Feb. 6, 1951

G. M. MOTIS

ARTIFICIAL ARM HOOK OR HAND WITH FORCE MULTIPLIER AND LOCK

2,540,375

Filed March 30, 1948

3 Sheets-Sheet 1

Fig. 1.

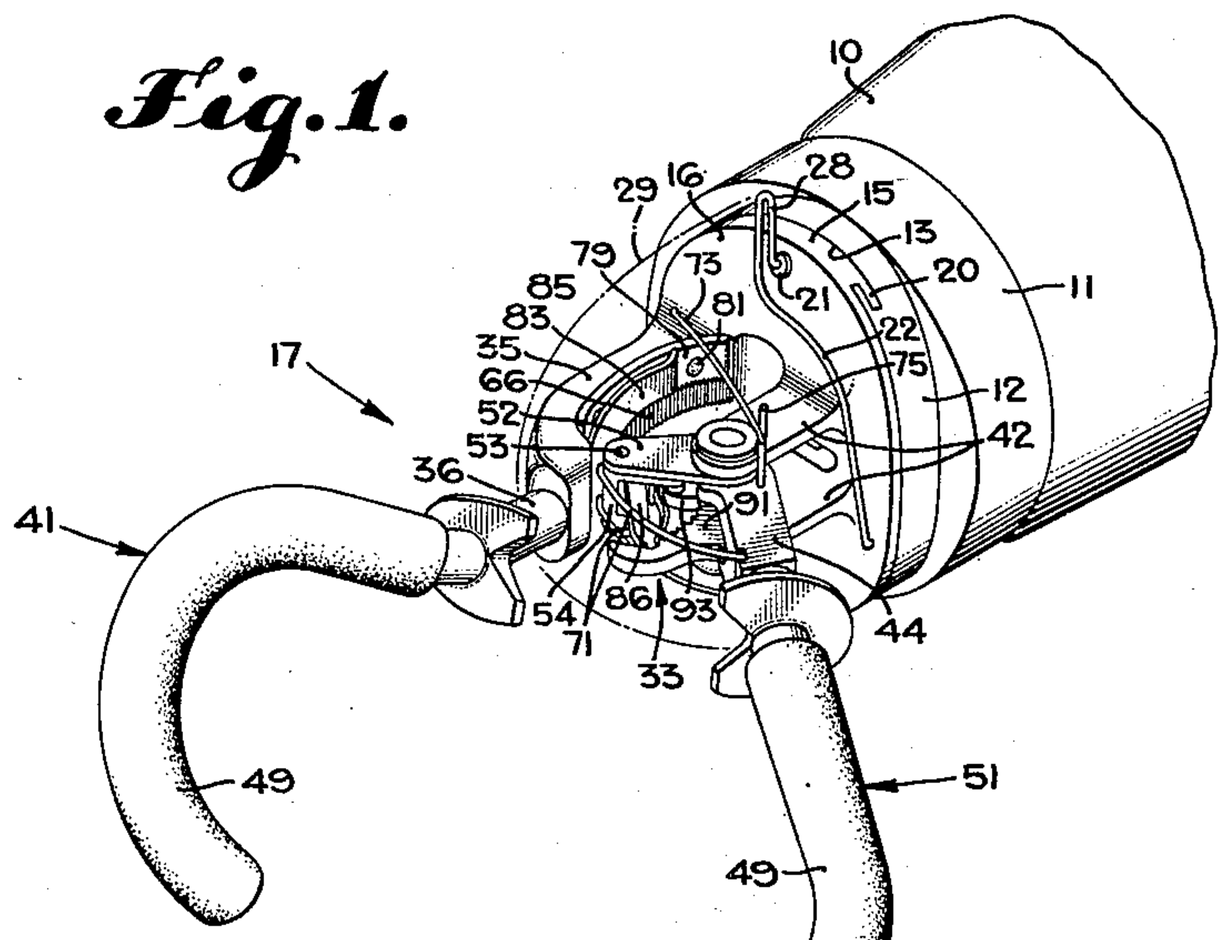

Fig. 2.

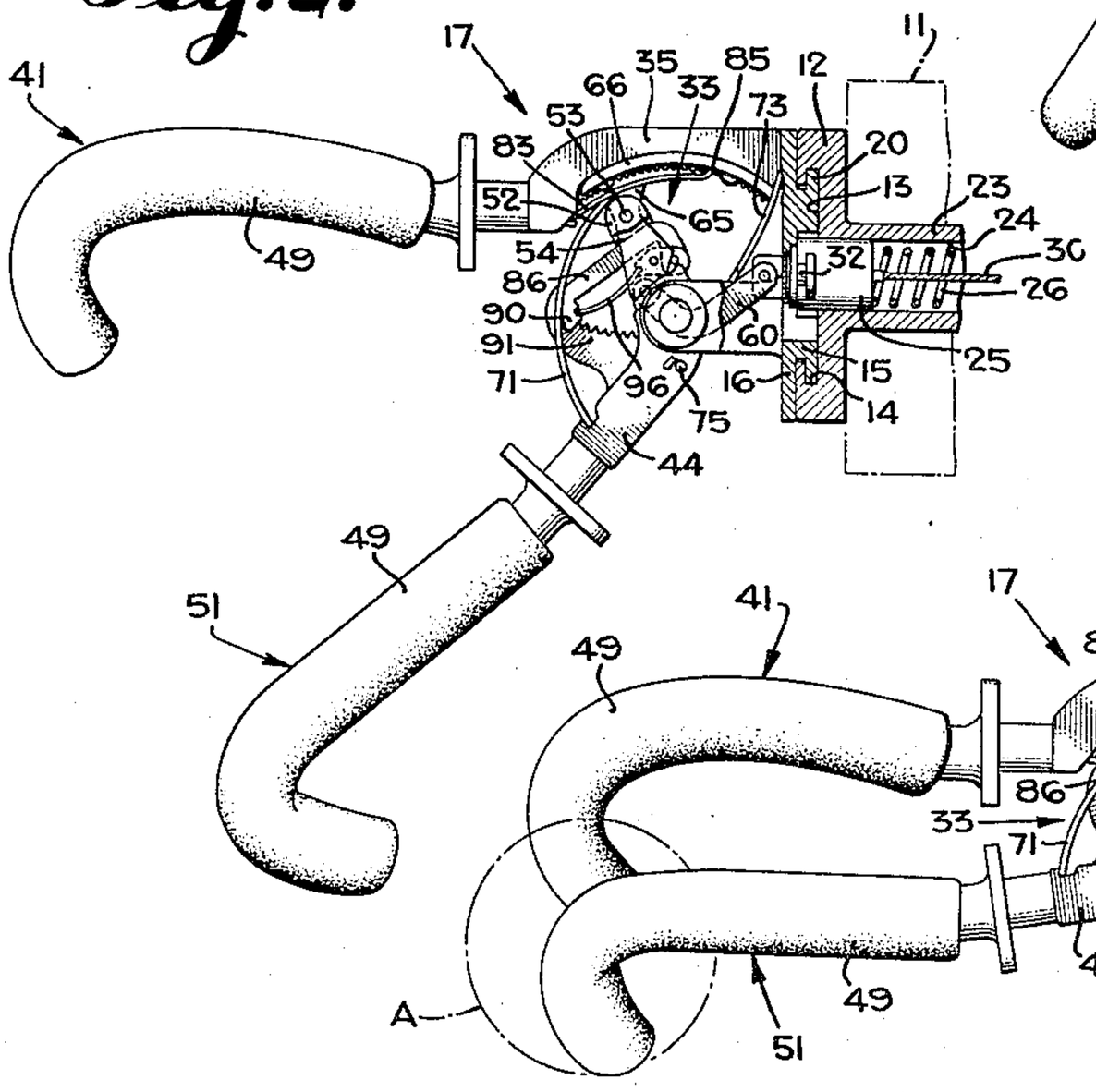

Fig. 3.

INVENTOR,
Gilbert M. Motis
BY Ernest J. Lilly
ATTORNEY

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3 Sheets-Sheet 2

Fig. 4.

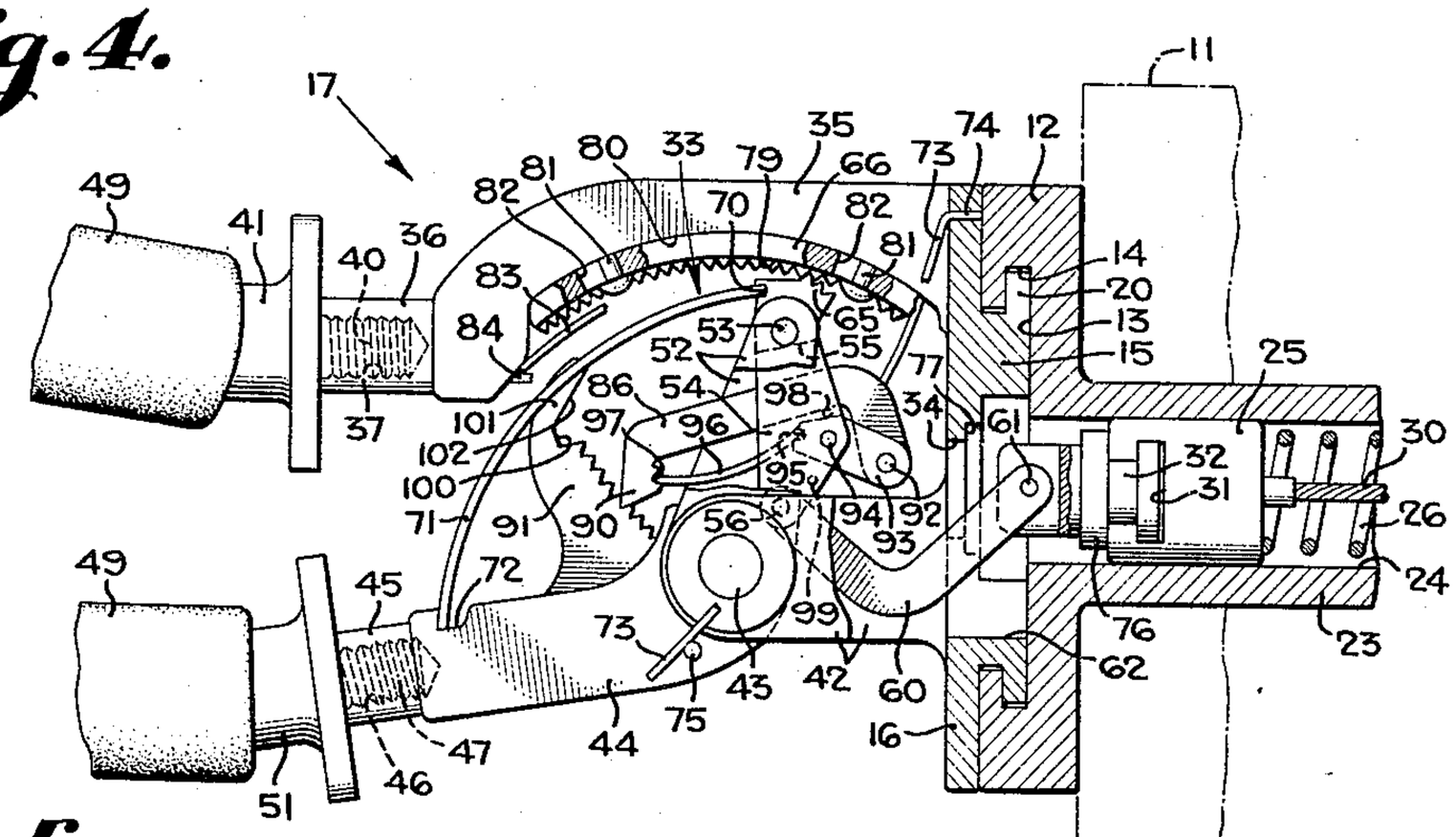

Fig. 5.

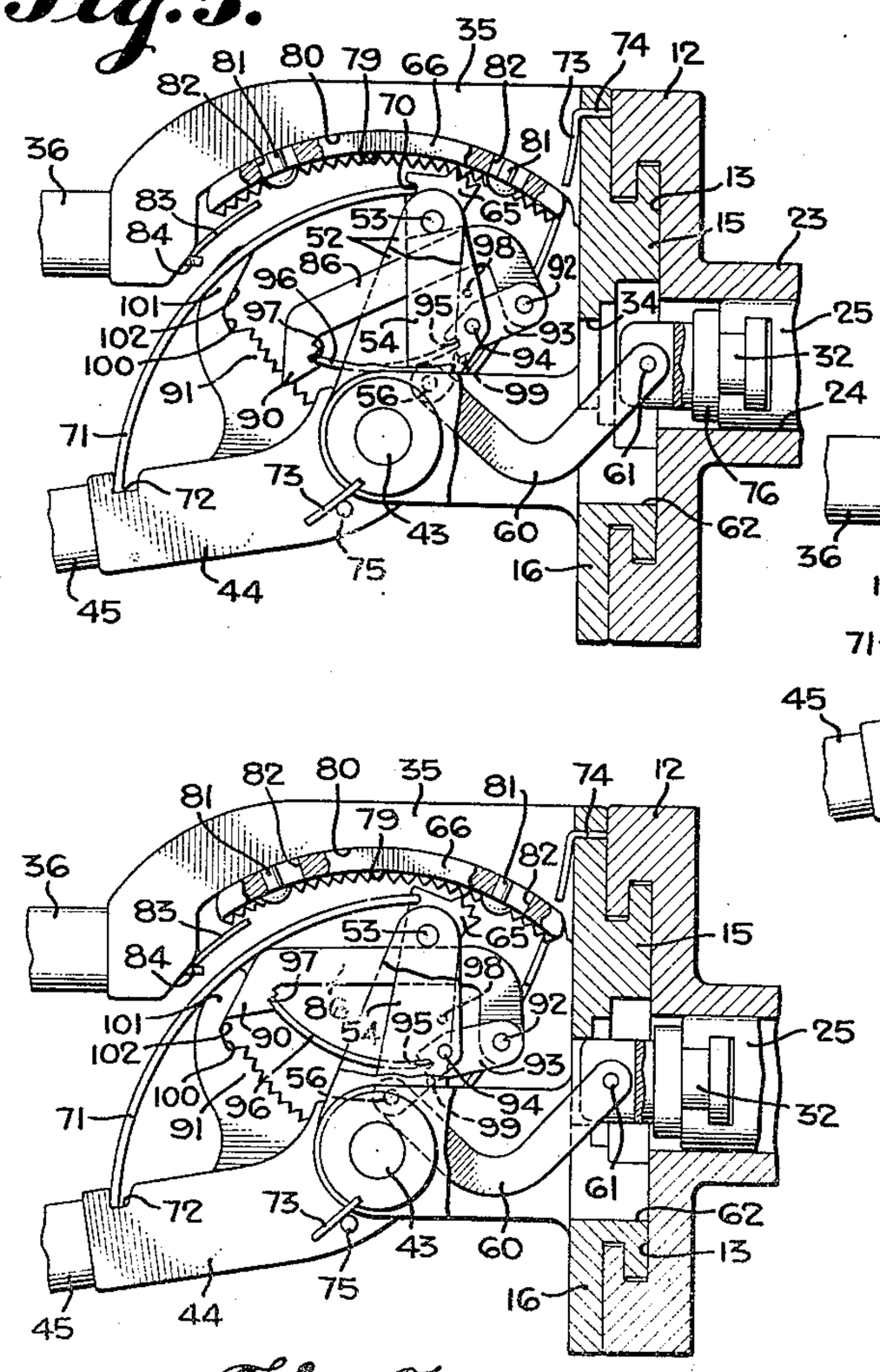

Fig. 6.

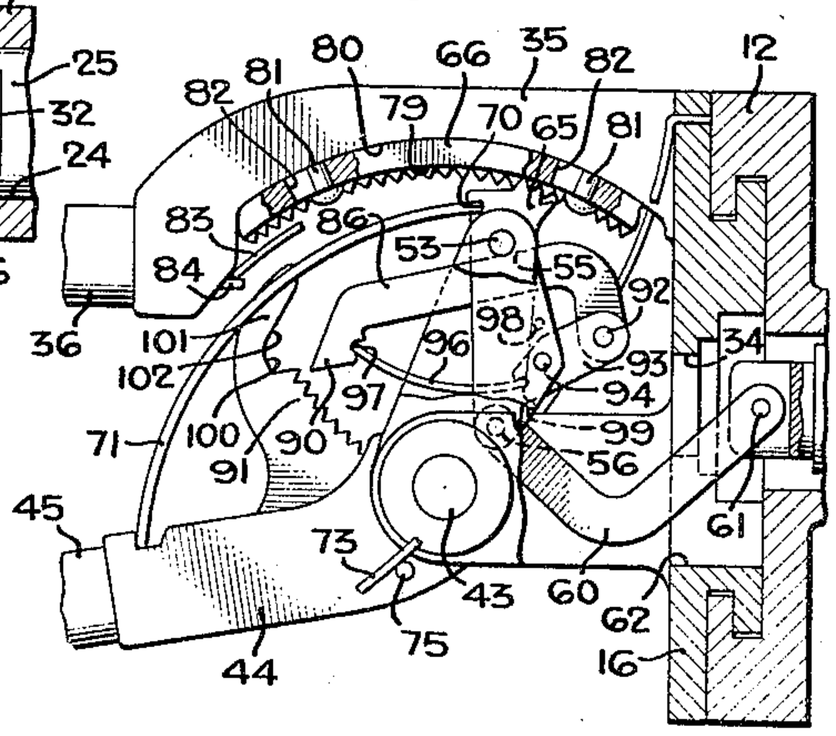

Fig. 7.

INVENTOR,
Gilbert M. Motis
BY Forrest J. Lilly
ATTORNEY

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3 Sheets-Sheet 3

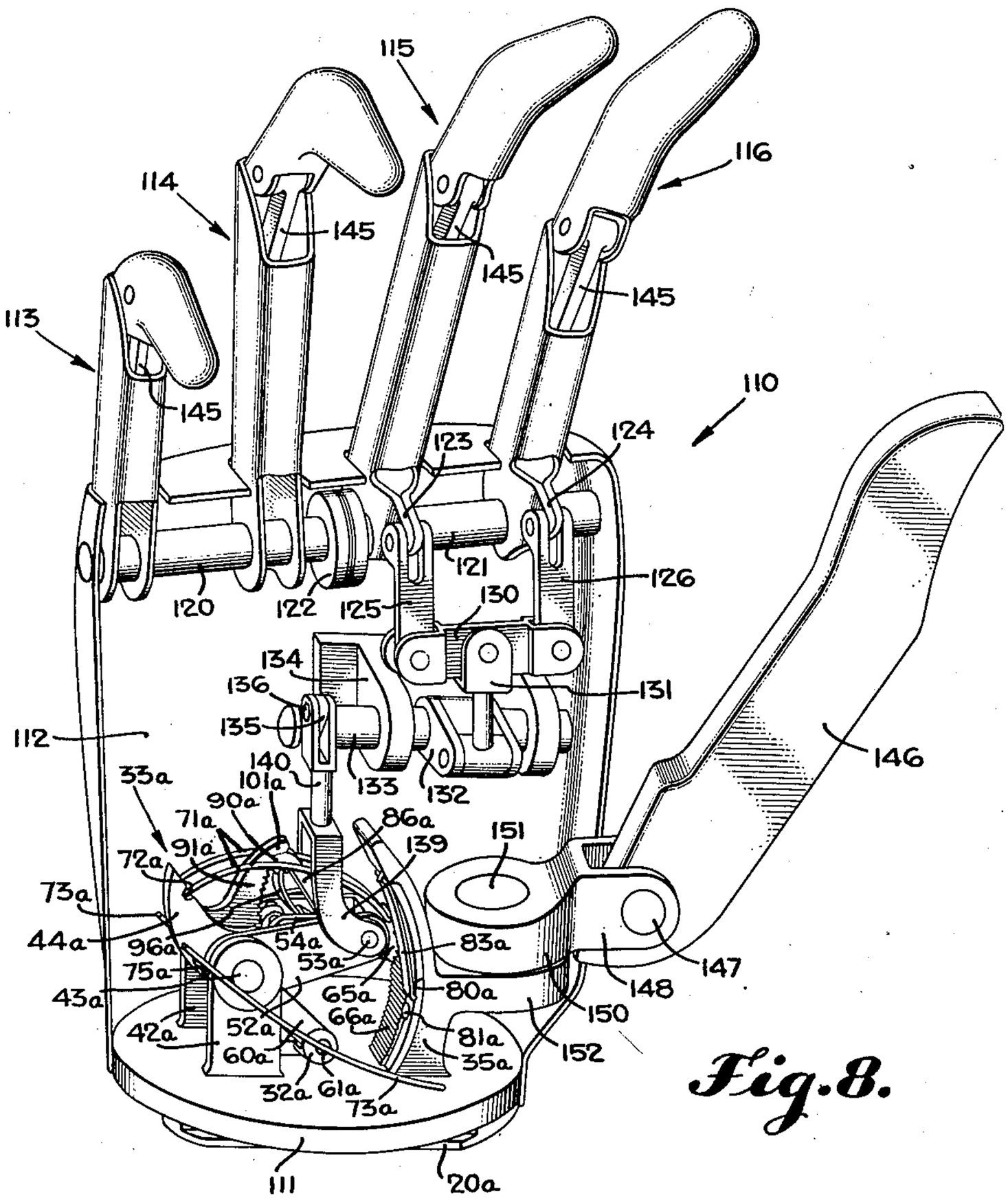

Fig. 8.

INVENTOR,
Gilbert M. Motis

BY Thomas J. Tilley

ATTORNEY

Patented Feb. 6, 1951 2,540,375

UNITED STATES PATENT OFFICE

2,540,375

ARTIFICIAL ARM HOOK OR HAND WITH FORCE MULTIPLIER AND LOCK

Gilbert M. Motis, Burbank, Calif., assignor to Northrop Aircraft, Inc., Hawthorne, Calif., a corporation of California

Application March 30, 1948, Serial No. 17,996

7 Claims. (Cl. 3—12)

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The present invention relates to hooks or hands for artificial arms, and more particularly to that class of hooks or hands wherein the movable hook members or fingers are normally opened out to the extended position by light spring pressure, and are closed by the application of a control force to the actuating mechanism.

One of the most difficult problems in connection with the design of such hooks or hands is that of providing both a large amount of travel for the movable gripping members so that the hook or fingers can be opened wide, and at the same time, a high mechanical advantage in the system so that a powerful grip can be obtained on the article to be grasped. The actuation of the hook or fingers is usually accomplished by means of a control member, such as a Bowden cable or the like, which is connected to a shoulder harness in a manner whereby a shrug of the shoulder produces a pull on the control member. The muscular effort available for closing the hook or fingers is rather limited, however, both in the magnitude of the force that can be applied and in the length of travel that can be obtained in the control member, and as a result, it has heretofore been necessary to settle with a compromise solution, using the maximum mechanical advantage that would still allow the hook or fingers to be fully closed with the limited travel available in the control member. Any attempt to increase the mechanical advantage of the system has necessarily been accompanied by a corresponding sacrifice in the amount of travel of the movable hook member, which is undesirable, and prior hooks or hands have therefore been characterized by a relatively weak closing action.

The primary object of the present invention is to overcome these difficulties by providing a hook or hand combining the desirable characteristics of a high mechanical advantage with a large amount of angular travel of the movable gripping member. This has been accomplished by providing means whereby the movable gripping member is closed with a fast motion and low mechanical advantage during the no-load portion of its travel while moving from the fully opened position up to the point of its engagement with the article to be grasped, and then changes automatically to a condition giving a slow travel and high mechanical advantage while tightening its grip on the article.

Another object of the invention is to provide a hook or hand of the manually closed type wherein the movable gripping member is automatically locked in the closed position when the

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force exerted by the control member is released, thereby enabling the amputee to relax the harnessed shoulder while still maintaining his grasp on the article.

A further object of the invention is to provide a self-locking hook or hand of the class described, having means operable by the next succeeding pull on the control member to release the lock, permitting the movable gripping member to be opened.

Still another object of the invention is to provide a manually closed, self-locking hook or hand embodying yieldable spring means in the actuating mechanism which is adapted to be stressed at the time the movable gripping member is tightened up on the article, so that when the tension in the control member is released and the gripping member is locked in closed position, the stressed spring means applies a force back into the actuating mechanism, causing the movable gripping member to exert a substantial spring pressure on the article held thereby. This is an important feature when handling hard, unyielding objects, since without such spring action, it would be impossible to maintain the necessary firm grip on the article except by sustained muscular effort.

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 two illustrative embodiments thereof, reference being had to the accompanying drawings, wherein:

Figure 1 is a perspective view of a hook embodying the principles of the invention;

Figure 2 is a top plan view of the same;

Figure 3 is a view similar to Figure 2, showing the movable hook member closed on an object, with the actuating mechanism depicted in the condition giving a fast motion with low mechanical advantage, as during the initial no-load travel of the hook;

Figure 4 is an enlarged, partially sectioned, plan view of the actuating mechanism, showing the positions of the several parts thereof when the mechanism is in the condition giving slow motion with high mechanical advantage, as when the movable hook member is being drawn tight on the object;

Figure 5 shows the actuating mechanism in the locked position which is assumed when the force exerted by the control member is relaxed;

Figure 6 shows the manner in which the lock is released when the next succeeding force is applied to the control member;

Figure 7 shows the actuating mechanism in the final phase of the operational cycle, during which the control member is being relaxed to open the hook, and the locking pawl is being cammed down to the point at which the associated spring and link are caused to snap over center to their initial position, in readiness for the next cycle of operation; and

Figure 8 is a perspective view of an artificial hand embodying the principles of the invention in the finger-closing mechanism.

Reference is had first to Figures 1 to 7, inclusive, of the drawings, wherein the numeral 10 designates the forearm component of an artificial arm, the outer end of which terminates in a wrist cap 11, having an attach plate 12 mounted thereon in any suitable manner. The outer face of the attach plate 12 is milled out to form a shallow, vertically extending slot 13 having grooves 14 cut into the opposite side walls thereof. The slot 13 is open at the top and is adapted to receive a companionate rib 15 formed on the back side of the base 16 of a hook unit 17, providing a quick-detachable coupling for connecting the hook unit onto the arm. The rib 15 has flanges 20 projecting from its opposite side edges, and these flanges are adapted to slide endwise down into the grooves 14 in the attach plate. A locking pin 21 which is slidably disposed within a hole in the base 16 near the top edge thereof, is urged rearwardly by a cantilever spring 22, and is adapted to drop into a hole in the face of the attach plate 12 when the hook unit is fully seated thereon, to lock the hook unit in place.

The attach plate 12 may be rotatably mounted on the cap 11, or it may be stationary with respect thereto, and since the details of the connections between them form no part of the present invention, they have accordingly been omitted from the drawings. A centrally disposed tubular extension 23 projects rearwardly from the back of the attach plate 12 through an opening in the cap 11, and slidable axially within the bore 24 thereof is a cylindrical coupling member 25. The bore 24 extends through the plate 12 and opens at its front end into the bottom of the slot 13. A spring 26 bears against the back end of the member 25, urging it outwardly, or to the left, as shown in the drawings. Attached to the coupling member 25 in any suitable manner is the tension-transmitting wire 30 of a Bowden cable control. The Bowden cable includes the usual flexible, spring-wound conduit (not shown) which encloses the wire 30 for a substantial portion of its length, said wire being freely slidable within the conduit. The conduit and wire extend upwardly along the length of the arm, and the upper end of the wire is attached to the usual shoulder harness (not shown), which is constructed and arranged so that a shrug of the shoulder produces a pull in the wire 30, in a manner well understood in the art.

The outer end of the coupling member 25 is adapted to project beyond the bottom surface of the slot 13, and is milled out to form a T-shaped slot 31 which is open at the top side of the coupling member so as to receive a circular, radially flanged connector 32 projecting from the back of the base 16, when the hook unit 17 is inserted down into the slot 13. The connector 32 is connected to actuating mechanism 33 of the hook unit, and, when coupled to the member 25, serves to transmit the pull of the control wire 30 to the actuating mechanism to operate the same. Since the connector 32 is the means by which the actuating mechanism is operated, it might be considered as the control member of the hook, and is referred to as such in the appended claims. It is to be understood, however, that the "control member" of the claims is not limited solely to connectors such as the one shown at 32, but might include any force-transmitting element, such as the control wire 30 or its equivalent.

The actuating mechanism 33 is preferably enclosed within a laminated plastic shell, or housing 29, indicated in phantom lines in Figure 1, which protects the mechanism and prevents the clothing from becoming entangled therein. The housing 29 may be attached to the base plate 16 in any convenient manner, and is provided with suitable openings through which the two cooperating hook members project. Another opening in the top of the housing 29 permits a handle extension 28 on the wire spring 22 to project through to the outside so that it can be grasped by the fingers of the other hand to unseat the pin 21 from its hole in the attach plate 12, and thereby unlock the hook unit 17 for removal therefrom.

The base plate 16 of the hook unit is shaped to conform to the outline of the attach plate 12, and is apertured centrally to provide an opening 34 which receives the connector 32. Projecting forwardly from one side of the base plate 16 is a post 35 which terminates at its outer end in a cylindrical extremity 36 having a threaded socket 37 formed therein. The threaded stud 40 of a stationary hook member 41 is screwed into the socket 37. On the other side of the centerline of the plate 16 from the post 35 are two vertically spaced, outwardly projecting lugs 42 which are apertured at their outer ends to receive a pivot bolt 43. Disposed between the lugs 42 and journalled on the pivot bolt 43 is a bell crank member 44, one arm of which extends in a generally outward direction and terminates in a cylindrical extremity 45 having a threaded socket 46 to receive the stud 47 of a movable hook member 51. Both the stationary hook member 41 and the movable hook member 51 are preferably covered for the greater portion of their lengths by pieces of rubber tubing 49 which provide a good frictional surface for the hooks, as well as a slight amount of elastic yield, or cushion, to facilitate handling smooth or hard objects. The other arm of the bell crank member 44 is bifurcated, forming two spaced arm portions 52 which extend laterally in the general direction of the post 35. The outer ends of the arm portions 52 are drilled to receive a pivot pin 53.

Disposed between the arm portions 52 and journalled on the pin 53 is an operating lever 54, the longer arm of which extends laterally inward toward the axis of the pivot bolt 43. This inwardly extending arm of the operating lever 54 is bifurcated, being slotted out lengthwise to form a shoulder at 55 adjacent the pivot pin 53. Disposed between the side portions of the operating lever 54 adjacent the free end thereof and pivotally connected thereto by a pin 56 is an L-shaped link 60, the other end of which extends into a slot in the connector 32, and is secured by a pin 61. The attach plate 16 is slotted out at 62 between the lugs 42 to provide clearance for the link 60.

The outer end of the operating lever 54 projects radially outward beyond the pivot 53 and is provided with a toothed sector 65 which is engageable with the teeth of an arcuate rack 66 mounted on the post 35, when the operating lever is rocked in a counterclockwise direction. Formed

in the front outer corner of the operating lever 54 is a notch 70, and seated therein is one end of a bowed, U-shaped spring 71, the other end of which is engaged in a notch 72 in the bell crank member 44. The spring 71 exerts a pressure on the operating lever 54 tending to rotate the same in a clockwise direction so as to move the toothed sector 65 out of engagement with the rack 66. Opposing this clockwise torque is a counterclockwise torque which is produced in the operating lever by the pull of the control wire 30, acting through the coupled members 25, 32, and link 60. The force exerted on the operating lever by the spring 71 is somewhat greater than the torque which must be applied thereon by the hook-closing control force at point 56 to overcome the light spring pressure urging the movable hook member to the open position. The spring pressure referred to is exerted by a pair of cantilever springs 73 disposed on opposite sides of the hook members. Preferably, the springs 73 are formed of spring steel wire, each being bent to an angle at one end, as at 74, and inserted into a snug-fitting hole in the attach plate 16 for anchorage. The other end of each of the springs bears downwardly against and is slidable over a pin 75 projecting laterally from both sides of the bell crank member 44. Since pin 75, which is the point of application of the force exerted by springs 73, is located below the axis of pivot 43, it will be seen that the bell crank member 44 and associated hook member 51 are urged in a counterclockwise direction, away from the stationary hook member 41. Counterclockwise rotation of the member 44 causes the link 60 and connector 32 to be drawn toward the left, as viewed in the drawings, and the angular travel of the member 44 is limited at the fully opened position of the hooks by the engagement of a flange 76 on the connector 32 with an annular shoulder 77 in the opening 34.

From the foregoing, it will be seen that the only force to be overcome during the initial no-load travel of the members 44, 51, is the torsional force exerted thereon by the two cantilever springs 73. Since the torque applied to the operating lever 54 by spring 71 exceeds the torque which must be applied thereto by the control force to overcome the torsional force of the springs 73, the operating lever remains stationary with respect to the arm 52 during the no-load travel of the movable hook member 51, and the effect is the same as though the link 60 were connected directly to the arm 52 at point 56. It will be noted that the moment arm between the point of force application at pin 56 and the axis of pivot 43 is relatively short, and as a result, a relatively large angular travel is obtained in the bell crank member 44 with a relatively small linear travel of the control wire 30 and coupled members 25, 32. While the torque applied to the members 44, 51 by the control force acting directly on point 56 is sufficient to overcome the hook-opening force of springs 73, the adverse mechanical advantage of the system due to the relatively long moment arm from the axis of pivot 43 to the outer end of the movable hook member 51 makes it impossible to apply any effective pressure on an object A (Figure 3) held between the outer ends of the hook. Accordingly, when the movable hook member has closed solidly against the object, and further travel is resisted thereby, the actuating mechanism 33 goes into operation to change the force transmission system over to a condition giving a high mechanical advantage. This second phase of the operating cycle, illustrated in Figure 4, will now be described.

As the movable hook member 51 meets the resistance of the object A and is brought to a stop, the amount of muscular force applied to the control wire 30 through the shoulder harness is voluntarily increased, producing an increased counterclockwise torque in the operating lever 54 which presently overcomes the torque of the spring 71. With the overpowering of the spring 71, the operating lever 54 is rocked in a counterclockwise direction about the pivot pin 53, bringing the teeth of the sector 65 into engagement with the teeth of the rack 66. At this point, the operating lever 54 becomes a fulcrumed lever arm, wherein the point of engagement of the sector teeth 65 with the rack 66 constitutes the fulcrum point; pin 53 being the load; and pin 56, of course, representing the point of application of the force. In the embodiment illustrated in the drawing, the length of the lever arm from the center of pin 53 to the center of pin 56 is roughly three times the length of the lever arm from pin 53 to the pitch line of the intermeshed teeth; hence the actuating force (load) applied at 53 is approximately three times as great as the control force applied at 56. A second factor which must also be considered is the fact that the control force is now applied to the bell crank arm 52 at the pin 53, instead of at the pin 56. The moment arm of pin 53 with respect to the axis of the bell crank pivot 43 is about four times as great as that of the pin 56, and this four-to-one leverage ratio gives a total force multiplication in the system of approximately twelve-to-one over that which was obtained before the operating lever 54 was rocked to engage the teeth 65 with the rack 66. It will be understood, of course, that the above ratios and proportions are merely illustrative, and might be varied widely without departing from the scope of the invention.

The arcuate rack 66 is preferably formed separate from the post 35 and is slidably mounted on an arcuate face 80 thereof, the center of curvature of which lies at the axis of the bell crank pivot 43. The teeth of the rack 66 extend only about half way across the width thereof, leaving a smooth strip 79 extending alongside the toothed portion. The rack is secured to the face 80 by two rivets 81 which extend through circumferentially elongated slots 82 in the smooth portion 79 of the rack, permitting a limited amount of sliding movement of the latter with respect to the post 35, within the limits of the slots. The rack 66 is urged toward the right, as viewed in the drawings, by a bowed leaf spring 83, one end of which is lodged under a pin 84 projecting from the post 35 adjacent the outer end of the rack, and the other end of said spring being engaged in a notch 85 in the smooth portion 79 of the rack at the far end thereof. The spring 83 is fairly substantial, and exerts a pressure of about 50 pounds on the rack 66, the purpose of which will become apparent hereinafter.

When the movable hook member 51 has been drawn up tight to the desired pressure against the object A, the force on the control wire 30 is voluntarily relaxed, causing the actuating mechanism 33 to assume a locked holding condition, illustrated in Figure 5. The locking action is accomplished by a generally U-shaped locking pawl 86, one end of which is formed with a pointed, wedge-shaped lip 90 which is adapted to ratchet over and engage any one of the inclined teeth of an arcuate rack 91. The rack 91 is formed

integral with the bell crank member 44 and projects laterally therefrom in the general direction of the post 35. The center of curvature of the line of teeth on the rack 91 is preferably, although not necessarily, located at the center of the pivot 53 for the operating lever 54.

The pawl 86 extends through the slot in the operating lever 54 and is pivotally connected at its other end by a pin 92 to a link 93. The link 93 is also disposed between the sides of the slotted operating lever 54 and is pivotally connected thereto intermediate its ends by a pin 94. The other end of the link 93 projects beyond the pivot 94 and is provided with a notch 95 which engages one end of a bowed leaf spring 96. The other end of the spring 96 is seated in a notch 97 formed in the back of the wedge-shaped lip 90 of the pawl 86. The link 93 is limited in its angular travel about the pivot 94 by two pins 98 and 99 which extend through alined holes in the side portions of the slotted operating lever 54. The link is shown in its extreme clockwise position in Figure 4, and in its counterclockwise-limited position in Figure 5. The notch 95 is located so that when the link is in its clockwise position, the notch lies above a centerline drawn through the notch 97 and the center of pivot 94; and when the link is in its counterclockwise position, the notch lies below the said centerline. With the parts shown in the relative positions occupied in Figure 4, the spring 96 exerts a force on the free end of the pawl 86, urging the lip 90 downwardly against the teeth of rack 91. This is the initial condition of the linkage at the time the closing operation of the hook is first started.

It might be noted at this point that there is a notch 100 formed in the rack 91 adjacent the outer end thereof, and beyond the notch is a tongue 101 having an inclined cam face 102. The lip 90 of the pawl is normally seated in the notch 100 when the hook is at rest. During the tightening phase of the operation, described earlier, the counterclockwise rocking movement of the operating lever 54 with respect to the bell crank arm 52 causes the link pivot 94 to move toward the right in an arcuate path about the operating lever pivot 53 as a center. Since the pawl 86 is supported on the operating lever through the medium of the link 93, this movement toward the right of the operating lever carries the pawl along with it, lifting the lip 90 out of the notch 100 and causing the lip to ratchet over the teeth of the pawl. When the force on the control wire 30 is relaxed, the lip 90 on the pawl drops into locking engagement with the last tooth passed over, and the pawl is thereby prevented from moving back toward the outer end of the rack.

As the hook is drawn up tight on the object A, the reaction of the toothed sector 65 on the arcuate rack 66 causes the latter to be pushed outwardly, or to the left, against the pressure of the leaf spring 83. In Figure 4, the rack is shown at the extreme left hand position. With the release of the tension in the control wire 30, the rack is pushed back slightly by the stressed spring 83, to a position somewhere between its extreme positions, as shown in Figure 5, carrying the toothed sector 65 with it. Since the bell crank member 44 and movable hook member 51 are limited against further clockwise rotation by their engagement with the unyielding object A, the pivot 53 remains stationary, and the operating lever 54 therefore tends to rock in a clockwise direction about the pivot 53. However, in order for the operating lever 54 to rotate clockwise from its position in Figure 4, it is necessary also for the pivot pin 94 to move toward the left in an arcuate path about the axis of the pivot 53 as a center, but such movement of the pin 94 is resisted by the spring-pressed link 93 and pawl 86, which are connected thereto. The pawl 86, being engaged with the rack 91, is prevented from moving toward the left; and the pin 92, which might also be considered a part of the pawl, is likewise prevented from moving toward the left. Hence, the only movement of which link 93 is capable is clockwise rotation about the pivot 92.

With the linkage in the position shown in Figure 4, the pin 94 lies slightly above the bottom of its arcuate path about the pin 92; the bottom being considered as the point at which a line drawn through the centers of the pins 53 and 94 is tangent to the circular path of the pin 94 about the pin 92. Accordingly, a force toward the left, applied by the operating lever 54 to the pin 94, causes the latter to ride down its arcuate path about the pin 92 until the notch 95 passes a centerline drawn through the notch 97 and pin 94. When this happens, the spring 96 snaps the link 93 down to the counterclockwise position limited by pin 99, as shown in Figure 5, and spring 96 now exerts a force on the outer end of the pawl tending to urge the same away from the rack 91. The lip 90 of the pawl is held by the tooth of the rack, however, and is thus prevented from moving away from the latter.

From the foregoing explanation, it will be seen that the spring 83, acting on the sliding rack 66, exerts a spring force back through the actuating system when the latter is locked, causing a spring pressure to be exerted on the object A by the movable hook member 51 when the control force has been relaxed and the mechanism is locked. When in the locked condition just described, the actuating mechanism 33 is relatively immovable, and the force of the spring 83 is, in effect, applied directly to the bell crank 44 at a moment arm equal to the distance between the center of the pivot 43 and the pitch line of the teeth in the rack. Since this moment arm is about one-fourth of the moment arm of the movable hook member 51, measured from the pivot 43 to the object A, a fifty-pound force exerted by spring 83 on the rack 66 results in a twelve and one-half pound pressure by member 51 on the object A. This is considered adequate for most purposes.

The next step in the operating cycle might be termed the unlocking step, and this is shown in Figure 6. When the amputee wishes to release the object A, he shrugs the harnessed shoulder again, applying another force to the control wire 30, which exerts a counterclockwise torque on the operating lever 54. Again, since the bell crank member 44 and movable hook member 51 are limited against further clockwise rotation by their engagement with the unyielding object A, the only relative movement possible in the system is counterclockwise rotation of the operating lever 54 with respect to the bell crank member, which is permitted by virtue of the sliding movement of rack 66 against the pressure of spring 83. This limited rotation of the operating lever causes the lip 90 of the pawl 86 to be lifted clear of the teeth of rack 91, so that the spring 96 is enabled to snap the pawl up to the position shown in Figure 6. Upward movement of the pawl is limited by its engagement with the shoulder 55 at the bottom of the slot in the operating lever 54.

The locking pawl 86, being now disengaged from the rack 91, no longer prevents clockwise rotation of the operating lever 54, and the lever is accordingly rocked in a clockwise direction by the spring 71 until the toothed sector 65 disengages and clears the teeth of the rack 66. The movable hook member 51 and bell crank 44 are then returned to their open position by the cantilever springs 73.

In the final phase of the operating cycle, the locking pawl 86 is reset to its initial condition, with the lip 90 seated in the notch 100 and urged by the spring 96 down toward the teeth of the rack 91. This occurs as the several parts of the actuating mechanism approach their normal positions of rest, and is shown in Figure 7. Clockwise rotation of the operating lever 54 under the urging of spring 71 carries the pawl 86 around to the left so that the lip 90 thereof engages the cam face 102. The final portion of the angular movement of the operating lever with respect to the bell crank arms 52 causes the lip 90 to be cammed down into the notch 100, and at the same time, forces the pin 92 to ride down its arcuate path about pin 94 as a center, until the notch 95 passes above the centerline drawn through notch 97 and pin 94. The spring 96 then snaps the link 93 up to its clockwise limited position, and the mechanism is now reset to its initial condition, in readiness for the next cycle of operation.

Those skilled in the art will readily appreciate the many advantageous features of the hook described hereinbefore. The fast-motion, low-mechanical-advantage prevailing in the system during the initial no-load closing movement of the hook enables the hook to be closed rapidly with a minimum of muscular effort at the harnessed shoulder. When the hook has closed on the object and a high mechanical advantage becomes desirable for the purpose of obtaining a firm grip on the object, the mechanism shifts automatically to a slow-travel, high-mechanical-advantage condition. The self-locking feature, with spring pressure applied to the movable hook member when the actuating mechanism is locked, and the provision of means for unlocking the mechanism responsive to the next succeeding application of force to the control wire 30, will likewise be recognized as important advantages.

Another highly desirable feature of the invention is the fact that the spring 83 allows the arcuate rack 66 to yield slightly under excessive loads, which permits the hook 51 to open sufficiently to release its grip in an emergency. This prevents injurious shock loads from being transmitted back to the arm of the wearer, and also safeguards the hook mechanism against damage. The spring 83 thus serves as a load limiter, in addition to its spring-loading function.

Figure 8 illustrates another embodiment of the invention, showing the manner in which the previously described actuating system with its force multiplier action may be modified slightly to permit its use in an artificial hand to actuate the fingers thereof. In this embodiment, parts which are similar to those of the preceding construction are given the same reference numerals, with the suffix "*a*" added.

The hand is designated in its entirety by the reference numeral 110, and comprises a base 111 having coupling flanges 20*a* on the back side thereof which are adapted to be engaged in the companionate grooves of the attach plate. The main body portion of the hand may be formed as

a thin-walled shell 112 of aluminum or other light weight material, which is attached in any suitable manner to the base 111 around the periphery thereof. The shell 112 is preferably divided into front and back halves for convenience of manufacture; the front half being removed in the drawing to show the mechanism in the interior.

At the outer end of the hand are movable fingers 113, 114, 115 and 116, each of which is jointed intermediate its ends for articulation. The proximal ends of fingers 113 and 114 are fixedly mounted on a transverse shaft 120 which is rotatably supported on the back half of the shell 112 by suitable bearings (not shown). The proximal end of finger 115 is fixedly mounted on another shaft 121 coaxial with shaft 120, and the forefinger 116 is rotatably mounted on the shaft 120 for independent movement with respect thereto. Shaft 121 is rotatably supported in suitable bearings (not shown) and is coupled to shaft 120 by a friction clutch 122. Fingers 115 and 116 are manually closed by the actuating mechanism 33*a* through the agency of a linkage system which will be described presently; while the outer two fingers 113 and 114 are closed by the torque transmitted to shaft 120 through the friction clutch 122. Thus, the principal gripping force applied by the fingers to an object held in the hand is that exerted by fingers 115 and 116, and the force exerted by fingers 113, 114 is relatively insignificant, being limited by the torque capacity of the clutch 122.

Projecting from the proximal ends of the fingers 115, 116 are ears 123 and 124, to which links 125 and 126 are connected. The links 125 and 126 are pivotally connected to opposite ends of a transversely disposed equalizer bar 130, and the latter is connected at its midpoint to a link 131. The link 131 is connected, in turn, to a bifurcated lever arm 132 which is fixed on a shaft 133. The shaft 133 is journaled in a bracket 134 mounted on the back half of the shell 112, and one end of the shaft projects laterally beyond the bracket and has an arm 135 fixed thereto. Pivotally connected at 136 to the outer end of the arm 135 is a link 140, the lower end of which is provided with a yoke 139 that passes down over the outer sides of both of the arm portions 52*a* of the bell crank member 44*a*. In this embodiment, the pin 53*a* projects beyond the arms 52*a* and its ends are received within aligned holes in the yoke 139.

The actuating mechanism 33*a* is substantially the same as that in the preceding embodiment, with the exception of the bell crank member 44*a* which terminates just beyond the notch 72*a* that anchors the spring 71*a*. The connector 32*a* (referred to in the claims as the control member) is connected by a link 60*a* to one end of an operating lever 54*a* which is pivoted at 53*a* on the arms 52*a* of the bell crank member 44*a*. At the outer end of the operating lever 54*a* is a toothed sector 65*a* which is adapted to mesh with an arcuate rack 66*a* that is slidably mounted on a curved face 80*a* of a post 35*a*. As in the prior example, the rack 66*a* is urged downwardly by a bowed leaf spring 83*a*, and the toothed sector 65*a* is urged out of engagement with the teeth of rack 66*a* by a spring 71*a*. A locking pawl 86*a* is connected with the operating lever 54*a* by a link (not shown) similar to the link 93 of the hook actuating mechanism 33, and the wedge-shaped lips 90*a* of the pawl is engageable with an arcuate rack 91*a*. A bowed leaf spring 96*a* is seated at one end in a notch in the pawl 86*a*, and at the other end engages the link corresponding to 93,

to urge the same to one or the other of two positions, as described earlier.

The action of the operating mechanism 33*a* is identical to that of the previous example. When the hand is mounted on the attach plate at the write of an artificial arm, the connector 32*a* is connected to the coupling member 25 at the end of the Bowden cable control wire 30, and a shrug of the harnessed shoulder causes a pull to be applied to the member 32*a*. The force exerted on the member 32*a* is transmitted by link 60*a* to the operating lever 54*a* and bell crank 44*a*. As long as the force required to rock the bell crank 44*a* about its pivot 43*a* against the pressure of springs 73*a* is less than the force exerted by spring 71*a* against the sector 65*a*, the operating lever 54*a* remains stationary with respect to the bell crank 44*a*, and the latter rocks on its pivot 43*a* as though connected directly to the link 60*a*. This gives the fast-motion, low-mechanical-advantage action during the no-load portion of the bell crank's travel. When the load on the bell crank 44*a* is increased to the point where the spring 71*a* is overcome, the toothed sector 65*a* engages the rack 66*a*, and the lever 54*a* thereafter functions as a fulcrumed lever, giving the system a slow-travel and high-mechanical-advantage action, whereby the fingers are enabled to close with a powerful grip on any object held thereby.

The actuating mechanism 33*a* is operatively connected to the fingers by the yoke 139 and its associated linkage. As the outer ends of the bell crank arms 52*a* swing downwardly, the yoke 139 and link 140 are pulled down with it, rocking the shaft 133 and causing the outer end of the lever arm 132 to swing downwardly. This pulls the link 131 downwardly, which causes the equalizer bar 139 to exert an equalized pull on both of the links 125, 126. Link 125, being connected to finger 115 which is fixedly mounted on the shaft 121, causes the said finger to close and the shaft to rotate. Link 126, which is connected to finger 116, causes the latter to close at the same rate as finger 115 as long as there is no load, or the load is equally distributed between them. Since shaft 120 is connected to shaft 121 by the friction clutch 122, fingers 113 and 114 are likewise closed in unison with fingers 115 and 116 as long as there is no load on any of the fingers. However, if either of fingers 115 or 116 is loaded more than the other, the equalizer bar 130 enables the fingers to move relative to one another until the load is equalized; such relative movement being permitted by virtue of the pivotal connection of finger 116 to the shaft 121. Fingers 113 and 114 are permitted to yield under load by the slippage of clutch 122 when the torque capacity of the latter is exceeded.

The distal ends of fingers 113, 114, 115, and 116 may be connected to the back shell 112 of the hand by cross-over links 145 in a manner well known in the art, so that the fingers are flexed at the same time that they are closed.

The thumb 146 may be of any desired construction, and may be either passively positioned, as in the case of the illustrated hand, or manually operated. For the sake of simplicity, I have shown a rigid, one-piece thumb 146 that is pivoted at 147 on a bifurcated bracket 148 projecting radially from a turn-table 150. The turn-table 150 is rotatably connected by a pin 151 to a ledge 152 that extends laterally from the back side of the post 35*a*. Suitable friction means may be interposed between the thumb 146 and bracket 148, and between the turn-table 150 and ledge 152, to provide a certain amount of resistance to angular movement about each of the pivots 147 and 151.

From the foregoing, it will be seen that the prinicples of the invention can be utilized with equal advantage in either a hand or hook, the only differences being in the manner of transmitting the output force of the actuating system to the movable gripping members. In the one instance, the gripping member is simply a pivoted hook; whereas in the other case, the gripping members consist of a plurality of individually movable fingers which are connected together to move in unison. The actuating mechanism 33*a* might also be utilized in any other form of hook or hand mechanism, and is not limited to the specific constructions shown.

While I have shown and described in considerable detail what I believe to be the preferred form of my 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 scope of the invention, as defined in the appended claims.

I claim:

1. In an artificial hand or hook having a movable gripping member, actuating means connected to said gripping member to operate the same, said actuating means including a pivoted member having an arm projecting radially from its axis of rotation, an operating lever pivoted on the outer end of said arm and extending inwardly toward said axis, said operating lever being engageable with a substantially stationary element when rocked in one direction, a spring urging said operating lever in the other direction for holding the same out of engagement with said stationary element, a control member connected to said operating lever in a manner whereby the application of a force by the control member tends to rock the operating lever in said one direction against the pressure of said spring, said movable gripping member being closed with a fast travel and low mechanical advantage as long as the torque on said operating lever due to the pressure of said spring exceeds the torque due to the force exerted by said control member, and when the torque due to the force of said control member exceeds the torque due to said spring, said operating lever is rocked into engagement with said stationary element, giving a fulcrumed lever action on the outer end of said arm, whereby said movable gripping member is thereafter closed with a slow travel and high mechanical advantage, a link pivoted intermediate its ends on said operating lever, stops for limiting the angular movement of said link between a first position and a second position, a locking pawl connected to one end of said link and extending around to the opposite side of the pivot point thereof, an arcuate rack projecting laterally from said movable hook member, said rack being engageable by the free end of said pawl, a spring bearing against the other end of said link and against the free end of said pawl, said last-named spring being operative to urge said free end of the pawl into engagement with said rack when said link is in said first position, and out of engagement therewith when said link is in said second position, said link being initially disposed in said first position while said movable gripping member is being drawn tight on an object, whereby said pawl is ratcheted over said rack and engages one of the teeth thereof when

the force exerted by said control member is relaxed, said pawl and said link thereafter holding said operating lever in the position occupied by the latter when said control member was relaxed, whereby said movable gripping member is locked in closed position, said link being moved to said second position when said control member is relaxed, whereby the next succeeding application of force by said control member causes said pawl to be lifted out of its seating engagement with said rack, allowing said last-named spring to move said pawl clear of the rack and releasing said operating lever, said operating lever being moved out of engagement with said stationary element by said first-named spring, permitting said movable gripping member to open, and means engageable by said pawl for moving the same in a direction to cause said link to return to said first position.

2. In an artificial hand or hook having a base and a movable gripping member, actuating means connected to said gripping member to operate the same, said actuating means including a pivoted member having an arm projecting radially from its axis of rotation, an operating lever pivoted on the outer end of said arm and extending inwardly toward said axis, said operating lever having a toothed sector projecting outwardly from its pivot support, an arcuate rack mounted on said base and engageable by said toothed sector, said rack having its center of curvature on said axis of said pivoted member, a force-transmitting control member connected to said operating lever, spring means connected to said operating lever to apply a torque thereto opposing the torque exerted by said control member, said spring means being operable to hold said toothed sector normally out of engagement with said arcuate rack, whereby said movable gripping member is closed with a fast travel and low mechanical advantage by virtue of the direct application of force of said control member to said arm as long as the torque of said spring means on said operating lever exceeds the torque of said control member thereon, and when the torque on said operating lever produced by said control member exceeds the torque produced by said spring means, said toothed sector is moved into engagement with said arcuate rack, giving a fulcrumed lever action on the outer end of said arm, whereby said movable gripping member is thereafter closed with a slow travel and high mechanical advantage, an arcuate rack mounted on said pivoted member, a locking pawl supported at one end on said operating lever and engageable at the other end with said last-named arcuate rack to hold the operating lever in its position of maximum deflection when the pull on said control member is relaxed, a spring having one end engaging said other end of said pawl, and means acting on the other end of said spring to move the same alternately from one to the other of two positions each time said control member is operated, said spring being operable to urge said pawl into engagement with said last-named arcuate rack when said other end thereof is at one of said two positions, and to urge the pawl out of engagement with the arcuate rack when at the other of said two positions.

3. In an artificial hand or hook having a base and a movable gripping member, actuating means connected to said gripping member to operate the same, said actuating means including a pivoted member having an arm projecting radially from its axis of rotation, an operating lever pivoted

on the outer end of said arm and extending inwardly toward said axis, said operating lever having a toothed sector projecting outwardly from its pivot support, an arcuate rack mounted on said base and engageable by said toothed sector, said rack having its center of curvature on said axis of said pivoted member, a force-transmitting control member connected to said operating lever, a spring connected to said operating lever to apply a torque thereto opposing the torque exerted by said control member, said spring being operable to hold said toothed sector normally out of engagement with said arcuate rack, whereby said movable gripping member is closed with a fast travel and low mechanical advantage by virtue of the direct application of force of said control member to said arm as long as the torque of said spring on said operating lever exceeds the torque of said control member thereon, and when the torque on said operating lever produced by said control member exceeds the torque produced by said spring, said toothed sector is moved into engagement with said arcuate rack, giving a fulcrumed lever action on the outer end of said arm, whereby said movable gripping member is thereafter closed with a slow travel and high mechanical advantage, and releasable locking means operatively connected to said actuating means for locking said movable gripping member in closed position when the force exerted by said control member is relaxed, said locking means comprising a link pivoted intermediate its ends on said operating lever, a locking pawl pivoted on one end of said link and extending around to the opposite side of the pivot axis thereof, a rack on said pivoted member engageable by the free end of said pawl, and a spring bearing against the other end of said link and against the free end of said locking pawl, said link being operable to move said spring alternately between a position wherein the pawl is urged into engagement with said rack and another position wherein the pawl is urged away from said rack.

4. In an artificial hand or hook having a base and a movable gripping member, actuating means connected to said gripping member to operate the same, said actuating means including a pivoted member having an arm projecting radially from its axis of rotation, an operating lever pivoted on the outer end of said arm and extending inwardly toward said axis, said operating lever having a toothed sector projecting outwardly from its pivot support, an arcuate rack mounted on said base for limited sliding movement along its arc of curvature and engageable by said toothed sector, said rack having its center of curvature on said axis of said pivoted member, a spring acting on said rack to urge the same in one direction to the extremity of its travel, a force-transmitting control member connected to said operating lever, another spring connected to said operating lever to apply a torque thereto opposing the torque exerted by said control member, said last-named spring being operable to hold said toothed sector normally out of engagement with said arcuate rack, whereby said movable gripping member is closed with a fast travel and low mechanical advantage by virtue of the direct application of force of said control member to said arm as long as the torque of said last-named spring on said operating lever exceeds the torque of said control member thereon, and when the torque on said operating lever produced by said control member exceeds the torque produced by

said spring, said toothed sector is moved into engagement with said arcuate rack, giving a fulcrumed lever action on the outer end of said arm, whereby said movable gripping member is thereafter closed with a slow travel and high mechanical advantage, said toothed sector being operative to move said arcuate rack in the direction against the pressure of said first-named spring, thereby causing the spring to be compressed, and locking means connected to said operating lever for holding the same in the position of maximum deflection when the force exerted by said control member is relaxed, whereby said movable gripping member is locked in closed position, the pressure of said first-named spring against said arcuate rack acting on said arm of said pivoted member through the toothed sector of said operating lever to cause said movable gripping member to exert a spring-pressure on the article gripped thereby.

5. In an artificial hand or hook having a base and a movable gripping member, actuating means connected to said gripping member to operate the same, said actuating means including a pivoted member having an arm projecting radially from its axis of rotation, an operating lever pivoted on the outer end of said arm and extending inwardly toward said axis, said operating lever having a toothed sector projecting outwardly from its pivot support, an arcuate rack having its center of curvature on said axis of said pivoted member, said rack being mounted on said base for limited sliding movement along its arc of curvature, and being engageable by said toothed sector, a spring acting on said rack to urge the same in one direction to the extremity of its travel, a control member connected to said operating lever, another spring connected to said operating lever to apply a torque thereto opposing the torque exerted by said control member, said last-named spring being operable to hold said toothed sector normally out of engagement with said arcuate rack, whereby said movable gripping member is closed with a fast travel and low mechanical advantage by virtue of the direct application of force of said control member to said arm as long as the torque of said last-named spring on said operating lever exceeds the torque of said control member thereon, and when the torque on said operating lever produced by said control member exceeds the torque produced by said spring, said toothed sector is moved into engagement with said arcuate rack, giving a fulcrumed lever action on the outer end of said arm, whereby said movable gripping member is thereafter closed with a slow travel and high mechanical advantage, said toothed sector being operative to move said arcuate rack in the other direction against the pressure of said first-named spring causing said spring to be compressed, means responsive to the relaxation of the force exerted by said control member for locking said operating lever against angular movement with respect to said arm, whereby said movable gripping member is locked in the closed position, the pressure of said first-named spring against said arcuate rack acting on said arm of said pivoted member through the toothed sector of said operating lever to cause said movable gripping member to exert a spring-pressure on the article gripped thereby when the force exerted by said control member is fully relaxed, and means responsive to the next succeeding application of force by said control member for releasing said locking means to permit said movable gripping member to open.

6. An artificial arm hook comprising a base having a stationary hook member rigidly fixed thereto, a movable hook member pivoted on said base for swinging movement toward and away from said stationary member, actuating means including an arm projecting radially from said movable hook member adjacent the axis of rotation thereof, an operating lever pivoted on the outer end of said arm and extending inwardly toward said axis, said operating lever being engageable with a substantially stationary element on said base when rocked in one direction, a spring urging said operating lever in the other direction for holding the same out of engagement with said stationary element, a control member connected to said operating lever in a manner whereby the application of a force by the control member tends to rock the operating lever in said one direction against the pressure of said spring, said movable hook member being closed with a fast travel and low mechanical advantage as long as the torque on said operating lever due to the pressure of said spring exceeds the torque due to the force exerted by said control member, and when the torque due to the force of said control member exceeds the torque due to said spring, said operating lever is rocked into engagement with said stationary element, giving a fulcrumed lever action on the outer end of said arm, whereby said movable hook member is thereafter closed with a slow travel and high mechanical advantage, a link pivoted intermediate its ends on said operating lever, stops for limiting the angular movement of said link between a first position and a second position, a pawl connected to one end of said link and extending around to the opposite side of the pivot point thereof, an arcuate rack projecting laterally from said movable hook member, said rack being engageable by the free end of said pawl, a spring bearing against the other end of the said link and against the free end of said pawl, said last-named spring being operative to urge said free end of the pawl into engagement with said rack when said link is in said first position, and out of engagement therewith when said link is in said second position, said link being initially disposed in said first position while said movable hook member is being drawn tight on an object, whereby said pawl is ratcheted over said rack and engages one of the teeth thereof when the force exerted by said control member is relaxed, said pawl and said link thereafter holding said operating lever in the position occupied by the latter when said control member was relaxed, whereby said movable hook member is locked in closed position, said link being moved to said second position when said control member is relaxed, whereby the next succeeding application of force by said control member causes said pawl to be lifted out of its seating engagement with said rack, allowing said last-named spring to move said pawl clear of the rack and releasing said operating lever, said operating lever being moved out of engagement with said stationary element by said first-named spring, permitting said movable hook member to open, and a cam surface on said rack engageable by said pawl as said operating lever approaches its initial position, for deflecting the free end of the pawl in a direction causing said link to move to said first position.

7. An artificial arm hook comprising a base

having a stationary hook member rigidly fixed thereto, a movable hook member pivoted on said base for swinging movement toward and away from said stationary member, actuating means including an arm projecting radially from said movable hook member adjacent the axis of rotation thereof, an operating lever pivoted on the outer end of said arm and extending inwardly toward said axis, said operating lever having a toothed sector projecting outwardly from its pivot support, an arcuate rack mounted on said base and engageable by said toothed sector, said rack having its center of curvature on said axis of said movable hook member, a force-transmitting control member connected to said operating lever, a spring connected to said operating lever to apply a torque thereto opposing the torque exerted by said control member, said spring being operable to hold said toothed sector normally out of engagement with said arcuate rack, whereby said movable hook member is closed with a fast travel and low mechanical advantage by virtue of the direct application of force of said control member to said arm as long as the torque of said spring on said operating lever exceeds the torque of said control member thereon, and when the torque on said operating lever produced by said control member exceeds the torque produced by said spring, said toothed sector is moved into engagement with said arcuate rack, giving a fulcrumed lever action ou the outer end of said arm, whereby said movable hook member is thereafter closed with a slow travel and high mechanical advantage, a link pivoted intermediate its ends on said operating lever, stops for limiting the angular movement of said link between a first position and a second position, a pawl connected to one end of said link and extending around to the opposite side of the pivot point thereof, another rack engageable by the free end of said pawl, a spring bearing against the other end of said link and against the free end of said pawl, said last-named spring being operative to urge said free end of the pawl into engagement with said last-named rack when said link is in said first position, and out of engagement therewith

when said link is in said second position, said link being initially disposed in said first position while said movable hook member is being drawn tight on an object, whereby said pawl is ratcheted over said last-named rack and engages one of the teeth thereof when the force exerted by said control member is relaxed, said pawl and said link thereafter holding said operating lever in the position occupied by the latter when said control member was relaxed, whereby said movable hook member is locked in closed position, said link being moved to said second position when said control member is relaxed, whereby the next succeeding application of force by said control member will lift said pawl out of its seating engagement with said last-named rack, allowing said last-named spring to move said pawl clear of the rack and releasing said operating lever, said operating lever being then moved out of engagement with said first-named rack by said first-named spring, permitting said movable hook member to open, and means engageable by said pawl for moving the same in a direction to cause said link to return to said first position.

GILBERT M. MOTIS.

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