United States Patent

Crapanzano

[15] **3,683,423**

[45] **Aug. 15, 1972**

[54] **GRAVITY ACTIVATED PROSTHETIC DEVICE**

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[21] Appl. No.: **107,791**

[52] **U.S. Cl.** 3/1.1, 3/12.6, 3/12.7, 200/182

[51] **Int. Cl.**.....**A61f 1/06**

[58] **Field of Search**.....3/1.1, 1.2, 12–12.7

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Primary Examiner—Richard A. Gaudet
Assistant Examiner—Ronald L. Frinks
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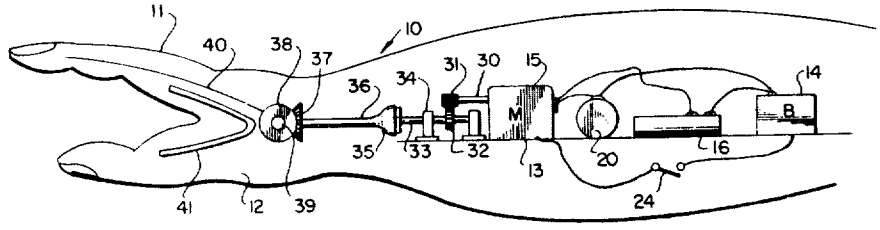
[57] **ABSTRACT**

A prosthetic device, especially for use as an artificial arm and hand. An electrical device operates grasping elements at the outer end of the prosthetic device. The flow of electrical current to the electrical device is in turn controlled by mercury switches which are positioned such that the position and orientation of the prosthetic device determines whether or not current is transmitted to the electrical device to operate the grasping elements.

20 Claims, 11 Drawing Figures



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SHEET 1 OF 2

FIG. 1

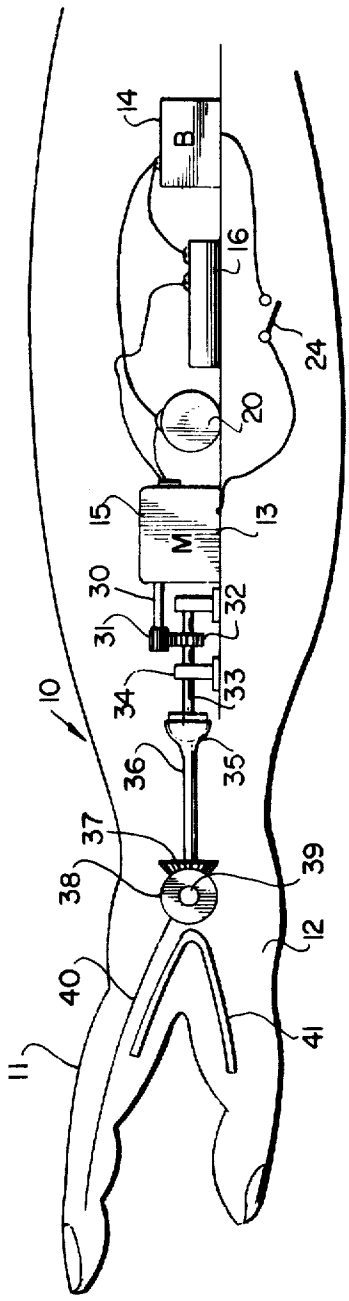
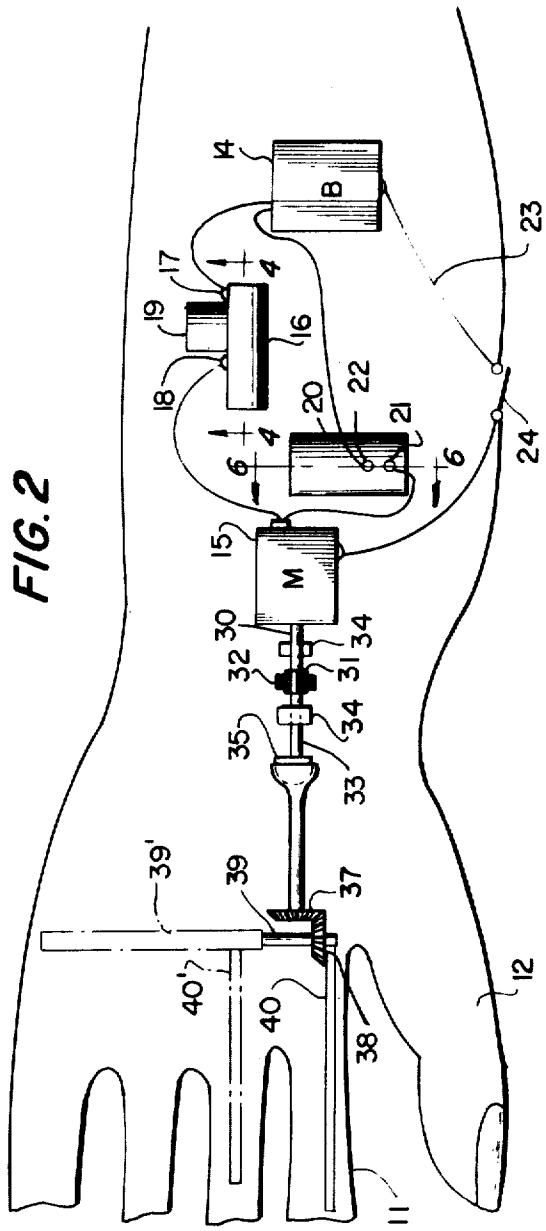


FIG. 2



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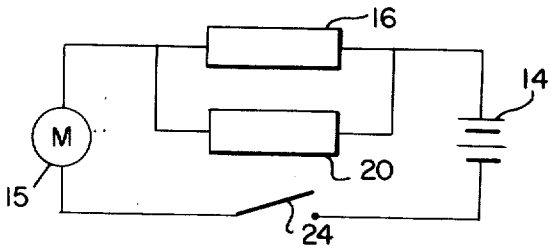

FIG. 3

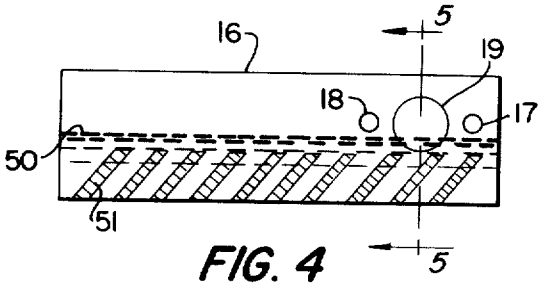

FIG. 4

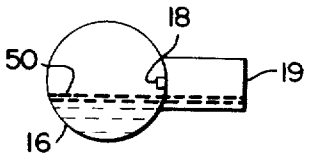

FIG. 5

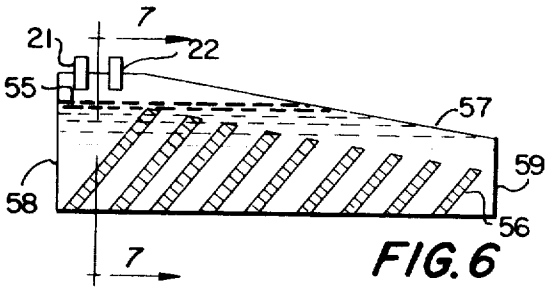

FIG. 6

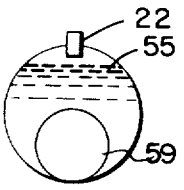

FIG. 7

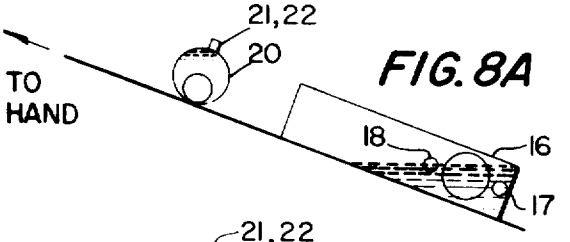

FIG. 8A

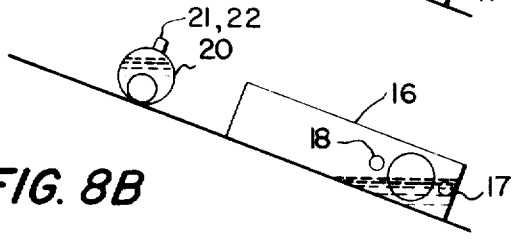

FIG. 8B

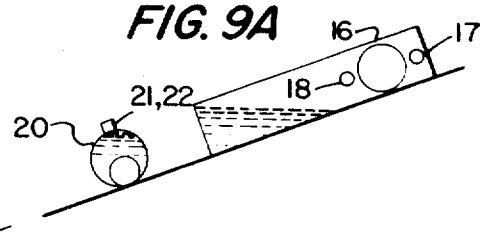

FIG. 9A

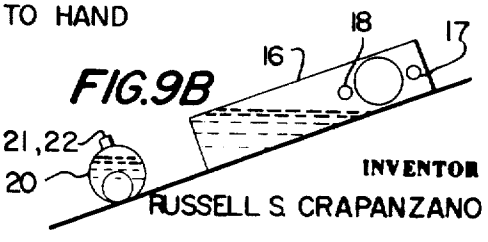

FIG. 9B

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GRAVITY ACTIVATED PROSTHETIC DEVICE

BACKGROUND OF THE INVENTION

This invention relates to prosthetic devices, and in particular it relates to a new and improved prosthetic device, especially for use as an artificial arm and hand.

Prosthetic devices have been known heretofore. Generally, however, they have been quite complex and hence quite expensive. For example, the thrust of the development heretofore has been concerned with procedures for simulating as closely as possible natural body movements; and such devices tend to be quite complex, and hence quite expensive. An example of such a complex prosthetic device is shown in U.S. Pat. No. 2,701,370. More recent developments are concerned with procedures for operatively interconnecting the nerves of the user with the prosthetic device itself so that the device will operate automatically in response to their impulses. While such developments intrigue the imagination and represent a significant advancement in the art, they will nonetheless continue the trend of greater complexity and cost in prosthetic devices.

Unfortunately, however, these developments towards more efficient, but more complex and more expensive devices do not satisfy the need. Because of their expense, the devices are beyond the financial reach of many persons who need an artificial arm, but simply cannot afford one. This present state of affairs is especially tragic in the case of persons for whom a less complex, and hence a less expensive device would at least partially suffice.

Another disadvantage of known prosthetic devices is that the means for operating them has either been located externally, (cords, straps and the like) thereby marring the appearance of the device or has required surgery (for example in devices linked to the nerves of the user).

Thus, there exists a need for a new and improved prosthetic device which is simple to operate, and hence relatively inexpensive, and which at the same time has good esthetics.

SUMMARY OF THE INVENTION:

The purpose of this invention is to provide a new and improved prosthetic device which overcomes the disadvantages of the prior art.

This purpose of the present invention is achieved by providing a prosthetic device in which the moving parts are actuated by an electrical means which is in turn controlled by gravity actuated means such as one or more mercury switches. The switches would be strategically positioned such that the electrical means would be operated in dependence upon the position and orientation of the prosthetic device itself.

For example, in a preferred arrangement of the invention for use as an artificial arm and hand, the mercury switches would be positioned such that movement of the arm above shoulder level would actuate one switch and movement of the arm below the shoulder level would actuate another switch. The actuation of either switch could be sufficient to operate the electrical means. In the preferred arrangement of an artificial arm and hand, the electrical means could be connected by a suitable slip clutch and suitable gearing to one or more of the fingers for urging said one or more fingers against the thumb to effect a grasping action. A leaf spring or the like could be provided normally urging the fingers and the thumb apart whenever the electrical means is not operating to cause the grasping movement. A manually operated switch could be provided to completely deactivate the system when it is desired to raise or lower the arm without effecting a grasping movement.

Thus, it is an object of this invention to provide a new and improved prosthetic device which is relatively simple in its construction and operation.

It is another object of this invention to provide a prosthetic device in which the operating means such as gravity operated switches are located internally within the device so that operability can be achieved without marring or complicating the external appearance of the device.

It is another object of this invention to provide a new and improved artificial arm and hand having a system of gravity operated mercury switches which operate in dependence on the position and orientation of the user's arm.

It is another object of this invention to provide a new and improved artificial arm and hand having a system of mercury switches arranged such that movement of the arm above and below a horizontal plane through the shoulder activates the switches while rotational movement of the arm about its axis de-activates the switches.

Other objects and advantages of the present invention will become apparent from the detailed description to follow, together with the accompanying drawings.

BRIEF SUMMARY OF THE DRAWINGS

There follows a detailed description of the preferred embodiments of the invention to be read together with the accompanying drawings.

FIG. 1 is a side elevational view of an artificial right hand constructed in accordance with the features of the present invention, viewed from the central or mesial plane.

FIG. 2 is a plan view of FIG. 1.

FIG. 3 is a circuit diagram showing the operation of the invention.

FIG. 4 is an enlarged cross-sectional view of one of the mercury switches and is taken along line 4—4 of FIG. 2.

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 4.

FIG. 6 is an enlarged cross-sectional view of the other mercury switch in FIG. 2 and is taken along line 6—6 of FIG. 2.

FIG. 7 is a cross-sectional view taken along line 7—7 of FIG. 6.

FIGS. 8A and 8B show the operation of the mercury switches when the arm is raised.

FIGS. 9A and 9B show the operation of the mercury switches when the arm is lowered.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Referring now to the drawings, like numerals represent like elements throughout the several views.

Referring to FIGS. 1 through 3, there is shown a prosthetic device 10 in the form of an artificial arm and hand including an index finger 11 and a thumb 12.

The operating elements are located internally within the device 10. 13 represents a horizontal reference plane which will be referred to hereinafter. A battery 14 is arranged to drive an electric motor 15. One line between the battery 14 and the motor 15 includes two gravity operated mercury switches 16 and 20 which are arranged electrically in parallel with each other. The other line 23 between the battery 14 and the motor 15 includes a manually operated switch 24 located externally of the device 10.

Referring to FIG. 2, and also to FIGS. 4 and 5, the switch 16 is an elongated capsule arranged generally parallel to the longitudinal axis of the device 10. It includes a pair of electrical terminals 17 and 18 connected respectively to the battery and the motor. These terminals are purposely located at the end of the capsule remote from the hand. This capsule also includes a reservoir chamber 19 extending outwardly to the right relative to the mesial plane of the user. The purpose of this reservoir chamber will be explained in greater detail below in the description of the operation of the invention. The mercury level in switch 16 is shown at 50 in FIGS. 4 and 5. The device may also include baffles such as 51 (see FIG. 4) for controlling the flow of mercury within the capsule.

Referring now to FIGS. 2, 6 and 7, a second mercury switch 20 includes a pair of terminals 21 and 22 connected with the motor 15 and the battery 14, respectively. This switch is arranged perpendicular to the longitudinal axis of the arm and its cross-section tapers downwardly as shown at 57 in FIG. 6 between an enlarged end 58 and a smaller end 59. This downward taper extends in the direction from the mesial plane to the right. It will be noted that the terminals 21 and 22 are located on top of the switch 20 at the portion thereof having the largest cross-section. The mercury level 55 is shown in FIG. 6. This switch may also include baffles 56 for controlling the flow of mercury within the capsule.

Whenever either of the switches 16 or 20 (and the switch 24) is closed, current will be transmitted to drive the motor 15 thereby turning the motor shaft 30. Fixed therewith is a gear 31 which rotates a gear 32 fixed on a shaft 33 mounted in bearing supports 34. The outer end of shaft 33 is connected by a suitable slip clutch 35 such as the cone shaped slip clutch shown in the drawings to a further shaft 36 which has fixed thereon a bevel gear 37 which meshes with and hence turns a bevel gear 38 mounted on a cross shaft 39. Fixed for rotational movement with either the gear 38 or the cross-shaft 39 is a rod 40 which extends up into the index finger. Therefore, turning of the shaft 39 causes the index finger 11 to move towards, that is flex towards the thumb 12. This will cause the desired grasping action. A spring 41 normally urges the index finger 11 and the thumb 12 apart. Therefore, when a force is no longer applied urging the index finger 11 toward the thumb 12, the index finger and the thumb will separate from each other.

Although the above description is concerned with flexing only the index finger 11, suitable means may be employed to cause flexing of one or more of the remaining fingers. For example, referring to FIG. 2, the shaft 39 may be extended as shown in dotted lines at 39' and further rods 40' may extend from this shaft 39' into any of the other three fingers.

The switches 16 and 20 have been described as "-mercury" switches. This is the common name for this type of switch. However, it is to be understood that the substance within the switches need not be pure mercury but may be any composition which at room temperature is at a liquid state and which conducts electricity.

The energy source is shown as a battery 14. However, energy may be supplied by using electrical transformers or any other source desired.

The operation of the embodiments shown in FIGS. 1 through 7 will now be described, especially with reference to FIGS. 8A, 8B, 9A and 9B.

When the user wishes to utilize the present invention to grasp an object between finger 11 and thumb 12, he first of all closes the manual switch 24. If he wishes to raise his arm above a horizontal plane extending through his shoulder, mercury will flow to the end of the capsule 16 closest to the shoulder thereby crossing the terminals 17 and 18 as shown in FIG. 8A. Current will then flow to the motor 15. If the user now wishes to cut off the flow of current to motor 15 while maintaining his arm in an upright position (and without opening the switch 24) he may simply turn his right arm about its longitudinal axis towards the outside. The term "-towards the outside" is defined as clockwise motion of the right arm when viewed from the shoulder. This motion will cause a sufficient quantity of mercury in capsule 16 to flow into the reservoir chamber 19 such that there is insufficient mercury remaining in the main portion of capsule 16 to contact both the terminals 17 and 18. FIG. 8B is a cross-sectional view of the two mercury switches taken after such rotation about the longitudinal axis has occurred. There appears to be less mercury in the capsule 16 and this is because a quantity of mercury has flowed into the reservoir chamber 19 such that the mercury no longer crosses the terminals 17 and 18.

Although the main purpose of the mercury switch 20 is to activate the motor when the arm is lowered, the arrangement of this switch must also be considered for the situation in which the arm is raised. As shown in FIG. 8A, when the arm is raised, the mercury may reach and hence cross the two terminals 21 and 22. However, this is of no consequence since it will occur only when the terminals 17 and 18 are also being crossed by the mercury within switch 16. However, it is important to note that the terminals 21 and 22 are located at the inside end of the switch 20. Therefore, when the arm is rotated outwardly in the manner described above, the mercury in capsule 20 will also flow to the outside (to the right as shown in FIG. 6) so that it does not cross the contacts 21 and 22. Note the lower level of mercury in the switch 20 in FIG. 8B.

When the user wishes to grasp an object with his arm in the lowered position (that is, in a position extending beneath a horizontal plane through the shoulder), the mercury in the switch 20 will contact both of the terminals 21 and 22 to cross the same as shown in FIG. 9A. The user may then terminate the flow of current through switch 20 by simply rotating the arm outwardly. The mercury will then flow to the outer end of

switch **20** in the same manner as described above in the arm raised position. This rotated, lowered position of the capsule **20** is shown in FIG. **9B**. Meanwhile, at all times during the arm lowered position, the mercury in capsule **16** is sufficiently far forward of the terminals **17** and **18** that it will at no time cross these terminals.

During a grasping motion, the motor **15** will continue to operate, the output force thereof continuously being held at the rod **40**. While the object is being held, the shaft **33** will simply slip at the clutch **35** relative to the shaft **36**.

Although the invention has been described in considerable detail with respect to the preferred embodiments thereof, it will be apparent that numerous variations and modifications are apparent to those skilled in the art without departing from the spirit and scope of the invention.

I claim:

1. A prosthetic device for replacing an extremity of the body comprising: a joint construction having elements capable of movement between different positions, an electrically operated drive means operatively connected to the joint construction to cause said movement, a source of electrical energy, circuit means selectively electrically connecting said source to said drive means to operate the latter, and at least one mercury switch included in the circuit means between the source and the drive means, said mercury switch being positioned such that in certain orientations of the prosthetic device the mercury switch closes the circuit means between the source and the drive means to deliver current, and in other orientations of the prosthetic device the mercury switch opens the circuit means between the source and the drive means.

2. A device according to claim **1**, wherein said mercury switch is constructed such that the mercury therein crosses the terminals of the switch to close the circuit means in dependence on the rotational orientation of the switch about both (a) a reference axis passing through the switch and perpendicular to a vertical plane which includes the longitudinal axis of the device and (b) said longitudinal axis.

3. A device according to claim **2** including a pair of mercury switches connected electrically in parallel between the source and the drive means, the two switches being positioned such that movement of the device in said vertical plane about said reference axis to a first orientation closes one of said mercury switches and movement of the device in said vertical plane about said reference axis to a second orientation closes the other of said switches.

4. A device according to claim **3**, said mercury switches being further constructed such that in either of said first or second orientations, a predetermined rotation of the prosthetic device about said longitudinal axis can open the circuit means.

5. A prosthetic device for replacing the lower arm and hand of the body comprising: a joint construction at the outer end of said device and capable of undergoing a grasping movement, an electrically operated drive means operatively connected to the joint construction to cause said movement, a source of electrical energy, circuit means selectively electrically connecting said source to said drive means to operate the latter, and at least one mercury switch included in the circuit means between the source and the drive means, said mercury switch being positioned such that when the device is in place as a replacement for a missing lower arm and hand, in certain orientations of the arm, the mercury switch closes the circuit means between the source and the drive means to deliver current, and in other orientations of the arm, the mercury switch opens the circuit means between the source and the drive means.

6. A prosthetic device according to claim **5**, wherein said mercury switch is constructed such that mercury therein crosses the terminals of the switch to close the circuit means in dependence on both (a) the vertical position of the arm and (b) the rotational position of the arm about its longitudinal axis.

7. A prosthetic device according to claim **6**, including a pair of mercury switches connected electrically in parallel between the source and the drive means, a first one of said switches positioned to close when the arm is raised such that the outer end of the prosthetic device is above the shoulder, and the second of said switches positioned to close when the arm is lowered such that the outer end of the device is below the shoulder.

8. A prosthetic device according to claim **7**, said mercury switches being further constructed such that rotational movement of the arm about its longitudinal axis in a predetermined direction by a predetermined amount opens both mercury switches.

9. A prosthetic device according to claim **7**, wherein said first switch is an elongated capsule partially filled with mercury and extending generally parallel to said longitudinal axis with both of its terminals located near the end thereof closest to the shoulder, and wherein said second switch is a capsule partially filled with mercury with both of its terminals located near the top thereof.

10. A prosthetic device according to claim **9**, wherein each capsule includes a chamber extending away from its terminals in a direction which is horizontal when the arm is in a horizontal position, both said chambers extending in the same direction from their respective terminals, such that when the arm is turned about the longitudinal axis in said direction towards which the chambers extend, mercury in both switches flows away from the respective terminals and both of said switches are opened.

11. A prosthetic device according to claim **5**, wherein said mercury switch is an elongated capsule extending generally parallel to said longitudinal axis and having both terminals located near the end thereof closest to the shoulder, whereby when the arm is raised above the shoulder, mercury flows to the terminals to close the switch.

12. A prosthetic device according to claim **11**, said switch including a reservoir chamber extending outwardly sideways from the elongated capsule near the terminals such that turning of the arm about its longitudinal axis toward the reservoir causes the mercury in the capsule to flow into the chamber and hence open the switch.

13. A prosthetic device according to claim **5**, wherein said mercury switch is an elongated capsule extending generally perpendicular to said longitudinal axis and having the terminals located on the top thereof such that when the arm is lowered beneath the shoulder level, mercury flows to the terminals to close the switch.

14. A prosthetic device according to claim 13, wherein the cross-section of said elongated capsule is tapered downwardly, the terminals being located on the top of the switch at the part having the largest cross-section.

15. A prosthetic device according to claim 5, said mercury switch including baffles located therein to limit the flow of mercury therein.

16. A prosthetic device according to claim 5, said joint construction having grasping parts to perform such grasping movement, and including a spring normally urging the grasping parts of the joint construction apart, and including a slip clutch connected between the drive means and the joint construction such that operation of the drive means in one direction causes the grasping parts to perform the grasping movement, said clutch slipping when the drive means force exceeds a predetermined limit, and wherein upon release of the driving force, the spring causes the grasping parts to separate.

17. A prosthetic device according to claim 16, wherein the outer extremity of the device is in the shape of a hand, said grasping parts including the thumb and forefinger of the hand, and said spring being arranged to normally urge the thumb and forefinger apart.

18. A prosthetic device according to claim 17, said drive means being an electric motor having an output shaft, a further shaft drivingly engaging the forefinger, and urging it towards the thumb, the slip clutch being located between the motor shaft and the further shaft, a cross-shaft extending generally perpendicular to the longitudinal axis, and the forefinger part of the hand being fixed to the cross-shaft for movement therewith in said grasping movement.

19. A prosthetic device according to claim 17, wherein at least one finger other than the forefinger of the hand is a grasping part and is movable under the influence of said drive means towards the thumb during said grasping movement.

20. A prosthetic device according to claim 5, including a manually operated switch located externally of the arm for completely disenabling the said drive means.

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