Sept. 1, 1970 J. J. IVKO ET AL 3,526,007

PROSTHETIC ARM HAVING HUMERAL ROTATION

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FIG. 1

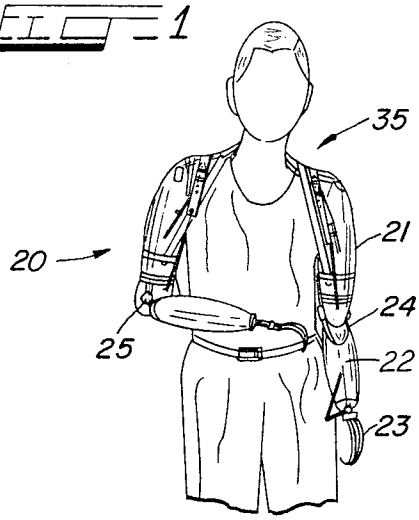


FIG. 2

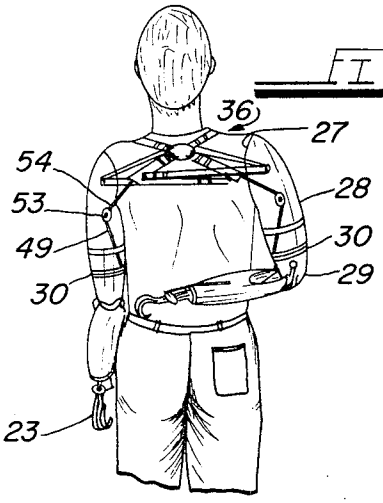


FIG. 3

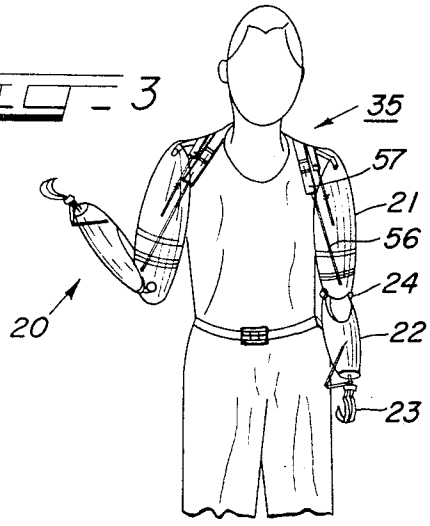
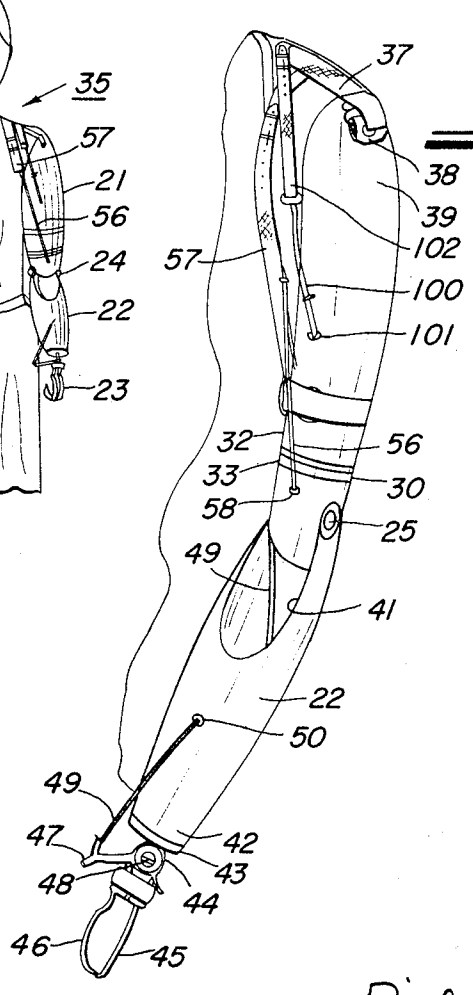


FIG. 4



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PROSTHETIC ARM HAVING HUMERAL ROTATION

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FIG 5

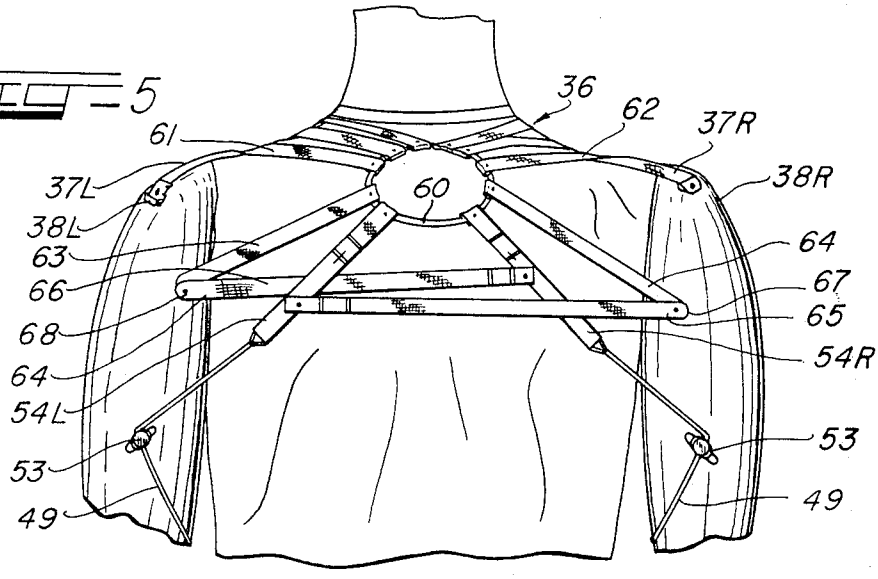


FIG 6

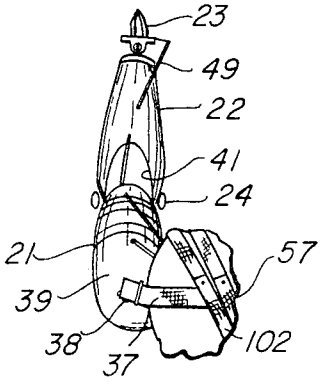
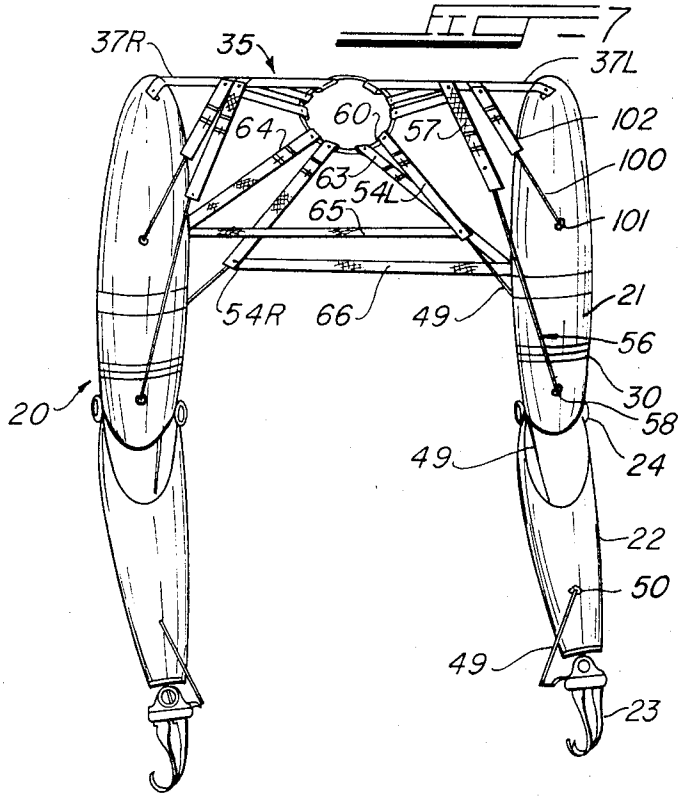


FIG 7



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FIG - 9

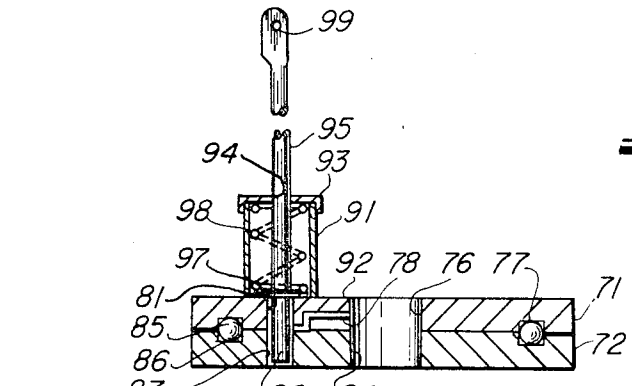


FIG - 10

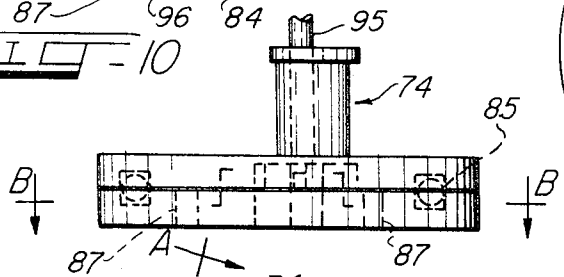


FIG - 12

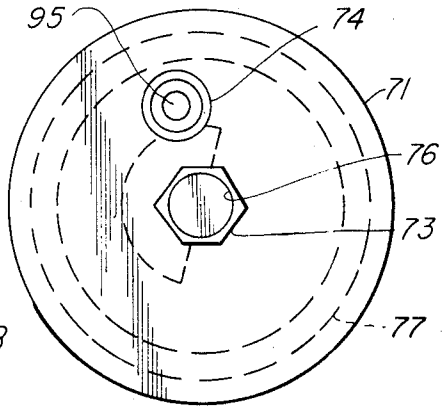


FIG - 8

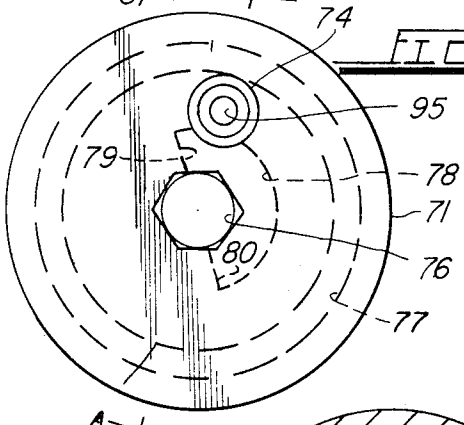


FIG - 13

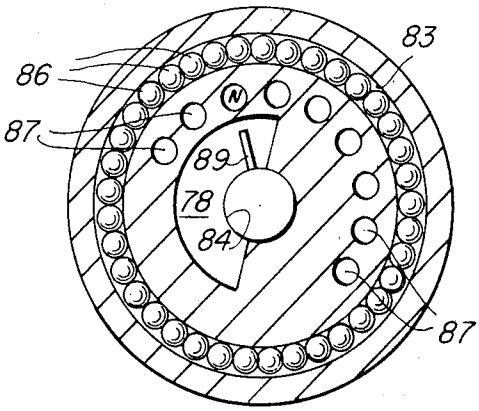
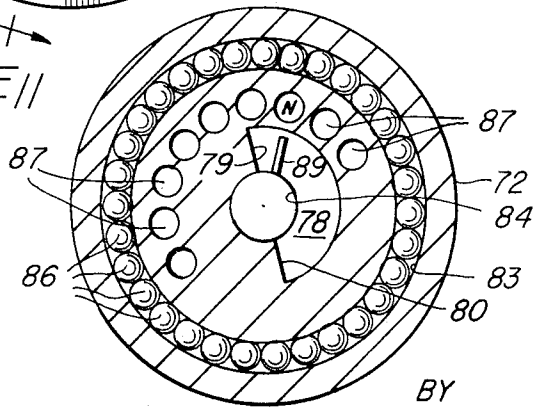


FIG - 11



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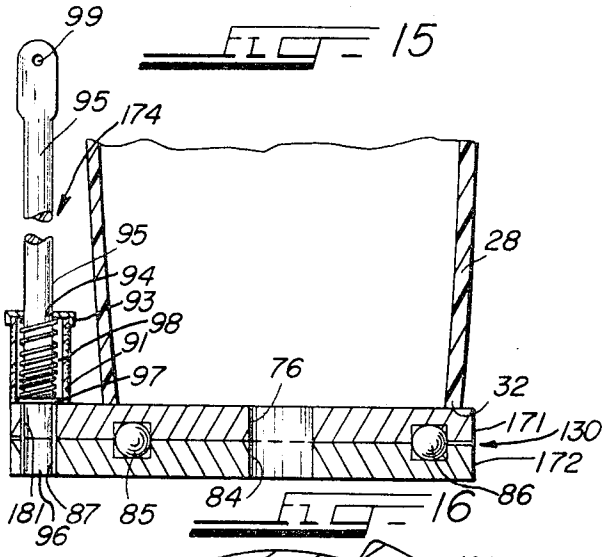


FIG - 15

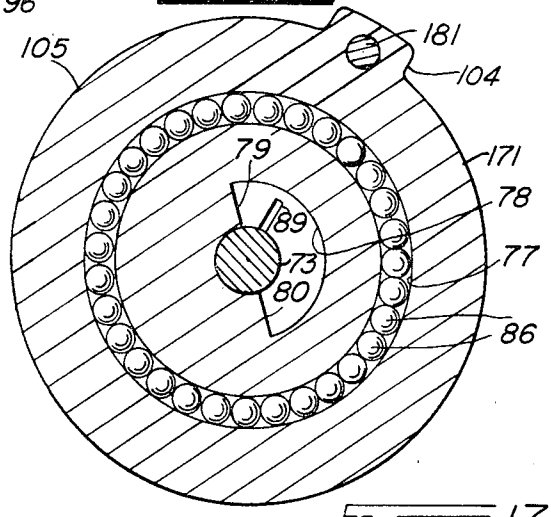


FIG - 16

FIG - 17

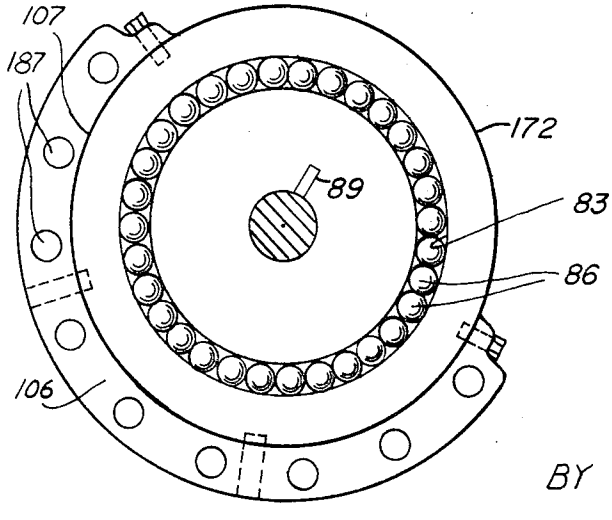
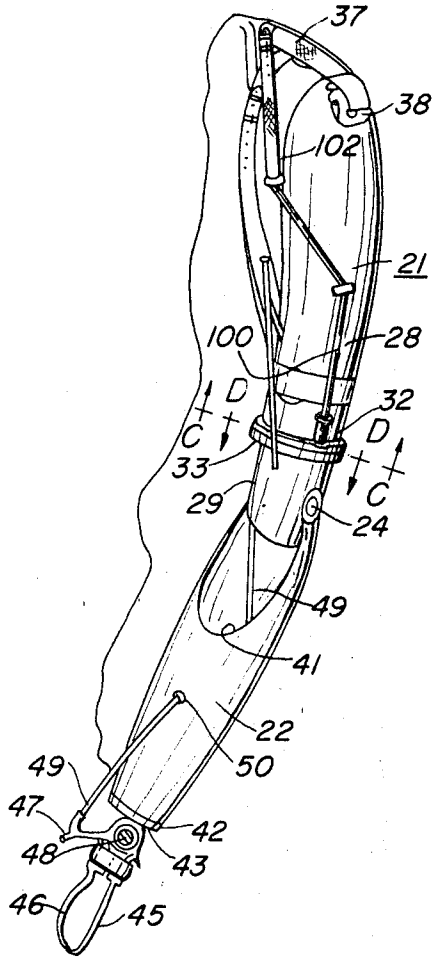


FIG - 14



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United States Patent Office 3,526,007
Patented Sept. 1, 1970

3,526,007

PROSTHETIC ARM HAVING HUMERAL ROTATION

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Int. Cl. A61f 1/04, 1/06
U.S. Cl. 3—12.1 16 Claims

ABSTRACT OF THE DISCLOSURE

A prosthetic device for upper arm amputees which permits the realization of substantially natural movements including humeral rotation of about 180° by the incorporation therein of selectively actuatable bearing assembly responsive to voluntary excursions of the deltoid muscles associated with the limb upon which the device is mounted.

The present invention relates generally to prosthetic devices and more particularly to a prosthesis for use by upper arm amputees whereby a substantial number of natural arm functions, especially humeral rotation of about 180°, can be provided.

The device is especially well suited for bilateral upper arm amputees whereby those natural movements may be obtained which will permit the wearer to be reasonably self-sufficient, especially in those personal matters of toilet, grooming, dressing, eating and the like.

As will be apparent, our device also offers many advantages for the uni-lateral upper arm amputee.

Many devices have been developed from time to time in an effort to help those individuals who, either through the ravages of war or as a result of domestic or industrial accidents, have lost all of their hand and forearm and a major portion of their upper arm.

However, even the most modern developments in this field suffer from their inability to provide substantially natural humeral rotation such as one needs to perform such mundane and commonplace tasks as eating, dressing, going to the toilet, shaving and the like as well as more sophisticated tasks such as driving an automobile, practicing cursive writing and the like.

Of the prior devices known to relate to prosthetic arm devices generally, the vast majority are concerned with mechanisms for bending the elbow to provide lifting and flexing actions. See for example, U.S. Pat. Nos. 2,477,463, Otterman, July 26, 1948; 2,553,830, Motis, May 22, 1951; and 2,979,730, Bloom, Apr. 18, 1961.

Others such as Harris, U.S. Pat. No. 1,504,121, Aug. 5, 1924, attempt to deal with humeral rotation although the specific ball and socket mechanism therein disclosed is quite crude and ineffectual.

Generally, the major problem of the prior art devices, and one which is substantially overcome by the device herein described, arises from the inability of the prior devices to provide substantially natural humeral rotation or to even simulate slight humeral rotation without resorting to cumbersome, weighty and mechanically complicated devices.

One guiding factor in the development of our device is size since the size of an artificial arm should be approximately that of a normal arm and any mechanisms for perfecting arm movement should be containable within its dimensions. The devices and mechanisms must also be such that natural variations in arm length can be provided without requiring a change in any portions except the outer shell.

Weight and balance are likewise important considerations in such devices. Not only is total weight a factor from the standpoint of comfort and energy conservation,

the distribution of weight is also critical to a well-balanced system. We therefore have strived to design a device whose related mechanisms are disposed relatively close to the rotational axis of each of the parts whereupon moment values, which would otherwise cause nonbeneficial expenditure of energy, are minimized.

Of course, strength is also important because prosthetic arms act as levers and the wearer is deprived of both his sense of touch and pressure. In use, very high stresses occur even though most objects which are handled are of light weight material. Thus, such devices must be able to withstand everyday wear and tear and yet be light enough for comfortable use over long periods of time.

Selection of materials is also an important consideration for the parts which contact the wearer's skin must not cause irritation by either abrasion or possible allergic effects. On the other hand, the materials should not be affected by perspiration, should be easy to clean and should be free of odor.

A critical consideration and one which is especially well met by our device, is that of service. Like any mechanical device, prosthetic arms should require only minimal attention to keep them in proper operating condition. Ease of assembly and disassembly are meaningful standards in this consideration as well as is the avoidance of the entry of foreign matter, such as dust, dirt and the like, into the operating mechanisms.

Other factors which are considered important in prosthetic design and which are amply fulfilled by our device, include the elimination of lost motion such as arises when the stump and the terminal device have uncontrolled relative movement between them. Noise of operation is also kept as low as possible so as not to direct undue attention to, and thereby embarrass the user.

The present invention is predicated upon our discovery of a new and improved design for prosthetic arm devices in which a novel bearing arrangement is uniquely disposed in cooperative relationship with strategically located transmission means to provide the wearer with substantially normal arm movement, including enhanced 180° humeral rotation, all in a manner which is completely controllable and operable by the muscular action of the wearer.

The present invention thus opens new horizons for bilateral upper arm amputees and permits a rehabilitation of such individuals, both physically and psychologically, to a degree not heretofore obtainable by any device known or commercially available to such individuals. This we know from personal experience for one of us is an upper arm bilateral amputee, who, since wearing the device of this invention, has in a very short time obtained an entirely new perspective of the life ahead of hm.

Accordingly, it is a prime object of the present invention to provide a prosthetic device, especially for upper arm amputees, which will substantially duplicate natural arm movements including the provision of about 180° of humeral rotation.

Further objects of the present invention include the provision of a prosthetic device for upper arm amputees which is of substantially normal size, which is of relatively light weight and well-balanced, which possesses the strength necessary for the user to accomplish substantially all everyday tasks which will confront him, which is comfortable to the wearer and not offensive to either the wearer or his companions, which is easily serviced and can be readily assembled and disassembled, which minimizes lost motion and enables energy expenditure to be directed principally to useful movement, and which does not create a noise level which would direct unnecessary attention to the user.

Still other objects of our invention include the provision of a prosthetic device which can be controlled by

the amputee's own muscle structure and does not require either foreign forces or another limb to position or relocate it into various working positions.

Still a further object of the present invention is to provide, especially, for bilateral upper arm amputees, a prosthetic device which can return the amputee to a more normal life than has heretofore been possible with currently available devices, whereupon even such mundane chores as grooming, toilet, eating, dressing and the like, can be readily accomplished without outside assistance.

A still further object of the present invention is to provide, especially for bilateral upper arm amputees, a prosthetic device which can enable the amputee to qualify for and operate automotive vehicles under normal traffic conditions without endangering either himself or other drivers on the road.

Still another object of the present invention is to provide a prosthetic device for upper arm amputees which will enable the wearer to practice cursive writing or print or otherwise draw in a manner closely resembling the operation of normal limbs.

These and still further objects, as shall hereinafter appear, are fulfilled by the present invention in a remarkably unexpected fashion as can be readily discerned from a careful consideration of the following detailed descriptions of exemplary embodiments thereof, especially when read in conjunction with the accompanying drawings in which:

FIG. 1 is a frontal view of a bilateral upper arm amputee, with shirt and coat removed, equipped with and wearing prosthetic arms embodying the present invention;

FIG. 2 is a rear view of the amputee of FIG. 1 showing the extreme range of arm movement obtainable with the device of the present invention;

FIG. 3 is a frontal view of the amputee of FIG. 1 with the device of the present invention voluntarily moved to still another position;

FIG. 4 is an enlarged isometric of a device of the present invention as installed on the stump of an upper left arm amputee;

FIG. 5 is an enlarged rear view of a pair of devices and a shoulder mounting arrangement suitable for use therewith;

FIG. 6 is an isometric view of the left side of FIG. 5 viewed from above;

FIG. 7 is an isometric view of devices and mounting harnesses of the present invention in a condition to be worn;

FIG. 8 is a plan elevation of a humeral bearing for use in a left arm device in accordance with this invention;

FIG. 9 is a cross-section taken along line A—A of FIG. 8;

FIG. 10 is a side elevation of the bearing of FIG. 8;

FIG. 11 is a cross-section taken along line B—B of FIG. 10;

FIG. 12 is a plan elevation of a humeral bearing for use in a right arm device in accordance with this invention;

FIG. 13 is a cross-section of the bearing of FIG. 12 taken along line corresponding to line B—B of FIG. 10;

FIG. 14 is an isometric view of an embodiment of the invention especially modified for an upper arm amputee having an elongated stump;

FIG. 15 is a cross-section of the humeral bearing of the device of FIG. 14;

FIG. 16 is a plan section of the upper plate of the humeral bearing of FIG. 15 taken along line C—C thereof; and

FIG. 17 is a plan section of the lower plate of the humeral bearing of FIG. 15 taken along line D—D thereof.

Referring now to the drawings in which like parts bear like numerals throughout the several views, a representative embodiment of our device is indicated by the general reference **20**.

Each device **20** comprises an articulated prosthetic arm especially designed for unilateral or bilateral upper arm amputees. The exact details of our device shall now be described in detail.

Referring to FIGS. 1–4, it can be seen that device **20** comprises an upper arm portion **21**, a forearm portion **22** and a terminal portion **23**. Upper arm **21** and forearm **22** are pivotally connected for pivotal movement relative to each other by means of elbow joint **24**. In its simplest form, elbow joint **24** may be provided by a pin **25** which extends through upper arm **21** and forearm **22** at the joint **24**. In such a structure, suitable means (not shown) are provided to initiate and control the flexing action of of the arm and hence, the angular relationship between the central axis of upper arm **21** and the central axis of forearm **22**. This angle is normally known as the "angle of flexion."

The elbow joint **24** may be provided by any of the conventional means currently available as the specific type of elbow joint employed is not considered essential to realizing the full benefits of our device.

Referring to upper arm portion **21**, it is formed to resemble a natural arm in configuration and is provided with an open end or socket **27** which is adapted to receive the stump of the amputee therein in a secure nesting relationship thereto.

Directing attention to the embodiment of FIG. 4 wherein a left arm device is illustrated, upper arm **21** is produced in two parts, namely, upper part **28** and lower part **29**. Parts **28** and **29** are joined by means of a humeral bearing **30**, which shall be hereinafter described in detail.

For the moment it will suffice to note that bearing **30** is connected to upper part **28** at the lower edge **32** thereof and is connected to lower part **29** at the upper edge **33** thereof.

The device **20** is connected to the amputee by suitable attachment means **35** which generally comprise a harness **36** formed of a sequence of criss-crossed belts which pass over the shoulder and around the torso of the wearer as shown in FIGS. 1 and 2. Attention is also invited to FIG. 7 wherein an entire attachment means **35** for mounting a pair of devices for a bilateral amputee is illustrated.

As will hereinafter appear in greater detail, attachment means **35** is provided with a number of auxiliary belts or straps, such, for example as strap **37**, which serve to maintain the stability or to control the operation of the device. Special mention shall hereinafter be made to a number of such straps in conjunction with their special functions.

Strap **37**, as mentioned above, is a stabilizing strap which extends from hardness **36** to a buckle **38** affixed at the shoulder portion **39** of part **28**. When strap **37** is drawn into buckle **38** so as to take up all slack in strap **37** when the stump is in socket **27** and device **20** in place, device **20** is stabilized against slippage and remains firmly in its proper operating position.

Forearm **22** is likewise made to resemble the natural member, that is, the natural forearm, and preferably is of unitary construction.

Both forearm **22** and upper arm **21** are preferably hollow and are formed from lightweight, durable, odor-free plastic material so as to facilitate both maintenance and wearer comfort.

Forearm **22** is provided with a generally hyperbolic cut-out portion **41** to permit lower part **29** of arm portion **21** to pass thereinto and obtain a greater range to the angle of flexion between lower arm **22** and upper arm **21** about elbow joint **24**.

At the end **42** of forearm **22** which is most remote from elbow joint **24**, a cap member **43** is fitted thereupon and provides a mounting means **44** which receives and holds terminal portion **23** for operation therein.

Terminal portion **23**, or terminal device, as it is more commonly known, may be a hook, as is illustrated, or an

artificial hand or any of the other grasping or holding devices that have been developed for such purposes. All include a center axle (not shown) which is insertable into mounting means 44 and permits the device 23 to be manually rotated therewithin. As will be apparent, the selection of the specific terminal device is not material to the effective operation of our invention. The means for operating and controlling terminal device 23 is, however, important and its full significance will be developed below.

From the operational standpoint, terminal device 23 will comprise at least two principal members, that is, a stationary or base member 45 and a moveable or thumb member 46. These members are intended to correspond in function to a natural thumb and forefinger and thereby simulate the grasping action effected between the thumb and forefinger of a healthy hand.

To effect the operation of the terminal device 23, a lever 47 is provided which is secured by and fulcrumed about bolt 48. Lever 47 may be integrally formed with thumb member 46 as a secondary lever or it may function to pry members 45, 46 into a separated position.

The bolt arrangement 48 will usually also secure in operative relationship thereto a spring bias (not shown) which urges members 45, 46 into engagement with each other. The force of the spring bias urging members 45, 46 together, may be overcome by applying an upward force on lever 47, transmitted thereto via cable 49, whereupon members 45, 46 are separated as a prelude to obtaining a grasping action. Thus, when the desired object is interposed between separated members 45, 46, the pulling force on lever 47 from cable 49 is relaxed and the spring bias again takes over to force members 45, 46 toward each other and hence into engagement with the desired object.

While, as we have explained, the particular terminal device selected is of no import, the fact that it is force-actuated is important. You see, the special way we route cable 49 from the terminal device 23 to where it can receive the effect of the amputee's muscular excursion is important and will now be described.

In our preferred embodiment, as illustrated in FIGS. 2 and 4, cable 49 extends from terminal device 23 in an upwardly direction along forearm 22 to an aperture 50 defined in forearm 22. Cable 49 passes through aperture 50 into the interior chamber of forearm 22 and thence along forearm 22 to cut-out portion 41 where it exits from forearm 22 to pass along the exterior surface of upper arm 21, essentially between upper arm 21 and the amputee's body (see FIG. 2), to and through a cable holding guide means 53 into connective relationship with an auxiliary strap 54 which in turn is connected to harness 36. The location of strap 54 is important and it is disposed so that an excursion of the amputee's scapula will create tension in strap 54 and cable 49 thereby pulling lever 47 upwardly so that it rotates about fulcrum 48 and opens the terminal device 23. When the muscle beneath strap 54, i.e., the scapula, is relaxed, the tension in cable 49 is withdrawn and terminal device 23 is closed in the manner previously described.

A similar control arrangement is utilized to operate the elbow joint 24, previously described. This arrangement comprises a cable 56 which extends between elbow 24 and attachment means 35. As is shown in FIG. 4, cable 56 extends downwardly from connective engagement with auxiliary strap 57 into the upper arm 21 through an aperture 58 defined therein, and then is attached to the latch mechanism (not shown) of the elbow joint 24.

While any of the commercially available elbow latch mechanisms can be incorporated into our invention without altering our results, a simple mechanism such as an arcuate series of detents positioned in the plane of forearm movement and associated with selectively actuatable latch means, is highly satisfactory. Such latch means are normally responsive to muscular excursions of the amputee transmitted thereto by means of the control arrangement just described.

Referring now to FIGS. 5, 6 and 7, suitable attachment means 35 for use with the invention shall be described. It is, of course, understood that any conventional type of prothesis mounting systems may be used with this invention provided they are caused to include the auxiliary strap connections herein described.

A very comfortable and successful arrangement and one which is especially well-suited for installing a pair of our devices on a bilateral upper arm amputee comprises a harness 36 which is formed by a generally circular or elliptical ring member 60 to which are connected a pair of obliquely extending straps 61, 62 which pass over the amputee's left and right shoulders to engage the anterior surface of the respective arms, and a second pair of obliquely extending straps 63, 64 which are connected to the posterior of the left and right devices, respectively. As is apparent from FIG. 5, auxiliary strap 54 (designated 54L and 54R for each arm) also connect to ring member 60. If desired, straps 54L, 54R may be stabilized by the use of auxiliary straps 65, 66 to independently interconnect straps 54L, 54R and the right and left arm posteriors, respectively, as at points 67, 68. Connection points 67, 68, conveniently, may also be used to provide connection to the arms for the appropriate one of straps 63, 64.

Referring now to FIGS. 8–13, one embodiment of our novel and unique humeral bearing design is clearly illustrated.

Humeral bearing 30, see FIGS. 9 and 10, comprises an upper plate 71 and a lower plate 72 mounted for rotation relative to each other about axle 73. Suitable latch means 74 are carried by plate 71 as shall appear.

Upper plate 71 which, preferably, consists of a circular disc, is provided as by machining, with a central opening 76 for permitting the passage of axle 73 therethrough, an annular channel 77 and a semi-circular cut-out 78. The radii of both channel 77 and semi-circular cut-out 78 are centered on the center of opening 76. As formed, cut-out 78 presents a first abutment 79 and a second abutment 80 angularly disposed from each other at, preferably, about 180°.

Disposed at about 15° from leading abutment 79 and spaced radially from cut-out 78, a second opening 81 is provided as by drilling. The function of channel 77, abutments 79, 80 and opening 81, will become clear as the description proceeds.

Lower plate 72 is also provided with an annular channel 83 and a central opening 84 for permitting the passage of axle 73 therethrough. When plates 71 and 72 are mounted in their desired surface-to-surface relationship about axle 73, channels 77 and 83 are in substantially exact registry with each other and define a bearing raceway 85 which is filled with a plurality of suitably sized ball bearings 86.

A plurality of positions are next provided in lower plate 72 as by drilling or otherwise defining a sequence of holes 87 disposed arcuately from the center of opening 84 on a radius equal to that employed in defining opening 81 in upper plate 71.

In our preferred embodiment, the several holes 87 extend arcuately for about 180° around opening 84 and are disposed concentrically thereto. The angular disposition between individual positions is believed to provide maximum benefit when it is about 15°.

A stop member 89 is suitably affixed to lower plate 72 as by welding and is located on a radius of plate 72 to define "neutral" position for the bearing. In practice, stop member 89 will be a relatively thin rectangular plate having a length of slightly less than that of the radius differential of cut-out 78 and opening 84 and a height of approximately but slightly less than the depth of cut-out 78.

Referring now to FIGS. 9 and 10, a suitable latch means 74 for use in the present invention shall now be described. As shown, latch means 74 comprises a cylin-

drical housing **91** disposed upon and carried by the upper surface **92** of plate **71** and approximately circumscribes opening **81**. A cover member **93** is tightly secured to housing **91** and contains a central opening **94** to permit the extension of a latch shaft **95** therethrough.

The lower shank **96** of shaft **95** is provided with a radially extending flange **97** having a diameter in excess of the diameter of both opening **81** and opening **94** and thereby provide a limitation to the axial movement of shaft **95**. A suitable compression spring **98** is disposed within housing **91** and coacts with cover member **93** and flange **97** to force lower shank **96** through opening **81** into one of the positioning holes **87** when one of the position-holes is in proper registry with opening **81**.

To retract shank **96**, an opposing force is applied to shaft **95** which force is of sufficient magnitude to overcome the bias of spring **98** and permit shank **96** to be withdrawn from within positioning hole **87**. When shank **96** is retracted to a position above plate **72**, it thereby ceases to inhibit movement of plates **71**, **72** relative to each other.

The specific means with which we prefer to apply the opposing force upon shaft **95** will now be described.

At the end of shaft **95** away from shank **96** is provided a suitable connection means, such as our eyelet **99**, to which a suitable cable **100** is joined. Cable **100**, in the embodiment of FIG. 7, then extends from connection means **99** through the interior of arm portion **21** to an aperture **101** provided therein. Cable **100** then passes through aperture **101** to the exterior of arm portion **21** where it meets and is connected to auxiliary strap **102**. Strap **102** is connected at its other end to harness **36** and extends across the anterior deltoid muscle of the amputee. The slack in cable **100** and strap **102** is eliminated so that both are placed in tension by the amputee via a simple excursion of his anterior deltoid muscle. When cable **100** is under tension, shank **96** is withdrawn from its locking position within one of holes **87** and plates **71** and **72** may be rotated, within the limits defined by the coaction of stop member **89** with abutments **79**, **80**, to alignment with any different one of the positioning holes **87**.

To achieve controlled humeral rotation by means of bearing **30** when latch **74** is unlocked, the amputee merely creates an excursion of his scapula muscle which places cable **49** in tension and turns the arm.

The transmission of the muscular impulse or signal from the amputee's muscles by means of straps and cables to humeral bearing **30** is herein referred to as signal means.

As is now apparent, the above-described embodiment is especially well-suited for use with upper arm amputations in which 30% or less of the humerus remains. And while such surgery has heretofore been considered to be a shoulder disarticulation from the standpoint of fitting with prosthesis, that is, supplied with prosthesis purely for cosmetic purposes, it is now apparent that we have developed a prosthetic device which is of considerable functional value to the amputee.

Now we would like to describe a modified embodiment of our device which is designed to help the amputee having a long stump.

A special problem faces the long-stump amputee in attempting to use the embodiment of our device already described which arises out of the lack of clearance between the bottom of the stump and the top of latch shaft **95** when shaft **95** is in a retracted position. Thus, to assure the amputee that the latch shaft will be properly operative, we have developed an embodiment in which we have relocated our latching and signalling mechanism, that is, we have created a humeral bearing in which the latching means is disposed outside of the upper arm cavity.

One such manner of accomplishing this result is obtained by constructing our humeral bearing in the manner shown in FIGS. 14, 15, 16 and 17. It should be noted, however, that as our device becomes better known we would expect the surgeons to engineer the amputations they perform in such a manner that the patient will be able to employ our principal embodiment. However, since it is not our desire to cause existing amputees to suffer new surgery in order to enjoy the better life our prosthesis will enable them to achieve, the alternate embodiment of our concepts appear justified.

Referring to FIGS. 14–17 and acknowledging that the principals of operation of this embodiment are essentially the same as those of our first embodiment, we shall now describe its structure. Those parts and members which are identical in both embodiments shall bear the reference numerals previously used and those parts and members which are identical in function but differ somewhat in structure shall employ numerals which are **100** greater than the corresponding part in the first embodiment. This is done to facilitate comparison without creating confusion.

As illustrated in FIG. 15, humeral bearing **130** comprises an upper plate **171** and a lower plate **172** mounted in face-to-face relationship about centrally disposed axle **73**. Latch means **174** are carried by plate **171**.

Upper plate **171** is provided with a central opening **76** to receive and pass axle **73** therethrough. Annular channel **77** is defined in that surface of plate **171** which faces plate **172** and is concentric to opening **76** in spaced relationship thereto.

A semicircular cut-out portion **78** is provided in plate **171** and is defined upon the same center as opening **76**. As shown in FIGS. 16 and 17, cut-out **78** provides abutments **79**, **80** which are disposed approximately 180° from each other. It should further be observed that abutments **79**, **80** each define an angle of approximately 15° with a vertical center line extending through the center of opening **76**. The significance of this relationship will become more fully apparent below.

Lower plate **172** is provided with a stop member **89**, dimensioned as previously described, which coacts with abutments **79** and **80** to provide limits to the angulation of the bearing.

It should be understood that while cut-out **79** has been described with respect to upper plates **71**, **171** and stop member **89** has been described with respect to lower plates **72**, **172**, these members can be reversed so that stop member **89** is associated with the upper plate and the cut-out **78** appears in the lower plate without materially altering the function of this arrangement.

Referring to FIG. 16, it will be seen that latch opening **181** is again disposed radially from the center of opening **76**. Now, however, it is located at a distance which is sufficiently greater than the radius of the upper arm portion **21** to permit latch member **174** to be mounted in superposition thereto. One manner of locating opening **181** in its desired situs is achieved by an outwardly extending flange **104**. Flange member **104** may either be formed separately and suitably attached to the edge **105** of upper plate **171** or upper plate **171** may be cast to include flange **104** as an integral part thereof.

It is apparent in FIG. 15 that latch opening **181** is disposed sufficiently distant from upper arm portion **21** to enable latch means **174** to be properly aligned with and superpositioned relative to opening **181**.

Latch means **174** is constructed substantially as before and comprises a housing **91**, a cover member **93** having an opening **94** through which latch shaft **95** is passed. The lower shank **96** of the latch shaft **95** is provided with detent means **97**. Operatively interposed between the detent **97** and cover member **93** to effectively bias shank **95** into a locking engagement with plate **172** is a suitable compression spring **98**. Connecting means **99**, such as the eyelet shown, is provided at the end of the latch shaft **95** remote from the bearing plates.

Lower plate **172** is also provided with an annular

channel **83** which cooperates with annular channel **77** of plate **171** to define bearing raceway **85** which, when assembled, contains roller bearings **86**. Lower plate **172** also contains central opening **84** which is in substantial registry with like opening **76** of plate **171** and through which axle **73** is received and passed.

Lower plate **172** is also provided with a plurality, preferably nine, positioning holes **187** which are disposed at approximately 22½° from one another to provide a total angulation of 180°. Holes **187** are of substantially equal diameter to latch opening **181** and are positioned, relative to the center of opening **84**, on a radius substantially to that defined by opening **181**. Holes **187** are defined in flange member **106** which may be a separate member attached to the peripheral edge **107** of lower plate **172** or the lower plate **172** may be formed, as shown in FIG. 17, to comprise an integral structure of sufficient additional diameter to permit holes **187** to be arcuately aligned with each other and radially spaced from the center of center opening **84**, a distance equal to the distance between the centers of openings **76** and **81**.

When the plates are assembled in operative relationship one to the other as shown in FIGS. 14 and 15, the action of the latch means **174** is such that the lower plate can be selectively engaged and disengaged by lower shank **96** and thereby selectively freed for rotation in response to a signal generated by muscular excursions of the amputee.

The bearing **130**, when freed for rotation, is then rotatable in response to the transmission of scapula excursions via cable **49** in the manner already described.

In both of the embodiments described, it is apparent that the humeral bearing provides a plurality of positioning holes **187**, which include a neutral position and extend between the limits of angulation defined by abutments. In all instances, the neutral position for a left arm device is 15° to the right of center line (see FIG. 11) and one limit of angulation is approximately 15° to the left of the center line or approximately 30° to the left of neutral position. The second limit of angulation is located to the right of the neutral position and provides approximately a 150° range of motion. The right arm arrangement will, of course, be just the reverse. Thus, in a right arm, the neutral position is approximately 15° to the left of the center line while one limit of angulation is 15° to the right of the center line providing a range of 30° to the right of the neutral position. The second limit of angulation is located to the left of the neutral position to provide approximately a 150° range of additional motion.

The ability of the arm to obtain humeral rotation of 30° from neutral in the one direction and 150° in the other provides the amputee with substantially identical movement to that obtainable by a normal, healthy arm. In this way, he can easily and quickly perform the many tasks and do the many things described earlier which in the absence of this ability would be permanently denied to him.

Thus constructed, our device is well suited for use by both unilateral and bilateral upper arm amputees.

To illustrate a representative installation and the operation of our device, reference is made to the bilateral unit shown in FIGS. 5 and 7. To put the device in place, the amputee slips attachment means **35** about his neck and torso while placing his stumps into their respective sockets **27**. The several buckles **38** are tightened and the device is stabilized and ready for use.

To use the device, terminal device **23** and elbow joint **24** are operated in substantially the same manner as with present equipment. Thus, terminal device **23** is actuated in response to strong muscular signals created by the amputee's excursion of his scapula. These signals are then transmitted from the scapula, via strap **54** and cable **49**, to lever **47**.

The flexion of elbow joint **24** is accomplished as a response to strong muscular signals originating with an excursion of the amputee's chest muscles which are transmitted therefrom, via strap **57** and cable **56**, to the locking mechanism in the joint **24**.

Humeral rotation is accomplished by the coaction of strong muscular signals originating from an excursion of the amputee's anterior deltoid muscles which free the humeral bearing for rotation, and a lesser muscular signal originating from the amputee's chest muscles, which apply torque upon the lower part **29** of the upper arm **21** and cause it to rotate to a desired position where, upon relaxation of the anterior deltoid, the bearing is locked.

This device permits an amputee to obtain a full 180° of humeral rotation, from limit to limit.

To restore the arm to a neutral position or to obtain outwardly rotation, the amputee need only to release latch means **174**, by flexing his anterior deltoid, and flip his stump outwardly or nudge the arm upon a convenient object, whereupon the arm can be rotated to its outermost limit. As explained, these inner and outer limits or angulation are defined by the coaction of stop member **89** with abutments **79** and **80**.

From the foregoing, it is apparent that a new and highly beneficial prosthetic device has been herein described which employs a unique humeral bearing and cable arrangement to achieve its results. It is also noted that the device includes a unique disposition of terminal device cables to provide pressure on the medial arm to motivate humeral rotation inwardly through a 180° range of motion, said range of motion being obtainable as 150° from neutral inwardly and 30° from neutral outwardly.

It thus becomes apparent that a normal range of humeral rotation so necessary in toilet, driving an automobile, eating, reaching shelves and other like tasks is restored for the upper arm amputee by our device and that all of our aforestated objectives have, indeed, been accomplished.

What we claim is:

1. For upper arm amputees, a prosthetic device comprising: an articulated arm; attachment means for connecting said arm to an amputee; bearing means mounted within said arm to provide said arm with controlled humeral rotation, said bearing means comprising a first plate member, a second plate member and an axle member, said plate members being mounted upon said axle member for rotation thereabout in surface-to-surface engagement with each other, said first plate member carrying latch means thereupon, said second plate member having a plurality of discrete locator holes defined therein, said latch means being selective extendible through said first plate into and retractable from engagement in a preselected one of said locator holes in response to the transmission thereto of the force of a muscular excusion of said amputee, said first plate member having a cut out portion defined therein in facing relationship to said second plate member to provide a first and second abutment disposed in substantially 180° relationship to each other, said second plate member carrying an upstanding stop member to coact with said abutments to limit the clockwise and counterclockwise movement of said plate members relative to each other when said latch means is retracted from said locator holes.

2. A device according to claim **1** in which said articulated arm comprises an upper arm portion, a lower arm portion, an elbow portion disposed between and pivotally connecting said upper and said lower arm portion, and a terminal device operatively extending from said lower arm portion remote from said elbow portion, said bearing means being operatively mounted in said upper arm portion.

3. A device according to claim **1** having signal means operably disposed between said attachment means and said latch means to transmit the force of a muscular excursion by said amputee to said latch means and thereby control the movement of said plate members relative to each other.

4. A device according to claim **3** in which said latch means comprises a shank member and a spring member,

said spring member engaging said shank member to bias said shank member into an extended position relative to said first plate member in said second plate member, said signal means being connected to said shank member to retract said shank member from within said second plate member by overcoming the force of said spring member with the muscular impulse transmitted thereby.

5. A device according to claim **4** in which said signal means comprises a strap member adapted for motion-responsive relationship to the muscular structure of said amputee and a cable member connected to said strap member.

6. A device according to claim **5** in which said attachment means comprises a harness having a strap member adapted to lay across and respond to excursions of the amputee's anterior deltoid muscle, said signal means being connected to said strap and extending therefrom into operative connection with said shank member of said latch means.

7. A device according to claim **6** in which said latch member is disposed adjacent to and exterior of said upper arm portion.

8. A device according to claim **6** in which said latch member is disposed within said upper arm portion.

9. A device according to claim **3** in which signal transmitting means interconnect a terminal device and said attachment means whereupon said terminal device is operatively responsive to the amputee's muscular excursions within said attachment means when said bearing means are in a latched condition and said upper arm receives a rotational torque in response to said muscular excursions when said bearing means are in an unlatched condition.

10. A device according to claim **9** in which said signal transmitting means are disposed relative to said articulated arm to provide, when stressed and said latch means is in an unlatched condition, an inwardly humeral rotation to said arm.

11. A device according to claim **1** in which the lower surface of said first plate member contains a centrally defined opening for receiving said axle therethrough and said cut-out portion is defined upon the center of said opening with its base line passing therethrough, said base line being broken into two segments by said opening to provide said first and second abutments disposed in substantially 180° relationship to each other.

12. A device according to claim **11** in which said upstanding stop member is attached to the upper surface of said second plate to coact with said abutments to limit the clockwise and counterclockwise rotation of said bearing.

13. A device according to claim **12** in which said first plate contains a latch opening axially therethrough disposed in radial spaced relationship to said central opening and in registered operative relationship with said latch means.

14. A device according to claim **13** in which said second plate locator holes comprise a plurality of positioning openings extending axially therethrough and sequentially registrable with said latch opening in said first plate

15. A device according to claim **14** in which each of said positioning holes are disposed angularly 22½° from at least one adjacent one of said holes.

16. A device according to claim **15** on which said first and second plates coact to provide 150° inwardly rotation and 30° outwardly rotation relative to a neutral or normal position of said upper arm.

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