FEEDBACK FOR ELECTRICALLY POWERED PROSTHESES AND ORTHOSES[1]

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Basically, pressure feedback systems for upper limb electrically powered prostheses consist of sensors about the prehensile area, electronic processing circuits, and actuators that contact the body. Sensors require careful installation and tend to be vulnerable to damage. Processing circuits leave that much more delicate equipment to coordinate. Actuators sometimes unduly complicate construction and fitting.

The system to be described here makes use of the characteristic current response of an electric motor encountering a load — current increases in proportion to the load. This response is directly employed as the combined feedback/actuating signal. It is sent to a miniature direct current electric motor.[4] (fig. 1). The top of figure 1 shows three Micromo motors and the bottom of the figure, the assembled unit. On the shaft of the motor an eccentric mass is mounted. (Several such masses are shown on the right of figure 1.) This causes the motor to vibrate in proportion to the motor speed (motor speed is proportional to current). When this motor is rigidly mounted to virtually any portion of a prosthesis, the entire prosthesis will vibrate in turn (fig. 2). Thus, the entire surface of the skin in contact with the prosthesis receives feedback information. The units installed thus far in patients' below-elbow myoelectric prostheses have been fixed at the distal end of the socket with a hose clamp which has been laminated to the socket (fig. 3).

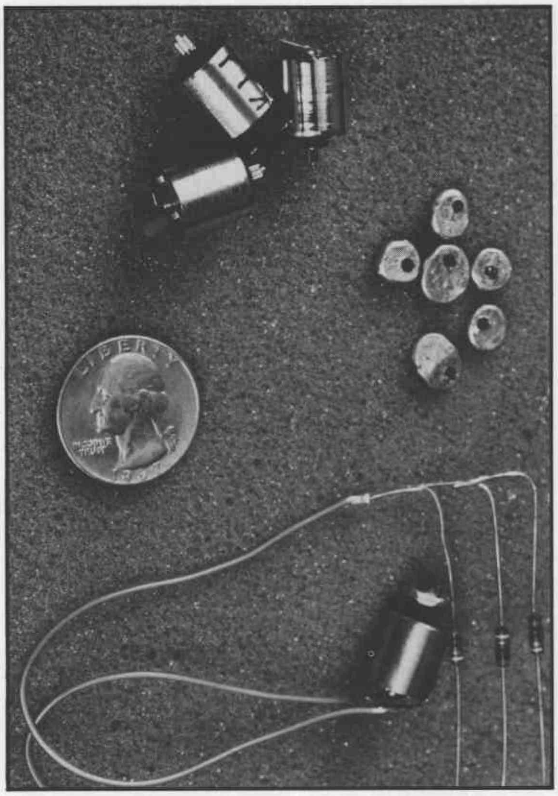

Fig 1

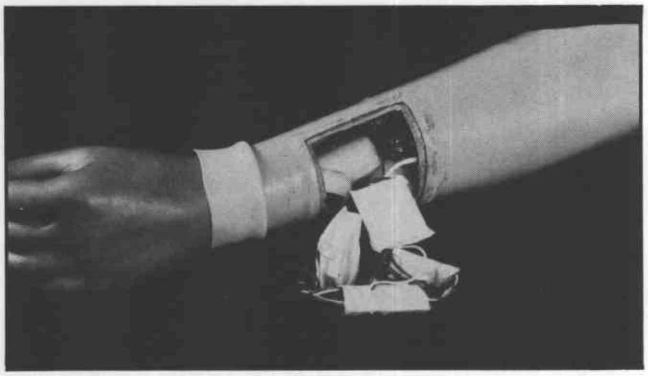

Fig 2

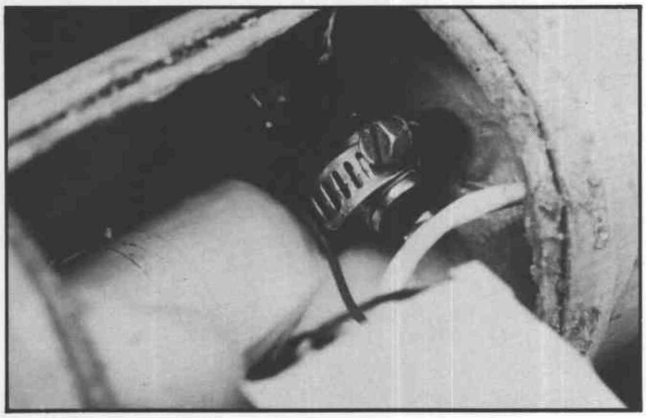

Fig 3

The feedback motor can be installed in virtually any electrically powered prosthesis by putting it in series with the drive motor(s). So that most of the current flows to the drive motor(s) and to avoid overloading the small feedback motor, a resistor of approximately three ohms is placed in parallel with the feedback motor. In order to fine tune the system, it would be convenient to have this resistor be of the variable type.

This system has been applied to myoelectric prostheses for seven patients at the Institute of Rehabilitation Medicine, New York University Medical Center. It is being applied explicitly for force feedback. But it appears to serve for position feedback as well, since the prosthetic hand unit and glove offer resistance to the drive motor as the hand opens, i.e., the greater the opening, the higher the vibration frequency. The hardness or, more importantly, brittleness, of objects could also possibly be determined by the sensing of rate of change of vibrations, i.e., vibration rate of change for a hard object like an egg is greater than that for a soft object like a paper cup. There have been no controlled studies as yet to verify these possible benefits.

A variation of the principle has been applied in the laboratory to an electric arm orthosis tried by a C-4 lesion quadruplegic patient. The feedback motor is either clipped to the user's lapel (fig. 4) or to the back of his wheelchair.

Another orthotic variation of the principle was tried in the laboratory by replacing the feedback motor with a flashlight-type light bulb to provide proportional visual feedback. Brightness of the bulb is proportional to pressure at the desensitized finger tips when used with an electrically-driven prehension orthosis.

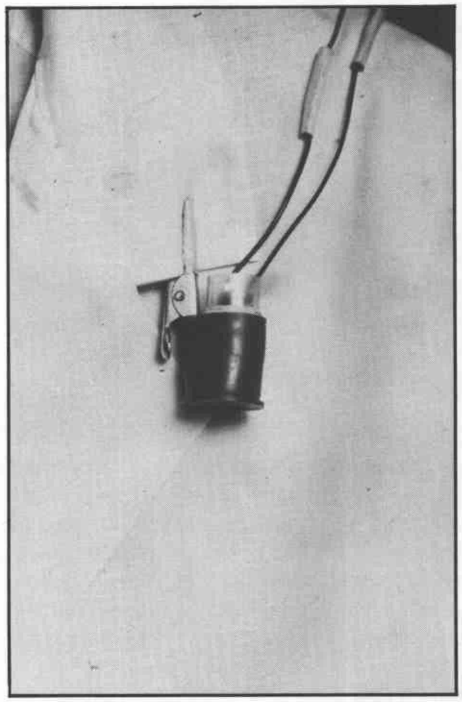

Fig 4

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