An Experience With External Power In Upper Extremity Prosthetics

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Throughout the years prosthetists have been aware of the need for more efficient and functional upper extremity prostheses. Conventional upper extremity prostheses are now vastly superior to those available in the past. However, there is still much need for improvement, especially for the more severely involved cases. Although previous attempts to increase efficiency and function through the application of external power have met with varying degrees of success, in many instances the designs produced were too complex for practical application.

Greater emphasis is now being placed upon the use of external power in order to provide amputees with an answer to their prosthetic needs. Our cooperative efforts in this direction have resulted in the development of a successful pneumatic upper extremity prosthesis utilizing modified standard prosthetic and orthotic components.

A 20-year-old male S/D amputee was fitted with this type of prosthesis. He is successfully using it at the present time. Three additional shoulder disarticulation patients are now being fitted with similar prostheses. This utilization of standard components has proved to be both economical and expedient, contributing greatly to the degree of success.

BASIC INVESTIGATION

The success of pneumatically activated orthotic devices indicated the possibility of adapting many of the same components for activating prostheses.

A basic investigation indicated the feasibility of utilizing the artificial muscle for motive power. This was abandoned when available space proved inadequate for containing a muscle of sufficient length to fulfill power requirements. Later investigations indicated that the most promising approach would be to utilize two pistons: one piston to be attached to the proximal end of the wrist, and the other to the proximal end of the elbow.

PROTOTYPE DEVELOPMENT

1. *Components*

A push-type piston was designed for attachment to the Sierra Constant Friction Wrist and activation of both hand and hook through the axis of

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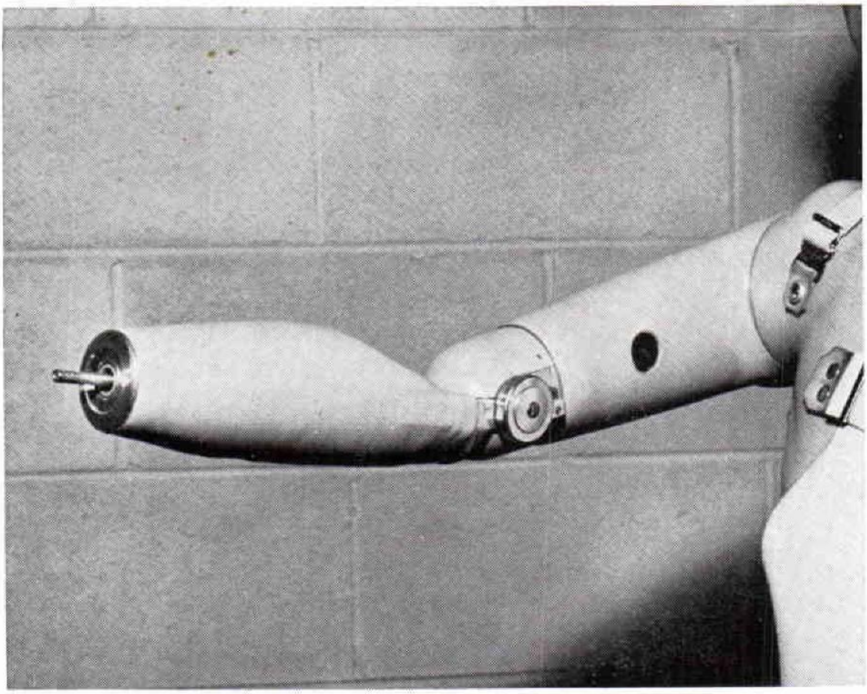

FIGURE 1

their attachment studs (Figure 1). This wrist proved satisfactory for location and alignment of the piston and adjustment of friction without affecting total piston stroke requirements.

A pull-type piston was designed to be attached to the turntable compression ring of the Sierra Elbow which proved to be satisfactory for the retention of adjustable turntable friction and freedom of rotation without affecting location or alignment of the piston.

The elbow was then modified by reversing its position relative to the arm (Figure 2), machining a new shaft with reoriented forearm attachment slots, and drilling a clearance hole in the plate and lock assembly for the piston rod to pass through.

A pin driven into the shaft was connected to the piston rod by means of a short roller chain with disconnect links at each end.

The elbow lock assembly was modified by substitution of a simple shaft and lever in place of the alternator type lever and cam system.

Both the elbow and wrist were designed to permit factory mounting and alignment of pistons to simplify final installation.

The APRL Hand and Hook were chosen for their adaptability to push activation, and then modified by substituting a simple spring loaded, push activated linkage system in place of the usual mechanisms and drilling the attachment studs to permit the piston rod insertion. Both hand and hook are connected to or removed from the wrist in the usual manner.

2. *Complete Prosthesis*

Conventional casting, measurement and fabrication techniques were used, substituting the modified components for those normally installed. The patient was then fitted and harnessed utilizing a conventional chest strap

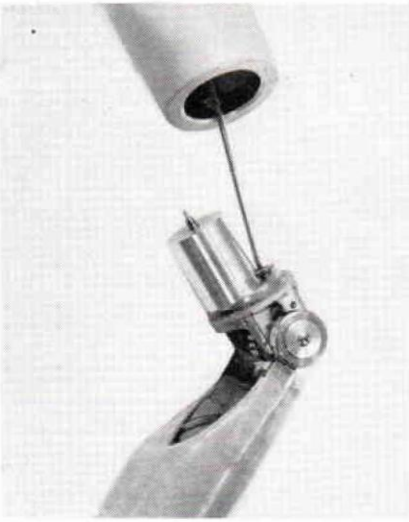

FIGURE 2

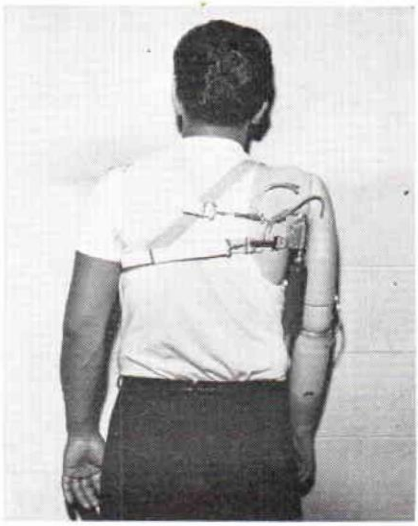

FIGURE 3

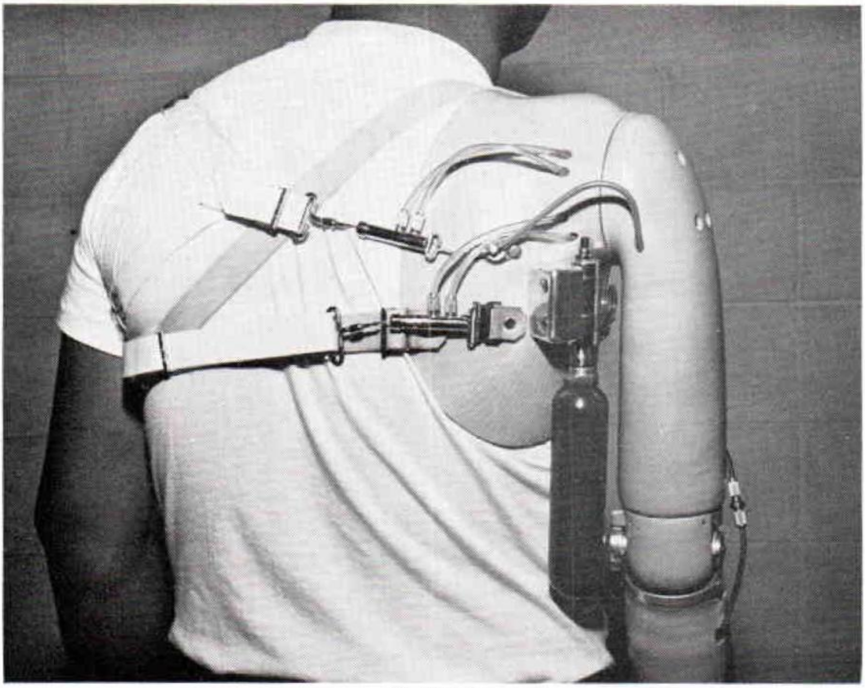

FIGURE 4

and axilla loop harness. The terminal device piston was connected to a standard OSCO slide valve activated by chest expansion (Figure 3). An additional OSCO slide valve was modified by installing a stronger return spring, then connected to the elbow piston and its distal end attached to the lock cable (Figure 4).

Both lock and piston are activated by a single force exerted through the axilla loop. When pull is applied to the valve the elbow lock bar is lifted before the slide valve can move to either the exhaust or fill positions. When tension is released the valve returns to the hold position and the lock bar drops.

A conventional tank and regulator were connected to the valves through a simple combination manifold and flow control block which permits individual adjustment of the rate of flow to both pistons, but does not affect exhaust flow. An additional flow control was installed on the elbow piston vent. The purpose of this system is to provide control over flexion without affecting extension. A Sierra round type shoulder bulkhead permits pneumatic lines to pass through the shoulder axis.

FIGURE 5

FIGURE 6

FIGURE 7

FIGURE 8