

# ENAMELING CAST BRONZE

RESEARCH AND EXPERIMENTAL PROJECT

COMPLETED BY

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## I. Materials

15 bronze tiles in an identical size; each tile cast in the dimension of 4 1/2 inches long, 3 inches wide and 1/4 inch thick.

LOW TEMPERATURE-HIGH EXPANSION ENAMELS in 47 colors (Make sure to purchase these particular enamels for aluminum, brass and 300 series stainless steel. Other types of enamels such as medium temperature-medium expansion enamels for copper, gold and silver do not adhere to bronze. All enamels can be purchased from Thompson Enamel. See the address below.)

## II. Preparing the Metal For Enameling

i. Sandblast the cast bronze thoroughly to remove fire scales and other impurities on the metal surface.

ii. Scrub with a tooth brush and pumice powder under running water. If you have trouble achieving a bright, clean surface, scrub the metal with either steel wool #0/0 or a 3M scouring pad, again under running water.

iii. When the metal looks completely clean, perform a quick test for confirmation: run clear water slowly onto the surface of the metal; if the water "draws up" and lies in puddles or beads, the surface of the metal still carries oily residue; if the water lies in a complete sheet over the surface, the metal is clean and ready for enameling.

iv. For the final rinsing, use distilled water instead of tap water to maintain the cleanest surface possible.

While preparing the metal for enameling, AVOID TOUCHING THE SURFACE OF THE METAL WITH YOUR FINGERS.

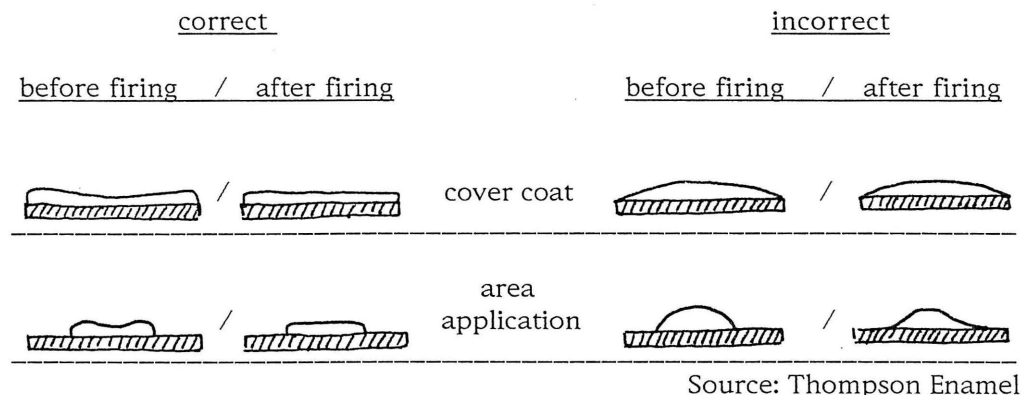
## III. Application of the Enamel Onto the Metal

i. Dusting method (For plain backgrounds on either flat or curved surfaces, this method is the logical choice.)

1. Spray the area to be coated with distilled water.

2. Apply dry enamel by sifting through a sifter or screen. For a large area, use sweeping motions to achieve an even application. Do not apply thick coat of enamel--if too thick, the enamel will crack and chip off after firing. A coating of dry enamel should not exceed 1mm in thickness. See the diagram below for the correct/incorrect applications of enamels. If the piece has

vertical sides, it is essential to spray and respray the surface of the enamel with a mixture of distilled water and Klyr-Fire (a binding solution sold by Thompson Enamel) to the saturation point.



3. Air dry completely prior to firing.

4. Thompson Enamel Company cautions, "It is important that the primary coat of enamel be as complete and as perfect as possible for the first firing. Faults in the enamel are not easy to correct after the enamel has been fired in place." (Please refer to the attached sheets for more technical tips given by Thompson Enamel.)

ii. Wet-packing method (This method is ideal for intricate surfaces or highly three-dimensional pieces.)

1. Mix dry enamel with distilled water and a small amount of binding solution such as Klyr-Fire to a mudlike consistency.

2. Place the wet enamel on desired area with a small enameling spatula. (Small spatulas can be purchased at CSU Chemistry Department Stock Room.)

3. Spread into a thin layer using a bent wire or brush as a spreader.

4. Air dry completely before firing.

#### IV. Firing

i. Preheat the kiln at 1250 F for bronze. (It is advisable to turn the kiln temperature up 50 to 100 F degrees higher than needed, for there will be some heat loss when the kiln door is opened.)

ii. Place the prepared metal on a firing rack.

iii. Position the assemblage gently in the center, toward the back of the preheated kiln using a firing fork. (Wear tinted eye protection and heat resistant gloves.)

iv. Fire for 9 to 10 minutes for a 3" x 4-1/2" x 1/2" bronze tile.

v. The length of time required for firing varies according to weather conditions, size of kiln and size of project, and thus it is a good practice to check the firing process after 7-8 minutes. Caution: Do not open the kiln door wide when checking.

vi. First, the enamel will turn black and appear granular.

vii. Second, the enamel will begin to glow slightly and its quality will change to an orange-peel appearance, resembling the skin of an orange.

viii. Finally, the piece will take on a soft red glow from its inner heat, and the enamel will have a glossy, liquid-like quality. At this point, the enamel has fired to maturity, and is ready for removal from the kiln.

ix. Check the surface of the enamel immediately after removal from the kiln; if it still has the orange-peel effect, return it immediately to the kiln, and continue firing for another couple of minutes.

x. If the enamel surface has pulled away from the edges of the metal, the piece may have been overfired. Another cause of the same trouble can be attributed to heavy or irregular application of the enamel.

xi. Hot enamel which cools rapidly because of a sudden temperature change will sometimes crack and craze from the extremes. In order to avoid such accidents, create a small temporary walled-enclosure near the kiln to cool the piece slowly away from draft. If there is another kiln (unheated) nearby, transfer the hot enameled piece into it, shut its door and let the piece cool.

xii. Keep in mind that enameling the pieces with steep vertical surfaces demands more advanced skills. If the vertical surfaces are to be enameled in a single color or a multiple of colors in nonobjective designs, use the dusting method mentioned in the section XXX-i. Adhere the enamels carefully by spraying with more concentrated binding solution. If the piece requires a more precise application of enamels, follow the wet-packing method explained in the section XXX-ii. Firing the three dimensional pieces is difficult, since the enamels run quickly towards the lower portion of the pieces.

Some tips for avoiding the mistakes;

- Apply enamels thinly, (Coat the lower portion of a piece even thinner than its top portion.) fire and stone (See the section V-i for the stoning method.) Repeat these three steps two or three times until a desired effect is achieved. Thin, careful coating each time is crucial.
- If the piece requires more than one firing, rotate it on a firing rack so that it does not sit on the same side in every firing. Allow the enamel to melt in an even thickness throughout the surface--this is also critical in achieving a successful result.
- Do not place the enameled surface directly on a firing rack. Use an adjustable trivet (purchased or studio-made to meet your specifications) in order to avoid the molten enamels from adhering to a rack.

## V. Cleaning the Enameled Bronze

i. Stoning method: To stone the edges of the enameled metal, hold the cold piece under running water, and with an Alundum stone held at right angles use a filing motion to remove just the discolored edges of the metal. Be careful not to remove any enamel from the face of the project. Flush well with running water to remove the stoning residue. Any overflow of enamel will be removed from the edges at the same time.

ii. Brushing with a brass brush method: Follow the same procedure for stoning method mentioned above.

## VI. Basic Supplies For Beginning Enamelists

- \*The enamels in powder form
- \*Adhesive agents such as Klyr-Fire
- Distilled water

Pumice powder (Do not substitute cleanser.)

## VII. Basic Tools for Enameling

- \*Lightweight plastic sifters in various sizes with 80 mesh screen
- \*Small spatula/scriber/spreader/brush
- \*Alundum stone
- Brass brush
- \*Firing rack
- \*Firing fork
- \*Heat resistant gloves
- Tinted eye protection
- Protective dust mask

\*These supplies and tools are available at:

Thompson Enamel  
650 Colfax Avenue  
Bellevue, KY 41073

Phone: 1-606-291-3800  
Fax: 1-606-291-1849

For placing the catalogue request and VISA & M/C orders:  
Call 1-800-545-2776 (24 hour order line)

For technical inquiry: Call 1-606-291-3800, and request the technical expert who is ready to answer any questions you may have.

## VIII. Safety Precautions\*\*

- i. Keep in mind that all enamels are glass products, therefore do not ingest them!!
- ii. Keep your work area clean and tidy. Keep your clothing clean.
- iii. Use the enamels in a well-ventilated work area. Wear a protective dust mask if you are going to work with the enamels for an extended period of time.
- iv. Wash your hands well prior to eating. Do not smoke or handle food when you are working with enamels.

\*\*Source: Thompson Enamel

References;

Thompson Enamel catalogue

Kenneth F. Bates. The Enamelist. 1991. Wooden Porch Books,  
Middlebouene, WV.

CSU Library has some helpful books on enameling techniques.  
Although these books are mainly for copper, silver and gold, the  
basic techniques are equally applicable to bronze and other metals  
such as brass, aluminum, stainless-steel and iron.

## List of 47 Enamel Colors for Bronze

(Low Temperature-High Expansion Enamels)  
(From Thompson Enamel)

### Opaque Colors

#### WHITE

3010 WHITE  
3015 OFF WHITE

#### BROWN

3110 TAN  
3120 NUT BROWN  
3130 CHAMOIS BROWN  
3160 CORDOVA BROWN  
3190 BRIARWOOD BROWN

#### YELLOW

3210 PALE IVORY YELLOW  
3230 GOLDENROD YELLOW  
3270 CHROME YELLOW

#### GREEN

3310 LIGHT PALE GREEN  
3320 PEA GREEN  
3330 LETTUCE GREEN  
3370 HUNTERS GREEN  
3390 SPRUCE

#### TURQUOISE

3430 ROBIN EGG TURQUOISE

#### AQUA

3520 LIGHT BLUE GREEN

#### BLUE

3610 LIGHT GRAY BLUE  
3630 PORCELAIN BLUE  
3680 LIGHT COBALT BLUE  
3690 COPEN BLUE

#### ORANGE/RED

3820 PUMPKIN ORANGE  
3840 ORANGE RUST  
3860 CHINESE RED  
3890 BRICK

#### GRAY/BLACK

3910 SMOKE GRAY  
3930 SLATE GRAY  
3960 CHARCOAL GRAY  
3990 BLACK

### Transparent Colors

#### CLEAR TRANSPARENT

4000 CLEAR

#### BROWN

4120 LIGHT REDDISH TAN  
4150 ROSE BROWN  
4180 SEAL BROWN

#### YELLOW

4205 TAN YELLOW  
4210 WAX YELLOW

#### GREEN

4310 LT. SHAMROCK GREEN  
4320 GRASS GREEN

#### AQUA

4405 LIGHT AQUA  
4420 EMERALD AQUA

#### BLUE

4610 LIGHT GRAY BLUE  
4620 CHINCHILLA BLUE  
4640 OLD SILVER BLUE

#### LAVENDER PURPLE

4710 ORCHID PURPLE  
4730 LAVENDER PURPLE

#### RED

4820 RUBY RED

#### GRAY

4920 GRAY  
4940 DARK GRAY

## Color and Technical Descriptions

### of My 15 Enameled Bronze Tiles

Preparation of the metal for enameling: same procedure explained in the section II.

Application of the enamels: the dusting method through a small size sifter, 1/2" dia. x 1/2" d., with 80 mesh screen.

Size of the kiln used: its interior dimensions are 20" wide x 8" high x 21" deep.

Firing: 9-10 minutes for each firing in the kiln which was preheated at 1250 F + 75 F. Most of the tiles have one coat of enamels, and were fired once excepting the tiles #2, #4 and #8 for which I performed the additional experiments. (See the descriptions of experiments attached to these tiles.)

Cleaning and finishing: vigorous scrubbing with a brass brush under running water to remove the fire scales, and also to polish the fired enamels for more brightness.

Tiles #1 & #2: Opaque white and brown

|      |      |
|------|------|
| 3010 |      |
| 3015 |      |
| 3110 |      |
| 3120 | 3130 |
| 3160 | 3190 |

Tile #1: Fired for 9 1/2 minutes. Cleaned and polished with a brass brush, but some fire scales left untouched to enhance the white enamel.

Tile #2: Fired for 10 min. As soon as the tile was pulled out of the kiln, it was sprayed first with liver of sulfur solution and then cupric acid solution. Immediately returned into the kiln and fired for additional 2 minutes. No cleaning or polishing afterward.

Tiles #3 & #4: Opaque yellow and green

|      |      |
|------|------|
| 3210 | 3310 |
|      | 3320 |
| 3230 | 3330 |
|      | 3370 |
| 3270 | 3390 |

Tile #4: Same procedure as Tile #2.

Tile #5: Opaque red (Caution: Red enamels burn easily. Therefore, fire one or two minutes shorter than other colors.)

|      |
|------|
| 3820 |
| 3840 |
| 3860 |
| 3890 |

Tiles #6, #7 & #8: Opaque gray and blue

|      |      |
|------|------|
| 3520 | 3910 |
| 3610 | 3930 |
| 3630 | 3960 |
| 3680 | 3990 |
| 3690 |      |

Tile #6: The enamels coated thinner than Tile #7. No cleaning or polishing after firing.

Tile #8: After the enameled metal cooled, the surface was first heated gently with a gas torch, and then immediately sprayed with liver of sulfur solution and cupric acid solution for oxidation. Repeated heating and oxidizing several times until the desired effects were achieved.

Tile #9: Transparent brown

|      |
|------|
| 4000 |
| 4120 |
| 4150 |
| 4180 |
| 4205 |
| 4210 |

Tiles #10 & #11: Transparent green and aqua

|      |
|------|
| 4310 |
| 4320 |
| 4405 |
| 4420 |

Tile #10: Under fired. Notice the dullness of the colors. No cleaning or polishing after firing.

Tiles #12 & #13: Transparent blue

|      |
|------|
| 4610 |
| 4620 |
| 4640 |

Tile #12: No cleaning or polishing after firing.

Tiles #14 & #15: Transparent lavender, purple, red and gray

|      |
|------|
| 4710 |
| 4730 |
| 4820 |
| 4920 |
| 4940 |

Tile #14: The coating of the enamels was too heavy. Therefore, chipping and cracking of the enamels occurred.

# Enameling Tips provided by Thompson Enamel

**First Coat.** It is important that the primary coat of enamel be as complete and as perfect as possible for the first firing. Faults in the enamel are not easy to correct after the enamel has been fired in place. In most cases the best that can be done is a reworking of the design.

The first coat should cover all metal areas unless fire scale is meant as part of the design. Specific plans should be made for the cleaning of the exposed metal after firing which will not harm either the metal or the enamel surface, i.e. champleve.

**Counter Enamel.** It is not always necessary to counter enamel. The purpose of counter enamel is to reduce stress exerted on the enamel by the metal after the piece is cool or during cooling. Counter enamel literally equalizes or counters the pull of the metal on the enamel. The thickness of the metal and the thickness of the enamel are relative in this matter. As the enamel thickness increases, the support thickness must also increase unless other structural considerations have been made in the metal.

## Enamel Applications per Technique.

With the correct application the enamel will, during firing, equalize or pull toward the metal edges, where the greater mass of enamel is located.

When enamel is applied less correctly the enamel may draw away from the metal edges. This may cause flaws due to exposed metal oxidation. Such oxidation is especially true for copper and the alloys of silver and gold. See Fig. 1.

**Firing Temperature and Time.** The factors of time and temperature are considered as a single unit of concern since they depend on each other to such an extent, that if one is to vary the other must also vary. These two factors will also vary with the following relationships; (1) Metal type, thickness and shape; (2) Enamel type and thickness; (3) Size of firing chamber in relationship to size of the object; (4) Position or placement in the firing chamber; (5) Size and type of support for object; (6) Furnace design.

## Firing Temperature and Time (cont.)

The ideal fire (temperature and time) for transparents is one which produces a smooth surface and few, if any, entrapped bubbles.

The disadvantages to a hard fire are; (1) The piece may be distorted; (2) The color of the enamel may change; (3) The enamel may soften too quickly and pull from the edges.

If the temperature is too low the enamel may not adhere, transparents may discolor due to excessive oxide at the interface, strain lines may develop, and the surface may be rough.

The firing time and temperature must be just right. Each piece will have its own set of variables.

In general firing temperatures are: **Soft fusing** -1400°-1450°F; **Medium fusing** - 1450°-1500°F; **Hard fusing** -1500°-1550°F.

**Enameling Aluminum.** There are several excellent books available on the techniques of enameling on copper, gold, and silver.

However, there is very little information available on the enameling of aluminum so we are giving general information for your introduction to this new medium.

**Type of Aluminum.** Type 3003 aluminum is the most suitable for enameling. It is readily available from your local warehouse. Sheet aluminum of about fifty thousandths (.050) in thickness is satisfactory for most items. Other types of aluminum alloys can be used in a limited manner, but some will not produce nice transparencies, while others can be fired only two or three times.

**Cleaning the Aluminum.** Remove grease and oil by prefiring at 1050°F for 5 to 10 minutes. Caution: do not use household cleaners containing chlorine.

**Application of the Enamel.** The normal dusting method used for copper enameling may be used to apply the first coat.

An alternative method - an exciting new one to enamellers - is the **Hot Dust Method**. This is an adaption of the commercial method used to

Fig. 1 - Enamel Application per Technique, Cross Section Drawings

| More Correct  |              |                  | Less Correct  |              |
|---------------|--------------|------------------|---------------|--------------|
| Before firing | After firing |                  | Before firing | After firing |
|               |              | Cover Coat       |               |              |
|               |              | Area Application |               |              |
|               |              | Champleve        |               |              |
|               |              | Cloisonne        |               |              |
|               |              | Plique-a-Jour    |               |              |
|               |              | Basse Taille     |               |              |

### **Application of the Enamel (cont.)**

enamel cast-iron bathtubs and sinks for many years. Using a sifter, the enamel powder is dusted onto the hot aluminum. Experience will quickly show how much to apply. The article is placed back into the furnace. If necessary, you can apply a second coat to obtain complete coverage. This hot dust method has many advantages. The most obvious one is the time saved in not having to wait for the article to cool before applying another coat.

When cool, subsequent coats can be applied using the normal copper enameling techniques, some of which are described.

#### **Cold Dusting Method.**

1. Spray the area to be coated with water.
2. Apply enamel by shaking through a screen. If you desire a thin coat with areas of the base coat showing through, continue with step six. If you desire a solid coat, continue with step three.
3. Wet out with a spray of water, being careful not to apply enough to cause the enamel to run.
4. Screen on another thin layer if desired.
5. Wet out again with a spray of water. It is not necessary to make this final spray very wet, however a slight spray of water aids in obtaining a smooth surface after firing at these low temperatures.
6. Dry.
7. Fire at 1050°F-1150°F until glossy - about 10 to 15 minutes.

Two or three siftings and firings may be necessary for the first coat. Each coat of enamel should be thin, .002"-.004". A long low heat is better than a high short heat.

The fines should not be removed since that would make the enamel too coarse and retard the achieving of a smooth surface when fired.

The enamel may also be mixed with water and applied by placing on desired area with a small spatula. Enamel is spread into a thin layer using a bent wire or brush as a spreader.

**General Information.** The use of gums and other binders should be used only when necessary. Then only as sparingly as possible.

Scouring powders, containing chlorine, should not be used to clean the aluminum. The chlorine will cause the enamel to chip from the surface when cool. Aluminum has a high expansion compared to copper. Every effort should be made to apply the enamel as thin as practical unless you counter enamel. As the second and subsequent coats begin to fuse, you may hear some cracking noises in the furnace. This is normal due to the high expansion of aluminum. The strains caused at this time will heal over with proper firing. Less strains will be formed if the enamel is removed from the edge or rims prior to firing. The aluminum is not cleaned between firings. The normal stencil techniques can be used.

At first you probably will feel enameling on aluminum is a little more sensitive than copper enameling. With a little practice, you will find enameling on aluminum is every bit as easy.

**Use of Pallons.** A very pleasant surprise is to find that ordinary household aluminum foil can be used. The same technique may be used as with enameling on copper, The major difference being less heat and no fire scale.

### **Procedure for Enameling Gilding Metal Stampings**

#### **Gilding Metal**

These pieces have been chemically cleaned of grease, dirt and fine metal chips which come during the manufacturing process and interfere with a good hard enamel job.

The enamel may be applied to the desired areas by first mixing with water to a mudlike consistency and depositing the amount required with fine pointed spreader. Improved clarity and brilliance of the colors, particularly the transparents, will occur if the fines of the enamel are washed and decanted away using a petri dish or similar container. Final draining of water away from the enamel will give a good packing enamel/water mix. Wet packed enamel must be allowed to dry before firing to prevent splattering at the high temperatures.

Enamel may also be used on one color jobs or larger surfaces by sifting through a fine screen taking care to clean off any rings with a fine dry brush. The piece is then fired and stoned when cool enough to handle. This operation will remove all the excess enamel which is covering the fine line detail in the stamping, bringing it to the new enamel surface. The abrasive action of the stoning will remove the glazed surface of the enamel which may now be restored with a finishing firing.

For best results the stone must be kept constantly water wet during this hand grinding operation, and the piece must be thoroughly washed and brushed with water to remove the loose enamel film before firing.

One handy technique for stoning small stampings is to use very small wire brads (wire nails) and a piece of wood. Build a chuck by taking the object to be stoned, place it on a piece of wood and tap in three or four small wire brads around the edge to hold it in place. When you stone your first piece the stone will level the brads flush to the surface. Once one piece is done it easily lifts out and can be replaced by another.