

RESEARCH INTO ELECTROMYOGRAPHIC CONTROL OF PNEUMATIC POWERED HAND PROSTHESES

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The human hand can be seen mechanically as being a grip construction. This grip construction is suspended on two relatively fixed bars (ulna and radius).

The gripper itself consists of a fixed middle block (metatarsalia) on which five arms with turning joints are fastened. Four of the five hinge at two points and can turn in one direction. The fifth arm (the thumb) can also make a rotating movement with respect to the middle block. A desired position of the hand in the space can be reached by the turning and rotating movements of the two bars of the forearm and arm.

The gripping mechanism can embrace objects with a maximal diameter of 8 inches (20 cm). The grip adjusts itself on the form of the object. This is also made possible by the movements of the arm.

Such a grip mechanism requires not only many independent pushers for the different arms but also a control apparatus for the required coordination of the different moving parts, so that the human being at every moment is informed about the position or movements of the hand and arm.

The mechanical possibilities of the present hand devices are restricted to a hinging movement of the thumb and of the fingers together. These devices also do not inform the wearer about the contact of the hand with the surroundings.

A sophisticated design of a hand prosthesis thus has to incorporate flexion of fingers, rotation of the thumb and a kind of pressure feedback. As Napier¹ (1956) and Landsmeer² (1962) have pointed out the grip mechanism of the human hand can be differentiated roughly into power grip and precision grip (precision handling).

This duality in function implies that we have to find at least three independent signals for the control, or rather four. Restricting ourselves to electromyographic control signals, the literature does not give precise indication on the method of obtaining these four independent signals. There are several possibilities: inserting needles through the

skin into the muscle, Reswick¹ (1966), or subcutaneously, Scott² (1963), or even implants, Ko³ (1965). However, till now almost every amputee refuses to permit wires or needles to be inserted in his body. Therefore, we have to rely on surface electrodes. One of the possibilities then is the three-state control but this unfortunately deprives us of proportional control. Rather than two three-state controls, Scott (1966), with two functions each, we would like to have four independent signals. The picking up of four signals from the arm yields much crosstalk problems. By training, some amputees can learn to contract so forcefully that one EMG is always stronger than the others.

So, in conclusion, we would like to have a method of getting an independent proportional control signal out of a surface EMG. After several investigations we thought that the only reliable method was that of using adjustable thresholds.

After amplification the surface EMG is rectified and led to an adjustable threshold. Only the higher peaks of the rectified myogram can pass this threshold. The peaks are then transformed into pulses. In this way it is indeed possible to obtain four separated signals.*

For several reasons, such as low weight, flexibility of movement, and design features of the artificial hand, a construction with a pneumatic drive is preferable. However, because the electromyographic signals are electrical we need a transducer from the electrical output to the pneumatic actuator.

This transducer, therefore, has to be an electrical control valve. To make the hand controllable we tried to design this valve in such a manner that both speed of movement (closing as well as opening of the hand) and the force applied to the object (only closing of the hand) can be smoothly controlled in a wide range by muscle contraction.

To implement this controllability we chose an on/off valve. This valve is fully opened for a certain period (e.g., 3 millisecs) by an electrical pulse which is excited by a myo pulse. In the interval between two pulses the valve is fully closed, so that the resulting gas flow is also pulsed. Thus a proportionality is obtained between the repetition rate of the myo pulses and that of the gas flow pulses. For technical reasons the frequency of the myo pulses per second has to be divided by 10 or 8, so that one out of 10 or 8 myo pulses gives an electrical pulse that opens the valve.

Our method needs some learning time after placing the electrodes on the forearm stump. Experience with more than fifteen amputees showed that most of them could learn controlling signals in an afternoon. The pairs of electrodes were (without jelly) mostly placed on the area of long flexors of forefinger and little or ring finger and on the area of the extensors of these fingers.

The problem of feedback had been investigated in earlier years.** Therefore, a system with piezo-pressure transducers and electrical

* to be published shortly in more details.

** to be published shortly (1966).

stimulation of the skin was developed. This system can also control the force of the grip.

In our opinion a hand prosthesis has to become part of the body image. Therefore, we principally rejected an automatic system, that makes a tool of a prosthesis.

References

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