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ELECTRICALLY DRIVEN PROSTHETIC ELBOW

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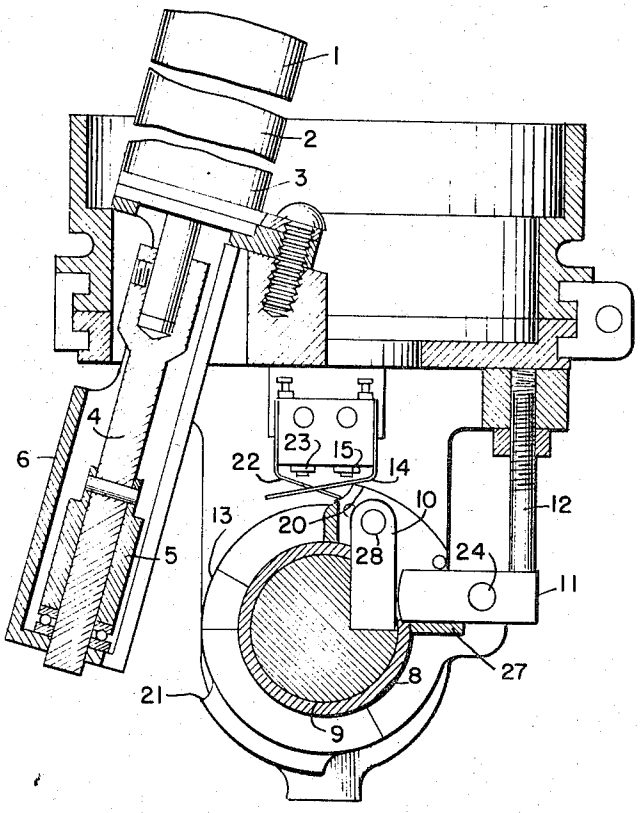


FIG. 1

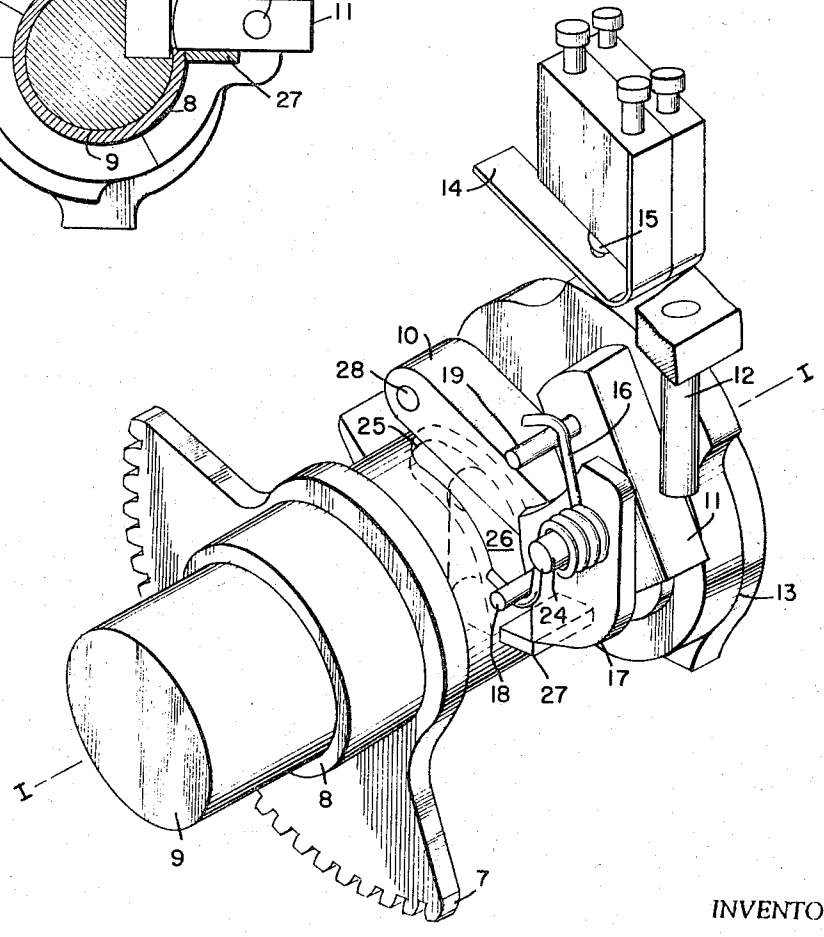


FIG. 2

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ELECTRICALLY DRIVEN PROSTHETIC ELBOW

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U.S. Cl. 3—1.1 4 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to an improved electrically driven prosthetic elbow wherein the elbow is capable of being rigidly locked into place in any desired position, and upon driving the arm to the fully extended position, the elbow is automatically unlocked.

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

BACKGROUND OF THE INVENTION

The use of external power in human upper extremity prosthesis is rapidly becoming more important for the rehabilitation of the severely handicapped. Electrically powered prosthetic elbows that have been developed to date are generally self-locking in all functional positions which is not the most advantageous design since the amputee in certain situations can experience discomfort, inconvenience and embarassment due to the inability to unlock the elbow. For example, in the simple act of sitting at a table, a locked prosthetic arm in the fully extended position will contact the chair before the amputee. In order to avoid this awkward movement, the amputee must either swing his arm at the shoulder and let the arm hang over the side of the chair, or he must drive the elbow to a convenient flexed position. The choice of letting the arm hang over the side of the chair presents an unnatural position for the amputee and is thus undesirable. With the elbow flexed, however, the amputee must keep in mind that he cannot leave the table by standing directly, but must first be sure that his artificial arm will miss the table. Besides the inconvenience of having to keep these thoughts in mind, the fact that the amputee would probably stand with his prosthetic arm in an uncosmetic flexed position presents another undesirable alternative. The present invention is designed to overcome these prior art inconveniences by allowing the amputee to manipulate his artificial limb in a lifelike manner with the ability to lock his artificial limb into any desired position.

SUMMARY OF THE INVENTION

The present invention directs itself to an electrically powered prosthetic elbow which is designed to overcome the disadvantages of existing electrically driven prosthetic mechanical elbows in that the present elbow provides for a simple locking means which will lock in any desired position and which automatically unlocks when the arm is placed in the fully extended position. This unlocking feature permits the amputee to simulate normal movement of his prosthesis and thus overcome the major disadvantage of existing prior art prosthetic elbows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cut-away side view of the mechanical elbow depicting the locking mechanism in the locked position.

FIG. 2 is an isometric view of the mechanical elbow in the unlocked position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more particularly to the drawings, in FIGS. 1 and 2, a reversible direct current motor **1** is connected to speed reducer **3** through connector **2**. The motor **1** drives the speed reducer **3** which in turn drives worm **5** through a coupling **4**. The worm **5** is covered by the worm cage **6**. The motor **1**, connector **2**, speed reducer **3**, coupling **4**, worm **5** and worm cage **6** are all located in a cavity in the stump attachment of the prosthetic arm located above the elbow. The worm **5** drives gear **7**, the combination being self-locking if exterior forces tend to drive the system. Gear hub **8** and its assembly (limiting ring **13**, locking lever **10**, bracket **17** and bar **11**) and shaft **9**, which is mounted in the elbow cavity, rotate independently of each other about axis I—I except when locking lever **10** rests within cavity **26** and bar **11** is in its locking position (FIG. 1). Plate **27** is affixed to gear hub **8** and prevents bar **11** from moving below its locking position. Unlocking stud **12** is capable of rotating bar **11** about fastening pin **24**. Locking lever **10** is also capable of rotating about fastening pin **28**. Spring **16** is affixed to fastening pin **24**. One end of spring **16** is affixed to pin **18** which is rigidly affixed to bracket **17**. The other end of spring **16** is affixed to pin **19** which is rigidly affixed to bar **11**. Limit switch actuators **14** and **22** are designed to actuate switches **15** and **23** when limit lobes **20** and **21** respectively of limiting ring **13** come into contact with the switch actuators.

In the preferred embodiment of the invention, a prosthetic hand and forearm are attached to the elbow such that the vertical motion of the hand and forearm corresponds to the clockwise and counterclockwise rotation of shaft **9** about axis I—I. A cavity **26** for receiving locking lever **10** exists within shaft **9** as does a cavity opening **25** exist within gear hub **8**. In the unlocked position, FIG. 2, shaft **9** is capable of rotation about center axis I—I independent of gear hub assembly **8**, **10**, **11**, **13** and **17**. Limiting ring **13**, bracket **17** and gear hub **8** are affixed so that they jointly rotate about axis I—I when driven by power train **1**, **2**, **3**, **4**, **5**, **6** and **7**. Support pins **18** and **19** and fastening pin **24** form the spring holding assembly for spring **16**. Locking lever **10** and bar **11** are rotatably attached to limiting ring **13** by fastening pins **28** and **24** respectively as shown in FIGS. 1 and 2.

In normal operation, the patient starts with the elbow fully extended with the artificial arm hanging by his side. FIG. 2 represents the physical relationships of cavity **26**, bar **11**, locking lever **10**, limiting ring **13** and unlocking stud **12** at this fully extended free swing position. In this position limiting lobe **20** of limiting ring **13** has contacted limit switch actuator **14** which in turn actuated limit switch **15**. Limit switch **15** stopped motor **1** thus ending any further rotation about axis I—I in a counterclockwise direction of limiting ring **13**, locking lever **10**, bar **11**, gear hub **8** and shaft **9**. At this position, bar **11** has been forced to rotate in a clockwise manner about fastening pin **24** as a direct result of the force applied by unlocking stud **12** to the end of bar **11**. The resultant force, applied by unlocking stud **12** to the end of bar **11**, is sufficient to overcome the counterclockwise torque about fastening pin **24** applied to bar **11** by spring **16**. The result is the unlocking of locking lever **10**. With bar **11** rotated out of its locking position, locking lever **10** is free to rotate about locking pin **28** and out of cavity **26**. Gear hub **8**, worm gear **7**, limiting ring **13**, locking lever **10** and bar **11** depend upon the activation of motor **1** for their rotation about axis I—I. However, shaft **9**, whose rotation about axis I—I is representative of the movement of the artificial forearm and hand, is not dependent upon motor **1** for movement when bar **11** is

forced out of its locking position as depicted in FIG. 2. In this unlocked position, the patient is able to place his artificial arm into any desired position, and upon driving the gear hub **8** and its assembly into a locking position, lock the elbow at that new position.

As the patient begins to place his arm from its fully extended position into a desired position, shaft **9** begins to rotate clockwise about axis I—I. In so doing, the walls of cavity **26** force locking lever **10** to rotate counterclockwise about fastening pin **28**. Since bar **11** has been forced to rotate out of its locking position, locking lever **10** is capable of counterclockwise movement about fastening pin **28**. When the patient has his artificial arm in the desired position, shaft **9** has been rotated clockwise about axis I—I and thus cavity **26** has also been rotated and is no longer in aligment to receive locking lever **10**. To lock the elbow into the new position, the patient actuates motor **1** to cause worm gear **7**, gear hub **8** with its cavity opening **25**, limiting ring **13**, locking lever **10** and bar **11** to rotate clockwise about axis I—I. As the assembly rotates clockwise about axis I—I, bar **11** is no longer brought into contact with unlocking stud **12**. As a result, the overbalancing force applied by unlocking stud **12** to bar **11** is removed and the tension of spring **16** forces bar **11** to rotate counterclockwise about fastening pin **24**. In this position, bar **11** applies a force to locking lever **10** causing locking lever **10** to rotate clockwise about fastening pin **28**. The blunt end of locking lever **10** is thus forced through gear hub cavity opening **25** and is pressed against shaft **9** as locking lever **10** and the rest of the gear hub assembly rotate about axis I—I seeking to bring locking lever **10** and gear hub cavity opening **25** into alignment with relocated cavity **26**. The patient continues to actuate motor **1** causing the rotation of the gear hub assembly until locking lever **10** locks into place within cavity **26**. At this moment, the patient stops the motor and the elbow is now locked into place. In this position, gear hub cavity opening **25** has aligned itself with cavity **26**, the blunt end of locking lever **10** is no longer sliding along the circumference of shaft **9** but rather has been fitted into cavity **26** by the force applied to it by bar **11**, and bar **11** has rotated counterclockwise about fastening pin **24** and has come to rest at its locking position. Plate **27** prevents rotation of bar **11** about fastening pin **24** beyond the desired locking position. In this locked position, with the motor off, counterclockwise rotation of shaft **9** and thus upward rotation of the artificial arm about the elbow is prevented due to the inability of shaft **9** to rotate independently of the gear hub assembly when locking lever **10** rests within cavity **26**. Clockwise rotation of shaft **9** and thus downward rotation of the artificial arm about the elbow is prevented due to the inability of locking lever **10** to be rotated out of cavity **26** when bar **11** is in the locked position. In both of these cases, power train **1**, **2**, **3**, **4**, **5**, **6** and **7** provides the locking effect as it is directly coupled to the elbow mechanism, and in the deenergized state, the power train provides great frictional resistance to any external attempts at moving the system. In the locked position, the movement of shaft **9** and thus the positioning of the artificial arm is directly controlled by motor **1**. The patient can either raise or lower his arm depending upon how he operates motor **1**. Limits, however, are imposed upon this movement by the interaction of limiting ring **13** with its lobes **20** and **21**, limit switch actuators **14** and **22** and limit switches **15** and **23**. One limit of movement is being approached in FIG. 1. FIG. 1 represents the approaching of the fully extended arm position. As the limit is reached, lobe **20** of limiting ring **13** comes into contact with switch actuator **14** which in turn activates switch **15**. Switch **15** in turn causes motor **1** to shut off. The other extreme limit of movement for

the elbow is the position represented by the bending of the elbow to bring the artificial arm and hand up towards the shoulder. In this position lobe **21** of limiting ring **13** comes into contact with switch actuator **22** causing switch actuator **22** to actuate switch **23**. Switch **23** will also cause motor **1** to shut off. Diodes are placed across switches **23** and **15** to permit current to flow in a reverse direction thus enabling the patient to mechanically drive the elbow in an opposite direction after one of the extreme positions has been reached.

I claim:

1. An electrically driven prosthetic elbow comprising:
- (a) an inner rotatable shaft representative of the rotational movement of a prosthetic elbow;
- (b) an electrically driven gear hub, said gear hub being independently rotatable about said inner shaft;
- (c) locking means capable of securing said inner shaft to said gear hub;
- (d) switching means capable of controlling the limits of angular movement of said gear hub; and
- (e) means for automatically unlocking said gear hub from said inner shaft at one of the limit positions of said gear hub.

2. An electrically driven prosthetic elbow as described in claim **1** wherein:
- (a) said inner shaft contains a cavity;
- (b) said gear hub contains an opening capable of alignment with the cavity of said inner shaft;
- (c) a limiting ring is attached to said gear hub;
- (a) a first pin is attached to said limiting ring;
- (e) a locking lever is rotatably attached to said first pin and aligned so as to be capable of insertion through said gear hub opening into said inner shaft cavity;
- (f) a second pin is attached to said limiting ring;
- (g) a bar is rotatably attached to said second pin and in relationship with said locking lever so as to have a common surface with said locking lever; and
- (h) a spring is carried by said second pin and in relationship with said bar so as to cause said bar to place a constant force upon the common surface with said locking lever.

3. An electrically driven prosthetic elbow as described in claim **2** wherein the switching means comprises:
- (a) limit lobes attached to said limiting ring, said limit lobes being offset from each other; and
- (b) a limit switch in alignment with each of said offset limit lobes, said switches capable when actuated of cutting out an electrical power source.

4. An electrically driven prosthetic elbow as described in claim **3** wherein the unlocking means consists of an unlocking stud aligned with said bar so as to force said bar to rotate out of contact with said locking lever when said limiting ring approaches one of its limits.

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3—12.3; 287—14, 99; 74—527