FINE ART
METAL CASTING

An Illustrated Guide to Mould Making and Lost Wax Processes

Richard Rome NDD, FRCA, FRBS
and Hamish Young MA

ROBERT HALE • LONDON
12 Patination and Protection of Metal Castings

Preparation of the casting for patination

Health and safety

Working environment and equipment requirements

Bronze
Patination by heat application only
Patination recipes and application methods
- Base patina
- Cold patination
Hot patination
- Immersion
- Fume process
- Burial

Aluminium

Stabilization and protection of patina and cast surface

The acquisition of a natural patina or surface coloration during prolonged exposure to the atmosphere, immersion in sea water, burial in the ground or the handling of certain metals formed the basis of the modern chemical technology for artificial patination treatments. The appearance of a natural patina is dependent upon the chemicals present in a given environment, their concentration, temperature and duration of exposure to the metal. Since these extraneous variables considerably vibrate natural environments, patinas are largely achieved by chance and may take many years to develop. The patina will continue to develop and may eventually cause breakdown of the metallic structure unless the chemical reactions are arrested and fixed by artificial means. Artificial patination is used to achieve controlled surface coloration of metals comparatively rapidly through specific chemical application. There are a number of techniques, from the application of chemicals to the cold metal surface to the complete immersion of the casting in a hot chemical solution.¹

Artificial patination is to some extent a precise and predictable science in which the desired surface coloration can be produced with a given chemical formulation and application technique. However, certain chemical agents will make the grain structure of the metal alloy visible and so the structure is variable, even within a single casting (see chapter 9), coloration and pattern may vary, in some cases abruptly. Although the application of heat will recrystallize the metal, creating new grain structures, the process is hard to control since its effects are only noticed under the microscope or after chemical application.

The coloration of the metal casting using patination will not, in itself, hide defects in the casting. Inclusions such as refractory mould materials will become clearly visible and should be removed. Chafing, grinding and welding blemishes will also be revealed unless they are adequately matted and blended into the cast surface. It is essential to use filler rod of correct alloy specification to match the cast metal to ensure an even chemical coloration.

Preparation of the casting for patination

To ensure an even and adherent patina, the surface of the casting should be prepared to receive chemicals. It must be cleaned of all residue investment material and degreased to remove machine-tool deposits and finger marks which will inhibit even coloration. Castings can be effectively prepared by immersing them in a dilute acid or alkali solution, which dissolves any residual investment material and exposes the structure of the metal surface for chemical reaction.

However, apart from the health and safety implications of storing and using vats of dilute acids or alkalis, if they are not entirely removed or neutralized from the porous surfaces and interiors of castings they may later cause corrosion resulting in damage to the metal and its patinated surface. A safer alternative is to use a shot-blasting medium in a blasting cabinet or, in the case of very large castings, in a blasting room or yard. Blast cleaning has the great advantage of being a dry process, and therefore the integrity of the cast is not endangered by unarrested corrosion. A sufficiently fine blasting medium such as Safagrin recycled aluminium oxide 120/180 mesh size or Honey glass beads 120/170 mesh size should be used to ensure that no discernible damage is inflicted on the cast surface textures by excessive erosion.

Colouring is usually easier to achieve on open-textured surfaces. Polished surfaces should therefore be washed with a mild scourer to provide a fine texture for chemical application, to aid adhesion.

Lint-free gloves should be worn when handling cleaned castings to prevent greasy contamination before colouring.

Health and safety

Before using any chemical read the technical data sheet and any relevant health and safety information supplied with the chemical. It is essential to wear adequate safety clothing to prevent chemical inhalation and contact with skin and eyes. Respirators should be worn with recommended filters to prevent inhalation of harmful fumes and chemical spray. A rubber apron and gloves should be worn on top of long-sleeved overalls, with a clear full visor to protect the face and eyes. Adequate footwear, which can be easily washed down, should also be worn.

Protective clothing for patination.
Chemicals must be stored in a locked steel cupboard. Facilities for the safe and legal disposal of waste chemicals should be available (refer to the data sheet of the chemical for its safe storage, handling and disposal). Do not dispose of chemicals down the sink.

The make-up of chemical solutions should be clearly labelled before storage.

**WORKING ENVIRONMENT AND EQUIPMENT REQUIREMENTS**

Patination should ideally be carried out in a purpose-designed room with good natural and artificial lighting to enable the coloration to be determined in conditions similar to the proposed location of the finished casting. The room should be well ventilated, with an efficient fume extraction system for the removal of noxious gases. The patination room walls and floor should be tiled and stainless steel work surfaces used for mixing chemical solutions to enable adequate cleaning of any chemical spillages. A hot and cold water supply should be accessible. Patination can, however, be carried out in any well lit and ventilated space or out of doors in good weather.

The casting should be placed on a suitable turntable stand with a stainless steel top at a convenient working height for patination. Lifting equipment should be available for moving large castings into position.

**Tools**

Patination equipment.

- Accurate scales for weighing chemical solids and measuring cylinders or calibrated jugs for measuring chemical liquids
- A gas torch with either a propane or a natural gas supply for heating castings for chemical application
- A mortar and pestle for grinding chemicals to a powder
- Glass beakers and other suitable receptacles for mixing and storing chemical solutions
- Natural bristle or other heat-resistant bristle brushes, sponges and scourers for chemical application to and removal from the casting
- Plastic spray gun of the type used for spraying garden plants for mist application of the chemical

**Bronze**

**PATINATION BY HEAT APPLICATION ONLY**

It is possible to produce a limited range of dark patinas without chemical application by heating a bronze casting in a kiln or with a gas torch. This induces the formation of natural oxides that produce a range of surface colorations from natural metal colour through golden browns and reds to brownish black.

The coloration of the metal can be controlled by the temperature and the length of exposure. Higher temperatures up to 400°C and increased exposure for up to two hours will result in a dark patina. Rapid cooling by quenching in water can produce a range of purples.

**PATINATION RECIPES AND APPLICATION METHODS**

A large number of chemical recipes and various application techniques are used to produce a wide variety of patinas for bronze castings. However, the following chemicals can be used in solution to achieve some common patinas ranging from light orange-brown to apple green. Although tap water is often adequate, chemical solutions should ideally be made up using deionized or distilled water to achieve consistent results.

Patina solutions should be tonally lighter than the finish effect desired since the wax application used to seal and protect the patina from atmospheric reactions tends to darken them.

| Ferric nitrate | Light golden brown to rich red brown |
| Potassium sulphide (poly) | Golden to dark brown/black |
| Cupric nitrate | Light green to dark blue green |

Undesirable patinas can, to some extent, be removed by scrubbing with a stiff brush using water, though for complete removal the cast should be blasted using the mediums previously described. The patination process should then be restared and adapted accordingly.

**BASE PATINA**

In order to avoid a superficial appearance and achieve a patina with visual depth, a number of applications may be required over a base patina. The application of a base patina, either dark brown or black, provides the appearance of depth to subsequent chemical colorations. Between each chemical application the surface of the casting may be scrubbed with a kitchen scourer or wire (brass or stainless steel) brush to remove some of the patina from raised elements of the surface whilst leaving any recesses slightly darker (the light and dark contrast can be controlled by the amount of scrubbing). The bronze cast should be allowed to cool before scrubbing to avoid colour changes to certain chemical applications. Potassium sulphide applications, that are scrubbed whilst the casting is hot for instance, will result in a leaded appearance that is difficult to remove.

Potassium sulphide, colloquially called liver of sulphur, will produce a dark brown base patina over which other chemicals can be applied to produce a range of colours. Dilute potassium sulphide (approximately 1 part potassium sulphide to twelve parts water by volume) can be applied as a hot or cold patina using a brush or spray and, according to the strength of the solution and amount of heat applied, can in itself produce colours ranging from light golden to a deep blackish brown.

Ferric nitrate is often used for producing a base patina, although it produces good coloration on its own, ranging from light golden brown through to rich dark reddish brown by adjusting the concentration. Ferric nitrate can also be applied over other patinas for colour modifications towards gold and brown. Dilute ferric nitrate (approximately one part to 120 parts water by volume) should be applied as a hot patina using a brush or spray to achieve an opaque or translucent patina respectively.

**COLD PATINATION**

Cold patination involves the application of chemicals to the casting at the ambient temperature. The speed of chemical reaction is usually slow—it takes many days for some chemical solutions to achieve coloration. A warm dry atmosphere will speed up the reaction. Because of the gradual build-up of surface coloration during slow chemical reaction, cold patination provides a considerable degree of control, allowing the reactions to be arrested when the desired coloration is achieved.

The prepared casting should be placed on a stainless steel turntable stand at a comfortable working height for chemical application. It should be raised slightly from the stand surface using bronze rod or wedges to prevent the base standing in chemical that pools on the work top during application. This prevents the casting taking up any chemical by capillary action, which would cause the formation of the equivalent of a water mark around its base. Chemicals are usually applied by sponge or brush to leave the surface of the cast sparingly moist and avoid the formation of pools of chemical solution in the casting recesses. The coat should be left to dry thoroughly before further applications.

**Cold patination method – Dark brown and green**

A small lump of liver of sulphur is mixed in solution.
To produce the green, ammonia chloride is mixed in solution and applied to the dry-casting in thin coats using a stippling action with a brush.

The solution is applied with a brush using a stippling technique. Coloration is rapid but may be slowed by weakening the solution.

Coloration will only occur when the casting is sprayed with water. The surface may appear powdery and should be washed down before further applications to produce even coloration.

The application is allowed to dry before further applications, in order to build up even coloration.

HOT PATINATION

Hot patination involves heating the bronze with a gas torch and applying chemical solutions by brush, cloth or spray. Provided an even temperature is maintained, the coloration will be even.

For most chemical applications the bronze is evenly heated with a gas torch to a temperature at which the solution is applied it immediately boils off with a sizzling sound. If the temperature is too high the chemical solution will not mix and small globules of liquid appear to ‘dance’ on the hot metal, falling to wet the surface. Further heating will result in some chemical applications burning and producing a dark, scorched appearance requiring removal from the casting by abrasive blast cleaning.

When the metal is sufficiently hot chemical solutions can be applied by brush or sponge, using a stippling or dabbing technique, to produce an opaque patina or spraying with an aerosol spray to produce a translucent patina or ‘birds eye’ speckled effect. Chemical solutions can be diluted or strengthened, as required, during application.

This is a versatile method that can be used on castings of virtually any size, though it may be difficult to achieve uniform heating on very large ones. Small castings are usually maintained at the correct temperature by alternating between flame and solution application.

**Blue-greens and emerald greens**

Apply a solution of one part cupric nitrate to thirty parts water as a hot patina over a medium strength ferric nitrate base patina to achieve light greens or over a potassium sulphide base for dark blue-greens. The green coloration may also be adjusted by varying the concentration of the cupric nitrate solution. Weak solutions will produce light greens and stronger solutions or a larger number of applications will achieve dark blue-greens.

**Apple green**

Alternate layers of the following chemical solutions using hot patina techniques will achieve an apple green, though a number of applications may be required. The chosen base patina will determine the tone of the green achieved.

1 part cupric nitrate to 60 parts water
1 part ferric nitrate to 200 parts water

Between applications of different chemical solutions the casting should be washed with cold water, using a sponge, to accelerate coloration. This will also remove excess chemical and prevent contamination of the subsequent chemical mix.

**Olive green**

A weak potassium sulphide solution or ferric nitrate solution (1 part to 120 parts water) over an apple green patina will produce an olive green.

**Light to golden brown and green**

Apply one part ferric nitrate to one part cupric nitrate and forty parts water over a base patina chosen to determine the tone of coloration. A number of applications may be required to achieve the desired coloration.

Hot patination method – ‘green and olive green’

A liver of sulphur solution can be applied to a hot casting to produce a dark brown base patina. The casting should be warmed until a temperature is achieved at which the chemical solution boils when stippled on the cast surface. The temperature should be maintained by alternating heat and chemical applications.

The solution is applied until an even colour is achieved. The cast should then be washed with clean water.

To achieve a green copper nitrate is mixed in solution for application.
It should be applied by heating the casting to a temperature at which the chemical solution boils and fizzes when stippled on the cast surface. Alternate application of heat and chemical will maintain the temperature of the casting.

Once the desired even coloration is achieved the casting should be rinsed under water and dried before applying a thin layer of wax as a protective coating.

Ferric nitrate in solution can also be sprayed onto the heated casting to achieve a speckled effect.

Wax can be diluted using white spirit to achieve a thin application.

The chemical is applied until an even green is achieved. The green can be washed and sealed with a wax coating at this stage.

Hot patination method - red/orange brown
A layer of sulphur base is applied and rubbed back using scourer to highlight casting extremities.

This method produces a rusted cast iron colour.

The thin application will not form a perceptible wax layer on the cast surface, ensuring that the subtle coloration remains visible and is enhanced.

Ferric nitrate solution is applied to the heated casting at a temperature at which the chemical solution fizzes when stippled with a brush onto the cast surface. The temperature is maintained during application by alternate application of heat and chemical and the casting rotated to achieve an even patina.

Applying wax to a warm cast will tend to result in a perceptible wax layer.

The casting can be rubbed back gently to highlight any high points and increase the lustre.
IMMERSION

It is possible to immerse bronze casts in either a hot or a cold chemical solution to produce a wide range of patinas. The health and safety requirements and financial implications of handling large quantities of chemical solutions generally prevent this for castings of any size and the process is therefore usually restricted to very small castings.¹

FUME PROCESS

Vibrant patinas can be produced by exposing the casting to chemical fumes. The casting is placed in an airtight container with a quantity of liquid chemical, which provides a fume. This process can produce some beautiful effects, but is difficult to control and is impractical for large castings. A 50 ml cup of ammonia placed in the bottom of a sealed 5 litre container, with a casting, for example, will produce a deep cobalt blue bloom after a few hours.²

BLURIAL

Burial in a mixture of sand or sawdust moistened with chemical reagent can produce stippled and encrusted patinas similar to the natural patinas found on bronze or copper artefacts which have remained buried in the ground for many years. The degree of encrustation and patination is proportional to the length of time that the casting is buried and the burial temperature. The patina is, however, difficult to control and may take a considerable amount of time to develop fully.³

Aluminium

A limited range of patinas such as a reddish tone or black can be achieved on aluminium castings but will require the casting to either be baked in a kiln before and after application of the chemical or immersed in a vat of chemical solution. Aluminium castings can,

however, be dyed to virtually any colour by dipping in a dilute solution of sodium hydroxide or potassium hydroxide (used in industrial drain and oven cleaners) to produce a soft etched surface before immersing in a household cloth dye.⁴

Stabilization and protection of patina and cast surface

The chemical reaction with the cast metal surface, may continue indefinitely with some chemical applications (particularly chlorides), and will not necessarily be arrested by washing with cold water. The surface of a casting is also vulnerable to abrasive and chemical attack from the atmosphere and requires protection with a wax or lacquer. A bronze casting whose surface is not protected and which is permanently sited outside will gradually acquire a patina produced by the metal reacting with chemical agents in the atmosphere in that particular location. For example, a casting situated by the sea and constantly exposed to the marine atmosphere, will react with the salts and rapidly become coloured, with shades of green predominating. By contrast a casting sited in a polluted industrial atmosphere with a high proportion of sulphides in the air will tend to blacken. Over time bronze rot may also set in if a casting is left unprotected from the atmosphere. This process is caused by the gradual dissolving of the bronze surface by chemical action and is manifested in pitting and small craters appearing on the surface of the metal, which gradually increase in size until the surface is destroyed.

After rinsing the casting with water it should be dried thoroughly and evenly by dabbing with an absorbent cloth to prevent patches forming on the surface through evaporation. Castings may also be dried in an oven or kiln at a sufficiently low temperature to ensure that the coloration is not affected. If desired, the surface of the casting may be gently abraded with a brass brush or fine scourer to highlight prominent textures before fixing and sealing by applying a protective layer of wax, lacquer or both.

Beeswax or Renaissance wax are widely used to form the protective coating but coloured waxes, such as good quality shoe polishes, may also be applied and can modify a patina by producing a transparent coloured film over the patinated surface. Wax applications will darken a patina but tend to afford it a degree of translucence. A thin layer of wax should be applied by soft brush or cloth so as not to produce a visibly waxy coating. Although waxes may be applied to a warm casting they should ideally be applied, thinned with white spirit, to a cold casting to maintain control of the wax thickness. Lacquers are normally used on highly polished bronze castings to protect the polished metal from the tarnishing effects of the atmosphere. A lacquered surface is highly reflective but this can be mitigated by the application of a wax coat, which when polished will produce a softer reflective sheen.

Protective wax or lacquer applications should be maintained on site by regular recoating to prevent deterioration of the patina. Castings sited outside may require additional wax applications twice yearly whilst those under cover may only require renewal every five years.

¹ For techniques of immersion see Hughes, R. and Rowe, M. The Colouring, Bronzing and Patination of Metals
² For further information on fuming techniques see Hughes, R. and Rowe, M. The Colouring, Bronzing and Patination of Metals
³ For further information on burial techniques see Hughes, R. and Rowe, M. The Colouring, Bronzing and Patination of Metals
⁴ For further information on aluminium patination see Young, R. D. and Fennel, R. A. Methods for Modern Sculptors