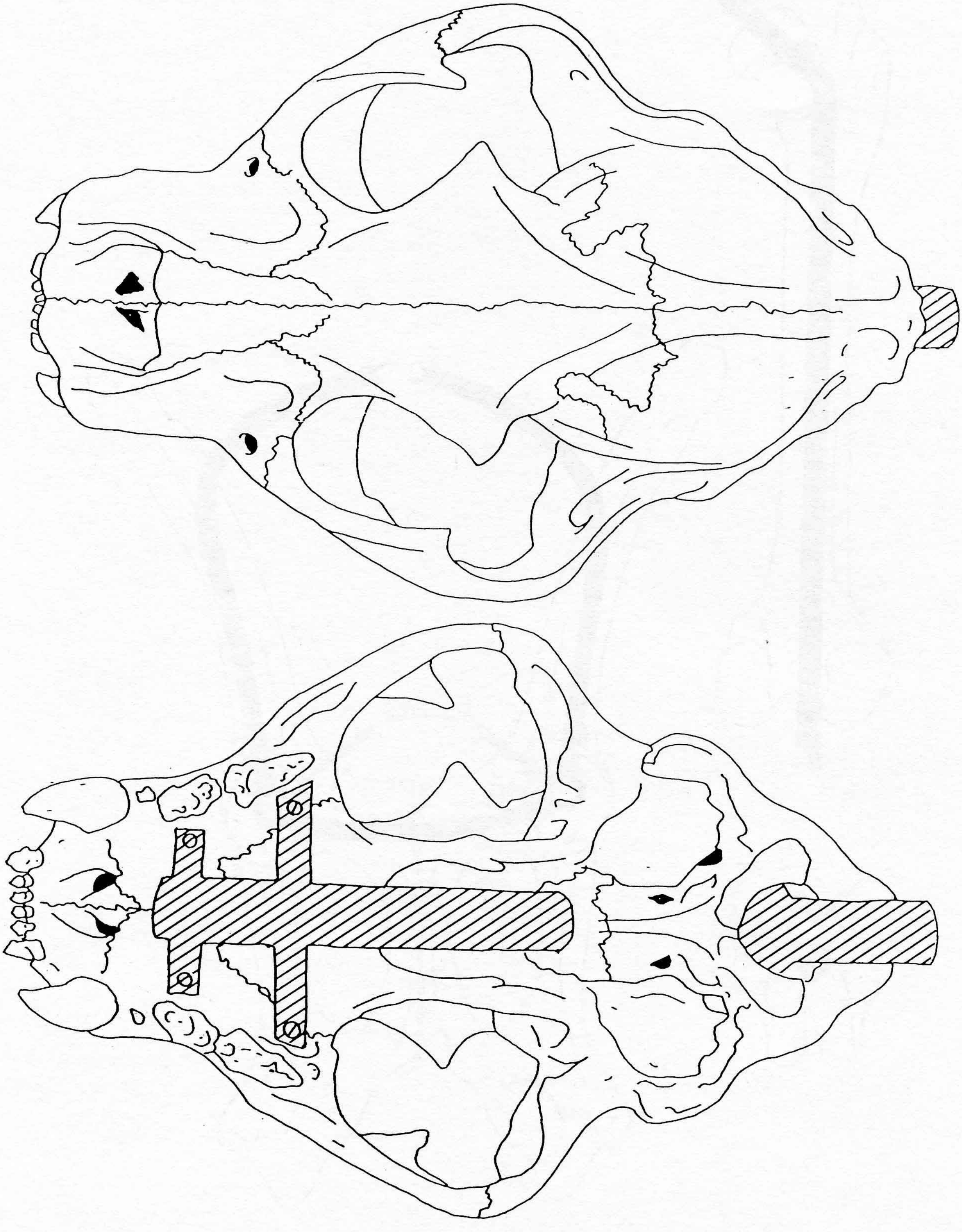

**FIGURE 6-10. Detailed rod support attachments to a skull.**

# CHAPTER 7

# CASTING TECHNIQUES

## Latex Moldmaking

The art of moldmaking and casting of fossil specimens is an integral part of paleontological research. Important specimens are most often too valuable (and just as often too fragile) to loan to other researchers or institutions; however, without a vigorous exchange of ideas and specimens paleontological research would end. This dilemma is resolved by reproducing the specimens in plaster or plastic resins of various types. A properly made cast is not only identical to the original in gross appearance, but it is also accurate enough for scientific measurements to be made.

Casting and moldmaking has been a human endeavor since the dawn of civilization. The Classical Greeks and Romans cast objects in plaster, terra cotta, and metal. Although these materials continue to be used today, the 20th Century has seen the introduction of many new materials to the casting and moldmaking process. Fiberglass, silicone rubbers and epoxy and other resins are just a few which we will discuss in this chapter.

Prepping the specimen is the most tedious and time-consuming part of the entire moldmaking process. As much matrix as practical should be removed from the fossil; however in some cases, such as nasal regions and other smaller openings, it is best to leave them plugged with matrix. This adds the necessary strength required to cast fragile thin-walled specimens. After the specimen has been cleaned to the satisfaction of the research scientist, a very thin sealant coating is applied using Butvar B-76 (polyvinyl butyral) diluted with acetone. The thinned solution should pour with the approximate viscosity of water. Paint a uniform coating over the whole specimen. The dry bone will rapidly absorb the sealant solution, so continue to apply the Butvar until a very slight glaze appears over the specimen. This process fills all small cracks and punky fossilized areas with the plastic resin. The specimen is thus uniformly hardened, making it much more likely to safely withstand the moldmaking process.

The next stage in prepping the specimen is to plug all openings not naturally plugged (Converse, 1976). Modeling clay is used to plug the foramen magnum, infraorbital foramen, ear openings, or any other deep and large passages. A plug of clay also must be inserted if the nasal passage is open. Smaller openings and cracks can be filled with a water soluble wax, such as carbowax. Carbowax is removed easily with hot water and does not stain specimens as clay does. Without these plugs, the trapped latex will make mold removal very difficult and also can damage the specimen. All plugs, including the nasal plug, should be recessed to preserve the natural appearance of these areas on the cast specimen. The openings within the zygomatic arches also must be closed off, and they will require the largest plugs. The zygomatic plugs should be as thin as possible, yet fill the entire zygomatic openings. On large skulls, a waxed piece of cardboard can be carefully cut and inserted into the zygomatic openings, and the edges around the cardboard can be sealed using wax or modeling clay. The latex would be impossible to remove from the specimen if it was allowed to flow through the zygomatic openings. All clay used on the specimen during these preparations should to be recessed so as not to distort the contours of the fossil skull (Figure 7-1).

The fossil must be surveyed for the best area for the pouring spout (Converse, 1976). Usually the most ideal area for a skull is either the foramen magnum or the nasal region. A base of modeling clay can be built up for mounting a single mandible and will also serve as a simple pour-in spout. Study the specimen closely for contour lines. Ask yourself the question: How easily will trapped air bubbles flow toward the pouring spout? A primary concern is to find a spout area where all angles curve up to the pour spout and air bubbles are not trapped in the higher spots. Try to have the bubbles flow away from critical diagnostic features such as teeth. The wider areas of the specimen usually should be at the opposite side the pouring spout. Some specimens just do not have the proper contours nor do they allow a pouring spout at either end, in which cases the top of the cranium may offer the best alternative site. The pouring spout can be carefully trimmed without defacing any of the diagnostic features of the specimen (Figure 7-2).

Identifying markings should be placed in the clay somewhere on the specimen. The pouring spout or a plug inside the zygomatic arch area works very well for this marking. A catalogue number is usually all that is necessary, but species name or location data is sometimes desirable.

The work area should be protected by either covering a piece of paper or cardboard before applying latex to the specimen. This protects the work table from a build-up of dried latex which, over a period of time, can be difficult to clean up.

Large specimens will require the latex build-up to be done in stages over a period of several days. The dorsal side of a skull can be coated to the desired thickness and then turned over and the ventral side coated. The contact edges between the top and the bottom should be trimmed to a smooth surface to prevent uneven flexibility of the mold and also to insure a proper bond between the two surfaces.

A thinned solution of latex should be prepared for the first and second applications. The thinning is done by adding water and a small amount of ammonia to the latex solution. The ammonia added to the water keeps the latex from clotting and makes a uniformly thinned solution. The trapping of air bubbles on the specimen when applying latex can be avoided by coating the specimen with a solution of ammonia (Rixon, 1976).

Before dipping the brush in latex, wet it with full strength dish detergent and wipe off the excess with a paper towel. This will prevent latex from clotting and ruining a good brush. Paint the thinned latex over the specimen using flowing strokes. Keep the brush full of latex at all times and allow it to flow onto the specimen. This process makes it easier to apply the first coat without air bubbles. After the first coat is dry, the second coat should be applied in the same manner.

Bubbles in the first two coats should be removed immediately by slowly dabbing them with a dry brush. The bubbles will pop and allow the latex to flow into the voids if the brush is kept clean and dry. It is better to do smaller areas at a time. This allows one to remove any bubbles before the latex starts to dry.

When finished applying a coat of latex, squeeze the latex out of the brush with a paper towel, then rinse the brush in running water to remove the remaining latex and detergent. When applying the next coat of latex, remember to dip the brush in dish detergent again---BRUSHES ARE EXPENSIVE.

Several additional coats of thicker latex are applied, allowing each coat to dry before the next is applied. Now a layer of cheesecloth is fitted over the entire latex area. It can be trimmed to conform to the contours. It is easier to apply the cheese cloth when the latex is still a little tacky. The cheese cloth reinforces the mold and keeps it from collapsing on itself. A double-ply of cheesecloth is all that is needed over the entire mold. Once all areas are tightly tucked with cheesecloth, a coating of thinned latex is applied over the surface. Try to avoid trapping air between the latex and cheesecloth. Trapped air separations can create problems later when trying to pour the mold.

At this point one must study the specimen very carefully to determine where to make the necessary split lines for safe removal of the specimen and of future casts. The splits should be placed in non-critical areas that will not deface diagnostic features with a split-line impression. On a skull they may be just off center or along the crest of the cranium. Strips of cheesecloth are cut to build these areas up. They must be thicker than the mold itself so there will be a broad enough surface to glue the seam back together. Usually a 1/2 inch strip is satisfactory. A thickness of approximately 1/4 inch is appropriate. Areas too much thicker make the unzipping process difficult and one runs the risk of damaging the specimen or cast in the removal process. Usually two to four additional coats of thicker latex over the cheesecloth is enough to build the mold zipper up to about 1/8 inch (Figures 7-3, 7-4).

Allow the latex to cure until it is dry to the touch. This is occurs within 24-48 hours after the final coat is applied, but a region's humidity plays an important role in the curing speed.

The latex mold is now complete and preparation of the overmold must be planned. The purpose of the overmold is to prevent the outward push of the plaster and prevent distortion in the required configuration of the mold. The overmold retains the original shape of the specimen as the plaster pushes outward into the mold.

The first step in preparing the mold for the overmold process is to plug all undercuts or large openings that could otherwise make the removal of the overmold difficult. In the past this was done by making a series of interlocking plaster blocks, sometimes requiring two to eight blocks to fill an area. A new technique developed at the Florida Museum of Natural History employs the use of silicone caulking compound (Dow Corning Adhesive/Sealant RTV-732) to do the same job (Converse, 1982). We found that by adding a small amount of water to a beaker of silicone caulk and whipping it until it turns from a translucent to a white opaque appearance the material would set in approximately 10 minutes. The normal curing time for this caulk is 24 hours. The exact amount of water added does not matter, because the silicone will only absorb a small amount and the balance will remain in the bottom of the beaker. The water apparently dilutes the acetic acid within the silicone thereby reducing the drying time (Figure 7-3).

We also discovered that when several molds were being processed at the same time, the use of various epoxy pigments in the caulk can create the necessary color coding required to keep the various sets of silicone plugs separated from one another.

The next step after mixing the caulk and water uniformly is to apply it to the desired area of the mold using a spatula. A wooden handled, 4-inch-blade spatula works well for this process. No separator is required between the latex and the silicone caulk. As long as the water has been mixed uniformly it will not bond to the latex. The caulking material cannot be used right out of the tube, as it will adhere to the latex or to almost anything else.

Keep building up the filler block areas until the contours of the mold have been smoothed out. Since the silicone caulk mix will bond to itself, even after the first application has dried, it can be modified. The surface of the plugs can be smoothed out by using the clean blade of the spatula.

In the past, several plaster blocks were required to fill areas such as orbits, to level the dentition, or to smooth the complex area in the ear region of the skull. Now a one-piece construction will fill each of these difficult areas. There is just enough elasticity in the silicone caulk to allow the plug to be removed safely without damaging the specimen or the cast and still be rigid enough to retain the original shape of the specimen. Each plug should be removed, trimmed, and returned to the mold after it has dried. A small amount of Vaseline will act as a separator if two overlapping silicone plugs are required. Use caution to keep the Vaseline from coming in contact with the latex, however, because any such petroleum product will cause the latex to expand, distorting the mold. An overmold can be applied once all major contours are plugged and the mold surfaces have been smoothed with filler blocks.

Study the specimen again to determine how many pieces will be required for the overmold. Usually four or more are required for skulls, while only two pieces will be needed for a single mandible half. With the shape of each piece in mind, lay a retainer wall using modeling clay. Then form the necessary flanges for fastening one piece to another. Cut plaster bandage into small squares or strips. Dip each piece of bandage into a container of water and start applying from the flange area toward the center of the piece (Converse, 1981). Build up the plaster bandage until a thickness of approximately 3/16 to 1/4 inch is obtained. Try to maintain even edges around the flange. Any overlap can be folded back to maintain these edges. Allow this section of the overmold to set before starting the next. It does not need to be totally dry, but it should feel firm to the touch. Slowly remove the overmold section from the mold when it has hardened. This is to insure an easy removal. The edges can be trimmed using large shears before starting the next section.

Place the finished section back on the mold and build up whatever retainer wall is needed, using the existing flange as one surface. Apply a separator of Vaseline to the plaster bandage for the second section. This insures a parting of the seams at the plaster contacts. Apply the necessary layers of plaster bandage as in the first section and separate after it is hard for ease of removal and trimming. Continue using the same procedure to finish the remaining sections of the overmold.

Allow the plaster bandage of the overmold to dry completely. This usually takes 24 hours. Remove each section and coat inside and out with a thinned solution of Butvar B-76. Keep applying this material until a glaze becomes apparent. Place each section back over the mold and clamp in place. Drill a series of holes large enough to accommodate 1/4-20 bolts with wing nuts. These will clamp and lock each section in place (Figure 7-5).

Completely disassemble the mold including the overmold and filler blocks. Carefully start parting the mold at the designed split seam using a razor blade or scalpel. Separate the latex from the specimen by carefully splitting the seams. The specimen should be removed from the mold and placed in a protected area until the plugs and other molding materials can be removed. The split latex mold should be washed inside and out to remove any excess build-up of foreign materials and hung up to dry.

Once the mold is dry, the seams are carefully zipped back up using standard rubber cement. A thin film of this cement is applied to each surface and allowed to totally dry. The two surfaces of the split seam are then carefully brought together to form a tight seal. Continue this operation until all seams have bonded. Look at each seam to be sure there are no gaps that might allow leakage when filled with plaster. Start assembling the filler blocks and overmold pieces. Once the overmold is bolted tightly together the mold is ready to be poured.

## Casting in Plaster

Prepare the plaster powder prior to starting the casting procedures. A large mixing/storage container should be two-thirds filled with fresh HYDROCAL white cement, which should be carefully measured so you can determine the quantity of coloring pigment to be added to the dry mix. Standard cement coloring is used for this process. The coloring tint breaks the harsh white glare in the finished cast and gives a softer tone. The two basic colors used are tan and brown. Brown alone comes out with a dark redwood effect and does not offer the softer tone desired. The proportions mixed together are three parts tan to one part brown. Other tones can be used as desired. Add one level teaspoon of pigment for each 1000 ml of plaster. It can be added to the mixing/storage container of HYDROCAL and uniformly mixed (Figure 7-6).

Determine the approximate volume of plaster required to fill the mold. The exact amount can be reached by completely filling the mold with water and then measuring the total volume. Completely empty and dry the mold before pouring the first cast.

Measure the determined amount of water, taking into consideration an approximate (33-1/3%) increase in volume when adding the plaster powder. Use a softsided plastic pail for mixing the plaster. This aids in the cleanup removal of the left over plaster when all is done. Just flex the sides of the pail and the plaster will pop out.

Slowly sprinkle the HYDROCAL powder into the predetermined volume of water. Continue to add the plaster until the water will no longer consume the plaster and it forms small islands on the top of the water. Set aside some of the dry mixture for later touch-up work. Stir the mixture using a flat mixing stick similar to a paint mixing stick. Perform this operation slowly, avoiding a build-up of bubbles. Plaster, especially pail-size volumes, should be allowed to slake (soak up water) for 45-60 seconds; this allows it to absorb all the moisture it can and prevents lumping. When the mixture is ready to pour into the mold, it should have the consistency of heavy cream. If any bubbles have accumulated on the top of the plaster mixture, they should be carefully skimmed off using a paper cup. No bubbles should be poured into the mold (Figure 7-6).

Pour the mixture slowly and steadily into the mold. Roll and tip the mold during the pouring operation to insure the release of any trapped air from within the mold. Fill up into the pour spout, but not clear to the top. Leave enough room so the mold can be slightly tipped while slowly tapping the outer surface of the overmold. A rubber or leather mallet is ideal for this operation. Tilt, tap, and rotate until all trapped air has been released through the pouring spout. Top off the mold with the remaining plaster. There are times when the water in the mixture will separate before the plaster has set. This usually takes place in the pouring spout region or at the highest point in the mold. It could settle down into the mold itself and cause some minor voids in the area around the spout if left unattended. If the water can be dipped out, do it. If not, dab off the excess water using a dry paper towel and continue to do this until the water has been absorbed. Top off the void with additional mixed plaster (Figure 7-7).

Setting occurs a few minutes after the plaster has been poured into the mold. This process involves the solidifying and heating up of the casting material. At times the mold can become too hot to handle. Once the plaster has set (about 15-20 minutes is safe) the overmold and filler blocks can be removed from the latex mold which will allow much more rapid cooling.

The mold with cast should be left overnight (or at least several hours) before trying to remove the cast to assure that it bas fully set. The split seams of the mold are unzipped, and the latex mold is carefully peeled away from the cast. If any cosmetic touch-up is required due to air bubbles or zipper seams, do this process immediately. The cast will accept dry or moist plaster while still in the damp condition. Use a small amount of dry plaster from the same batch used in mixing the plaster of the cast. Each time a new batch is mixed, it is best to save a small container of this plaster just to use for cosmetic touch-ups. You thus guarantee the same color blend.

Touch up of small bubble holes can be performed by simply dipping a moist finger into the dry plaster and rubbing this into the small holes (McCarty, 1982). This new plaster will blend right into the original configuration of the cast. Larger voids may require a small amount of plaster to be mixed with water and applied with a small spatula. All casting defects can be covered up in this manner without affecting the cast in any way. If the cast has already dried, this cosmetic touch-up can be accomplished by mixing the colored plaster with a small amount of white glue and applying it to the defects.

The pouring spout should be removed while the cast is still wet. This is not required in all cases, but skulls most always need this done. The trimming is easily done with a sharp knife to cut the spout down to the original bone contours. Then the area can be smoothed out so it is very difficult to ever know it was there. The cast is now left out in an open area and allowed to completely dry.

When dry, a wash of thinned Butvar B-76 should be applied over the entire cast. It is very important for the cast to be completely dry, or the Butvar will leave a white film on lt. If the room air is moist, a heat lamp will help to dry the cast fully. Coat the cast until a slight glaze is reached. This adds a protective hard plastic shell over the cast without interfering with scientific dimensions.

The latex mold should be completely washed, allowed to dry, and carefully zipped back up to make it ready for pouring the next cast. If no more casts are needed, the mold should be refilled with plaster following the same procedure as in the original casting and stored on a open shelf. Storing the mold with a cast inside prevents the latex mold from folding or collapsing during storing.

The split seams build up an excess of rubber cement after extended usage, which needs to be removed periodically. This is can be done by rubbing the contact surfaces with a small amount of rubber cement thinner, which will not affect the latex. If the rubber cement is allowed to accumulate, the split seam becomes wider and causes some distortion to the cast.

After the basic requirement of casts has been reached at the Florida Museum of Natural History, six additional ones are poured and stored with the mold for possible future use or exchange.

## Silicone Moldmaking and Centrifugal Casting

The discovery of silicone rubber as a molding compound revolutionized casting techniques in paleontology. It made it possible for the preparator to make a mold quickly and to pour it using various resins as casting substances. Silicone rubber offers high fidelity reproductions, captures delicate details, masters intricate shapes, and holds severe undercuts when used to make molds.

Specimens to be cast in silicone rubber are usually smaller in nature than ones normally setup for latex molds. Specimens that are fine and delicate, which would be very difficult to duplicate in plaster, can be very easily cast using the stronger resins.

Preparation and setting-up procedures are nearly the same as for latex casting. As described above, all openings, such as foramina, must be carefully plugged with modeling clay. Silicone rubber flows into every crack and void freely and tends to tear more easily than latex. A careful check for problem openings must be made and plugged if necessary to prevent severe damage to the fossil.

Usually the fossil is set up on a pouring spout which will be used as a base during the moldmaking process. Some identification, such as a catalogue number, is marked into this base. A retainer wall of modeling clay is then constructed. This is done easily by taking a portion of modeling clay and rolling out a large flat piece of clay, using a household rolling pin. For ordinary size molds a thickness of approximately 1/8 to 1/4 inch thickness usually makes the walls strong enough to hold the silicone rubber until it has set. Place the retainer wall around the specimen leaving enough space to give the mold walls enough strength so they will not be distorted in a vacuum or centrifuge. A plastic vial of about 1-1/2 to 2 inches in diameter and 3 inches high can work very well as a retainer wall for small specimens, such as rodent teeth or small lizard jaws. The plastic vial must have the bottom cut away and a split cut down the side. The plastic cylinder now can be slipped around the specimen and pressed into the clay base. A small bead of clay is pressed into the split seam and blended smooth. The top of the specimen should be at least 1/4 to 3/8 inch below the top of the retainer wall or plastic cylinder to insure an adequate thickness in the base of the mold (Figure 7-8).

The silicone rubber most commonly used in museums around this country is Dow Corning's Silastic 3110 RTV Rubber. It is available with the standard catalyst #1, which cures in 24 hours, and also a rapid curing catalyst #4 which cures in 20 minutes. The rapid cure catalyst can be used only in small quantities because its working time is 4 minutes. If a mold must be degassed to remove air bubbles, the slow curing catalyst must be used.

Dow Corning 3110 RTV has one drawback; it tears easily. General Electric makes a silicone rubber, GE 700 RTV, which is much more tear resistant; however, it is more viscous than the Dow Corning product and is not easily degassed.

Weigh the estimated amount of silastic 3110 needed to fill the mold retainer, add the proper ratio of catalyst 1, and blend thoroughly. Place the material inside a vacuum chamber and pull between 27 and 29 inches Hg to degas the mixture. At first it expands and then it recedes to its original level. It is now ready to pour. To prevent air entrapment, pour the silicone rubber across the specimen from the side or top. Do not pour directly over the specimen. Let the rubber slowly seek its own level until the retainer wall is full. The unit can be placed back into the vacuum system and degassed once more as a safeguard. This will pull any trapped air out. When done, remove the mold from the vacuum chamber and allow to cure the recommended amount of time. Do not rush the process (Figure 7-9).

Carefully break down the retainer wall or remove the plastic vial after the 24 hours, or whatever curing time was selected for the mold. The vial can be removed easily by expanding it and sliding it over the silicone plug. Extreme care should be taken in removing the fossil from the mold. Simple teeth usually can be lifted right out, but more complex configurations may require you to make a small slit down the side of the mold. Once the specimen has been removed from the mold any splits or tears can be repaired with silicone caulking sealant.

There are numerous plastic resins available commercially that are suitable for casting. Most are epoxies or polyesters that require a catalyst to activate them. Hobby shops, hardware stores, and stores that specialize in boat or auto body repair materials are good sources for plastic resins. They also can be purchased direct from the manufacturer or distributor. All plastic resins require care in their use. The preparator should wear rubber gloves and work with them in a fume hood, outdoors, or in a well ventilated area.

Plastic resins are found with different rates of curing time, from several hours to 24 hours, and different degrees of hardness and gloss. Most plastic resins will take pigments so different colors can be produced. For paleontological specimens, dark gray is a good color for showing detail well in the cast. In the previous paragraphs we made our molds, and now we will continue with the casting procedure.

The epoxy resin is carefully measured so there is enough to generously fill the mold. Carefully follow the instructions for mixing in the proper amount of catalyst. It is advisable at this point to add to the mixture a small drop of epoxy pigment of your color choice. The mixture is poured onto the mold when blended, and the mold is weighed. Then a counter-balance of sand is measured to the same weight and placed in the centrifuge. A hand-operated or clinical centrifuge can be used, but care must be taken to keep the mold upright in the centrifuge carrier to prevent the spillage of epoxy. Crank up the centrifuge to a normal speed and then brake it right back to a stop. The whole procedure usually takes only a few seconds. Remove the mold from the carrier and set on the bench to cure for approximately 24 hours. The cast removal should be much easier than the removal of the specimen. The resin is much harder and rarely subject to any breakage Figure 7-10).

Silicone rubbers for moldmaking are relatively expensive compared to latex. As of this writing, the price is about 25 to 15 dollars a pound depending on the type and source. A more economical method for some molding applications is a composite mold comprised of both RTV silastic rubbers and silicone caulking compound which is available at hardware stores. With this procedure, the more expensive RTV rubber is applied with a brush to form an impression coat over the specimen. This coat only needs be 1/4 inch thick. If you use a rapid cure catalyst which sets up in a few minutes, you need to work with small quantities (about 30 grams) which can be brushed on before it sets up. For a large specimen such as a skull, you will need many of these small quantities measured out ahead of time. Add the catalyst to one of the premeasured cups of RTV, stir, and brush on. Repeat this procedure until the impression coat is complete.

On top of this impression coat, silicone caulking compound may be applied directly from the tube and smoothed with a spatula. Again, build the layer up about 1/4 inch; if much thicker, it may not cure properly. If a thicker mold is desired, a layer of cheesecloth may be pressed onto the layer of silicone caulk and another layer of caulk applied after the first coat has cured overnight. Where RTV silastic rubbers are used, a separator or mold release is not generally required on the specimen; however, when using silicone caulk applied directly to the specimen, a separator must always be used (Figure 7-11).

An even less expensive method of moldmaking is to use the silicone adhesive sealant (caulk) alone as a molding compound. The detail will not be as good as with RTV silastic used as an impression coat, but it will produce a serviceable mold for many applications. When using the caulk by itself, it is mandatory that a separator such as a spray wax or dish detergent be applied to the specimen before molding begins. If dish detergent is used, it should be applied full strength and then allowed to dry (Figure 7-12).

Before applying the caulk on the specimen, it must be thinned with toluene, mineral spirits, or rubber cement thinner. The latter two solvents are less toxic than toluene, which should only be used in a fume hood or extremely well ventilated areas. Thin the caulk only to the point where it can be easily dabbed and spread thickly with a brush. Be sure to eliminate air bubbles and trapped pockets of air. Allow the completed mold to cure overnight before continuing.

When using this method, it is preferable to build up at least two layers of caulk, each of which should be allowed to dry overnight or 24 hours. Both layers should be about 1/4 inch in thickness or less. A layer of cheesecloth between layers of caulk will add strength and prevent tearing.

Skulls are usually cast in two-piece molds, whereas mandibles are simple pour-in type molds. In constructing the two-piece mold a generous lip must be extended around the specimen with interlocking grooves and indexing holes evenly spaced around the lip. To attain a tight seal and prevent leakage around the mold, apply a thin film of Dow Corning High Vacuum Silicone Grease to the top and bottom lip areas of the mold and properly clamp the two parts together (Figures 7-13, 7-14).

The soap is easily washed from the specimen and from the impression areas of the mold after the molds are completed. Standard epoxy pouring techniques are employed using centrifugal casting.

The end results using this technique will give reproduction of the finest details at a much lower cost than straight Silastic 3110 with the same high speed. The resultant mold also is more substantial and therefore has a longer shelf life.

## Fiberglass Molds and Casts

Working with fiberglass involves material and equipment that not every laboratory will want to have, nor be able to provide. Fiberglass cannot be used within a closed environment. The fumes given off from the chemicals are injurious to one's health when inhaled. Adequate ventilation must be used at all times. Another factor that might discourage some laboratories is the high cost of the materials used in this process. On the other hand, the advantages offered by fiberglass casting are major. It is almost a must when very large casts are required because of its strength and light weight. Items such as dinosaur and proboscidean limbs would be extremely heavy and nearly impossible to handle when cast in plaster.

Careful study must be made to determine the entire procedure to be employed when preparing a specimen for fiberglass casting. Two methods of moldmaking can be utilized. The first and simpler method is the standard latex process described near the beginning of this chapter. This procedure allows the preparator to make molds of fewer pieces than the second mold construction method because the latex is so flexible. Also, less attention can be devoted to undercuts on some specimen, although skulls and other more complexly contoured specimens will require more.

The second method of mold construction uses the fiberglass itself. Here several pieces are usually required for ease of removal once cast. Each piece can be fastened together easily, using either clamps or other bolting devices.

The latex mold must be constructed using keyed flanges usually several inches in width. Modeling or other types of clay, including the water soluble forms used in the ceramic trade, can be used for constructing the platforms for these flanges (Jeremiah, 1980). The desired split line area is framed up with this clay and indexing depressions are formed by using a small round light bulb. These should be evenly spaced around the entire flange. Once the frame of clay has been laid for the flange, the latex is brushed on using the same technique employed in the standard latex moldmaking procedures. On larger specimens a thicker layer of latex must be built-up and strengthened with cheesecloth. The entire area of the flange is to be covered with this layer of latex. Allow the latex to cure totally.

An overmold must be constructed in the same manner as described above in the standard latex moldmaking technique (Jeremiah, 1980). An additional clay lip must be prepared to extend the flange an additional 2 inches beyond the latex mold. This allows the fiberglass overmold pieces to interlock. Fiberglass materials are used in place of the plaster bandage. The latex is totally coated with a mold release wax (Mirror Glaze) especially designed for use with epoxy resins. This is allowed to dry on the latex.

The first coat of plastic resin is applied. Usually the resin is a polyester gel-coat. A pre-accelerated type of gel-coat is advisable to prevent excessive run off of the material from the mold (O'Brien, 1961). A colored gel-coat (preferably white) is used so that one can recognize variations in density and thus avoid leaving any thin areas. Usually two coats of gel-coat will be required. Allow the first coat to dry thoroughly before applying the second. Before the second coat of gel-coat has hardened tack small pieces of fiberglass mat onto the surface. Always tear more pieces than are needed to complete the side being coated. These small pieces of mat are totally soaked with epoxy resin. A brush is the best tool to flow the resin over the mat. Work air bubbles out of the mat material so that it conforms tightly to the gel-coat surface by using the bristles of the brush. A second application is usually applied to the flange area for the additional strength that will be required when the overmold pieces are clamped together.

The chemical reaction of the catalyst starts to take place and the resin turns rubbery not too long after the resin has been coated over the mat. This is the best time to trim off any excess material around the edges. It can be easily trimmed with a razor blade or scalpel.

After the epoxy resin has cured, several hours later, remove the clay used for the flange build-up and clean the surfaces. The specimen is rotated and the opposite side is coated in the same manner as before. Note that a separator must be used between the two sections where latex will be in contact with latex. The separator should only be applied to the flange areas. PVA (polyvinyl alcohol) and sodium silicate work very well as a separator for latex (Cassidy, 1964). This is a water soluble solution that is applied by brush and allowed to dry. The residue after the mold is completed can be easily washed away. The fiberglass process is repeated as before. Remember that all contact surfaces must have a separator between them when the second half of the latex mold is completed.

The entire mold is separated from the specimen when both HALVES (or all of the pieces) have cured. Remove the fiberglass overmolds and then remove the latex from around the specimen. The mold is now ready to be cast.

Polyvinyl alcohol is applied to the casting surface of the latex mold and allowed to dry. Each half of the mold is set up separately, and a thin coating of white gel-coat is brush-flowed over each half of the mold. Gel-coat makes a very good impression layer for the fiberglass cast. A second coating of gel-coat is applied over the mold halves. Do not slop over the edges; try to stay within the impression areas. This insures that the two halves will easily go back together while the fiberglass epoxy is setting.

Following the same procedure used for the overmold, lay up the fiberglass mat material and flow on the epoxy resin. Trim off any excess and check to see if the two halves will fit together when the epoxy resin becomes rubbery.

A mixture of gel-coat and ground fiberglass, which thickens the mixture, is used to bond the two halves together. The gel-coat mixture is carefully applied over the edges of the two fiberglass halves after the catalyst has been added. Pull the two halves together tightly making sure all indexing tabs are in place and clamp or lock together. Allow the gel-coat to harden (Figure 7-16).

The mold is unfastened, and the overmold and latex are separated from the cast. Trim any excess at the seam lines by using a small hand grinder. The seam can be carefully blended so that it does not show at all. The completed cast can be painted naturally by using and blending earth-tone acrylic paints.

The second method of construction uses silicone rubber in the place of latex, which is preferable for smaller objects. One advantage to using the silicone instead of the latex is that it does not require a mold release agent. In all other respects the process is the same.

All tools, hands, etc., can be cleaned after this process by using acetone. Spatulas and brushes should be soaked and cleaned before the resins harden.

Any casting defects can be repaired by using the same thickened gel-coat used to bond the pieces together. It can be applied with a spatula to conform to the necessary contours.

## Molds Without Pour Spouts

Both latex and silicone molds can be constructed without using pouring spouts. This type of casting leaves the finished product clear of any unwanted plaster or resin other than a small split line seam. Skulls or postcranial material can be easily cast using this technique.

The most important thing to remember when using this type of moldmaking or casting is that the top of each half of the mold must be flat and level during the casting process. If not, the casting compound will run out of the mold, and the finished cast will be only partially complete.

The specimen is prepared in the same manner as all other mold- making techniques. All openings must be plugged. The fossil, whether a limb or a skull, must be divided equally in half with an imaginary line. A clay base is built up to this imaginary line allowing for a fairly wide lip around the specimen. A groove is carved into the clay around the specimen. This groove will produce a locking area in the mold so the casting material will not be allowed to flow out. Several indexing keys should be placed into the outer flange area where the overmold will be laid over the latex or silicone mold. The preparation should be checked again to insure the surface is flat when the clay is properly formed around the specimen. The specimen is now ready for the molding compound (Figure 7-17).

Latex is built up over the specimen and flanged wall using the same technique in standard latex moldmaking procedures. Make sure that an adequately wide lip is maintained around the specimen taking in the grooved area.

There are two choices that can be employed in silicone moldmaking. A retainer wall can be constructed around the specimen and the RTV silicone can be poured filling this retainer wall. Make sure all degassing procedures have been followed. The second is using thinned RTV and brushing it over the specimen the same as latex. The mold is then thickened with silicone caulk. Refer to page 25 for this procedure. The poured mold will not require an overmold, but the thinned process will.

An overmold must be constructed after the latex or thinned silicone mold has been completed. The plaster bandage process works very well here. Be sure the thickness is adequate to prevent any mold distortion.

The specimen, mold, and overmold are turned over and the clay is thoroughly cleaned from the specimen once the overmold has set. The exposed latex flange is coated with PVA and allowed to dry. The second half of the mold is applied using the same procedure as the first. Use vaseline as a separator over the plaster bandage when making the second overmold. Do not get this material on the latex. All petroleum products cause the latex to swell. Build up the overmold the same as the first side.

Separate the overmold and mold from the specimen. Clean the mold thoroughly, and let dry before starting casting procedures.

Prepare the plaster mixture as for a normal mold pouring. Fill each half up to the top edge of the mold. Make sure each mold half is level. Allow each to set until the plaster begins to thicken. Carefully place the two halves of the mold together. Make sure the locking groove is well seated. Draw the edges of the overmold down tight and fasten. Clamps are fast and work very well for this process. A metal springed paper fastener is adequate for smaller molds. Let the plaster totally cure before removing from the mold (Figure 7-18).

Resin can be cast in the silicone molds using the same procedures. The two halves are pulled together and fastened once the epoxy or polyester has jelled and becomes rubbery.

This type of mold can be used to make hollow casts. Without a gimbaled device that would rotate in all directions at one time, simple hand rotation is adequate. The mold is very slowly hand-rotated while the casting medium is still liquid. End over end, side over side; the mold is tumbled in all directions until the medium has had time to solidify. Care must be taken to insure filling of all areas in complex molds such as skulls. Due to the thinner walls of the casts, caution must be taken in the removal and handling of the cast until it has totally dried and a hardener is applied.

All split line seams can be trimmed carefully from the above casting techniques after removal from the mold. Plaster is trimmed easily while the cast is still wet. Resin casts can be trimmed using a razor blade or sharp scalpel.

## REFERENCES


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_____. 1981. "Bean-pod" overmolds. Soc. Vert. Paleont. News Bull. 122:60-61.

_____. 1981. Repairing silicone rubber molds. Soc. Vert. Paleont. News Bull. 123:49-50.

_____. 1982. New techniques in "Bean-pod" casting. Soc. Vert. Paleont. News Bull. 125:45-46.

_____. 1983. A new procedure in silicone rubber moldmaking. Soc. Vert. Paleont. News Bull. 128:65-66.

Jeremiah, C.J. 1980. Fiberglass molding techniques in paleontology. The Plaster Jacket 35:3-13.

McCarty, R. 1982. Salvaging flawed plaster casts. Soc. Vert. Paleont. News Bull. 126:50-51.

O'Brien, P.J. 1961. Casting in fiberglass. Curator IV/2:108-116.

Rixon, A.E. 1976. Fossil animal remains--their preparation and conservation. The Athlone Press, London. 304 pp.

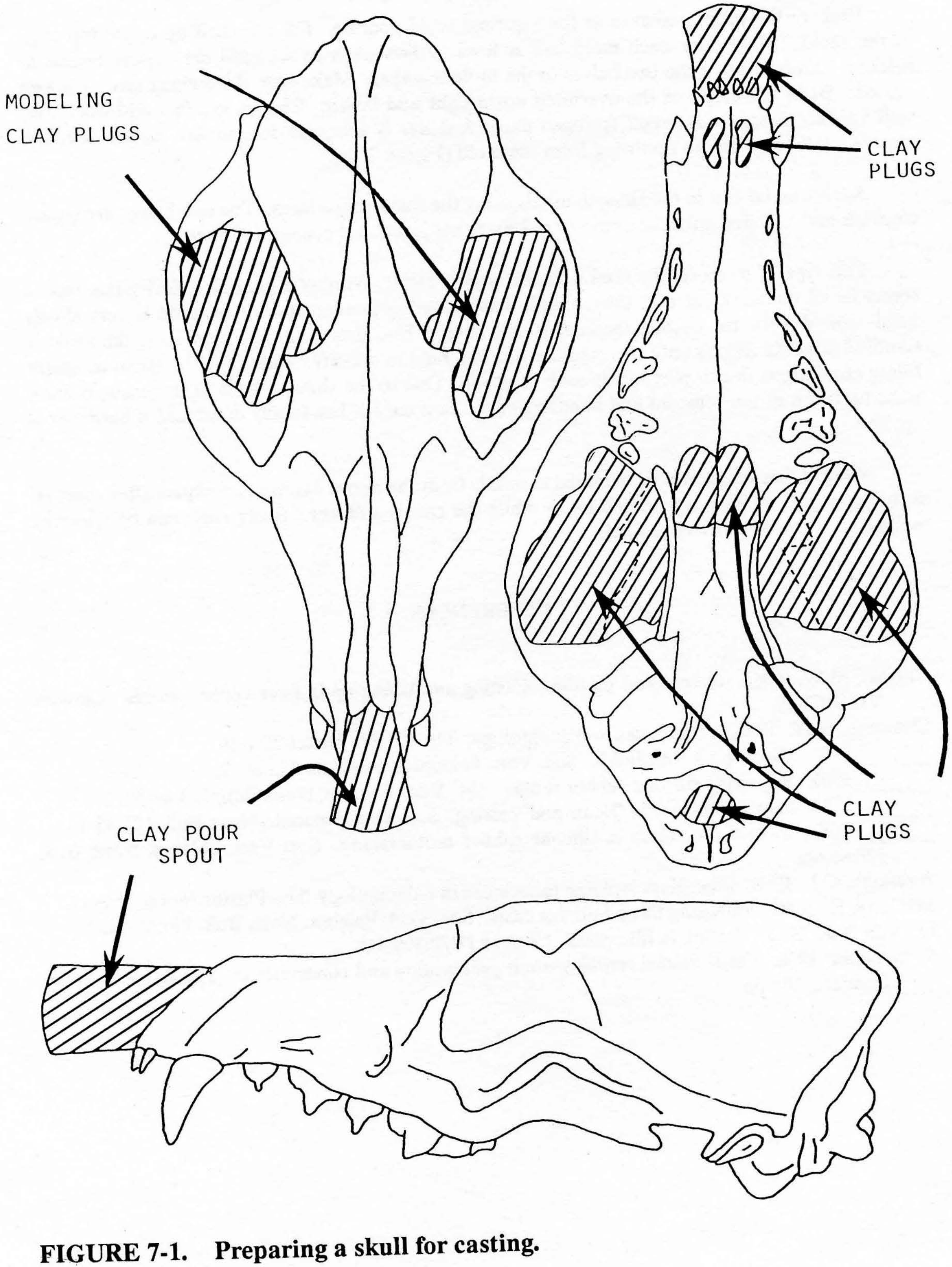



**FIGURE 7-1. Preparing a skull for casting.**

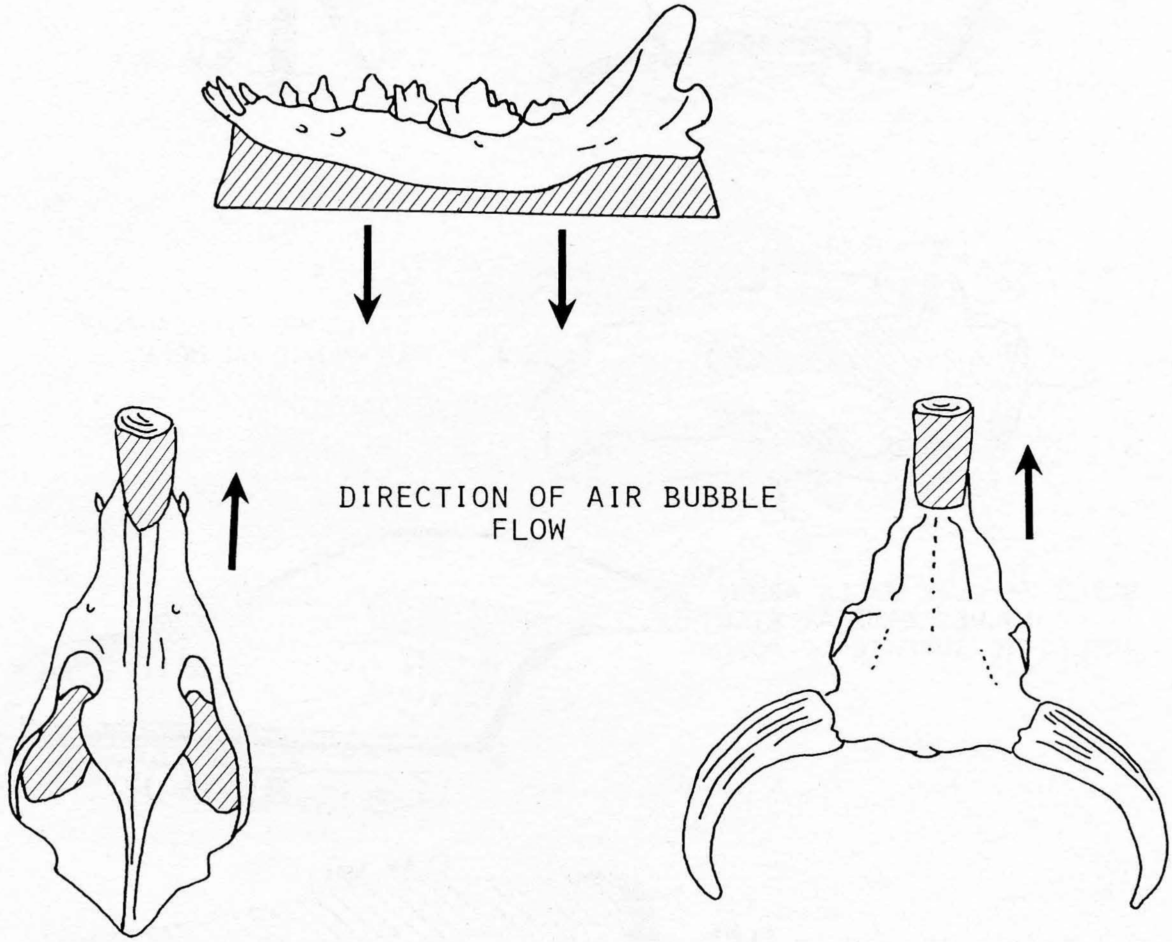



**FIGURE 7-2. Suggested locations of modeling clay pour spouts.**

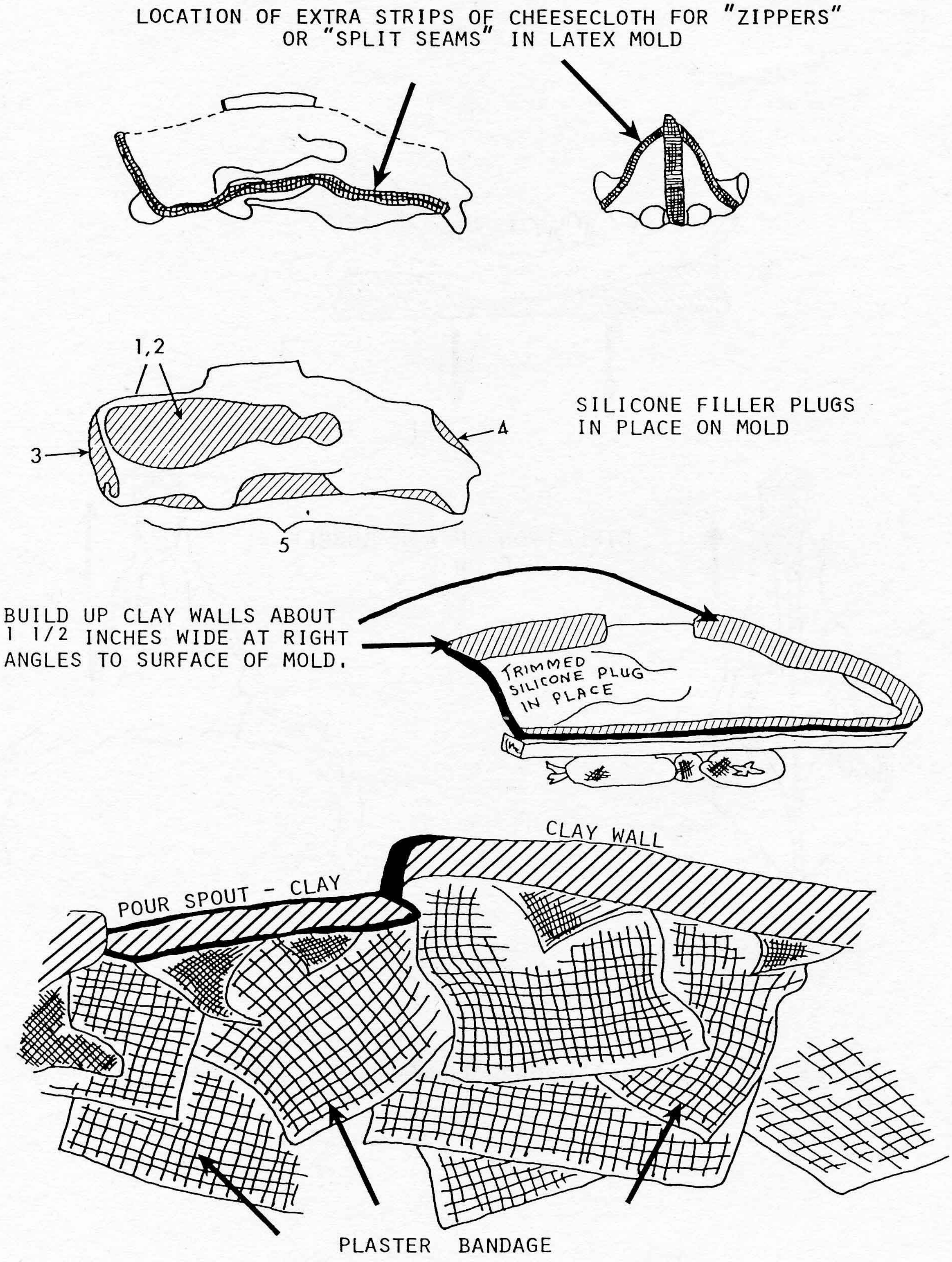

LOCATION OF EXTRA STRIPS OF CHEESECLOTH FOR "ZIPPERS" OR "SPLIT SEAMS" IN LATEX MOLD
1,2
3
4
5
SILICONE FILLER PLUGS IN PLACE ON MOLD
BUILD UP CLAY WALLS ABOUT 1 1/2 INCHES WIDE AT RIGHT ANGLES TO SURFACE OF MOLD.
TRIMMED SILICONE PLUG IN PLACE
CLAY WALL
POUR SPOUT - CLAY
PLASTER BANDAGE

**FIGURE 7-3.**

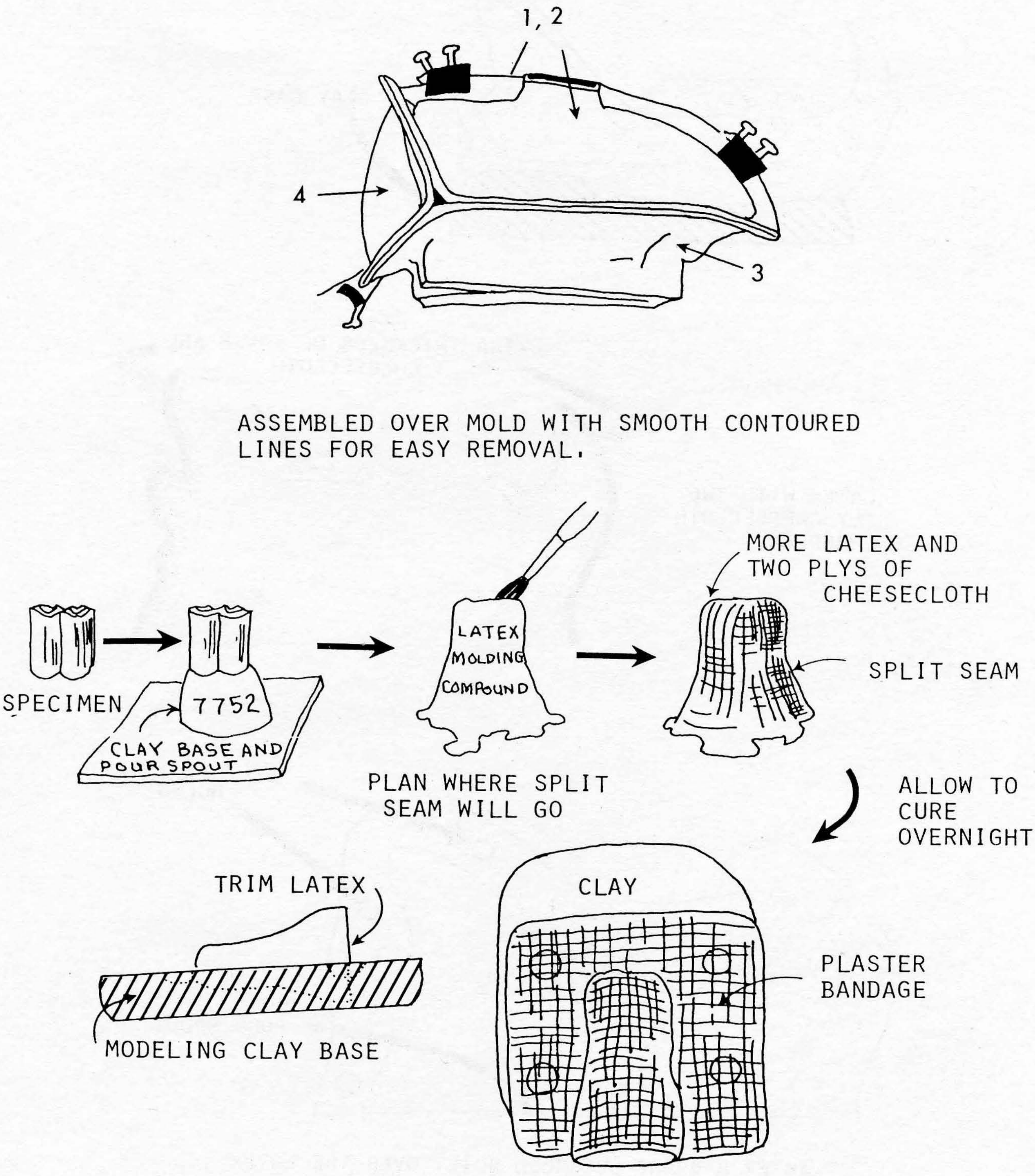



**FIGURE 7-4. Small specimen latex moldmaking.**

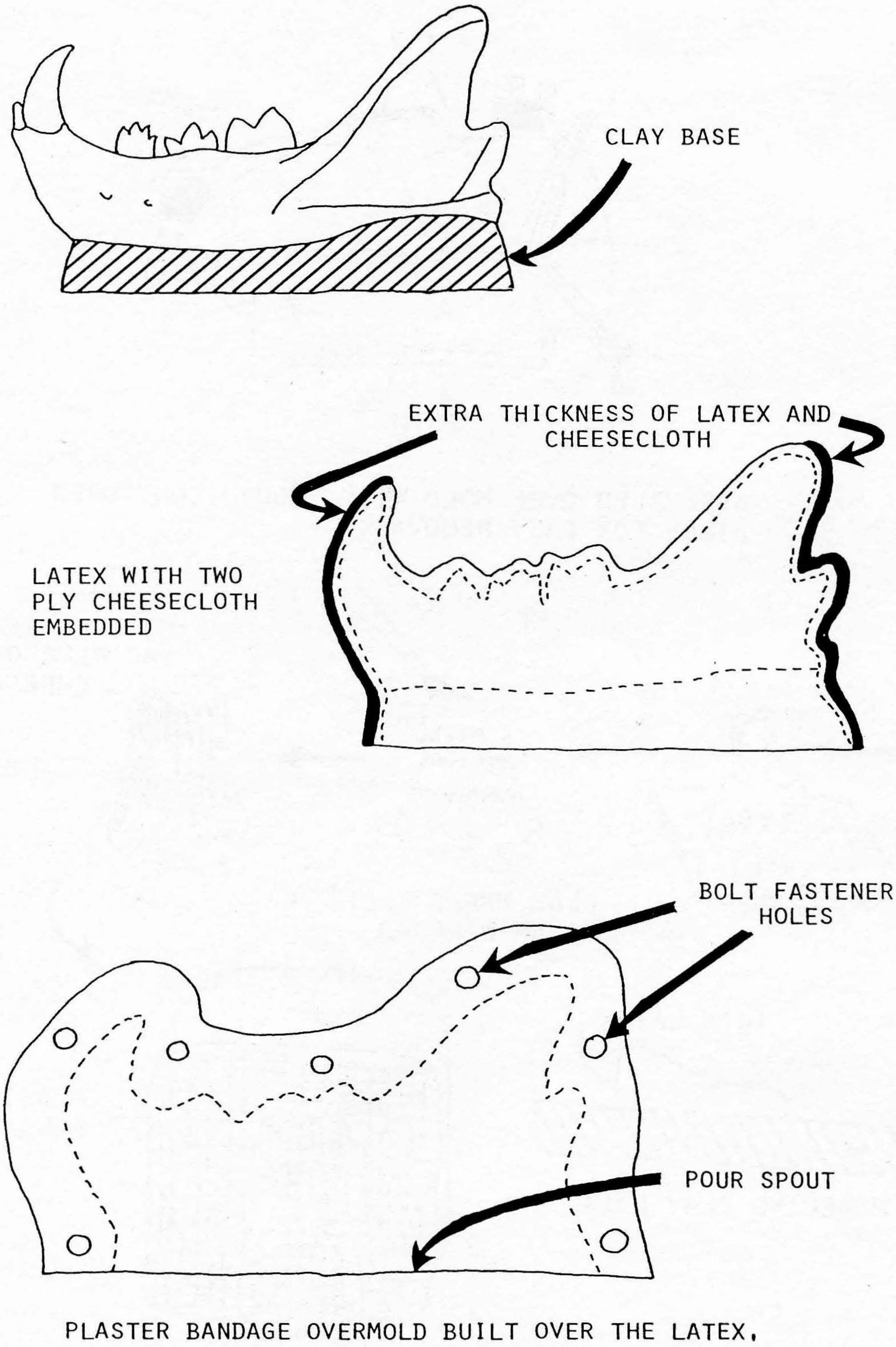
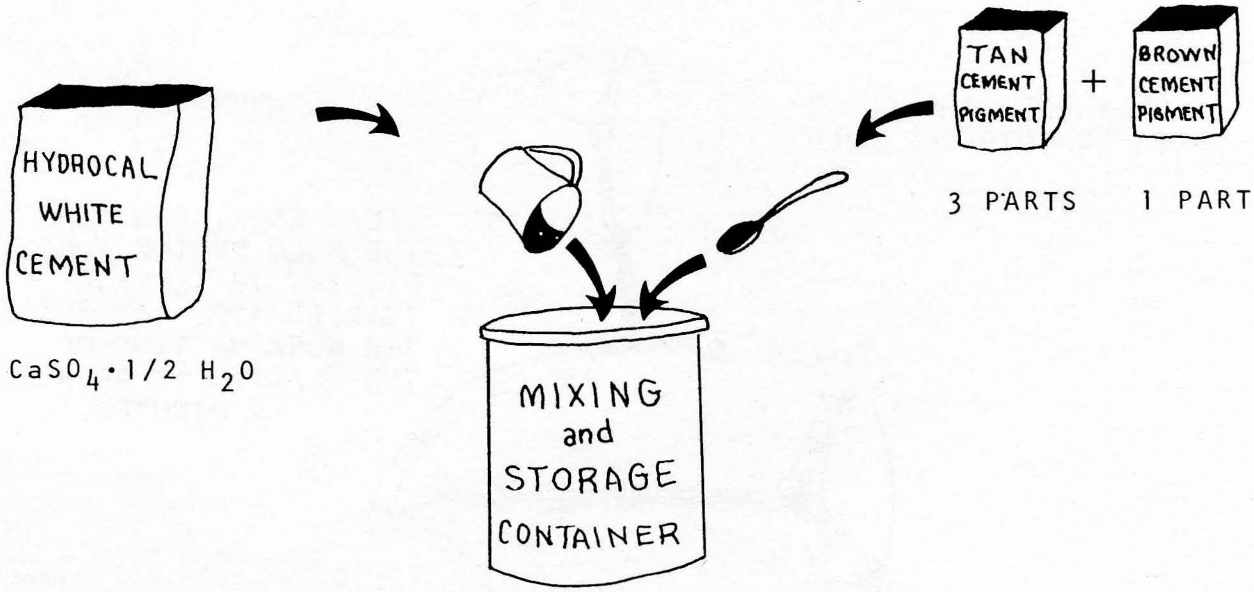
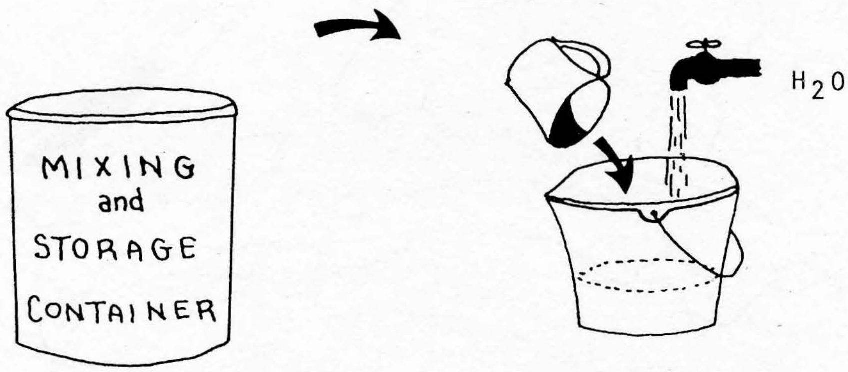

CLAY BASE
EXTRA THICKNESS OF LATEX AND CHEESECLOTH
LATEX WITH TWO PLY CHEESECLOTH EMBEDDED
BOLT FASTENER HOLES
POUR SPOUT
PLASTER BANDAGE OVERMOLD BUILT OVER THE LATEX.

**FIGURE 7-5.**




MIX ONE TEASPOON OF PIGMENT TO ONE LITER OF PLASTER.
BLEND UNTIL UNIFORM




FILL A SOFT PLASTIC BUCKET WITH A DETERMINED AMOUNT OF WATER. SPRINKLE THE PLASTER SLOWLY OVER THE WATER UNTIL IT STARTS TO FORM ISLANDS ON TOP. BLEND THE MIXTURE SLOWLY.

**FIGURE 7-6.**

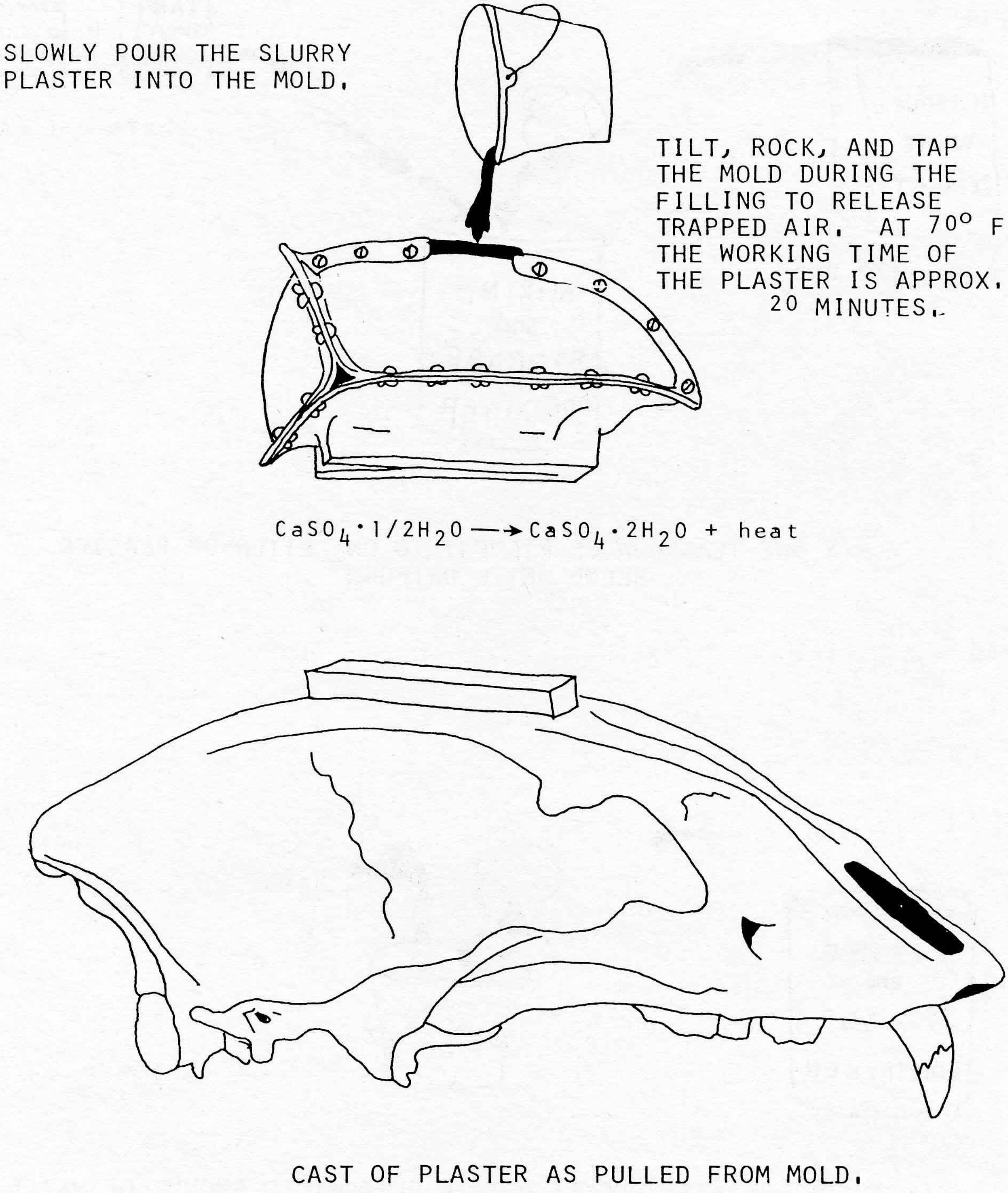
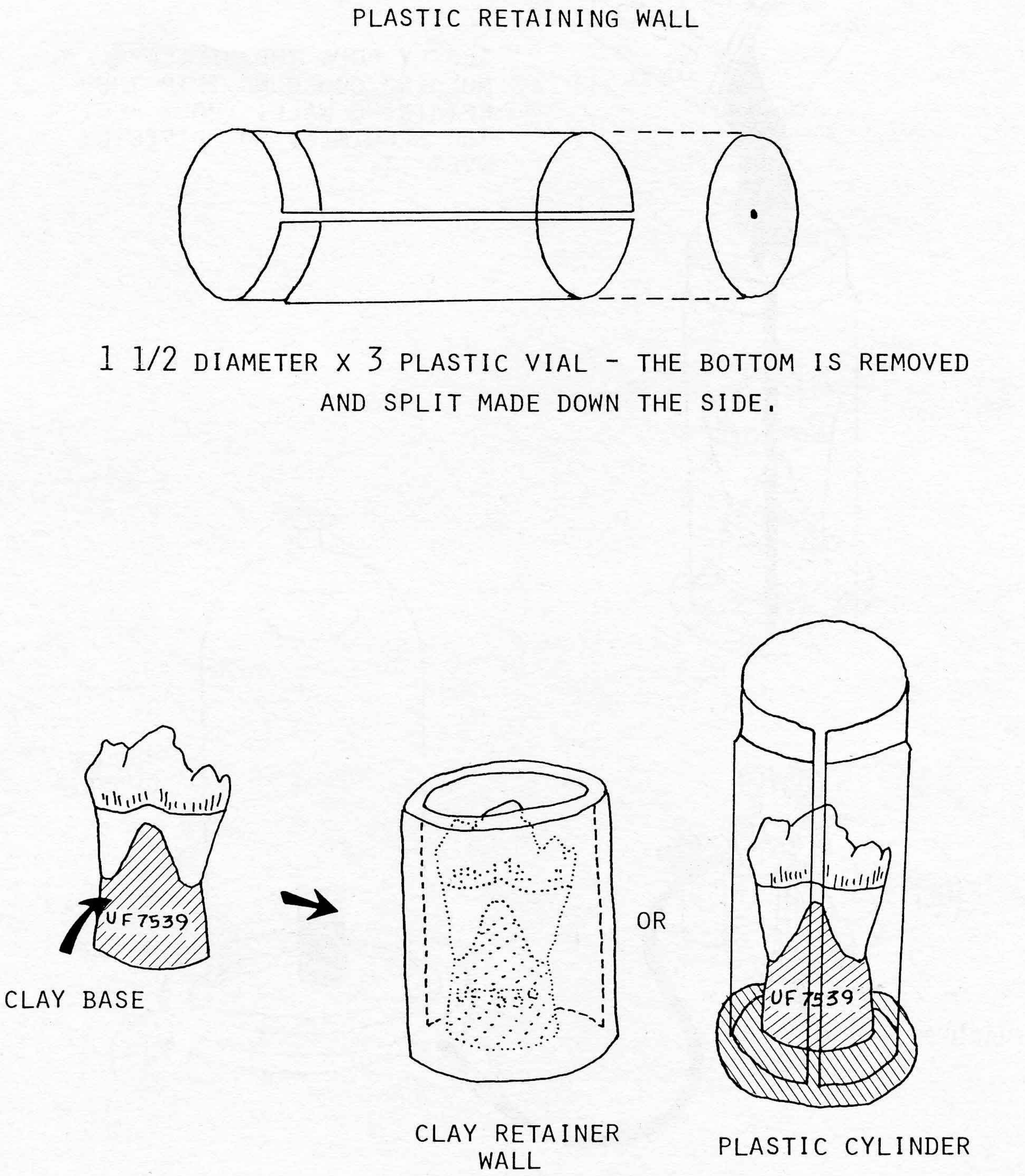
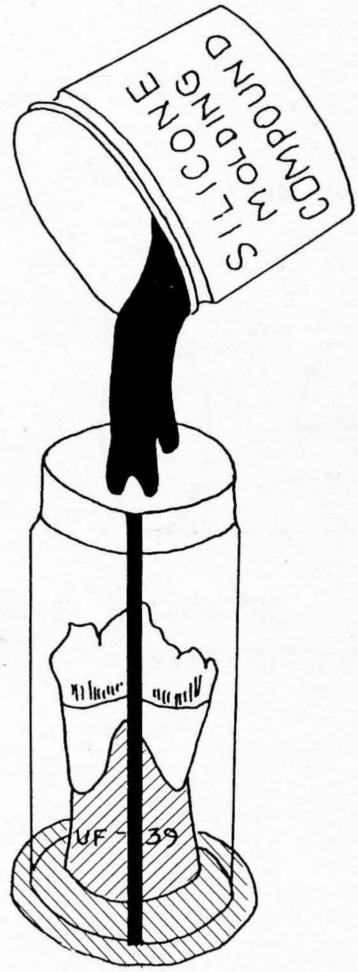

SLOWLY POUR THE SLURRY PLASTER INTO THE MOLD.
TILT, ROCK, AND TAP THE MOLD DURING THE FILLING TO RELEASE TRAPPED AIR. AT 70° F. THE WORKING TIME OF THE PLASTER IS APPROX. 20 MINUTES.
$CaSO_4 \cdot 1/2H_2O \longrightarrow CaSO_4 \cdot 2H_2O$ + heat
CAST OF PLASTER AS PULLED FROM MOLD.

**FIGURE 7-7.**

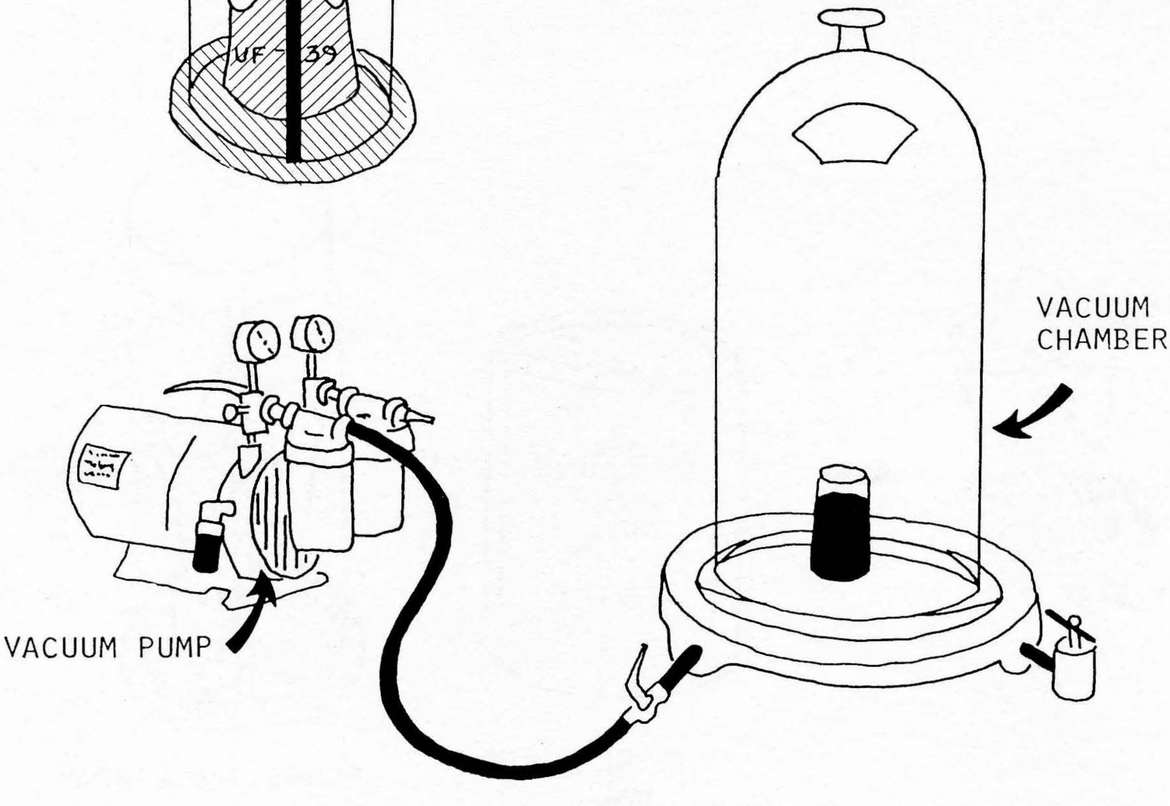



PREPARING AND SETUP OF SPECIMEN FOR SILICONE MOLD MAKING.

**FIGURE 7-8.**



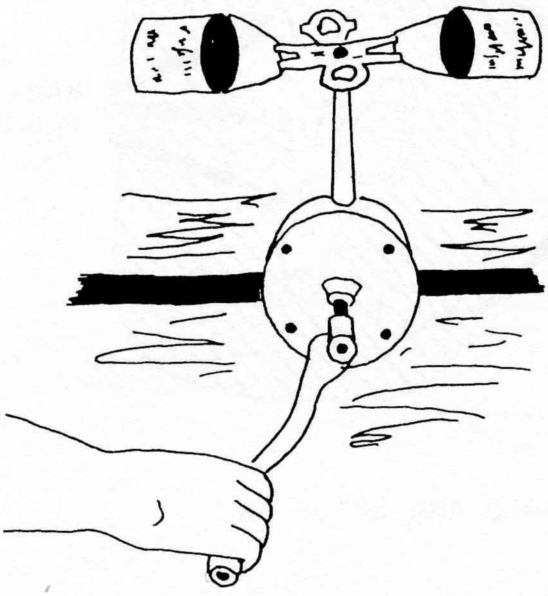

SLOWLY POUR THE SILICONE MOLDING COMPOUND INTO THE RETAINING WALL. POUR ACROSS THE SPECIMEN, NOT DIRECTLY OVER IT.




DEGAS THE SILICONE RUBBER AFTER MIXING, AND AFTER POURING INTO THE MOLD USING A VACUUM CHAMBER PULLING 27-29 INCHES HG.

**FIGURE 7-9.**

ONCE THE RESIN HAS BEEN POURED INTO THE SILICONE MOLD IT SHOULD BE SPUN IN A CENTRIFUGE.



LARGER MOLDS CAN BE SPUN USING A MODIFIED HAND-OPERATED CENTRIFUGE WITH CANS ADAPTED TO THE CARRIER.

SMALLER MOLDS ARE EASILY SPUN USING A LARGE CLINICAL CENTRIFUGE. BOTH FORMS REQUIRE A COUNTERBALANCE. A SMALL VIAL OF SAND OF EQUAL WEIGHT TO THE MOLD WORKS WELL.

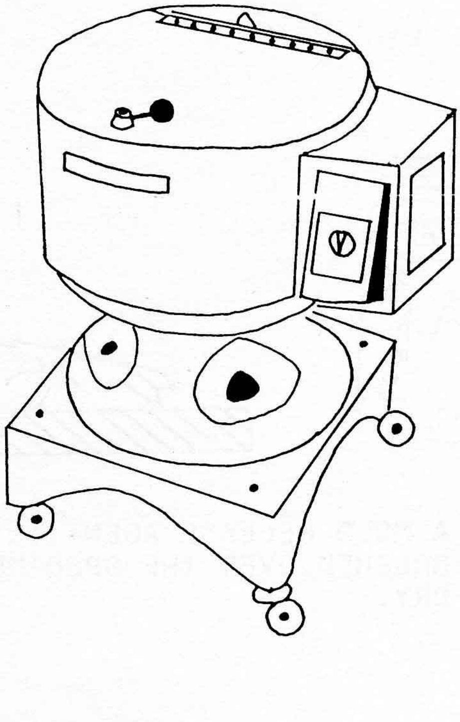
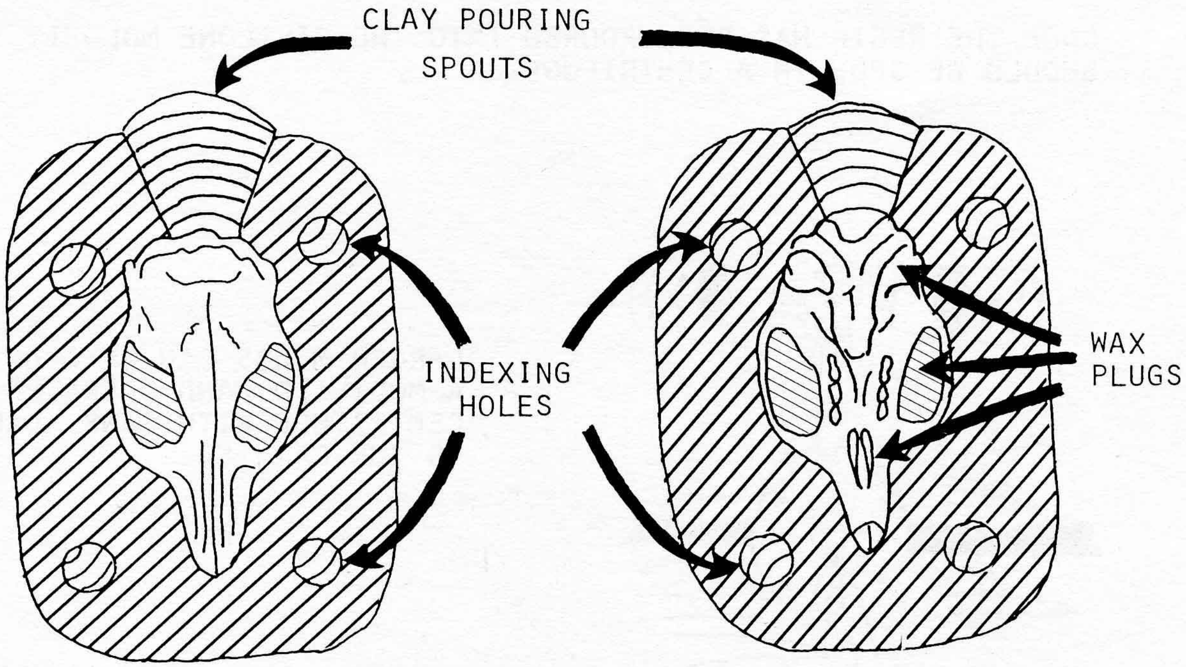
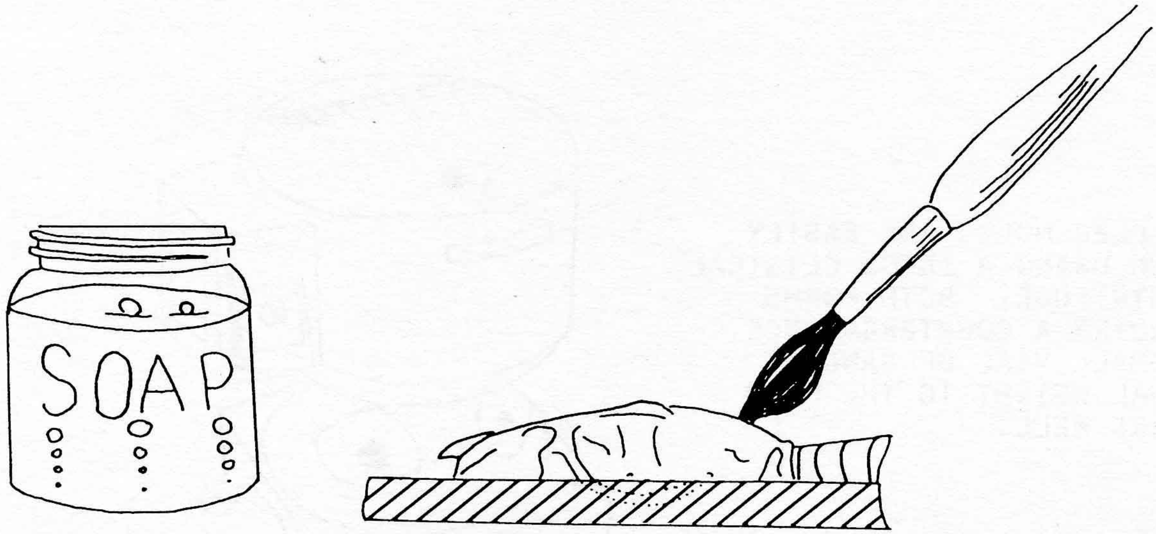


**FIGURE 7-10.**

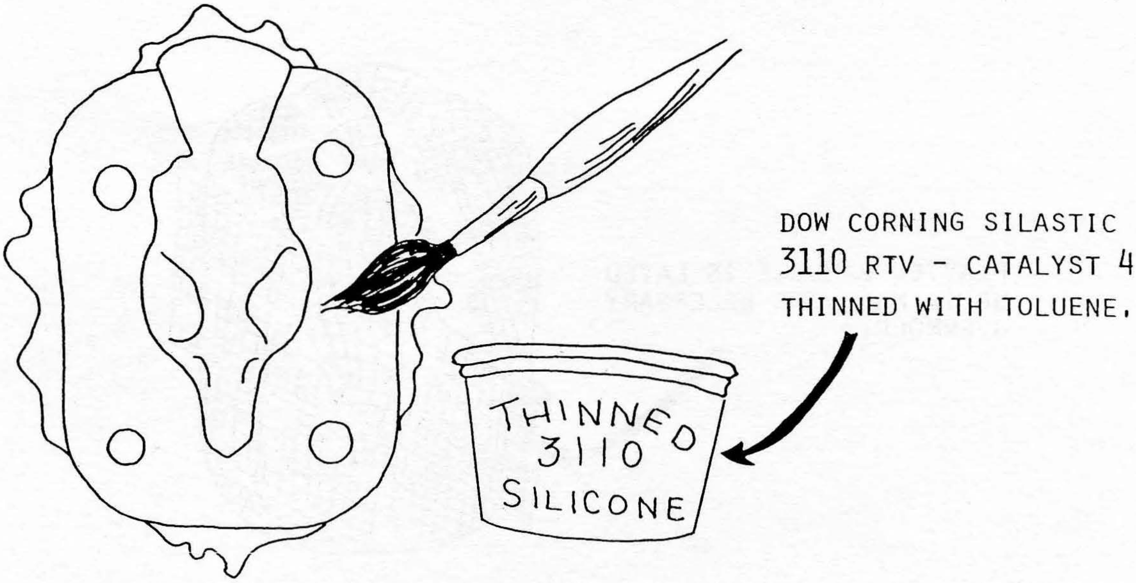



SMALL SPECIMENS ARE PREPARED AND SETUP ON A MODELING CLAY BASE.

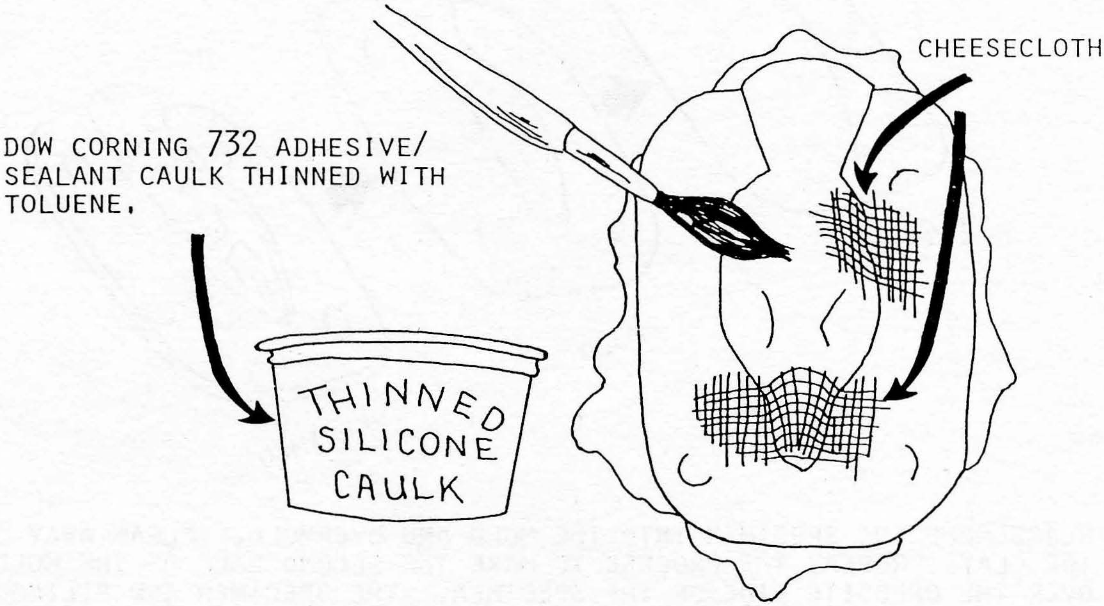



A MOLD RELEASE AGENT (LIQUID DETERGENT) IS UNIFORMLY BRUSHED OVER THE SPECIMEN AND CLAY BASE. ALLOW TO AIR DRY.

**FIGURE 7-11.**

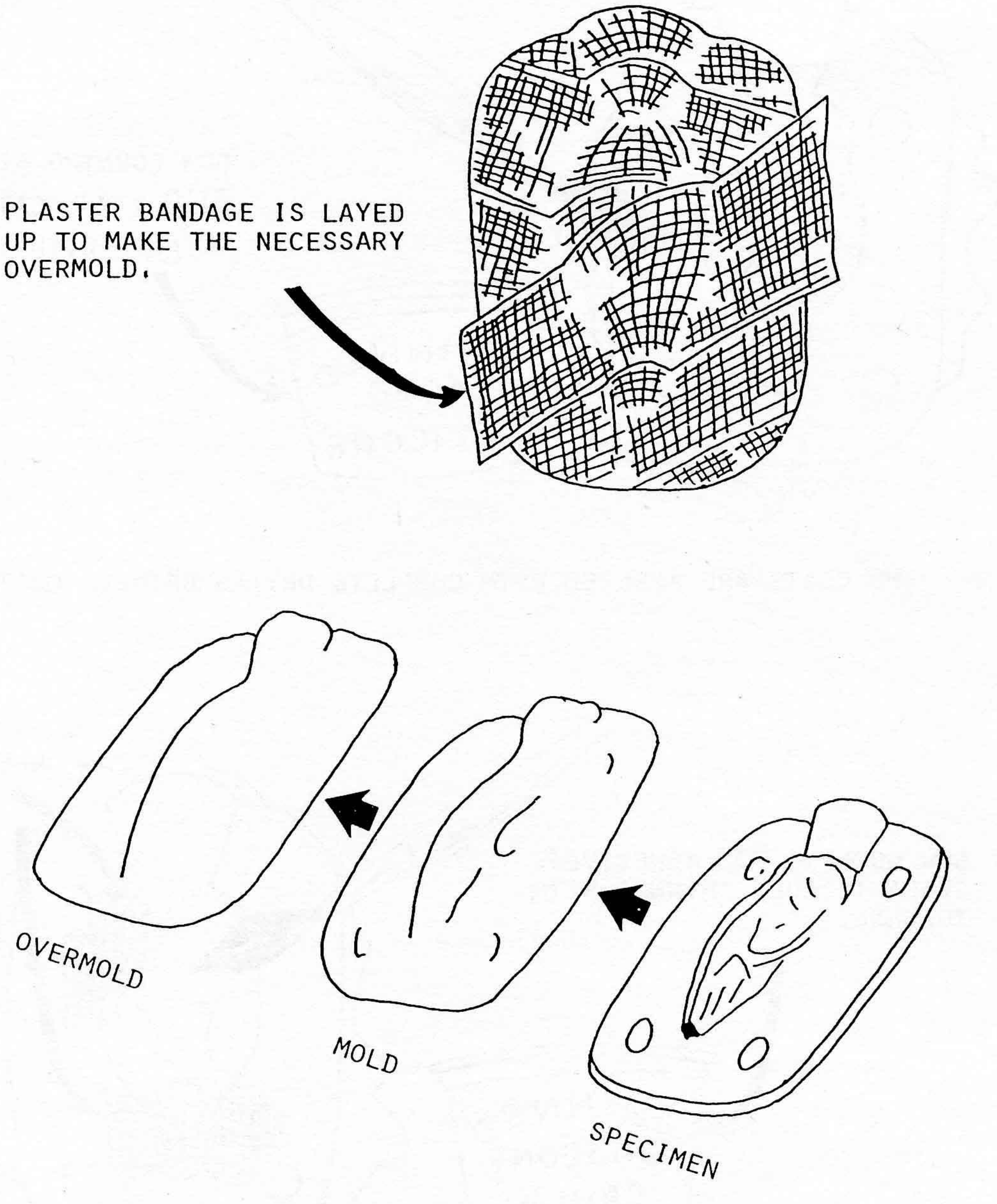



TWO COATS ARE APPLIED WITH COMPLETE DRYING BETWEEN COATS.




TWO COATS ARE APPLIED WITH A SINGLE-PLY OF CHEESECLOTH PLACED OVER THE FIRST COAT WHILE STILL TACKY. THE SECOND COAT IS FLOWED OVER AND INTO THE CHEESECLOTH.

**FIGURE 7-12.**




REASSEMBLE THE SPECIMEN INTO THE MOLD AND OVERMOLD. CLEAN AWAY THE CLAY. REPEAT THE PROCESS TO MAKE THE SECOND HALF OF THE MOLD OVER THE OPPOSITE SIDE OF THE SPECIMEN. THE SPECIMEN AND SILICONE MUST BE COATED WITH LIQUID DETERGENT MOLD RELEASE AGENT BEFORE APPLYING NEW SILICONE COMPOUND.

**FIGURE 7-13.**

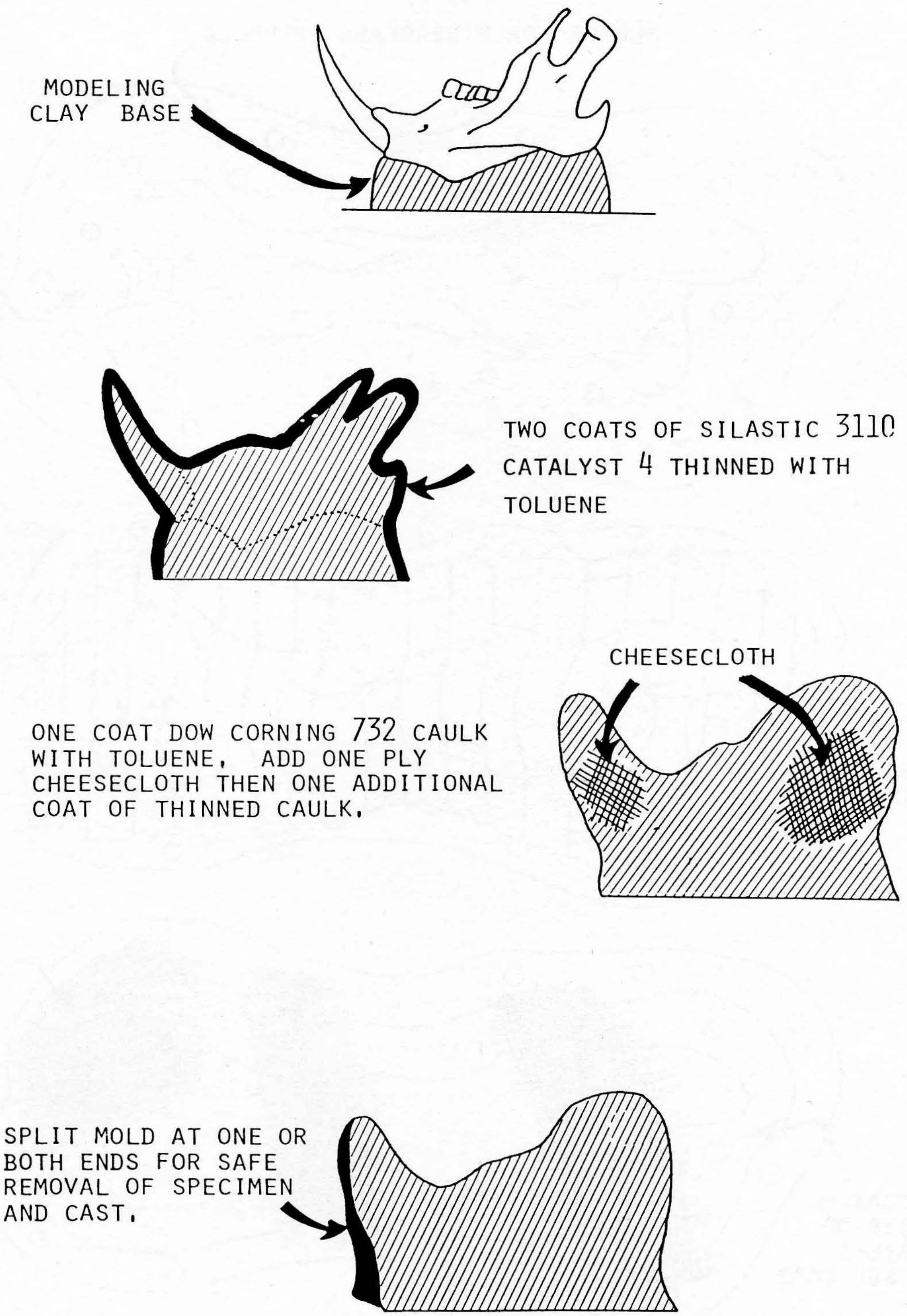

MODELING CLAY BASE
TWO COATS OF SILASTIC 3110 CATALYST 4 THINNED WITH TOLUENE
CHEESECLOTH
ONE COAT DOW CORNING 732 CAULK WITH TOLUENE, ADD ONE PLY CHEESECLOTH THEN ONE ADDITIONAL COAT OF THINNED CAULK.
SPLIT MOLD AT ONE OR BOTH ENDS FOR SAFE REMOVAL OF SPECIMEN AND CAST.

**FIGURE 7-14.**

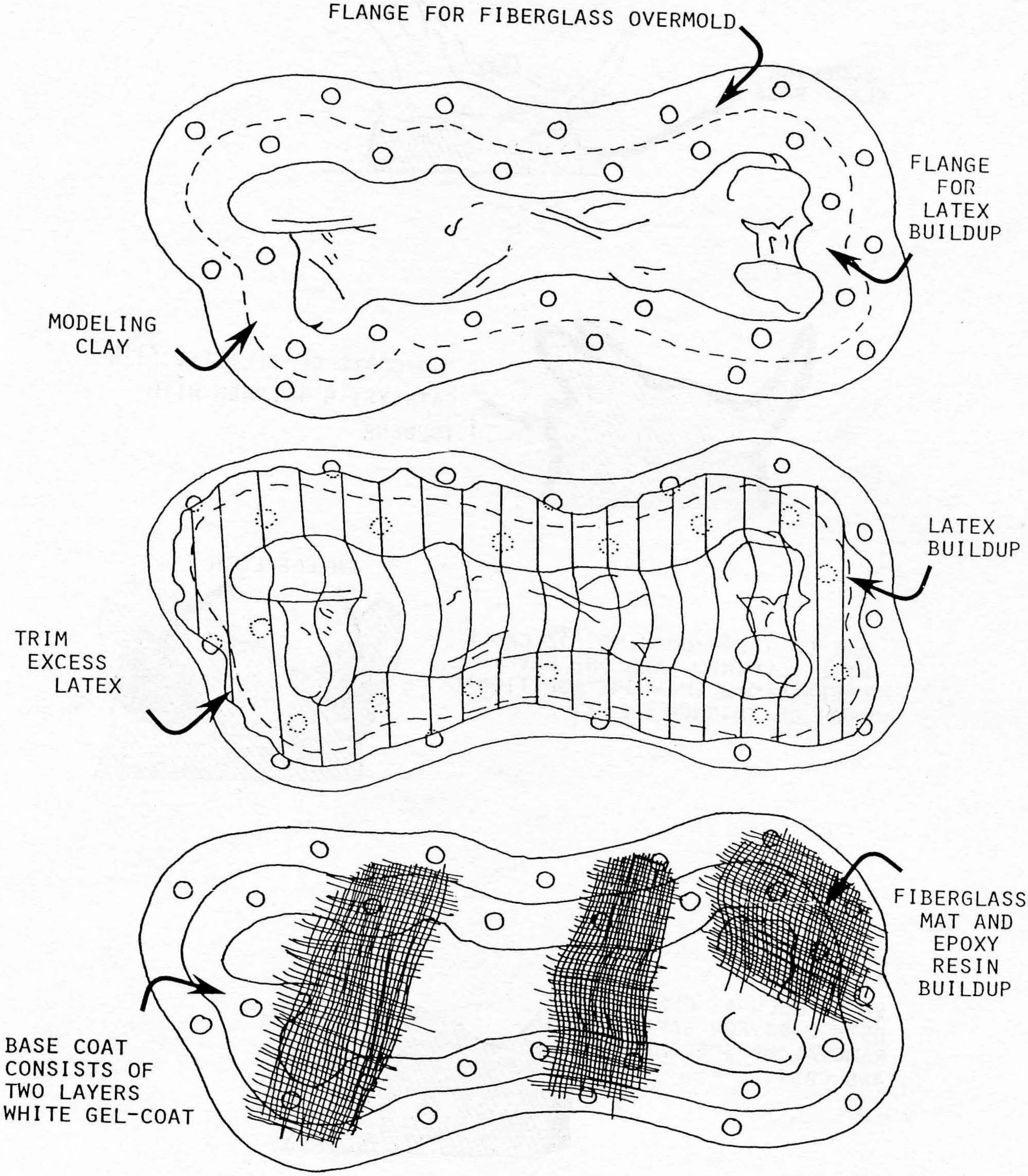
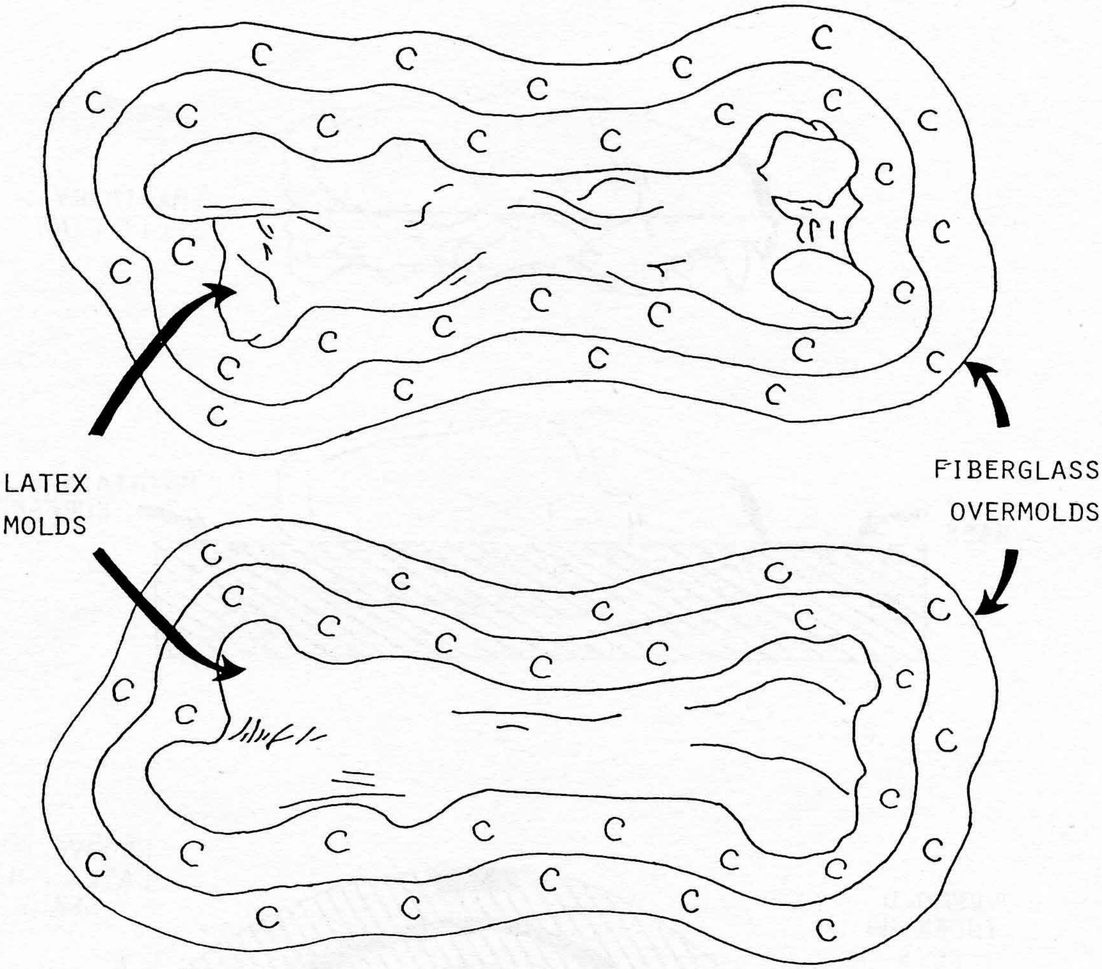
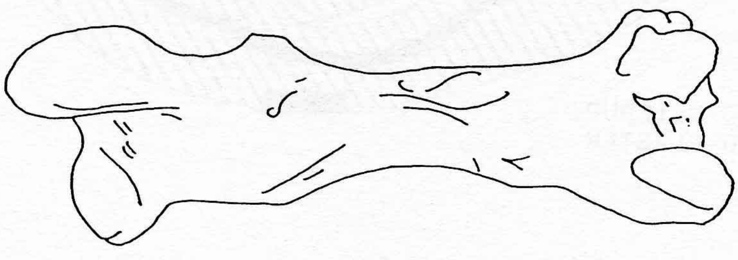

FLANGE FOR FIBERGLASS OVERMOLD
FLANGE FOR LATEX BUILDUP
MODELING CLAY
LATEX BUILDUP
TRIM EXCESS LATEX
FIBERGLASS MAT AND EPOXY RESIN BUILDUP
BASE COAT CONSISTS OF TWO LAYERS WHITE GEL-COAT

**FIGURE 7-15.**




APPLY GEL-COAT AND LAY UP FIBERGLASS MAT WITH EPOXY RESIN TO BOTH HALVES. BOND BOTH HALVES TOGETHER WITH THICKENED GEL-COAT AND CLAMP UNTIL CURED. TRIM OFF EXCESS.



FINISHED CAST

**FIGURE 7-16.**

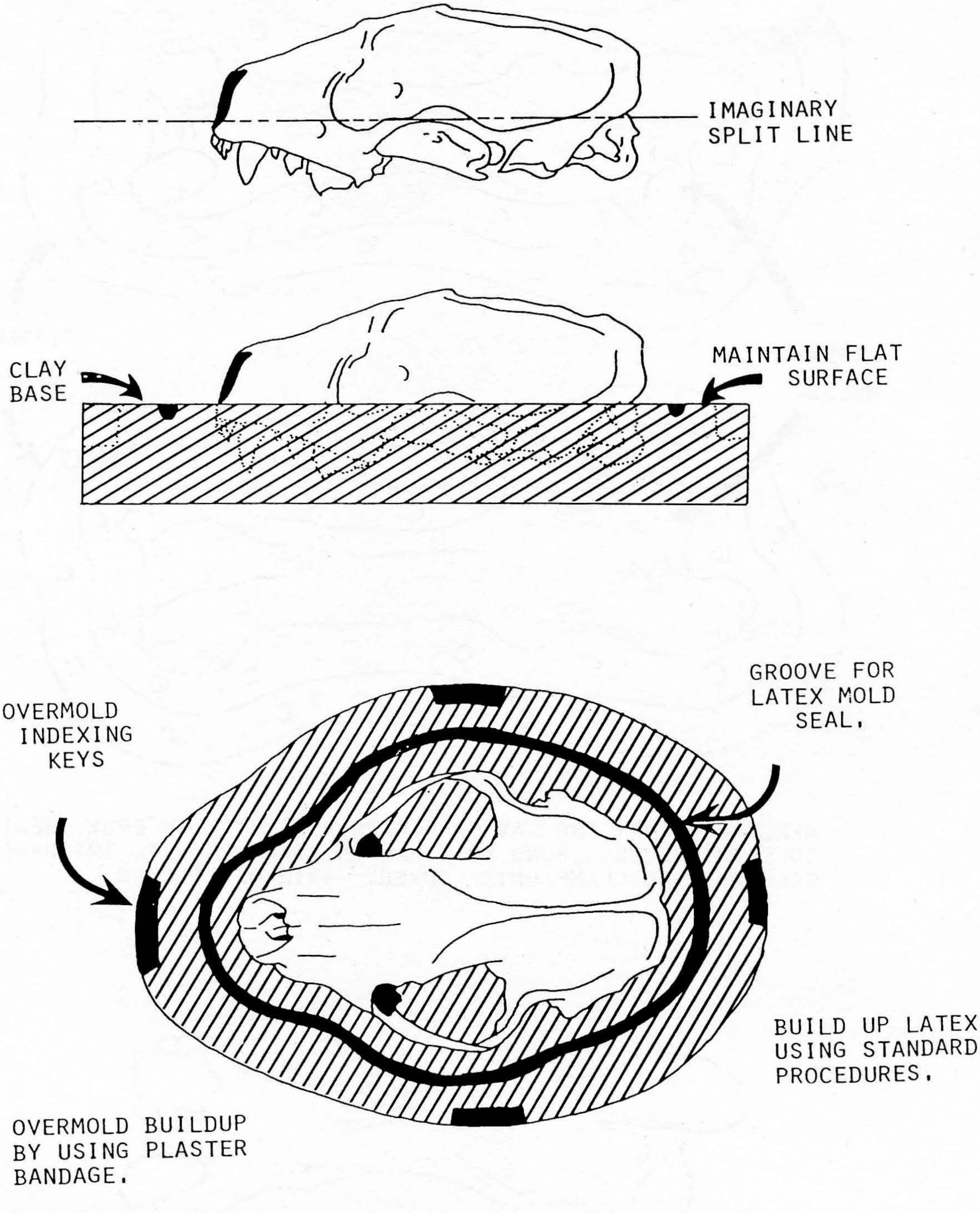

IMAGINARY
SPLIT LINE
CLAY
BASE
MAINTAIN FLAT
SURFACE
OVERMOLD
INDEXING
KEYS
GROOVE FOR
LATEX MOLD
SEAL.
BUILD UP LATEX
USING STANDARD
PROCEDURES.
OVERMOLD BUILDUP
BY USING PLASTER
BANDAGE.

**FIGURE 7-17.**

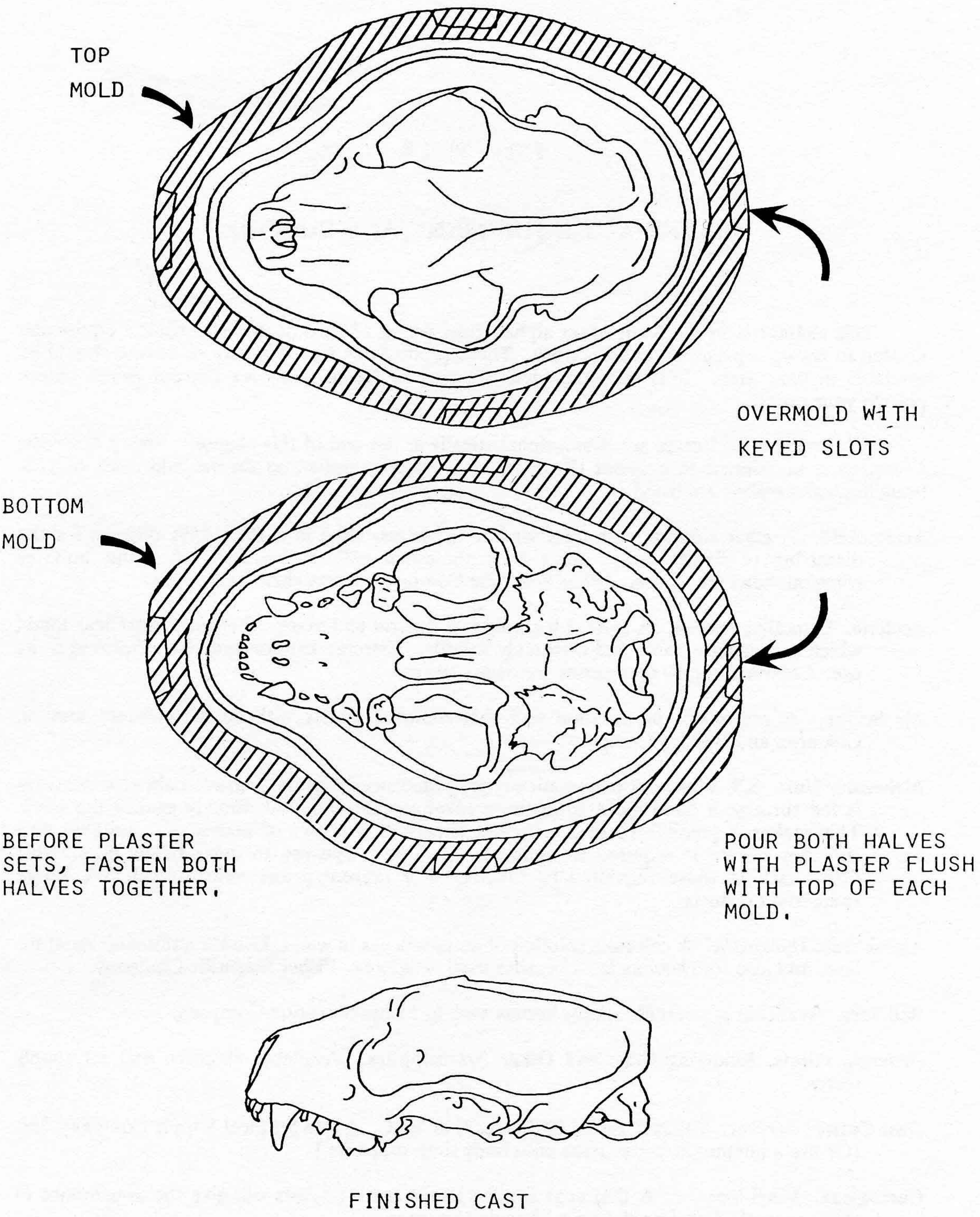

TOP
MOLD
OVERMOLD WITH
KEYED SLOTS
BOTTOM
MOLD
BEFORE PLASTER
SETS, FASTEN BOTH
HALVES TOGETHER.
POUR BOTH HALVES
WITH PLASTER FLUSH
WITH TOP OF EACH
MOLD.
FINISHED CAST

**FIGURE 7-18.**

# CHAPTER 8

# MATERIALS, EQUIPMENT, AND SUPPLIES

This chapter is in the form of an alphabetical listing of consumable and capital equipment needed to set up a preparation laboratory. These products or a satisfactory substitute should be available in your area. It is recommended you contact the supplier for current prices before placing your order.

All suppliers' addresses are listed alphabetically at the end of this chapter. Fisher Scientific Company is mentioned throughout this work as a major supplier, so several addresses of U.S. branches/sales offices are listed.

**Acetic Acid.** A clear solution with odor similar to vinegar used in a 10 to 15% dilution for the dissolving of limestone or other rock cemented with carbonates. A fume hood is recommended for its use. Fisher Scientific Company, or any chemical supplier.

**Acetone.** Dimethyl Ketone. A solvent for polyvinyl butyral and many other plastics. Clear liquid which is very flammable and extremely volatile. Extreme caution must be employed in its use. Chemical supply companies, hardware stores.

**Air Scribe.** A pneumatic preparation tool that removes matrix with an air hammer motion. Cameron and Barkley Company.

**Airbrasive Unit.** S.S. White. A pneumatically propelled stream of finely graded abrasive particles is fed through a hand piece from the control cabinet and shot directly against the work. This makes it possible to drill, cut, and abrade thin layers of matrix.. A suitable dust collector system is required to maintain operator's exposure to dusts below permissible limits such as those regulated by OSHA. For current prices write or call S.S. White Industrial Products.

**Ammonium Hydroxide.** A colorless solution of ammonia gas in water. Used s a thinning agent for latex and also for cleaning latex brushes used with latex. Fisher Scientific Company.

**Bell Jars.** Available at scientific supply houses such as Fisher Scientific Company.

**Brushes, Paints, Modeling Clay, and Other Art Supplies.** Available at office and art supply stores.

**Cast Cutter.** Stryker. Takes 2" or 2 1/2" blades, 115 VAC. Arista Surgical Supply Company, Inc. (Or use a pneumatic cutter from auto body shop suppliers.)

**Castogloss.** Vinyl lacquer. A thin coat applied to the teeth of casts will give the appearance of shiny enamel. Carolina Biological Supply Company.

**Cement.** White HYDROCAL Gypsum, U.S.G. United States Gypsum and Contractors Supply, Inc..

**Centrifuge.** A. Hand operated. Light weight aluminum body with steel shaft. Fisher Scientific Company. B. For electrical centrifuges check with your local surplus or scientific supply houses..

**Cheesecloth.** 80 yards X 0.30 yards. Any large cloth supplier.

**Colors, Cement.** For coloring cement, plaster, or stucco. Excellent for tinting casts. Blue Ridge Talc Company, Inc. or cement and rock suppliers.

**Grease.** Dow Corning High Vacuum. Fisher Scientific Company.

**Magnifier.** Edroy Distortion-free Stereoptic, with 3-wire fluorescent lamp. Brings your work into sharp focus. Assures continuous, fatigue-free sorting of microfossils. Although designed primarily for miniature and sub-miniature work, the magnifier's 15" height provides space for larger work, tools and hands. The 48 square inch lens (6 X 8") has a magnification of 2.5X. Jensen Tools, Inc.

**Modeling Clay.** Permaplast. A much better quality clay than most plasticine clays due to less oil being present. Takes a little more work to soften, but is much stronger. Most art suppliers have it.

**Mold Release.** Dishwashing detergents, the blue or green liquids are best. Spray waxes, Pam spray.

**Motor Tool.** Flexible Shaft. Foredom Miniature Power Tool. Flexible 37.. shaft and compact handpiece allowing access to difficult places. Speed is adjustable by standard foot rheostat. Bench Type GG. Bits available at Jensen Tools, Inc., and at hardware stores.

**Oven.** Drying. Isotemp series 100 Utility Lab Oven, gravity convection models. Light weight, heats to 200°C. (392°F.), low wattage elements, outside dim. 17 1/8 X 16 1/8 X 21 1/2. (SEE FIGURE AT TOP OF NEXT PAGE.) Fisher Scientific Company.

**Paints.** An acrylic waterbase paint is used to approximate the natural coloration of the specimen. Basic earth tones used are: H172 Raw Umber, H171 Raw Sienna, HO23 Burnt Sienna, H167 Portrayt (Red Oxide), H212 Titanium White, H134 Mars Black, H244 Yellow Ochre, Light. Available at art supply stores.

**Pigments.** Epoxy. Various colors, popular gel-match coloring agent that blends with polyester resins, Gel-Pasts, or Epoxy resins. Will also color silicone molding compounds or silicone caulk. Evergreen Coloring Agents. AIN Plastic, Inc., or auto body shop and boat repair suppliers.

**Polyethylene Glycol.** P.E.G. 'Carbowax', a solid wax material soluble in water. Used in the field to consolidate fragile specimen for safe removal to the lab. Also used in mechanical development techniques and casting prep procedures. Fisher Scientific Company.

**Polyvinyl Alcohol.** PVA, a white powder soluble in water. Used as an adhesive over wet specimens or a separator in various casting techniques. Fisher Scientific Co.

**Polyvinyl Butyral.** Butvar B-76, a white powder which is soluble in alcohol or acetone. The acetone being the most useful due to its high evaporation rate. Considered the best consolidation material. Monsanto Chemical

**Resins.**

A. Epoxy---A man-made plastic resin used in fiberglass work or pouring casts. The resin is activated by various catalysts and will not shrink. Once the resin has cured, it becomes very difficult to break down chemically. Vapors are toxic and flammable. Tapox 4-1 Epoxy Resin. Tap Plastic, Inc., Magnolia Plastics, auto body shop suppliers, boat repair shops.

B. Polyester---Used for embedding and casting where clear casts are required. Can be used as a partial specimen embedding material where acid development is employed. Inflammable and will break down in chloroform or methylene chloride. AIN Plastic, Inc., hobby shops

**Rubber Cement and Thinner**. Available at office and art supply stores.

**Rubber Latex**. A natural rubber material that has been used for many years in mold making. Available at art supply stores.

**Saw, Diamond**. ISOMET. A low speed saw coupled with a thin, continuous rim diamond impregnated blade to accomplish true cutting of nearly all solid material. Check for current price from Buehler, Ltd.

**Silicone Silastomers.**

A. The very best molding materials, but quite costly. Consists of a highly viscous white, opaque material that is activated for hardening with a catalyst. Dow Corning 3110; Conservation Materials, Ltd., GE RTV 700; and plastics companies.

B. Adhesive Sealant caulk can be used to meet a variety of sealing needs. It adheres to glass, non-oily woods, metal, and can be used as a molding. Whipped with water, it will set within 10 minutes and makes superior mold filler blocks. Available at hardware and building supply stores.

Starlite Grinder. High speed rotary grinder for detail work. Starlite Industries Inc.

**Stirrers**. Available from Fisher Scientific Company.

**Toluene**. A colorless solution used as a solvent for most silicone mold making compounds. A fume hood is recommended for its use. Fisher Scientific Company.

**Tongue Depressor**. Fisher Scientific Company.

**Vacuum Plate**. For BELL jars. Heavy ground-glass plate (10" dia.) cemented on low cast-iron base for bell jar or other vessels to be evacuated. Fisher Scientific Company.

**Vacuum Pump**. Portable Combination Pressure/Vacuum. Delivers pressure to 103K Pag (15 psig) or vacuum to 92K Pag (27" Hg.). Fisher Scientific Company.

**Wax Pot, Electric**. A thermostatically controlled pot that keeps the temperature and consistency of the wax steady. 1 qt. capacity. Conservations Materials, Ltd.

**Miscellaneous items**, such as dental picks, can usually be obtained through a local surplus supply depot or as discards from local dentists. Equipment for field work (picks, trowels, etc.) can be purchased through companies like Forestry Suppliers, Inc., or Ben Meadows Company; both have attractive, easy-to-use catalogues.

# LIST OF SOME SUGGESTED SUPPLIERS

AIN Plastic, Inc.
249 E. Sanford Blvd.
P. O. Box 151
Mt. Vernon NY 10550

Cameron and Barkley
P. O. Box 659
Jacksonville FL 32201

Fisher Scientific Company:
SEE BELOW FOR LIST OF ADDRESSES

Forestry Suppliers, Inc.
P. O. Box 8397
Jackson MS 39204

Imperial Adhesives & Chemicals, Inc.
6315 Wiehe Road
Cincinnati OH 45237

Monsanto Chemical
ATTN: John Bouer
800 North Lindburg
St. Louis MO 63167

Sprits
Suite 200
555 Broad Hollow Road
Melville NY 11746

Apperson Chemicals, Inc.
2903 Strickland Street
P. O. Box 2555
Jacksonville FL 32200

Ben Meadows Company
P. O. Box 80549
Atlanta GA 30366

Buehler, Ltd.
2120 Greenwood Street
Evanston IL 60204

Conservation Materials, Ltd.
340 Freeport Blvd.
Sparks NV 89431

GRS Corporation
P. O. Box 1157
Boulder CO 80302

Jensen Tools, Inc.
7815 S. 46th Street
Phoenix AZ 85040

S.S. White Industrial Products
151 Old New Brunswick Road
Poscataway NJ 08854

Starlite Industries, Inc.
1111 Lancaster Ave.
Rosemont PA 19010

Tap Plastic, Inc.
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