

## THE RUSSIAN MYO-ELECTRIC ARM

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The possibility of using myo-electric potentials to control the operation of prostheses was shown by Battye, Nightingale and Whillis in 1955. The first indication of the work being undertaken in Russia came in a paper by Kobrinski and by co-workers read in Moscow in 1960. The first model to go into production as a result of this work is now being tested in this country. This arm is intended only for patients with forearm amputation and provides means of controlling the opening and closing of an artificial hand by the electrical potential produced by active use of the forearm muscles of the stump.

Surface electrodes are mounted in the socket of the prosthesis in apposition to the flexor and extensor groups of muscles, and a neutral electrode or "earth" is placed over the olecranon or some other suitable site. The muscle potential is fed to an amplifier which is of relatively low impedance and has two channels, one for the flexors and one for the extensors. The output is used as an on/off signal to control the motor which drives the hand. The closure and opening of the hand therefore occurs at a fixed speed and the force of grasp can be modulated only by timing. The hand is of reasonably acceptable appearance and is covered with a cosmetic glove. The drive causes the index and middle fingers and the thumb to move away from each other or to approximate, giving a grasp of the three-jaw-chuck type. The reversible direct current motor and its gear train and screw-jack are housed within the palm. Passive wrist rotation against friction is provided. There appears to be no built-in feedback and no means of preventing battery drain through the motor continuing to be energised under stall conditions. The electronic pack is about the size of a non-crush packet of twenty cigarettes; the battery and charger are carried in a slightly larger pack. Both these packs are carried about the person.

### CLINICAL TRIALS

The Russian arm is being fitted to seven unilateral forearm amputations in this country in a preliminary trial. The first essential training procedure is to teach the subject to isolate the contraction of the forearm muscle groups; he instinctively tends to use his muscle rather vigorously, and inevitably the antagonist muscle produces some contraction and therefore some myo-electric signal simultaneously. If signals are received simultaneously in both channels of the amplifier, neither signal is transmitted to the motor switches and the appliance is ineffective. There is also the problem of "cross-talk." By this is meant the transmission of myo-electric potential round the soft tissues to be picked up by the electrodes on the opposite side of the arm, a phenomenon particularly likely to occur with a low impedance system. Should this happen the signal is passed to the second channel and also cancels out the signals to the motors. Five of the seven patients have learnt to isolate their myo-electric signals fairly readily, but two experienced considerable difficulty. The subjects are able to contract the appropriate muscle by calling to mind their phantom hand and performing the appropriate voluntary movement of the phantom. This has been possible even for patients who had had their amputation twenty years ago.

It is too early yet to form an opinion as to the value of myo-electric systems in general or of the Russian arm in particular. There are several complicating factors. Firstly, the Russian arm is linked to a mechanical hand, and it is known that as a prehension device none of the mechanical hands produced to date is as effective functionally as a hook. Nevertheless, a mechanical hand is undoubtedly more aesthetically acceptable than a hook. The wearer of

a conventional arm prosthesis derives considerable sensory information from the reactions through his harness of the tensions on the cable controlling the prehension device. The interpolation of a powered motor in the system deprives the wearer of this direct sensation. Nevertheless, with the Russian device, information is derived from the noise of the motor, which changes pitch when the fingers close on an object, and from the vibrations of the motor, which slow down when the fingers meet resistance. Undoubtedly patients will appreciate being able to dispense with the shoulder harness. It is a matter for conjecture whether it will be less of a nuisance to carry about the battery and electronic packs together with the trailing wires leading to the prosthesis, with the addition of the chore of routine recharging of the battery. With the conventional arm there are certain positions of the upper extremity as a whole in relation to the shoulder girdle, in which the control cord becomes ineffective. This is eliminated with a myo-electric system, as indeed it is with the biceps cineplasty. Nevertheless it is safe to say that there are few if any tasks which could be performed with the Russian arm in its present form which could not be performed as effectively with conventional arms. Again, the Russian arm in its present form is not sufficiently robust to perform many of the heavy duty tasks which can be undertaken with conventional equipment. Of course this does not invalidate the principle of a myo-electric system, and it would be necessary to design a rugged motorised prehension device for heavy work for a fair comparison to be made.

One of the subjects who has now worn the arm for some months is highly delighted with it. The following are examples of his comments: "I know without looking how hard I am gripping and how far the hand is open. I think I can tell this by feeling the vibrations of the motor. I use the position of my phantom hand to control the position of the fingers of the artificial hand. I think the appearance is much more natural. Even my own child now likes to be touched by it, though he does not like my old arm. I like being able to do without the harness. The arm feels part of me. I know this arm is not strong enough for heavy work but I use my old arm for this, although I don't really like having to do so."

It will be seen that this patient reacted very favourably to the new device, but it would be appropriate to draw attention to the fact that in addition to introducing the myo-electric control, two other features were introduced at the same time. The socket of the trial arm was made according to the Munster principles (Hepp and Kuhn 1960); the top of the socket was moulded around the olecranon posteriorly and a groove made anteriorly to accommodate the biceps tendon, thus making the prosthesis self suspending and probably permitting a greater degree of control. This was very much appreciated by this particular patient. Secondly, the hand with its cosmetic cover proved particularly attractive to this patient. A new arm incorporating these two features in association with conventional controls is being made for the patient in order to provide a basis of comparison of the value of the myo-electric control *per se*. The other subjects have been less unreservedly enthusiastic.

It may be of interest that the Russian arm is also being tested in Canada at the Rehabilitation Institute of Montreal. A recent delegation to Moscow from Germany decided that it did not have the functional potential of the Heidelberg pneumatic arms (Blohmke 1964).

Work on more advanced systems is proceeding in Moscow. A forearm prosthesis with three degrees of freedom is believed to be undergoing trials. In addition to prehension, active pronation and supination and wrist flexion and extension are provided. It is not clear whether these movements are controlled sequentially by the same pair of muscles, or whether a multi-channel system is provided, using myo-electric signals from other muscles. It is believed that work is also proceeding on an above-elbow prosthesis and on a proportional control system. In this country we feel the latter is an important principle (Bottomley and Cowell 1964).

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