PRESSED SOFT METAL MOLDS

by

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ABSTRACT

In spite of the almost complete domination of flexible molds for the production of wax patterns the various forms of rigid molds should be considered . The increasing use of patterns made by plastic injection and the desirability of producing thin items of known weight may lead to a revival of various types of nonflexible molds. Pressed soft metal dies are a relatively simple way of building such molds. This paper describes two types of such molds: a standard two part mold and another which accomodates more complex threedimensional, undercut models.

KEYWORDS

Flexible Molds, Various Types of Rigid Molds, Bismuth Alloys, Component Parts of Soft Metal Molds, Mold Cases, Model Requirements, Model Imbedment, Pouring Soft Metal, Pressing Soft Metal, Molds with Multiple Parts, Ring Arbors both Plain and Split, High Pressure Wax Injection, Sprayed Molds.

PRESSED SOFT METAL MOLDS

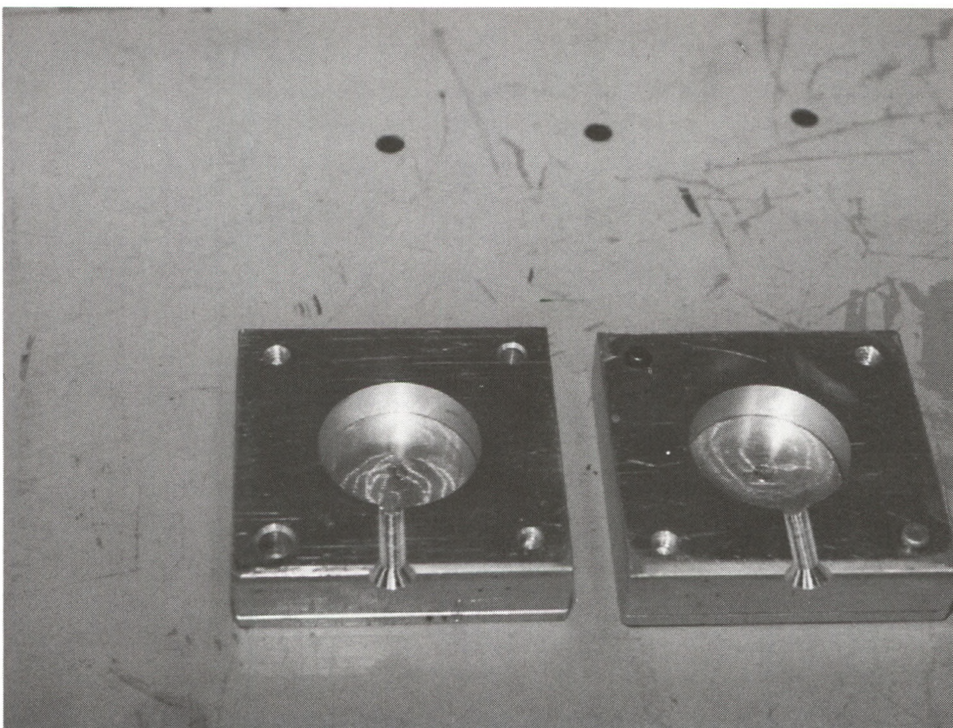
Flexible molds wether made of rubber, RTV materials, or any number of silicone compounds, have for many years been the standard technique for producing wax patterns for lost wax casting.These molds have numerous advantages. Their flexibility permits the use of often very complex three dimensionsl models which may have severe undercuts; they are fairly easy to make, they can be made in a relatively short time, they are inexpensive, and in most cases many good wax patterns can be produced before the mold needs to be discarded.

Nonetheless, even these paragons of usefulness have certain disatvantages:

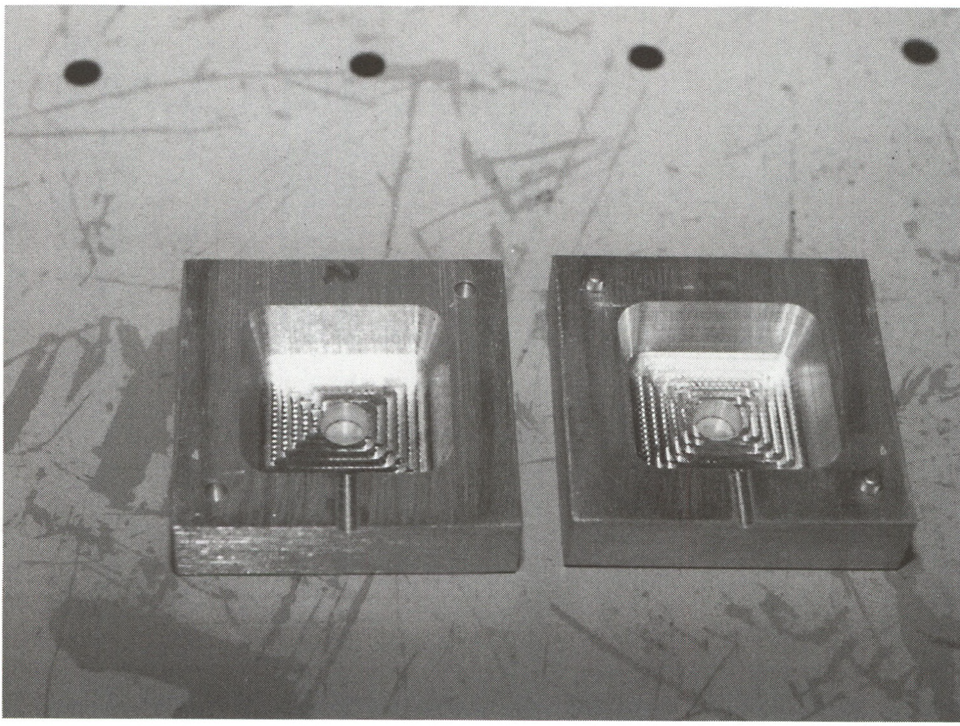
- Precise metal weights are difficult to maintain since changes in injection pressure may cause some differences in the weight of a wax pattern and thus change, however slightly, the weight of the cast piece.
- Thicknesses of a model of less than .020" may be difficult to reproduce in flexible molds. This is particularly true of large surfaces.
- Flat surfaces are notoriously difficult to reproduce unless they are properly compensated by making the flat surfaces somewhat convex.

All these and some other minor difficulties can be overcome through the use of rigid molds which permit high pressure injection of wax or plastic materials.

There are many types of these rigid molds or, as they are usually called, metal molds.They may be machined, pantographed, produced by EDM machining,, a.s.o. Most molds are made for reproducing two dimensional items. Any form of undercut requires molds with inserts which will add considerably to the complexity and the cost of a mold. Very early in the history of lost wax casting a technique was perfected which resulted in very precise molds, often multiple piece molds, capable of producing waxpatterns without shrinkage and with excellent detail. With the advent of the Second World War most flexible molding materials disappeared and



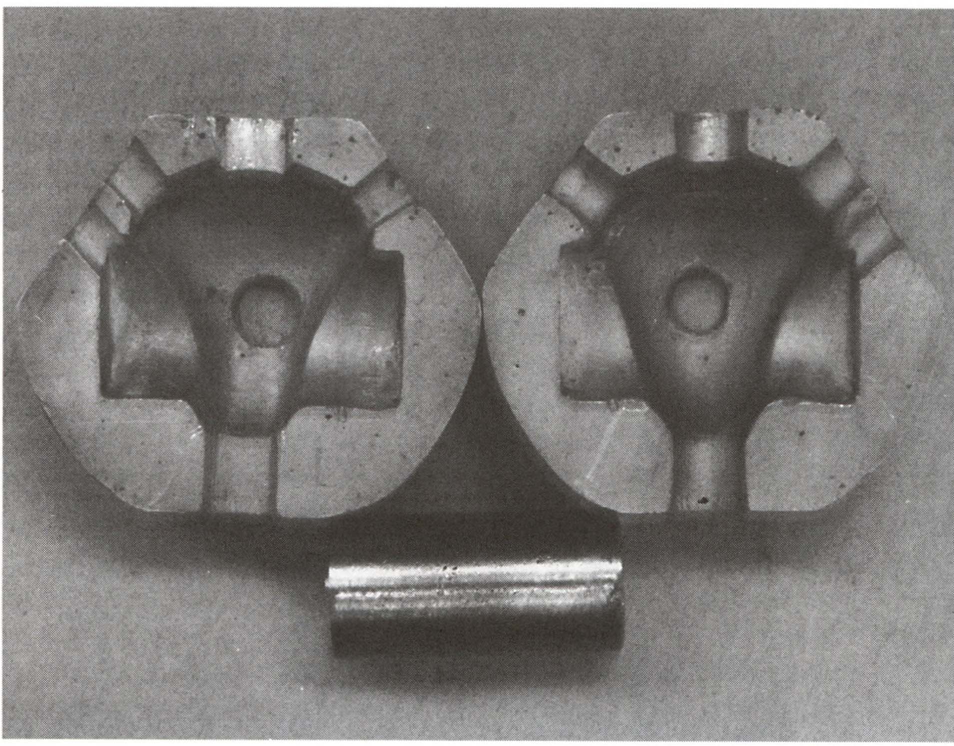
Machined Mold Case with Plunger



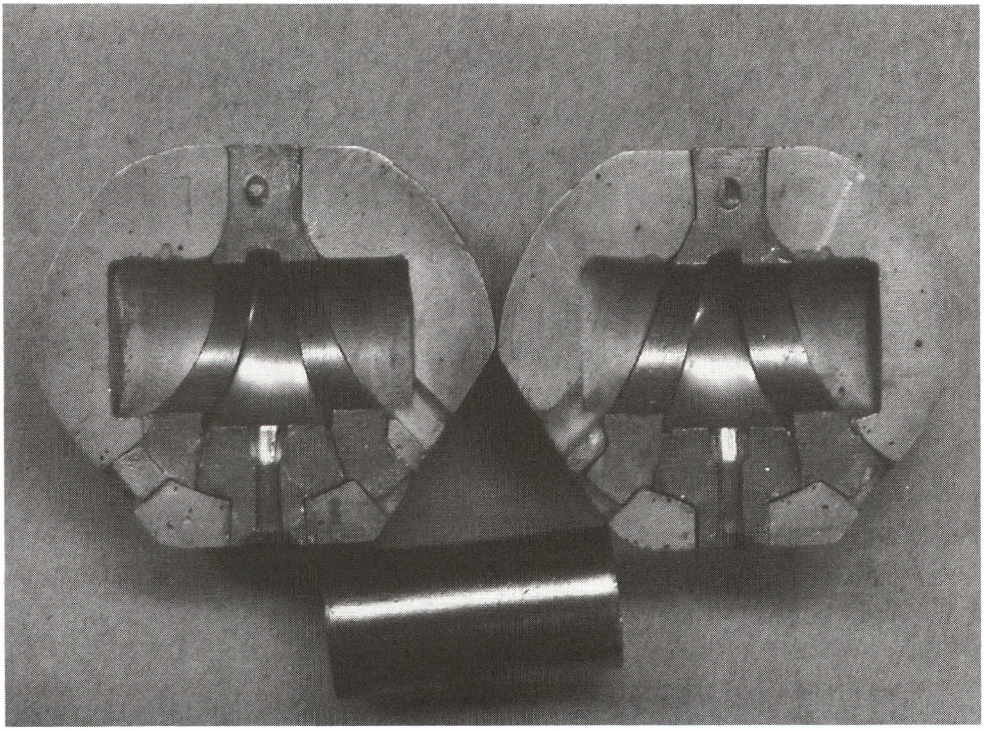
Machined Mold Case

for the duration these socalled soft metal molds were in extensive use. Today except for a few specialised applications they have pretty well disappeared from the scene but with the increasing popularity of patterns made by plastic injection they may be headed for a rebirth.

The key to soft metal molds is a variety of bismuth based alloys. Bismuth is a heavy, coarse crystalline metal which expands as it solidifies. This characteristic it shares with antimony and water but bismuth expands even more than water, 3.3% by volume. The alloying metals used may be lead, tin, cadmium or indium. Alloys containing more than 50% of bismuth will tend to expand during solidification; alloys containing less will tend to shrink. Depending on the alloying materials we find melting points ranging from about 115 degrees F to a little under 500 degrees F. A number of alloys are eutectic, i.e. they have no freezing range between liquidus and solidus. Other alloys do exhibit definite freezing ranges. These materials were first developed and marketed beginning around 1930 by Cerro de Pasco under the trade names of Cerrobend, Cerrosafe,, Caerromatrix, Cerrocast, a.s.o.; the names referring to primary uses and also to the melting point of the various alloys. Today there are a number of manufacturers of these alloys. They are widely used in industry for making a variety of holding fixtures, as bearing materials, as fillers for tube bending, and so on. Most alloys will show no shrinkage after they are cast, a few will even grow minutely at the rate of a few tenthousandth of an inch. While this helps to insure perfect adhesion in many applications it is of lesser importance in the making of pressed molds where we rely on a final application of pressure to insure perfect reproduction of a surface.
We are going to examine two representative types of metal molds.
The first type will be a simple, twodimensional mold consisting of two halves. While the model to be reproduced may be threedimensional it is important that there be no undercut of any kind. In a way the model will be similar to a hub used in a diestruck piece.
The second type will be a more complex threedimensional mold consisting again of two halves of a moldcase but containing at least three segments which when disassembled will permit the extraction of a fully threedimensional waxpattern with undercuts. A typical example of such a



Sandcast Case for Ring Mold



Complete Ring Mold with Arbor-Sandcast Case mold might be a ring where a solid or a split removable arbor is used. This arbor will hold the waxpattern after the mold halves have been removed.The pattern may then be slipped off the arbor. This theme has many variations; the important part being that the outer case of the mold contains a number of inner mold segments which, when assembled, will produce a fully dimensional waxpattern.

Before discussing the actual construction of a metal mold we should look at its component parts.
There is always an outer casing which contains the soft metal parts while they are poured around the model and subsequently while they are pressed. In most instances this case forms a permanent, integral part of the mold and permits proper alignment of the mold parts during the clamping and injection cycles. It should also be noted that the soft metal parts are not very strong, can easiliy be scratched or otherwise damaged, and are best handled safely contained in a casing. The cases are usually aluminum. They may be sandcastings or they may be machined. Aluminum is light in weight which is a factor in the ease of handling of molds during the injection and opening cycles. The cost of the casings is a major factor in the total material cost of a metal mold. From this point of view cast cases are preferable, especially if no further work needs to be done to the raw castings. However, machined cases in spite of their much higher costs have advantages which should be considered.If the molds are to be used for plastic injection molding machined cases are essential for proper clamping and for accurate location during injection. Another advantage: if the soft metal inserts are easily removable from the case more than one mold may be made using one case. However, care must be taken in storing the delicate inserts and care must be taken not to distort the case during pressing a subsequent mold where cast cases have been known to distort and even to break. My personal preference is for machined cases. One other point: If guide pins are used to assemble top and bottom of a case it is best if the two pins are of different sizes to assure proper alignment.
As mentioned previously there are many different soft metal alloys. The choice depends in part on the type of mold to be made. For wax injection

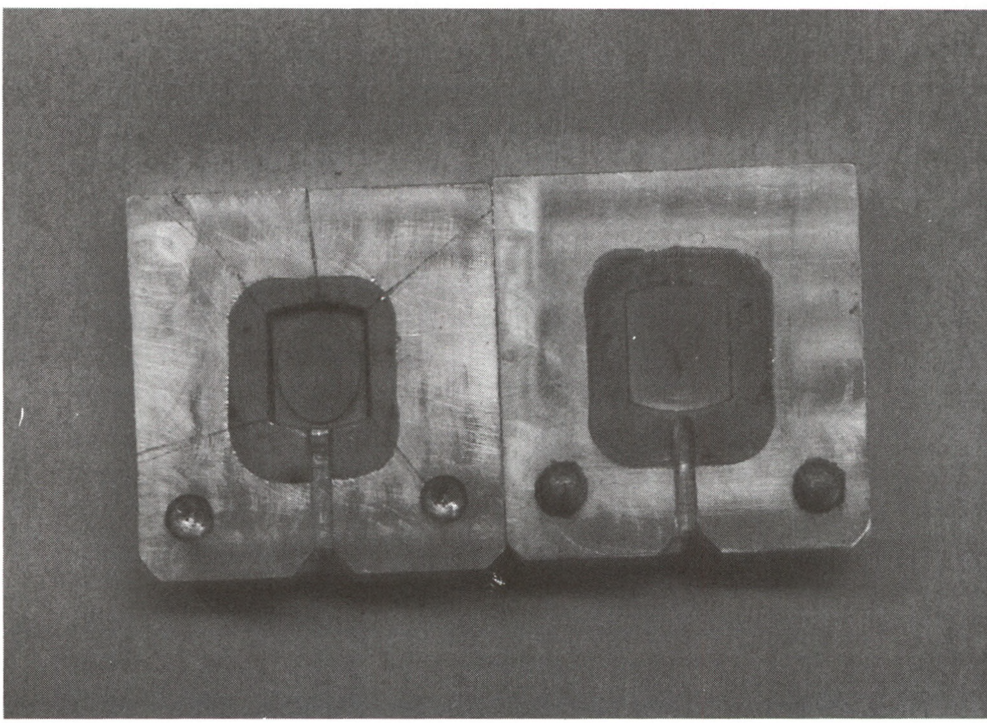
one can use any alloy with a minimum melting point of about 150 degrees F. The most popular alloy would appear to be one with a melting point of about 290 degrees F. For making molds for plastic injection it is best to use an alloy at the upper melting range; this is around 500 degrees F. Pressing such an alloy is considerably more difficult; it needs a heated platen which can reach almost this temperature and ordinary vulcanizersd which are otherwise quite suitable may fall short . The cost of lowmelting alloys is high; figure around $ 30 per pound. This may be compensate for to some extent by keeping the cavity to be filled by the softmetal alloy as small as possible, this is another instant where a custom machined case may be of value; aluminum being a lot less expensive than the alloy. For melting a temperature controlled small melting pot such as is used for soft solders is suitable. With care one can also melt the metal in a ladle over a bunsen burner; however this makes it easy to overheat the metal.

Models to be used for making metal molds have a few differ somewhat from those for flexible molds. The main difference is that there will be no shrinkage in the mold and thus there need be no allowance for shrinkage in the model. Models to be used in two part molds must not have any undercuts whatever; they may be highly dimensional but in order to release them from the mold they must have no undercuts and preferably a slight draft. Highly finished models are suggested since the softmetal alloys will duplicate a polished surface with great fidelity. Rhodium plating is feasible and often helpful provided that the model is not an assembly of soldered part which may require future repair. It normally is not necessary to attach a gate to the model; a short stub or is sufficient since the actual gate is usually formed by drilling or engraving after the mold is pressed.

And now we can begin.

The first metal mold will be a simple two part mold. The model, as mentioned previously, will have no undercuts but beyond that it can be threedimensional.

The case, or as it is sometimes called, the chase for this particular mold consists of four parts: top and bottom plus two covers. You will notice that the covers have a protruding segment which will fit flush into either



Tie Tack Mold-2 Parts

the top or bottom casing; this protrusion acts as a plunger or a piston. Its main purpose is to exert force on the soft metal part of the mold while the mold metal is being heated until it reaches a plastic state. This will the press the softened metal against the model and this will ensure a faithful reproduction of one half of the model.

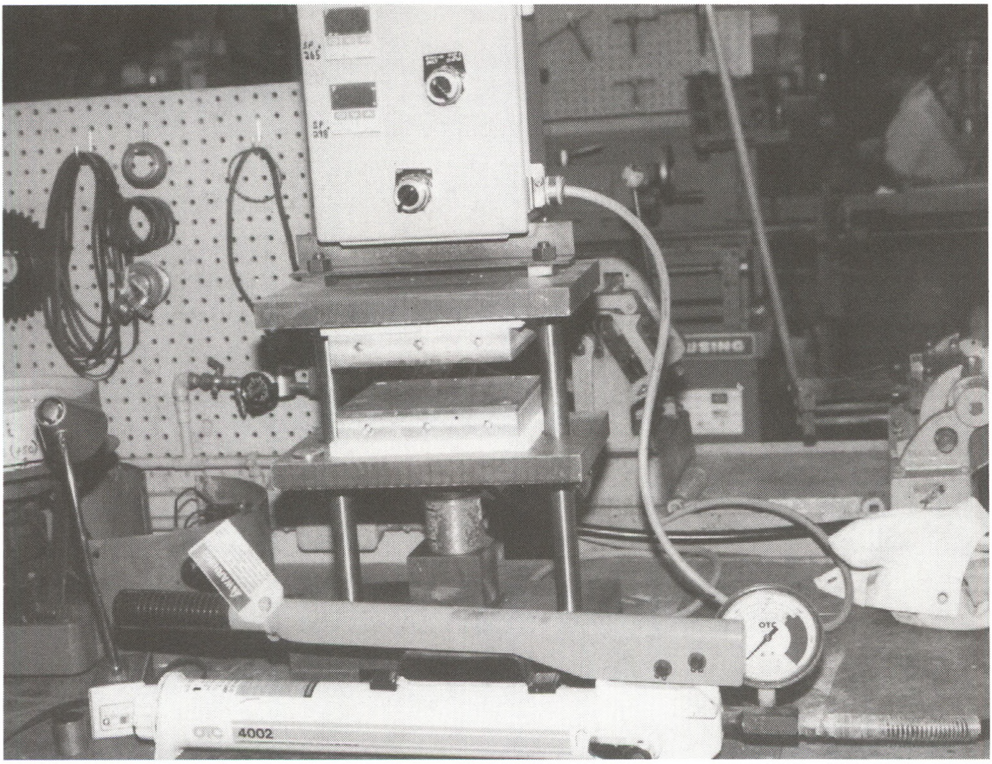
The actual procedure is as follows:
One half of the chase with its cover attached is filled with some form of modeling clay or plasticene. The model is placed in position and at this point the parting line is established. Usually the front part of the model is pressed into the clay, however this is not a rigid requirement.. The model may be coated with talc or sprayed with a silicon spray which will prevent the clay from sticking to it which would necessitate subsequent removal of any clay adhereing. The surface of the clay should be reasonably smooth and some miter marks might be provided at this time; half round dimples are as good as anything else.
The second half of the chase is now placed over the first half but without the cover. At this point a suitable amount of dental stone is mixed and poured over the embedded model. Do not use investment as a substitute for the dental stone; investment as some of us have learned to our sorrow does not have the compressive strength required when the soft metal is pressed against the stone. If possible, it is a good idea to vaccum the mix before pouring. It is best to pour from a corner rather than directly over the model Some prefer to paint the model with a coating of the dental stone and then pour the rest. This method will prevent any air bubbles forming on the model; however it requires time and care to do this coating properly and the working time of dental stone is limited. When in doubt read the instructions as to a safe work time. As to the quantity to be poured: The chase can be filled completely and as the stone begins to set any surplus can be removed with a straight edge. Another method fills the chase only partially so that the cover together with the plunger can be used to close the chase. This method is. more tricky since the amount of stone to be poured has to be fairly accurate. After the stone sets it should be left to cure at least until any exothermic heat has been dissipated. The mold is then opened and the clay removed.

Pouring the metal for the first half of the mold can now begin. Some particularly careful people will first seal the dental stone section with shellac or a similar coating; it wont hurt but is it really necessary? Next the mold metal needs to be melted. This can be done in a ladle over a bunsen burner. However it is easy to overheat the metal that way and it is far better to use a temperature controlled melting pot. A pot used for melting soft solder is good, there are other units available such as glue pots, etc. The metal should not be heated much beyond its melting point; the closer to that temperature it can be kept the better. For molds to be used for plastic injection a melting point somewhere in the vicinity of 500 degrees F is needed. The ladle, either an ordinary small cast iron ladle or a stainless steel ladle, must be preheated slightly either by keeping it in the melting pot or warming it over a flame. The molten metal must now be skimmed and any dross removed. Pouring into the open half is always done away from the model, preferably from the side. The chase is not filled all the way, just slightly over the point where the plunger would be if it were in place. After the metal has solidified the mold frame can be taken apart and the poured section is checked. If all goes well there will now be an approximate negative of half the model. There should be no voids anywhere on the surface, but if there are they can either be filled by using a softsoldering iron or else the metal mold half is discarded and a new half is poured.

Now we come to a parting of the ways. One school would press the first mold half against the stone. This, it is claimed, will give a precise parting line and will finish one half before the scond half is poured. The other way is to destroy the dental stone section at this time and pour the second half before the first half is pressed. My preference is for the first method; it is safer and if the pressing of the first half should fail for some reason it can easily be poured again..

For the actual pressing or squeezing the best tool is still an ordinary vulcanizer. The only change made is that one of the platens, usually the bottom platen, is disconnected. The vulcanizer should have a reasonably good temperature control and a method of checking its accuracy.

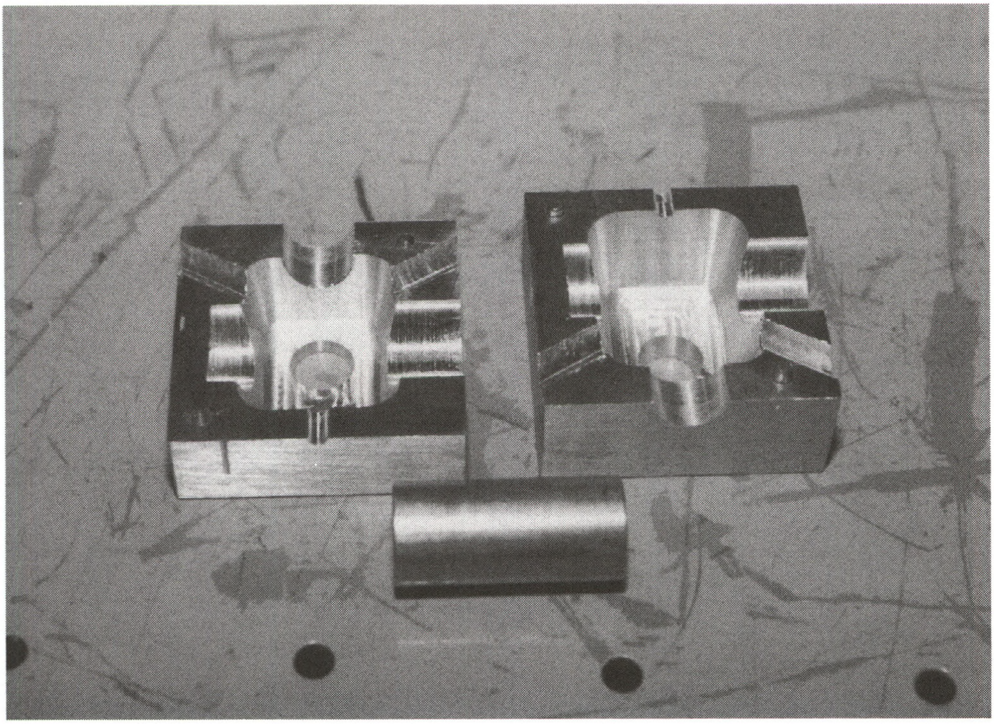
The mold is assembled; the top cover must not go all the way into the top chase. If it does more metal must be added to the mold half. This can be



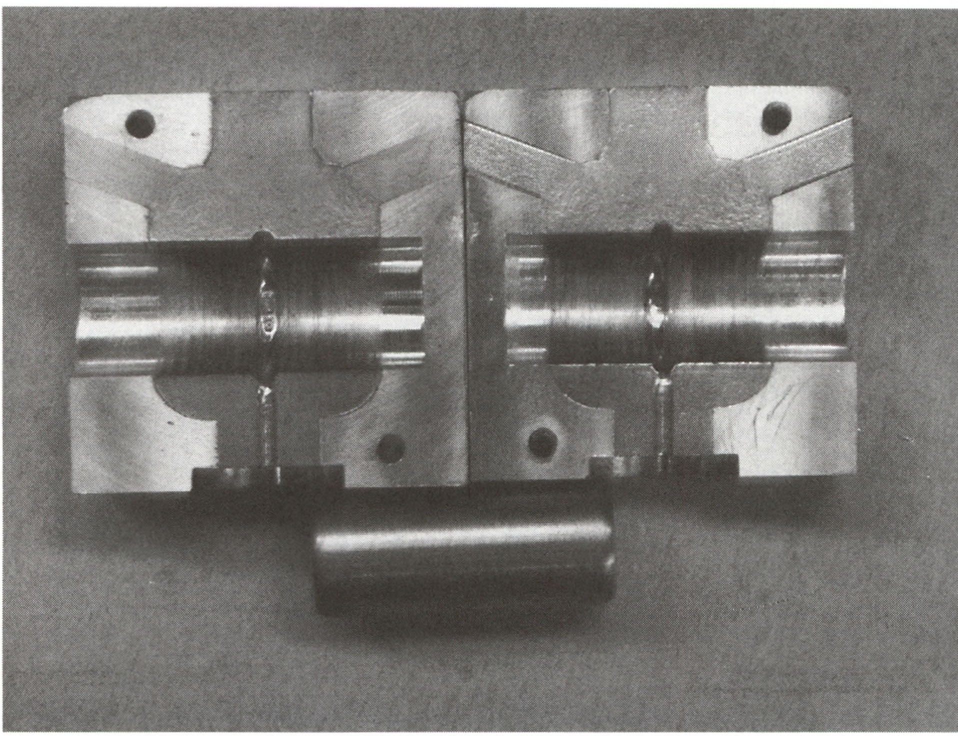
Hydraulic Vulcanizer

done by pouring a small amount or by adding it with a soldering iron. The assembled mold is placed in the vulcanizer with the metal half against the heated platen which should have a temperature just a few degrees below the melting point of the soft metal. when the top half of the chase reaches the temperature of the vulcanizer pressing can begin. There is no need to exert a lot of pressure, what is important that the soft metal becomes plastic and can thus be squeezed against the model. It can happen that a few drops of molten metal will squeeze out from the splitline of the mold or through the opening where eventually the gate will be. In any case after enough pressure has been applied shut off the vulcanizer and keep pressure on the mold. After the mold has cooled to the point where the metal is again a solid mass the mold is removed and opened. The model must not be removed at this time. If the impression against the dental stone looks good the stone can now be removed and the second half poured. this pour is the tricky part. It is best to put a parting compound on the first half; this may be a separating powder, a silicon spray, or, what was used years ago, nail polish. The metal to be poured must be as cool as possible so that it will not melt into and adhere to the first half. After this second pour the mold is disassembled once more. If this is difficult a thin knifeblade may be inserted between the two halves and the mold split that way. If the second pour was successful this half can now be squeezed in the same way the first half was done and after cooling the mold may be split and the model removed. This can be made easier by having a little metal stub on the model at the point where the gate will be cut. The gate, as previously mentioned, may be drilled or engraved, the mold can then be tested using either a high pressure wax injector or, if the mold is designed for it, a plastic injector.

In order to save time many people pour the first half directly against the clay and then, after removing the clay, pour the second half against the first without first pressing the first half. In many cases the two halves are pressed together which works if parting lines are of no importance. An example of this would be a flat piece such as a medal..
Molds for flat pieces without a design on the back can be made by simply making only the front part, the back would be a flat piece of aluminum.



Machined Ring Mold Case with Arbor



Complete Ring Mold with Arbor-Machined Case

Metal molds for rings pose a number of problems. The casing is different; usually two aluminum castings with the inside accomodating the ring mounted on an arbor. There are a number of openings through which the metal may be poured The arbor on which the ring is mounted must be a good fit. In many cases the arbor itself will consist of two pieces because the inside of the ring forms an undercut. We then speak of split arbors. Usually they consist of a hard metal arbor on the palmside of the ring. Part of the arbor has been milled away and this forms the base for the removable soft metal part of the arbor. Often the ring may have a setting on top and this too will require a separate part so that even a simple stoneset ring may consist of five parts: the front and back parts of the mold, a two part arbor, and a separate part for the setting.

Setting up the mold for pouring, the split arbor is replaced temporarily by a solid arbor. The setting segment and the second half of the mold are blocked off with clay. The first half is poured and the clay removed from the second half but not from the setting. The second half is poured against the first half, then the plug for the setting is poured after the clay blocking it off has been removed. The mold is taken apart , the solid arbor is removed and replaced by the split arbor. The mold is reassembled and the split arbor section is poured. At this point the parting lines are adjusted and pressing is started on one half. Some moldmakers press both halves at the same time; a somewhat riskier procedure.

Here I would like to pay tribute to the best ringmoldmaker I knew: he had no vulcanizer and so he used his wife's flatiron instead and with this simple techique he made some beautiful molds. .

This has been a short survey of but two methods of building soft metal molds. In fact there are many more ways of doing the job and I suspect that every experienced moldmaker finds his own ways. One alternative method deserves a brief mention: molds which are made by spraying the molten metal against the model with a heated spraygun. Only a thin coat is needed which can then be backed up with poured metal or even dental stone. This method will produce very fine detail; the literature mentions up to five thousand lines per inch. However, this method does not seem to have been used to any extent by jewelers.

Finally, I rather doubt whether this talk will persuade many of you to play with metal molds. And yet, even as a historical curiosity it deserves to be at least a footnote in the checkered history of jewelry manufacturing.