

Canadian Experience with the Soviet Myoelectric Upper-Extremity Prosthesis

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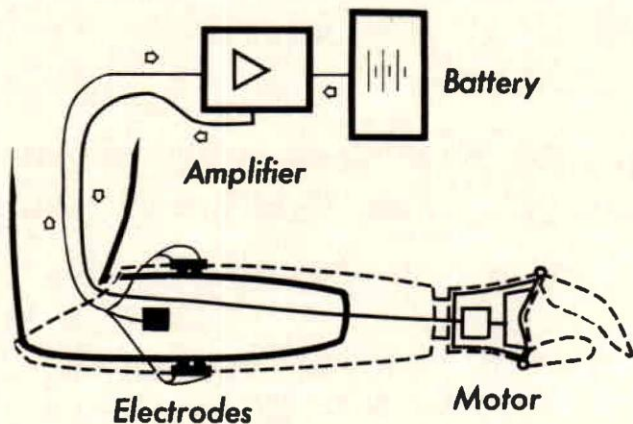
The prosthetic requirements of the upper extremity amputee are quite often extensive and complex in terms of functionality. Furthermore, the higher the level of amputation, the more body functions are needed to power a conventional prosthetic device while at the same time, the number of available controlling muscles decreases. Artificial effectuators may be used to produce mechanical functions in prosthetic systems, supplied from an external source of energy in the form of electricity or compressed gas. Combining humans and machines in this way requires a control system to interconnect the two, if the human and technical elements are to operate compatibly. Using muscle action potentials for control signals provides an excellent means of establishing communication between man and machine.

Several laboratories on this Continent and elsewhere experimented with external power in connection with myoelectric control for prosthetic devices. However, a group of Soviet researchers produced the first practical device. Perhaps their greatest merit is due to their decision that myoelectric control was practicable. The device is a simple hand prosthesis, performing the function of fingertip prehension. The control signals are provided by two muscles of the forearm, preferably one of the finger extensors and one of the flexors. The servo-mechanism loop is completed through the visual observation of the amputee-operator.

To date, the Rehabilitation Institute of Montreal has equipped 12 below-elbow amputees, 11 male and one female adults of various amputation history, with the Soviet device. Three of these amputees are bilateral cases. Working with this prosthesis provided the Institute with immediate clinical experience, greatly reducing the time delay required by independent research.

The Rehabilitation Institute of Montreal, responsible for the care of more than 30 thalidomide children, followed the developments and the literature on myoelectric control. A team travelled to Moscow to visit the Central Prosthetic Research Institute, and in the fall of 1964, through a grant from the Province of Quebec, purchased the manufacturing rights and ten prototypes. The purpose of this undertaking was to evaluate the possibilities of the Soviet device with a view of applying myoelectric control to prostheses for congenital amputees.

The functional components consist of a hand shell made of plastic material, housing the drive motor in the metacarpal area. The fingers and thumb are hinged corresponding to the metacarpo-phalangeal joint. The interphalangeal joints are fixed in a slightly flexed position. In the Soviet prototype, spring loaded electrode cups containing abrasive electrolytic paste



1. Diagram of the prosthesis with external power and myoelectric control.

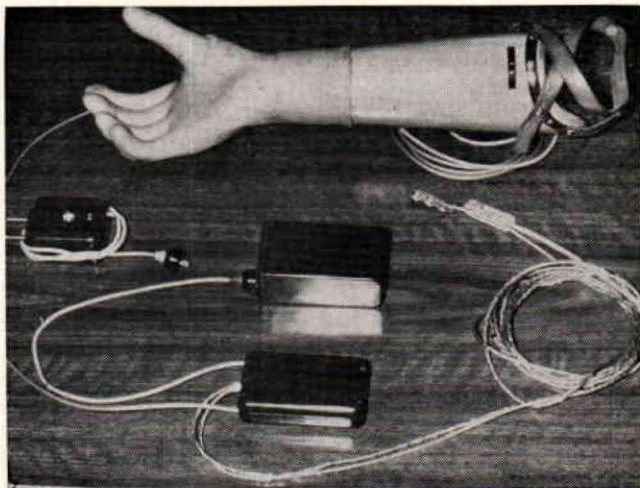
are installed over selected control muscles. Movement of the fingers and the thumb is caused by a lever, one end of which is connected to a slider block. The latter is driven back and forth by a leadscrew.

The system is powered by a rechargeable battery of 13.75 volts weighing 320 grams. The capacity of the battery is sufficient to sustain operation of the hand for 15 hours depending on the frequency of use. A small charger restores energy to the battery overnight.

Power is directed to the motor by two small relays, which control operation in opposite directions. Each of the relays is energized by a control channel consisting of a set of electrodes, myoelectric preamplifier, an integrator and a power amplifier; the latter directly connected to the relay coils. Muscle potentials are detected by the electrodes, amplified, and smoothed to produce a DC voltage approximately proportional to the activity in the control muscles. The control amplifier is designed to differentiate between the muscle signals and extraneous (electronic) noise, effectively rejecting the latter. Even with the present surface electrodes, little trouble is experienced in establishing a satisfactory signal pick-up. Most of the Institute's patients find they can operate the device without skin preparation, although using a small amount of conductive jelly helps to eliminate a short warming-up period in the morning. The control unit containing the two channels, including the relays, originally encased in a plastic box, weighs 170 grams.



2. Blind amputee patient using acoustic signals to train controlling muscles for independent operation.



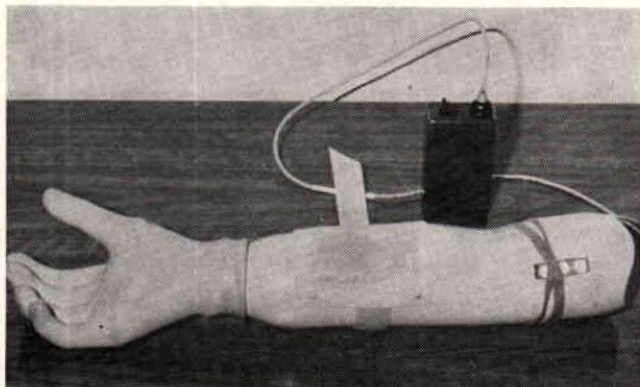
3. Prototype of bioelectric prosthesis.

The average pinch force available at the fingertips is 1.5 kilogram, which may be increased to a maximum of 2 kg., by repeating the closing command. The mechanical noise generated by the operation of the drive is audible but hardly objectionable; in fact, it provides the amputee with an indication of activity of the hand even when visual observation is not possible. An average below-elbow prosthesis with this drive weighs 0.9 Kg., exclusive of the battery.

When a set of possible sites have been identified, a multichannel device is used to determine the amount of interference or cross-talk between the muscles. The most promising pair, not necessarily anatomic antagonists, are finally selected and electrode locations established in the socket. With visual display, a significant improvement can be achieved by the amputee, greatly increasing the degree of independence of the control points.

To display myoelectric activity, an indicating meter appears to be a better choice than the oscilloscopic display or electromyographic signals.

A sightless subject was successfully trained to operate the hand by using audio-signals.



4. Modified bioelectric prosthesis constructed by the Rehabilitation Institute of Montreal.

