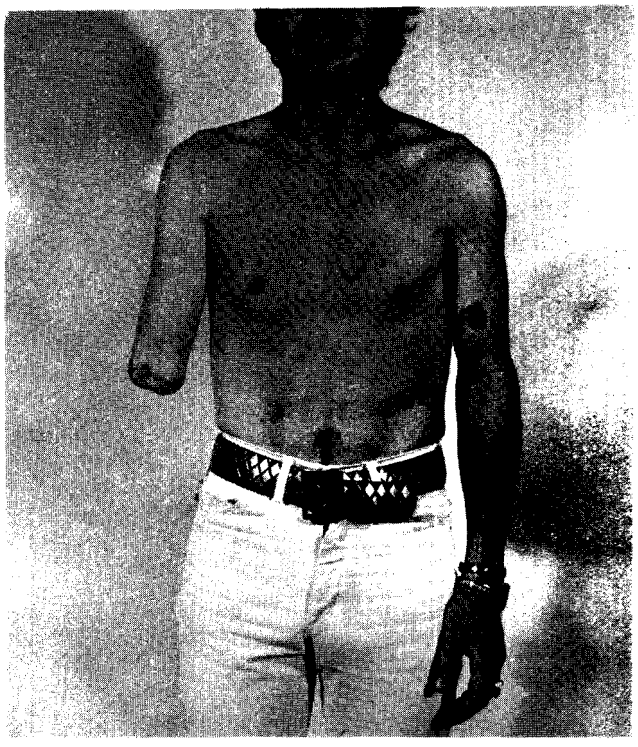
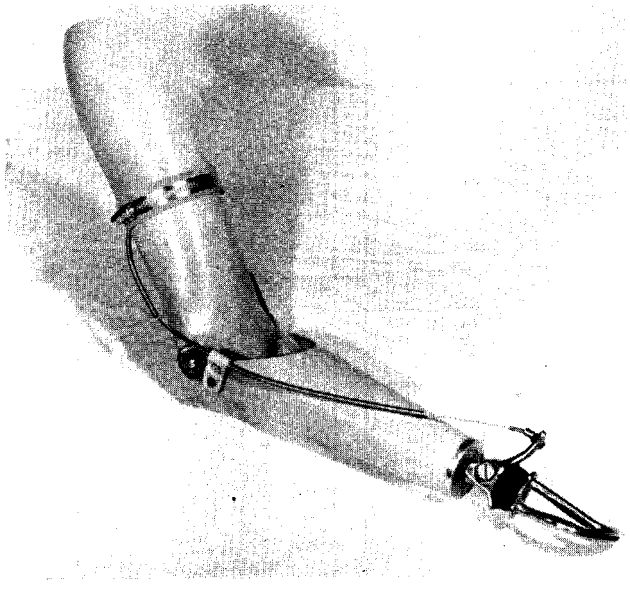
OUTSIDE LOCKING HINGE PROSTHESIS FOR LONG ABOVE ELBOW AMPUTATIONS

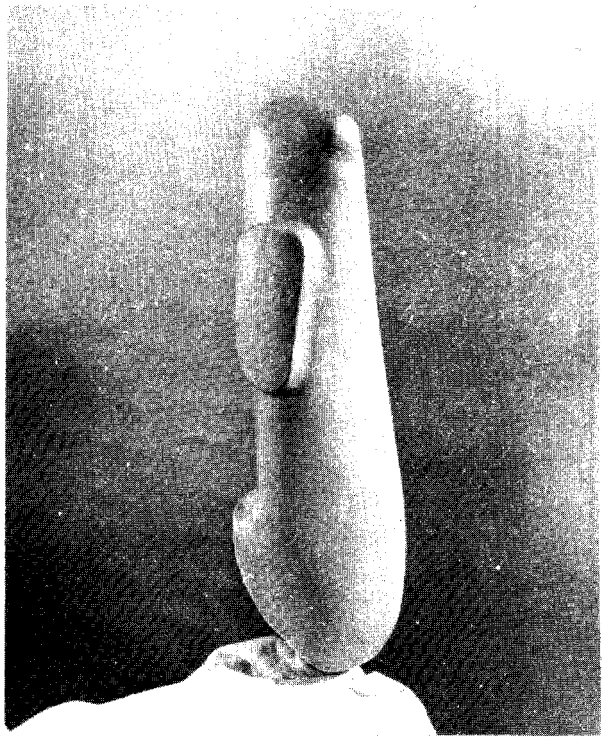
Introduction

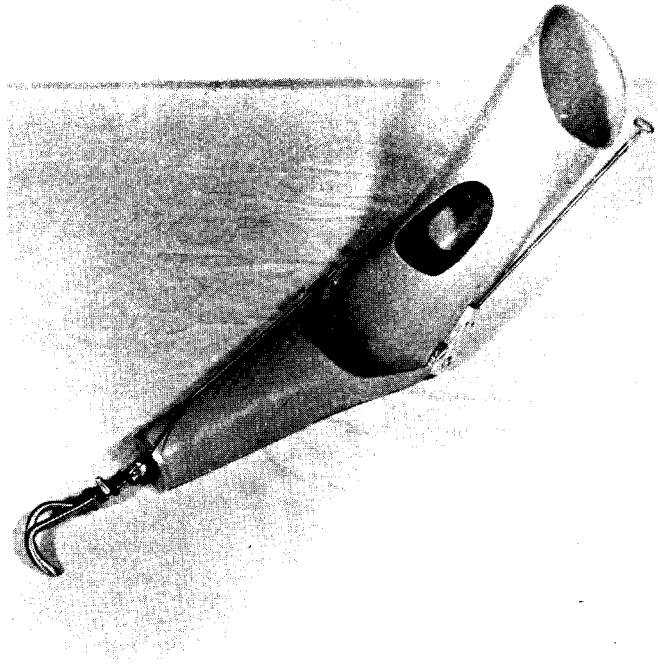
Outside locking hinges are used for amputations at the elbow or distal humerus when use of the prosthetic elbow would excessively elongate the humeral section of the prosthesis. The standard overall length of the prosthetic elbow is 2". True elbow disarticulation amputation: Note the wide mediolateral dimension of the distal end compared to the anteroposterior dimension, giving it a "screw-driver" shape.





In the illustrations below, the stump model and finished prosthesis for the window procedure, is shown. The variations in procedure are indicated in text.

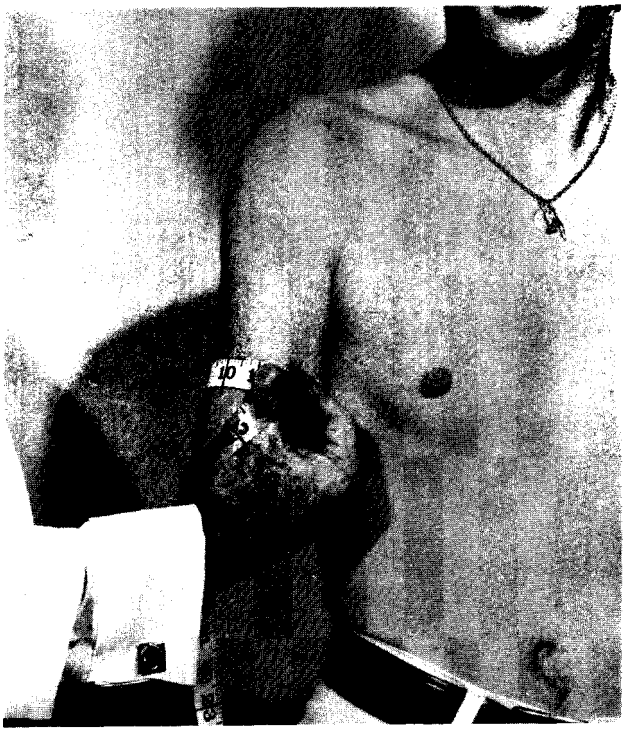




1. Take all information and make measurements on the sound side as shown on side A of the prosthetic information form.

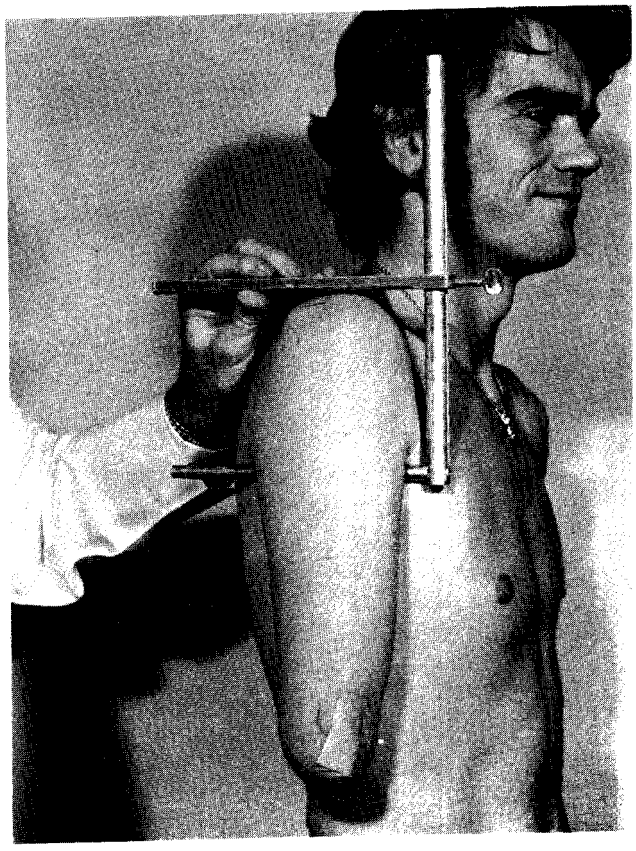
2. To fill in all the information on side C, first measure the circumference of the stump at the axilla.

3. Repeat this at the mid-line.



4. Measure the distal circumference at largest point of the condyles.

5. Measure the length from the acromion to the distal end with a straight edge ruler.

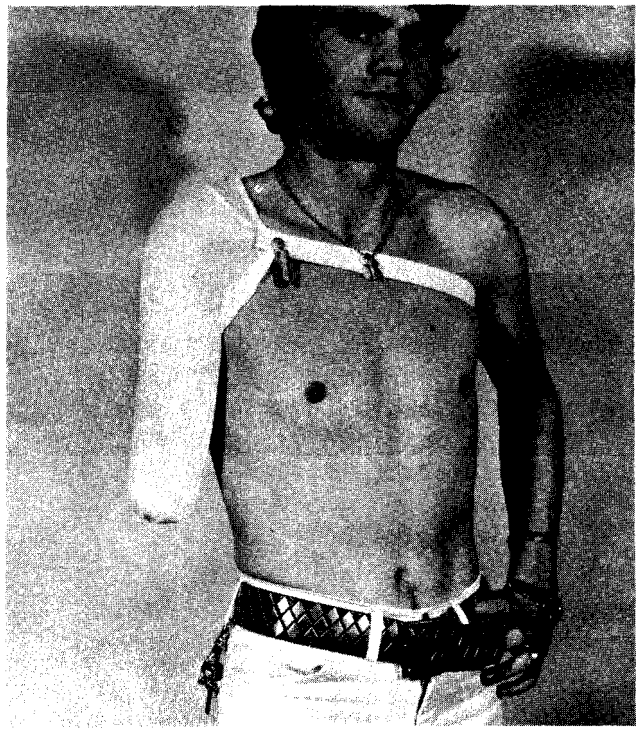


6. Measure the distance from the axilla to the top of the acromion. Take any additional measurements that may be helpful to modify the cast. Record all of the above measurements on side C on the prosthetic information form.

Wrap Cast

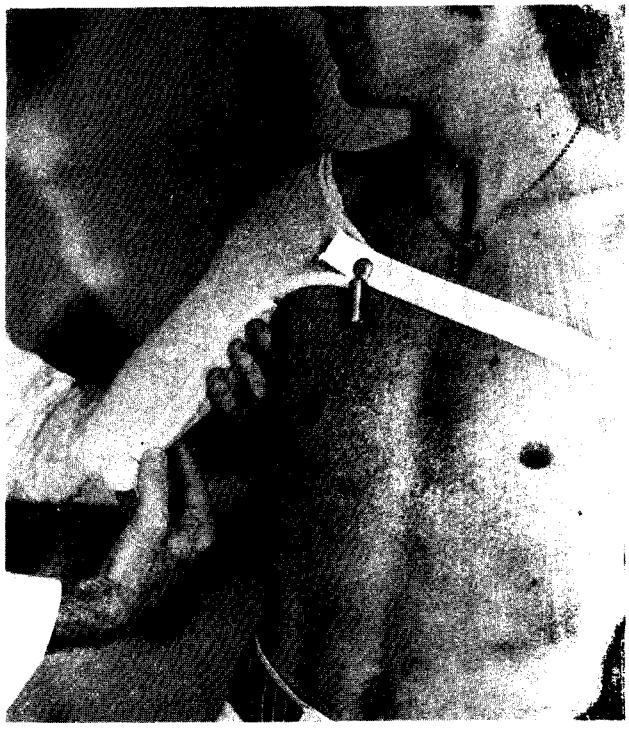
1. Apply stockinette sewn at the end or tube gauze. In this illustration sockinette is used.

2. Hold the casting sock in place with webbing. In this illustration tube gauze and elastic webbing are being used.



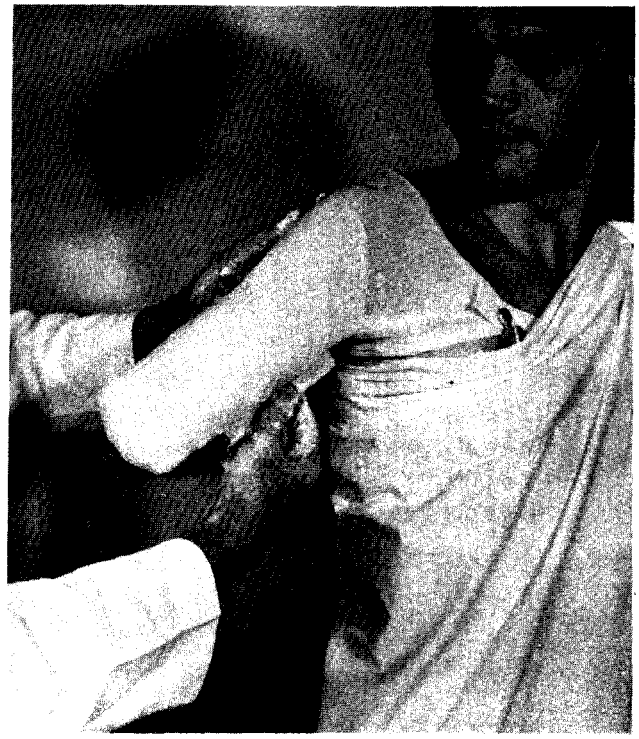
3. Placement of pads over the epicondyles will form reliefs for the boney protruberences in the wrap cast. When the stump is more narrow proximal than the distal condyl es, place a piece of webbing material or metal strip to facilitate cutting the wrap cast for removal.

4. When the ML dimension of the condyle area is only up to 1/4" larger than the proximal tissues, incorporate in the wrap a strip of felt one inch wide on the medial aspect just above the condyle so that the wrap cast can be removed without cutting.



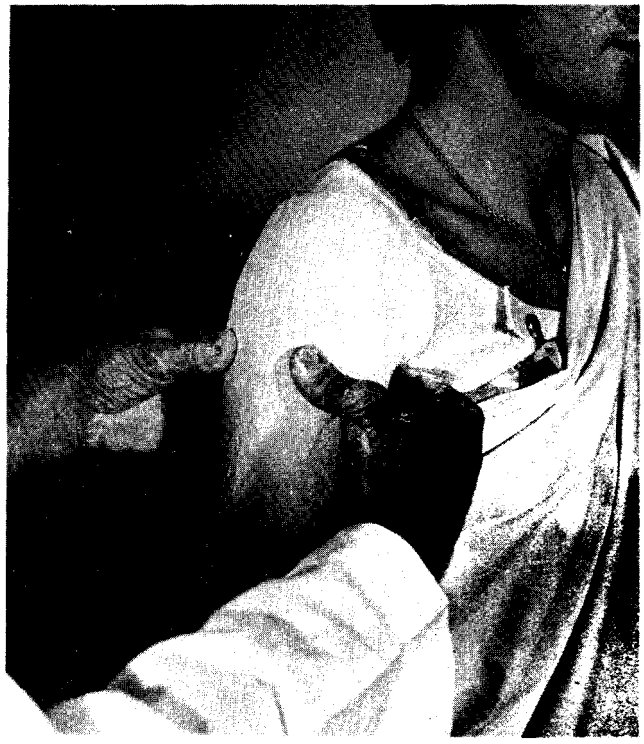
5. Begin the wrap at the distal end using a figure of eight pattern. Apply the plaster wrap without tension. Elastic or non-elastic plaster can be used. It is important that the neutral rotation position of the condyles be maintained throughout the wrapping and forming procedure.

6. Continue spiraling the wrap to a thickness of at least three layers. Do not pull the plaster tight on the proximal area.



7. Lay extra material across the axilla as shown in the illustration. The wrap should include the acromion. Smooth all wrinkles and mold to contour.

8. With the index fingers placed in the axilla, position the arm to the side compressing the area of the deltoids and shoulder to eliminate gapping.



9. Form the screwdriver shape for rotation. Gently compress the anterior and posterior of the wrap over the condyles making sure the humerus is in the neutral position for rotation.

10. Remove the cast.

When the condyles of the humerus are larger than the area proximal to them:

a. Mark index lines on the lateral aspect of the wrap cast. cut the cast over the protective material. Make the cut so that when the cast is spread open, the condyles will pass through.

b. Do not cut the cast when the condyles are only slightly larger than the proximal area. When felt channel strips are used, remove the medial strip first before removing the cast.

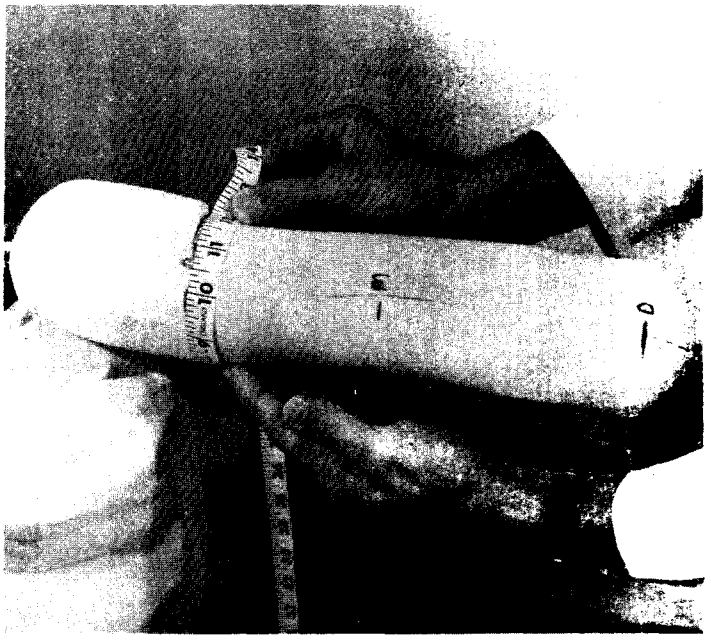
Inspect the inside of the cast to see that:

there are no wrinkles, bulges or indentations,
the cast is high enough to include the acromion, and
length from the acromion to the end of the stump agrees with the stump measurement.

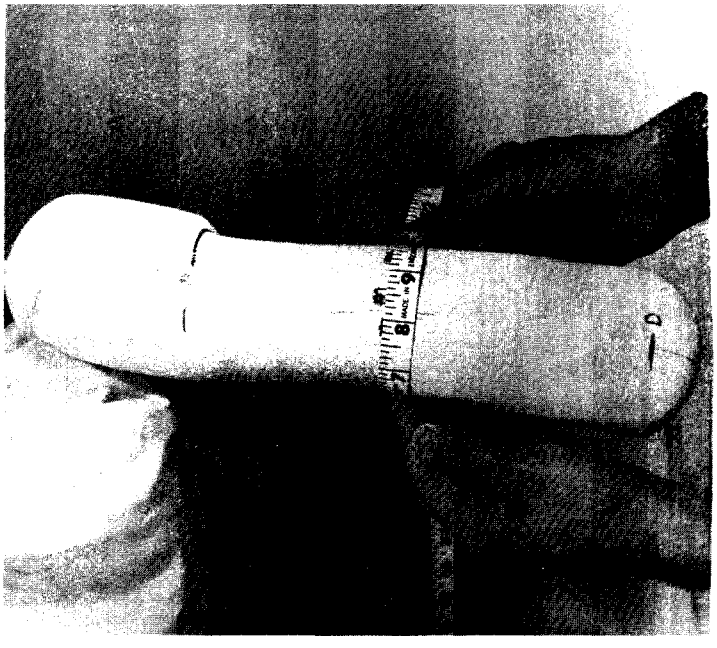
Close the slot and seal it with plaster Put a parting agent on the inside for future removal of the cast from the model. If the amputee plans to wear a stump sock, remove the stockinette from the cast. Pour a smooth mixture of plaster and water into the wrap cast to form the model. Avoid air bubbles by pouring alongside the cast and jiggling to allow air bubbles to escape. Before the plaster hardens, insert the mandrel for later use in handling the model. The mandrel should not touch the sides.

The Check Socket Model

List of Materials:
plaster
knife
sureform files
tape measure
straight edge ruler
sandpaper or screen
outside calipers
(with blunt tips)
parting agent for
model

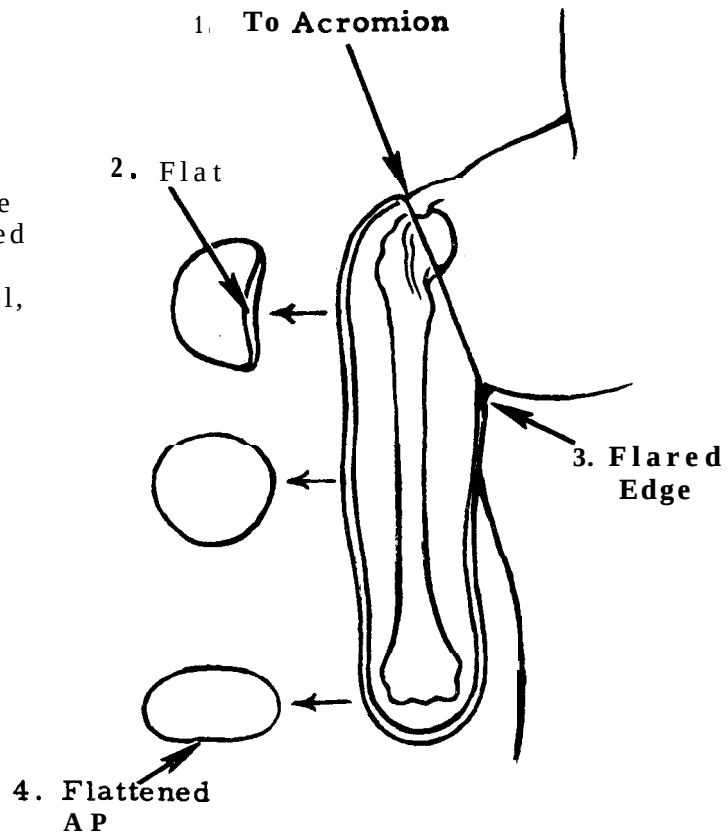


1. The model must now be modified to provide a functional and comfortable socket fit. Begin by bringing the circumferences of the model to match the circumferences of the stump, maintaining the contours of the model.

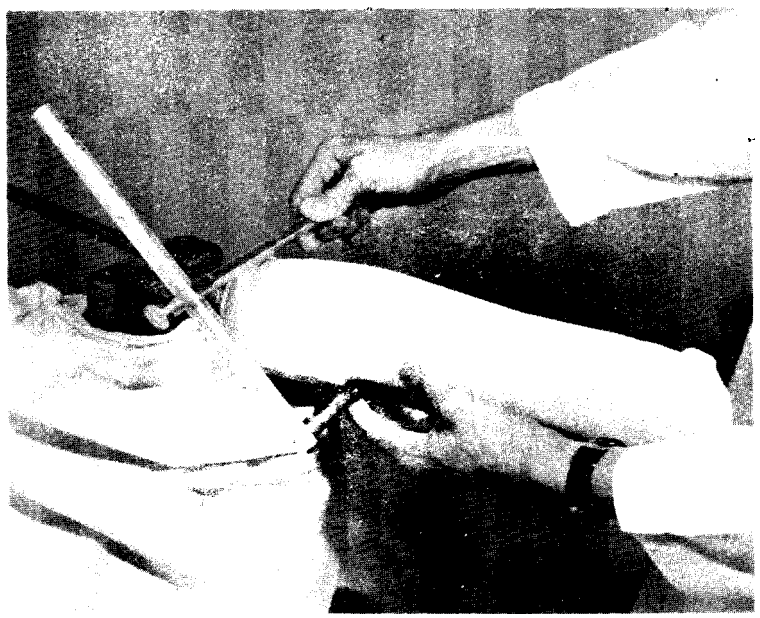


2. Make a plan for the condyles to pass into the socket before removing plaster from the medial or lateral aspect. Plaster is never removed from the ML when a channel is to be used as shown in the illustration.

3. Modify the axilla area to provide a flat axillary wall with a rolled edge. As shown in the cross-sectional drawing at axilla level, round the corners of the "D" for the pectoralis and latissimus dorsi muscles. General shapes are also illustrated for the critical areas of the socket.

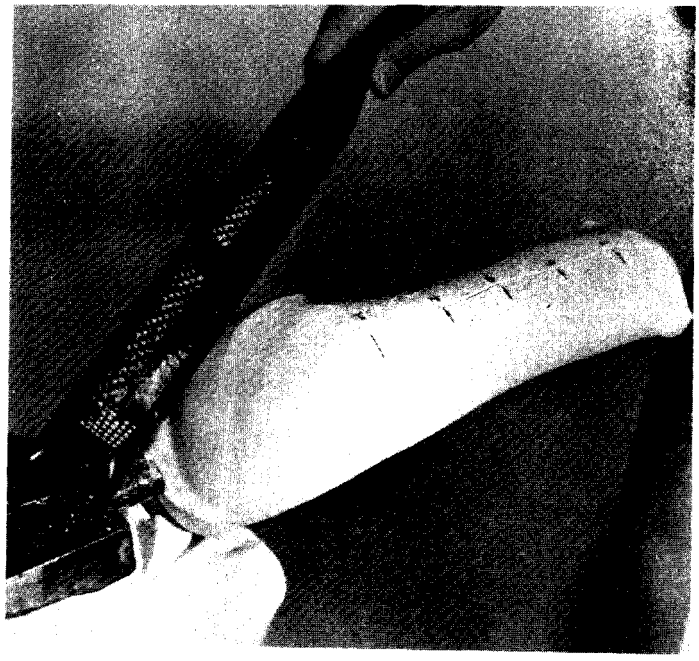


4. Check the acromion to axilla measurement from the prosthetic information form before making the plaster removal.

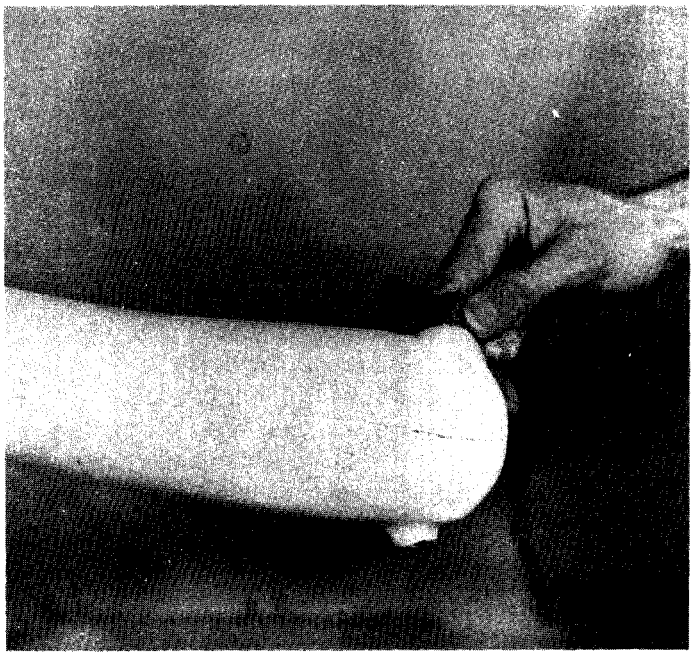


5. This illustration shows the shapes and flares of the proximal area.

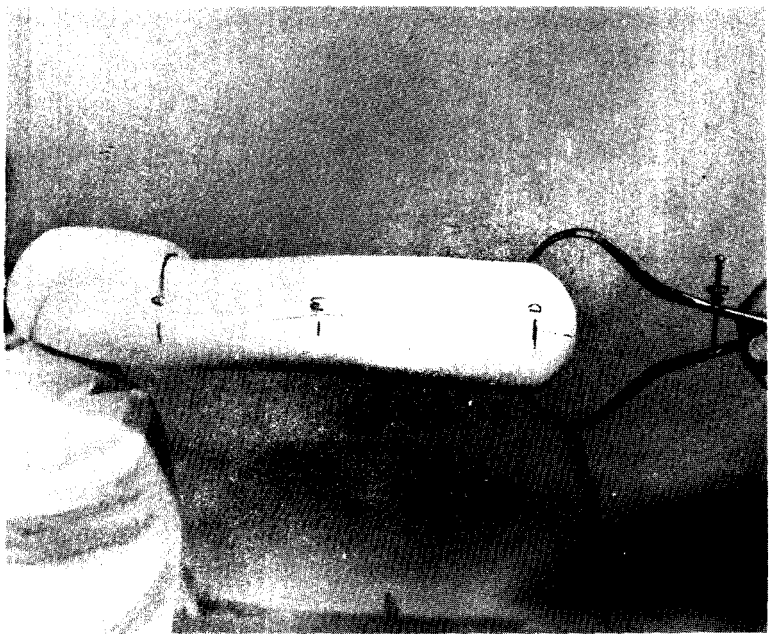
6. Because of bulging in the cast, excess plaster is usually on the model in the delto-pectoral groove. Remove a small amount of the plaster in this area to form a close fit into the soft tissue in the delto-pectoral groove.



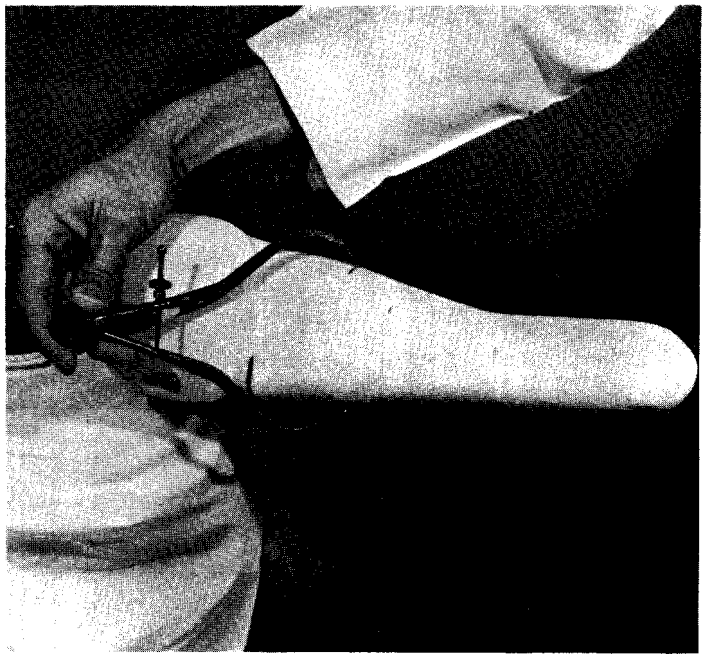
7. Check the width of the epicondyles on the stump model and compare it with the stump measurements. Build up with plaster to allow approximately 3/16" over the stump measurements if needed. When relief pads are used when making the wrap, blend the plaster into the model as illustrated.



8. To determine how far proximal to make the window in the socket, set the calipers at width of the epicondyles stump measurement.



9. Move the calipers proximal until that width is reached in the A-P direct ion. To relocate this level on the wax check socket, measure with a straight edge its distance from the distal end. Note this on the information form.



The window will be located in the anterior wall of the socket because the hinges will be on the lateral and medial walls and the control system attachments will be on the posterior wall. Put a parting agent on the model for ease in removing the wax check socket later.

The Wax Check Socket (Patient should remain until after breakout mold is made.)

List of Materials:
- cotton stockinette (about 3 inches wide)
- string
- scissors
- molten wax
- knife
- straight edge ruler
- wood burning tool
- talcum powder
- heat gun
- plumb bob
- outside calipers (with sharp tips)
- 1/2 inch bag punch
- elbow joint spacer assembly
- parting agent for wax check socket

The purpose of the wax check socket is to get a good socket fit and alignment before laminating the final socket of plastic. Care exercised in the fitting of the wax check socket will pay good dividends in the final prosthesis.

1. Put six layers of about 3 inch wide cotton stockinette over the model by putting one layer on and doubling it back and repeating this two more times.

2. After tying off the stockinette, impregnate it thoroughly with molten wax.

3. Place the model in **cool** water to harden the wax. (Do not get any water into the container of hot wax; a violent reaction results.) Before the wax hardens completely, form the wax check socket well over the model with your hands so no bridging exists.

4 Cut the wax check socket with a knife to the approximate desired proximal trim.

Note: Window procedure is described in steps 5, 6 and 7. When the window is not needed, proceed to step 8 after removing the wax check socket from the mold.

5 When there is to be a window, mark the window on the wax check socket as follows:

mark the proximal edge of the window according to the distance found in step on page
mark the distal edge of the window just above the level of the epicondyles
draw the window in the anterior, leaving space enough on the lateral and medial sides for placement of the hinges.

6. Cut out the window as drawn and pull the wax check socket off the model. Smooth the edges (a wood burning tool will do the job) for fitting on the patient. Save the model in case another wax check socket must be made.

7. The next steps are important in fitting the wax check socket to the patient, who should now be present. Powder the inside of the socket to allow it to slide on the stump easily. Apply the socket on the stump to see if the window is big enough to allow entry and exit of the stump. Enlarge the window as necessary.

How to fit the wax check socket for the outside locking hinge prosthesis (ED)

Referring to the introduction, Above Elbow Chapter (see page) amputees who retain the humeral flares and condyles should have the highest performance ability of the above elbow levels.

In addition to the ability of active rotational control of the prosthesis by the humerus, it also affords the longest lever arm of the above elbow group. The socket should be stabilized at the shoulder joint but never in itself limit glenohumeral joint motion. The following steps outline a procedure which should provide a comfortable socket and at the same time enable the amputee to give maximum performance.

1. Apply the wax check socket and mark a trim line beginning at the outer edge of the acromion, across the head of the humerus to the delto-pectoral groove at the axilla, leaving a small flare or roll for the pectoral tendon. Make a similar trim posterior to the latissimus tendon; only a small roll is needed through the axil la.

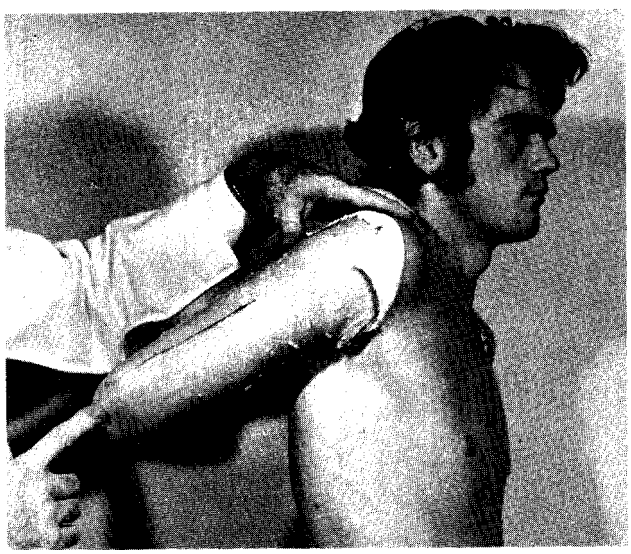
2. Trim and smooth the edges.

3. Re-apply and inspect the proximal edges of the check socket. It should fit snugly without gapping.

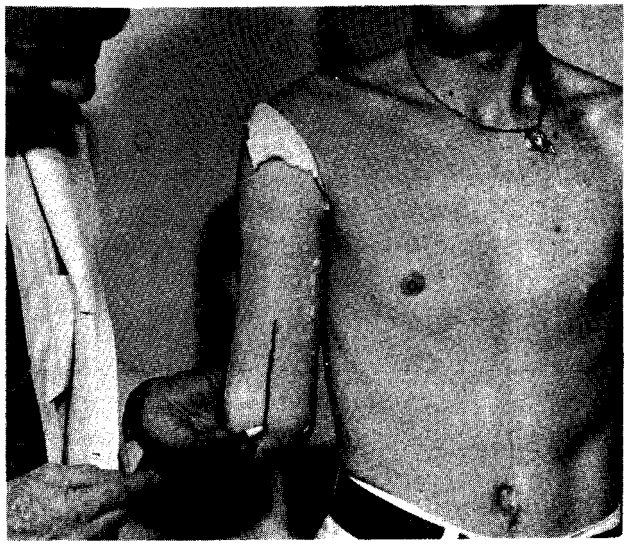
4. Direct the amputee to abduct the socket. There should be no restriction of the range of motion by the socket.

5. Direct the amputee to bring his arm into forward flexion. Observe the proximal trim. There should be no impingement of the brim to inhibit full range of motion.

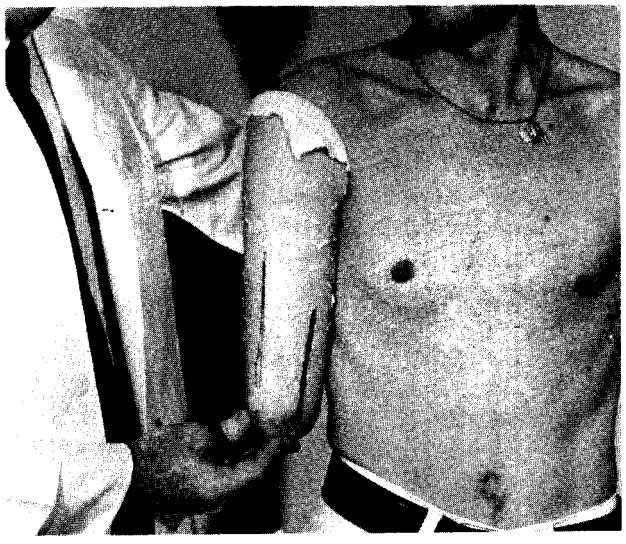
6. Normal extension range should be obtained.



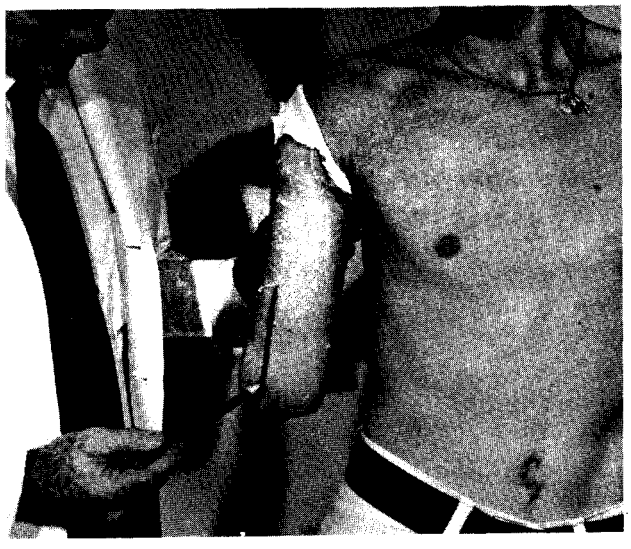
7. Mark a line on the anterior for the rotation test. The rotation of the humerus at the glenohumeral joint should be noted without the check socket before proceeding to the next step.

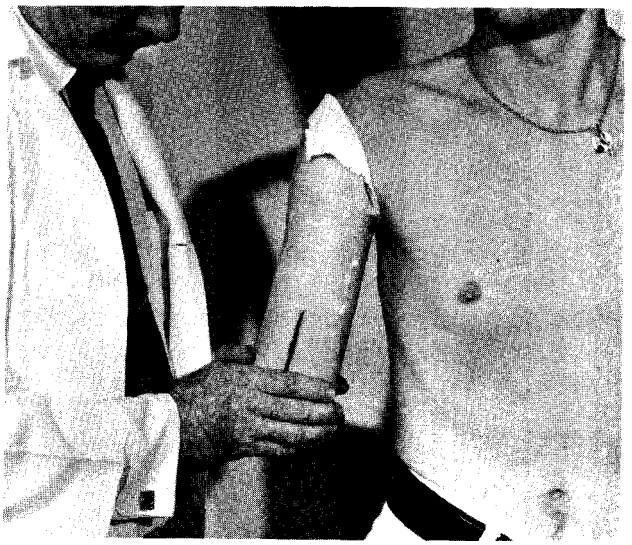


8. With the check socket applied, direct the amputee to internally rotate his arm. The amount of internal rotation should be similar to that as without the socket on.



9. Repeat the test above in external rotation.





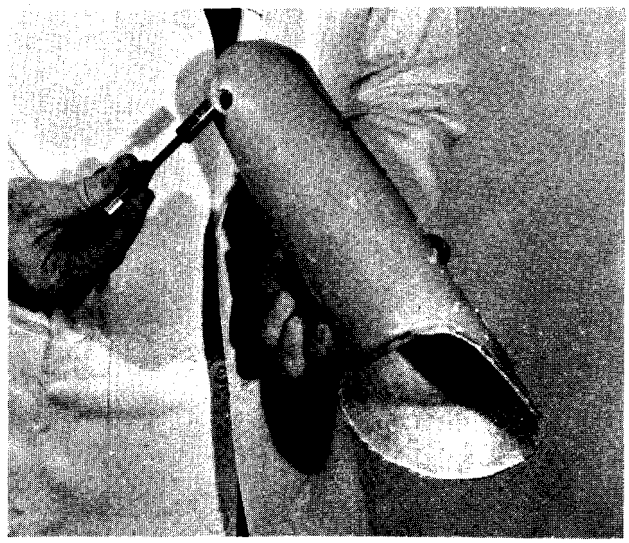
10. When the internal or external rotations of the check socket are less than that of the amputee's humeral condyles, squeeze the check socket on the anterior and posterior aspects as illustrated. This problem can also be caused by the proximal brim impinging at the delto-pectoral groove.

Location of the Joint Hinges and Axis

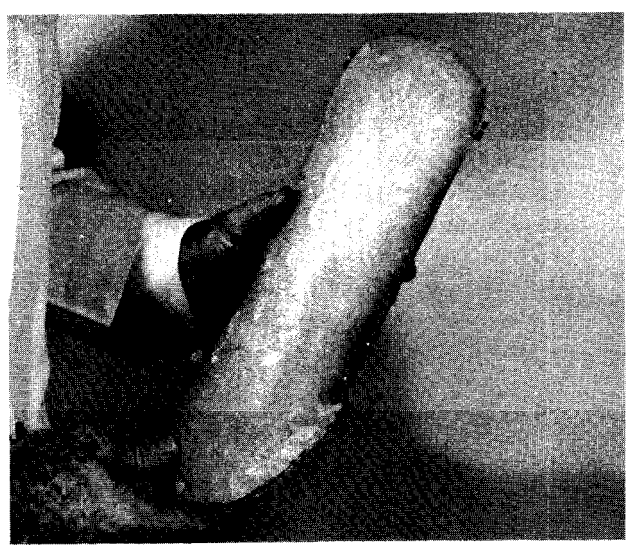
11. The hanging position of the prosthesis should be similar to the sound arm and hand. An equal symmetry in the overall appearance. The forearm of the prosthesis should duplicate the position and angle of the normal forearm so that the terminal device will be in a natural position for each individual. Location and placement of the joint hinge axis on the check socket will determine this. The reference is made from the humerus on the amputated side with the amputee standing erect. Facing him directly, observe the normal hanging angle of the upper arm, forearm and hand of the sound side. Compare this with the amputated side. Place the calipers on the check socket so that they will duplicate the hanging angle of the sound side forearm. The finished prosthesis should hang in a similar manner. Locate the joint axis, position the sound arm as shown in the illustration, elbow flexed 90°, wirst and fingers fully extended, thumb position upward, position the forearm toward the center line of the body. Place the outside caliper points on the

check socket, perpendicular to the humerus and over the epicondyles. The end of the caliper pointing toward the fingers of the sound hand-positioned at the center line of the body. Move the calipers downward as though the forearm were at the side of the body and observe the position. It should be similar to the sound arm in the hanging position. When the desired position has been obtained, make a mark at the caliper points for the location of the elbow joint axis. This should equal the distance of the acromion to epicondyle measurement on the sound arm.

12. Prepare the joint spacer by selecting a spacer which will span across the check socket. Partially cut through the shaft so that it can be pulled from the plastic socket. Install the spacer in the check socket.

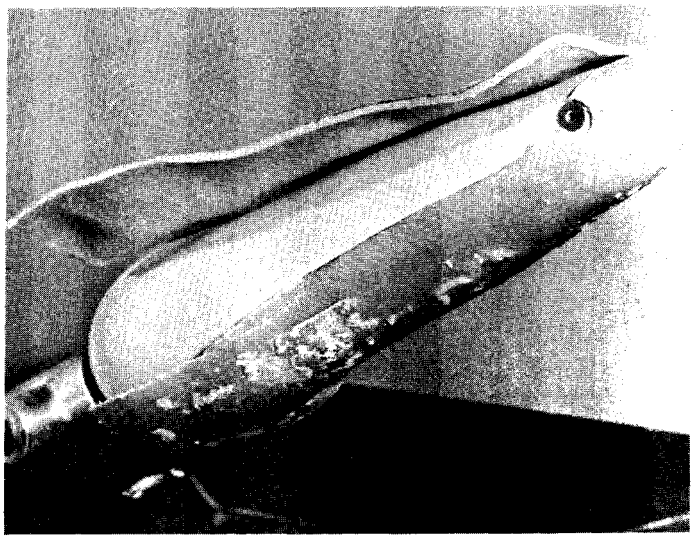


13. The distance the face will protrude from the inner wall will determine the thickness of the socket. One fourth inch is usually sufficient.

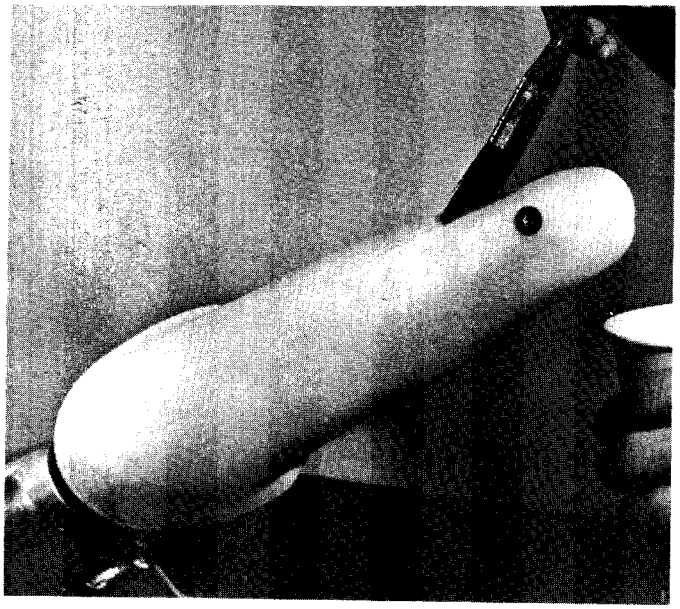


1. Make a breakout mold as described on page . Insert a mandrel for holding the mold.

2. After the plaster has set, carefully remove the wax check socket. (Heating the wax with a heat gun will allow easier removal.)

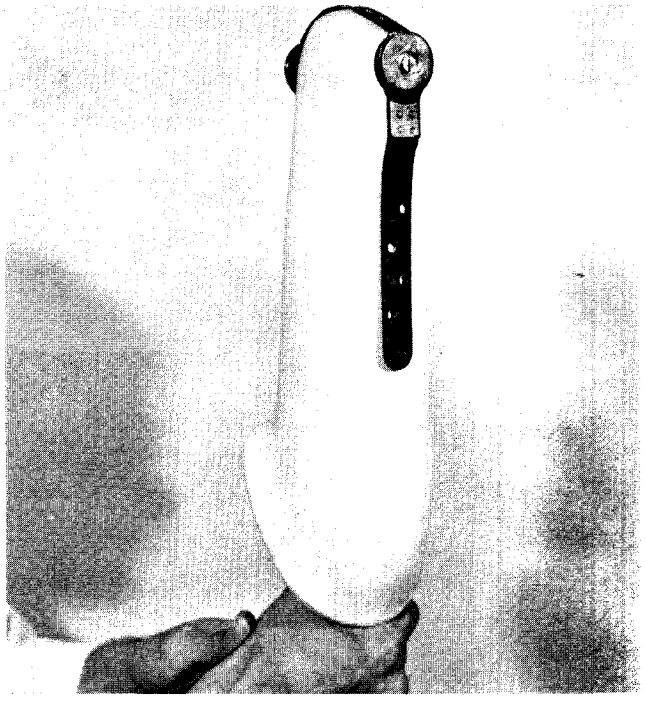


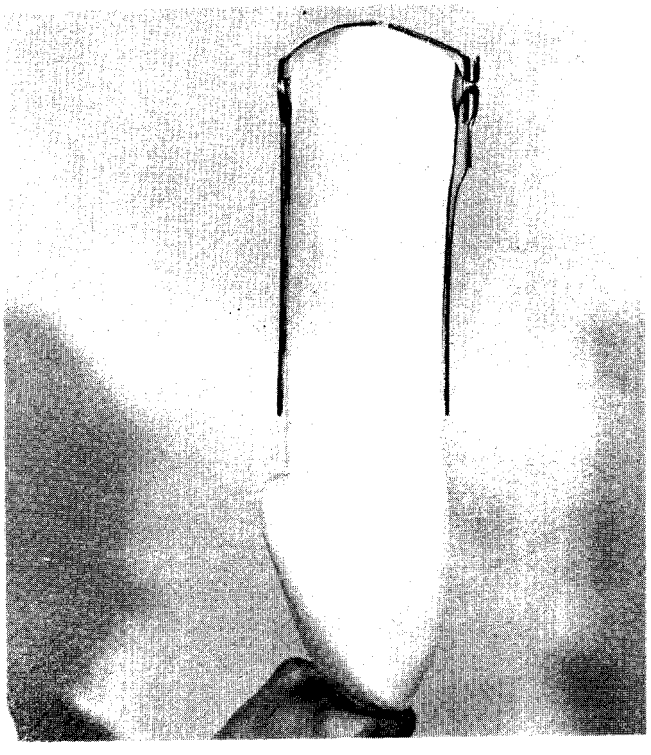
3. Smooth the whole mold, being particularly careful to get a smooth, rounded edge on the trim lines. Apply a parting agent to the mold for the final lamination.



The Plastic Socket

List of Materials:
dacron felt
nylon stockinette (about 3 inches wide)
string
knife
bending irons
PVA bag
resin, promoter, catalyst and color pigment
sander
outside locking hinges
spacer

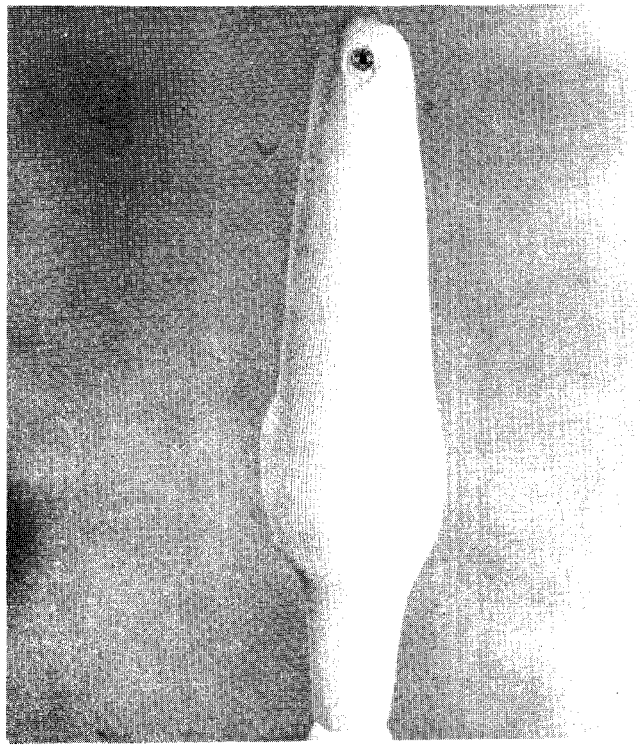




3. Remove the locking mechanism and shape the metal hinge straps to the model. Be careful not to bend the area where the locking mechanism or the joint heads attach. The straps should be shaped to allow one dacron and two or three layers of nylon stockinette beneath the straps.

4. Drill the straps for a better bonding of the resin. The distal socket straps can also be soldered together for added strength. Remove the joints and apply the lamination layup.

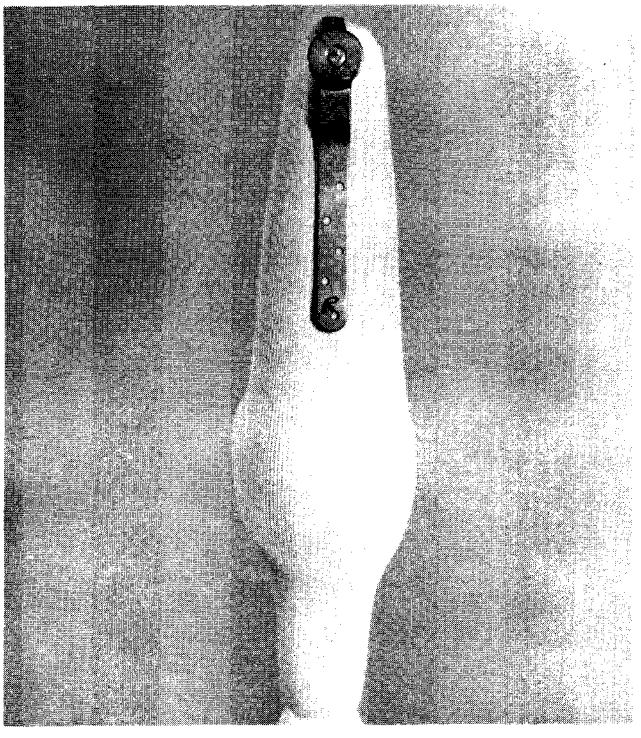
5. Make and pull over the mold one dacron felt bag. Sew across the ends of 3-inch wide nylon stockinette and pull two layers over the dacron. Tie it at the bottom and cut small holes in the stockinette and dacron to allow the round nuts of the joint spacer to protrude as shown in the illustration



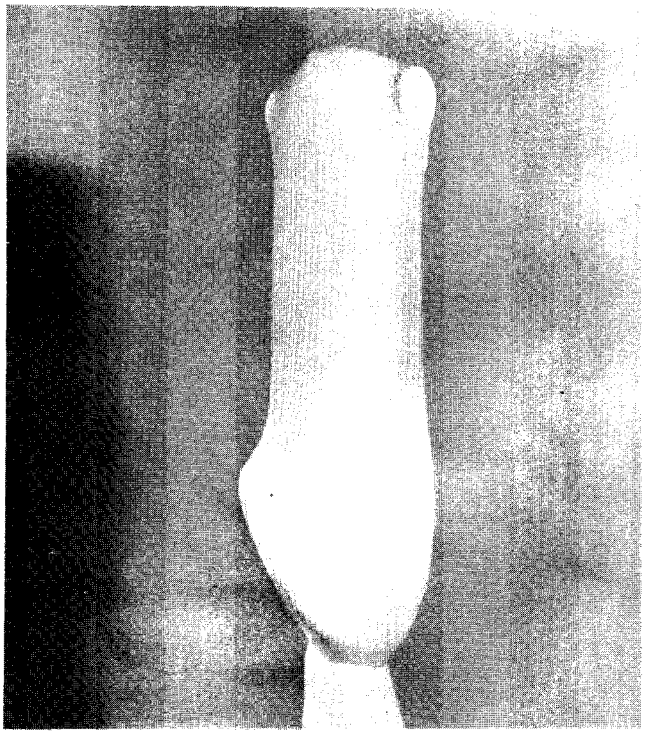
6. Reapply the joints making sure the straps do not bind and complete the following procedures

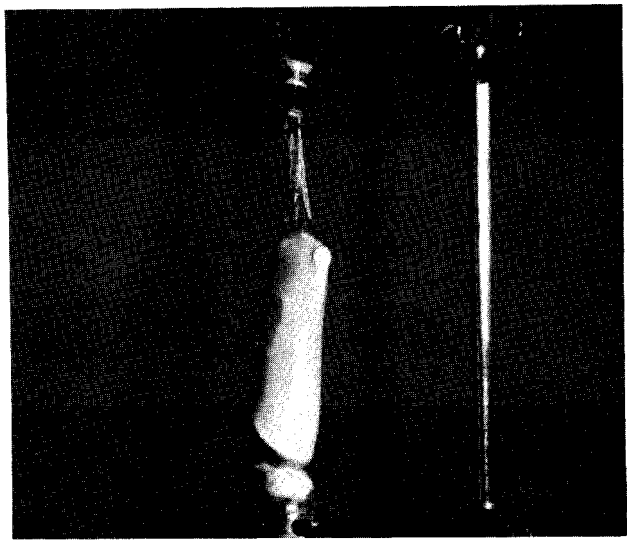
   (a) Apply a parting agent on the outer joint surfaces so that the final lamination can be cut away easily.
   (b) Insert a double thickness of wood tongue blade into the clevis on the non-locking side as illustrated to prevent the hinge from bending when the 8-32 flat head screw is tightened to the spacer. Fill in the balance of the clevis with clay or other material to prevent unwanted entry of resin.
   (c) Fill in the four holding screw holes on the locking side with clay.

7. Align the joint straps so that they are parallel to each other, then tighten the joint holding screw.

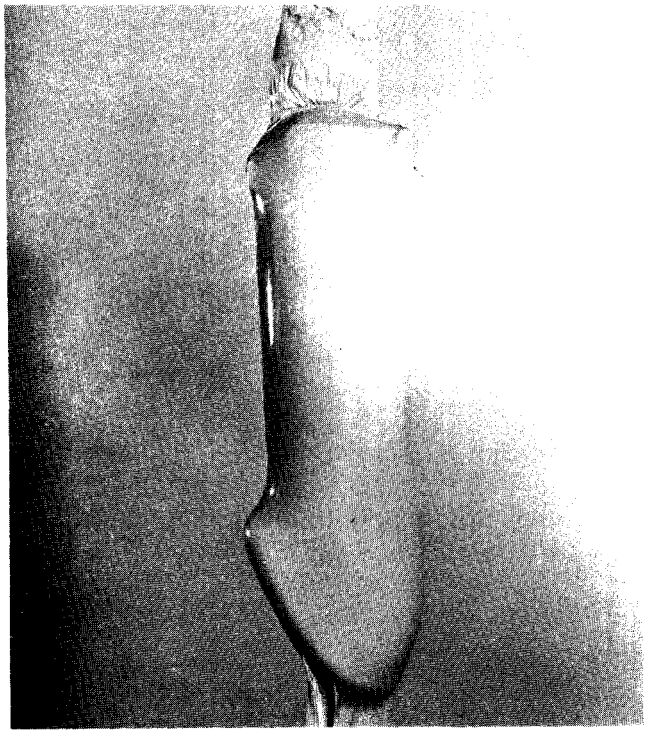


8. Put three layers (more for very heavy duty) of nylon stockinette over the hinges so that the straps will be imbedded in the plastic socket. Tie off with string at the bottom.





9. Make a PVA bag to fit over the mold. Dampen and pull it down tightly so there are no wrinkles and tie it at the bottom. Use of vacuum is recommended to make the socket light but strong (see page) Note that there is a window on the model in the illustrat ion.



10. Mix polyester resin with its promoter, catalyst and color pigment. (See page). Pour the resin into the top of the PVA bag and work into stockinette. Tie off the top of the bag to remove excess resin.

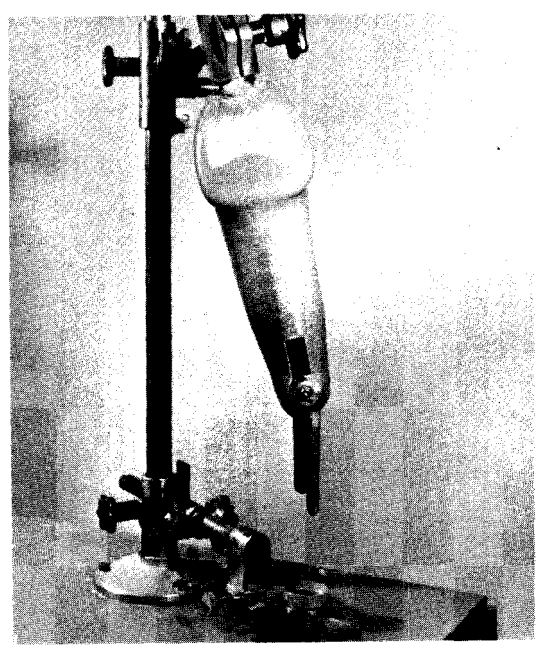
11. When the resin has hardened, trim the plastic from the joint surfaces so that the forearm straps can be applied. Do not remove the PVA bag at this time.

Making the Forearm

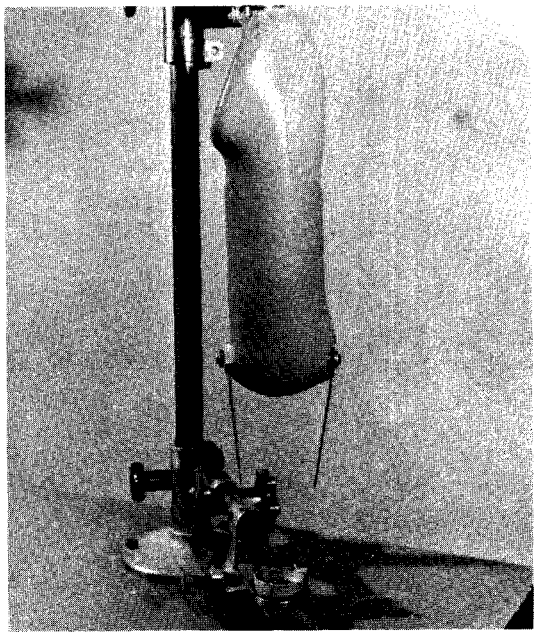
List of Materials:
cardboard
wrist unit
masking tape
PVA
straight edge ruler
molten wax
sureform files
knife
bending irons
nylon stockinette (about 2 inches wide)
string
polyester resin, promoter, catalyst and color pigment
oven
sander

There are three main ways to make the forearm for the outside locking hinge prosthesis. Methods are similar, but the materials to make the mold are different. One method is to make the forearm model of wax. This method is still most commonly used and is described below. It has two disadvantages: time is consumed in waiting for the wax to melt and then harden, and, the molten wax burns skin if an accident occurs.
Another method is to use plaster instead of wax.
A third and new method is to use polyurethane foam instead of wax or plaster. This method is fast and safe. It has the added advantage that foam can be left in the forearm, with little added weight, for strengthening a forearm for heavy duty use or simply to fill the space inside the forearm shell. This method is described in making a forearm for the Muenster type below elbow prosthesis.

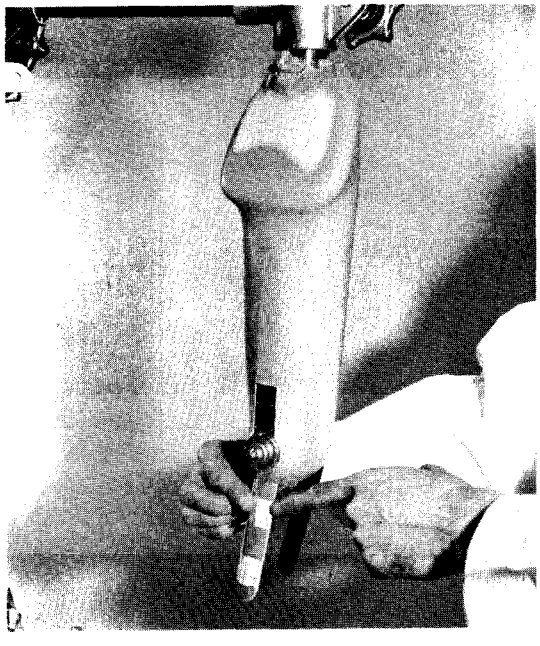
1. Place the socket in a holding device with the forearm straps applied. Adjust the socket so that the straps are vertical and centered over the wrist unit. The distance from the joint axis to the face of the wrist unit equals the distance measured from the lateral epicondyle to thumb tip minus the terminal device.



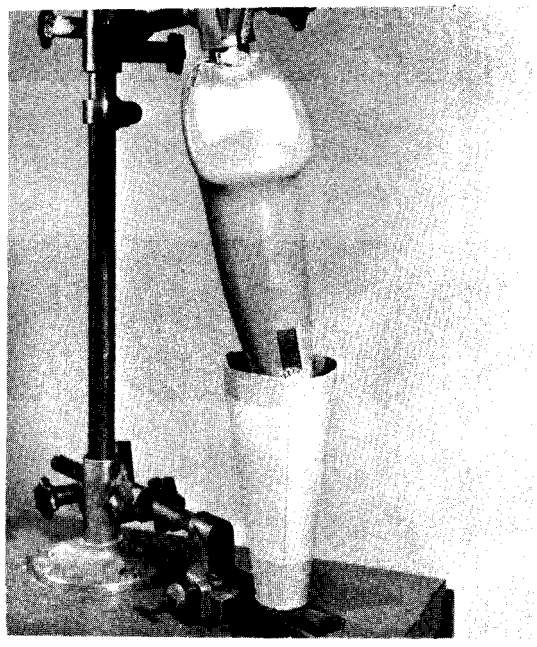
2. The wrist unit face is parallel with the elbow joint axis and centered at mid-point between the joints. Shape the joints so that they point and are in a straight line with the outer flanges of the wrist unit.



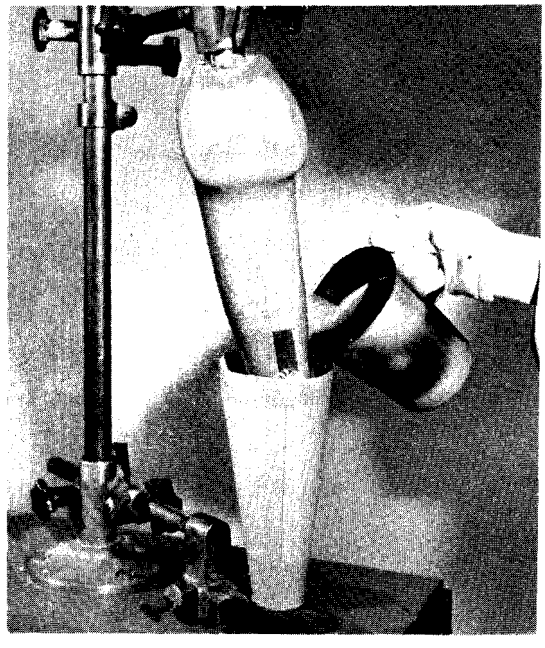
3. To form a channel in the wax for lower hinges. Tape a piece of 1/8" - 3/16" thick neoprene or other material to the inner side of both forearm straps allowing the material to extend from the edges about 1/8 inch. Put Vaseline on the material, straps and joint heads.



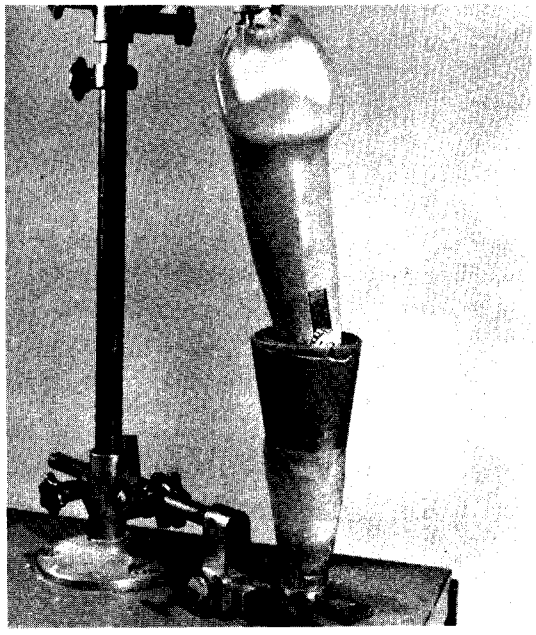
4. Shape a cone fit snugly over the forearm straps and fastened to the wrist unit with masking tape. Seal all openings so that the hot wax will not leak through. Be sure to cover the knurled surface of the wrist unit with tape to keep the surface free of wax.



5. Pour melted bee's wax into the cone to the level of the joints.

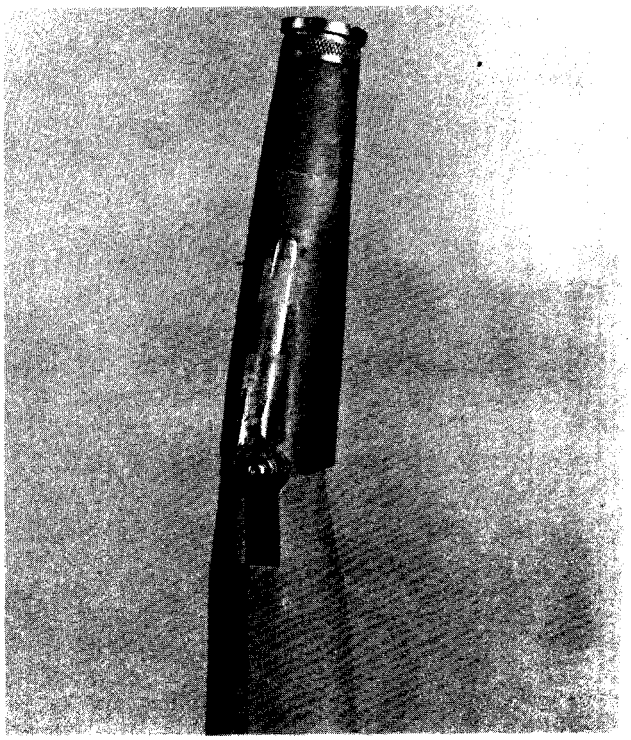


6. Remove the cone after the wax has cooled.



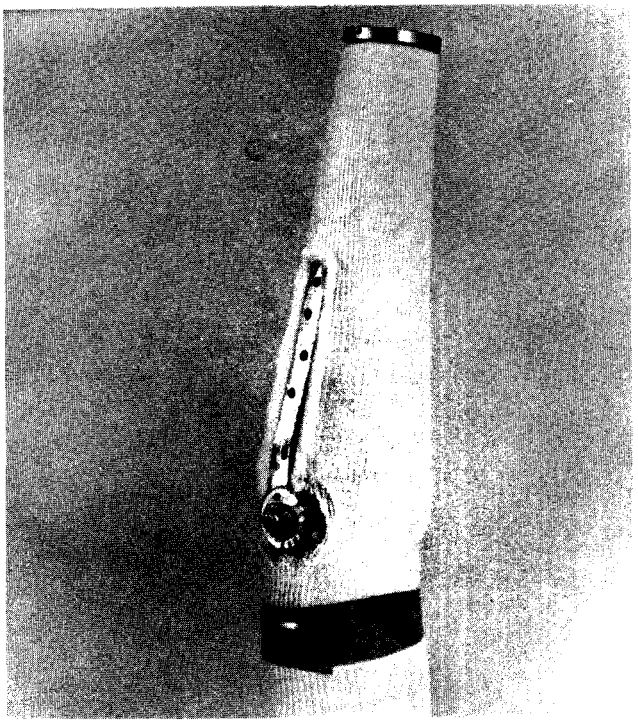
7. Shape the forearm to size by removing the excess material.

8. Dis-assemble the forearm straps. Remove the filler material on the inner side. Clean all the wax from the straps and joints.

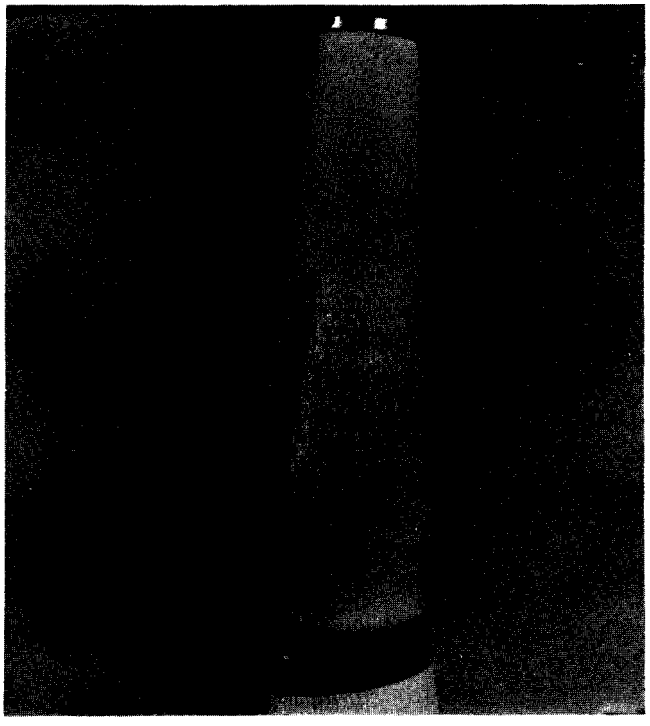


9. Replace the straps and observe the channel made by the material; smooth the edges if needed. The channel under the straps will form space for the layup material. Apply a parting agent on the wax.

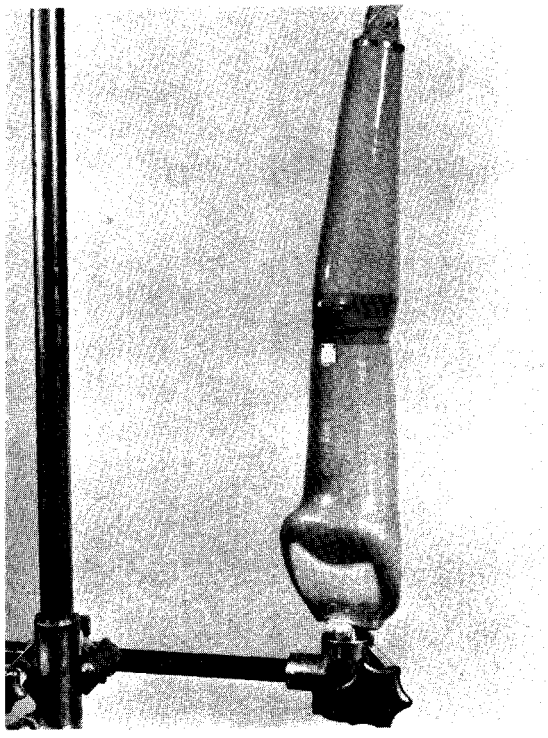
10. Apply two layers of nylon stockinette. Tie the stockinette to the wrist unit groove with string. Cut holes for the joint heads. Fill in with dacron felt any spaces between the straps and the stockinette. It may be easier to remove the joints while applying the first two layers.



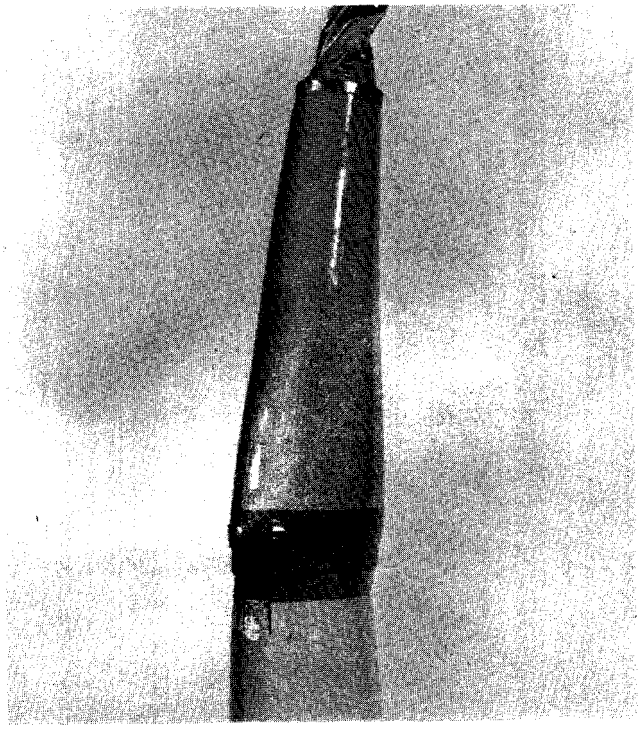
11. Add two or more layers of nylon stockinette over the layup as illustrated.



12. Make a PVA bag and pull it down tightly over the stockinette. With the PVA bag pulled very tightly over the conical shape, a thin lamination will result and the use of vacuum will not be necessary.



13. Mix polyester resin with its promoter, catalyst and color pigment. (See page). Pour it into the top of the PVA bag and work it into the stockinette. Tie off the top of the bag to remove excess resin. Pull tape around the joint heads to seal off the resin.

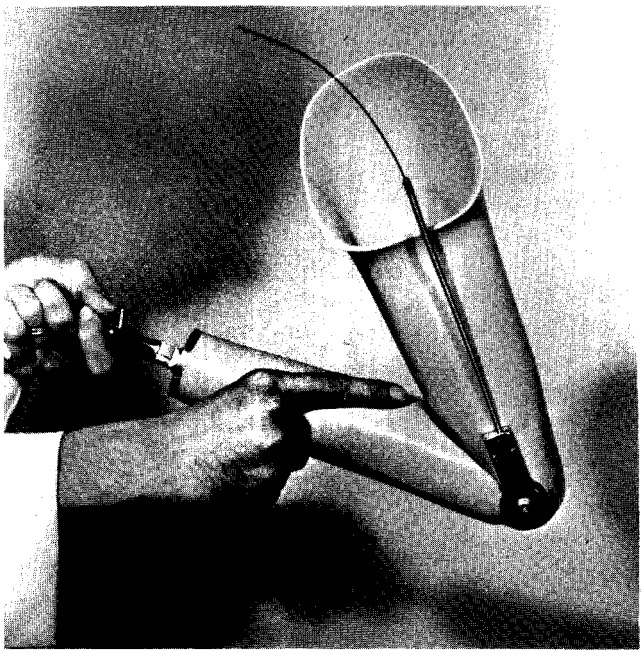


After the resin has set, remove the forearm from the socket and hang the forearm in an oven to melt out the wax. (Temperature of oven depends on kind of wax.)

While the wax is melting out of the forearm shell, break out the plaster mold from the socket and trim the socket to the lines previously established on the mold from the wax check socket.

14. Assemble the forearm to socket and mount the alternating lock. (Refer to manufacturer? instructions for parts assembly.)

15. Trim the forearm to allow full elbow flexion. Also, attach the terminal device to be used and adjust the pronation/supination friction.



Final Assembly

List of Materials;
drill and tap
elbow flexion attachment
diagonal shears
cable
large cable housing
teflon tubing
swaging tool or soldering kit
swivel terminal
retainer
base plate
adjustable hanger

Apply the control cable assembly to the prosthesis. The patient need not be present at this time. (See page .)

The completed assembly is illustrated. The control cable hanger and retainer are attached to be adjustable on the patient. The outside locking hinge prosthesis is now ready for harnessing.