Richard Austin (1936-1990) was a metalsmith and author, with several hundred articles to his credit.

After his death I was given custody of an extensive collection of manuscript material-mostly on the technical issues of metalworking.

This text represents the first effort to organize the material—an attempt merely to group the files by topic. None of this is finished, and the text makes reference to illustrations that were never done—illustrations which were stored separately in any case, making it extremely difficult to bring the parts together.

It is unlikely that I will ever be able to spend the time to sort this all out. But it seemed a shame to let these articles languish unread by those who might benefit from them in some small way. So I have decided to release them in their roughly sorted form in the hopes that someone may find them useful.

This information is provided without warranty of any kind. No liability for its use will be assumed by the publisher. It is provided purely as an historic document.
The hydrophobic nature of waxes which have been cast in silicone rubber molds makes wetting particularly difficult. The wetting agents which work quite satisfactorily on most wax often will not work at all on surfaces which have been cast in silicone rubber. The wetting agents tend to bead up like waster on a greasy plate. This concentration of wetting agents may in certain cases cause poor surface texture. There are at least two possibilities for dealing with this situation. The simplest, and usually satisfactory, technique is simply to use no wetting agent at all in the plastic. If the parts are not unduly complex (and they're usually not if they're cast in a mold), careful investing will usually eliminate any problems. In many cases, I have observed that untreated waxes provide better surface texture than treated. If you do feel compelled to treat the surfaces, wetting can be improved by pre-washing the models with a very strong cleaning agent. Household spray cleaners such as Fantastic can be sprayed on the models so they can be immersed. Rinsing with cold water removes the detergent and typically discloses a somewhat improved surface. There is another benefit to treating the molds in this fashion. Because of the intimate contact between the wax and the silicone rubber and the high electrical resistance of both materials, models tend to
develop a tremendous static charge when they are removed from the mold. This can actually cause liquid wax to spray off a spatula and, of course, the model attracts every piece of wax dust within ten feet of your work bench. If you quickly wash the models after removing them from a mold, this static charge is completely dissipated and the work can proceed much more quickly.

There is a unique situation in the application of silicone rubber molds. First, since they are totally nonreactive, there is no deterioration of the mold surface due to reactions with the model material. Combined with the fidelity of detail which can be achieved in the silicone mold, tremendously high surface quality can be achieved in the rubber mold. This means that good finish transfer is possible but, more importantly, there is a very intimate contact between the mold wall and the wax. It might be useful to understand how static electricity charges can be generated. Whenever two objects are placed in intimate contact, if they are suddenly separated, there is a tendency to develop an electrical charge. The charge developed relates to the quality or intimacy of this contact and to the electrical resistance of the materials themselves. Both the wax and the silicone rubber are very good in electrical resistors. Combined with the intimate contact, this suggests that very high static
electricity charges are not only possible but likely.
Since the casting model is destroyed during the casting process, an intermediate step is necessary if you wish to produce multiple items. This step is the preparation of a mold and the production of multiple wax masters from that mold. Traditionally, the molds have been prepared from various elastomeric substances. However, more recently metal molds are used for higher volume production and greater precision.

Among the elastomers which can be used, there are a wide variety. Some of these include:

- Rubber (conventional)
  - Vulcanizing
  - Polysulfide
  - Emulsions
  - Hot Melt

- Synthetic Elastomers
  - Polyurethane
  - Silicone

By far and away the most common mold making material in the industry at the present time is vulcanizing rubber. The majority of our discussion will focus on these materials. In
simplest terms, there are five steps to the preparation of wax patterns by this method. They are:

- Preparation Of A Master
- Mounting
- Packing The Frame
- Vulcanizing
- Cutting

Wax Injection (six steps - note)

**Preparation Of A Master** - The temperatures and pressure associated with the vulcanizing process require that the master be made from metal. Several other factors should be taken into consideration. In the design area, it is important not to have too many undercuts or long projections. This makes it difficult to cut the mold, and ultimately difficult to remove the waxes from the mold.

Although the master can be made from brass, silver or gold, the quality of the service of the mold relates somewhat to the material used. The vulcanizing process releases a good deal of silver, which will tend to deteriorate both the surface of the model and the surface of the mold. For example, a silver master will produce a very dark discoloration in both the rubber and the silver. If you intend to make very long production runs or if a very high quality finish is required,
this deterioration can be significant. The best quality of mold surface (and longest lasting) are produced from masters which are rhodium plated. If you're going to make true production molds, this is the best process.

Mounting - The actual vulcanizing process is conducted between two metal plates inside a frame which contains the rubber. The next step is to mount the model within the frame. This can be done in various ways and it may or may not include a molded-in sprue area. In some cases, the sprue can be burned in after the vulcanizing process. In any event, the model has to be securely positioned within the mold frame. This is typically done by soldering it to a brass rod.

Pack The Frame - The vulcanizing rubber comes packed as large rolls, strips or individually cut pieces. The number of sheets of rubber used depend on the thickness of the sheet and the mold. Typically, several sheets would be placed on either side of the pattern within the frame. Note that the rubber must be kept clean. Any talcum powder should be removed with benzine or gasoline and all separator sheets should be removed. If you cut your own material, note that the rubber should all be placed in the same direction. After the frame is fully packed, it is placed between two metal sheets and it's ready for the vulcanizing process.
**Vulcanizing** - Initially, the plans and the press are tightened very loosely. After about ten to fifteen minutes of heating, the plates can be tightened further; and after about 25 to 30 minutes, they can be fully tightened. Vulcanizing typically requires 50 to 70 minutes with a temperature of about 300°F. However, you should note the manufacturer's directions for the particular rubber which you are using. If you wish to do an occasional piece, it is possible to vulcanize the frame in a conventional oven. In this case, "C" clamps are used to hold the two face plates on the frame and the clamped unit is put in a conventional oven at about 300°F.

The mold can be allowed to cool slowly at room temperature or it can be immersed in room temperature water until it's fully cooled.

Other techniques can also be used during this process. It is possible to place a thin metal sheet between two halves of a mold to provide the basic parting line. Done correctly, this can simplify the cutting process. Although it is seldom used, it's also possible to embed half of the pattern in plaster or investment material, vulcanize half the mold, remove the plaster and vulcanize the second half. Generally speaking, these techniques are not used in contemporary production.
Cutting - The splitting or cutting of the mold is a skill-oriented process. Basically, the mold is simply cut in half along the parting line. In practice, some skill is required. Typically, a clamp is used to pull the two halves apart and provide some tension. This also provides a visual signal since the area of maximum tension in the rubber will blush or appear lighter. The cuts are made along the parting line following this blush. It should also be noted that some special cutting is required to insure that the two halves of the mold interlock securely. If this interlock is not provided, the final waxes will usually show a very severe parting or mold line.

Wax Injection - The specific characteristics of the various injection wax have been treated in another section. If the mold is properly prepared, vented and a suitable release has been applied, the actual injection process should be straightforward. The wax is brought to a temperature in the injection machine (follow the manufacturer's direction). The mold is held between two smooth metal plates to provide even pressure and the wax is injected. The injection step has some of the same characteristics of the metal casting operation. That is, it is sensitive to both the temperature of the wax and the mold. Obviously, the mold temperature will rise
slightly with each injection. Either the timing has to be slowed to prevent excessive heat build-up or more than one mold can be used and the operator can cycle through a number of patterns.

Proper release of the wax from the mold generally requires a release agent. There are a number of commercial sprays which typically contain a small amount of silicone which can be used for this material. The more traditional process is to dust the mold lightly with talcum powder. Both of these options have their advantages and disadvantages. The silicone releases create a film on the waxes which makes subsequent joining or adjustments rather difficult. However, they provide extremely good surface quality. On the average, the talcum release provides somewhat less high-quality surface, but it does not interfere with subsequent processing.

As we have discussed previously, casting shrinkage in the metal is usually very small. However, in the case of wax injection molding, larger shrinkages occur. These may come from changes in the dimension of the rubber, but more significantly from the shrinkage of the wax during cooling. There are constant efforts to find waxes which shrink less. However, the single element which the operator has in his control is that of temperature. The lower the temperature,
the less total cooling will be required and the smaller shrinkage will be. However, it may be necessary to compensate in the master of the design for a certain amount of shrinkage. This can be a factor in preparing stone seats and/or developing rings of a specific size.

Polyurethane - Polyurethane mold making materials are available as clear liquids. These are simply poured into a mold frame and baked in an oven. Although these materials are generally more expensive, they have several useful characteristics. First of all, they don't require a vulcanizing press. The heating is done in an oven, so you eliminate the need for this particular piece of equipment. Another popular feature is the fact that they are transparent when fully cured. This makes the process of cutting somewhat simpler for the beginner.

Silicone Rubber - There has been a tremendous interest over the years in the use of silicone rubber for mold making. On the surface, it has almost ideal characteristics. It has extremely low shrinkage, it is resistant to high temperatures and it provides its own release. Unfortunately, it has one compensating defect. It has low physical strength and particularly a low tear strength. This makes the cutting of the molds much more difficult. However, in recent years
silicone rubber materials have become available in the same form as the vulcanizing rubber; that is, sheet material which can be packed in the conventional way. Alternately, liquid silicone materials are available which can be used in the same manner as the polyurethanes. These liquid silicone rubbers are generally referred to as RTV, which stands for room temperature vulcanizing. That is, they harden at room temperature. These are two-part systems which must be carefully mixed in the proper proportions. Once they're mixed, their setting time can be anything from a few minutes to 24 hours. Because of their low tear strength, they are somewhat less suitable for molds which must be cut. However, their properties are outstanding for the production of one-piece open molds. Typically, these would be the molds to prepare small medallions or flat ring shanks. In application, some care must be used. The components must be carefully measured and thoroughly mixed. Mixing generally introduces significant amounts of air which must be removed by vacuuming before the material is cast. There is a tremendous temptation to select the rubber which has a short setting time. However, both for ease of use and for physical properties, the rubbers with a longer setting time are outstanding. It would generally be recommended that you use a rubber with an 8 to 24 hour setting time.
There is one unique characteristic of the silicone rubbers which makes them particularly valuable. That is they do not require heat, and no physical stress is applied to the model. This means that wax patterns or organic materials can be used as the masters.
MOLD MAKING

Mold making materials cover a range of compounds. The type of material to be used is based on the nature of the original model or master and the number and quality of impressions or wax patterns which you wish to lift from the mold. The mold making materials can be classed as:

1. Rubber
2. RTV Silicone
3. Colloidal
4. Latex
5. Urethane
6. Other - Melt Compounds.

The use of any form of mold making can be divided into two basic problems. Essentially the first question is do you need a one piece or two part (or more) mold. Thin flat objects can often be reproduced adequately with a single mold shell. Basically the object to be molded is put on a flat surface and covered with the mold making compound. The master is removed from the mold and wax is cast simply by pouring wax into the depression. If a thin shell or section is required the wax is simply poured in and poured back out. The wax that hardens against the shell makes the model. In the more complex case of a model in the round a two part mold is required. The juncture of the two halves of the mold is called the parting line. Models with a parting line are appreciably more difficult to construct.
When wax is poured out of a mold shell there is often a wide range of thickness in the wax. Figure 17 is a typical wax section. As shown, the deeper the relief in the pattern the more variation there will be in thickness. If the section becomes too thin it can be built up with wax and a spatula before the pattern is removed from the mold.

There are at least half a dozen major brands or formulations of wax for molding. The desired properties include:

1. Flexibility
2. Strength
3. Low Melt Viscosity
4. Low Shrinkage
5. Low Melting Point

The use of commercial wax patterns can greatly expand the scope of your work. They are especially useful where:

1. You want more detail than your skill provides.
2. You wish to minimize the labor content of your work.
3. You want to make a number of identical pieces.

Obviously you will sacrifice originality when you use these models. There are also some problems. The quality of the molding varies widely. A prominent mold line is common and small surface bubble pits are also a problem. The detailing of the back or inside of the models is sometimes poor. In addition to such obvious quality problems these waxes are sometimes hard to work with.
Many are brittle at room temperature. At the same time they often have low sharp melting points. A drop of hot inlay wax will often destroy a model by melting right through it. The low temperature and melt viscosity make it hard to add a hot spatula texture.

If you are going to size a commercial wax model begin by bringing to a temperature of 75° to 80° F. Do not overheat your spatula and either warm your metal mandrel or work on a wooden mandrel to bend or mold the work.
MOLDS

REVERSAL

The basic molding process is one of constructing a master, encasing it in rubber and then using the rubber mold to create wax duplicates of the original master. The excellent dimensional properties of silicone rubber offer other opportunities. For example, it might be desirable to reverse the pattern or texture of the original master. If you were trying to construct a seal or medallion it might be more convenient to create a master which was actually the impression which you wished to make with the seal. If this master is cast in silicone rubber, the rubber itself is a positive impression of the final shape which you wish to achieve. If you take this first silicone rubber impression, coat it with mold release and place wax in the second mold, you will have created a master which is a reversal of the original pattern.

This technique has some other advantages if you're going to make a detailed master for a long production run. If you make the original pattern in wax and cast it in metal you will find that it's easy to polish the highlights and very difficult to polish deep recesses. However, if you lift a silicone mold, do a reversal and do a second casting, the model is reversed and the low spots become the high spots and are easy to polish. At this point, another mold can be lifted for the final production of multiple pieces.
KERR BOOK

RUBBER MOLDS

One of the key factors in the expansion of investment casting as a jewelry production technique is the ability to "tool up" one item at a very nominal cost. Vulcanized rubber molds are typically prepared for costs in the range of $15.00 to $50.00. When this cost is amortized over a few thousand waxes the mold cost is about one cent per wax. Most models can be produced in quantity with a labor and material cost of $0.10 to $0.50. In precious jewelry production the cost of waxes
The mold reversal process can also be used in the preparation of short tun, epoxy steel dies. Begin with a master. Prepare the first mold and then the reversal. If plastic steel is cast against the second mold a female die will result.
RTV MOLD MAKING

There are a number of RTV (Room Temperature Vulcanizing) silicone rubbers available for mold making. General Electric Company RTV-11 is my current favorite. RTV-11 is available from:

Engineering Materials Company
3045 North Elston Avenue
Chicago, Illinois 60618
(312) 267-9110

Like many suppliers, they don't like to bother selling small sample cans, but if you insist they have a sample size for about $15.00. This should make 10-20 jewelry sized molds.

Most industrial instructions call for a vacuum system to debubble the mix. However, with care you should be able to make good molds without a vacuum system.

The RTV-11 directions call for using the catalyst at 0.5% by weight. It is practically impossible to measure the material this way, so I've worked out a formulation using drops. The catalyst comes in a small plastic tube. Pierce the top with a pin. Hold the pin hole opening straight downward and squeeze gently; uniform sized drops will fall, one by one.
Use one drop of catalyst for each four grams of resin. This gives a reasonable combination of open time (the amount of time before the material starts to set up) and overall hardening time. It is important that the resin be weighed accurately. The best way to do this is to use a small paper cup. Weigh the cup, add an appropriate amount of resin and weigh the combination. Take the difference in weight and add one drop of catalyst for each four grams of resin. The catalyst must be mixed very thoroughly. The best way to do this is with a sweeping or wiping motion around the outside of the paper cup with a small, wooden splint. Try not to whip bubbles into the mix.

One sided objects should be put on a piece of cardboard or glass and the edges sealed down with blue injay wax and/or disclosing wax. Excess wax is scraped away and a small wall or dike is built around the material from balsa wood, cardboard, or sheet wax. Keep the wall relatively close to the model to conserve material.

Allow the mixed resin to set for five to ten minutes so that air bubbles come to the surface. In you have a vacuum apparatus, debubbleize at this point. Next, take a small, artist-type paintbrush and very carefully paint the resin over the surface of the master to be modelled. After the whole surface has been covered, let is set for a few moments. If any small bubbles are obvious, break these with

Number-2
the brush. When you are satisfied that the master is completely coated, pour the mold material slowly into one corner of the recess and let it flow gradually across the work. A good way to do this is to use small paper funnel or pointed paper cup with the tip cut off. The opening at the bottom would be about an eighth of an inch in diameter and should be held quite close to the surface of the work. For convenience, you can set up a wire frame to hold the funnel and simply fill it and allow it to flow slowly into the work. If the filling process requires five to ten minutes, so much the better.

The material should remain undisturbed at room temperature for at least 24 hours. The surface of the mold will appear hard and fully cured when the material next to the surface of the model is still sticky and soft. There is a great temptation to remove the mold too soon. Avoid this and wait at least 24 hours. Carefully pry the material away from the model. RTV-11 is characterized by low adhesion. If it seems at all sticky, it is too soon.

Kerr, Wax Pen Wax is the best material I've found for making models in the open, one sided molds. It has a very low viscosity and doesn't retain bubbles. Melt some of the wax in a teaspoon over the alcohol lamp and pour it into the mold. This should give a bubble free, clean wax pattern. Be careful not to overheat the wax since it could burst into

Number-3
flame. The first few models do not come away as well as subsequent modelings. One or two wax patterns should be made and thrown away to cure the surface of the resin.

Figure II on the following page shows how to treat the parting line on a one-part mold of a thick part. Basically, the object is built up wax, to its major dimension. The parting need not be straight. If it wanders about, up and down, this is no problem as long as it stays on the major dimension of the model. If the mold is completed as shown in Figure II, you would simply end up with a deep recess with half of the master at the bottom.

The process of making a two-part (or multiple) part mold requires another step. Obviously, if you're going to have a two-part mold, there has to be some access to the outside. The model is set up with a small, cone-shaped base, exactly like a miniature sprue base. This sprue base can be adjusted to fit the nozzle on a commercial wax injector. If the wax is simply going to be poured into the mold by hand, this fit is not required.

Figure III illustrates how you proceed with a two-part mold. On the right hand side, you will see the sprue base and connector to the head. Again, the material is half embedded in wax, and silicone rubber is poured over the model. When it is completely hardened, the part is removed from the

Number-4
frame, and the wax removed from the back of the model. At this point, the model and the sprue base can be put back into the half mold, so that the back side projects from the silicone rubber. Obviously, if you poured silicone rubber of this second half, it would completely embed the pattern. This would provide the second half of the mold, and rubber tends to adhere to itself. For this reason, the silicone rubber needs to be treated with a parting agent, so that you can separate the two halves of the mold when you're done. A good parting agent is a mixture of xylene and paraffin. About 2-3% (by weight) can be dissolved in the xylene, and this mixture painted on the silicone rubber. When the xylene evaporates, it will leave behind a very thin film of wax, which will prevent adhesion between the two mold halves. After the parting agent has dried, you can simply pour rubber on the back, and allow it to cure exactly like the front. When the mold is complete, you should be able to gently pry the two halves apart, and they should be in an essentially perfect fit.

In some cases, you may wish to use some kind of locating or marking buttons on one half of the mold to insure that both halves fit together. Also, you can use a 2 or 3 piece mold. For example, you might wish to begin by casting a cylinder of silicone rubber, and slipping this inside a ring master. If you embed the core plus the ring, you would now have the two-part mold, which could mold the inside of the ring, as
well as the outside.

The self-adhesion of silicone rubber is useful for salvaging molds. Occasionally, you will find that there is a small air bubble which has attached itself to the surface of the master, and ends up as a pit in the silicone rubber mold. This bubble will fill with wax, and end up as a wax sphere, or hemisphere on the surface of a cast wax model. If these are spotted before the surface becomes too impregnated with wax, you can use a toothpick to add a little silicone rubber from your next batch to fill the hole. It will adhere to itself, and repair the flaw.
SILICONE RUBBER MOLDS

There are specific problems unique to the use of silicone rubber molds. These manifest themselves in different ways as you work with the material but they are all related directly to the character of the material. If you pour wax in the mold and allow it to cool, the contact between the two surfaces is very intimate. As these two parts, the mold and the wax are pulled apart, tremendous electrical charge develops. This is characteristic of any electrically resistive materials which are brought into intimate contact and then quickly separated. Because the wax is an insulating material, this electrical charge remains on the surface of the wax for an extended period of time. This is particularly true in winter, when humidity is low, and the charge cannot be dissipated into the air.

If you remove a wax from the mold and then decide to work on it to touch up a pit or perhaps add a small part, a curious phenomenon occurs. If you pick up a little wax and melt it on a spatula, as you bring the spatula toward the work, it will suddenly spray wax. The electrical charge is so powerful that it breaks up the wax and yanks it through the air onto the surface of the model. What you end up with is a very fine spray of molten wax all over your beautiful new wax casting.
There are two ways to beat this problem. First of all, the problem goes away if you allow the waxes to sit for a day or two. Most of the charge gradually bleeds off into the atmosphere. The time that this requires relates to the amount of moisture in the air. If you feel pressed to go ahead on a rush job, the wax can be washed with water and detergent. The part can then be blow dried and you can proceed without too much static problem.

There is another particularly aggravating characteristic of silicone rubber. The tiniest traces of silicone tend to act as chemical barriers to adhesion or contact between surfaces. Minute traces of the silicone substances are transferred to the surface of wax which is prepared in silicone rubber molds. This means that, in the language of our previous discussions, the molded surfaces are quite highly hydrophobic. Extra care is required to ensure that the surface of the mold is well wet out and that all of the detail is filled. If I am particularly concerned about this, I sometimes prewash the sprued model with strong detergent solution, then rinse and dry it before proceeding to the investment process. This tends to remove some of the material from the surface. A rinse with acetone may also be used at this point. However, if you are using plastic material in combination with the wax, remember that many of these are highly soluble in acetone.
MOLD MAKING

Generally, the preparation of vulcanized or silicone rubber mold is associated with the reproduction of a specific piece of jewelry. However, the techniques (particularly silicone rubber) can be applied to other very interesting applications. One of these is the lifting of texture from various surfaces.

For example, the pin illustrated on the right was prepared by making a silicone rubber impression from a cement sidewalk. This impression was then filled with wax and the textured wax was used as a basis for the design shown.

The highlighting effect which can be achieved with antique silver or gold enhances any of these textures. You should consider using all kinds of stone, weathered wood, or any other material that has an interesting texture. In some cases you will find that the materials actually have too much texture, that is, the texture extends so deeply that the mold will be hard to life because it will consist of many tiny little fingers projecting into the textured surface. In cases like this you can treat the textured surface with melted wax and then remove most of the excess wax. This can simply be done by heating the surface and allowing the excess to penetrate or you can warm the material and remove the excess with a stiff bristle brush. This kind of treatment will tend to tone down the degree of texture in the surface.
There have been a number of articles published on making rubber
dies for casting wax. After having read at least six such articles and
ing a number of molding compounds I've decided to have my own say
the subject.

Specifically I'm going to talk about mold making with Silicone Room
perature Vulcanizing Rubber. Although this is the most expensive type
material it is a good bet for the home workshop for several reasons:
It requires no special equipment
It gives very high quality Reproduction
It is easy to use.
It has low shrinkage
the matter of cost: since most jewelry molds are rather small the
rage mold still only requires about a dollars worth of rubber.
personal opinion has always been that if you were only going to
2 3 or 4 molds per year it was hardly worth the extra effort to
2 25 to 50¢ per mold on the material.

There are a number of different grades of Silicone RTV. For our
ose theri principle difference is in the viscosity of the liquid
per and the tear strength rubber and lower viscosities
ield lower tear strength in the mold. Both of these properties are
ortant but for our purposes viscosity is probably most significant.

At best all of the liquid rubbers are thick and stickey and they
a strong tendency to trap air bubbles. Just like the air bubbles
he investment process these tend to end up on the
ace of the work. The higher the viscosity of the liquid the worse
bubble problem. In professional applications a vacuum is used to
we the bubbles (again this is like the investment process). However,
't have a vacuum apparatus so this procedure is designed to do without.
The simplest possible situation is a one piece mold. This will only work well for items which have a plain (preferably flat) back and no sections. A good example would be a ring shank. Although there are literally thousands of commercial shanks available I like to have something original for my work. For this reason I've made a number of ring shank molds. I usually make the master and mold flat and then either the wax or the metal shank itself. The master for this particular shank was plastic. It was made from a swizzle stick acquired on my travels. In other cases I have made a wax master and then cast and polished the shank. This has the advantage of producing a very fine finish on both the master and mold.

When you have a master smooth a thin layer of hot sticky wax on the back with a heated spatula. Spread the wax to an even, paper thin layer. Press the back onto a sheet of glass (other smooth hard surfaces will work but I like glass the best). Use the heated spatula to spread hot dental inlay wax into the fine crack between the master and the glass. Next use sharp tools to remove all the excess wax from master and the glass.

Next cut strips of sheet wax approximately 3/8" wide. Use the strips to build a wall about ½" away from the model. Hold everything in place with sticky wax until you have all the pieces cut and fitted. Seal all joints with the glass and corners with a heated spatula.

All my experience with the Silicone RTV's indicates that you should use care in measuring the materials. Although I've modified the manufacturer's recommended proportions of ingredients you still must be sure the materials to get consistent results. I've had reasonably good luck weighing the materials on a postal scale. In the case of the
-II the main material can be measured on the scales and the catalyst fed with an eye dropper.

The care and storage of the Silicone RTV;s if worth some comment. Even in an unmixed state the materials tend to slowly thicken. Eventually they reach the point where they can no longer be used. My own experience indicates that 4 - 8 months storage at room (68 – 72 F) temperature is acceptable. Higher temperatures will dramatically decrease shelf life. In...
Weigh out the proper amount of material in a small paper cup. Add a popsicle stick or other disposable stick. Try to blend the materials slowly. Rapid stirring tends to blend in more bubbles. When the R.T.V. is mixed allow it to stand for 5 to 10 minutes. This will allow most of the air bubbles to surface. Pour the liquid slowly to the mold starting with a corner and allowing the material to move slowly over the face of the master. This will help prevent bubbles from being trapped on the surface of the model.

Although the R.T.V. does not adhere to most materials it will generally stick to itself very well. For this reason you may need a parting agent or mold release if you want to make multiple piece molds. There are a number of commercial materials available but I usually make my own. A 3% solution of paraffin in Xylene works very well. One caution, Xylene may soften certain plastics so you should test any plastic materials. If you buy 4 ounces of xylene at the drug store and stir in to 3½ grams of paraffin you should have a lifetime supply of release. It will take a while for the paraffin to dissolve but that is no problem. Usually just set it aside and it dissolves overnight.
THE MOLD

The simplest possible situation is a one piece mold. This will work well for items which have a plain (preferably flat) back and no thin sections. A small piece of glass makes a good base for preparing your mold. Just be sure that the edges have been sanded or taped so that you don't cut yourself working with it. Begin by taking your master pattern and adhering it to the glass with sticky wax. Next, use a heated spatula to flow dental inlay wax or sticky wax all around the joint between the pattern and the glass. Use the spatula to remove any excess material and then a sharp knife to remove all of the wax except what is required to seal the pattern against the glass. Build a small dike or dam around the pattern to contain the mold material. The mold should be 1/8" to 3/16" larger than the pattern and at least 1/4" deeper than the highest point on the pattern. I usually use balsa wood sticks to build up the edges of my mold. Cut them to length and stick in place with wax. Seal the joints very carefully with wax and proceed to pour the silicone rubber.

TWO PART MOLDS

If you wish to make a two part mold you obviously have to have some way to cast the rubber on both sides. There are two approaches to this problem. The classic approach would be to cast the rubber all around the pattern and use a sharp knife to cut the pattern in half form a line. This would be identical to the practice used in vulcanized rubber molds. My own preference is to cast a mold in two parts. Simply begin as you did previously by putting the master pattern on a sheet of glass. However, in this case it is assumed that it will be a thicker three dimensional object. Use wax to build up and embed half of the pattern up to where you require a parting line.
Proceed as before to build a dike around the pattern and cast the rubber over the pattern. Next, remove the mold and place the pattern back in the half completed mold. You can then proceed to build a new dike around the completed mold but extending it in the area that was previously occupied by the wax. Treat the half mold with a silicone release agent and simply cast the other side. My personal experience has been that this will provide a much more precise and sharp parting line. If you can't obtain a commercial release agent a 2 or 3% solution of paraffin in xylene works well. Paint the solution on the silicone rubber surface and allow to dry. It will leave a wax film that prevents adhesion.
MOLD MAKING

Water soluble wax can also be used as mold making material. The soluble wax is poured over the original. The resulting mold is filled with conventional wax and the mold is dissolved away with a water and vinegar mixture.

Silicone rubber can be used to provide unusual textures for jewelry making. Cement, brick or stone surfaces can provide the master. The rubber mold lifts the impression and you can cast wax sheets for use in fabrication.
I've experimented with various RTV (Room Temperature Vulcanizing) silicone rubbers for mold making. General Electric Company RTV-11 is my current favorite. RTV-11 is available from:

Engineering Materials Company
3045 North Elston Avenue
Chicago, Illinois  60618
(312) 267-9110

Like many suppliers, they don't like to bother selling small sample cans, but if you insist they have a sample size for about $15.00. This should make 10-20 jewelry sized molds.

Most industrial instructions call for a vacuum system to debubblize the mix. However, if you follow these instructions you should be able to make good molds without a vacuum system.

The directions call for using the catalyst at 0.5% by weight. It's practically impossible to measure the material this way, so I've worked out a formulation using drops. The catalyst comes in a small plastic tube. Pierce the top with a pin. Hold the pin hole opening straight downward and squeeze gently; uniform sized drops will fall, one by one.
At the present time, I am using one drop of catalyst for each four grams of resin. This seems to give a reasonable combination of open time (the amount of time before the material starts to set up) and overall hardening time. It is important that the resin be weighed or measured accurately. The best way to do this is to use a small paper cup. Weigh the cup, add an appropriate amount of resin and weigh the combination. Take the difference in weight and add one drop of catalyst for each four grams of resin. The catalyst must be mixed very thoroughly. The best way to do this is with a sweeping or wiping motion around the outside of the paper cup with a small, wooden splint. Try not to whip bubbles into the mix.

One sided objects should be put on a piece of cardboard or glass and the edges sealed down with a blue inlay wax and/or disclosing wax. Excess wax is scraped away and a small wall or dike is built around the material from balsawood, cardboard, or sheet wax. Keep the wall relatively close to the model to conserve material.

Allow the mixed resin to set for five to ten minutes so that air bubbles come to the surface. Next, take a small, cheap artist-type paintbrush and very carefully paint the resin over the surface of the master to be modelled. After the whole surface has been covered, let it set for
a few moments. If any small bubbles are obvious, break these with the brush. When you are satisfied that the items are completely coated, pour the mold material slowly into one corner of the recess and let it flow gradually across the work. A good way to do this is to use small paper funnel or pointed paper cup with the tip cut off. The opening at the bottom should be about an eighth of an inch in diameter and should be held quite close to the surface of the work. For convenience, you can set up a wire frame to hold the funnel and simply fill it and allow it to flow slowly into the work. If the filling process requires five to ten minutes, this is all the better.

The material should remain undisturbed at room temperature for at least 24 hours. The surface of the mold will appear hard and fully cured when the material next to the surface of the model is still sticky and soft. There is a great temptation to remove the mold too soon. Avoid this and wait at least 24 hours. Carefully pry the material away from the model. RTV-11 is characterized by low adhesion. If it seems very sticky, it is too soon.

Kerr, Wax Pen Wax is the best material I've found for making models in the open, one sided molds. It has a very low viscosity. Melt some of the wax in a teaspoon
over the alcohol lamp and pour it into the mold. This should give a relatively bubble free, clean wax pattern. Be careful not to overheat the wax since it could burst into flame. One or two wax patterns should be made and thrown away to cure the surface of the resin. The first few models do not come away as well as subsequent modelings.

Figure I on the following page shows how to treat the parting line on a one-part mold of a thick part. Basically, the object is built up wax, to its major dimension. The parting need not be straight. If it wanders about, up and down, this is no problem as long as it stays on the major dimension of the model. If the mold is completed as shown in Figure I, you would simply end up with a deep recess with half of the master at the bottom.

The process of making a two-part (or multiple) part mold requires another step. Obviously, if you're going to have a two-part mold, there has to be some access to the outside. The model is set up with a small, cone-shaped base, exactly like a miniature sprue base. This sprue base can be adjusted to fit the nozzle on a commercial wax injector. If the wax is simply going to be poured into the mold by hand, this fit is not required.

Figure II illustrates how you proceed with a two-part mold. On the right hand side, you will see the sprue
Figure I. One Sided Mold - Parting Line

Figure II. Two Sided Mold - Step 1.

Figure III. Two Sided Mold - Step 2.
base and connector to the head. Again, the material is half embedded in wax, and silicone rubber is poured over the model. When it’s completely hardened, the part is removed from the frame, and the wax removed from the back of the model. At this point, the model and the sprue base can be put back into the half mold, so that the back side projects from the silicone rubber. Obviously, if you poured silicone rubber over this second half, it would completely embed the pattern. This would provide the second half of the mold, and rubber tends to adhere to itself. For this reason, the silicone rubber needs to be treated with a parting agent, so that you can separate the two halves of the mold when you’re done. A good parting agent is a mixture of xylene and paraffin. About 2-3% paraffin (by weight) can be dissolved in the xylene, and this mixture painted on the silicone rubber. When the xylene evaporates, it will leave behind a very thin film of wax, which will prevent adhesion between the two mold halves. After the parting agent has dried, you can simply pour rubber on the back, and allow it to cure exactly like the front. When the mold is complete, you should be able to gently pry the two halves apart, and they should be in an essentially perfect fit.

In some cases, you may wish to use some kind of locating or marking buttons on one half of the mold to insure that both halves fit together. Also, you can use a 2 or 3 piece mold. For example, you might wish to begin by
casting a cylinder of silicone rubber, and slipping this inside a ring master. If you embed the core plus the ring, you would now have the two-part mold, which could mold the inside of the ring, as well as the outside.

The self adhesion of silicone rubber is useful for salvaging molds. Occasionally, you will find that there is a small air bubble which has attached itself to the surface of the master, and ends up as a pit in the silicone rubber mold. This bubble will fill with wax, and end up as a wax sphere, or hemisphere on the surface of a cast wax model. If these are spotted before the surface becomes too impregnated with wax, you can use a toothpick to add a little silicone rubber from your next batch to fill the hole. It will adhere to itself, and repair the flaw.
SILICONE RUBBER MOLDS

There are specific problems unique to the use of silicone rubber molds. These manifest themselves in different ways as you work with the material but they are all related directly to the character of the material. If you pour wax in the mold and allow it to cool, the contact between the two surfaces is very intimate. As these two parts, the mold and the wax are pulled apart, tremendous electrical charge develops. This is characteristic of any electrically resistive materials which are brought into intimate contact and then quickly separated. Because the wax is an insulating material, this electrical charge remains on the surface of the wax for an extended period of time. This is particularly true in winter, when humidity is low, and the charge cannot be dissipated into the air.

If you remove a wax from the mold and then decide to work on it to touch up a pit or perhaps add a small part, a curious phenomenon occurs. If you pick up a little wax and melt it on a spatula, as you bring the spatula toward the work, it will suddenly spray wax. The electrical charge is so powerful that it breaks up the wax and yanks it through the air onto the surface of the model. What you end up with is a very fine spray of molten wax all over your beautiful new wax casting.
There are two ways to beat this problem. First of all, the problem goes away if you allow the waxes to sit for a day or two. Most of the charge gradually bleeds off into the atmosphere. The time that this requires relates to the amount of moisture in the air. If you feel pressed to go ahead on a rush job, the wax can be washed with water and detergent. The part can then be blow dried and you can proceed without too much static problem.

There is another particularly aggravating characteristic of silicone rubber. The tiniest traces of silicone tend to act as chemical barriers to adhesion or contact between surfaces. Minute traces of the silicone substances are transferred to the surface of wax which is prepared in silicone rubber molds. This means that, in the language of our previous discussions, the molded surfaces are quite highly hydrophobic. Extra care is required to ensure that the surface of the mold is well wet out and that all of the detail is filled. If I am particularly concerned about this, I sometimes prewash the sprued model with strong detergent solution, then rinse and dry it before proceeding to the investment process. This tends to remove some of the material from the surface. A rinse with acetone may also be used at this point. However, if you are using plastic material in combination with the wax, remember that many of these are highly soluble in acetone.
MOLD MAKING

SILICONE RUBBER

For occasional small projects my favorite mold making material is silicone, room temperature vulcanizing rubber. Although this is the most expensive type of raw material it is useful in a limited production shop for a number of reasons:

. It requires no special equipment
. It provides high quality reproduction
. It is easy to use
. It has low shrinkage
. It releases clean

Like so many good things RTV has a few drawbacks. It is relatively expensive and requires skill to use. However, I feel that its advantages far outweigh its disadvantages. Since most jewelry molds are rather small the average mold only requires about a dollar's worth of RTV. If you are going to make a few molds per year it is hardly worth the extra equipment expense to save 25¢ or 50¢ per mold on the material. Most of the application problems stem from a lack of understanding of the material or the wrong selection of the grade of material used.

There are a number of different grades of Silicone RTV. For our purpose the principle differences are in the following
properties:

. Viscosity - The material can range from a thick paste to a fluid about like room temperature honey.
. Setting Time - Setting time typically ranges from 5 minutes to 24 hours.

Various formulations will produce a final rubber which varies with regard to tear strength, heat resistance and flexibility. As a practical matter viscosity and setting time remain the prime considerations.

At best all of the liquid RTV rubbers are thick and sticky and they have a strong tendency to trap air bubbles just like the air bubbles in the investment process. The higher the viscosity of the liquid, the worse the bubble problem. In professional applications a vacuum is used to remove the bubbles (again this is like the investment process). However, a vacuum is not required to achieve good results. Simply use a material that has a relatively low viscosity and a long setting time and use the procedure described in Illustrations 41-52.

Low viscosity minimizes air entrapment and a long setting time allows the air to work its way out. Look for a low viscos material with a long (12-24 hour) setting time.
MOLD MAKING

Rubber molds of various kinds are widely used in commercial jewelry manufacturing to produce multiple copies of wax models. The technology and special skills required are well developed. This discussion will not be focused on the commercial practice. The emphasis here will be to review techniques that are particularly useful for the artist/craftsman.

The traditional commercial method of making molds for the reproduction of wax parts has been to use vulcanized rubber. This process consists of packing sheets of uncur ed rubber around the model, placing the model and rubber in a steel frame, clamping under pressure and heating it to the vulcanizing temperature of the rubber. The mold is cooled and separated by careful cutting to develop a two piece mold with a parting line. This technique has some obvious advantages and disadvantages.

On the positive side, it is relatively inexpensive in terms of the material. Once the technique is mastered it is more than satisfactory for commercial application. For this reason it has been a popular method in the jewelry industry. On the negative side this technique requires considerable skill to cut a good parting line. The mold materials are somewhat heat sensitive and may deteriorate in use, and the technique puts quite a bit of strain on the master model. For this reason the master model must usually be constructed of metal. Because of these drawbacks I have never been a fan of this technique. Although I used it for a while, I don't do any of this type of mold making in my shop at the present time. If you are interested in learning more about this technique there are many good references in jewelry making books. It's worth noting that there are a number of firms in the industry
that offer mold making services.

In recent years the plastics industry has provided several different plastic formulations which can be used to make superior quality molds. Although most of these materials are considerably more expensive than rubber, the amount of material used in a mold is small enough to make this problem insignificant. I have found that even the most expensive materials seldom cost more than $2.00 to make a typical ring mold. In theory, any one of a number of elastomeric materials would be suitable for mold making. Flexibility is desired to provide for good mating of the mold values but especially to facilitate removal of the model from the mold. Flexing of the mold tends to break the bond between the wax and the mold and to release slight undercuts in the mold. There are several basic classes of material used for mold making:

I. Rubber (Conventional)
   A. Vulcanizing
   B. Polysulphide
   C. Hot Melt
   D. Emulsions
II. Polyurethane
III. Others
IV. Silicone Rubber

Each of these materials has different characteristics and applications. The conventional vulcanizing rubber materials have already been discussed. The polysulphide rubber systems are somewhat different. They are generally two part, cold cure systems. Two materials (the rubber and a catalyst) are mixed together and poured into a mold frame. The material cures at room temperature to form a resilient high quality mold.
EXPANSION ADJUSTMENT

The dimensional rules which I've described up to now hold true when castings are made directly from the original master. When an original metal master is used for reproduction, a different set of problems arise. The series of steps from preparing a metal master through a vulcanized rubber mold, wax injection and casting may provide some very serious shrinkage problems. Cumulatively, these may add up to more than a one percent shrinkage and certainly may require a significant size adjustment in order to achieve any particular ring size or stone fit.

It should be noted, that the various processes for the preparation of rubber molds may yield a different result. Different mold making materials may provide different degrees of shrinkage (particularly between vulcanized and silicone rubber). In addition, there are variations in the shrinkage of most injection waxes. Obviously, an optimum formulation for injection wax would have minimum shrinkage but all waxes have a significant degree of shrinkage during solidification. You will note that most injection modeling waxes have a low, sharp, melting point. This characteristic provides the minimum shrinkage for injection waxes.
WAX MODELING
NON-COMBUSTABLE MODELS

When people consider preparing models, they generally think of using wax or other combustable materials for the model. However, the modern cold cure mold materials (such as silicone rubber) allow the use of a wide range of modeling materials for preparation of a master model. The process is straightforward. The master is prepared, a silicone rubber mold is lifted from the master, and wax is cast into the mold. Plasticscene is an oil base non-hardening modeling clay which is excellent for preparation of the master models. The silicone rubber may also be used to reproduce the texture of materials such as stone or concrete. Generally speaking this technique is simplest with flat, two dimensional object such as pins or pendants. Three dimensional objects or deep undercuts may require special care or techniques.
Faces - This is an example of the use of cast dental acrylic as a component in a larger project. Sometime ago, I made a mold from a small woman's face, which I often incorporate in different designs. At one point in time, I case these in wax and worked with them. Unfortunately, the wax is quite fragile and it often damaged the face in the course of adding detail such as hair. To eliminate this, I began to cast them in acrylic, which remains undamaged and easy to work to. In this case, you can see the mold was simply a one-sided open mold. Acrylics are cast in place, the excess trimmed away, and finally, the back hollowed out to whatever thickness is appropriate. These acrylic components have been combined with the balance of the model and wax is used to build up any detail. As you can see from the final casting, the material burns away cleanly and provides excellent detail. This particular type of dental acrylic does not provide an extremely high gloss on the cast parts, so I continue to look for other alternatives. However, at this time, dental acrylic is still my favorite.
I've been thinking about a number of topics which might be of interest to your readers. Just to get them on paper, I'd like to list some topical areas and give you a brief description of what would be covered. I suspect that each of these topics is narrow enough to be encompassed in a single article, although in a few cases, it might take two issues to bring them out:

1) **Silicone Rubber Mold Making** - Silicone rubber seems to have a relatively poor reputation in the industry, primarily because of its low tear strength. On the other hand, it requires no equipment that won't be found in almost any silversmith shop. In my experience, the primary difficulties with using silicone rubber relate to trying to treat it exactly like vulcanized rubber: specifically, casting a one-piece mold and knife-cutting it. The knife cuts form jagged edges which begin the tears in the silicone. There is a simple alternate technique of casting the silicone rubber mold in two parts so that no cutting is required. This accomplishes two things. First of all, it eliminates the need for any cutting skills as well as the vulcanizing equipment, and perhaps more important, it greatly increases the tear resistance of the mold. An appropriate article would deal with the differences in the various silicone rubbers, their physical properties and the specific application to the mold-making process.
Almost every dentist I have ever talked to has made at least one or two pieces of jewelry during his dental training. This should not be any particular surprise since the materials, equipment and techniques involved between dentistry and jewelry are practically identical. For this reason, I always end up talking to my family dentist about jewelry whenever I am in his office. The last time I was chatting with the family dentist, we got to talking about mold-making materials and the use of the various silicone clay impressions materials. Somehow the conversation wandered around until he asked me if I had ever tried to use Algimate. Now this is a mold-making material available from Kerr. I don't fully understand how this material is made, but I understand it is an organic material derived from seaweed. Fundamentally, it is a dry white powder which you can mix with water to form a kind of gel. I checked in Kerr's jewelry catalog and they do offer this material for sale to the jewelry trade. However, I called a couple of local rock shops and didn't find it available. I finally ended up purchasing mine through a local dental supply house. If you have any trouble in getting the material, I would suggest the same approach. What follows is a general discussion of the material and a critique which I made using Algimate molds.
MOLD MAKING

The traditional method of making molds for the reproduction of wax parts has been to use volanized rubber. This process consists of packing sheets of uncured rubber around the model placing the whole thing in a steel frame and claping under pressure and heating it to the volanizing temperature of the rubber. The material is then cooled and the mold is separated by careful cutting to develop a two piece mold with a line. This technique has some obvious advantages and disadvantages. On the positive side it is relatively inexpensive in terms of the material. Once the technique is mastered it is more than satisfactory for commercial application. For this reason it has been probably remains the most popular method in the general jewelry industry. On the negative side this technique requires considerable skill to cut a good parting line. The materials are somewhat heat sensitive and may deteriorate in use under certain conditions, and the technique puts quite a bit of strain on the master model. For this reason the master model must usually be constructed of metal or some strong material which is not deformed by heat or pressure. With all of these drawbacks I have never been a particularly large fan for this technique, although I used it for a while in school, I don't do any of this type of mold making in my shop at the present time. In recent years the plastics industry has provided several different plastic formulations which can be used to make superior quality molds. Although most of these materials are considerably more expensive than rubber the amount used in a mold is small enough this will solve the problem. I found that even the most expensive
materials seldom cost more $2.00 to make a typical ring mold. I would like to take time enough to describe a method used for making _______ molds in greater detail.
When you examine the data sheets, two properties will be important. The first is the viscosity of the material and the second is the cure time. Generally speaking, the best tear strength and overall strength comes with materials which have a high viscosity and a long cure time. Conversely, the worst physical properties in the final rubber are associated with low viscosity and short cure times.

Let's talk a little about viscosity first. Generally speaking, low viscosity systems are easier to work with since it's much easier to get them into the mold and to remove the bubbles. Certainly it's a matter of operator convenience.

Low viscosities are to be preferred. Generally speaking, I lean toward using low viscosity materials. The RTV-11 from General Electric which I recommended is a relatively low viscosity liquid.
Cure time is a curious situation. Most mold makers seem to be infatuated with the idea of a short cure time. Systems are available which have cure times in the range of ten minutes. This is certainly attractive, since you can work very quickly. However, the best systems seem to have cure times in the range of twenty-four hours. Frankly, my preference is to use materials which have a long cure time. This provides kind of a trade-off between the bad properties of a low viscosity system and the good properties of a slow curing system. There are several other advantages to a relatively long cure time. The silicone rubber mold materials require a longer and more intensive vacuuming to insure the complete absence of bubbles. In some cases, I have had material with a ten minute cure time begin to set up before it was fully vacuumed.

Like any other material, the finished molds have their good points and bad. The primary criticism of silicone rubber mold materials is that they tend to tear. This tearing is usually associated with the cutting process which leaves sharp lines or corners in the rubber. Tearing proceeds from these just like a glass window would break beginning with a crack. Obviously, anything that minimizes these sharp edges helps minimize the tearing problem. For this reason, I very often cast my molds in two parts rather than cut them from one
piece. Basically, the procedure is to imbed half of the model in Plasticine or wax and pour silicone rubber over the form. After the first half is cured, the Plasticine or wax is removed, a parting agent or separating agent is applied to the silicone rubber and the second half of the mold is added. Since the rubbers tend to stick to themselves very well, a good parting agent is required. The Rio Grande catalog has a spray agent. Also a 2% solution of paraffin xylene works very well. However, you may find that the use of xylene is restricted for health reasons. Certainly, it has to be used with some care. Using this technique, you can build in your registration interlocks, and prepare molds of as many pieces as you want. In a few cases, I've prepared molds with as many as five separate interlocking segments. Quite frankly, that's almost impossible to do with a cut rubber mold.

The curing process can be accelerated considerably by warming the mold. However, this is not desirable in every case. One excellent reason for using silicone rubber master materials is the fact that you don't have to have a metal master pattern. I've made molds using plastic, wax or even clay masters. However, these don't stand up in the heat. Some of the American mold manufacturers specifically advertise that they are able to mold from nonmetallic materials using the silicones.
The silicones have some other good points and bad. First of all, they probably have the most remarkable surface detail of any material I've ever seen. Second, they are completely self-releasing. I've never had any problem with sticking in a silicone mold. The characteristic of the silicone rubber does cause one problem. Waxes injected into a silicone rubber mold have a microscopic coating of silicones. This material is tremendously hydrophobic, which causes water to bunch up very badly. None of the conventional wetting agents does much good in this case. Usually, I simply rinse the molds off with a very strong detergent and proceed. With good investment practices, the results are fine. In injection molding, you've probably observed cases where the model comes out with a very strong static electric charge. If you try and work with them immediately (for example, spruing them), you may actually have problems with molten wax spattering out of the surface from the static electric charge. This problem tends to be a lot worse with the silicone rubbers. However, a brief rinsing with water or detergent removes the static charge even though it leaves some of the silicone coating behind.