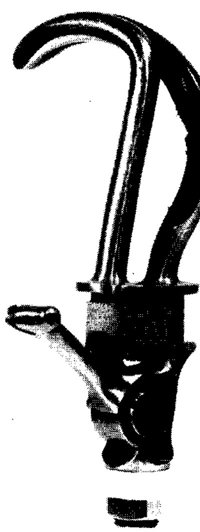
CHAPTER 3

COMPONENTS

All the components that are used in the fabrication of upper extremity prosthetics are listed in this chapter. In addition to this, the function of each component is described. Detailed information on the size, weight, cost, installation and maintenance of the components may be found in the manufacturers' catalogs and directives. Cosmetic components are described in Chapter 9.

Terminal Devices

The terminal device is a substitute for the missing hand. Both mechanical hands and hooks are used as terminal devices. Advantages and disadvantages of each are listed below.



Hook	Hand
Light weight	Heavier than a hook
Can see object being grasped	More difficult to see object being grasped
Mechanically simple	Mechanically more complex
Can get into pockets	Cannot get into pockets
Versatile	Less versatile than a hook
Not Cosmetic	More cosmetic in appearance

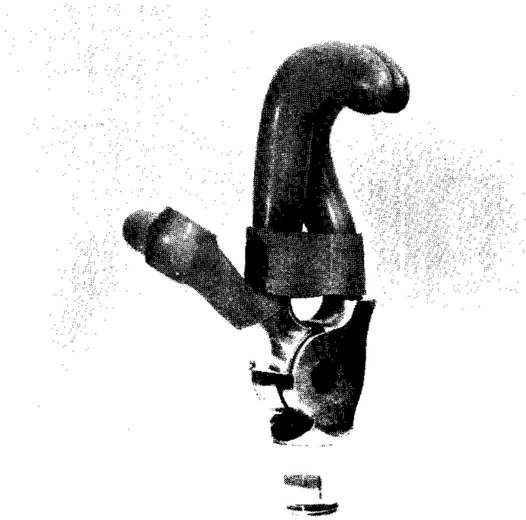
The primary advantage of the mechanical hand is its natural appearance. For many amputees this is more important than the functional advantages of the hook. Amputees often combine the advantages of each terminal device by using a hook for work and a hand for dress. Bilateral upper extremity amputees usually wear hooks for maximum function.

Both mechanical hands and hooks are controlled by a cable running to a harness on the amputee. Each type of terminal device is made with either a voluntary opening (VO) or a voluntary closing (VC). VO terminal devices open with a cable pull and close by spring force. VC terminal devices close with a cable pull and open by spring force. Results of studies* to determine the superiority of either the VO or VC terminal device have indicated that choice is simply a matter of individual preference. The prosthetist should realize, however, that the VC type is more mechanically complex and used less frequently than the VO type.

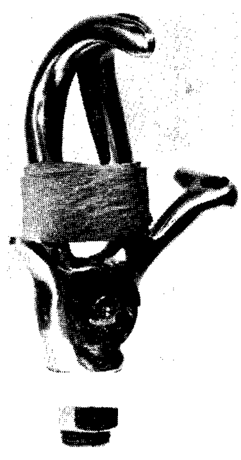
Hooks

Hooks are made in a variety of ways to meet specific needs.

Small sized hooks with plastisol (a PVC plastic) coatings are made for infants and small children.

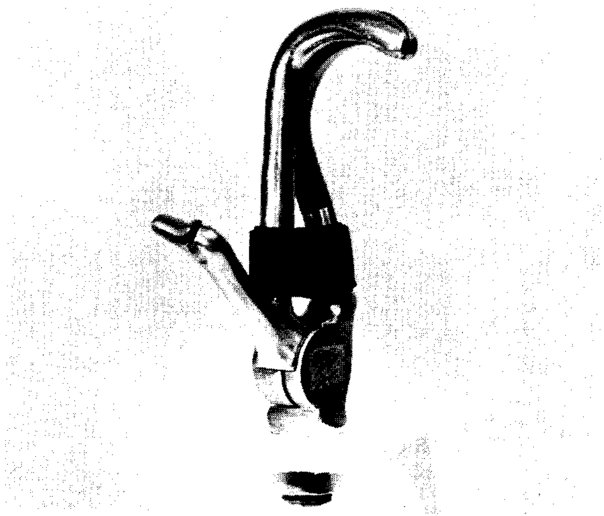


Medium sized hooks of aluminum or stainless steel are made for girls, boys, and small women.

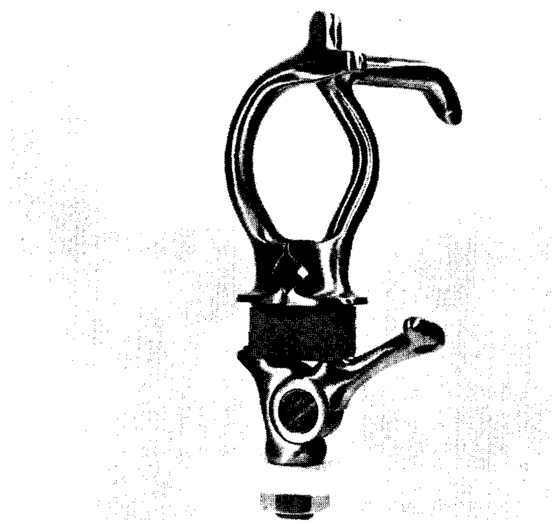


*Groth, H., & Lyman, J., Special Technical Report No. 23, Feb., 1957, "An Experimental Assessment of Amputee Performance with Voluntary Opening and Voluntary Closing Terminal Devices?

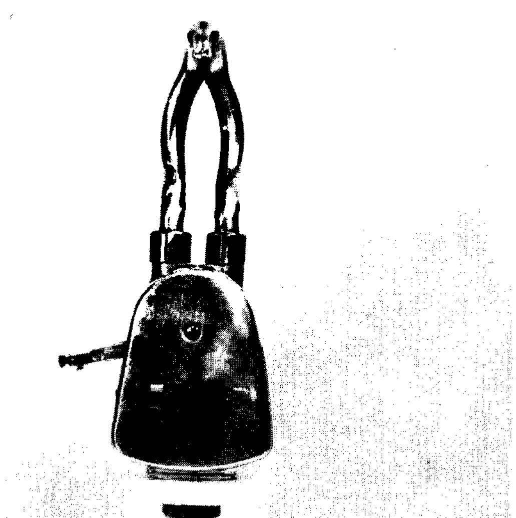
Large sized hooks of aluminum or stainless steel are made for adults.



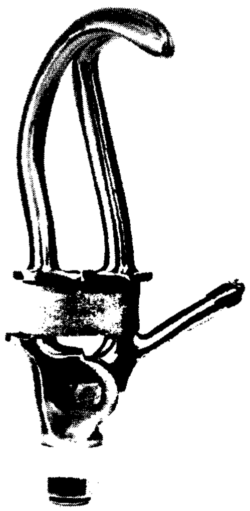
Many hooks are made for one task. The handyman's hook shown here is used for holding various tools.



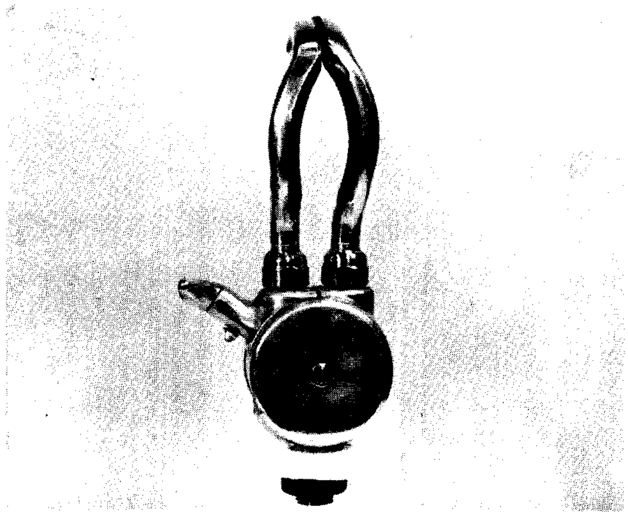
This VC device provides controllable prehension force with automatic locking in the grasp position performed by a cam-quadrant mechanism similar to that of the APRL-Sierra hand. Starting in open position, the first cable pull brings the movable finger against the stationary finger. Removal of all tension from the cable until the mechanism clicks results in locking the hook to maintain the grasp. To open the lock, the cable pull must be greater than the pull which closed the hand. Opening ranges of 0 to 1 3/8" and 0 to 3" are selected by setting a small switch on the case. When the switch is moved toward the fingers, the hook is set for the 3-inch opening; when it is moved toward the wrist, the 1 3/8-inch opening is used; and when it is the center position, the opening is 1 3/8" but the locking mechanism does not come into play.



Adult sized hooks are made in two configurations: "canted" and "straight approach". Advantages and disadvantages of each are listed below.



Canted



Straight Approach

Canted

Side Approach: objects more visible while grasping
Object is rolled into its grasp
Cannot pick up pins well

Straight Approach

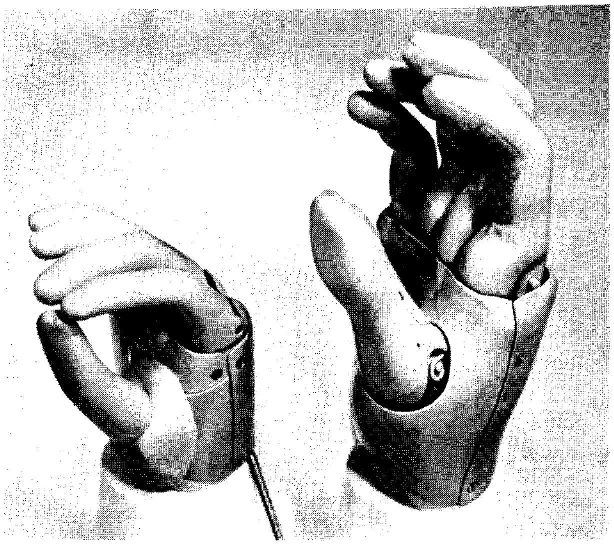
Straight approach: more applicable to bottle or cylindrical shapes
Object is pinched
Can pick up pins

The canted hook is used more frequently than the straight-approach hook.

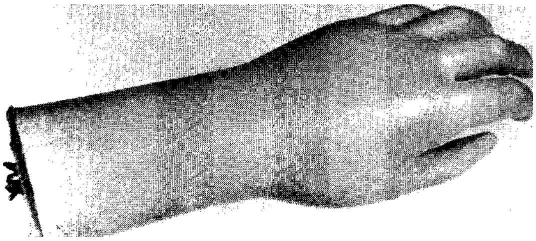
Hands

The most frequently used type of hand grasp is the one with three-point prehension using the thumb, index finger, and middle finger.* Most mechanical hands, therefore, are designed to provide this type of prehension grasp. The remaining two fingers are passive and positionable on some hands, and active and move with the index and middle fingers on others. Most mechanical hands have a grip lock to prevent accidental opening when an object is being carried; the hand is opened by pulling the cable.

Like hooks, mechanical hands are made in different sizes to fit children and adults.



The soft mechanical hand is a new development whereby the mechanism is covered with PVC foam material which feels similar to human flesh.



A plastic, cosmetic glove is usually worn over the mechanical hand.

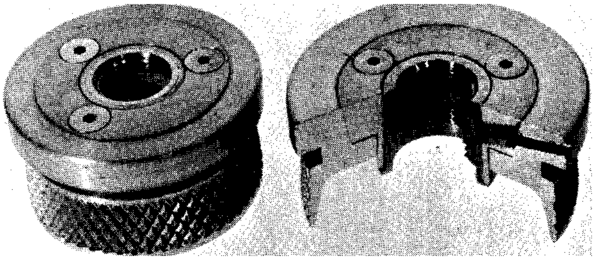
*Taylor, C., & Schwarz, R.: Artificial Limbs, May, 1955, "The Anatomy and Mechanics of the Human Hand".

Wrist Units

The wrist unit attaches the terminal device to the forearm and enables the terminal device to be manually pre-positioned. Several types of wrist units are made for different purposes. All wrist units are attached to the terminal device by inside threads on the unit and a threaded shaft on the device. Wrist units are made in both round and oval shapes.

Rotation Type

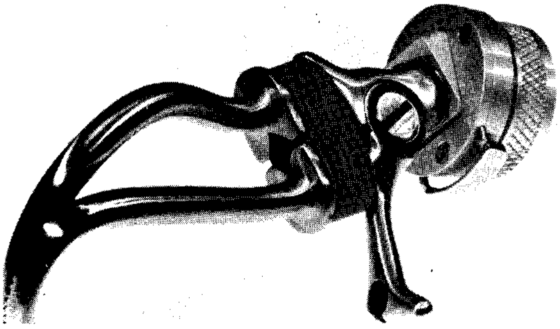
Most rotation wrist units provide pronation and supination of the terminal device with an adjustable friction setting in the unit.



In addition, a rotation wrist unit is made which has a positive lock controlled by a cable.

Rotation -Flexion Type

This wrist unit provides both rotation and flexion of the terminal device. The rotation has an adjustable friction setting and the flexion has positive locking positions at 0°,30° and 50°.

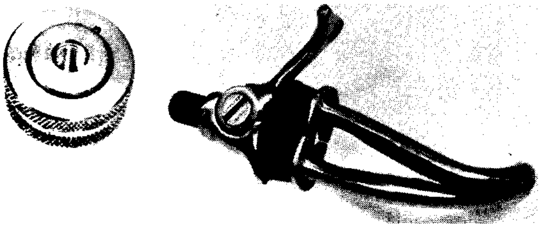


Quick Change Type

Quick change wrist units allow the hooks and hands to be interchanged without the need to unthread one and thread the other. They also are occasionally used to pre-position the terminal device in rotation with the positive lock. With these units, one terminal device is popped out, and the other popped in.

The pop-out unit has a button which unlocks the terminal device and allows it to be rotated or removed.

The ring unit has a lock which is operated by turning a ring on the unit. Rotating the ring in one direction unlocks and releases the terminal device; rotation in the other direction locks the terminal device in position This unit is not recommended for bilateral amputees.



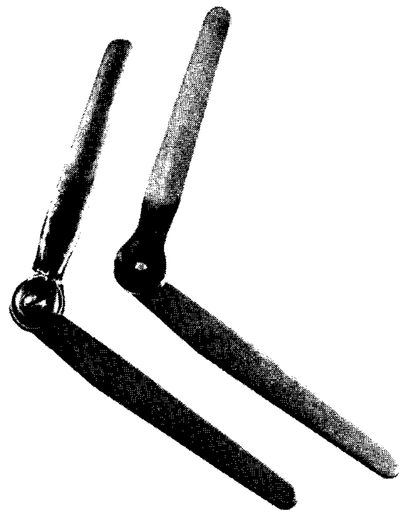
Both types of quick change wrist units have a positive lock against rotation.

Elbow Joints

For Below Elbow Prostheses

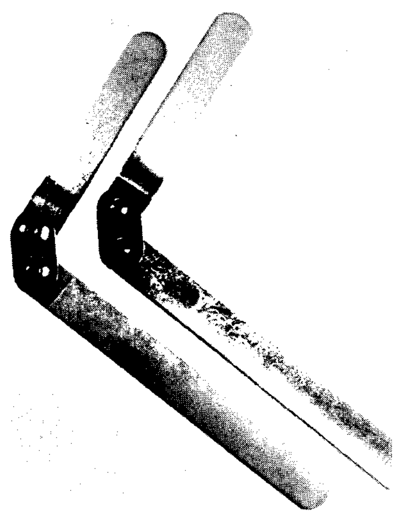
Single Axis Hinged Joint

An elbow flexion axis for the forearm of the BE prosthesis is provided by a pair of these hinges. The upper and lower straps are mounted to the cuff by riveting and to the forearm by laminating. The slotted lower strap has a trunnion bearing for the upper strap. An extension stop prevents hyperextension.



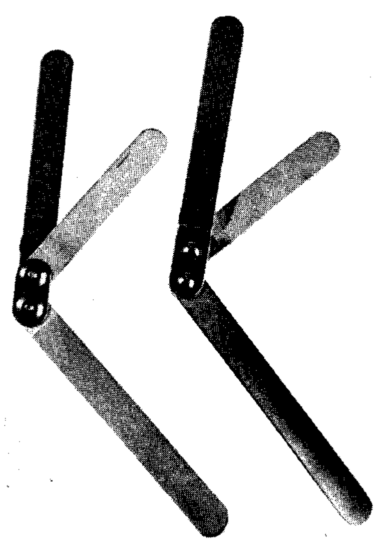
Geared Polycentric Axis Hinged Joint

Mating gear teeth on the cuff and forearm straps of these hinges impart a displacing action to the socket as the stump is flexed. This action increases the distance from the axis of the epicondyles to the anterior socket trim line during flexion, to provide clearance for bunching of flesh and clothing in the crook of the elbow. The last teeth of the gear segments serve as extension stops.



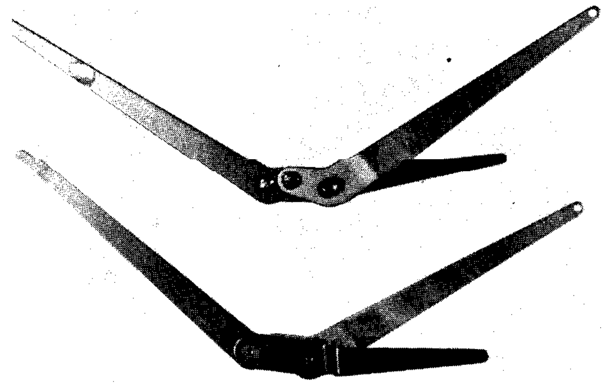
Geared Step-Up Hinged Joint

For the Very Short Below-Elbow amputee type where usable stump flexion is limited, this hinge provides a ratio between forearm and stump socket flexion in the split-socket prosthesis. The cuff and forearm straps have gear teeth identical to those of the polycentric hinge, and an additional elbow strap converts these gears into a planetary gear system, with the planet gear of the socket strap moving around the sun gear of the cuff strap which is centered on the axis of the epicondyles. This gear system allows the prosthetic forearm to be moved through almost twice the flexion angle through which the stump (socket) moves.



Sliding Pivot Step-Up Hinged Joint

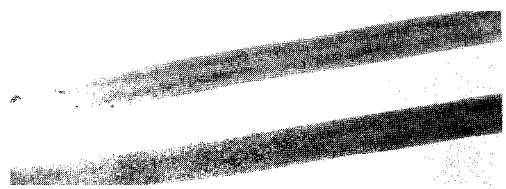
The purpose of this joint is the same as the above step-up joint, but the action is different. This joint provides a variable ratio step-up, (starts at a low ratio, has a high ratio in mid-flexion, and ends with a low ratio) which averages about 1-1/2: 1.



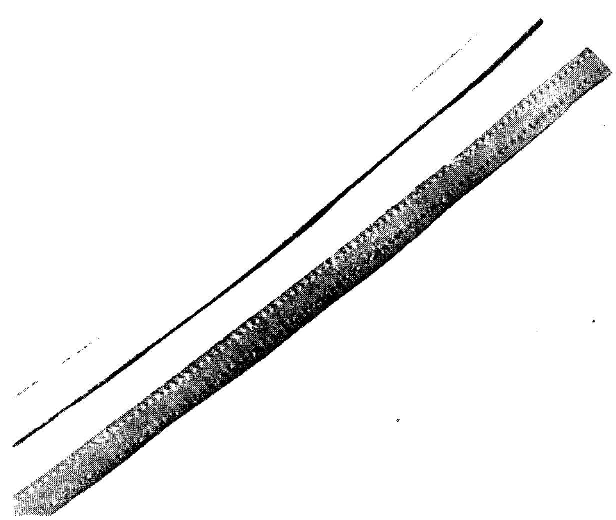
Flexible Joints

The purpose of flexible joints is to retain the socket on the stump and allow residual forearm rotation.

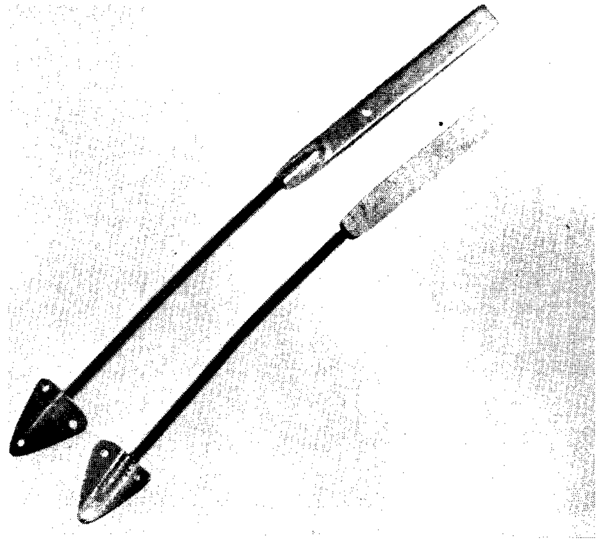
Flexible joints can be made of 1/2-inch dacron webbing impregnated with flexible polyester plastic. The joints are strong, light and hygienic.



Leather Reinforced with Dacron

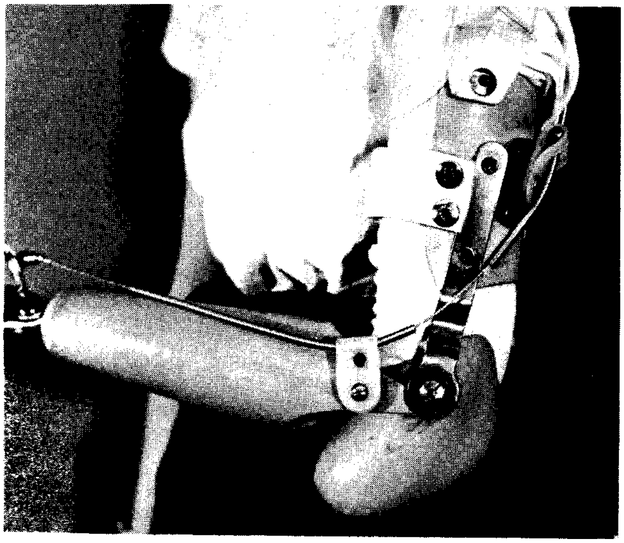


Flexible Metal Cable



Stump Activated Lock Hinged Joint

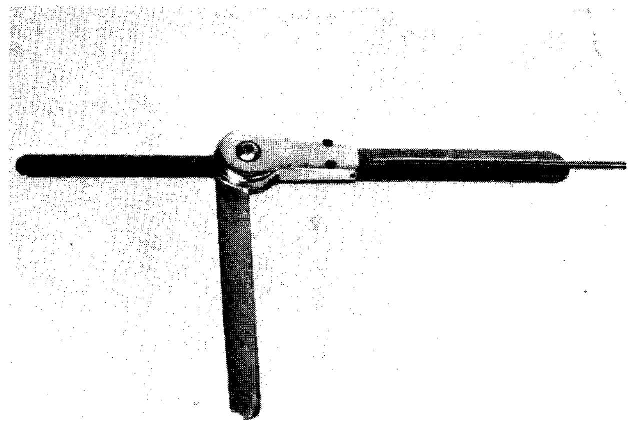
This joint retains the socket on the stump, provides rotational stability, and allows a very short below elbow stump to operate the elbow lock on the joint.



For Above Elbow Prostheses

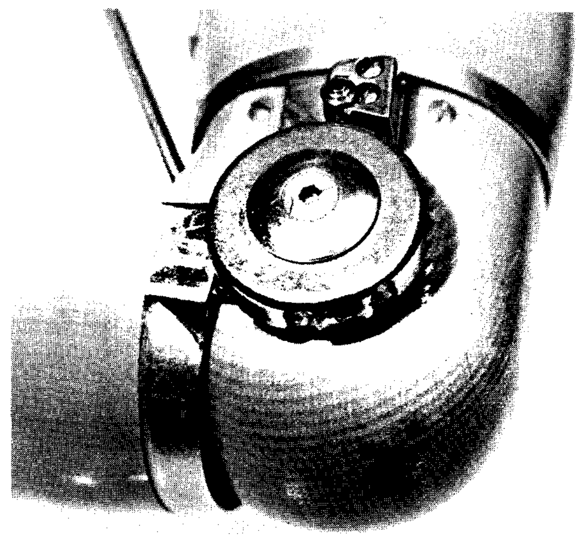
Outside Locking Hinge

Designed for use with elbow disarticulations and stumps amputated 2-1/4" or less from the distal end of the humerus on the adult size and 1-11/16" on the children size. There are seven locking positions of flexion with an alternator-type locking mechanism on the medial hinge only.



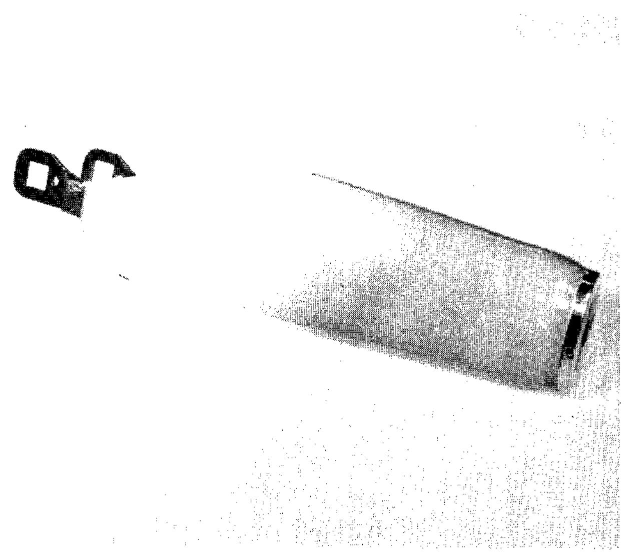
Prosthetic Elbow Unit

For humeral stumps that are more than 2-1/4" shorter than the normal side. The mechanism includes an alternating lock for 11 locking positions from 10° to 135° of elbow flexion in addition to the turntable socket connection which permits manual pre-positioning (rotation) to substitute for gleno-humeral rotation. An optional addition to the unit, a clock spring called an elbow flexion assist, counterbalances the weight of the forearm, thereby making it easier to flex the elbow.



Forearms

Used with the prosthetic elbow unit for above elbow and shoulder prosthesis. Commercially available, the forearms are made in incremental lengths, skin colors, and with the wrist unit of choice fabricated into the forearm.

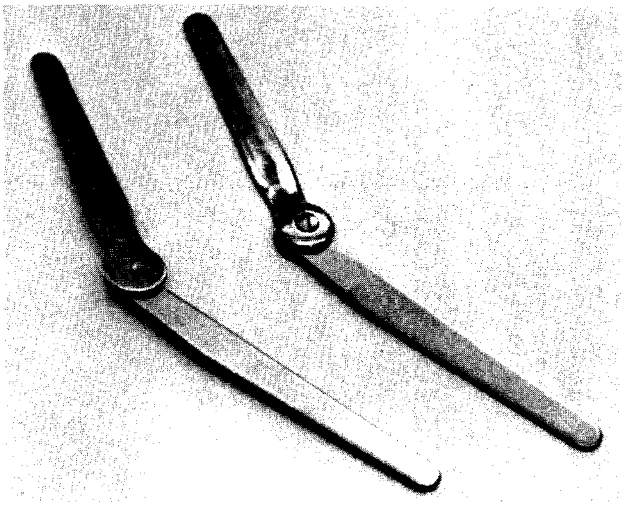


Shoulder Joints

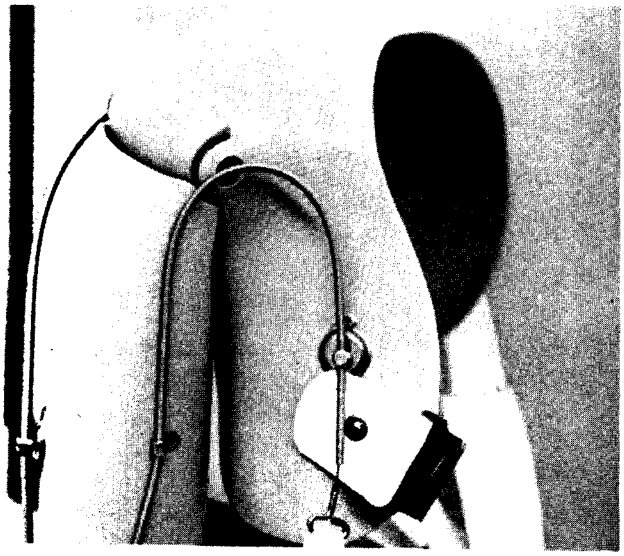
The shoulder joint allows the humeral section to be manually pre-positioned. Two basic types of shoulder joints are commercially available: single-axis and double-axis. Type of motion desired, cosmetic appearance, and site of amputation will all determine which type of shoulder joint to use.

Single-Axis Shoulder Joints

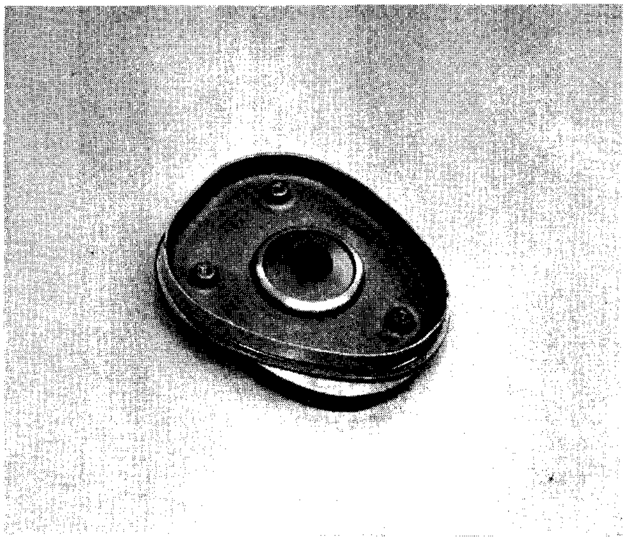
The single-axis shoulder joint is used when the humeral head is present. The joint is installed at an angle to the frontal plane so that motion will produce both shoulder joint flexion and abduction.



This joint permits a more natural appearance even when the humeral head and neck are present as shown.

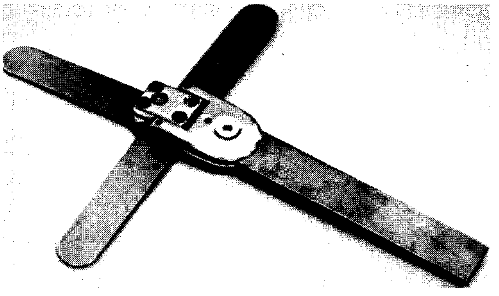


The bulkhead joint allows single axis motion. The joint is usually installed in a position of external rotation to achieve both abduction and flexion. This is used for true shoulder disarticulations and interscapulo thoracic amputations.

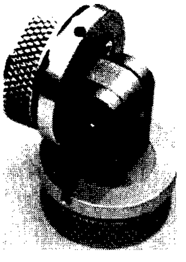


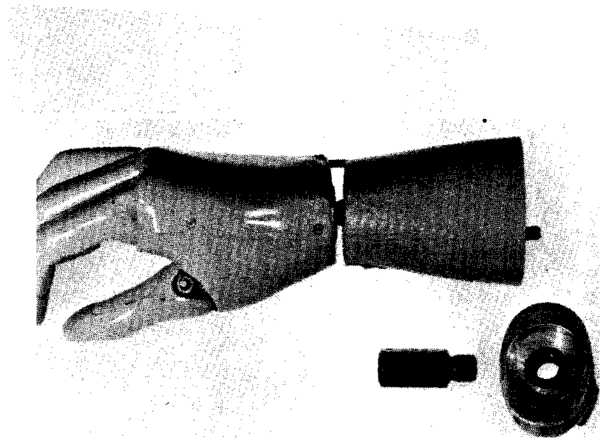
Double Axis Shoulder Joints

The flexion-abduction joint allows double axis motion in the frontal and sagittal planes. It is adaptable to all types of shoulder amputations.



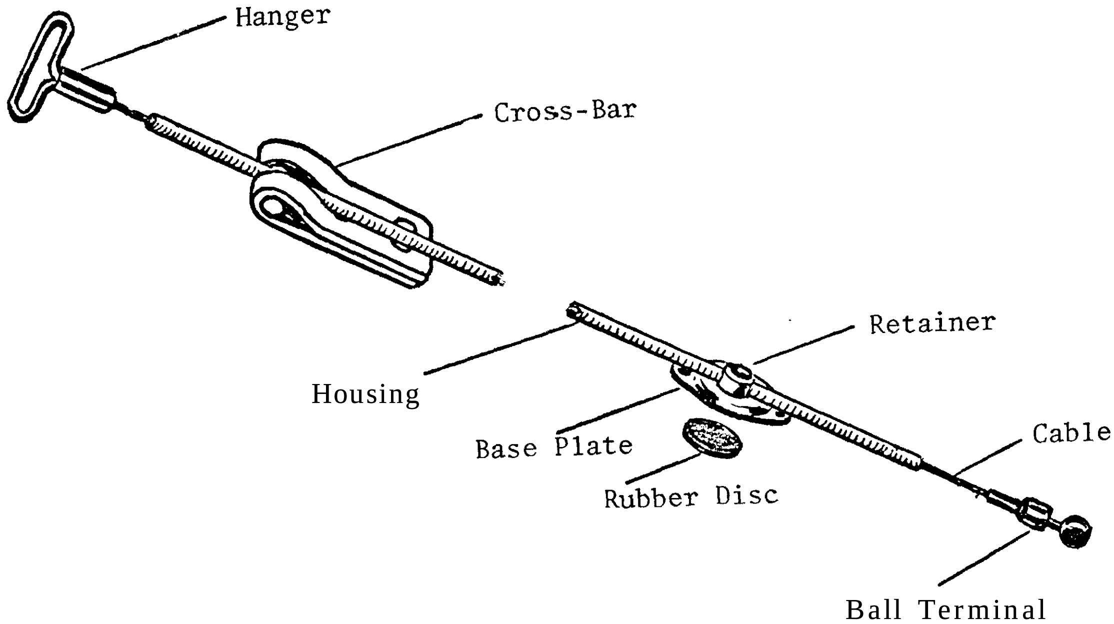
The universal joint allows double axis motion in the frontal and sagittal planes. In addition, it allows rotation around each of the two axes. This is for shoulder disarticulations only.



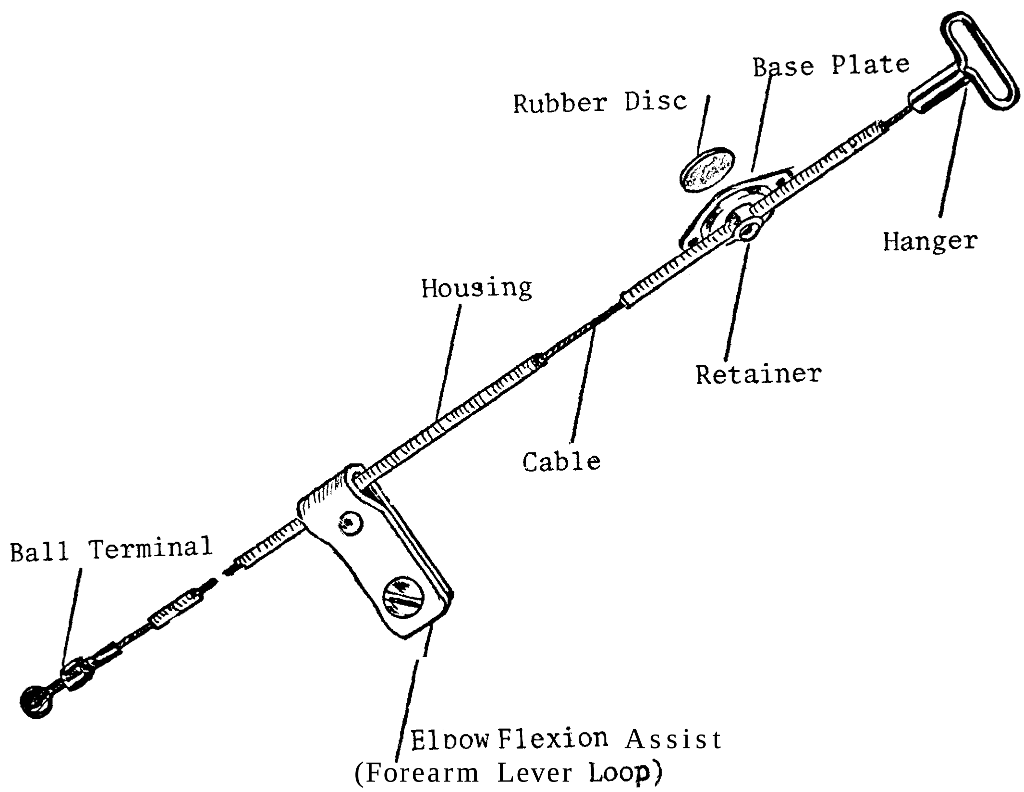


Control System Components

Functional upper extremity prostheses are controlled by cables which run from the harness to the prosthesis. Typical below-elbow and above-elbow control systems are shown below.



Control System For Below-Elbow Prostheses



Control System For Above Elbow Prostheses

Control System Components

The cable is the means by which body power is transmitted from the harness to the prosthesis. Cables are made of braided stainless steel wire and have a smooth surface tc reduce noise and friction.

The housing guides the cable from the harness to the prosthesis. It protects the amputee's skin and clothing from the moving cable and, made of coiled, stainless steel wire, provides a smooth surface for the cable.

The ball terminal is the means by which the cable is attached to the hook. It is stainless steel which can be swaged or soldered to the cable. A ferrule type fitting is used as a terminal for mechanical hands and elbow units.

The hanger attaches the cable to the harness. The neck of the stainless steel hanger is swaged or soldered to the cable, and the harness webbing is threaded through the slot on the hanger.

The retainer, base plate and rubber disc are the means by which the cable housing is attached to the prosthesis. The base plate containing a rubber disc is riveted to the plastic forearm or humeral section; the retainer is threaded on the housing and inserted into the base plate. The retainer can rotate in the base plate, thereby providing a swiveling anchor point for the housing. The retainer and base plate are made of stainless steel. The rubber disc holds the retainer snugly in the base plate.

The cross bar assembly is the means by which the housing is attached to the triceps pad or half cuff on a below elbow prosthesis. The plate and loop are riveted to the pad or cuff; the cross bar is threaded on the housing and inserted into the loop. The assembly provides a swiveling anchor point for the housing. The plate is made of stainless steel; the flexible loop is made of leather or plastic.

The elbow flexion attachment provides elbow flexion for the above elbow prosthesis with a dual control system. The flexible loop, made of leather or plastic, is riveted to the forearm just distal to the elbow center; the loop is clamped to the housing with a rivet. The length of the loop provides a lever arm so that when the cable is pulled (with the elbow unit unlocked), the elbow is flexed.