found not only in fecal samples but also in the CSF, and the significance of isolations was further confirmed by demonstration of serological response. In addition, the presence of antibodies to ECHO 31 in sera of about 16% of meningitis cases, from whom no virus was isolated, should be considered as further evidence of the etiological role of ECHO 31 in cases of meningitis.

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SPECIAL REPORT

A Russian Bioelectric-Controlled Prosthesis:

Report of a Research Team from the Rehabilitation Institute of Montreal

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FOLLOWING the publicity in the medical and lay press concerning a revolutionary artificial arm designed and developed in Russia, an investigation team sponsored by the Research and Training Unit of the Rehabilitation Institute of Montreal visited the United Kingdom and the U.S.S.R. from July 11 to 23 to obtain further information about this device. The official arrangements for the visit were made by the Department of National Health and Welfare, acting in concert with the Ministry of External Affairs who consented to implement this request by action through the appropriate diplomatic channels. The Rehabilitation Institute of Montreal is indebted to the Canadian Government for its efforts which helped to ensure the success of this mission.

This group was headed by Dr. G. Gingras, Executive Director, and included Dr. M. Mongeau, Chief of Service, Physical Medicine and Rehabilitation, Mr. A. Lippay, Consultant Engineer, and Mr. C. Corriveau, Consultant Prosthetist, all of the Rehabilitation Institute of Montreal.

During a brief stay in the United Kingdom the group met with Lady Hoare, Chairman of the British Trust Fund for Thalidomide Children, and with Sir Reginald Watson-Jones, both of whom had travelled recently to the U.S.S.R. to inspect the new bioelectric artificial limb developed by the Central Prosthetic Research Institute of the U.S.S.R.

As had been reported in the press, the Lady Hoare Trust Fund, through the contribution of an anonymous benefactor, recently purchased the rights to manufacture this Russian prosthesis in the United Kingdom.

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The Russians claim that some 125 patients are using the appliance successfully; this number includes double upper arm amputees. Prototypes of the arm were inspected and demonstrations were given, both in Roehampton, at the National Prosthetic Centre of the United Kingdom, and at the Central Prosthetic Research Institute of the U.S.S.R. in Moscow.

DESCRIPTION OF THE RUSSIAN ARTIFICIAL ARM WITH MYOELECTRIC CONTROL (Fig. 1)

Engineering Principles

The externally powered active component of this device is the hand, which houses the drive motor in the metacarpal area and produces a single movement of simple pinch or grasp with a maximum force of 15 kg. available at the fingertips. A detailed analysis of the motor could not be made but, according to the British group, it contains an integral gear reduction and a worm gear drive. The motor operates at a high speed with an acceptable noise level, and the small size of the battery which provides the power indicates that this type of motor is a very efficient energy converter. This development is probably a by-product of space navigational research.

Control is effected by myoelectric signals picked up by twin electrodes placed in contact with muscles selected for this purpose. The signals are magnified by a miniature transistorized amplifier, which in turn drives an electronic gating unit or relay to control the motor. The motor then runs in the desired direction to open or close the hand, stopping when the signal is discontinued. The position of the hand is then mechanically held until a reverse signal is received by the amplifier. Should both control muscles issue commands simultaneously, the system automatically shuts itself off to conserve the battery.

A simple contraction of the control muscles is sufficient to turn on the amplifier. Visual feedback through the eyes of the operator is used to follow the action of the hand. Normally, antagonistic muscles are used to provide "close" and "open" commands through individual electrode pairs and amplifier channels, operating through the same motor drive. The response of the system is rapid, without noticeable delay; the stopping and reversing is almost instantaneous and the time delay from signal input to motor action is negligible.

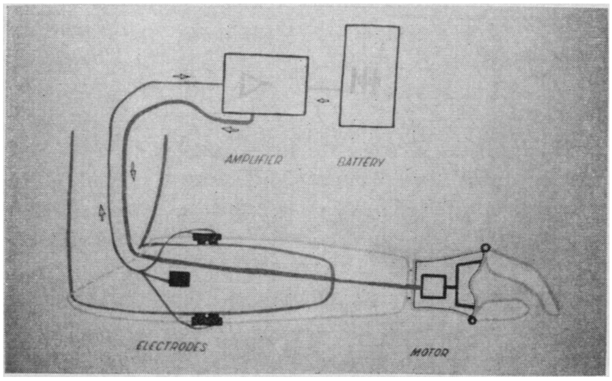

Fig. 1.—Diagram indicating the connections of the apparatus from the battery and amplifier to the motor in the hand. (See text.)

Prosthetic Aspects

Construction and materials.—The glove encasing the hand is apparently made of semi-elastic rubber compound, and according to Russian claims will ordinarily last for one month. The colour of the glove matches the skin, a feature which is desirable for cosmetic reasons. As well, it provides a good coefficient of friction for grasping. The glove is fitted loosely over the hand to afford room for movement without undue interference.

Terminal device.—The handpiece consists of a metacarpal base which lodges the drive motor. The proximal end attaches to the wrist joint, and the fingers and thumb are attached to the base by means of hinges. It was not possible to ascertain the type of material and the manufacturing process employed to construct this piece of the device, but its light weight suggested that it is made of aluminum. The fingers appear to have a metal insert with a hard felt covering. The hinged suspension corresponds anatomically to the metacarpophalangeal joints. The interphalangeal joints are fixed in a slightly flexed position. Upon closure of the hand, the tip of the thumb falls between the tip of the middle and index fingers, and the pinch or grasp occurs approximately in the centre line of the forearm.

Wrist.—This prosthesis has no wrist joint corresponding to the types used in Western practice. The handpiece is attached to the distal end of the forearm socket by means of a bayonet-type inter-

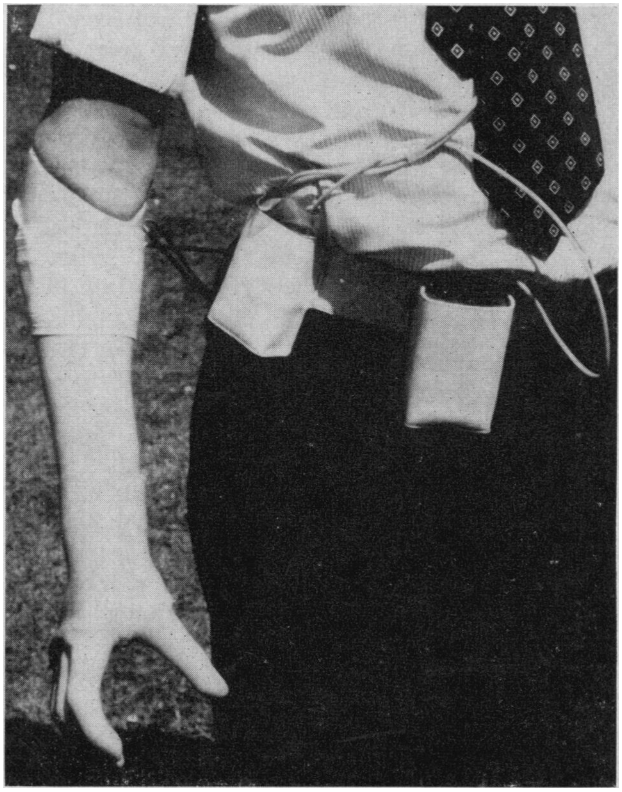

Fig. 2.—A patient in Roehampton, England, wearing the Russian bioelectric artificial arm and attachments. (See text.)

locking unit, providing minimal rotational adjustment of the wrist, which is maintained by friction. There appears to be no allowance made for the interchangeability of terminal devices such as a hook.

Forearm.—The forearm is made of flesh-coloured, laminated plastic material with a double wall construction, and this type of socket represents no major deviation from the conventional plastic prosthesis generally in use today. The proximal end of the socket is terminated in a cup surrounding the olecranon process. Windows are provided in the socket to hold the control electrodes over the muscle sites.

Suspension.—A light leather strap is used as a means of suspension which has a medial and lateral point of attachment, approximately 1½ inches below the true axis of the elbow joint. This strap encircles the condyles of the elbow and secures the socket in place. In this application there is no need for an elbow joint.

Accessories.—The control amplifier and the battery powering this prosthesis are carried in two small pouches attached to the amputee's belt. The wiring is cabled and looped around the opposite shoulder, then routed to the electrodes and the motor drive along the arm and forearm, entering the handpiece at the level of the wrist (Fig. 2).

Physiatric and Clinical Aspects

Muscular strength and at times strenuous exertion are necessary to perform movements of the terminal devices in conventional prostheses. With the myoelectric-control prosthesis, no great effort is required to initiate movements.

The amputee using this prosthesis does not appear to become tired, as he uses only isometric contractions of muscles of the stump to perform the movements of the artificial hand. With the ordinary prosthetic appliance, the amputee has to use gross movements of the shoulder girdle to activate the terminal devices, and he tires more rapidly.

When the amputee uses the isometric contraction of one muscle in his stump to perform one movement, without resort to any other compensatory movement, he has the impression that he performs the pinch or grasp with his own hand. This is virtually realistic, as the pinch or grasp is performed by contraction of the flexor muscles and the fingers are extended by contraction of the extensor muscles.

As there is direct contact of the stump with the interior wall of the socket, the stump sock is completely eliminated.

With this new type of prosthesis, the fingers of the artificial hand can be flexed and extended at whatever position the elbow and the shoulder might be at the time. The utilization of this hand therefore considerably improves the performance and dexterity of the amputee.

The appearance and function of the prosthesis are superior because the flexion and extension of *all of the five fingers* are present. In the conventional prosthesis, the 4th and 5th fingers are not functional and they do not move.

The Russian hand with myoelectric control has been used only by adult amputees who have had below-elbow amputations for some time past. The prosthetic training of an amputee wearing a prosthesis with myoelectric control will be quite different from the training of the amputee wearing a conventional prosthesis or a prosthesis activated by carbon dioxide. Such training is divided into two phases. The initial training will take place in the research laboratory where the amputee, with the aid of oscillographs, will learn how to individualize isometric contractions of the selected muscles. It is essential that the amputee should be able to individualize contractions of two, four, or six muscles in his forearm. The second phase of the training will be carried out in the occupational therapy department.

CONCLUSIONS

The bioelectric-controlled prosthesis is cosmetically acceptable and its operation is satisfactory. Its response is rapid, and the stops and reverses of its action occur almost instantly. The operation of the motor does produce some noise which may be objectionable under certain conditions, and measures should be effected to reduce this factor.

The present design of the hand provides for one size only, i.e. a male adult hand. Further development will be necessary to apply this prosthesis to female and child amputees as well as to accommodate other interchangeable terminal devices, such as a hook, etc.

The Russian bioelectric prosthesis at present has only two motions: opening and closing of the hand. Powered supination and pronation, wrist flexion and extension, as well as elbow flexion for above-elbow amputees, would be highly desirable.

This prosthesis cannot be used at present for thalidomide children with severe upper extremity malformations. It should be possible at approximately the age of four to teach a child with phocomelia of the upper extremity to activate electronically a hand, wrist, forearm and possibly an elbow, by using the digits of the phocomelic hand.

There is no doubt that the Russian development of the bioelectric artificial limb represents a major contribution in the field of prosthetics. The future of advanced prosthetic appliances for the upper extremity lies in research in the further application of electronic principles.

More research in this area is indicated, with the ultimate goal of providing the thalidomide child with a bioelectric limb consisting of more channels to enable a normal range of motions, as well as an efficient prosthetic device for upper extremity amputees. The principles of myoelectric control could conceivably be applied in the future for other types of disability in patients with upper or lower motor neurone lesions.

PAGES OUT OF THE PAST: FROM THE JOURNAL OF FIFTY YEARS AGO

THE ORE SO WIDELY SCATTERED

From the time of the Alexandrian School to the present, no great medical centre ever developed apart from good libraries. Osler has said, "it is hard to speak of the value of libraries in terms which would not seem exaggerated. To study the phenomena of disease without books is to sail an uncharted sea, while to study books without patients, is not to go to sea at all. For the teacher and worker a great library is indispensable. They must know the world's best work and know it at once; they mint and make current coin, the ore so widely scattered in journals, transactions and monographs." It should therefore be our steady aim to make this one of the great medical libraries of the world, and I believe many of us will live to see the day when this shall have been accomplished. It may be of interest to you to know that among medical libraries at present, The Academy of Medicine, Toronto, ranks second in Canada, twenty-ninth on this continent, and seventy-sixth in the world.

When Dr. Billings took charge of the Surgeon General's Library at Washington in 1865, it contained less than two thousand volumes, while at present it has on file one hundred and seventy-five thousand five hundred and seven volumes, and its index-catalogue has a reference to every rare case that has been recorded since the discovery of printing, A.D. 1450.—H. B. Anderson, *Canad. Med. Ass. J.*, 4: 1038, 1914.