

April 17, 1951

M. FISHBEIN ET AL

2,549,074

ARTIFICIAL HAND WITH WORM AND GEAR DRIVE TO THUMB

Filed Aug. 5, 1948

3 Sheets-Sheet 1

Fig. 1.

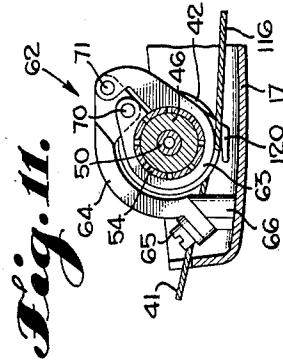
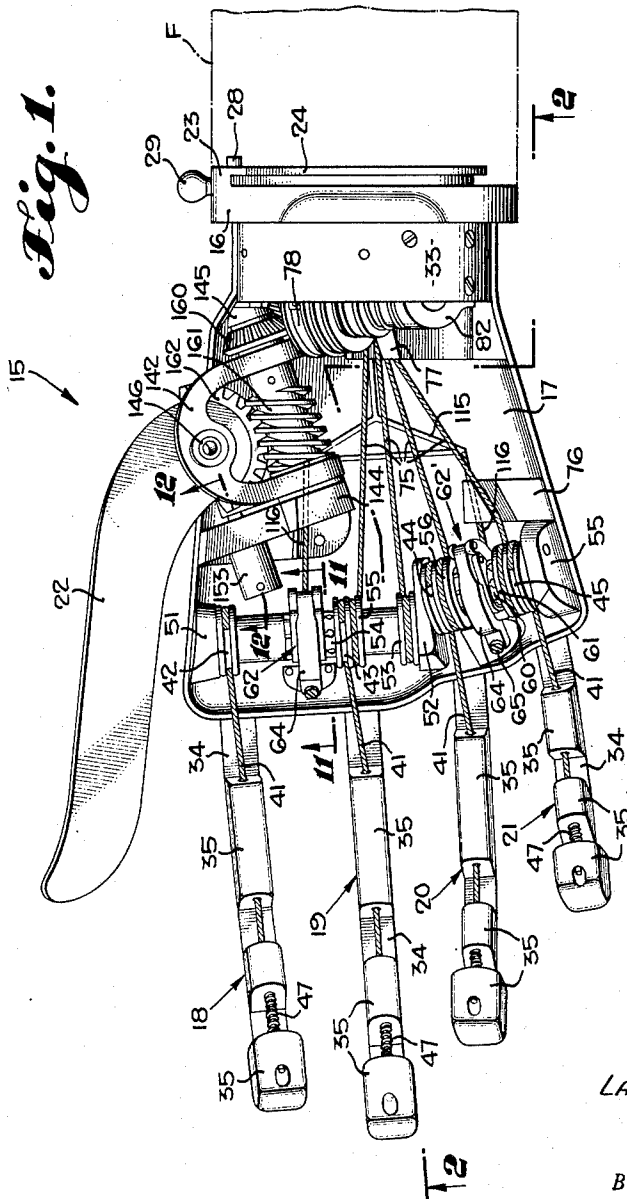
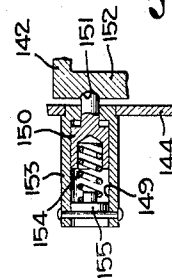


Fig. 12.



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3 Sheets-Sheet 2

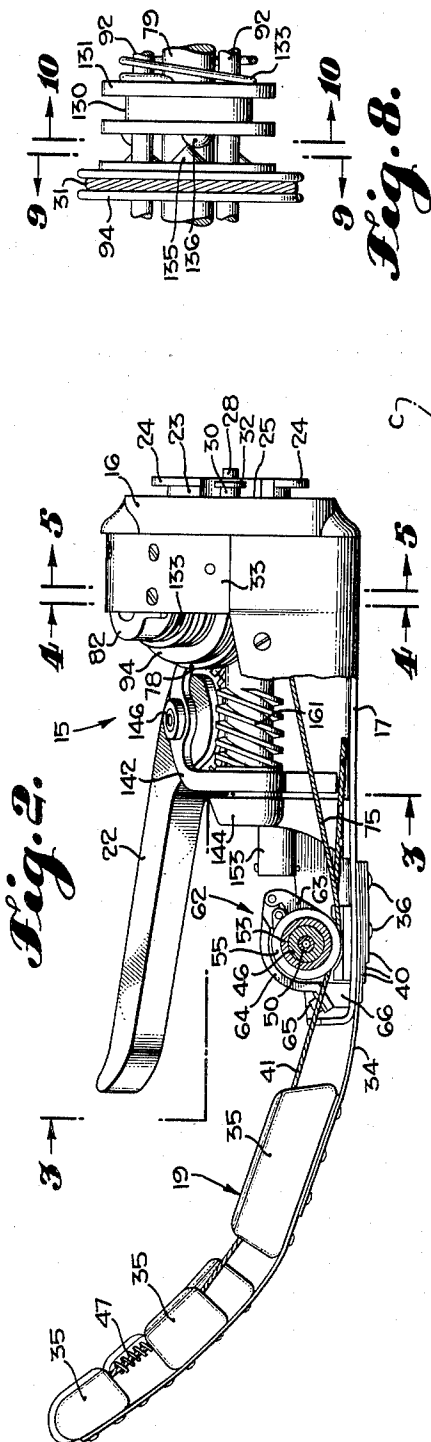


Fig. 2.

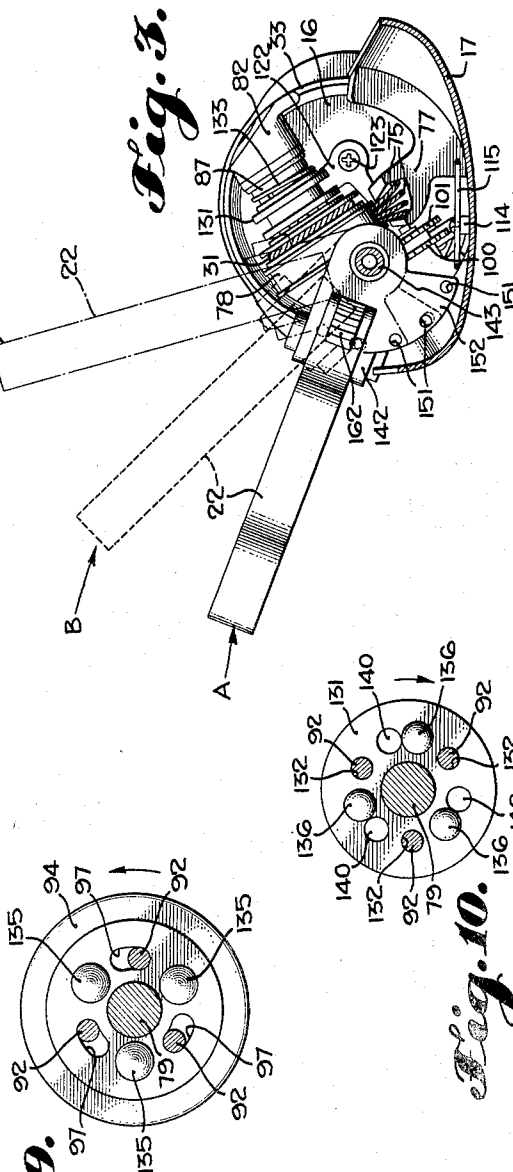


Fig. 3.

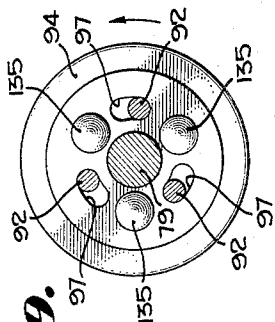


Fig. 9.

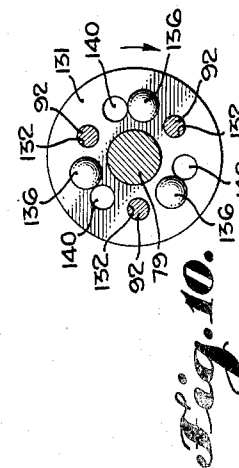


Fig. 10.

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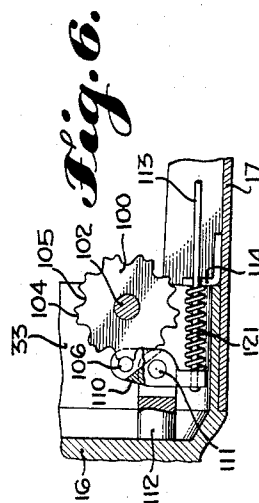
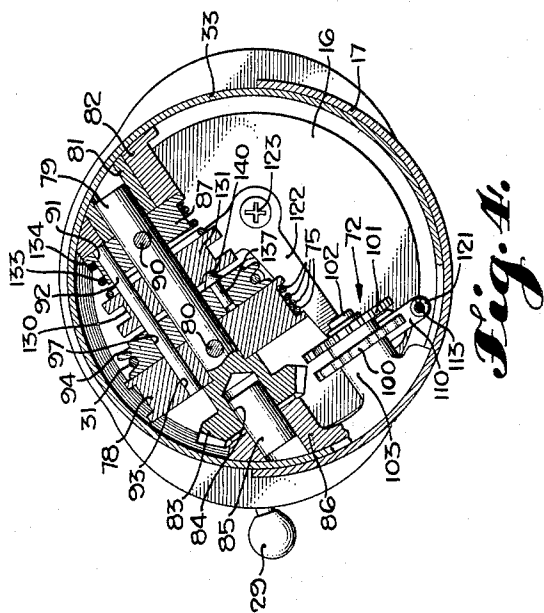
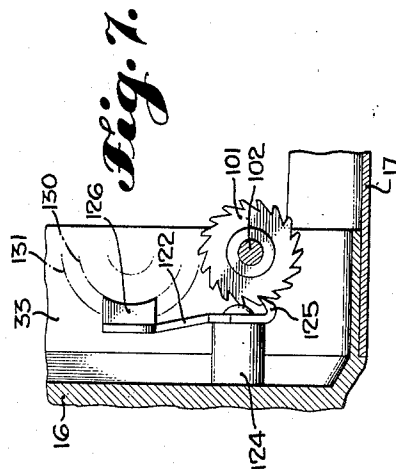
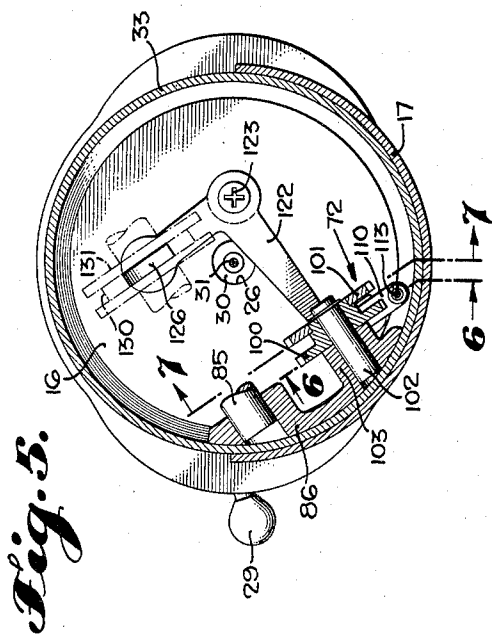
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ARTIFICIAL HAND WITH WORM AND GEAR DRIVE TO THUMB

Filed Aug. 5, 1948

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,549,074

ARTIFICIAL HAND WITH WORM AND GEAR
DRIVE TO THUMB

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Application August 5, 1948, Serial No. 42,606

15 Claims. (Cl. 3—12)

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The present invention relates generally to artificial hands, and one of its primary objects is to provide a hand having articulated fingers that are closed by a pull on the control cables, and which lock automatically and remain locked in any position of flexion upon relaxation of the pull.

Another object of the invention is to provide a hand of the type described above, wherein the finger lock is released by the application of a second pull on the control cable. One of the advantages of this arrangement is that it reduces the number of controls required, and simplifies the operation of the hand.

Another object of the invention is to provide an artificial hand that is adapted to grasp articles of irregular shape and widely varying sizes, and in which the closing force is equalized between the fingers.

Still a further object of the present invention is to provide an artificial hand having an articulated thumb that is pivoted for passive rotation between the adducted and abducted positions, and which can be locked in any one of several positions of adjustment.

Another important feature of the invention is that the thumb is likewise operatively connected to the control cables and is flexed with the fingers when the cable is pulled, so that the function of prehension is reproduced in a realistic and natural manner, enabling the amputee to grasp and hold many articles which could not otherwise be handled.

The foregoing and other objects and advantages of the invention will become apparent to those skilled in the art upon consideration of the following detailed description of the preferred embodiment thereof, reference being had to the accompanying drawings, wherein:

Figure 1 is a top plan view of an artificial hand embodying the principles of the invention;

Figure 2 is a partially sectioned side view of the same, taken substantially along the line 2—2 in Figure 1;

Figure 3 is a transverse sectional view, taken along the line 3—3 in Figure 2;

Figure 4 is a transverse vertical section, taken at 4—4 in Figure 2;

Figure 5 is another transverse sectional view, taken along the line 5—5 in Figure 2;

Figure 6 is a fragmentary sectional view, taken at 6—6 in Figure 5;

Figure 7 is another sectional view, taken at 7—7 in Figure 5;

Figure 8 is a fragmentary elevational view of

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the shifting mechanism that operates the alternator for releasing the finger locks on alternate pulls of the control cables;

Figure 9 is a sectional view, taken at 9—9 in Figure 8;

Figure 10 is a sectional view, taken at 10—10 in Figure 8;

Figure 11 is an enlarged sectional view, taken at 11—11 in Figure 1, showing details of one of the finger locks; and

Figure 12 is an enlarged sectional view of the thumb detent, as seen along the line 12—12 in Figure 1.

In the drawings, the hand is designated in its entirety by the reference numeral 15 and is seen to comprise a base plate 16, to which a body shell 17 is attached. Mounted on the body shell 17 are articulated fingers 18, 19, 20 and 21, thumb 22, and the actuating mechanisms therefor; the construction and operation of which will be described in detail presently.

The base plate 16 constitutes the wrist of the hand and is preferably, although not necessarily, provided with a quick disconnect arrangement of the type shown and described in the pending application of Gilbert M. Motis, Serial No. 24,598, filed May 1, 1948, now Patent Number 2,516,792 and entitled Quick Disconnect Coupling for Artificial Hand or Hook: to which reference may be had for full details of construction and operation. Briefly, the base plate 16 is adapted to be coupled to a companionate member on the distal end of a forearm component F (Figure 1), and to this end is provided on its back surface with a rearwardly projecting, vertically extending rib 23 having straight and parallel side edges which are provided with outwardly facing flanges 24. A shallow, vertically extending slot 25 (Figure 2) is milled out of the center of the rib 23, said slot being open at the bottom end and preferably closed at the top end. A circular hole 26 (Figure 5) is provided in the center of the plate 16, and slidably disposed within this hole is a connector 30 which is attached at its front end to a forwardly extending cable 31. The connector 30 extends rearwardly beyond the bottom of the slot 25 and has a radial flange 32 on the end thereof which is adapted to be received within a slot in the end of a coupling member (not shown) projecting forwardly from the face of an attach plate on the forearm member F. The said attach plate is companionate to the base plate 16, and is formed with channels to receive the flanges 24. The base plate 16 is coupled to the forearm member by sliding the flanged rib 23 endwise into a

corresponding recess in the attach plate and then locking the parts together, for which purpose a spring-pressed locking pin 28 is provided on the base plate adjacent the top end thereof. The pin 28 seats in a hole in the attach plate, and is adapted to be unseated therefrom by a manually operable handle 29.

As the base plate approaches its fully seated position, the connector 30 is engaged by the aforesaid coupling member on the attach plate which is attached to a Bowden cable control wire extending upwardly along the arm. The control wire is attached to a shoulder harness in the usual manner, and this arrangement causes a pull to be exerted on the control wire when the harnessed shoulder is shrugged forwardly. From the foregoing, it will be seen that the muscular force for operating the fingers and thumb is transmitted to the actuating mechanism of the hand by the connector 30, and the latter can therefore be defined as the "control member" of the hand, by which name it is identified in the claims.

Projecting forwardly from the base plate 16 is an annular flange 33 to which the body shell 17 and a palm cover shell (not shown) are attached by means of flat head machine screws. The body shell 17 constitutes the back half of the hand, and is preferably formed of heavy gauge sheet aluminum or other light metal. The fingers 18, 19, 20 and 21 may be of any desired construction and are herein shown as comprising flat strips 34 of beryllium copper spring tape, to which are attached inner finger blocks 35. The spring strips 34 are riveted at 36 to the back of the body shell 17, and are reinforced at their base ends by additional spring leaves 40. The inner finger blocks 35 are preferably formed of laminated phenolic resin and are attached to the spring strips 34 at spaced intervals so as to give the fingers the necessary stiffness between joints. The thumb and fingers, as well as the main body portion of the hand, may be covered with sponge rubber or plastic foam to give the hand a more natural appearance and feel.

The fingers are held in the normally open, or extended position by the spring tension in strips 34, and are closed or flexed in prehension by means of cables 41 which are attached to the tip end blocks 35 and extend rearwardly therefrom through holes in the other blocks to cable drums 42, 43, 44 and 45. Compression springs 47 encircle the cables 41 between the outer two blocks of each of the fingers, and these springs provide a certain amount of additional resistance to bending at the outer joints, so that the fingers tend to close in a natural manner, with a greater amount of angular deflection at the second and third joints than that obtained at the first joint.

The cable drums 42, 43, 44 and 45 are rotatably mounted on the body shell 17 adjacent the proximal ends of the fingers, and the finger cables 41 pass underneath and around their respective cable drums to a point of attachment therewith. Drums 42 and 43, serving the forefinger and middle finger of the hand, are grouped together coaxial with one another; while drums 44 and 45, serving the third and fourth fingers, respectively, are likewise grouped together coaxially, but with their common axis inclined with respect to that of drums 42, 43, as shown, so that the tip ends of fingers 20 and 21 tend to converge with the ends of fingers 18 and 19. This arrangement gives a slight cupping ac-

tion to the hand as the fingers are closed, similar to that of the natural hand.

The cable drums 42, 43 are mounted on a transversely disposed tubular shaft 46 (see Figure 2) which is mounted, in turn, on a tubular center support shaft 50. The ends of the tubular shaft 50 are held by bearing supports 51 and 52 that are fixed to the body shell 17 adjacent its inner edge and mid-section, respectively. Cable drum 42 is fixedly mounted on the outer end of the tubular shaft 46; while the inner end of the said shaft has another cable drum 53 formed integrally therewith. The other finger cable drum 43 is formed as an integral part of a sleeve 54 at one end thereof; said sleeve encircling the tubular shaft 46 between the hub portions of the drums 42, 53, and being free to turn on the shaft. Also integral with the drum 43 is another cable drum 55, the function of which is to drive the drum 43. The sleeve 54 is slotted longitudinally from the end opposite drums 43, 55, which makes it possible for the sleeve to be constricted against the tubular shaft 46, for reasons that will be explained hereinafter.

The two finger cable drums 44 and 45 are likewise mounted on a center support shaft (not shown) which is held at its ends by the center support 52 and by another bearing support 55 spaced laterally therefrom. Drum 44 has another drum 56 formed integrally therewith, and both of these are mounted rigidly on one end of a tubular shaft (not shown) which is journaled on the aforesaid center support shaft. Encircling the said tubular shaft and free to turn thereon is a sleeve 60 which is slotted longitudinally from one end in the same manner as sleeve 54, so that it too can be constricted about its tubular shaft. The finger cable drum 45 and another drum 61 are formed integrally with the sleeve 60 on the outer end thereof.

As viewed in Figure 2, the fingers are closed by the counterclockwise rotation of cable drums 42, 43, 44 and 45, and one of the features of the invention is the provision of locking means operable to lock the fingers in flexed position when the finger-closing force on the control member is relaxed. The locking means, in this case, consists of two self-energizing locks 62 and 62' which encircle and engage the slotted sleeves 54 and 60, respectively. The two locks are identical in construction, and each comprises a brake band 63 encircling its respective sleeve, and an anchor link 64, one end of which is secured by a screw 65 to a block 66 on the body shell 17. The two ends of the band 63 are connected to the anchor link 64 by pins 70 and 71 which are spaced apart in a generally radial direction, as shown in Figure 11. The band 63 is normally adjusted to drag lightly on the sleeve 54, and offers little or no resistance to counterclockwise rotation of the latter, which is the direction of rotation of the cable drums to close the fingers. When the finger-closing force on the cable drums is relaxed, however, the fingers tend to straighten out to the extended position, either by reason of the load carried by the fingers or due to the spring tension of strip 34, which tends to rotate the cable drums and sleeves 54, 60 in a clockwise direction. This tendency of the sleeve 54 to rotate in a clockwise direction causes the brake band 63 to wrap tightly around it, exerting a powerful braking action thereon. As the brake band 63 clamps tightly around the slotted sleeve 54, the latter is constricted around its tubular shaft 46 in the manner of a brake band, thereby preventing the shaft

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from turning with respect to the sleeve. Thus, both of the finger cable drums of each group are restrained by the locks 62, 62' against turning in the direction to open the fingers, and the fingers can therefore be kept locked in the flexed condition to enable the amputee to carry a load with the artificial hand without exerting a sustained muscular effort on the control cable. The locks 62, 62' are adapted to be released simultaneously responsive to the next successive application of force to the control member 30 following the relaxation of the finger-closing force; said lock-releasing action being effected through the agency of actuating means, designated generally at 72, which will presently be described in detail.

The finger cable drums 42, 43, 44 and 45 are driven by means of cables 75 which are trained around and attached to the drums 53, 55, 56 and 61. The cables 75 converge rearwardly from their respective drums through guide blocks 76 and 77, and are attached in any suitable manner to a wide drum 78 at the rear end of the hand. As best shown in Figure 4, the drum 78 is mounted on a transverse shaft 79, and is secured thereto by a pin 80. The shaft 79 is journaled at one end in a bushing 81 mounted in a support 82 which is fastened to the inside surface of the annular flange 33. A bevel gear 83 is formed on the other end of the shaft 79, and a central bore 84 is drilled into the end of the shaft on the axis thereof to form a journal for a short pilot shaft 85 which is mounted in and projects from a support member 86; said support member being attached to the inside of flange 33 across from support 82.

A drive pin ring 87 is mounted on the shaft 79 alongside the bearing support 82, and is secured to the shaft to rotate therewith by means of a pin 90. The ring 87 has three equally spaced holes 91 formed therein, only one of which can be seen in Figure 4. Drive pins 92 are pressed into the holes 91, and these extend parallel to the shaft 79 to the drum 78, where they are received within holes 93.

Mounted on the shaft 79 alongside the drum 78 is a main drive wheel 94 which is in the form of a cable drum, around which the control cable 31 is trained and then attached thereto. The main drive wheel 94 is slidable axially along the shaft 79 and has a limited amount of lost motion rotation with respect thereto. The lost motion of the wheel 94 relative to shaft 79 is limited to 20° of rotation, and is obtained by providing three circumferentially extending slots 97 in the wheel, through which the drive pins 92 pass. The wheel 94 is thus free to turn on the shaft 79 until the pins 92 engage one end or the other of slots 97; after which the wheel and shaft are constrained to rotate together. The purpose of this lost motion arrangement is to operate the lock-release mechanism 72, as will be explained shortly.

From the foregoing description, it will be seen that the control member 30 and cable 31 cause the main drive wheel 94 to rotate when a pull is applied to the control cable. Wheel 94 turns on the shaft 79 in the direction of the arrow in Figure 9 until the ends of slots 97 engage the pins 92, after which the wheel drives the shaft with its attached cable drum 78. As the drum 78 revolves, the cables 75 are pulled rearwardly, driving the finger cable drums 42, 43, 44, and 45, and thereby pulling the fingers closed. When the pull on the control cable is relaxed the locks 62 and 62' tighten up on their respective cable

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drums, as described earlier, leaving the fingers locked in the flexed condition.

The alternator mechanism 72 for releasing the locks 62, 62' on the next succeeding application of force to the control member 30 includes an alternator wheel 100 and a ratchet wheel 101, both of which are mounted on a short stud shaft 102 projecting from a boss 103 on the support member 86. The ratchet wheel 101 is fixedly attached to the alternator wheel 100, and the two wheels rotate as one on the shaft 102. The alternator wheel 100 is provided on its periphery with angularly spaced, alternate high and low cam portions 104 and 105, respectively, which are successively engaged by a pin 106 on a follower 110, (see Figure 6). The follower 110 is pivoted at 111 on a bracket 112 projecting forwardly from the surface of base plate 16, and one end thereof is bifurcated so as to straddle the alternator wheel 100; the pin 106 extending transversely across the slot in the bifurcated end. The other end of the follower 110 is slotted or drilled to receive the rear end of a wire rod 113 which extends forwardly therefrom through a slot in an angle bracket 114, and terminates at its front end in a transversely disposed triangular yoke frame 115. The yoke frame 115 is made of brass wire, silver soldered at the joints, and fastened to the opposite ends thereof are two forwardly extending cables 116 which are engaged on hooks 120 provided on the bottom sides of the brake bands 63 of the locks 62, 62'. When the cables 116 are pulled rearwardly, the brake bands 63 are pulled around very slightly in a counterclockwise direction (Figure 11), which releases the locks and frees the finger drums, allowing the fingers to extend by the spring tension of the strips 34. In order that the brake bands 63 may be free to rotate the slight amount necessary to release the lock, the anchor link 64 is fastened rather loosely to the block 66 by screw 65, and is therefore able to rock, or "give" slightly under the pull of the cable 116.

The lock-releasing pull on cables 116 is applied by a compression spring 121 (Figure 6) which encircles the yoke wire 113 and bears at one end against the lower arm of the pivoted follower 110; the other end of the spring abutting against the bracket 114. The spring 121 pushes rearwardly against the lower end of the follower, which causes the pin 106 at the top end thereof to bear against the periphery of the alternator wheel 100. When the pin 106 is engaged by one of the high cam portions 104, as shown in Figure 6, the spring 121 is compressed and the lock yoke wire 113 is relieved of tension. As the alternator wheel turns to the next position, wherein one of the low cam portions 105 is registered with the pin 106, the spring 121 rocks the follower 110 in a clockwise direction to cause the pin 106 to follow the periphery of the alternator wheel down into engagement with the low cam portion. This rocking movement of the follower 110 causes the lower arm thereof to move to the left, carrying the lock yoke wire 113 with it, and thereby exerting the lock-releasing pull on cables 116.

Rotation of the alternator wheel 100 to bring the high and low cam portions 104, 105 successively into engagement with the follower pin 106 is effected by means of a bell crank shifter 122 which is pivoted at 123 on a support 124 projecting from the base plate 16. One arm of the bell crank 122 is provided with a hook 125 which is engageable with the teeth of ratchet wheel 101

to advance the latter by an angular distance equal to the spacing between two adjacent teeth each time the bell crank is rocked on its pivot. It might be mentioned at this point that the ratchet wheel 101 has the same number of teeth as the alternator wheel 100 has cam portions 104 and 105, and therefore advancement of the ratchet wheel by one tooth causes the alternator wheel to advance from one cam portion to the other, i. e., from high to low, or vice versa.

The other arm of the bell crank has a rider 126 provided thereon which is shaped to fit within a circumferential groove 130 in a throw-out ring 131. The throw-out ring 131 is slidably mounted on the shaft 79 and is constrained to rotate therewith by the drive pins 92 which extend through holes 132 in the ring. One end of the throw-out ring 131 is engaged by a compression spring 133 which urges the ring toward the main drive wheel 94; said spring encircling the drive pin ring 87 and bearing against a radial flange 134 provided thereon.

The throw-out ring 131 is shifted axially along the shaft 79 responsive to the 20° of lost motion rotation of the main drive wheel 94 relative to the shaft, and this is accomplished by means of cooperating cam protuberances provided on the adjoining faces of the members 94 and 131. The cam protuberances on the main drive wheel 94 are designated by the reference numeral 135, and are preferably cone-shaped; while those on the throw-out ring, indicated at 136, are spherically rounded. Both sets of cam protuberances 135 and 136 may conveniently be produced by pressing rivets 137 with suitably shaped heads into holes in the members 94 and 131, as shown in Figure 4.

Spherical depressions 140 are formed in the sides of the throw-out ring 131 immediately alongside the spherical cam protuberances 136, and these depressions are adapted to receive the conical cam protuberances 135 when the main drive wheel 94 is at one end of its lost motion travel. This arrangement permits the throw-out ring 131 to move closer to the main drive wheel 94 than would otherwise be possible, and thereby increases the extent of axial displacement of the throw-out ring 131 along the shaft 79 when the cam protuberances are riding one on top of the other, as in Figure 8. Thus, during the initial rotation of the main drive wheel 94, the cone-shaped cam protuberances 135 climb up out of the depressions 140 and onto the tops of cam protuberances 136 on the throw-out ring 131, shifting the latter to the right (Figure 8) against the pressure of spring 133. This axial movement of the throw-out ring causes the shifter bell crank 122 to rock on its pivot 123, thereby advancing the ratchet wheel 101 by one tooth and carrying the alternator wheel 100 along with it. As mentioned earlier, the progressive advancement of the alternator wheel 100 causes first one and then the other of cam portions 104 and 105 to engage pin 106 on the follower 110, and thereby actuate the lock-release mechanism on alternate pulls of the control cable.

The thumb 22 is mounted on the body shell 17 for both flexion-extension and abduction-adduction movements, and to this end a U-shaped thumb yoke 142 is supported near the ends of its arms for swinging movement about an abduction-adduction axis extending diagonally across the palm of the hand, generally parallel to the back of shell 17. The arms of the yoke

142 are drilled and bushed to receive a tubular shaft 143 (Figure 3) which is journaled at its ends in spaced bearing supports 144 and 145, the latter being formed integrally with the bearing support 86 for the drive shaft 79. The bight portion of the yoke 142 is slotted out to receive the base of thumb 22, and the latter is connected to the yoke by a tubular pivot shaft 146. The axis of the shaft 146 represents the flexion-extension axis of the thumb, and swinging movement of the latter about said axis is defined as flexion when the thumb moves toward the fingers, and as extension when the movement is away from the fingers.

The thumb 22 is adapted to be swung to any one of three positions about the abduction-adduction axis, as shown at A, B, and C in Figure 3, and is locked in the selected position by means of a spring-pressed plunger 150 mounted on bearing support 144, which is engageable with any one of three recessed seat cavities 151 in a flange 152, projecting radially from the yoke 142 at one end thereof. The plunger 150 is slidably disposed with the bore 149 (Figure 12) of a cylindrical housing 153 that is mounted on a web portion of the bearing support 144, and bearing against the end of the plunger is a spring 154 which is backed up by a plug 155 closing the end of the housing bore. The seating engagement of the spring pressed detent 150 with the depressions 151 in the yoke provides a yieldable lock for holding the thumb in any one of its three positions, and to change its position, the thumb is forced around so as to overcome the spring force on the detent.

The thumb is flexed simultaneously with the fingers by the action of the control member 30, and to this end a driving connection is provided between the drive shaft 79 and the thumb; said driving connection being in the form of a bevel gear 160 which is fixed to the shaft 143 in mesh with the bevel gear 83 on shaft 79. Also fixedly mounted on the shaft 143 between the arms of yoke 142 is a worm 161 which meshes with a worm gear sector 162 fixed to the base of thumb 22 concentric with the axis of shaft 146. In the illustrative embodiment, the base of thumb 22 has been slotted out, and worm gear sector 162 is inserted into the slot and secured in place by pins (not shown). The worm and gear drive to the thumb is irreversible in nature, and the thumb is thus locked against displacement by the action of external forces.

The operation of the thumb is believed to be self-evident from the foregoing description. Rotation of the drive shaft 79 responsive to a pull on the control member 30 causes the bevel gear 83 to drive its companionate gear 160 and thereby rotate the worm 161. Worm 161, in turn, drives worm gear sector 162, which causes the thumb 22 to swing in toward the fingers, about the shaft 146. Since the driving force for flexing the thumb about axis 146 is transmitted along the abduction-adduction axis, flexion movement of the thumb is not appreciably affected by the position of the thumb about the said axis.

While we have shown and described in considerable detail what we believe to be the preferred form of our invention, it is to be understood that such details are not restrictive, and that various changes may be made in the shape and arrangement of the several parts without departing from the broad scope of the invention, as defined in the appended claims.

We claim:

1. In an artificial hand, the combination of a plurality of articulated fingers that are spring-biased toward the open position, a rotatable member journaled on said hand adjacent the proximal ends of said fingers, tension-transmitting means connecting said member to at least one of said fingers, whereby the latter is pulled closed when said member is rotated in one direction, a force-transmitting control member connected to said rotatable member so as to rotate the latter in said one direction when a force is applied to the control member, a self-energizing releasable friction lock engageable with said rotatable member to hold the same against rotation in the finger-opening direction when the finger-closing force on said control member is relaxed, a rotatable alternator wheel journaled on said hand and having alternate high and low cam portions provided thereon, a follower engaging said cam portions and connected to said lock, said follower being inoperative when engaged by one of said cam portions, and operable to release the lock when engaged by the other cam portion, and means operable by successive applications of force on said control member for progressively advancing said alternator wheel so that said follower is alternately engaged by said high and low cam portions.

2. In an artificial hand, the combination of a plurality of articulated fingers, a rotatable member journaled on said hand adjacent the proximal ends of said fingers, tension-transmitting means connecting said member to at least one of said fingers, whereby the latter is pulled closed when said member is rotated in one direction, a rotatable drive shaft connected to said rotatable member to drive the latter, a wheel mounted on said drive shaft for a limited amount of rotation with respect thereto, a control member connected to said wheel to rotate the same when a force is applied to the control member, releasable locking means frictionally engageable with said rotatable member to hold the same against rotation in the finger-opening direction when the finger-closing force on said control member is relaxed, and means actuated by the rotation of said wheel relative to said drive shaft for releasing said locking means upon application of the next succeeding force to said control member following the finger-closing force.

3. In an artificial hand, the combination of a plurality of articulated fingers, a rotatable member journaled on said hand adjacent the proximal ends of said fingers, tension-transmitting means connecting said member to at least one of said fingers, whereby the latter is pulled closed when said member is rotated in one direction, a rotatable drive shaft connected to said rotatable member to drive the latter, a wheel mounted on said drive shaft for a limited amount of rotation with respect thereto, a control member connected to said wheel to rotate the same when a force is applied to the control member, releasable locking means frictionally engageable with said rotatable member to hold the same against rotation in one direction when the finger-closing force on said control member is relaxed, a rotatable alternator wheel journaled on said hand and having alternate high and low cam portions provided thereon, a follower engaging said cam portions and connected to said locking means, said follower being

inoperative when engaged by one of said cam portions, and operable to release said locking means when engaged by the other cam portion, and means responsive to rotation of said wheel relative to said drive shaft for progressively advancing said alternator wheel so that said follower is alternately engaged by said high and low cam portions.

4. In an artificial hand, the combination of a plurality of articulated fingers, a rotatable member journaled on said hand adjacent the proximal ends of said fingers, tension-transmitting means connecting said member to at least one of said fingers, whereby the latter is pulled closed when said member is rotated in one direction, a rotatable drive shaft connected to said rotatable member to drive the latter, a main drive wheel mounted on said drive shaft for a limited amount of rotation relative thereto, a control member connected to said main drive wheel to rotate the same when a force is applied to the control member, a throw-out wheel slidably mounted on said drive shaft and non-rotatable with respect thereto, cooperating means on said main drive wheel and said throw-out wheel, whereby the latter is shifted axially on said drive shaft responsive to the limited rotation of the main drive wheel relative to the drive shaft, locking means engageable with said rotatable member to hold the same against rotation in one direction when the finger-closing force on said control member is relaxed, and means operable by said axial shifting movement of said throw-out wheel to release said locking means and allow said fingers to open.

5. In an artificial hand, the combination of a plurality of articulated fingers, a rotatable member journaled on said hand adjacent the proximal ends of said fingers, tension-transmitting means connecting said member to at least one of said fingers, whereby the latter is pulled closed when said member is rotated in one direction, a rotatable drive shaft connected to said rotatable member to drive the latter, a main drive wheel mounted on said drive shaft for a limited amount of rotation relative thereto, a control member connected to said main drive wheel to drive the same when a force is applied to the control member, a throw-out wheel slidably mounted on said drive shaft and non-rotatable with respect thereto, cooperating means on said main drive wheel and said throw-out wheel, whereby the latter is shifted axially on said drive shaft responsive to the limited rotation of the main drive wheel relative to the drive shaft, a self-energizing lock engageable with said rotatable member to hold the same against turning in one direction when the finger-closing force on said control member is relaxed, a rotatable alternator wheel journaled on said hand and having alternate high and low cam portions provided thereon, a follower engaging said cam portions and operatively connected to said locking means, said follower being operable to release said lock when engaged by one of said cam portions, and means responsive to the axial shifting movement of said throw-out wheel for progressively advancing said alternator wheel so that said follower is alternately engaged by said high and low cam portions.

6. In an artificial hand, the combination of a plurality of articulated fingers, a rotatable member journaled on said hand adjacent the proximal ends of said fingers, tension-transmitting means connecting said member to at least one of said fingers, whereby the latter is pulled closed when said member is rotated in one direction, a

rotatable drive shaft connected to said rotatable member to drive the latter, a main drive wheel mounted on said drive shaft for a limited amount of rotation relative thereto, a control member connected to said main drive wheel to drive the same when a force is applied to the control member, a throw-out wheel slidably mounted on said drive shaft and non-rotatable with respect thereto, cooperating means of said main drive wheel and said throw-out wheel, whereby the latter is shifted axially on said drive shaft responsive to the limited rotation of the main drive wheel relative to the drive shaft, a self-energizing lock engageable with said rotatable member to hold the same against turning in one direction when the finger-closing force on said control member is relaxed, a rotatable alternator wheel journaled on said hand and having alternate high and low cam portions provided thereon, a follower engaging said cam portions and operatively connected to said locking means, said follower being operable to release said lock when engaged by one of said cam portions, a ratchet wheel fixed to said alternator wheel, and a bell crank pivoted on said hand for rocking movement about an axis perpendicular to the axes of said ratchet wheel and said throw-out wheel, one arm of said bell crank being engageable with said ratchet wheel to advance the same when the bell crank is rocked so that said follower is alternately engaged by said high and low cam portions of said alternator wheel, and the other arm of said bell crank being engaged by said throw-out wheel, whereby the bell crank is rocked each time said throw-out wheel is shifted axially along said drive shaft.

7. In an artificial hand, the combination of a plurality of articulated fingers that are spring-biased toward the open position, actuating means for closing said fingers comprising a cable drum for each of said fingers, said drums being independently rotatable and arranged in coaxial groups of two adjacent the proximal ends of said fingers, a cable attached to each of said drums and extending forwardly therefrom along its respective finger to a point of attachment with the latter, said cables being operative to pull said fingers closed when said cable drums are rotated in one direction, a pair of self-energizing locks, each of said locks being engageable with both drums in one of said groups of two to lock the same against rotation in the finger-opening direction, a rotatable drive shaft connected to each of said cable drums to drive the same, a main drive wheel mounted on said drive shaft for a limited amount of rotation with respect thereto, a control member connected to said drive wheel to rotate the same when a force is applied to the control member, and means actuated by the rotation of said wheel relative to said drive shaft for simultaneously releasing both of said locks upon application of the next succeeding force to said control member following the finger-closing force, whereby said fingers are released and allowed to open.

8. In an artificial hand, the combination of a plurality of articulated fingers that are spring-biased toward the open position, actuating means for closing said fingers comprising a cable drum for each of the fingers, said drums being independently rotatable and arranged in coaxial groups of two adjacent the proximal ends of said fingers, a cable attached to each of said drums and extending forwardly therefrom along its respective finger to a point of attachment with the latter, said cables being operative to pull said

fingers closed when said cable drums are rotated in one direction, a pair of self-energizing locks, each of said locks being engageable with both drums in one of said groups of two to lock the same against rotation in the finger-opening direction, a rotatable drive shaft spaced rearwardly from said cable drums, a cable drum fixed to said drive shaft, cables attached to said last-named cable drum and to other cable drums fixed to each of said first-named cable drums, whereby the latter are driven by the drive shaft, a main drive wheel mounted on said drive shaft for a limited amount of rotation with respect thereto, a control member connected to said main drive wheel to drive the same when a force is applied to the control member, a throw-out wheel slidably mounted on said drive shaft and non-rotatable with respect thereto, cooperating cam means on said main drive wheel and said throw-out wheel, whereby the latter is shifted axially on said drive shaft responsive to the limited rotation of the main drive wheel relative to the drive shaft, a rotatable alternator wheel journaled on said hand and having alternate high and low cam portions provided thereon, a spring-pressed follower engaging said cam portions, a yoke connecting said follower to both of said locks, whereby the latter are released when the follower is engaged by one of said cam portions, a ratchet wheel fixed to said alternator wheel, and a bell crank pivoted on said hand for rocking movement about an axis perpendicular to the axes of said ratchet wheel and said throw-out wheel, one arm of said bell crank being engageable with said ratchet wheel to advance the same when the bell crank is rocked so that said follower is alternately engaged by said high and low cam portions on said alternator wheel, and the other arm of said bell crank being engaged by said throw-out wheel, whereby the bell crank is rocked each time said throw-out wheel is shifted axially along said drive shaft.

9. In an artificial hand, the combination of supporting means, a yoke pivoted on said supporting means for swinging movement about the abduction-adduction axis of the thumb, a thumb pivoted on said yoke for flexion and extension movement, a force-transmitting control member, and means connecting said control member to said thumb, whereby the latter is flexed responsive to the application of a force to the control member.

10. In an artificial hand, the combination of a body shell, a pair of spaced supports fixed to said shell, a yoke pivoted on said supports for rotation about the abduction-adduction axis of the thumb, a thumb pivoted on said yoke for swinging movement about a flexion-extension axis, a gear fixed to said thumb coaxial with said flexion-extension axis, another gear intermeshed with said first-named gear, and journaled for rotation about said abduction-adduction axis, and a control member connected to said last-named gear to drive the latter, whereby said thumb is flexed responsive to the application of a force to said control member.

11. In an artificial hand, the combination of a body shell, a pair of spaced supports fixed to said shell, a U-shaped yoke having arms pivoted on said supports for rotation about the abduction-adduction axis of the thumb, a thumb pivoted on the right of said U-shaped yoke for swinging movement about a flexion-extension axis, a worm disposed between the arms of said yoke and journaled for rotation about said abduction-adduc-

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tion axis, a worm gear sector fixed to said thumb concentric with said flexion-extension axis and meshed with said worm, a control member, and means actuated by said control member for rotating said worm to drive said worm gear sector and thereby flex said thumb.

12. In an artificial hand, the combination of a body shell, a pair of spaced supports fixed to said shell, a yoke pivoted on said supports for rotation about the abduction-adduction axis of the thumb, a thumb pivoted on said yoke for swinging movement about a flexion-extension axis, a spring-pressed detent on one of said supports engageable with said yoke to hold the same in any one of several angularly spaced positions about said abduction-adduction axis, a force-transmitting control member, and means connecting said control member to said thumb, whereby the latter is swung about said flexion-extension axis responsive to the application of force to the control member.

13. In an artificial hand, the combination of a body shell, a pair of spaced supports fixed to said shell, a U-shaped yoke having arms pivoted on said supports for rotation about the abduction-adduction axis of the thumb, a thumb pivoted on the bight of said U-shaped yoke for swinging movement about a flexion-extension axis, a spring-pressed detent on one of said supports engageable with said yoke to hold the same in any one of several angularly spaced positions about said abduction-adduction axis, a worm disposed between the arms of said yoke and journaled for rotation about said abduction-adduction axis, a worm gear sector fixed to said thumb concentric with said flexion-extension axis, a rotatable main drive wheel, a control member connected to said wheel so as to rotate the latter when a force is applied to the control member, and a driving connection between said wheel and said worm, whereby said thumb is swung about said flexion-extension axis responsive to the application of force to said control member.

14. In an artificial hand having a body shell, a plurality of articulated fingers, and a thumb, the combination of: a rotatable member adjacent the proximal ends of said fingers, tension transmitting means connecting said member to at least one of said fingers, whereby the latter is pulled closed when said member is rotated in one direction, a rotatable drive shaft connected to said rotatable member to drive the latter, a wheel mounted on said drive shaft for a limited amount of rotation with respect thereto, a control member connected to said wheel to rotate the same, locking means engageable with said rotatable member to hold the same against rotation in the finger-opening direction when the finger-closing force on said control member is relaxed, an actuating member connected to said locking means and operable to release the latter on alternate applications of force to said control member, a pair of spaced supports fixed to said shell, a yoke pivoted on said supports for rotation about the abduction-adduction axis of the thumb, said thumb being pivoted on said yoke for swinging

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movement about a flexion-extension axis, and means, including an irreversible gear, connecting said drive shaft to said thumb, whereby the latter is swung about said flexion-extension axis responsive to the application of force to the control member.

15. In an artificial hand having a body shell, a plurality of articulated fingers, and a thumb, the combination of: a cable drum for each of said fingers, said drums being independently rotatable and arranged in coaxial groups of two adjacent the proximal ends of said fingers, a cable attached to each of said drums and extending forwardly therefrom along its respective finger to a point of attachment with the latter, said cables being operative to pull said fingers closed when said cable drums are rotated in one direction, a pair of self-energizing locks, each of said locks being engageable with both drums in one of said groups of two, to lock the same against rotation in the finger-opening direction, a rotatable drive shaft connected to each of said cable drums to drive the latter, a main drive wheel mounted on said drive shaft for a limited amount of rotation with respect thereto, a control member connected to said drive wheel to rotate the same when a force is applied to the control member, means actuated by the rotation of said wheel relative to said drive shaft for simultaneously releasing both of said locks upon application of the next succeeding force to said control member following the finger-closing force, whereby said fingers are released and allowed to open, a pair of spaced supports fixed to said shell, a U-shaped yoke having arms pivoted on said supports for rotation about the abduction-adduction axis of the thumb, said thumb being pivoted on the bight of said U-shaped yoke for swinging movement about a flexion-extension axis, a worm disposed between the arms of said yoke and journaled for rotation about said abduction-adduction axis, a worm gear sector fixed to said thumb concentric with said flexion-extension axis and meshing with said worm, and a pair of intermeshing gears connecting said drive shaft with said worm, whereby the latter is driven to flex said thumb responsive to the application of a finger-closing force on said control member.

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