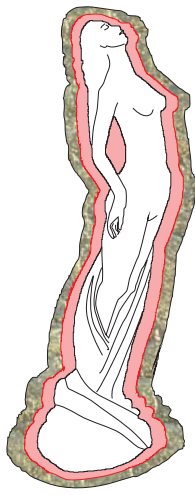


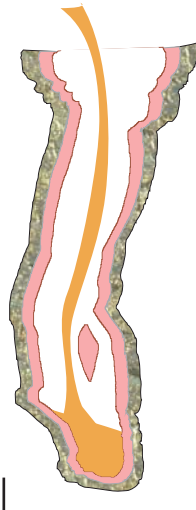
THE BRONZE CASTING PROCESS FOR SCULPTURE



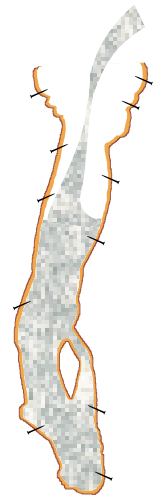
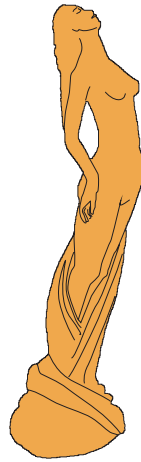
1. Original



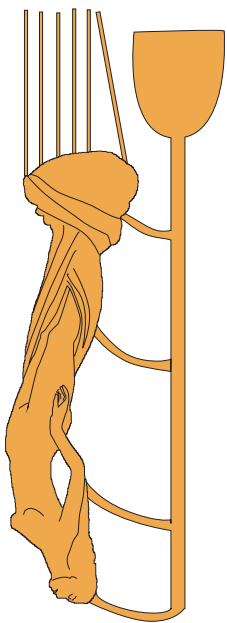
2. Rubber mould



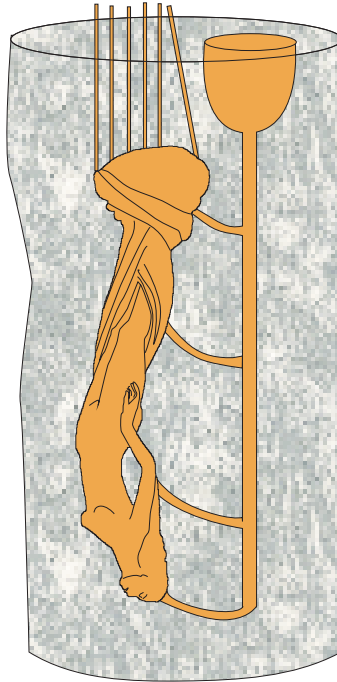
3. Wax is applied to create a hollow duplicate



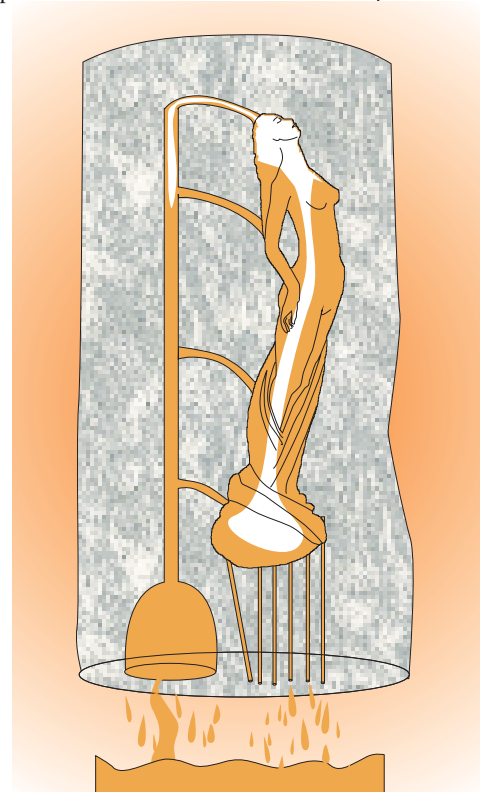
4. Core invest & pin



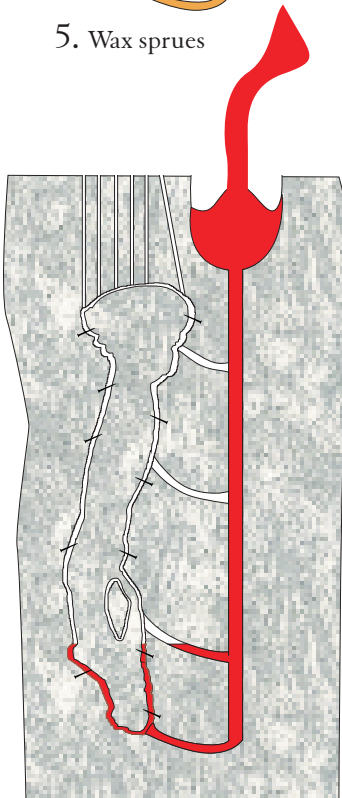
5. Wax sprues



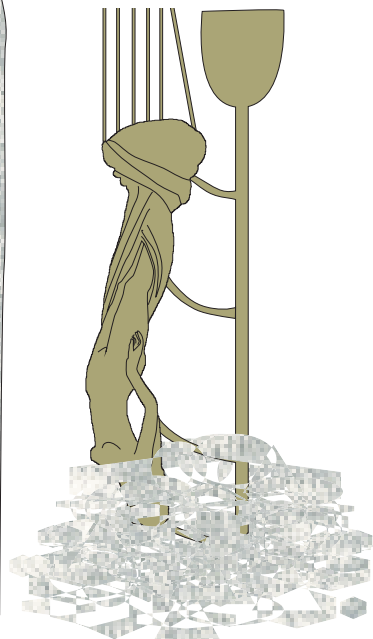
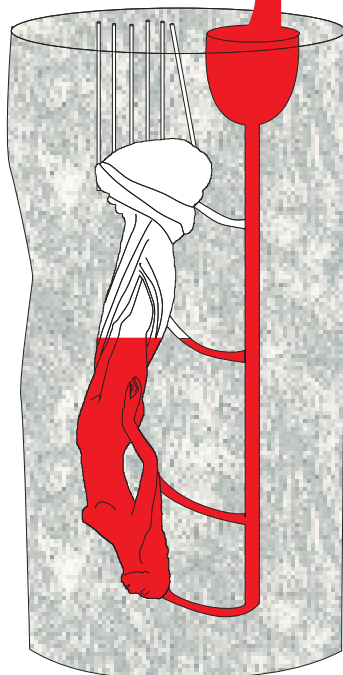
6. Refractory mould



7. Wax is melted out of refractory mould



8. Bronze is poured into the void left by the wax in the refractory mould



9. Crack-out



10. Bronze finishing

1. Original



~ Can be in clay, wax, plaster, wood or any preferred material



A concept maquette of a sculpture is a small version that the artist makes first, so as to develop the initial ideas, sculptural forms, the position of the parts and their relationship to each other.



The ability to enlarge a work is an essential skill for a figurative sculptor. The design idea from the maquette is enlarged by the artist using clay, wax or plaster as their sculpting material.

Figure sculpture is a fusion between what you know and what you see combined with an awareness of the history of sculpture, using the language of 3D form for visual interpretation.

2. Rubber mould



~ To make a duplicating mould of the original



Multiple segment acrylic resin & silicone rubber moulds

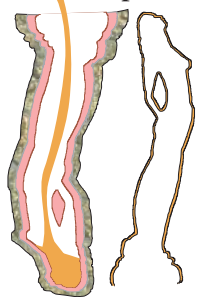


Metal strips make the walls for the mould segments. Every segment is carefully planned, as a mistake may result in a mould which will not come apart, or that will damage the sculpture.

Moulds for large sculptures have multiple segments that assemble like a three dimensional jigsaw to make up the form.

Every soft rubber mould needs a rigid case mould to support it. Each case mould must key and bolt on to the next.

3. Wax duplicate



~ to make a wax duplicate; identical to the original, but hollow



Brushing in the first layer of wax onto a rubber mould. Several layers are usually required. A final layer of cooler wax is poured in after the mould segments have been reassembled. The 'slush' cast binds all the brushed in segments together as a unified whole.



The wax copies are always about 3 - 5mm thick hollow shells. The completed bronze will also be hollow.

De-moulding the wax duplicates of various sculptures.

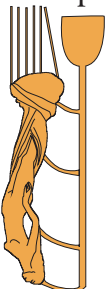


4. Core invest



~ to make a refractory mould core inside the wax duplicate

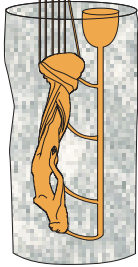
5. Wax sprues



~ sprues are tubes that channel the bronze as it flows into the sculpture duplicate



6. Refractory mould



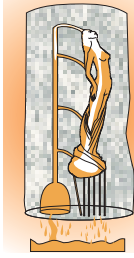
~ a fireproof mould constructed around the wax sculpture



The first layer of the refractory investment is brushed onto a wax duplicate of a sculpture (90 cms tall). This mould required 65 buckets or 250 kgs of refractory.



7. Wax melt-out



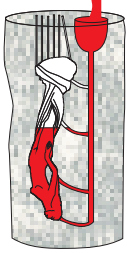
~ a large oven melts out the wax & steams the moulds dry

The trolley is loaded with the heavy refractory moulds and then rolled into the oven.



The oven fires up to 560° C. It has been designed for the specific needs of the studio. The unit has been fully tested for carbon emissions and approved as compliant to EPA regulations.

8. Bronze pour



~ bronze is poured into the void left by the wax



A crucible with a 40 kilo capacity is lifted manually by two foundrymen.



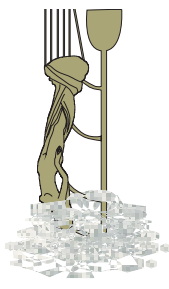
A crucible with 150 kg capacity is mechanically lifted. The pour of the molten metal is controlled manually by the foundrymen.



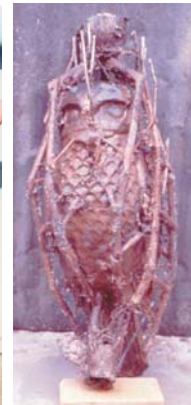
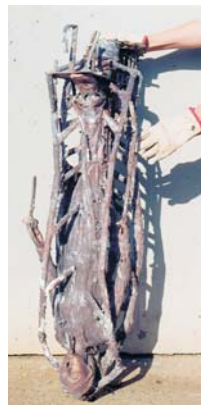
The bronze is poured at 1090° C



9. Crack-out



~ the refractory material is broken and blasted off the bronze



Water pressure at 1600 psi is used to blast the refractory mould off the bronze. The cast form still has its sprues attached. These are now bronze

10. Bronze finishing



~ sprues are removed and the surface is cleaned, ground and detailed
~ segments are welded together
~ chemicals are applied that colour the surface
~ wax is applied to protect the surface treatment



The sprues are cut off



Die grinding the surface



Above & Left: Segments that were cast separately are bronze welded together before patination
Right top: Several layers of patina chemicals are applied to obtain varied tones and depth of colour.
Right: A final wax is applied after installation of a sculpture into an outdoor site.



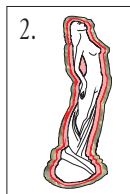
THE LOST-WAX BRONZE CASTING PROCESS

Original

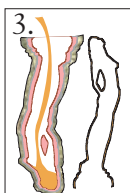


1. **Original;** The sculptor produces a solid clay sculpture. Modelled over a steel and wood armature the clay is kept damp and prevented from drying out after completion. Modelling of a life size original can take between six months to several years (depending on complexity). The sculptor works from a life model for the position and detail of the body form and facial features.

Reproduction of Original into wax



2. **Duplicate mould;** The original sculpture is duplicated into wax by making a silicone-rubber mould. This is a negative mould that is created around the original form. A precise imprint is taken of the surface texture and contours of the sculpture. Silicone rubber is a recent innovation which replaces earlier more toxic materials. Two moulds are made at this stage, as the rubber is very flexible and must have an outer support mould (or case mould) to prevent sagging and distortion. The case mould is rigid plaster or acrylic resin. A sculpture in a life-size scale will usually have twelve to fifteen mould segments, each with a support mould, interlocking like a three dimensional jigsaw puzzle.

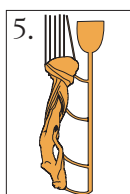


3. **Wax copy;** A wax positive is taken from the negative rubber mould. This wax copy is about 3-5mm thick, which means the finished bronze will be the same thickness. Large sculptural forms are always hollow because if they were cast in solid bronze they would shrink and distort as the metal cooled. The wax copy is hand finished by the artist and prepared for bronze casting. It is signed by the artist and numbered for an edition.

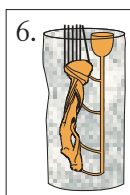
The wax copy is now processed for bronze casting



4. **Core investing;** - The 'core' is the internal space within the hollow sculpture. Core pins or nails are pierced through the wax 'shell' of the sculpture. Refractory plaster is then poured inside its hollow space to make a refractory core. The pins prevent movement during firing and casting. They maintain the uniform spacing of the core in relation to the outer face of the sculpture. An even 'shell' thickness.



5. **Sprues;** - The inlets and outlets that will eventually channel the molten bronze to flow into the sculpture are called sprues. They are like a network of plumbing, for fluid and gas. The tubes are designed around each specific form, so as to allow the hot bronze to flow down and run into the sculpture, whilst also forcing the air in the cavities to flow up and vent out. These sprues, runners and vents are made out of wax tubes, which are attached carefully to the high and low points of the sculpture.

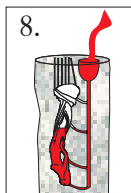


6. **Investing;** - A refractory mould is built around the wax and its sprue system. The actual material of the refractory mould is plaster, mixed with heat resistant calcinated flint clay. The sculpture is solidly embedded into the refractory, which is built-up in layers. The first layer captures the surface detail when a very fine mixture is brushed on the wax form. Then many course layers are slurried over it, adding the strength and density required to resist the intense heat and expansion of molten bronze.

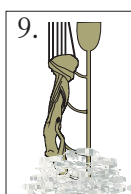
Firing and casting



7. **Wax melt-out;** The mould is now 'baked' slowly in a large drying oven that goes no higher than 600°C, so as to steam dry the moulds. The wax sculpture inside the refractory mould melts in the heat of the oven. Placing the mould upside down in the oven allows the melted wax to flow down and drain out, and to collect in large trays below the mould. (The wax is recycled.) All traces of water and wax need to be steamed out of the mould during this stage. The melting out of the wax figure has left cavities of empty space in the dry refractory mould. The cavity is the exact shape of the original sculpture. It is this void that the bronze will be poured into.



8. **Bronze pour;** The bronze is melted in a foundry crucible and poured into the refractory mould, which is still warm from the oven. The bronze flows down through the network of tubes into the figure. The bronze is poured at around 1090°C. It is a bright fluorescent orange colour. Silicone bronze is a new alloy of bronze which does not contain lead, it is used in lost wax foundries across the world.



9. **Crackout;** Allowed to cool overnight, the refractory moulds are cracked off the cast bronze figure. The refractory material is collected, crushed and recycled. A final pressured water-blasting removes the last crusts to reveal the results.

Finishing and patinating

10. **Metal cutting;** The tubes, which allowed the metal to flow in and the air to escape as the bronze was poured, are now also bronze. They are cut off the sculpture and the stubs are die-grinded, to match the contours of the original sculpture. The surface of the bronze is re-textured, cleaned and sand blasted.

Welding; Large or complex sculpture may be cast in segments. Segments are re-aligned and welded together. The seams of the join are hand detailed to match the original.

Patination; The metal is coloured using chemicals which react with the surface to produce the natural corrosion we associate with bronze, deep greens, olives, red browns and black. All chemicals are chosen in line with conservation practise, containing no chlorides or lead. The patination is built up in layers, each application of chemicals requires several days to dry and fully react. As many as seven layers of chemicals may be applied to a surface over several weeks.

Wax finishing; with a durable microcrystalline wax seals the surface and protects the sculpture from damage. Microcrystalline is recommended by museums as the best treatment for non-ferrous metals.

Recommended reading

* "From Clay to Bronze - a studio guide to figurative sculpture" by Tuck Langland. (Watson-Guptill Publications. ISBN 0-8230-0638-7.) This is a very comprehensive book covering a wide variety of sculpture materials, techniques, step-by-step guides and alternative methods.

* "Bronze casting techniques for sculpture" Churchill Fellowship Report; M. Judge - Churchill Fellow 2001
www.churchilltrust.com.au

LIQUID METAL STUDIOS

M. Judge & W. Kuiper; sculptors & bronze casters

email: liquid.metal@senet.com.au

(fold out cover to match text to diagrams) ➡