June 1, 1948. F. V. EBERLE ET AL 2,442,530

HYDRAULICALLY-OPERATED ARTIFICIAL BODY MEMBERS

Filed March 18, 1946 2 Sheets-Sheet 1

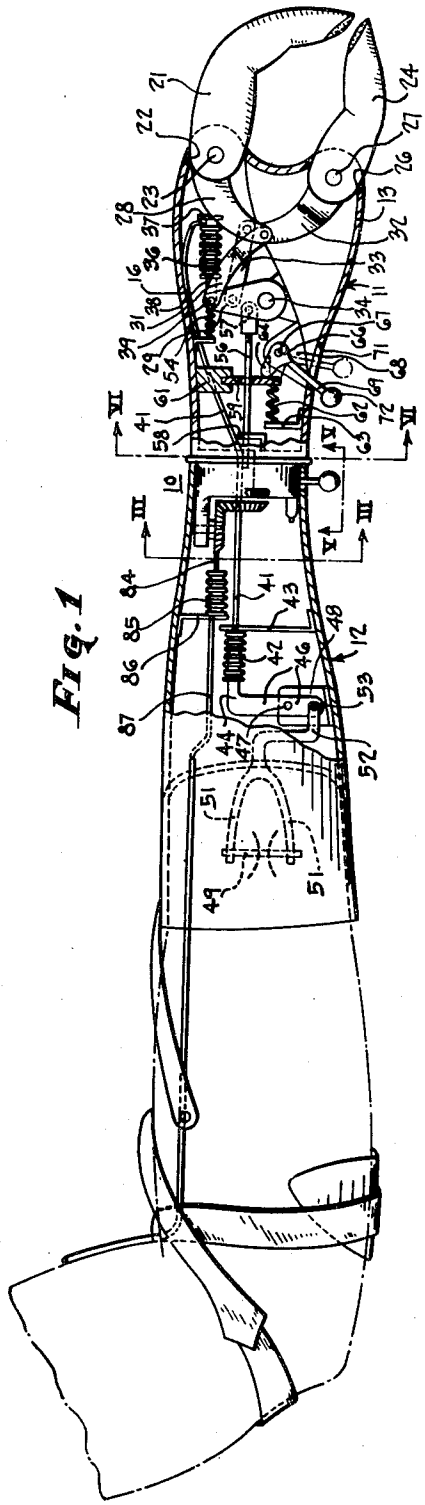


Fig. 1

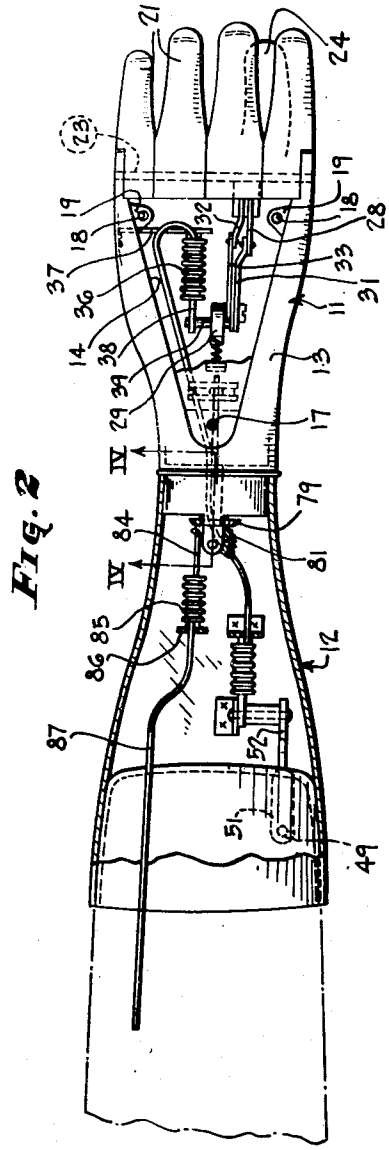


Fig. 2

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HYDRAULICALLY-OPERATED ARTIFICIAL BODY MEMBERS

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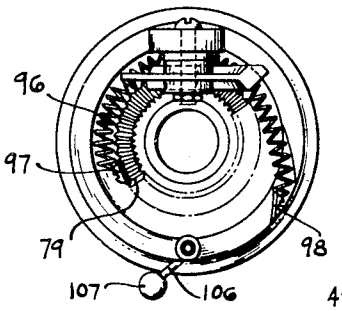


FIG. 3

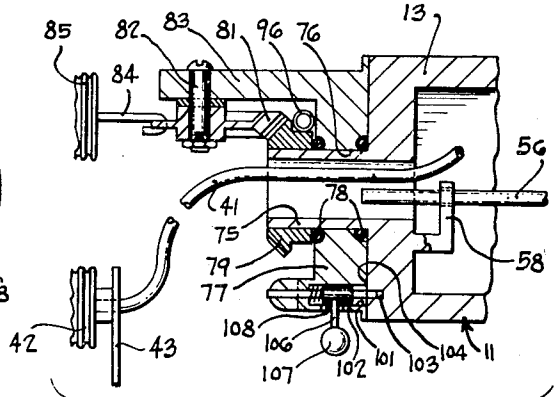


FIG. 4

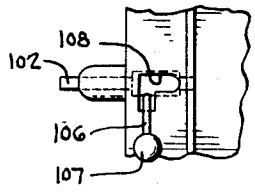


FIG. 5

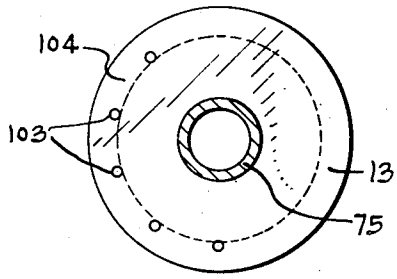


FIG. 6

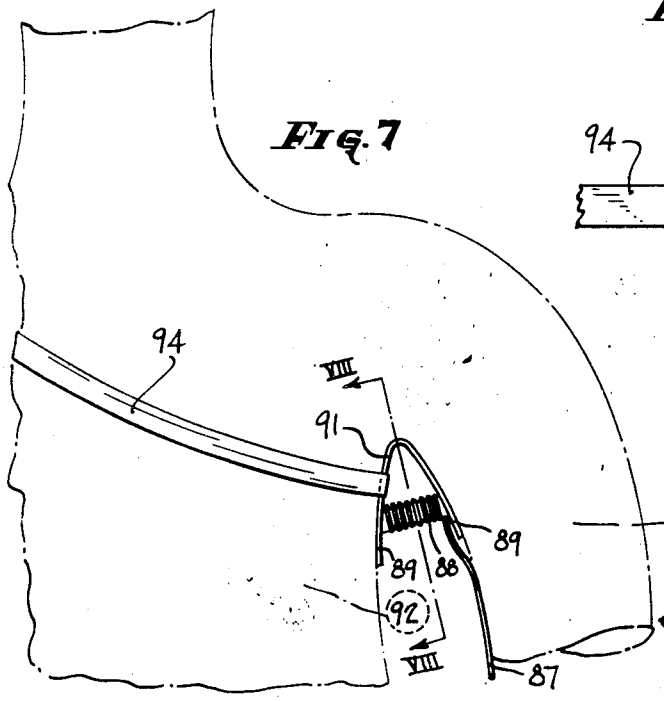


FIG. 7

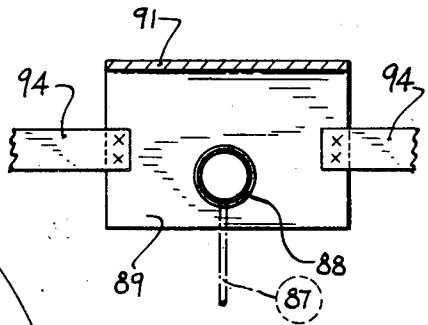


FIG. 8

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UNITED STATES PATENT OFFICE

2,442,530

HYDRAULICALLY OPERATED ARTIFICIAL BODY MEMBER

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Application March 18, 1946, Serial No. 655,278

8 Claims. (Cl. 3—12)

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This invention relates to artificial body members, more particularly to hydraulic operation of such members, and has for an object to provide improved operating mechanism of this character.

Another object of the invention is to provide an hydraulically-operated limb member wherein the initial operating impulse is obtained from action of the muscles of the remaining portion of the natural limb, functioning by means of a cineplastic operation.

A further object of the invention is to provide an artificial limb member whose parts are moved by hydraulic means including a closed hydraulic system, whereby leakage of the operating medium is avoided.

Another object of the invention is to provide an artificial hand and wrist assembly in which movement of the wrist and movement of the hand's digits are effected by independent hydraulic systems.

Yet another object of the invention is to provide, in an artificial body member, novel mechanism for locking parts of said member in any desired position of movement relative to remaining parts thereof.

These and other objects are effected by the invention as will be apparent from the following description and claims taken in accordance with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a side elevational view, partially in section, of an artificial hand and wrist assembly embodying novel features of the present invention;

Fig. 2 is a plan view of a portion of the structure shown in Fig. 1, partially in section and with the hand cover plate removed to more clearly show features of the construction;

Fig. 3 is a transverse sectional view, taken along the line III—III of Fig. 1, looking in the direction indicated by the arrows;

Fig. 4 is an enlarged fragmentary sectional view, taken along the line IV—IV of Fig. 2, looking in the direction indicated by the arrows;

Fig. 5 is an enlarged fragmentary plan view, taken along the line V—V of Fig. 1, looking in the direction indicated by the arrows;

Fig. 6 is a transverse sectional view, taken along the line VI—VI of Fig. 1, looking in the direction indicated by the arrows;

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Fig. 7 is a front elevational view of mechanism for obtaining an initial impulse for a closed hydraulic system, shown applied to the human body with the latter partially in phantom; and,

Fig. 8 is a sectional view, taken along the line VIII—VIII of Fig. 7, looking in the direction indicated by the arrows.

Referring now to the drawings more in detail, the reference character 10 indicates, in its entirety, an artificial hand and wrist assembly, the hand being designated 11, and the wrist or forearm 12.

Preferably, the hand 11 comprises a casing 13 provided at the top, or back of the hand, with an opening 14 for ready access to the mechanism housed therein, the opening normally being closed by the cover plate 16, secured by screws 17 threadedly received in openings 18 in the lugs 19, integral with the casing 13.

The forward end of the casing 13 carries four finger members 21, mounted in openings 22 for pivotal movement on rod 23, the four fingers 21 preferably moving as a unit towards and away from a thumb member 24, mounted in opening 26 on pin 27 for simultaneous opposed movement relative to the fingers 21.

An operating lever 28 extends rearwardly from the base of the fingers 21, in the space within the hand casing 13, the free end of lever 28 being joined to a crank 29 by a connecting link 31. Similarly, a lever 32 extends rearwardly from the base of the thumb 24 and has its free end joined to the crank 29 by connecting link 33. Preferably, link 33 connects with crank 29 at a point thereon which is closer to the pivotal support 34 of the latter than is the point of connection of link 31 therewith. Consequently, movement of the crank 29 about its pivotal support 34 imparts greater angular movement to the fingers than to the thumb, thereby simulating the relative movement of natural fingers and thumbs.

The structure so far described has been known heretofore, as evidenced by United States Letters Patent No. 2,382,403, to which reference may be had for further details. The present invention is concerned more particularly, and among other things, with the provision of hydraulic means for imparting the necessary operating movements

to the mechanism described above, and to other mechanism to be hereinafter described.

A Sylphon 36 is anchored at one end to a suitable fixed support 37, carried by the hand casing 13, and is connected at its other end by link 38 and pin 39, to the crank 29 (Figs. 1 and 2). A flexible, but non-expandible, tube or conduit 41 communicates at one end with the interior of the Sylphon 36, and at its other end with the interior of a companion Sylphon 42, secured at one end to the fixed support 43 which is mounted on the wrist member 12. The free end of the Sylphon 42 is engaged by a projection 44 at one end of a lever 46. This lever is pivotally mounted, intermediate its ends, as at 47, on a fixed support 48 carried by the wrist member 12.

In the construction herein illustrated, pivotal movement of lever 46 towards the Sylphon 42 is produced by action of the user's flexor muscle, functioning by means of a cineplastic operation. In cineplastic amputations, pegs are passed through canals in the muscles and heretofore have been attached to levers operating the artificial hand mechanism.

In the present invention, the peg 49, extending through the flexor muscle, carries a yoke 51 whose stem 52 is connected to the free end of lever 46, as at 53. Upon contraction of the flexor muscle, the end 53 of lever 46 will be moved upwardly or away from the hand and the corresponding reverse movement of the other end will compress the Sylphon 42 and reduce its volume. Inasmuch as the Sylphons 42 and 36 and their connecting conduit 41 are filled with a liquid, any compression of Sylphon 42 will be accompanied with a corresponding and simultaneous expansion of Sylphon 36. The expansion of Sylphon 36 operates through link 38 to move the free end of crank 29 away from the fingers and thumb, and this crank movement will operate through links 31 and 33 and levers 28 and 32 to pivot the fingers 21 and thumb 24 towards each other in gripping relation. As long as the flexor muscle is contracted, the gripping action of the fingers and thumb will be maintained. Upon relaxation of the muscular actuation, the crank 29 will be returned to its prior or normal position by spring 54, which was compressed upon hydraulic actuation of the crank 29. Return of crank 29 to its normal position will effect return of the digits and Sylphons to their original positions.

To relieve the flexor muscle of the necessity of maintaining the digits in gripping relation for any great length of time, a novel locking mechanism is provided. Referring to Fig. 1, it will be seen that a rod 56 is pivotally connected to the crank 29, at 57, and extends rearwardly therefrom with its other end slidably supported in a fixed support 58, carried by the wrist end of the hand casing 13 (Fig. 4). The intermediate portion of rod 56 is slidably received in an opening in washer 59. One end of the washer 59 is retained against movement longitudinally of the rod 56 by reception in a groove in block 61, fixed to the hand casing 13. This edge of the washer is held with sufficient looseness to permit tilting of the washer when the opposite edge thereof is moved longitudinally of the rod 56. Such tilting of the washer 59 causes it to bind upon and grip the rod 56, thereby holding the latter against longitudinal movement in either direction.

The washer 59 is normally urged into unlocking position by a compression spring 62 abutting the washer at one end and a fixed support 63

at the other end. In unlocked position, shown by solid lines in Fig. 1, the spring 62 holds the washer against the short arm 64 of bell crank 66, which is pivotally mounted, at 67, on the fixed support 68. The bell crank 66 has its long arm 69 extending through a slot 71 in the hand casing 13, and engagement of the long arm with one end of the slot retains the bell crank in unlocking (solid line) position.

Upon manual movement of the bell crank 66 to locking position, shown by dotted lines in Fig. 1, the short arm 64 thereof pushes the washer to tilted position, thereby locking rod 56 and holding the fingers and thumb in their relative positions. Preferably, the short arm 64 of the bell crank 66 passes dead center when moving from either position to the other position, with the result that it tends to remain in the selected position with the long arm 69 abutting one end or the other of the slot 71. Preferably, the long arm terminates in a spherical knob 72 for convenient manipulation.

As best illustrated in Fig. 4, the hand 11 is mounted on the wrist member 12 for rotary movement about the longitudinal axis of the latter, and to this end is provided with an axial hollow shaft portion 75, preferably integral with the hand casing 13, and rotatably received in an axial opening 76 in the block 77 at the hand end of the wrist member 12. Ball bearings 78 render relative rotation of the hand and wrist as nearly frictionless as practical. A bevel gear 79 is secured on the shaft 75 and prevents separation of the hand and wrist members.

A segmental beveled gear 81 is mounted on shaft 82, projecting at right angles to the shaft 75 from the lug or arm 83, integral with the block 77. The segmental gear 81 meshes with the gear 79 on the shaft 75 to rotate the latter and the hand 11.

As best shown in Fig. 2, one end of the segmental beveled gear 81 is connected by rod 84 with the movable end of Sylphon 85 which is supported at its other end by the fixed support 86, carried by the wrist member 12. The interior of the Sylphon 85 is in communication, through the flexible but non-expansible tube or conduit 87, with the interior of a companion Sylphon 88, secured in bridging relation to the spaced arms 89 of a U-shaped resilient member 91 (Figs. 7 and 8). As shown in these figures, the resilient U-shaped member is adapted to be positioned in the armpit of the user of the artificial limb with one leg 89 of the member engaging the user's body 92, and the opposed leg 89 engaging the inner surface of the user's adjacent arm 93, the member 91 being retained in position by suitable means, for example, the strap 94 passing over the back and chest and the opposite shoulder of the user.

It will be apparent that, in operation, movement of the user's arm 93 toward the body 92 will compress the Sylphon 88, reducing the volume thereof and forcing the non-compressible liquid therein through the tube 87 to correspondingly expand Sylphon 85. This will cause rod 84 to push on the segmental gear 81 and rotate meshing gear 79 to turn the hand 11 relative to the wrist 12. In the position shown in Fig. 2, the gears have been rotated by rod 84 and Sylphon 85 in the manner just described.

To rotate the hand in the opposite direction to return it to its original and normal position, upon release of pressure applied through Sylphon 88 by the user's arm, a tension coil spring 96

has one end attached to the bevel gear 79, as at 97, and the other end attached to the block 77, as at 98 (Figs. 3 and 4). As the gear 79 and hand 11 are rotated by the hydraulic mechanism, the spring 96 will be expanded and placed under increased tension, which tension will return the gear and hand to their original positions upon release of the hydraulically-applied force.

Under certain conditions it may be desirable to relieve the hydraulic system of the necessity of retaining the hand in a position of rotation other than normal, and to this end the block 77 is bored, as at 101, for reception of a locking pin 102, slidable longitudinally therein and adapted, at one limit of its sliding movement, to engage in any selected opening 103 of a series of such openings in the opposed surface 104 of the hand casing 13 (Figs. 4 and 5). The locking pin 102 has a lateral extension 106 terminating in a knob 107, the extension 106 projecting through a bayonet slot 108 in the side of the block 77. A compression spring 109 urges the pin 102 into engagement with one of the openings 103 when the extension 106 is in the longitudinal portion of slot 108. When the extension 106 is in the transverse portion of slot 108, the locking pin is prevented from engaging in any of the openings 103, and the hand is free to turn.

Obviously, the present invention is not limited to the particular body motions illustrated and described for operation of the hydraulic systems, as both systems may be operated by cineplastic muscular action, or by movement of other members of the user's body than those illustrated.

Accordingly, while the invention has been illustrated in only one form, it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. In an artificial hand, a casing, digits pivotally-mounted on said casing and movable toward and away from one another, mechanism housed in said casing and operatively associated with said digits for moving them and including a crank for operating said mechanism, a first Sylphon mounted in said casing and fixedly secured thereto at one end, the other end of said Sylphon being movable longitudinally as the Sylphon is compressed and expanded, means connecting the free end of said Sylphon with said crank, whereby expansion of said Sylphon will move said crank in one direction to actuate said digits, a spring in said casing and adapted to urge said crank in a direction opposed to that in which it is moved by expansion of said Sylphon, a second Sylphon adapted to be carried on the user's body at a place thereon other than said artificial hand, said second Sylphon being adapted to be compressed by muscular action on the part of the user, and an inexpandible conduit providing communication between the interiors of said Sylphons, whereby when said Sylphons and the communicating conduit are filled with liquid, muscular action compressing said second Sylphon will cause corresponding expansion of said first-mentioned Sylphon with consequent movement of said crank and operation of said digits.

2. Structure as specified in claim 1, wherein the pressure exerted upon the crank by the spring is sufficient to return said crank, the digits operated thereby, and the Sylphons to their normal positions when muscular action on the hydraulic system is relieved.

3. Structure as specified in claim 1, including

locking means associated with the crank for retaining the crank and the digits operated thereby in any position to which they are moved by the hydraulic system.

4. In an artificial hand and wrist assembly, a wrist member; a hand member rotatably mounted on said wrist member; a plurality of fingers and a thumb pivotally mounted on said hand member for relative movement toward and away from each other; a first pair of Sylphons; a first inexpansible conduit providing communication between the Sylphons of said first pair, whereby when said Sylphons and the communicating conduit are filled with liquid and one of the Sylphons is compressed, the other Sylphon will be expanded; means associated with one of said Sylphons for compressing the latter, the other of said first pair of Sylphons being carried by said hand member; means associated with said other Sylphon for moving said fingers and said thumb upon expansion of said other Sylphon; a second pair of Sylphons; a second inexpandible conduit providing communication between the Sylphons of said second pair, whereby when said second pair of Sylphons and their communicating conduit are filled with liquid and one of the Sylphons is compressed, the other Sylphon will be expanded; means associated with one of the Sylphons of said second pair for compressing said one Sylphon, the other Sylphon of said second pair being carried by the wrist member; and means associated with said last-mentioned Sylphon for rotating the hand member on the wrist member upon expansion of said last-mentioned Sylphon.

5. Structure as specified in claim 4, including means for locking the fingers and thumb in any position to which they are moved by the first pair of Sylphons, and means for locking the hand member in any of a plurality of positions of rotation relative to the wrist member to which said hand member is moved by the second pair of Sylphons.

6. In an artificial hand and wrist assembly, a wrist member; a hand member mounted on said wrist member for rotation about the longitudinal axis of the latter; a pair of Sylphons; an inexpandible conduit providing communication between the interiors of said Sylphons, whereby when said Sylphons and their communicating conduit are filled with liquid and one of the Sylphons is compressed, the other Sylphon will be expanded; means associated with one of said Sylphons for compressing the latter in response to muscular action by the user, the other of said Sylphons being secured to the wrist member; and means associated with the last-mentioned Sylphon for rotating the hand member relative to the wrist member upon expansion of said last-mentioned Sylphon.

7. Structure as specified in claim 6, including means for locking the hand member in any of a plurality of positions of rotation relative to the wrist member to which said hand member is moved by the Sylphons.

8. In an artificial hand, a casing, a pair of digits mounted on said casing for movement toward and away from each other, a crank pivotally mounted in said casing, means for moving said crank about its pivot, mechanism associated with said crank and said pair of digits for transmitting to said digits the motion imparted to said crank, a rod connected to said crank and adapted to be reciprocated upon pivoting of the crank, a tiltably-mounted locking member having an

opening therethrough in which said rod is adapted to reciprocate freely when said locking member is in a predetermined position and which grips and locks said rod against reciprocation when tilted from said predetermined position, and means for tilting said locking member when it is desired to lock the digits in any position to which they have been moved by said crank and its associated mechanism.

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