Jan. 27, 1970 D. M. IOFFE ET AL 3,491,378

ARTIFICIAL ARM HAVING BIOELECTRICALLY CONTROLLED FINGER MOVEMENT AND HAND ROTATION RESPONSIVE TO SHOULDER MUSCLE IMPULSES

Filed Feb. 28, 1967

3 Sheets-Sheet 1

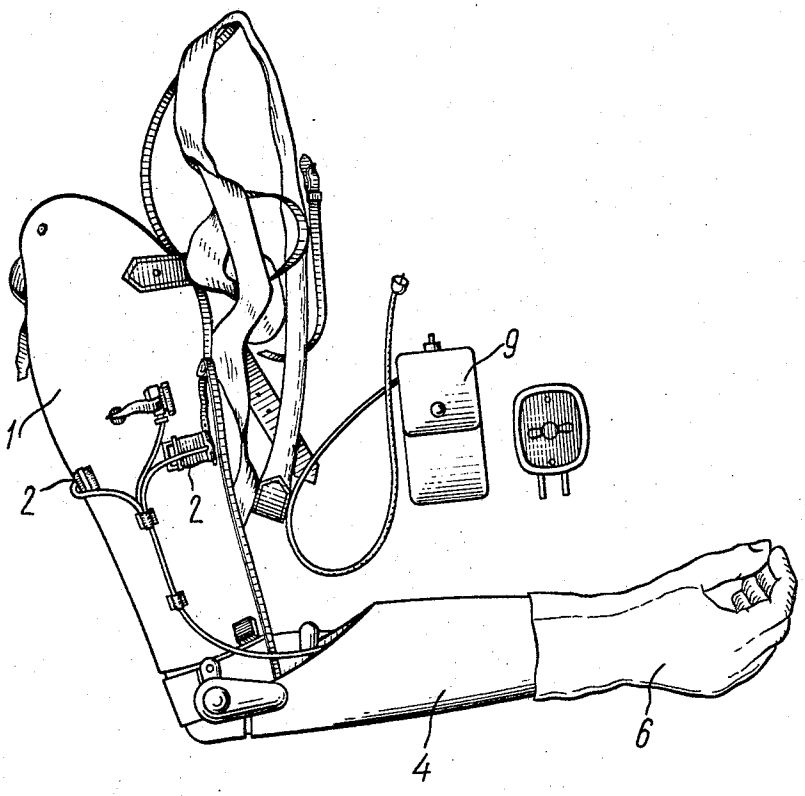

FIG. 1

Jan. 27, 1970 D. M. IOFFE ET AL 3,491,378
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Filed Feb. 28, 1967 3 Sheets-Sheet 2

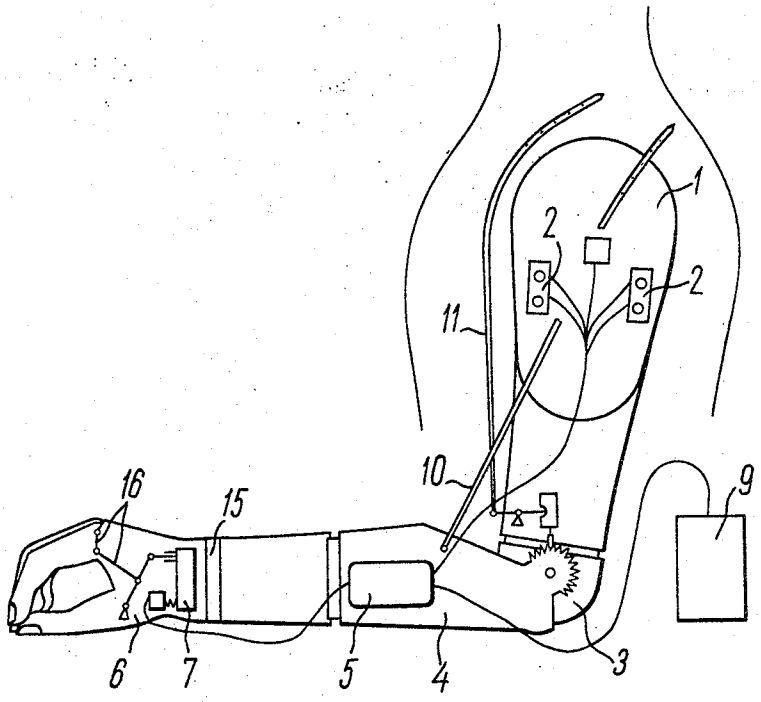

FIG. 2

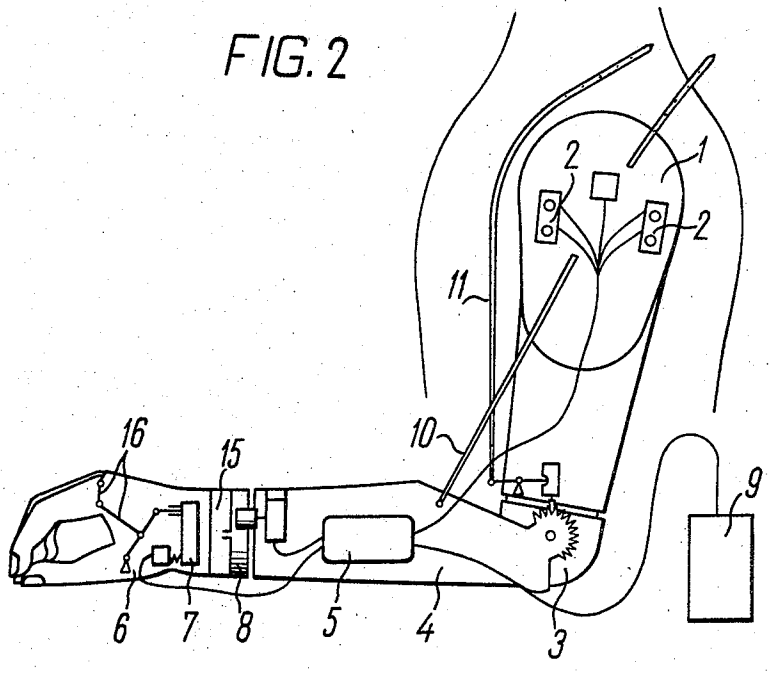

FIG. 4

Jan. 27, 1970 D. M. IOFFE ET AL 3,491,378
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Filed Feb. 28, 1967 3 Sheets-Sheet 3

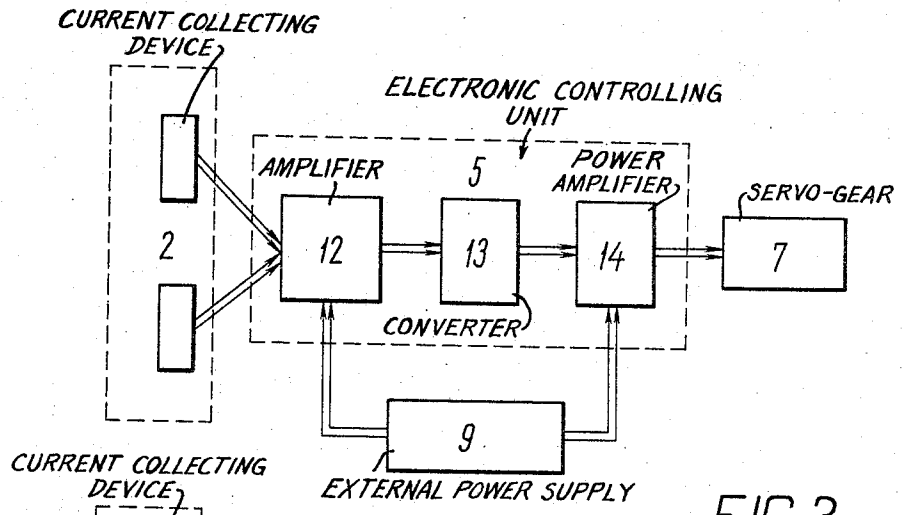

FIG. 3

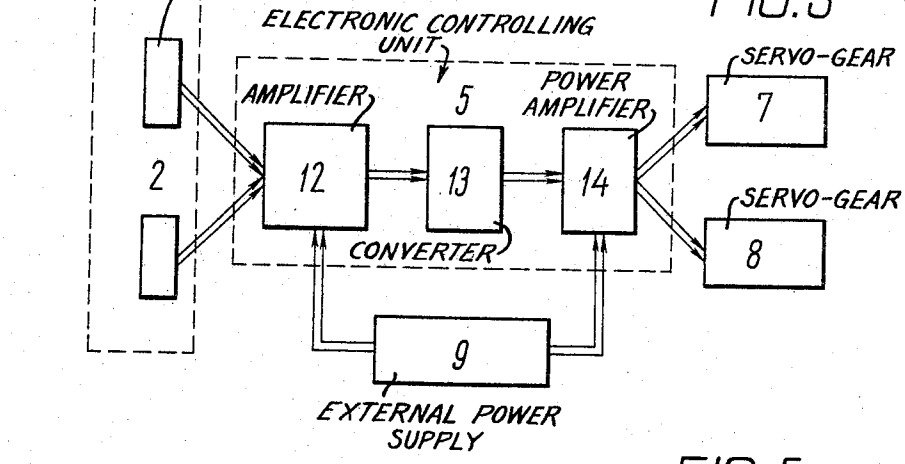

FIG. 5

United States Patent Office 3,491,378 Patented Jan. 27, 1970

3,491,378

ARTIFICIAL ARM HAVING BIOELECTRICALLY CONTROLLED FINGER MOVEMENT AND HAND ROTATION RESPONSIVE TO SHOULDER MUSCLE IMPULSES

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U.S. Cl. 3—1.1 2 Claims

ABSTRACT OF THE DISCLOSURE

An artificial arm in which the hand is provided with fingers capable of opening and closing movement and with the arm being capable of rotation relative to the forearm portion, the signal for the opening or closing of the fingers and/or the rotation of the hand being provided by current collecting devices located within a shoulder member activated by the biological current from the muscles of the shoulder stump. The power for actuating the finger movement is from an external source of power with both the signals and power being amplified and converted in an electronic control unit disposed within the forearm member.

The present invention relates to prosthetic devices and more particularly to active artificial arms having a combined control, both bioelectric and rod.

Artificial arms having a shoulder socket placed on the shoulder stump are known that comprise an elbow joint operated by means of rods and connected to the shoulder socket; a forearm socket pivotally attached to the elbow joint and provided with means for rotating the forearm (supination-pronation of the artificial hand); and an artificial hand complete with movable fingers united with the forearm socket. The main movements such as bending and straightening of the arm at the elbow joint and opening and closing of the fingers of the artificial hand are carried out in said prostheses by the aid of rods.

Movement by means of said active artificial arms requires great effort by the wearer of the arm. These efforts are particularly great when opening and closing the fingers of the artificial hand. The possibility of making these movements is restricted as they can be performed only in a number of certain positions of the stump (prosthesis). The process of transmitting these efforts from the shoulder and other parts of the body by the aid of rods is very uncomfortable and requires complex and often unsightly movements.

An object of the present invention is to eliminate the foregoing disadvantages.

The principal object of the invention is to provide an active artificial arm having a combined control, both bioelectric and rod, which insures a high functional and physiological controllability and does not require great efforts on the part of the wearer for performing movements, in which the most difficult process viz the manipulation of the artificial hand fingers would be effected by biological currents of muscles of the shoulder stump

in any position thereof, in which the movements of the fingers may be proportioned i.e. a person could effect different degrees of opening and closing of the artificial hand fingers, which would insure the bioelectric control over not only movements of the artificial hand fingers but also over the rotation (pronation-supination) of the hand.

To achieve this object, the proposed active artificial arm is provided with an electronic unit controlled by biological currents from the shoulder stump muscles and with a servo-gear electrically connected therewith and supplied with power from an external power source. The electronic unit includes switches, a current collector taking off the biological currents from the shoulder stump muscles, an amplifier of biological potentials, a converter, and a power amplifier connected to the servo-gear.

According to the present invention, the proposed prosthesis is provided with an additional reversing servo-gear of rotation for controlling the second pair of movements (pronation-supination of the hand) which is connected to the electronic unit and to the external power source.

The foregoing and other objects and advantages of the present invention will become more fully apparent from the following description of one embodiment of the active artificial arm, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a general view of the active artificial arm according to the present invention, which has a combined control, both bioelectric and rod;

FIG. 2 is a diagrammatic view illustrating an active artificial arm having a combined, control both bioelectric and rod, in which only one pair of motions (opening and closing of the fingers of the artificial hand) is controlled by the aid of biological currents;

FIG. 3 shows a block-diagram of the bioelectric control over one pair of motions;

FIG. 4 is a diagrammatic view illustrating an active artificial arm having a combined, control both bioelectric and rod, in which two pairs of of motions (opening and closing of the fingers of the artificial hand and the pronation-supination of the hand) are controlled by the aid of biological currents;

FIG. 5 shows a block-diagram of a system of the bioelectric control over two pairs of motions.

As can be seen from FIGS. 1 to 5, an active artificial arm having a combined control, both bioelectric and rod, consists of: a shoulder socket **1**, a current collecting device **2** for taking off the biological current from the shoulder stump muscles; an elbow joint **3**; a forearm socket **4**; an electronic controlling unit **5**; an artificial hand **6**; reversing servo-gears **7** and **8**; an external source of power supply **9**; and rods **10** and **11**.

The shoulder socket **1** is made of plastic and is designed to accommodate the shoulder stump therein. In the lower part of the shoulder socket there is the elbow joint **3** (FIGS. 2 and 4) which enables the wearer to effect an active bending of the arm at the elbow and a passive rotation of the shoulder.

The shoulder socket **1** is provided with the device **2** for taking off the biological currents of muscles controlling the shoulder stump.

The forearm socket **4** is pivotally attached to the elbow joint **3**. Disposed in said forearm socket **4** in the same casing is the electronic controlling unit **5** consisting of an amplifier bioelectric potentials **12** (FIG. 3), of a converter **13**, and a power amplifier **14**. Secured in the upper part of the shoulder socket are the rods **10** and **11** (FIGS. 2 and 4) by means of which the elbow joint **3** is operated.

The forearm socket **4** is connected to the artificial

hand **6** through a special ring **15**. The hand **6** is provided with the reversing servo-gear **7** consisting of an electric micromotor and a reducing gear (not shown). The movable thumb and the movable block of four fingers of the hand are connected to said reducing gear by means of levers **16**. An elastic cosmetic glove covers the hand. The external source of power **9** may be disposed either inside the prosthesis in the forearm socket **1** (if the shoulder stump is short) or outside the prosthesis, for example in the wearer's clothes.

The electronic controlling unit **5** (FIG. 3) has two independent identical channels, each of which controls one motion such as opening or closing of the fingers of the artificial hand. The bioelectric signal taken off by electrodes of the current collecting device **2** from the stump controlling muscle enters the amplifier **12** of biological potentials wherein its amplitude is amplified. From the amplifier **12** of bioelectric potentials said signal having an amplified amplitude passes into the converter **13** where it is transformed into a form convenient for operating the servo-gear **7**, and passes from it into the power amplifier **14**. The transformed and amplified power signal controls the power supply from the power source **9** to the servo-gear **7** which actuates the fingers of the artificial hand **6** of the prosthesis.

In cases when the prosthesis must effect the bioelectric control over two pairs of movements, such as over the opening and closing of the artificial hand fingers and over the rotation of the forearm (pronation-supination of the hand) as well, the forearm socket **4** is provided with the second reversing servo-gear **8** (FIGS. 4 and 5) which permits the rotation of the artificial hand **6** to be controlled with respect to the forearm socket **4**.

The system of bioelectric control may be designed so that it will permit the two controllable motions to be performed either simultaneously or successively. If it is necessary to insure the possibility of the simultaneous performance of different motions (opening-closing of the fingers of the hand and the pronation-supination thereof), the biological currents are taken off from four muscles, and the electronic controlling unit is designed with four identical channels. The successive performance of motions makes it possible to take off the biological currents from only two muscles and to design the electronic controlling unit with two channels; but in this case provision is made for switching the servo-gears in said electronic controlling unit. This switching is effected physiologically with the simultaneous feeding of the biological signals from the two controlling muscles.

The elbow joint is operated (the artificial arm is bent or straightened in the elbow joint) by means of the two rods **10** and **11** (FIGS. 2 and 4). The rod **10**, when pulled, accomplishes bending of the arm in the elbow joint, while

the rod **11** serves for fixing the elbow and releasing the elbow lock.

What is claimed is:

1. An active artificial arm including a shoulder socket member for receiving the stump of an amputated arm, an elbow joint member pivotally connected to the shoulder socket member, rod means operably connected to the shoulder member and the elbow joint member for manipulating the elbow joint member, collector means within the shoulder socket member for taking off the biological current from the muscles of the shoulder stump, a forearm socket member pivotally attached to the elbow joint member, a hand having movable fingers, means mounting the hand on the forearm socket member for relative rotation about the longitudinal axis of the forearm socket member, an electronic control unit within the forearm member operably coupled to the collector means, a reversing servo-gear means within the hand electrically connected to the electronic-control unit, means operably coupling the fingers with the servo-gear means for controlling the openings and closing motions of the fingers, means within the forearm socket member for rotating the hand relative to the forearm socket member operably coupled to the electronic control unit for effecting relative rotation between the hand and the forearm socket member, and an external source of energy operably connected to the electronic control unit for providing a power supply for such unit.

2. The active artificial arm as claimed in claim **1** in which said means for rotating the hand relative to the forearm includes a second reversing servo-gear means.

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U.S. Cl. X.R.

3—12.3, 12.5, 12.7