➔ PnP ➔ Sharpies, Paint pens ➔ Embossing Powder ➔ Finger Nail Polish/Lacquer Spray Paint/Asphaltum Based Grounds

**Durability Progression for Design Resists (from most to least durable)**
Imag-On ➔ PnP ➔ Asphaltum ➔ Lacquer Spray Paint/Embossing Powder ➔ Plastic Sticky Back Materials ➔ Paper Sticky Back Materials ➔ Paint pens ➔ Sharpies

**Durability Progression for Back and Edge Resists (from most to least durable)**
Plasti-dip ➔ Z-Acryl/Finger Nail Polish/Future/Lascaux Plate Backing Resist ➔ Lacquer Spray Paint ➔ Plastic Sticky Back Materials ➔ Asphaltum

**Controlled Design Potential (from most controllable to least)**
PnP, Imag-On, ➔ Sharpie and Paint Pens ➔ Asphaltum with silk screen ➔ Hand cut Sticky back material ➔ Spray paint with stencil ➔ Embossing powder with stamp

## CONSIDERATIONS FOR CHOOSING THE BATH

| ETCHANT (METAL) | INITIAL COST | CONTINUING COST | SPEED OF ETCH | HAZARD | EASE OF OPERATION |
|---|---|---|---|---|---|
| FERRIC NITRATE (SILVER) | 3 | 3 | 6 | 2 | 1 |
| FERRIC CHLORIDE (COPPER) | 2 | 2 | 5 | 3 | 1 |
| DILUTE $H_2SO_4$ ELECTROLYTE (COPPER) | 4 | 1 | 4 | 3 | 2 |
| DILUTE $HNO3_3$ ELECTROLYTE (SILVER) | 4 | 1 | 3 | 3 | 2 |
| NITRIC ACID (COPPER/SILVER) | 5 | 4 | 1 | 4 | 3 |
| SODIUM CHLORIDE ELCTROLYTE (COPPER) | 1 | 1 | 4 | 1 | 2 |
| FERRIC NITRATE ELECTROLYTE (SILVER) | 3 | 1 | 2 | 2 | 1 |
| SODIUM BISULFATE ELECTROLYTE (COPPER) | 2 | 1 | 3 | 2 | 1 |

My subjective comparisons of different baths. 1 = "good", i.e. least expensive, least toxic, fastest working. 6 = "bad", i.e. most expensive, most toxic, slowest working.

# APPENDIX SOURCES OF INFORMATION

*Books & magazines*


Alexander, Dauvit, "Electrolytic Etching", SNAG News, Vol. 15, No.2, March/April 2007.

Adam, Robert & Carol Robertson Intaglio, Thames and Hudson 2007. Instructions for use of safety conscious resists and mordants. Most of the techniques are for printmakers but some are applicable to jewelry etching.

Henley 20th Century Book of 10,000 Formulas. An amazing book of all kinds of formulas including those for etching mordants (etchants).

Kasten, Stephen, Electronic Prototype Construction, pp 214-219,1983. Instructions for regenerating cupric chloride. See the web listing below for www.xertech.net.

Leaf, Ruth Etching, Engraving and Other Intaglio Techniques, Dover Publishing 1984. Interesting etched texture suggestions.

Lewis, Tony, "Make your Own Etching Tank", Radio Electronics December 1989. Directions for making a vertical tank for chemical etching.

Woods, Louise Practical Printmaking, Anova Books 2003. Interesting techniques for adding etched texture to metal.


*Websites*


www.psigate.ac.uk Tutorials on electro-chemistry

www.engr.wisc.edu/roboclub/instructions, PCB Board Creation - directions for using photo paper for toner transfer resist

www.justified-sinner.com/cabinet of curiosities/materials/electrolytic etching. Pictures of his attempts at electro etching.

www.electroetch.com. Comparison tables and comparison plates showing chemical VS electro etching.

www.fullnet.com/~tomg/gooteepc.htm. Using ink jet photo paper for toner resist transfer.

www.ganoksin.com/borisat/nenam/safe_etching.htm. Directions for using the Edinburgh Etch with ferric chloride and citric acid.

www.ganoksin.com/borisat/nenam/photocopy_transfer-etch.htm. Directions for using transparency film to transfer toner resist to metal.

www.greenart.info/galvetch - Cedric Green's excellent explanation of electro-etching written for printmakers but useful for anyone interested in the science of electro-etching.

www.guildof enamelers.org/technical articles. "Reliable Electro-etching for Champlevé Enameling" by R.L. Jackson

www.instuctables.com/if/PCB-Etching-Machine. Video of a homemade rocker for an etching bath.

www.kahiko.com/electroetchsilver. Using phosphoric acid rust remover for electro-etching silver.

www.liquidicecoolant.com. A good chart of the HMIS (Hazardous Materials Identification System) Label fields and what they mean. Look under "F.A.Q's" and then "What is the HMIS label?"

www.macphersoncrafts.com → helpful tips → Lazertran. Instructions for using Lazertran as a toner transfer vehicle.

www.mallbaker.com. A source for clearly presented MSDS's.

www.members.optusnet.com.au. Directions for regenerating cupric chloride.

www.metacafe.com. Videos of a "rocker" etching device, a professional spray etching machine, applying Puretch photo resist and electro-etching set ups.

www.mordent.com. Electro-etching with a paper transferred toner resist.

www.pcmi.org - listing of photochemical machinists

www.polymetaal.nl. Directions for using Puretch film resist.
www.pulsarprofx.com. Directions for using a dowel to add pressure for ironing on toner reisist. Look under the "tips and tricks" section.
www.steampunkworkshop.com/electroetch.shtml. Electro-etching brass.
www.streampunkworkshop.com/altoid-etch.shtml. Electro-etching with salt water.
www.en.wikipedia.org/wiki/Electrochemistry. Explains the theory behind electro-etching.
www.polymetaal.nl → intaglio materials → photosensitive plates and films, Directions for using Puretch
www.xwetech.net/Tech/CuCl_ech.html. A web copy of the Stephen Kasten book segment listed above. The same link shows you his homemade bubble etching tank using a plastic ice chest.
www.youtube.com. Look under "photo resist etching" for videos on paper toner resist transfer.

Etched and enameled wall plaque, "Olympic Mountains"

**alligator clip** – A spring-loaded clip with serrated jaws, often used to make temporary electrical connections.

**Ammonium Persulfate** – $(NH_4)_2S_2O$, white crystals soluble in water used as an oxidizing agent in etching.

**amperage** – The rate of flow of an electric charge. In an electrolyte this flowing electric charge is carried by ions.

**anode** – The positive electrode in a circuit.

**asphaltum** – Bituminous material in oil of turpentine used as an etching resist.

**asphaltum plus** – Asphaltum with added rosin and beeswax to make it more durable.

**Basse taille** – An enameling technique in which a design is removed in the underlying metal by etching or other means. Translucent enamels are applied over the entire piece allowing the design to remain visible through the enamel. The hue of the enamel changes with the depth of the glaze, resulting in subtle variation in color over the high and low design elements.

**battery holder** – A plastic case with the shape of the housing molded to hold a flashlight battery.

**Baumé** – A measurement in degrees of the specific gravity of a liquid.

**bell wire** – A coated copper wire used in low-current, low-voltage applications such as doorbells.

**burnish (v)** – To rub with a tool in order to smooth or press a material down to a substrate.

**bus bar** – A solid electric conductor through which an electric current enters and can be distributed.

**cathode** – The negative electrode in a circuit.

**Champlevé** – An enameling technique in which depressions are created in a metal by etching or otherwise and filled with vitreous enamel powders. The raised metal lines form the design.

**chemical etching** – A means of removing metal with an appropriate acid or salt.

**citric acid** – A mild, food grade acid used to retard the formation of sludge while etching.

**constant current regulator** – An electronic circuit that generates a constant direct current.

**Cupric Chloride** – $CuCl_2$, a yellowish-brown powder soluble in water. Used as a copper etchant.

**DC power** – The abbreviation for "direct current", electric current flowing in one direction only.

**direct current** – See DC power.

**"direct rub"** – An etching technique wherein the etcher rubs a metal piece against a sponge soaked with ferric chloride or ferric nitrate etchant.

**electrode** – A conductive electrical terminal.

**electro-etching** – A means of etching with a DC power source and an electrolyte.

**electrolyte** - A chemical compound that ionizes to produce an electrically conductive medium.

**emulsion** - a light-sensitive coating on paper or film that consists of fine grains of silver bromide suspended in a gelatin.

**etchant** – An acid, salt, base or oxidizer solution used to chemically remove unprotected areas of a metal.

**exothermic** – Denoting a chemical reaction that releases heat.

**Ferric Chloride** – $FeCl_3$, a salt used to etch copper or brass.

**Ferric Nitrate** – $Fe(NO_3)_3 \cdot 9H_2O$, colorless crystals, soluble in water used to etch fine silver and sterling silver.

**firescale** – A red (cuprous oxide) and a black (cupric oxide) scale that forms on copper at high temperatures in the presence of oxygen.

**flash bite** – A short etch to determine if unwanted resist remains on an area to be etched.

**gray scale** – A strip of film usually divided into 10 discreet steps from clear to dark black. Used to determine exposure times for photosensitive films.

**Intaglio etching** – To etch by covering a plate of metal with an etching resist and scribing through the resist to create a design that will etch down into the plate.

**jumper leads** – A conductor that electrically connects one circuit element to another.

**leads** – See jumper leads.

**MSDS** – Abbreviation for Material Safety Data Sheets. An MSDS includes information on chemicals and may include instructions for the safe use and potential hazards associated with a particular material.

**multimeter** – An instrument designed to measure electrical quantities of AC or DC voltage, amperage and resistance.

**Nitric Acid** – $HNO_3$, a colorless, fuming, highly corrosive liquid used for etching metals. A strong acid that can cause severe burns.

**oxidation** – The result of a chemical reaction in which a material gives up electrons. Tarnish and firescale are examples.

**photosensitive films** – A film treated with a chemical that undergoes a chemical reaction when exposed to light.

**pickle** – A chemical solution used as a bath to remove scale and oxides from the surface of metals. Sparex™ and a solution of vinegar and salt are examples.

**pre-sensitized copper** – Copper treated with a layer of photosensitive material.

**rectifier** – A device that converts alternation current (AC) to direct current (DC).

**refractory fiber** – A material that has a high melting point and is hard to melt.

**relief etching** – To etch by protecting areas of a metal by applying resist to the areas that are to remain raised.

**resist** – A substance used to cover and protect metal from etching away.

**resistance** – A measure of the degree to which an electrical component opposes the passage of current (amperage).

**resist remover** – Any substance that will remove a resist.

**silicon rubber sheets** – A rubber-like material that is generally non-reactive, stable and resistant to extreme environments and temperatures.

**Silver Nitrate** – $AgNO_3$, a poisonous colorless crystalline compound that can be used to etch silver.

**sludging** – A semisolid material that may precipitate when etching metal with some etchants.

**Sodium Bisulfate** – $NaHSO_4$, an acid salt used for removing firescale and for electro-etching copper or brass.

**Sodium Carbonate** – a white powder used for developing and removing some photosensitive films.

**Sodium Persulfate** - $Na_2S_2O_8$, A strong oxidizer used to etch copper.

**stop out – A** resist to prevent an area of metal from etching.

**Sulfuric Acid** – $H_2SO_4$, a highly corrosive, colorless liquid used to etch metal.

**toner** – A powdery ink used dry to produce a photocopy.

**transfer paper** – A paper that is coated with a preparation for transferring a design to another surface.

**transparency master** – The term used in this book denoting the negative original on clear plastic for imaging photosensitive film.

**transparency sheet** – A piece of thin clear plastic that can be written on, photocopied on or drawn upon.

**undercutting** – The undesirable lateral etching of metal by etchants.

**voltage** – The potential to cause current, to cause something electrical to happen. A 1.5V. battery has the potential to deliver 1.5V of power once it connected to something.

**water break test** – The process of pouring water onto a surface to determine whether oil remains. If the water beads, oil is present.

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