Sept. 2, 1930. J. LIVINGSTON 1,774,715

ARTIFICIAL LIMB

Filed Feb. 10, 1928 3 Sheets-Sheet 1

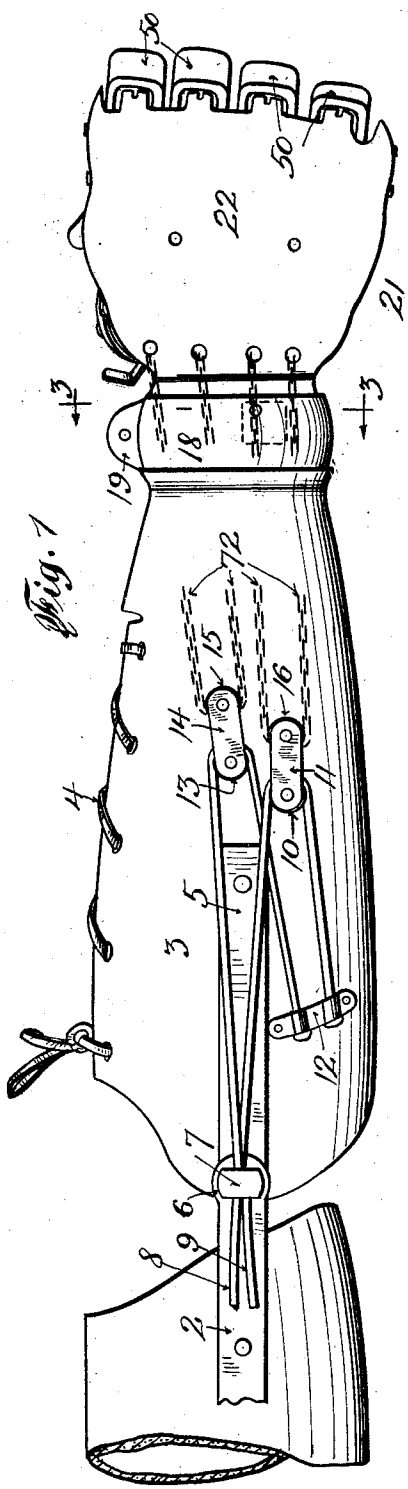

Fig. 1

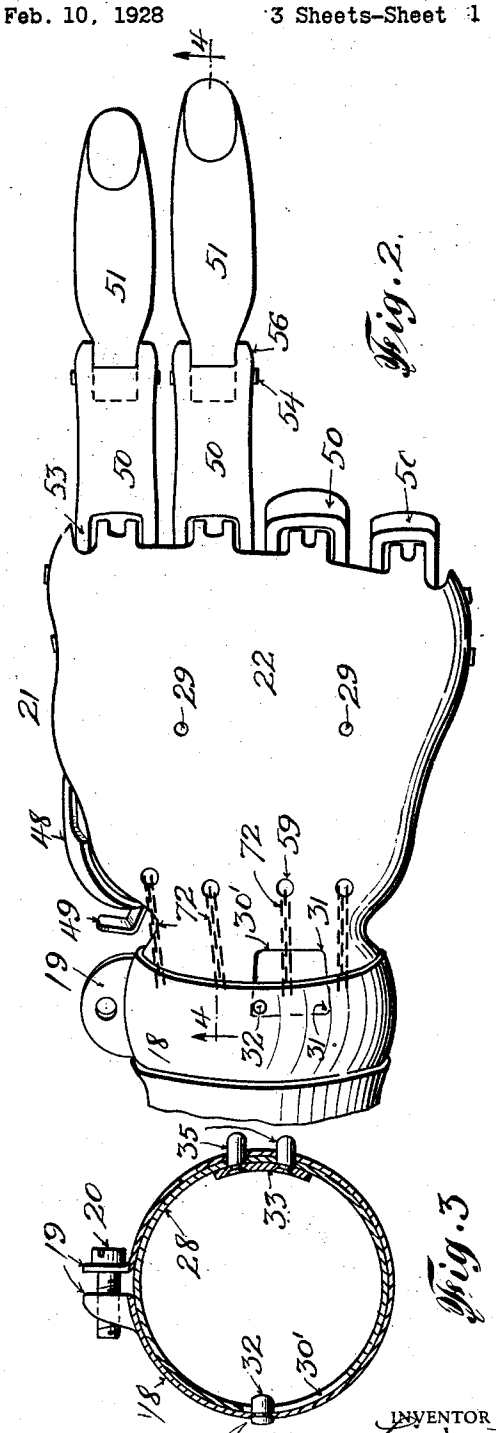

Fig. 2.

Fig. 3

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Filed Feb. 10, 1928 3 Sheets-Sheet 2

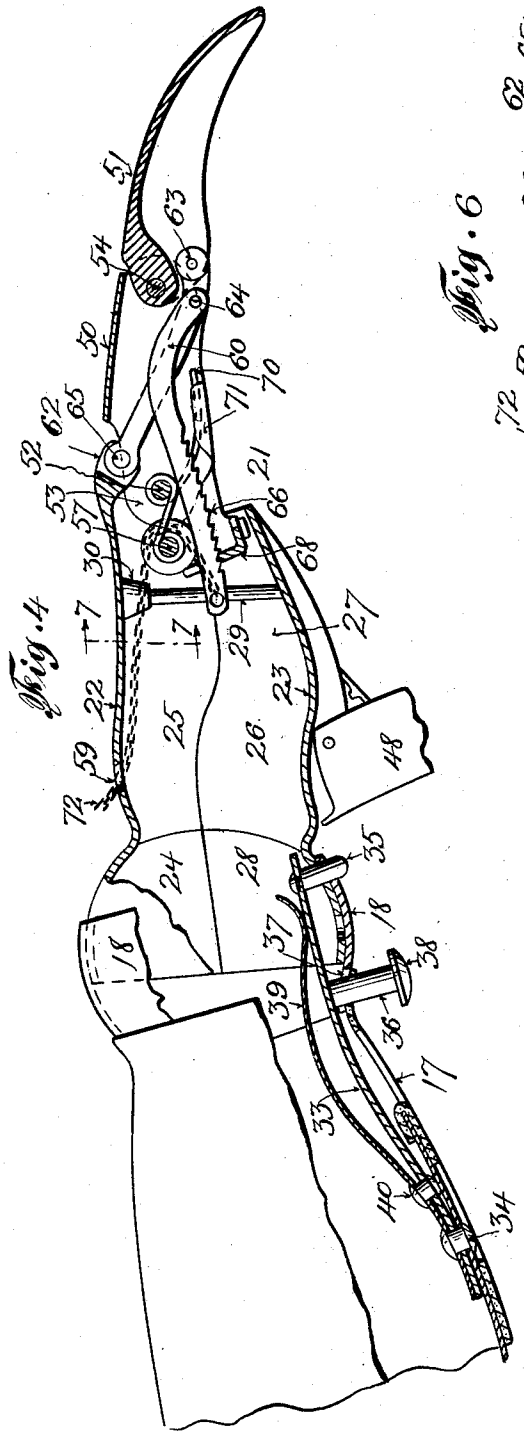

Fig. 4

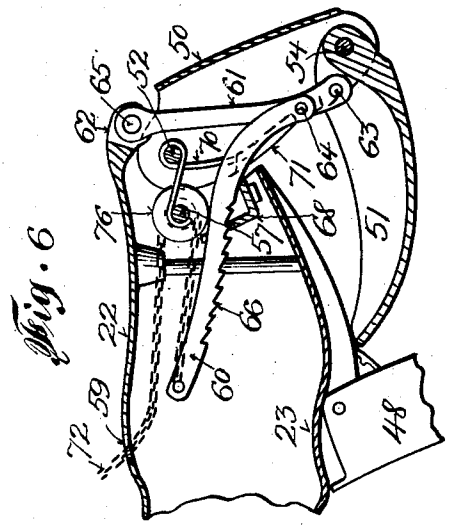

Fig. 6

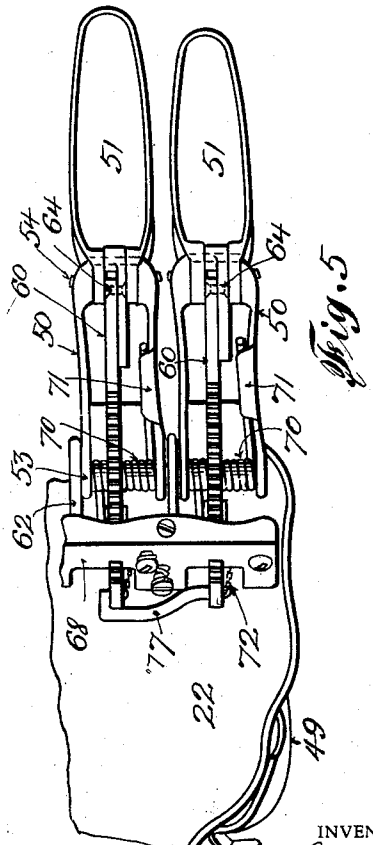

Fig. 5

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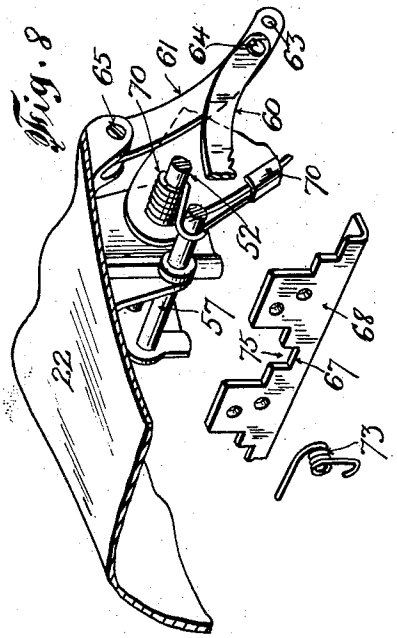

Fig. 8

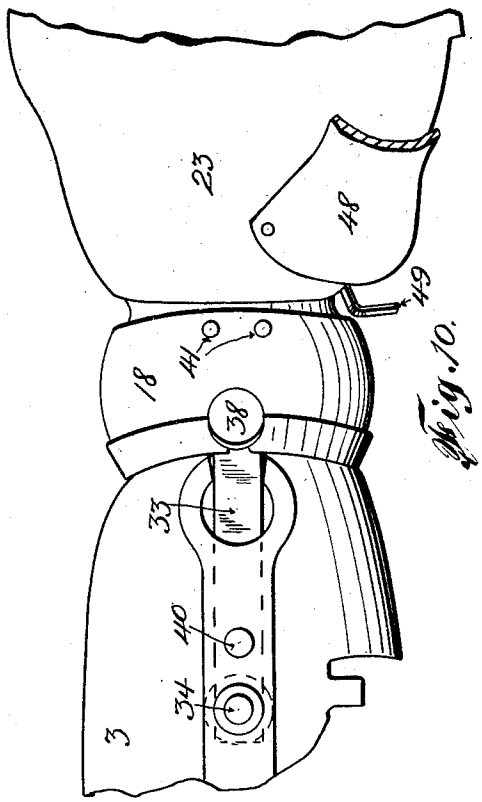

Fig. 10

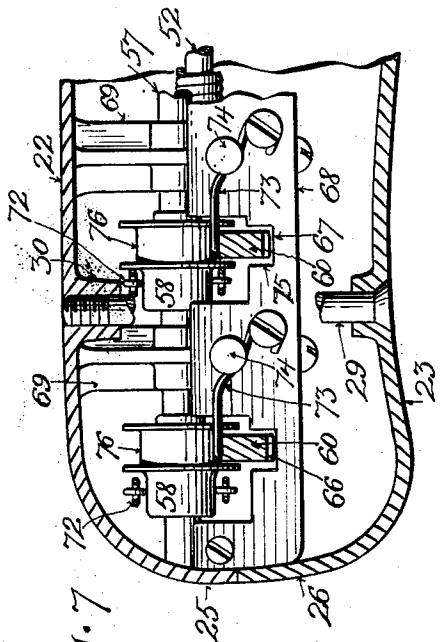

Fig. 7

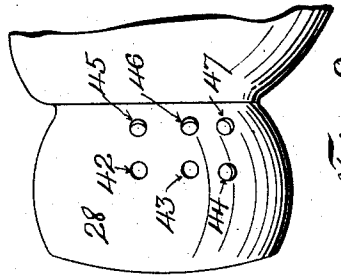

Fig. 9

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1,774,715

UNITED STATES PATENT OFFICE

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ARTIFICIAL LIMB

Application filed February 10, 1928. Serial No. 253,399.

My invention relates to artificial limbs and more particularly to an arm and a hand having articulated fingers and thumb, adapted to be manipulated and operated to perform any of the functions of the natural arm and hand. Letters Patent have been issued for devices of this kind, as follows: 1,507,680, 1,507,681, 1,507,682, 1,507,683, 1,608,689, and the present invention is an improvement on artificial limbs of the type shown in said Letters Patent.

One object of the present invention is to provide an artificial limb having a hand portion which is connected with the wrist portion by a pivotal joint with which is associated a locking device adapted to hold the hand in various angular positions of adjustment in relation to the wrist portion. This locking device is adapted to be unlocked or disengaged to permit of adjustment by the human hand and when it is in holding or locking position it is adapted to more firmly hold the hand in fixed adjustment against twisting stresses so that the hand may be used for heavy duty. This adjusting device includes means for limiting the swing of the hand member in relation to the wrist member while the locking member is disengaged for adjusting the hand. Furthermore, when the hand is adjusted in any one of several extreme positions it is held by means at opposite sides of the wrist in order to resist strains and prevent displacement to a greater extent than if held merely by the locking members at one side of the wrist.

Another object of my invention is to improve the spring device which operates the jointed fingers and to so locate the same that the springs lie within the palm member rather than within the fingers.

Another and important feature of my invention is to provide means for articulating the several fingers and to so associate at least two of the fingers that they will close together in order to facilitate the holding of instruments such as knives, forks and spoons to better advantage than where each finger closes individually. These and other advantages will be apparent in the following detailed description of my invention.

In the drawings forming part of this application,

Figure 1 is an elevation of an artificial limb embodying my invention,

Figure 2 is an elevation looking at the back of the hand and showing two of the fingers in closed position and two of them in open position,

Figure 3 is a sectional view taken on the line 3—3 of Figure 1,

Figure 4 is a sectional view taken on the line 4—4 of Figure 2,

Figure 5 is an elevation of a portion of the palm member and certain fingers looking at the inner side of the hand,

Figure 6 is a sectional view corresponding with the right hand end of Figure 4 and showing the fingers in closed position,

Figure 7 is a sectional view taken on the line 7—7 of Figure 4,

Figure 8 is a perspective view showing various elements of the finger operating device,

Figure 9 is an elevation of a portion of the palm member which engages the wrist member, and

Figure 10 is an elevation showing the joint of the wrist and palm members and the locking device therefor.

Certain parts of the device may be made to conform with the aforesaid Letters Patent. For instance, I have shown a sleeve member 1 which is adapted to be passed over the stump of the human arm and above the elbow, and this is provided at opposite sides with metal bars 2 preferably riveted to the sleeve member 1. There is a second sleeve member 3 which may also be made of leather or other suitable material and the stump of the lower arm is adapted to be inserted into this member. I have provided a lacing 4 for connecting the edges of a longitudinal opening in this sleeve member for the purpose of lacing the sleeve tightly onto the stump of the natural arm. This sleeve member 3 is also provided at opposite sides with metal bars 5 preferably riveted thereto, and these bars are hingedly connected to the ends of the bars 2 by pivot pins 6 at a point corresponding approximately with the elbow joint of the natural arm. The pivots 6 are provided with pro-

jecting apertured eyes 7 through which the draw cords 8, 9 which actuate the fingers are adapted to slide. The draw cords 8, 9 which pass through this eye are preferably extended up over the shoulder of the wearer and the same device may be attached to the body for operating these cords as is shown in Patent 1,507,681 or any other operating connections may be used, the purpose of which will be to pull to the left in Figure 1 on these operating cords when the arm is moved in one direction, and allow the cords to retract when the arm is moved in a reverse direction. Usually, these cords are actuated either by movement of the complete arm at the shoulder joint, or by the bending of the lower arm at the elbow joint, but as the device for manipulating these cords is fully disclosed in the above mentioned patents, it is unnecessary to show the same in detail herein. The cord 8 passes around a pulley 10 which is journaled in a pulley block 11 and the free end of this cord returns from the pulley and is secured to the sleeve member 3 by an attaching plate 12. The other cord 9 which also passes through the eye 7 engages around a pulley 13 journaled in another pulley block 14 and it returns along the sleeve and its free end is attached to the sleeve, preferably by the same member 12 which attaches the first mentioned cord. These pulley blocks 11, 14 which are independently movable along the outside of the sleeve 3 are provided at one end with pulleys 15, 16 around which certain chains engage as will appear more fully hereinafter. There is a metal member 17 permanently attached to the small end of the sleeve 3 and this has a spheroidal socket member 18 which is split and which is provided with lateral ears 19 having perforations therein whereby this spheroidal socket may be contracted by means of a screw 20 passing freely through one of the ears and having a threaded connection with the other one. This comprises all of the members which are carried directly upon the natural arm except for the locking device for locking the wrist joint.

The hand portion of the device is indicated generally by the numeral 21, consists of a rear portion 22 to which the several articulated fingers are connected, or on which they are mounted; and a palm member 23. The member 21 which is shaped to roughly represent the back of the hand, has one-half of a spheroidal socket member as shown at 24 in the drawing, and it has lateral or downwardly extending side members 25. The palm member 23 is also provided with laterally extending walls or flanges 26 at the sides which are adapted to rest against the flanges or walls 25 of the back member, so that the back and palm members form a hollow chamber 27 within which various working parts of the device are arranged. The palm member 23 is also provided with one-half 28 of the spheroidal socket member, which is attached to the hand. When the back and palm members of the hand are placed in assembled position, screws 29 pass through apertures in the palm member and are threaded into bosses 30 projecting inwardly from the back member 22, which serve to keep the back and palm members of the hand in assembled condition. When these members are in assembled position the two spheroidal socket portions thereof are continuous so that they form a spheroidal socket which is adapted to seat within the spheroidal socket member 18 carried by the sleeve 3. In assembling the device the screw 20 is eased off to allow the split spheroidal socket member 18 to expand; and the assembled hand is applied so that the spheroidal socket members 24, 28 extend into the spheroidal member 18 and then the screw 20 is tightened to contract the spheroidal member 18 until it partially encircles the socket members 24, 28 and locks the hand from disengaging from the sleeve member 3 by reason of the fact that the socket member 18 extends over the socket members 24, 28 beyond the maximum diameter of the latter, as shown in Figure 4. As shown in Figures 1, 2, 3 and 9 the socket member 24 which is integral with the back member 22 of the hand, is provided with an aperture 30′ which in the construction illustrated in the drawings is in the form approximately of a rectangle having four corners 31 where the side edges intersect. It will be apparent that the shape of this aperture may be varied and that in describing the particular shape illustrated herein I do not limit the scope of my invention to the particular aperture shown. Fixed to the socket member 18 which is carried by the sleeve 3 there is a pin 32 extending inwardly and this pin projects through the aperture 30′ just described. When the hand is moved in relation to the socket member 18 its movements are limited by the pin 32 which engages the edges of the aperture 30′ in various extreme positions of the hand member. That is to say, the hand member cannot be moved in any direction beyond the limits permitted by the pin.

At the front of the device there is a locking tongue 33 having one end attached to the metal member 17, being preferably attached by the rivet 34. The forward, free end of this tongue extends through the socket members 18, 28 and its end is provided preferably with two pins 35 which extend through certain apertures in the joint members, as will be set forth. In addition, the tongue 33 is provided with an operating pin 36 which extends through an opening 37 in the wrist member 17 and on its outer, projecting end is provided an operating head 38 which is adapted to be actuated with a thumb or finger of the natural hand, or by pressing against some object. The tongue 33 is normally held in

locking position by means of the bowed spring 39 which is secured to the wrist member by the rivet 34 and which is also secured to the tongue 33 by the rivet 40. The forward, free end of this spring engages the inner surface of the tongue 33 and presses the tongue downwardly in Figure 4 but it permits the tongue to be moved upwardly when the operating pin 36 is pressed.

The socket member 18 which is carried by the sleeve 3 is provided, in the construction illustrated, with two apertures 41 adapted to register with the locking pins 35 whereby the latter may project through these apertures when the tongue 33 is pressed downwardly in the position indicated in Figure 4. The socket member 28 is provided with a series of apertures, the rows of each series being adapted to register with the apertures 41. For instance, in the embodiment illustrated and with special reference to Figure 9, it will be observed that I have shown these apertures arranged in two rows spaced apart laterally of the socket member 28. These apertures are so located that the apertures 42, 43 may be brought simultaneously into register with the pins 35 of the socket member 18; or the apertures 43, 44 may be brought simultaneously into register with the pins 35, according to variations in the position of the hand member in relation to the wrist member. Furthermore, the apertures 45, 46 may be simultaneously brought into register with the pins 35 or the apertures 46, 47 may be simultaneously brought into register with the pins 35. The function of these parts will be brought out in the description of the operation of the device.

The hand member is provided with an articulated thumb 48 which may be formed and operated the same as the corresponding member of the aforesaid patents, and there is a locking member 49 for controlling the locking or releasing of the thumb member in its various positions, corresponding with the similar devices shown in the aforesaid patents. In other words, the thumb and its mechanism may be the same as in said patents.

There are four articulated fingers shown in the drawings, corresponding with the number present in the natural hand. For instance, the index finger consists of the member 50 representing one joint of the finger and another member 51 representing the tip or outer end of the finger. There is a shaft 52 extending crosswise of the hand member and attached to the lateral portions 25 and the finger joint 50 is provided with ears 53 extending into the hand portion and pivotally supported on this shaft. The opposite end of the member 50 is provided with a lateral pin 54 and the joint member 51 has a projection 55 extending between the ears 56 and it is journaled on the pin 54 whereby the second joint member 51 of the finger is pivoted or articulated in relation to the first joint member 50. The remaining fingers of the device are similar in construction so far as the members just described are concerned, and they are similarly lettered, so that this description may be read in connection with each of the other fingers up to this point.

The shaft 57 is provided with a pulley 58 one for each finger and arranged in line with the respective fingers. There are chains looped around the two pulleys 15, 16 carried by the pulley blocks 14, 11 as shown in Figure 1, so that there are two runs for each chain, making four runs in all, leading from the pulley blocks across a portion of the sleeve 3 and entering through the back hand member through the several apertures 59. Each run of a chain, after extending through an opening 59 passes partly around one of the pulleys 58 and the free end of the run of the chain is attached to one end of a locking ratchet 60. There is a link 61 pivoted between the ears 62 on the forward end of the hand member 22, and the other end of this link extends through the hollow joint 50 and the opposite end is pivoted to a pin 63 which extends crosswise and is fastened in the finger member 51 a short distance from the pivot 54 of this finger member. The locking ratchet member 60 is pivoted by means of a pin 64 to the link 61 at a point close to the pivotal point 63 or remote from the pivot 65 of the link 61, so that the ratchet member will have a comparatively long movement during the articulation of the jointed finger members. The ratchet member 60 extends backwardly through the hollow finger member 50 and it is provided with ratchet teeth 66 which are adapted to engage with the locking edge 67 on a plate 68 which is fixedly secured to the forward end of the hand section. I have shown a series of posts 69 which are integral with the back hand member 22 and to which the locking plate 68 is secured. There is a spring 70 which is coiled around the pin 52 on which the finger member 50 is pivoted, and one end of this spring is coiled around the shaft 57 to hold it, whereas the other end of the spring extends forwardly in the member 50 and engages against the shoulder piece 71 so that this spring continually exerts a pressure on this shoulder piece, tending to move the finger section 50 clockwise on its pin 52 in the position shown in Figure 4. Each of the four fingers shown herein is provided with similar springs, links and ratchet bars, and each ratchet bar is connected with one run of one of the chains 72 as just described. There are coiled springs 73 arranged around the pins 74 on the plate 68 and the free ends of these coiled springs press on the backs of the several rack bars 60 for urging the same into locking engagement with the edge of the plate 68; and these springs are similar for each of the rack bars.

I prefer to provide slots 75 in the plate 68 for each rack bar, for the purpose of limiting the lateral movement of the latter. On the shaft 57 there is a flanged pulley 76 for each rack bar, against which the back of the latter is adapted to press, so that the pulley will provide a rolling contact for the rack bar. The flanges of these pulleys also serve to prevent lateral displacement of the rack bar.

As above stated, there is a rack bar for each individual finger, and as far as the third and fourth fingers of the hand are concerned, they are individually operated, so that the fingers which they operate may close individually upon the object to conform with the shape of the latter. However, certain of the fingers, preferably the index finger and the second finger, are operated as a unit. That is to say, they are so connected together that both will open and close to the same extent, and therefore the jointed members of these fingers will remain in parallel relation throughout their operation. For this purpose I have shown a lateral bar 77 connected across between the free ends of the two rack bars 60 which operate the index and second fingers of the hand, as shown more clearly in Figure 5. While I prefer to have the runs of the chains connected individually with these two rack bars in order to exert the same pulling action on each, and therefore prevent binding, nevertheless the cross bar 77, being rigidly connected to both of these rack bars, compels the latter to move in unison.

Operation

As far as the thumb member is concerned, it is preferably constructed and operated in the same manner as the corresponding member shown in said prior patents, and therefore a description is unnecessary in the present case. The hand, in the construction illustrated herein, may be locked in any one of four positions as regards the spheroidal joint by which it is connected with the wrist member. It may be positioned with the palm portion of the hand turned toward the arm with a tilt either inwardly or outwardly, and likewise the hand may be turned with the palm directed away from the arm and with either a right or left tilt. When the wearer desires to use the hand it will first be necessary to determine which of these several positions of the hand in relation to the arm is most desirable, whereupon the operating pin 36 will be pressed with the thumb or finger of the natural hand on the opposite arm, or this pin may be pressed against any object, so that the tongue 33 is pressed inwardly to disengage the locking pins 35 from the several apertures 41 in the spheroidal member 18 and from the apertures in the spheroidal joint member 28. The hand member is then free to be swung upon the spheroidal joint, limited only by the scope of movement of the pin 32 in relation to the aperture 30′ in which it travels. While the locking pins 35 are disengaged, therefore, the artificial hand may be manipulated by the natural hand to place the former in any one of the four selected positions, and when so positioned the locking tongue 33 is released, so that it is pressed forwardly by its spring 39 and this will move the locking pins 35 through two of the apertures in the spheroidal member 28 which are in register with it, and these locking pins will also enter the locking apertures 41 in the spheroidal member 18. The limiting pin 32 will then be positioned in one of the corners 31 of the rectangular opening 30′, depending on which angle the hand is positioned at the time it is locked. When the locking tongue 33 is thus in locking position the hand is then fixed so that it will not turn on the spheroidal joint, even though considerable stress is exerted upon the hand, as when lifting heavy objects. Not only do the locking pins 35 lock the hand in one of its positions, but the limiting pin 32 engaging in one of the corners of the aperture 30′ also serves to resist pivotal movement of the hand in relation to the wrist. The hand will remain in its adjusted position until such time as it is desired to readjust it, and when readjustment is to be made the locking tongue 33 is released in the manner above described.

When it is desired to close the fingers of the hand upon an object in order to grasp it, the arm will be manipulated in the manner described in the aforesaid patents, so that the operating cords 8, 9 are drawn first to the left in Figure 1, in order to pull the pulley locks 11, 14 to the left in Figure 1. This action will draw the four runs of the chains 72 to the left or in the direction of the elbow joint and these several runs of the chain which pass around the pulleys 58 will draw on the free ends of the rack bars 60. This action will be independent, so far as the third and fourth fingers of the hand are concerned. As to the index and second fingers of the hand the runs 72 will also draw on the rack bars but the latter must move in unison because they are rigidly connected by the cross piece 77. As the drawing action of the several runs of the chains 72 takes place, the rack bars 60 are first disengaged from the locking plate 68 by the pull of the chains, and then the rack bars are pulled forwardly by the chains. The rack bars will act upon the links 61 forcing them outwardly, and this will cause both joints 50, 51 of the fingers to swing on their respective pivots 52, 54 tending to straighten the finger joints out to the position shown in Figure 4. As the rack bars are connected with the links 61, the above described motion of the rack bars causes both joints of the finger members to simultaneously rock upon their respective pivots. All fingers of the hand will be opened or extend-

ed by the above operation. If it is now desired to close the hand upon an object, the arm is moved again in another direction to release the pull on the operating cords 8, 9 and the several springs 70 pressing against the lips 71 will cause the finger joints 50 of each finger to swing toward the palm of the hand, each finger being operated by its individual spring. The pressure of the spring on the lip 71 directly actuates the finger joint 50, whereas the motion for the joint 51 is transmitted to it by the connecting link 61. When the finger members thus rock on their pivots in the closing action described, the rack bars 60 move inwardly within the hand member, the teeth 66 escaping over the edge of the bar 68 against the resistance of the pressing springs 73. When the finger joints have closed upon an object, the teeth of the rack bar 60 will lock upon the locking bar 68 so that the fingers remain clamped on the object until such time as the grip is released by another operation of the arm. As far as the third and fourth fingers of the hand are concerned, each will be independent in its closing action, and therefore the joints of each of these fingers may close different degrees to conform to the object being grasped. As far as the index and second finger of the hand are concerned, however, they will close to the same extent because the bar 77 is fixed to both of the rack bars of these fingers. Therefore, the index and second fingers move in parallel relation and close in the same manner upon an object. If, therefore, the handle of a spoon, a fork or a knife or similar object is gripped against the outer surfaces of the third and fourth fingers and the inner surfaces of the index and second fingers and against the surface of the thumb, the article so grasped will be held firmly and it will not have the same tendency to twist out of the grasp of the fingers, as would be the case if the index and second fingers were not operated as a unit. To release the grip from the object the arm may be swung in the direction necessary to draw the operating cords 8, 9 to the left in Figure 1.

It will be observed from this construction and the above description that the springs 70 for closing the fingers are arranged within the hand member rather than in an extended portion of the finger. At least two of the fingers are compelled to move in unison for the advantages above described. Furthermore, while the wrist joint provides for adjustment of the hand in various angular positions, nevertheless it is firmly locked in the several adjusted positions in such manner as to permit the hand to be used for heavy duty. The hand is positively and firmly locked in its various adjusted positions.

Having described my invention, what I claim is:

1. An artificial limb comprising a wrist member, a hand member, co-operating spheroidal socket members on said wrist and hand members, for permitting the hand member to pivot in various directions in relation to the wrist member, one of said spheroidal socket members having an aperture, a locking member having a pin registering with said aperture, another of said spheroidal socket members having a plurality of apertures any of which may be brought into register with said locking pin, a pin secured to one of said spheroidal socket members, and another of said spheroidal socket members having a polygonal aperture in which said pin engages, said pin engaging with the edges of said aperture to limit the relative movement of the spheroidal socket members and adapted to effect the register of said locking pin with said locking apertures.

2. An artificial limb comprising a wrist member, a hand member, co-operating socket members on said wrist and hand members for permitting the hand member to pivot in various directions in relation to the wrist member, a pin on one of said spheroidal members, means on the other of said spheroidal members, co-operating with said pin to permit limited movement of said hand member, and to stop it in various angular positions of adjustment, said spheroidal socket members having apertures adapted to register in different angular positions of the hand, means engaging in said latter apertures for locking the hand in different adjusted positions, said pin being adapted to act as a stop for said hand in different directions to cause the registering of said locking apertures.

3. An artificial limb comprising a wrist member, a hand member, a plurality of articulated finger members pivotally connected with said hand member, rack bars connected with said finger members for locking them in different positions, springs for closing said finger members, flexible members for actuating said rack bars to effect the opening of said finger members, and means for connecting a plurality of said rack bars together to cause a plurality of said finger members to open and close in unison.

Signed at the city, county and State of New York, the 27th day of January, 1928.

JEFFERSON LIVINGSTON.