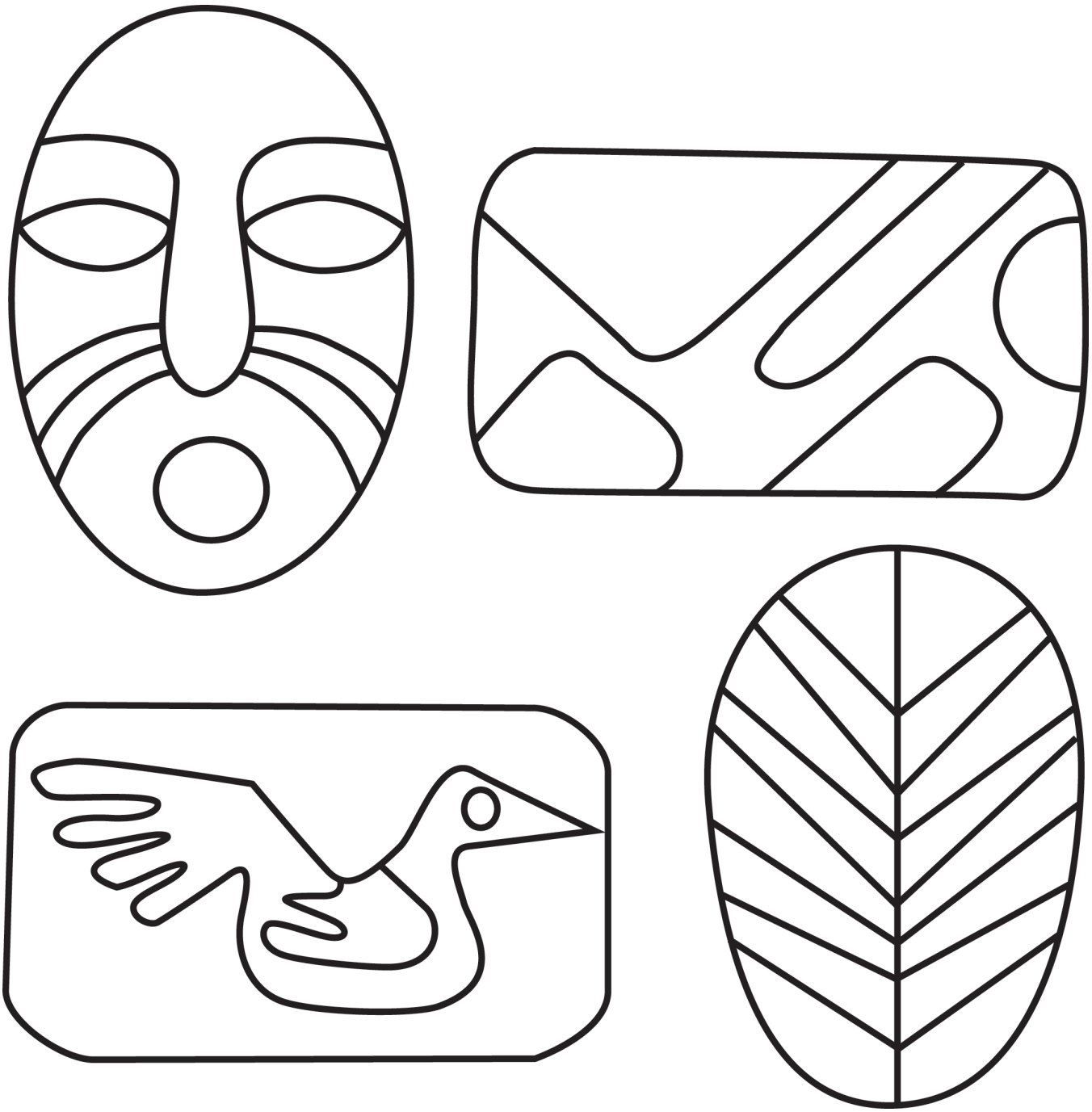
Arts & Communication

METAL ENAMELING

Member Guide

Pub. No. 4H158



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Introduction

Enameling is the process of applying a thin coat of finely ground glass to a metal. When heated to a high temperature, the glass melts and fuses to the metal.

Enameling is a vehicle for both a creative and technical art experience. The *art* of enameling involves the design of lines, shapes, colors and textures into imaginative images by means of the technique or *craft* of enameling. The practice of these techniques may take considerable experience before it is fully understood and controlled. Yet, there are many aspects of the process which allow simple steps on the way to achieving great skill.

Enamels applied to metals produce various color effects. With careful experimentation, the subtle variations in color and form can be controlled. The real joy in enameling lies in creating a design motif which exploits the brilliance of the enamel colors through technique and control. Fusing the enamel to the copper surface with heat completes a project which in the beginning existed only in one's imagination.

The processes of enameling are not difficult to learn, but should be taught and practiced in logical order to ensure good results and allow success. Most important is what is done with the knowledge gained and the skills developed and how these will differ with each experimenter. This becomes the personal and unpredictable ingredient in art called creativeness and it affords the greatest amount of satisfaction and pleasure.

You can start with simple jewelry projects, such as earrings, pins, pendants, tie clips, cuff links, plaques and shallow trays, which will be both useful and pleasing to the eye. With more experience, you can progress to the making of deep trays, cups and steep sided bowls. Enamel plaques or panels may be attached to wooden jewelry boxes, lamp bases and similar articles. You may choose to shape the metal (prior to firing) into various free-standing sculptural forms.

For more information on sources of supplies, resource books and periodicals, kiln preparation and maintenance, adhesive agents and binders, safety precautions and other suggestions, see your project helper or consult the *Metal Enameling Helper Guide* (CIROO9).

History of Enameling

It is believed that vitreous enamel work had its beginning with early civilizations around the Mediterranean from the sixth century B.C. or even earlier. Greek sculpture from the fifth century B.C. shows surfaces with areas of inlaid metal covered with enamel. The ancient Greek goldsmiths inlaid their jewelry with thin coatings of white and blue enamel between gold wires. This is one of the first examples of the cloisonné process. By the third century B.C., the enamel process had spread to England and Ireland. The process continued to move slowly from Europe to Asia Minor and the Middle East, to India and China, and then to Japan by the third century A.D.

The early Celtics of the British Isles left us many examples of unusual enamel work. The molten enamel was applied to their buttons and to their shields and swords. From them we acquired the process of applying enamel to sunken or carved out areas of metal. This process is called champlevé.

From the Byzantine Empire, around the sixth century A.D., we have found enameled details set in jeweled objects, such as bracelets, crowns, brooches and rings. The enamel work of these craftspeople during this period was outstanding and important to them, along with metal working and jewelry crafting. The enamel artisans of Europe became closely associated with the designing of royal jewelry and church art. Richly jeweled and enameled crucifixes, vessels and alter boxes are found very well preserved in many of the cathedrals today.

Shortly after 1500 A.D. an important new direction was taken in enameling. This occurred in the French town of Limoges. It was a process of painting with finely ground enamel on the surface of the metal. This method reached a high level of achievement in the miniature portraits of the day. In fact, Henry VIII of England chose one of his wives from a miniature portrait presented to him.

The Chinese and Japanese craftspeople contributed and continue today to create many fine examples of enamel work, particularly in cloisonné vases, urns, trays and boxes.

Early in the 19th century the process of enameling expanded from an art or artisan's craft into an industry. Today, many creative artists are attracted to the versatility of enamel techniques and materials for making small portable objects or even for panels integral to architecture.

Enameling today

We find many enamel articles regularly used in our homes, offices and schools. Enameling is being taught in colleges and schools across the country, both as a profession within the arts and as a hobby.

In the past the preparation of enamel for the craftsperson's use involved many hours of tedious grinding. Today, this has been eliminated through industrial processing so craftspeople can devote more time to the creative process. (Washing is still a good idea, as transparency, clarity of color and smoothness of surface are affected by cleanliness.)

The quantity of enamel used in craft activities is relatively small compared to what is used in the enameling industry. As a result, a higher quality of enamel is available at a lower cost for craft work.

Enamel or, more precisely, porcelain enamel is essentially a vitreous compound composed of silica, borax and potash. It is similar to the material used in making glass for chinaware. Unusual color effects are obtained by adding small amounts of metallic oxides to the base enamel.

The mass production of enamel for industrial use starts with melting large quantities of silica or sand, potash and borax with metallic oxides for color in a large furnace. The resulting hard material is called glass or frit. This is broken into smaller pieces and is ground in a Ball Mill with a capacity of 1,000 to 3,000 pounds. The pieces are ground to sieve fineness of 80, or 180 to 200 mesh, or whatever the manufacturer requires.

The size refers to the number of openings per inch between the wires in the sifting screen. Enamel for artistic use is obtained at this stage and packaged for individual use. Most craft enamels are purchased as 80 mesh, which is about equal in coarseness to table salt or sugar.

Commercial enamels are used extensively in the manufacture of domestic and industrial articles. Enamel applied to sheet iron and cast iron constitutes a major part of the ceramic industry in the United States today. This enamel coating has a hard glossy surface, highly resistant to corrosion and scratching. These properties make it invaluable in the manufacture of sanitary objects and food containers.

On an industrial basis, enamel has been used extensively for refrigerators, washing machine tubs and stoves. In recent years, porcelain enamel has been used for advertising signs, chemical and food tanks, hospital furniture and meat market cases. Further use for it has been discovered in architecture for facing the panels of interior and exterior building walls.

Materials

Enamel for crafts

Enamels are purchased in different types – finely ground powder, lumps, threads, liquid suspensions, oil based colors, etc. Enamel powders are either of opaque or transparent colors, each having its own characteristics. The opaque enamels produce a solid color effect completely covering the surface underneath. An opaque color is often used as a base coat with other enamels applied over it. Transparent enamel provides a color effect which permits the color of the enamel or metal underneath it to be seen. The effect is similar to looking through colored cellophane or tinted window glass.

The blending and overlapping of transparent with opaque enamels comprises a most creative aspect of enameling. After the basic processes of enameling are well understood through simple projects, experiments with mixtures of opaque and transparent colors should be tried on sample color pieces.

The lumps and threads of enamel are actually amounts of the enamel hardened from a molten stage into odd-shaped pieces or drawn-out threads of glass. These provide exciting spots or lines of brilliant color when used on solid areas of color or imbedded in transparent areas. Liquid form enamels are finely ground glass in distilled water; pre-mixed colors in oil are also available.

Metals for enameling

Copper has been the most inexpensive and satisfactory metal for use in enameling. It is easy to cut and shape and offers the fewest problems in fusing the enamels to its surface. Copper can be obtained in sheets or pre-cut shapes through enamel suppliers, at large industrial sheet metal shops, or art and hobby stores.

The thickness of copper is measured in gauge sizes. The most commonly available gauges for enamel projects are 16, 18 and 20 gauge. (The smaller the gauge number, the thicker the metal.) It is advisable to use 18 or 20 gauge for small-size projects, such as pins, bracelets and earrings. For small shallow trays and large deep bowls, the heavier 16 gauge is better. Copper foil (.0054" or .010" thick) as well as the more costly gold or silver foils may be used for interesting effects. (Fine silver, though more expensive, has the advantage of not oxidizing and accumulating fire scale as well as affording a cool luster under transparents.)

Choosing the proper thickness of metal for enameling is important because heat causes the metal to warp slightly. If the metal is of sufficient thickness relative to the size of the piece, the warping (bending due to uneven heating and cooling) will not affect the fusing of enamel to the surface. Ground-coated steel and iron tiles or plaques are available from enamel suppliers. It is possible to use steel plate for enameling, called enameling stock. This can be obtained from industrial metal shops in large sheets of 16 or 18 gauge. The tops and doors of electric kitchen stoves are of this type of steel panel.

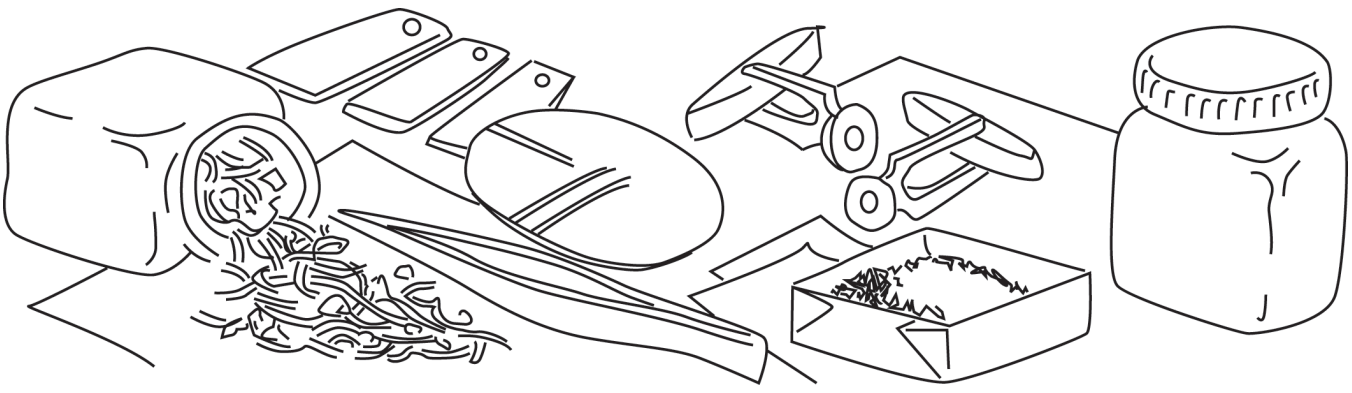
Fine or pure silver sheet and gold can be enameled very satisfactorily, but the cost may be prohibitive. However, they are often used for small jewelry pieces and are an especially handsome base for certain transparent colors. (Sterling silver is not advised.) Silver-plated steel and gilding metal from enamel suppliers are more economical than pure silver or gold for use with transparent enamels.

Other tools and materials

The basic materials and equipment recommended for beginning enameling are listed here. Please consult CIR009, *Metal Enameling Helper Guide,* for an expanded list.

- Opaque black.
- Opaque white.
- Clear enamel flux.
- Transparent – red, green, blue and yellow.
- Opaque – red, green, blue and yellow.
- Two-ounce twist-top glass jar for each enamel. Keep each enamel under cover in a glass jar to prevent any foreign substance from contaminating the powder and to prevent accidental mixing of colors. Baby food jars and lids or similar are useful, as are small black plastic film canisters with lids.
- Selection of either pre-cut or hand-cut copper blanks in square, rectangular, oval and circular shapes. These shapes should be approximately two inches or more in size.
- Several sheets of fine emery cloth.
- Fine steel wool (#00), if used with care.
- Fine mesh carburetor screen for use as a sifter. Stainless steel wire screen or bolting cloth in specific mesh openings may be purchased. A nylon stocking will work if stretched over a two-ounce glass jar.
- Safety gloves, to protect against the high heat radiating from the electric kiln and recently used tools and racks.
- Long-handled stainless steel spatula, useful in lifting dusted enamel pieces onto a rack or trivet. However, only heavy duty firing forks, swirling tools, etc., should actually be inserted *into* the kiln.
- Coarse whetstone useful in rubbing the edges of enamel pieces to smooth off the fire scale and enamel edges. (Hold the piece under running water to prevent deep scratches.)
- Vinegar and coarse salt (a paste mixture is made to use as a rubbing compound to remove grease and oxidation on the copper surface, before sifting on the enamel), or a non-chlorine cleanser like Bon Ami, or pure pumice powder and water used with an old toothbrush.
- Bottle of Scale Off, a liquid applied to the clean, bare copper to eliminate formation of fire scale in firing. Fire scale can be removed by filing and rubbing with emery cloth; however, the use of Scale Off simplifies the problem.
- Stainless steel trivets or ceramic stilts; nichrome firing trays.
- Fireproof surfaces on which to place objects just fired and removed from the kiln.

Image 1: Basic tools for metal enameling



- Adhesive gum for enamel, a liquid gum used to keep the enamel in place on the copper prior to firing; also used to hold lumps, threads and stencils in place.
- Metal files and rasps.
- Tweezers, large and small.
- Round-nosed, flat-nosed, chain-nosed, end-cutter, or diagonal-cutter small jeweler's pliers.
- Wooden or leather mallet.

Kilns

Torch kiln

An inexpensive kiln can be made from two empty coffee cans (a one-pound and a two-pound can) used to serve as a heat muffle. A small propane torch is used as the heat source. (See Image 2.)

Electric kiln

For more controlled enameling, an electric kiln is an essential piece of equipment. Electric enameling kilns or furnaces are available in a variety of sizes. The least expensive kiln is basically an electric heating coil, similar to a small portable electric cooking stove, with a ceramic or Pyrex cover over the coil area to contain the heat as the piece is being fired. The small firing area limits the number of pieces to be fired at one time. (See Image 3.)

Where there are several persons firing several enamel pieces, a portable, hinged-door electric kiln having an inside firing chamber of 4" x 8" x 8" is ideal. Five or six flat or small shallow pieces can be fired together, as well as rather deep bowls or cups. (See Image 4.)

Enameling Techniques

Work areas

For safety and cleanliness, work in enamel should be set up in three or four separate areas.

1. A sturdy work bench area for *fabricating* the copper pieces. All the tools needed for cutting, sawing, filing and cleaning of copper should be at hand. A nearby sink is a plus.
2. Another area should be set aside for the *application* of enamel. Separate sheets of clean paper are placed under each metal piece. After sifting the powdered enamel onto the copper surface, the piece can be carefully lifted to the firing area. The excess enamel powder falling on the paper can be checked and, if clean, poured back into its proper jar. Other application processes can also be worked on in this area.
3. The area near the electric kiln is the *firing* area. Sufficient firing stilts, trivets or nichrome wire trays are needed on which to place the copper piece. Safety gloves and a fireproof pad on which to set the tools used to transfer the piece in and out of the kiln should be available here. A heat-proof pad, board or metal plate should be available to allow the fired piece to cool after heating. It is important to keep the copper pieces away from the application (sifting) area or other pieces to be fired, as small particles of black scale or oxide tend to flake off the cooling copper surface and might fall into the powdered enamel nearby. One long table or several tables will be very satisfactory for a well arranged workshop, depending on the number of persons enameling.
4. The *design* area (where drawings, stencils, cloisonné and other ideas are worked out) may be a separate location. Some find it works out well in Area 2 as this is an area of quiet, careful effort.

Image 2: Torch kiln

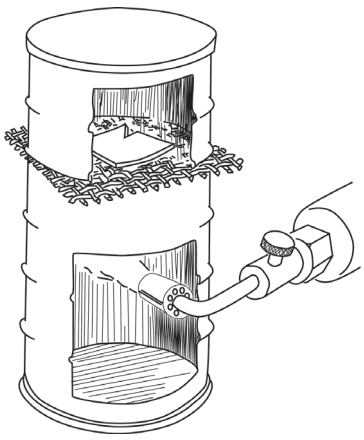


Image 3: Electric kiln

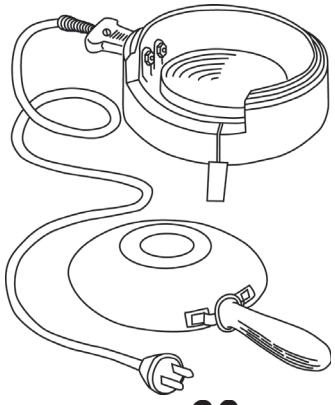
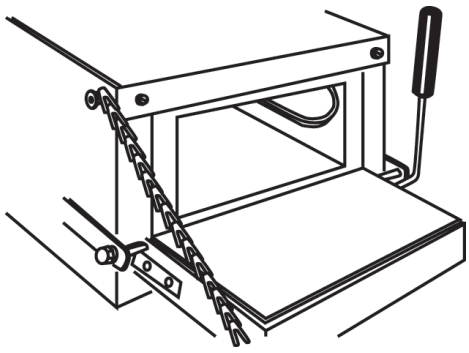


Image 4: Large electric kiln



Metal preparation

It is best that simple geometric shapes be used for beginning enameling projects. The basic shapes recommended for beginners are squares, rectangles, triangles, circles and ovals. These may be purchased in various dimensions, but it is advisable to experiment first on copper two inches or more in size, for ease of design. (See Image 5.)

It is not advisable to use the elaborate pre-cut shapes, such as those found in craft supply catalogs. These stamped designs will provide little opportunity for the beginner to relate the enamel color effects to the shape of the piece. They also give beginners a false sense of accomplishment in that they had no part in creating the shape. Elaborate or intricate shapes of copper contribute little to the total effect of an enamel piece and actually may cause many problems for the novice.

Well controlled experiments using the enameling techniques are of primary importance in the beginning and should be learned first. The emphasis should be placed on creating and controlling the enamel effect on the surface of the copper.

Image 5: Beginning enamel project shapes.

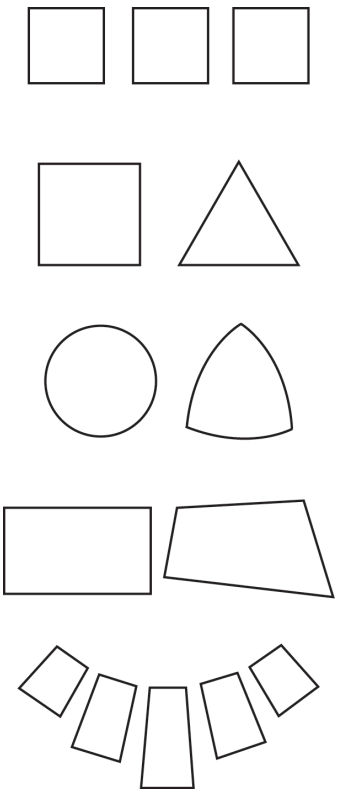
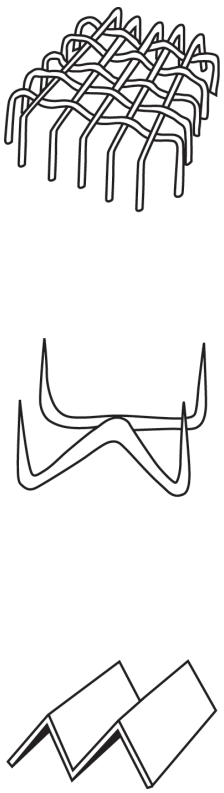


Image 6: Elaborate enamel project pieces.



Whether the simple copper shapes are purchased pre-cut from an art and hobby shop or cut from a copper sheet is a matter of choice. One advantage of using pre-cut or stamped geometric copper shapes is that enameling can begin immediately.

In order to cut shapes from a copper sheet, some practice may be needed in handling a jeweler's, piercing or coping saw, the large tinner's snips, plate snips or compound-action metal shears, but it is not difficult to learn.

Sixteen or 18 gauge copper is cut with a metal snips or shears. This is actually a large scissors which will probably seem heavy to a beginner. The cutting is most easily accomplished by placing the bottom of the shears directly on the work table. The free hand can then be placed upon the handle of the shears to provide added pressure for cutting. Very little strength is then needed to make straight cuts. Safety precautions should be observed: work gloves, goggles, etc. To make more than one cut on a straight or a curved line, the shears should be opened wide and reinserted up to the end of the last cut. Two-hand pressure can then be applied again.

Certain intricate cuts cannot be made with metal shears. Curved or straight cuts in the center of a copper piece will require the use of a jeweler's saw. This can be included as part of the experiences for advanced metal enameling members. Drills and bits are needed for starting a cut away from an edge, or at the interior of a metal piece. Have plenty of extra blades on hand. Always saw on one stroke (not up and down) and at a right angle to the surface being pierced.

The individual designing and fabricating of shapes for enameling is an important part of the creative experience. (See Image 6.)

Fire scale prevention

Fire scale or oxidation is a common problem in copper enameling. This condition can be avoided if reasonable precautions are taken in preparing the bare metal. Whenever bare copper is fired (heated in a kiln), a black scale or copper oxide is formed on the surface. For some projects there may even be areas of the copper piece where an enamel covering is not desired, such as the undersides of trays, pins and pendants.

In order to seal off oxygen and prevent the formation of fire scale on these surfaces, a special liquid coating (a clay slip) can be brushed on before the enameling process begins. This material may have a brand name like Scale Off or Amacote. It

is not expensive and will eliminate the tedious process of removing the fire scale by filing, sanding and polishing. Scale Off forms a protective coating on the copper. After the piece has been coated with enamel and fired, this protective coating flakes off. For each additional enamel firing, Scale Off must be reapplied.

During other stages of work, small particles of copper oxide or fire scale may flick off from another copper piece cooling nearby, onto a freshly sifted enamel piece ready for firing. These particles cause dull black spots to appear on the enamel surface after firing. They are considered defects and should be avoided. It is good practice to keep all pieces ready for firing away from any pieces which are cooling after firing. However, with care and a barely damp, fine-pointed (00 or 000) brush held in the manner of a Chinese calligrapher (at right angles to the surface), such bits may be lifted off the enamel powder. Otherwise, the dusting-on should be redone.

Applying the enamel

Extreme cleanliness is essential for successful enamel dusting. The enamel sifting area should be located away from the fabricating and firing areas. This eliminates any copper filings, dust, copper oxide or scale from contaminating the enamel powders. Protective dust masks are advised.
The metal to be enameled should have a sheet of clean, white paper placed beneath it to receive the excess sifted (dusted-on) enamel. Prior to sifting the enamel powder onto the copper, the piece is brushed with a light coat of liquid gum. This will ensure that the enamel powder will hold firmly to the copper surface and that no mere exhale or sneeze will dislodge it prior to firing. Commercial gum especially prepared for enameling can be used. An inexpensive substitute for gum is a thick liquid hair set lotion. Another substitute can be made from an ounce of gum Arabic dissolved in sufficient water to make a thick brushing solution. Any of these gumming agents will be consumed during the firing without disturbing the enamel powder. Scrubbing on the gum can cause air bubbles; apply a thin even coat, brushed in one direction.

After brushing the gum on the surface, the copper piece is carefully placed on a sheet of clean paper near the desired enamel. The enamel powder is poured into a sifter made from 80 (or other size) brass mesh or stainless steel wire screen. The sifters may be purchased or homemade. The commercial versions come in various sizes with handles which permit gentle tapping and better control. A metal screen can be obtained at an automotive supply shop, as carburetor screen, in three-inch squares. The sides of the screen are folded up to form a shallow box with walls about 1/2-inch high. This may serve as a good sifting device. The dusting of the enamel powder through the screen onto the copper surface should make an *even layer* on that surface. Make sure that the coating is dense enough so that no glints or the pink color of the copper show through the enamel. However, remember that the final or total finished glass coating must *not* be thicker over-all than the thickness of the metal itself.

The first enamel coat should be clear or transparent flux. This is a softer fusing enamel, less expensive than any of the colored enamels. It provides a good fusing base. Also, the flux will fire over fire scale, whereas the colors tend to flake off over scale. This quality has been put to good use by some artists.

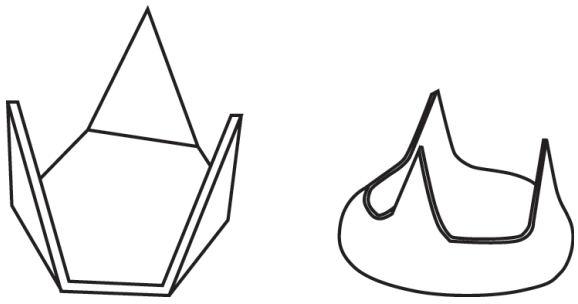
If upon firing the enamel is found to be too thin and lacks an even distribution, re-gum the copper and apply a second coat of flux. Only experience will teach you to determine how much enamel is needed to cover the metal. If flux was *not* used, pits may have formed in the enamel color and must be cleaned out before reapplying. Use a sharp tool, such as an old dental tool or a piece of sharpened coat hanger wire, to pick out the fire scale.

After the dusted enamel piece is transferred to the firing area, the excess enamel on the scrap paper can be “cleaned” and then poured back into the jar for further use. If the dusting procedure is followed as described, you can work comfortably and creatively in an efficient system, moving from one area to another.

Firing in the kiln

The piece is now ready to be fired in the kiln. A thin spatula or cake knife works very well to lift the piece from the paper and convey it to a nichrome wire tray, trivet or stilt. From there, the tray or trivet and the copper piece are transferred to the preheated kiln; heavy duty tools are needed for this.

Image 7: Trivets come in various sizes.



The electric kiln should always be preheated before any enamel piece is to be fired. A kiln may take from 20 to 90 minutes to reach the proper temperature (1350-1450 degrees F). Generally, the rule for enamel firing is a short firing at full heat. Therefore, in order to fire at the required temperature, you may need to overheat the kiln so as to compensate for the heat lost when you open the kiln door to insert the piece. (You'll lose 200 degrees F or so when you open the door.) If you are firing silver or silver-soldered work, you must use soft or medium, not high-firing, enamels. The distinguishing characteristic of good enameling is a smooth glossy surface. Any evidence of granulation or tiny craters indicates insufficient temperature. A sampler or practice tile set will help you predetermine firing temperatures. Some enamel books and catalogs indicate estimated firing temperatures.

Place the tray or trivet, with the enamel piece on it, on the kiln floor. The enamel will at first look black and powdery, or gravel-like, and gradually become smooth and molten and of a cherry red color. Within minutes, the enamel will begin to soften, smooth out and become glossy. Immediately remove the piece from the kiln and place it on a brick or heat-proof board to cool. Gradually the piece will change from a dark red to its true color.

It should be noted that enamel colors, in powder form, do not appear the same after firing. This explains why it is important to prepare a sample set of copper enamel pieces for color selection. Scraps or 1" squares are useful for making test tiles, or colors may be set out in dabs or strips on larger tiles. Try the color over bare metal, flux, foil or whites. Be sure to note temperatures and duration of firing if a temperature gauge is available on the kiln.

Additional coats of enamel or correction of uneven coats can be made immediately after firing. Avoid touching the enameled surface after cooling with fingers or hands. Fingerprints leave a thin film of oil on the surface and prevent full adhesion of additional enamel coatings.

Keep in mind that it is not unusual to have many firings for the completion of a single piece. In the event that transparent enamels are used, the first firings should always be with a flux enamel. This is necessary to achieve the beautiful transparent effects of additional colors. Also, it is imperative that transparent colors be washed and dried free of "fines" which may cause clouding. Washing is done by several decantings, whereby fines float off. The clean glass is spread out and air dried on a piece of foil.

There are several devices, trays or trivets available to hold the copper pieces in position during firing. Pieces placed directly on the kiln floor allow the melted enamel to flow over the edges and adhere to the kiln's floor, making them difficult to remove. Also, the floor of the kiln will become covered with fused enamel. Some unavoidable dripping and adhering of the molten glass can be neutralized by using "kiln wash," which is a white flint powder mixed with water to a paste consistency and brushed on the kiln floor.

The floor of the kiln should have been previously covered with a coating of kiln wash so that accumulations of the enamel on this coating can be periodically scraped away and a fresh layer of kiln wash applied. If kiln wash was not applied in advance, do not try to scrape off the glass drippings, because scraping will do serious damage to the floor of the kiln.

Triangular steel trivets or ceramic stilts can be purchased and are quite inexpensive. Various sizes, as measured across the points, will accommodate several sizes of enamel pieces from flat pendants to trays, from buttons to bowls. (See Image 7.) Stilts are made of porcelain clay with sharp nichrome wire points at the end of each arm. Stainless steel triangles with each corner bent up provide sharp points to hold the piece. An inexpensive substitute for these can be the metal chair gliders available at most hardware stores but they may be rather slippery on the wire trivets and hard to handle.

Enameling can also be done over the open flame of a small propane torch. A metal tripod or two-pound, cut-out coffee can may serve as a firing base.

An inexpensive kiln can be made from two empty coffee cans – a one-pound can placed over a two-pound can to serve as the heat muffle. A nichrome wire screen is used as an open support for the copper piece being fired. This screen is placed between the two cans, which have openings cut into the sides to allow room for the torch and heat shielding. It is necessary to use a nichrome wire screen because the high temperature will burn away other types of wire.

Image 8: Glass thread designs.

The propane torch flame is applied directly to the underside of the wire screen. The tip of the flame is moved about so that the copper piece is gradually heated until red hot, as evenly as possible. When the enamel has a smooth glassy appearance, gradually remove the flame. The copper piece is then removed from the screen with a spatula to a safe surface to cool. A metal weight, such as a flat iron, can be placed immediately on the hot copper piece to reduce warping of the metal.

Counter enameling

When a coat of a color or a mixed (gray) enamel is applied to the underside (counter) of the piece, it is known as "counter enameling." When an enameled piece is fired, the metal expands as the enamel is fused to the surface. Upon cooling, the metal contracts slightly more than the glass. The tension produced between the glass and the metal causes warping. This may even cause the glass to crack or craze and occasionally flake off. If the back of the piece is first covered with fired enamel and then the front surface, the warping strains are neutralized.

The counter enameling is done first, using the procedure described, with a protective coating of Scale Off applied to the front of the piece before enamel dusting. After the first firing, the Scale Oft coating will easily flake off. The clean copper surface of the front side will be exposed and ready for enamel dusting. The piece, with the counter enameled-side down, is carefully placed on a stilt or trivet so that only the sharp points touch the underside. After firing, the piece is easily separated from the stilt by applying slight pressure with a spatula or, when cooled, a slight tug. If small dimpled points of enamel show on the surface, they can be removed with fine emery cloth or a Carborundum.

The tiny marks are not objectionable; many pottery pieces will show the same marks on the underside.

The beginner in enameling can omit the counter-enameling process in the first projects, especially where the pieces are very small and warping will be limited. In any case, it is always recommended to use Scale Off to reduce the very laborious and tedious process of filing and scraping off the copper oxide. Quality enamel work will often be determined not only by an excellent design but also by the clean, bare copper or smooth counter enameling on the back side of the piece.

On shallow trays or bowls, it is essential to apply enamel on both the inside and the outside. In such cases, the counter enamel becomes an integral part of the enamel design.

Design Experiments

Your first project – a sampler

The first project to attempt is the preparation of a color palette, sampler or set of tiles. The basic procedures of enameling are used to prepare this sampler.

Powdered enamels do not always reveal their true color appearance until they have been fired on the copper. Therefore, a sampler will provide the beginner with a handy color reference of opaque and transparent enamels for future projects. This may simply be a collection of enameled squares mounted on a wood board for color identification. The color palette squares could also be attached to a wood block for use as a trivet hot plate. In either case, the samples are available to determine enamel color selections.

Through this first project, experience will be acquired in cleaning and preparing enamel pieces for firing, in sifting clear flux enamel, in using color enamel over the flux firing, and in basic enamel application. All of these processes will be repeated each time a different color square is made.

You can work alone or with a group in preparing a color sampler. Be sure to keep a log of color identification and (if your kiln has a pyrometer gauge) of the length of time and temperature of the firing. The same green or blue powder can look very different when fired at various temperatures. Don't forget to label each tile using a permanent marker directly on the cooled tile or write on self-stick labels or bits of tape.

A piece of copper about 1" x 2" or 2" square in size should be selected for each enamel color. Drill a 1/8-inch hole at the middle of a side, so that the piece can be mounted on a nail and hung on a wood panel with the other enamel samples. All the edges of the cut pieces should be filed smooth and perpendicular to the flat surface of the copper. Do not round off the edges. This slight lip or burr will ensure that the enamel does not drip off but will fuse entirely to the edge of the copper surface.

The copper is then cleaned to remove any dirt, grease and copper oxide from the surface. Any of these elements on the surface will prevent the enamel from adhering to the copper. Polish the copper to a shiny luster with medium-grade emery cloth, rather than steel wool. This will remove the oxidation. Any grease or oil remaining can now be removed by rubbing with a cloth dipped in a salt and vinegar paste. Wash in clear water and dry with a clean lint-free cloth or air dry.

Remember, do not touch the flat surface of the clean copper with your fingers. The slightest trace of oil or grease will prevent an even fusing of enamel. The piece can be moved around with a spatula or picked up carefully at the edges with clean fingers. Squares of paper placed under the metal can also serve to lift and move the piece of copper around.

Technical design approaches

After you understand and know how to obtain a well-fused basic enamel surface, you should begin experiments in design techniques.

It is important that an individual first become competent with basic design techniques before attempting to freely create designs. Begin with lines or dots made with glass threads, lumps or enamel powder applied to a base coat of either transparent or opaque enamel. Other designs based on simple shapes can be created with stencils or sgraffito (an Italian word meaning "to scratch"). Simple designs may be used separately or in combinations.

Each person should become thoroughly acquainted with basic design techniques through experimentation. This is important so that the effects of each technique can be studied and the processes controlled. The art and craft of enameling are so closely interwoven with technique, process and design that it is difficult to study them separately. From this experience the beginner can move with confidence into creating personal designs and specific projects. Stress should be placed on originality. Design techniques will then be the creative expression unique to each individual.

You should keep a brief record, with sketches and notes, of what was attempted and the results of each experiment. In this way the experiences can be recaptured, collected and further developed and shared by all.

Trailing technique

A line-design having narrow or broad, soft, diffused edges may be accomplished with the trailing technique. A copper piece is fired with an overall enamel color. The cooled piece should be once again brushed with a coating of gum to hold the enamel grains in place. A small amount of contrasting enamel color is picked up between the thumb and forefinger. The fingers are gently rubbed together above the piece so that a thin trail of enamel is deposited on the base coat and, at the same time, the hand is gently moved in one direction to make a continuous line deposit of enamel. The piece is then carefully lifted into the preheated kiln for full firing. Trailed lines are usually soft and fuzzy-edged in contrast to lines obtained through other techniques.

Sufficient control and experience can be acquired by practicing with grains of sugar or salt on colored paper. Small inlay tools, sandwich picks or tools made from hammered lengths of clothes hanger wire may be used, instead of trailing directly with the fingers.

Sgraffito technique

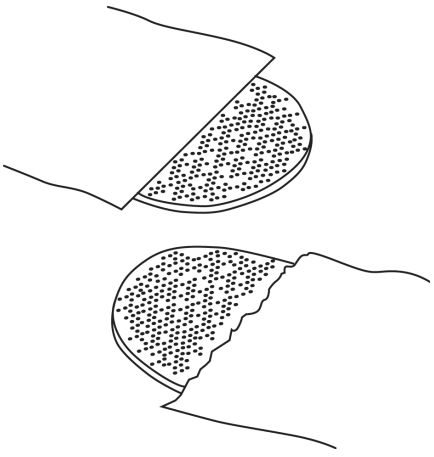
The sgraffito process provides another kind of line-design on enamel. A brush coat of gum is applied over a previously fired base of the enamel piece, followed by an even dusting of contrasting enamel color (e.g., white enamel over black enamel base). The piece is then allowed to dry.

Next, a pointed tool, such as a nail, sharp pencil, toothpick or a scriber, is used to gently scratch through the dusted layer to the fired enamel base. The lines can have varied thicknesses (widths) giving interesting character to such a design. Whole areas may be gently scratched away or grains individually pushed aside to create shapes. The excess enamel can be scraped away so that the opened spaces (lines) fire cleanly, showing the two-color design. Individual spots or grains can be lifted off and out with a small, barely damp brush.

Glass threads and lumps

The third line-design technique uses thread-like glass lengths. These may be purchased in a variety of colors and should be handled gently so that the threads are not accidentally broken in the box. These threads are selected and placed in position on a base-coat enameled piece with a tweezers. To keep them in position, it is best to first gum the surface or even dip the threads in the gum solution. The arranged piece should dry before firing or else excess gum

Image 9: Stenciling techniques.



will "boil" and the bubbling up will jostle the threads and move them off place. Careful attention to the amount of firing time in the kiln will provide relief effects or a total fusing with the base enamel color. The lines produced have a precise, sharp-edged quality.

The threads can be gently broken to fit any position on the gummed surface or they may be laid out in straight and curved combinations. Small pieces can be scattered at random over the surface for unusual effects. (See Image 8.)

When fired, the threads will gradually soften, melt and fuse into the base enamel. Early removal from the kiln will provide a raised line, if desired.

Experimenting with this technique and combination with other techniques will offer exciting design possibilities. These designs will grow out of the use of the materials and what they suggest in appearance to the experimenter.

In addition to glass threads, small chunks or lumps of colored opaque or transparent enamel can be used. These pieces can be placed on a base coat of enamel and, when fused, will produce interesting color spots and accents. Transparent enamel lumps will give a luminous jewel-like effect. A small piece of gold or silver foil previously fused underneath a transparent enamel will reflect the light from the foil for an unusual effect.

The lumps should be fused until they flatten out (or nearly do) on the surface as pools of color. Do not have the pieces remain as tall lumps on the surface, as they tend to pop loose after cooling. If pieces must be broken into smaller chips for your use, be certain to wrap pieces in heavy cloth before "striking," so that no pieces fly away dangerously.

Stencil technique

A stencil is simply a mask, made of various materials, such as paper or tape, placed on the enamel surface. (See Image 10.) When dusted or sifted with enamel powder, the mask blocks off a designated area. The stencil or mask is gently lifted off with a tweezers before firing.

You can cut a stencil or use the torn edge of a piece of paper. (See Image 9.) Hold the stencil over the gummed piece and dust it with enamel powder. After firing, the piece may be re-gummed and the stencil or edge held in a different position while dusting on another color. This process can be repeated until one is satisfied with the effect. The fired edges of the colored glass created by the torn stencil will be irregular and fuzzy; the fired edges from a cut stencil will be sharp. Dusting from a stencil held above the metal will be fuzzy, while dusting to a stencil set tightly down on the piece will be sharp.

Masking tape can also be pressed in place before the base enamel has been gummed. After sifting, be sure to peel away the tape. Interesting effects can be obtained by using transparent enamels to give depth to the overlapping stencils. Contact paper and the plastic film used for cutting stencils for printing may also be used. Be sure the gum has not dried before you apply the powder. Re-gum, if needed.

Paper stencils may first be prepared in pencil or fine-line permanent marker to fit within the area of the copper piece. You can use colored pencils or watercolors to represent different enamel colors. Usually, the base enamel serves as the first color. A small manicure scissors will cut neat curves; an Exacto knife or single-edge razor blade can be used for clean cuts, wherever a scissors is too awkward to use.

Image 10: A stencil is a mask, made of various materials, placed on the enamel surface.

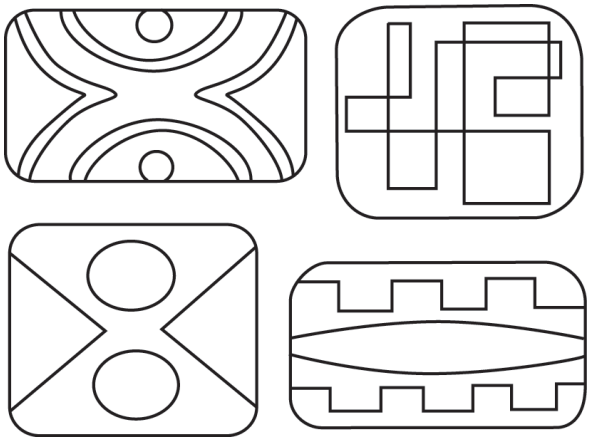
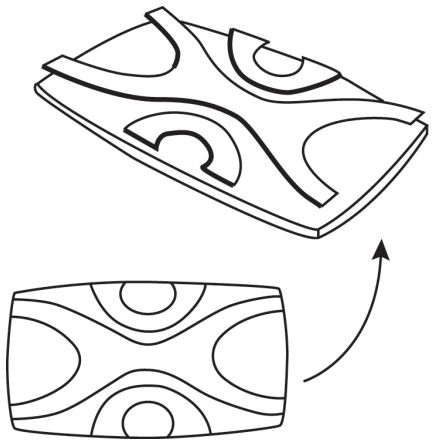


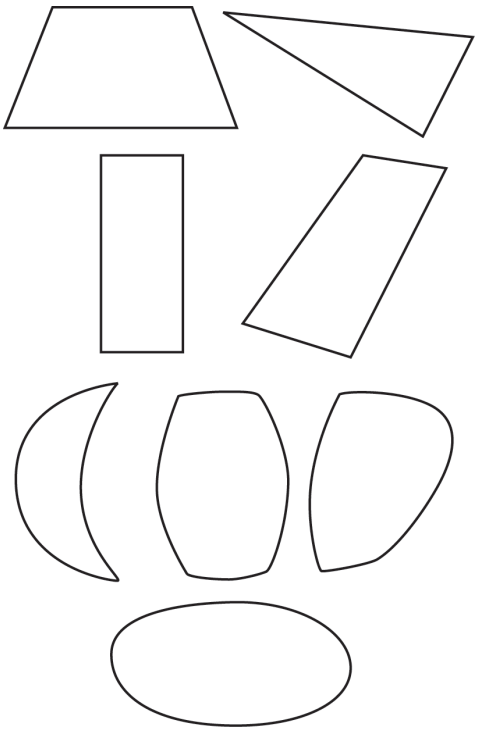
Image 11: Place the stencil pieces in position on the gummed enamel surface.



Cut along the penciled lines and place the masking section on the gummed surface of enamel. The process is as follows:

1. Sift an even coat of enamel over a clean, gummed copper piece. If clear flux is used beneath, two or more coats of colored enamel may be sifted over the initial fired coat.
2. Fire the piece in a preheated kiln. The enamel will gradually become a gravely gray and then soften to a glossy smooth level. When a cherry red color appears on the enamel surface, remove it from the kiln to cool. With a pyrometer, you can fire soft, medium and hard fusing enamels at recommended temperatures.
3. After cooling, the piece is gummed again and dusted with a second layer of enamel. This ensures a uniform base coating. Re-fire in the kiln and cool.
4. Prepare a cut paper stencil. Place the stencil pieces in position on the gummed enamel surface. (See Image 11.)
5. Sift an even layer of enamel contrasting in color to the base coat.
6. After the gum has dried, gently lift the paper stencil from the surface with a tweezers. Avoid having crumbs of enamel fall onto the exposed areas of base color. With a damp, fine-pointed brush held at right angles to the piece, carefully lift off unwanted bits of enamel powder.
7. Place in the kiln for firing.

Image 12: Some of the best designs are created from simple geometric shapes.



Designs created from paper stencils can also be used for wire cell or cloisonné. Often, beginners in enameling tend to attempt overly complicated designs. Some of the best designs are created from simple geometric shapes: square, circle, rectangle, oval and triangle. (See Image 12.)

If subject matter is desired, the design may be based on combining simple shapes to form the subject matter, e.g., fish and birds. The emphasis should be toward a more personally created form or subject, not merely realistically depicted. The art and craft quality will be determined by the controlling and handling of techniques into a balance of color, line, texture and shapes.

Unusual line designs can be obtained with white string or yarn. A length of cotton string or yarn is moistened with water. The length is gently dropped in place on a base enamel piece. A contrasting enamel color is sifted over the entire surface. The length of string is carefully lifted from the surface with a tweezers, exposing its linear pattern. The copper can then be fired in the kiln. As you see, this is a kind of stencil process.

A piece of lace or open mesh cloth can be used in the same manner as the string. The lace will produce a much more complex design. Care in the use of tweezers (two of them) is needed to lift off this stencil.

For those interested in the beautiful pattern and shape of natural forms, a selection of various leaves, grasses and stems provide the basic design. Arrange these carefully on a previously fired copper surface. Several siftings of various enamel colors will provide interesting contour designs after fusing.

Polyester acetate film stencils may be cut as above or with a wood burning tool traced along lines drawn with a marking pen.

Wire cloisonné enamel

First of all, be sure to coat the underside of the copper piece with Scale Off, etc. Thin, round or flat copper wire (18 to 20 gauge) may be used to form "walled off" areas of enamel on the copper surface. (See Image 13.) Better still, flat or round silver cloisonné wire may be used as it won't accumulate fire scale. The wire lengths are cut and bent to fit a design prepared on paper. A gentle filing off of cut edges of the wire will smooth the edges and allow closer contact. The wires must not overlap. After cleaning all pieces, coat the copper surface with enamel flux and set the wire pieces in place with

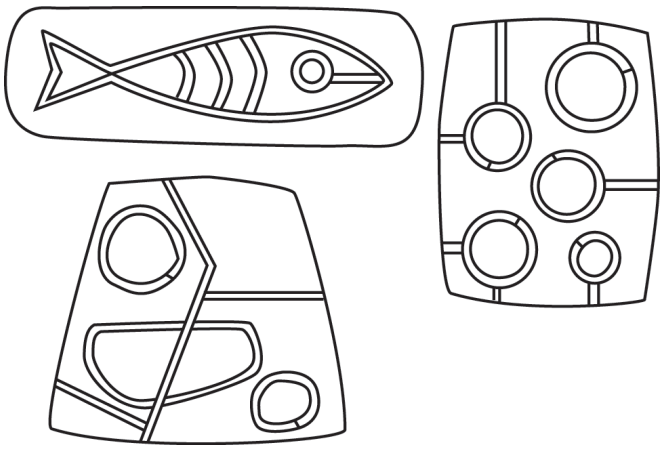
a tweezers. Fire the entire unit together. (If you are to fuse the wire onto an already fired opaque or transparent color, dip the wires into your gum adhesive solution and set down on the piece and allow to dry before firing.)

After the first firing, gum the enamel surface and add enamel colors to each cloisonné, or cell, carefully. Make sure each area is filled with enamel up to the top of the wire walls or slightly above, because the enamel will settle while melting or fusing. Small spatula, scriber and spreader inlay tools are most helpful here, but tools can be fashioned from coat hanger wire, tooth picks, etc.

To develop control of the technique, start with a simple geometric copper shape and divide it into three or four areas. Carefully cut and bend short lengths of wire. Practice setting the wires up on the surface of the enamel piece and see that the wire fits that surface snugly and with no kinks or openings which would allow molten glass to seep out. Some find that temporarily setting the cut wires up on the sticky side of some contact paper is helpful. When the wires are ready, set them in flux to adhere them to the copper base. Fire the wire onto the supporting flux. You will see the wire imbed itself. When removed from the kiln, see that all of the wire sits into, but upright, on the flux. A gentle press with a spatula, immediately upon removing from the kiln while flux is still molten, will settle any slightly loose or free wires. Inlay separate enamel colors in each cell area. Repeat with additional firings to fill up areas or cells.

All during this process of filling cells, care must be taken to keep "grains" of glass from collecting outside the designated area. A barely damp, fine-pointed brush can be used to lift out stray bits of powdered glass before firing permanently sets them.

Image 13: Thin, round or flat copper wire may be used to form "walled off" areas of enamel on the copper surface.



The shapes of copper may vary to satisfy individual choice. If simple geometric shapes are available, it saves considerable time in sawing or cutting preparation and allows you to proceed to the enameling process immediately. If pieces are to be used for pendants or bracelet units, be sure to drill or punch holes before enameling. This *cannot* be done afterward, without considerable effort or damage.

Unusual experiments

The sparkle of color and texture through light reflection can be discovered by using unusual glass materials. These materials are applied to previously fired, opaque, dark enamel pieces. One method is the use of an arrangement of strips and patches from woven white fiber glass cloth. This is the same material found in drapery fabrics. It is composed entirely of glass threads and will fuse perfectly into the base coat of enamel. The development of a design will depend on personal variations in the arrangement of the glass cloth. Take care in handling to avoid contact with your eyes; wash hands frequently.

Additional effects can be obtained with the use of glass beads or millefiore of every description and color. The pieces can be placed in arranged positions on the base enamel. (Found glass scraps, though attractive, are risky to fire.)

Pen and glycerin designs

Unique and interesting line designs can be made on an enameled surface with the use of glycerin which may be purchased at a drug store. First, dilute the glycerin with sufficient water to make it flow easily from a pen. Next, add a few drops of colored ink which will make glycerin visible on light colored enamel surfaces.

Before drawing, make sure the previously enameled surface is absolutely free of any grease or finger prints, wash it thoroughly with a detergent, and dry with a soft lint-free cloth or let it air dry.

Handle the copper piece with the fingers only on the edge or side of the piece. The lines are drawn or painted on the surface of the enamel plate.

Since the glycerin and water combination is slow drying, the line can be completed and immediately dusted with finely ground enamel. Enamel dust will adhere to the wet glycerin line. After the glycerin has absorbed all the enamel dust possible, the excess is gently shaken off and the powdery residue can be gently blown off.

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