DEVELOPMENT AND EVALUATION OF EXTERNALLY POWERED UPPER-LIMB PROSTHESIS [a]

SUMMARY OF RESEARCH PROJECT ACTIVITIES

July 1971–December 1971

Woodrow Seamone, B.A.E.
Principal Professional Staff

Applied Physics Laboratory
The Johns Hopkins University
8621 Georgia Avenue
Silver Spring, Md. 20910

Gerhard Schmeisser, Jr., M.D.
Chief, Prosthesis Clinic

The Johns Hopkins Hospital
601 No. Broadway
Baltimore, Md. 21205

During the latter half of 1971, clinical evaluation continued on eight upper-limb prosthesis External Power and Control (EXPAC) units (see BPR 10–16, pp. 169–176) which had been fitted during 1970–71.

Two basically different types were used: Type A with motor location within the above-elbow prosthesis, and Type B with the motor remote from the prosthesis, e.g., on the amputee's belt. Type B can, presumably, be used for amputations at any level as well as for powered braces (Fig. 1). Both configurations can be connected to provide either terminal device function or elbow flexion or both.

EVALUATION PROGRESS

Test amputees with an assortment of occupations and ages and with a full range of amputation levels were selected to determine system versatility and reliability as well as other factors related to user acceptance. All amputees were fitted with functional, conventional, Body-Powered (BP) prostheses to facilitate comparison with the Externally Powered (EP) prostheses. All amputees were interviewed and examined periodically. A summary chart of the results of the evalution to date is shown in Table 1.

[a] Based on work performed under VA contract.

TABLE 1.—*Clinical Experience*
JH APL — MI External Power and Control (EXPAC) System
(as of Jan. 1972)

All amputees were fitted and trained with conventional functional Body-Powered (BP) prostheses appropriate to their amputation levels. Externally Powered (EP) prostheses were of the same design and components except as appropriate to the addition of the EXPAC. All were *asked to alternate use of EP and BP prostheses* enough to maintain skill. All were given hand-hook interchange capability with both EP and BP prostheses.

I.D.	Age Sex	Occupation	Amp. lev.	EX-PAC	Con-trol	Prior BP use	EP use (mo.)	Amputee preference	
								EP vs. BP	Hand vs. hook
L.R.	27 M	Med. Stu.-Phys.	WD BE	B	ME	5 yrs.[a]	24	BP most tasks EP special tasks	Hook most tasks Hand special tasks
J.C.	17 M	Piano-High Sch.	Mid BE	B	ME	12 mo.[a]	15	BP most tasks EP special tasks	Hook exclusively
J.P.	48 M	Farmer-Mech.	Sht. ED	B	ME	8 mo.	13	EP exclusively	Hand most tasks Hook special tasks
U.S.	54 M	Machine Oper.	ED	B	ME	2 mo.	14	EP exclusively	Hook most tasks Hand rare social
H.T.	56 M	Unskill Lab.	AE	B	ME	0	12	EP exclusively	Hook exclusively
L.C.	30 M	Welder-Farm.	Lng. AE	A	ME	5–6 yrs.[a]	11	BP exclusively	Hook exclusively
L.B.	23 M	College Stu.	AE Mid	A	ME	9 mo.	19	EP exclusively	Hook exclusively
T.L.	18 M	Farm Worker	SD	A	SM	1 mo.	9	EP exclusively	Hook exclusively
Sum.	18 to 56	Diverse	WD to SD	5B 3A	7 ME 1 SM	6 yr. to 0	Av. 15	5 EP exclusively 2 EB–BP shared 1 EP failure	5 Hook exclusively 3 Interchange

[a] Preference for BP seems to correlate with duration of experience with BP prior to obtaining EP.

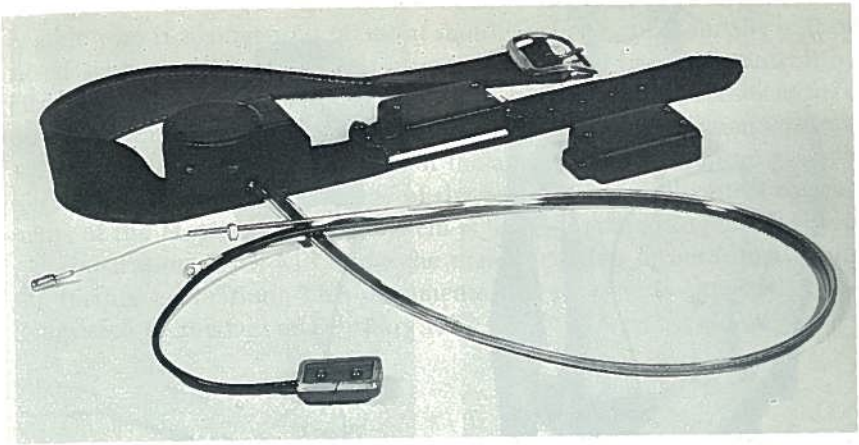

FIGURE 1

One of the above cases (T. L.) that has been of particular interest is an 18-year-old right shoulder-disarticulation amputee who lost his limb in a traumatic amputation secondary to a corn picker accident. He was initially fitted with a conventional body-powered prosthesis approximately 3½ months after amputation. This device provided negligible function and he wore it (for appearance) only on special occasions. Prior to being fitted with the externally powered prosthesis he had, for all practical purposes, totally rejected the conventional system. No myoelectric signals suitable for control of a prosthesis were found when a thorough exploration was made of the muscles of the injured side of the amputee's body. However, more than 1 in. of transverse motion of the scar results when the pectoralis muscle is contracted. The patient has excellent voluntary control of the motion of the skin. A special transducer was developed at APL to use this skin motion.

This transducer uses a movable magnet and stationary semiconductor elements that respond to changes in magnetic field strength. Approximately ⅜ in. of motion of the small string emerging from the front of the shoulder of the prosthesis (Fig. 2) controls the elbow and terminal device. When the prosthesis is in use, the end of the string is passed through the large hole close to where it emerges from the prosthesis and is attached to a button which is, in turn, attached to the skin with double-sided adhesive tape.

This amputee was fitted in May 1971, and the prosthesis was found to be quite useful for his tasks on the farm over the past 7 months.

The use of the magnetic transducer/skin motion input appears to be an attractive alternative to the use of an EMG sensor, particularly for higher level amputations. Further evaluation is planned to explore the potential of this technique.

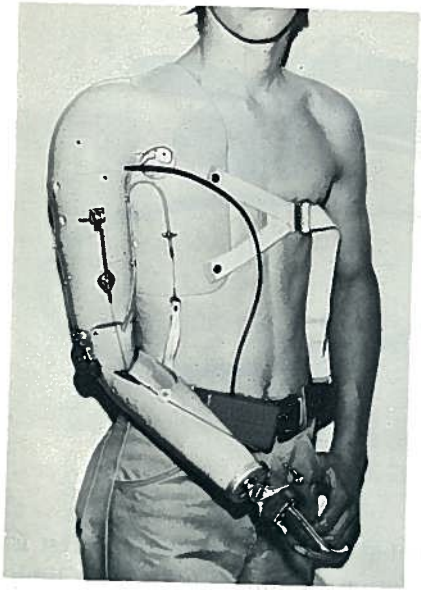

FIGURE 2.—See text for description of unique control.

FIGURE 3

During the latter part of the report period, investigation of the feasibility of using this belt-mounted power pack with an orthosis to obtain active joint motion in the presence of paralysis was initiated. The unit was connected to an articulated elbow brace (Fig. 3). The attachment points of the cable and its housing were oriented on the brace to produce elbow flexion when the motor is activated. Gravity is used for extension. The test wearer is a 49-year-old office worker with bilateral flail shoulders and elbow flexor muscle paralysis associated with a congenital anomaly of the cervical spine. The myoelectric sensor is attached to the lateral aspect of the brace over the proximal end of the wrist and finger extensors where a good signal is generated by contraction of these muscles.

With or without objects grasped in his hand, the wearer is able to flex his elbow voluntarily up to any point less than the maximum imposed by the brace (approximately 120 deg.). He is also able to control the speed of flexion and to maintain his elbow for short periods at a specific angle. System operation is silent.

Evaluation is being continued in order to explore the limitations of the EXPAC unit as a method of powering an anatomical joint.

FUTURE PLANS

In order to evaluate further the potential of the Hopkins powered system, one case currently in the fitting stage involves an 18-year-old

female who is a congenital bilateral shoulder disarticulation. She will be fitted with the lightest system possible for powering and controlling elbows and hooks on both arms. One magnetic skin motion sensor located on each shoulder will provide the control signals to the system.

In addition to the continuation of the amputee evaluation program, a documentation drawing package of the basic power and control components of the Hopkins powered system is being prepared for the Veterans Administration. This will allow the manufacturing of additional units for further evaluation. This documentation package is expected to be completed by the end of February 1972.