Sept. 9, 1924. 1,507,681

A. PECORELLA ET AL

ARTIFICIAL LIMB

Original Filed June 26, 1918 3 Sheets-Sheet 1

Fig. 1

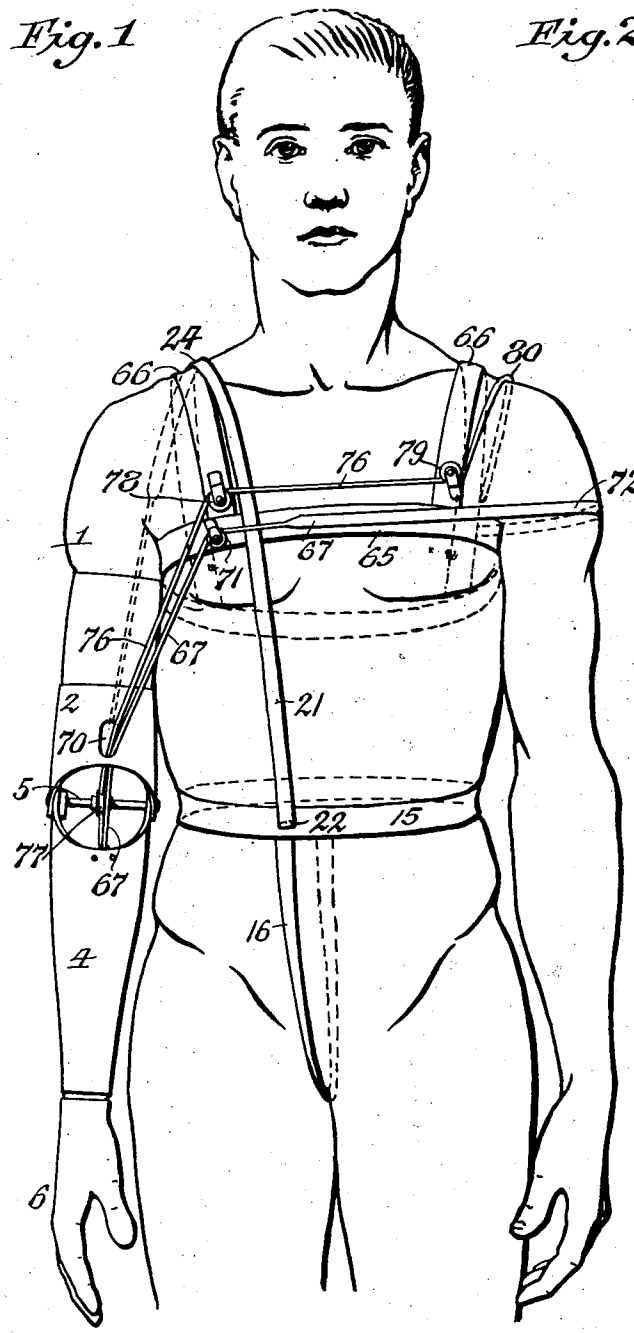
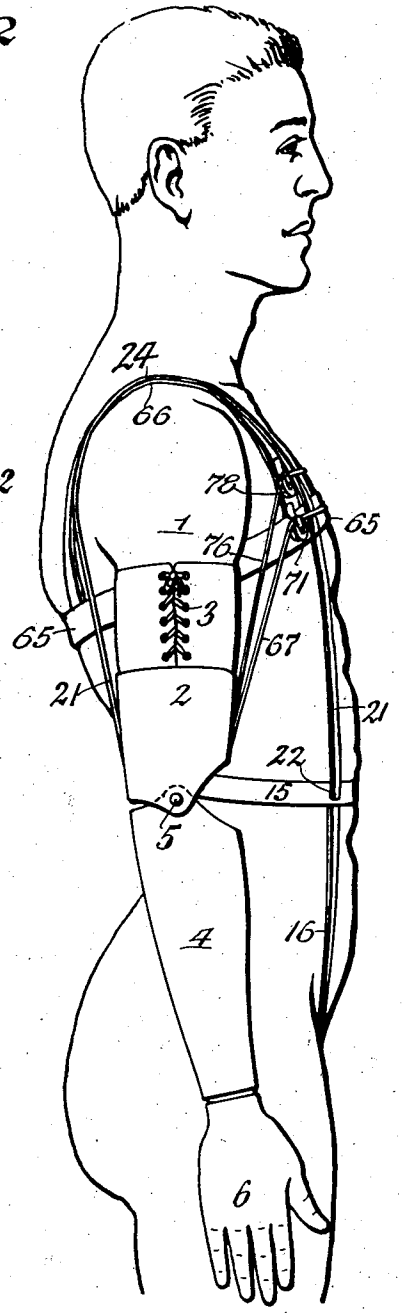


Fig. 2



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Fig. 3

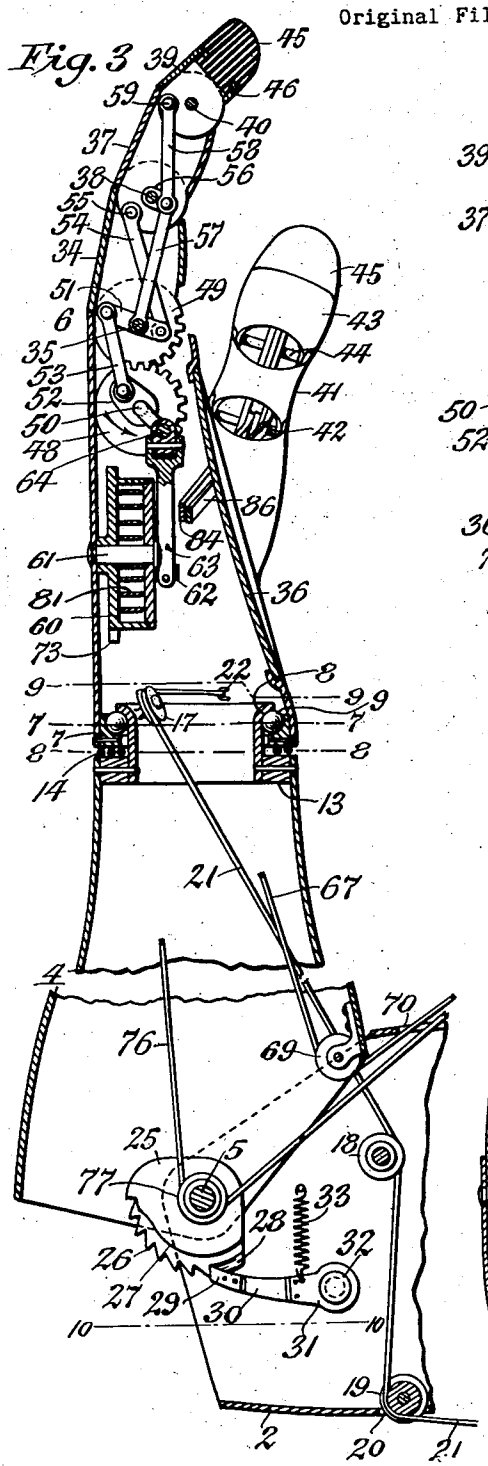
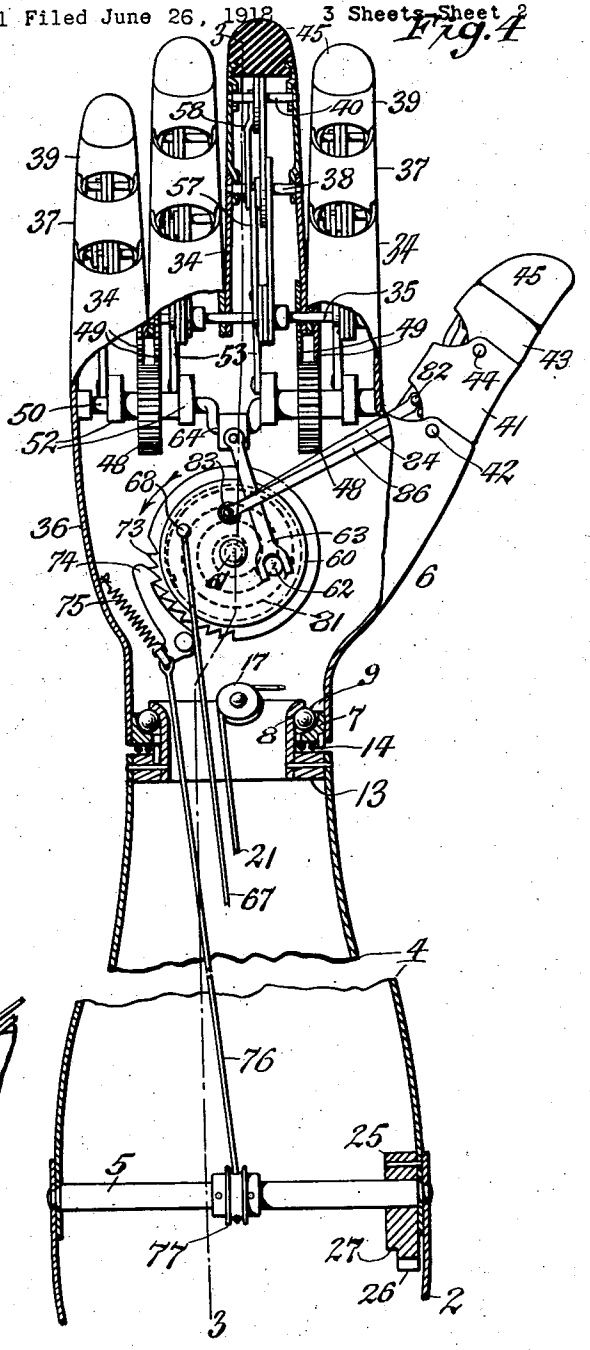


Fig. 4



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Fig. 5

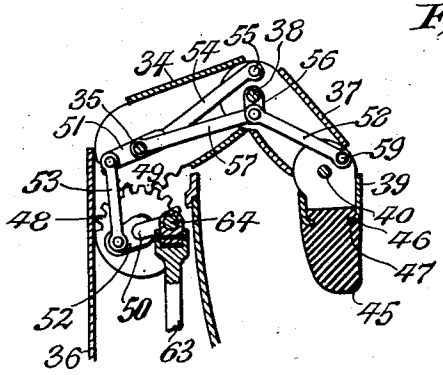


Fig. 6

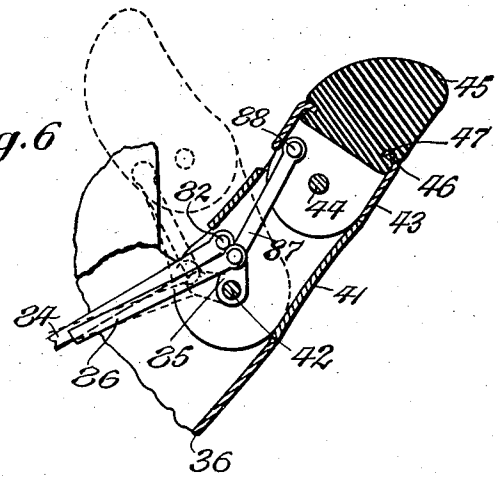


Fig. 7

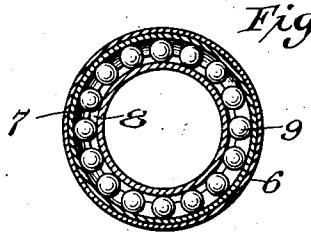


Fig. 8

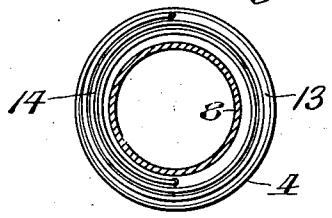


Fig. 9

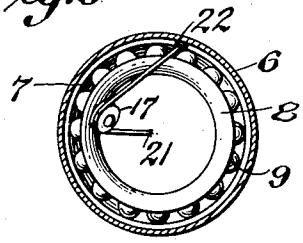


Fig. 10

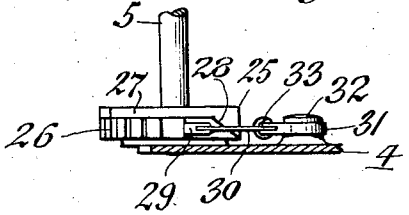
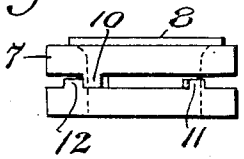


Fig. 11



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Patented Sept. 9, 1924. 1,507,681

UNITED STATES PATENT OFFICE.

ALBERTO PECORELLA AND VINCENT PATRICOLO, OF BUFFALO, NEW YORK, ASSIGNORS, BY MESNE ASSIGNMENTS, TO LIVINGSTON ARTIFICIAL LIMB COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

ARTIFICIAL LIMB.

Substitute for abandoned application Serial No. 241,927, filed June 26, 1918. This application filed March 14, 1924. Serial No. 699,372.

To all whom it may concern:

Be it known that we, ALBERTO PECORELLA, a citizen of the United States, and resident of Buffalo, in the county of Erie and State of New York, and VINCENT PATRICOLO, a subject of the King of Italy, and residing at Buffalo, in the county of Erie and State of New York, have invented new and useful Improvements in Artificial Limbs, of which the following is a specification.

This invention relates to an artificial limb, and more particularly to a limb which is intended to be used on the stump of a human arm in place of the usual arm, forearm and hand. This application is a substitute for abandoned application No. 241,927, filed June 26, 1918.

It is the object of this invention to provide such an artificial limb in which the movements of the several parts closely simulate the movement of the corresponding member of the human body, so that there will be little or no evidence that the wearer of this artificial limb has been mutilated.

In the accompanying drawings, Figure 1 is a front elevation of a person equipped with our improved artificial limb. Figure 2 is a side elevation of the same. Figure 3 is a fragmentary, longitudinal section of the artificial limb embodying our improvements, the section being taken perpendicular to the plane of the palm of the hand and on line 3—3, Fig. 4. Figure 4 is an elevation, partly in section, of this artificial limb viewed from the palm side of the hand. Figure 5 is a fragmentary, longitudinal section, showing one of the fingers of the artificial limb in its folded or closed position. Figure 6 is a similar view, on an enlarged scale, of the thumb constructed in accordance with our invention. Figures 7, 8, 9 and 10 are transverse sections taken on the correspondingly numbered lines in Fig. 2. Figure 11 represents a fragmentary side elevation of the wrist joint showing the means for limiting the forward and backward rotary motion of the hand relatively to the forearm.

Similar characters of reference indicate corresponding parts throughout the several views.

Our improvements are capable of being embodied in an artificial limb which is to take the place of the arm, forearm and hand, on either side of the body, but in the drawings the same are shown applied to the stump 1 of the right arm.

In its general organization, this artificial limb comprises an arm-section 2 which is preferably of tubular form and adapted to be secured to the stump of the arm in any suitable and well known manner, for instance, by means of lacing 3, as shown in Fig. 2, a forearm 4 also of tubular form, which is pivotally connected at its upper end to the lower end of the arm section by means of a horizontal pin 5, so that the forearm can be raised and lowered, and a hand 6 which is connected at its wrist with the wrist portion or lower front end of the forearm section by a rotary joint which permits the hand to be turned about an axis arranged lengthwise of the forearm and hand. The hand in its general construction is hollow and its walls are constructed of sheet metal or other suitable material. The walls of the arm and forearm are also constructed of thin material such as sheet metal.

Although the rotary joint at the wrist between the hand and the forearm may be variously constructed, that shown in the drawings, see particularly Figs. 3, 4, 7 and 9, comprises an outer annular or circular ball race 7 secured internally to the wrist-portion of the hand, an inner ball race 8 arranged within the outer ball race and connected with the wrist portion of the forearm, and an annular row of bearing balls 9 interposed between the outer and inner ball races, thereby forming a rolling bearing between the hand and the forearm which permits these parts to turn easily one relatively to the other about a longitudinal axis.

A stop device is provided for limiting the rotary motion of the hand relatively to the forearm, which device may be constructed in various ways, but as shown in Fig. 11 the same preferably comprises a stop lug 10 arranged on the outer ball-race so as to turn with the hand and adapted to engage either a front stop lug 11 of a rear stop lug 12 on the adjacent part of a connecting ring 13 which connects the inner ball-race with the forearm. Normally the hand is turned into a backward position in which the plane of the palm is parallel with the side of the body, at which time the stop lug 10 of the

hand engages with the rear stop 12 on the forearm. Upon turning the hand until its stop 11 engages the front stop lug 11 on the forearm, the hand makes a quarter turn or substantially so, and presents the palm forwardly or upwardly. The hand is yieldingly held in its normal position relatively to the forearm in which the same engages its stop 11 with the rear stop 12 of the forearm, this being preferably accomplished by a spring 14 which is of spiral form and arranged in the space between the wrist portions of the hand and the forearm and connected at one end with the outer ball race and at its opposite end with the connecting ring 13, as best shown in Figs. 3, 4 and 8.

Means are provided for causing the forearm section to be moved vertically relatively to the arm section together with the hand section and also cause the latter to be rotated on the forearm section by movement which is derived from the body of the wearer of the artificial limb. In its preferred form, this actuating mechanism for the forearm and the hand, as best shown in Figs. 1–4, 9 and 10, is constructed as follows:

On the lower part of the body of the wearer is mounted a lower harness which is adapted to serve as an anchor or fastening point for operating the forearm and hand. In its preferred form this lower harness comprises a horizontal belt 15 which is secured around the waist of the wearer and a vertical thigh-strap 16 which passes under the thigh of the wearer and is secured at its opposite ends to the front and rear sides of the belt. 17 represents a guide-pulley arranged adjacent to the wrist-joint on one side of the axis of the same and movable bodily with the forearm. In its preferred form, this guide consists of a pulley or roller and is mounted on the inner side of the inner ball-race 8, as shown in Figs. 2, 4 and 9. On the inner part of the arm-section adjacent to the pivotal connection between the same and the forearm sections are two rollers or guide-pulleys 18, 19, one of which is arranged adjacent to an opening 20 in the rear wall of the arm and the other being arranged intermediate of its walls. 21 represents a pull line which may be constructed of any suitable material such as a cord, strap, wire or the like, and which is connected at one end to the interior of the hand adjacent to the wrist thereof, as shown at 22, while its opposite end is secured to the front part of the belt 15, as shown at 22 in Fig. 1, while its intermediate part is arranged partly within the artificial limb and partly outside of the same, that part of this pull line within the latter passing around the guide rollers 18, 19 and 17, and that part of the same outside of the artificial limb having the form of an upright loop 24 which extends from the opening 20 on the rear side of the arm over the right shoulder of the wearer and to the belt 15, as shown in Figs. 1–4.

Upon raising the right shoulder, the wearer produces a pull on the line 21, the first portion of which causes the hand to turn on the forearm from the normal position shown in Figs. 1 and 2 to a position in which the palm of the hand faces forwardly, the extent of this movement being limited by engagement of the hand-stop 10 with the front forearm stop 11. During the continued pull on this line by reason of a further raising of the right shoulder of the wearer, the forearm is turned forwardly and upwardly on the arm together with the hand, the extent of this movement being preferably, though not necessarily, limited when the forearm reaches a position at right angles, or substantially so, to the arm-section of the artificial limb, this extreme position being indicated substantially in Fig. 3.

Means are provided whereby the forearm may be automatically locked at different points in its forward folded or elevated position relative to the arm-section, which means are preferably so organized that when the forearm is raised or folded a short distance beyond the maximum position in which it may be locked, then the locking device will be rendered inoperative and permit the forearm and hand to again return to their normal position. In its preferred construction this locking or detent device, as shown in Figs. 3, 4 and 10 is constructed as follows:

25 represents a detent disk which is secured to the forearm and preferably to the inner side of one of its walls around the pivotal connection 5 between the same and the arm, so that this disk is compelled to turn concentrically with the forearm. On its periphery this disk is provided with a segmental row of ratchet teeth 26 which are arranged concentrically with the pivotal connection between the arm and forearm, each of these teeth having an inclined front side and an abrupt rear side. Along one side of the teeth of the detent disk its periphery is provided with a plain, untoothed, curved return-face 27 the front end of which is transversely in line with the foremost ratchet tooth 26. In rear of the rearmost ratchet tooth of the detent disk the same is provided with an inclined face or cam 28 which leads from a point in rear of the ratchet teeth 26 to the plain face 27 of the detent disk. 29 represents a detent pawl or locking dog which is adapted to engage with the teeth, the cam or inclined face and the plain face of the detent disk, and which is connected by means of a spring arm 30 to a hub 31 which turns about a pivot 32 arranged on the interior of the arm section parallel with the pivotal connection

between the arm and the forearm. The spring-arm 30 is preferably constructed of a piece of plate steel or similar material which has its plane arranged crosswise of the axes of the pivots 5, 32, or in other words, parallel with the radius of the detent disk, so that the same is comparatively stiff in a radial direction relatively to this disk but flexible in a direction perpendicular to this radius. This pawl or dog, together with its spring arm and hub, are yieldingly drawn toward the periphery of the disk by means of a spring 33 connecting the hub 31 with the adjacent inner part of the arm-section of the artificial limb, as shown in Figs. 3 and 10. As the forearm is swung upwardly relatively to the arm, the ratchet teeth trip one by one past the detent dog and whenever the wearer after partially raising the forearm, relaxes the upward pull of his right shoulder on the loop 24 by lowering the same, then the forearm and the parts mounted thereon will be locked by means of the detent pawl in that position, so that by this means the forearm may be raised to different angles and then held there without requiring further attention on the part of the wearer. Whenever the wearer wishes to again lower the forearm and the parts mounted thereon, he raises his shoulder to such an extent that the forearm will be turned upwardly beyond the point where the same can be locked so that the last ratchet tooth clears the pawl 29 and the incline or cam 28 engages with the pawl 29. The wearer now lowers the left shoulder so as to relax the pull on the line 21 which permits the forearm to drop from its fully raised to its extreme lower position, this being possible by reason of the fact that when the detent disk also turns backwardly, its inclined face 28 deflects the detent dog 29 from a position behind the ratchet teeth into a position alongside of these teeth and into engagement with the plain curved face 27 of the detent disk in which position of the parts the detent pawl does not interfere with the free backward movement of the disk and the forearm. When the forearm reaches the end of its downward or unfolding movement, the plain face 27 of the detent disk directs the detent pawl 29 in line with the abrupt face of the foremost tooth of the detent disk so that the resilience of the spring arm 30 of this pawl again automatically throws this pawl into engagement with its foremost tooth, ready to resume its operation of locking the forearm in any position intermediate of its full stroke or folding movement.

After the forearm has swung downwardly into its lowermost position, the continued relaxation on the pull line 21 permits the spring 14 to also turn the hand from the position in which the palm faces forwardly to a position in which the same is parallel with the side of the body of the wearer.

In this artificial limb, the fingers and thumb are constructed in sections and are adapted to be folded and unfolded by motion derived from the body of the wearer, so that the action of these digits simulates those of the natural hand. As shown in the drawings, each of the fingers comprises a first tubular section 34 which is pivoted by means of a pin 35 to the palm 36 of the hand, a second tubular section 37 which is pivoted by means of a pin 38 to the first section, and a third tubular section 39 which is pivoted to the second section by means of a pin 40. The thumb comprises a first tubular section 41 which is pivoted by means of a pin 42 to the palm and a second tubular section 43 which is pivoted to this first section by means of a pin 44. Each of these digits is provided on its outermost section with a tip 45 of elastic material, such as rubber or similar material, so that a yielding touch of the end of the digits is produced when engaging another object. Each of these tips may be connected with the respective outer digit section in any suitable manner but preferably by providing each of these sections with an inwardly-turned flange 46 which engages with an external groove 47 formed on the base portion of the periphery of the respective tip, as clearly shown in Figs. 3, 4, 5 and 6.

Each of the first finger sections is turned with reference to the palm by means of a driving segment gear 48 arranged within the palm and engaging with a driven segment gear 49 mounted on the respective first finger section concentrically with the pivotal connection between the first finger section and the palm. For convenience in construction, one driving gear 48 is made sufficiently wide to engage the driven gears 49 of the first and second fingers and another driving gear 48 is made sufficiently wide so as to engage both the driven gears of the third and fourth fingers, as shown in Fig. 4. These two driving gears are mounted on a rock shaft 50 arranged within the palm of the hand section and journaled transversely in suitable bearings thereon.

The second section of each finger is turned with reference to the companion first section for folding and unfolding these members relatively to each other by means which preferably comprise a rock lever 51 pivoted concentrically with the pivotal connection between the first finger section and the palm by mounting this lever on the pivot pin 35, a rock arm 52 secured to the adjacent part of the rock shaft 50, a rear link 53 connecting the rock arm 52 with the outer arm of this rock lever 51 and front link 54 connecting the inner arm of this rock lever 51

with a crank pin 55 mounted on the second finger section 37 on one side of the pivotal connection 38 between the first and second finger sections. The third finger section is preferably actuated by means which comprise a rock arm 56 fulcrumed on the pin 38 which pivotally connects the second and first finger sections and a connecting member comprising an inner section 57 having the form of a link which connects the rock arm 56 with the pivot pin 35 between the palm and first finger-section, and an outer section 58 having the form of a link extending from the rock arm 56 to a crank pin 59 arranged on the third finger section on one side of the pin 40 which pivotally connects the third and second finger sections.

Upon turning the rock shaft 50 in the direction of the arrow shown in Fig. 3, the several sections of each finger will be shifted from the unfolded position shown in Fig. 3 to the folded position of these parts shown in Fig. 5, and upon reversing the rotation of this rock shaft the sections of the finger will be restored from the folded position shown in Fig. 5 to the unfolded position shown in Fig. 3.

This rocking motion of the shaft 50 may be produced in various ways by means which are under the control of the body of the wearer, and in the present case this mechanism is so organized that the same is operated and controlled by motion derived from the left shoulder and the left arm of the wearer. As best shown in Figs. 1–4, this digit operating mechanism is constructed as follows:

60 represents a rotatable drum arranged within the palm of the hand and pivotally mounted thereon by means of a pin 61 arranged perpendicular to the plane of the palm, as best shown in Figs. 3 and 4. On its face this drum is provided with a crank pin 62 which is connected by means of a link 63 with a crank 64 on the central part of the rock shaft, so that by turning this drum in one direction or the other, this shaft will be rocked and the sections of the fingers will be folded and unfolded. The forward turning movement of this drum for causing the digits connected therewith to close or fold is effected by means which are preferably constructed as follows:

On the upper part of the body of the wearer is mounted an upper harness which preferably comprises a horizontal belt 65 passing around the chest of the wearer, and two upright supporting loops or straps 66 each of which is connected at its opposite ends with the front and rear parts of the upper belt and extends over the left shoulder of the wearer, as shown in Figs. 1 and 2. 67 represents a closing pull line of any suitable construction which has its lower end connected with a crank pin 68 on the drum 60 opposite to the crank pin 64, while the adjacent part of this line is arranged within the palm, the forearm and the arm section and passes around guide rollers 69 mounted on the interior of the forearm section. The upper part of this line passes through an opening 70 in the front side of the arm section 2, thence over a guide roller 71 mounted on the right front part of the upper harness and then passes horizontally around the left-hand arm of the wearer in the form of a loop 72 from the front side of this arm to the rear side thereof, and then attaches at its upper end to the rear part of the left shoulder strap 66, as shown in Fig. 1. By means of this organization, an outward or lateral swinging motion of the left arm of the wearer will cause a pull on the closing line 67, which will turn the drum 60 in the direction of the arrow in Fig. 4, and thereby cause the fingers to be closed or folded. As the drum is turned forwardly, the same may be held at different points between its extreme rearward and forward movement for the purpose of retaining the fingers in a more or less closed or folded position without requiring any further attention on the part of the wearer. This is preferably effected by the following means:

73 represents a row of ratchet teeth arranged concentrically on the periphery of the operating drum 60 and 74 is a detent pawl or dog which is pivoted on the adjacent part of the palm of the hand and yieldingly held with its hook or bill in engagement with these ratchet teeth by means of a spring 75 connecting this pawl with the adjacent part of the palm. As the operating drum is turned forwardly, its ratchet teeth trip successively pass the nose of this detent pawl and whenever the lateral pull upon the loop 72 of the pull line by the left arm of the wearer is relaxed, this detent pawl will hold the operating drum at whatever point in its forward rotary movement the same may have reached, and thereby retain the fingers in the partially or fully closed position, whichever the same may occupy at that time. 76 represents a releasing line forming part of the means whereby the detent pawl 74 is released from the ratchet teeth on the drum by motion derived from the wearer. This releasing line has its lower part arranged within the arm, forearm and palm and guided on the roller 77 arranged on the pivotal connection 5 between the arm and forearm while its lower or front end is connected with the tail of the pawl 74, as shown in Figs. 2 and 4. The upper part of this releasing line passes through the opening 70 in the arm, thence over a guide-roller 78 on the

right front part of the upper harness, thence underneath a guide roller 79 on the left front part of the harness and then passes in the form of an upright loop 80 over the left shoulder of the wearer and has its upper end connected with the rear part of the left shoulder strap 66 of the upper harness. 81 represents a spiral spring arranged within the drum and connected at one end with the stationary pivot 61 and at its opposite end with some part of this drum. During the forward movement of the drum, the spring 81 is flexed. Whenever the wearer wishes to unfold the fingers, he raises his left shoulder so as to lift the loop 80, thereby producing a pull on the line 76 which releases the pawl 74 from the teeth on the operating drum thereby permitting the spring 81 to turn the drum backwardly and cause the fingers to be opened or unfolded.

The sections of the thumb are folded and unfolded in unison with the closing and opening of the fingers by means which are preferably constructed as follows and which are best shown in Figs. 3, 4 and 6.

84 represents a link which is connected at its inner end with a crank pin 83 arranged on the operating drum while its outer end is connected with a crank pin 82 arranged on the first section of the thumb adjacent to the pivotal connection 42 between this first thumb-section and the palm of the hand. 85 represents a rock arm journaled concentrically with the pivot 42 which connects the first section of the thumb and the palm, 86 an inner link connecting the crank pin 83 on the operating drum with the rock arm 85, and 87 an outer link connecting the rock arm 85 with a crank pin 88 arranged on the second section of the thumb on one side of the pin 44 which connects the second section with the companion first section of the thumb.

Upon turning the operating drum in the direction of the arrow for closing the fingers, the mechanism just described with reference to the thumb operates to shift the sections of the latter from the unfolded position shown in Fig. 6 to the folded position shown by dotted lines in the same figure, and vice versa.

In the completely finished artificial limb, the exterior of the hand and wrist is covered by a glove, so that the working parts of the hand are not visible as is commonly the practice.

This artificial limb can be easily and conveniently operated so that the several parts perform their functions in close imitation of the human parts for which they are substituted, and this operation for controlling these parts can be effected by movement of parts of the body of the wearer which can be accomplished without attracting undue attention, thereby rendering the use of this article more agreeable and satisfactory.

We claim as our invention:

1. An artificial limb comprising a palm, a digit having a first section pivoted on said palm, a section pivoted on said first section and a third section pivoted on said second section, and means for turning said third digit section comprising a shifting member extending from the pivotal connection between said palm and first digit section to said third digit section on one side of the pivotal connection between the same and said second digit section.

2. An artificial limb comprising a palm, a digit having a first section pivoted on said palm, a section pivoted on said first section and a third section pivoted on said second section, and means for turning said third digit section comprising an arm projecting inwardly from the pivotal connection between said first and second digit sections, a link extending from the pivotal connection between said palm and first digit section to said arm, and another link extending from said arm to said third digit section on one side of the axis of the latter.

3. An artificial limb comprising a hollow digit section provided at its outer end with an inwardly-turned flange, and an elastic tip provided with an external groove which receives said flange.

4. An artificial limb comprising a palm, a digit having a section pivoted to said palm, and means for turning said digit section comprising a drum pivoted on said palm, a crank on said drum connected with said digit section, a pull line connected with said drum and operating to turn the same forwardly, and a spring which is interposed between said palm and drum and which is flexed upon turning the drum forwardly so that the resilience of said spring turns said drum backwardly when the pull on said line is relaxed.

5. An artificial limb comprising a palm, adapted to be mounted on the arm of the wearer, a digit pivotally mounted on the palm, a drum pivoted on the body and having a crank, a connection between said crank and said digit, a harness adapted to be mounted on the chest of the wearer and provided with guides, a closing pull line connected at one end with said crank and at its opposite end with said harness and engaging some of said guides and having a loop adapted to pass over the shoulder of the wearer, a ratchet segment arranged on said drum, a pawl pivoted on said ratchet, a spring operating to hold said pawl yieldingly in engagement with said ratchet teeth, and a releasing pull line connected at one end to said pawl and at its opposite end to

said harness and engaging one of said guides and having a loop adapted to pass horizontally around one of the shoulders of the wearer.

6. An artifical limb comprising a forearm adapted to be mounted on the arm of the wearer, a hand, a joint arranged at the wrist between said hand and forearm and constructed to permit said hand to turn about an axis arranged lengthwise of the hand and forearm and comprising annular ball races arranged on adjacent parts of the hand and forearm and a row of bearing balls arranged between said ball races.

7. An artificial limb comprising a forearm adapted to be mounted on the arm of the wearer, a hand, a joint arranged at the wrist between said hand and forearm and constructed to permit said hand to turn about an axis arranged lengthwise of the hand and forearm, and a spring which is flexed upon turning said hand about said axis out of its normal position relatively to said forearm.

8. An artificial limb comprising a forearm adapted to be mounted on the arm of the wearer, a hand, a joint arranged at the wrist between said hand and forearm and constructed to permit said hand to turn about an axis arranged lengthwise of the hand and forearm, a stop device for limiting the rotation of said hand out of its normal position relatively to said forearm, and a spring which is flexed upon turning said hand about said axis out of its normal position.

9. An artificial limb comprising a forearm adapted to be mounted on the arm of the wearer, a hand, a joint arranged at the wrist between said hand and forearm and constructed to permit said hand to turn about an axis arranged lengthwise of the hand and forearm, and means for turning said hand relatively to the forearm by motion derived from the bodily movement of the wearer comprising a harness adapted to be worn on the lower party of the body of the wearer, guides arranged on said forearm, and a pull line connected at one end with said hand and at its opposite end to said harness and having a loop which is adapted to pass over a shoulder of the wearer.

10. An artificial limb comprising an arm, a forearm pivoted to said arm so as to be capable of folding and unfolding relatively thereto, a hand pivoted to said forearm so as to be capable of turning about a longitudinal axis relatively to said forearm, and means for causing said forearm to be folded and said hand to be turned by motion derived from the movement of the body of the wearer comprising a guide arranged on said forearm on one side of the axis of said hand, a guide arranged on said arm on one side of the pivotal connection between said arm and forearm, a harness adapted to be applied to the lower part of the body of the wearer and a pull line connected at one end with said hand and at its opposite end with said hand and engaging its intermediate part with said guides and having a loop adapted to pass over the shoulder of the wearer.

11. An artificial limb comprising two arm sections which are pivotally connected so as to be capable of being folded and unfolded, and a detent device interposed between said arm sections constructed to permit of folding said sections and holding the same in a partially unfolded position and preventing said sections from again unfolding until the same have reached their maximum folded position, said detent device comprising a segment mounted on one of said arm sections and having a row of ratchet teeth, a plain face alongside of said teeth and an incline leading from the rear end of said row of teeth to said plain face, a pawl adapted to engage said teeth, incline and plain face, a spring arm carrying said pawl and pivoted on the other arm section and yieldable in a direction crosswise of said teeth and plain face, and a spring operating to move said pawl radially toward said teeth and plain face.

In testimony whereof we affix our signatures.

ALBERTO PECORELLA
VINCENT PATRICOLO.