

# An Externally Powered Modular System for Upper-Limb Prostheses

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In the past, conventional harnessing arrangements in upper-limb prostheses have been used to provide both suspension and transmission of power to the prosthetic components. By encumbering an intact, contralateral, segment of the body, the prosthetist found a base for suspending the prosthesis and a semi-mobile anchor point for obtaining relative motion between body segments to provide cable-type functions. Obtaining function by this arrangement requires motion from either the intact side or the prosthetic side of the body, or by motion

of both sides. Very little function can be provided in this manner to patients who have a high level amputation or restricted range of motion.

To improve the functional value of upper-limb prostheses, the Johns Hopkins Applied Physics Laboratory and the Johns Hopkins Medical School, working together, have developed a modular, externally powered system. A block diagram of the basic system is shown in Figure 1.

When body motion is not required to gain function, harnessing may be kept to a minimum and is needed only to provide suspension when necessary. Harnessing may be eliminated completely when the suspen-

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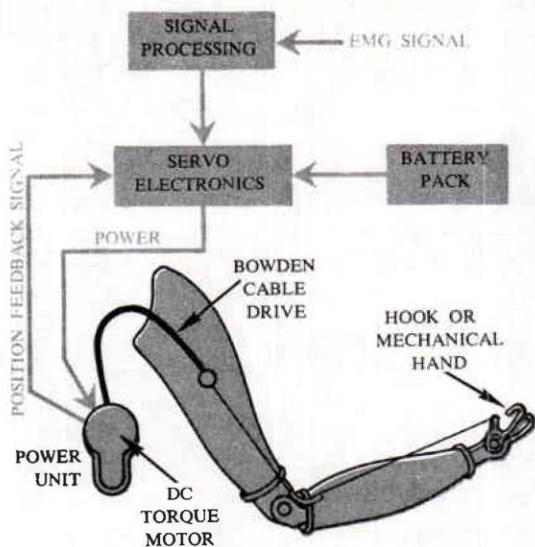


Fig. 1

Block diagram of the externally powered system for upper-limb prostheses developed at Johns Hopkins University.

sion function can be incorporated into the socket.

A special type of single-site myoelectric sensor can be used with the Johns Hopkins system. Most other myoelectric systems use two separate sensors and provide power in two directions. By using the basic design of conventional prostheses, only one sensor site is needed in the new design. The signal to open the terminal device is the only one necessary because the terminal device can be closed by elastic bands or springs in the conventional manner. And, only one signal is needed to lift the forearm, because gravity will produce extension when it is allowed to do so. The sensor and amplifier arrangement provides proportional control over all functions. The faster the amputee generates the signal, the faster the system op-

erates. Because the amputee needs to learn to manage only one proportional control, the training time required is quite short. The system in operation is practically silent, and it is applicable to all types of upper-limb amputations.

One of the unique features of the Johns Hopkins externally powered system is that conventional prosthetic components are used. The only modification necessary is the provision of an opening in the wall of a standard socket for installation of the sensor electrode. The socket design can be modified so that suspension is the only objective that may challenge the prosthetist. The modifications for suspension have included use of single supraepicondylar cuffs with flexible hinges, figure-8 harness with triceps cuff, modified chest-strap harness, full suction

above-elbow sockets, and the Muenster designs.

Externally powered systems can provide the upper-limb amputee with a full range of motion in all planes without limiting the function of any of the other limbs. High-level amputees and those with limited range of motion may enjoy the full function of prosthetic devices through the use of external powered systems. For some patients prostheses have been made with battery, motor, or both incorporated into the hollow sections of the prostheses.

Power for the Johns Hopkins system is provided by small rechargeable electrical batteries. The actuator is a direct-current torque motor that has no clutches, brakes, or mechanical stops. A two-stage reduction gear is used, and the system is

virtually silent. The motor will produce up to 30 pounds of force in the cable and will not be damaged if this force is held for several seconds. The system is activated by means of a single myoelectric signal sensor. The battery pack provides an average of eight hours use before recharging is necessary.

The modular aspect of the Johns Hopkins system provides a truly unique degree of versatility. The same power and control components can be assembled in different ways with conventional prosthesis components to create a variety of externally powered prostheses to satisfy the needs of individual patients with amputation at any level.

For example, a typical below-elbow prosthesis uses flexible hinges, triceps cuff, figure-8 harness, the se-

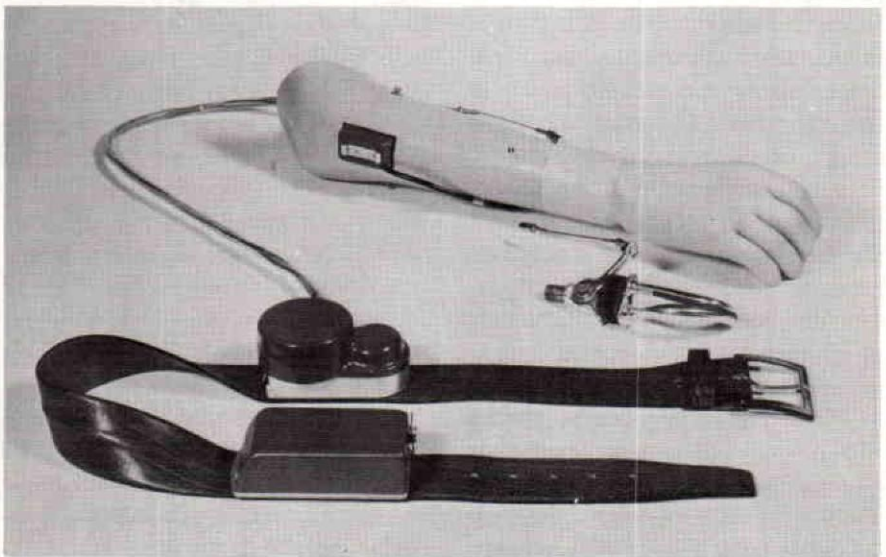


Fig. 2  
Components for a below-elbow system.

lected terminal device, and is controlled by use of a Bowden cable. To convert this conventional prosthesis to an externally powered system, the cable is simply connected to the motor instead of being attached to the harness. Harnessing may then be modified to provide suspension only or it may be eliminated entirely if the Muenster type socket can be provided (Figs. 2 and 3).

The conventional above-elbow prosthesis components consists of a double-wall socket, Hosmer turntable-type locking elbow with lift assist, friction wrist, figure-8 or saddle harness, and a terminal device. Again the harness provides both suspension and a basis for function.

The typical cable system would be the fair-lead which allows the amputee to select either the elbow-forearm function or terminal-device function by locking or unlocking the elbow. To convert this system to the Johns Hopkins system, the prosthetist needs only to eliminate the control cable strap attachment. The cable then can control both the forearm position and the terminal device as the patient wishes. The cable is connected directly to the motor and all other components remain the same—one motor, elbow and terminal device powered. The same applies to the shoulder-disarticulation case. Figure 4 illustrates an attempt to provide suspension without straps.

Although the Johns Hopkins system does indeed permit conversion of a body powered prosthesis to an electrically powered prosthesis, each of the prostheses illustrated in this report was actually created as a dup-



Fig. 3

Patient wearing the system shown in Figure 2.

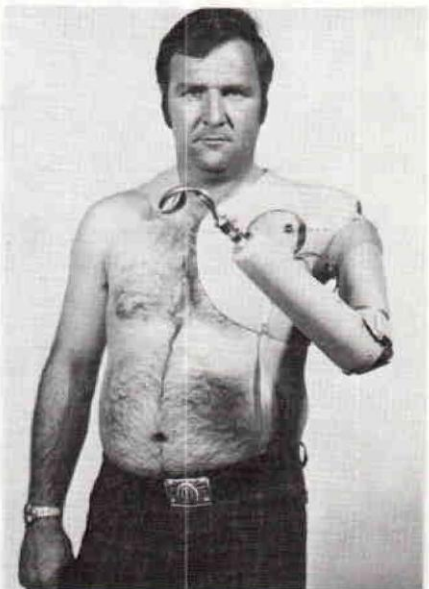


Fig. 4

The Johns Hopkins system applied experimentally to a shoulder-disarticulation patient. Note the absence of harness.

licate of the amputee's pre-existing body powered prosthesis. This was done in order to compare functions achieved with the two different power systems.

The principal research group for the Johns Hopkins system design are Gerhard Schmeisser, M.D. of

the Johns Hopkins Medical School and research engineers Woodrow Seamone and C. Howard Hoshall of Johns Hopkins Applied Physics Laboratory.

The results of early clinical trials are discussed in the article that follows this one.