Nov. 11, 1958 D. B. BECKER 2,859,450

ARTIFICIAL FINGERS AND HAND MECHANISM

Filed Jan. 7, 1955 2 Sheets-Sheet 1

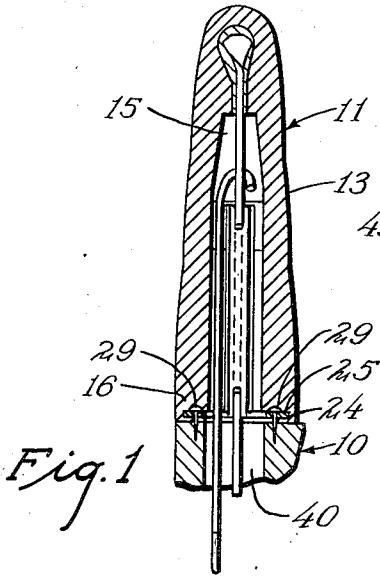


Fig. 1

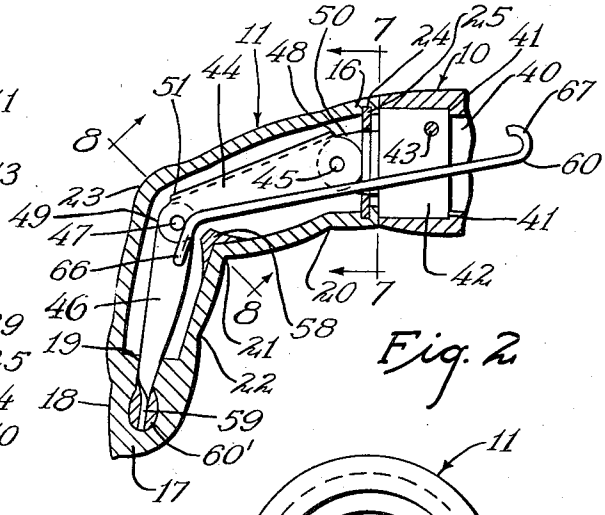


Fig. 2

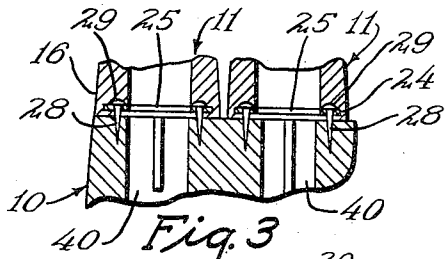


Fig. 3

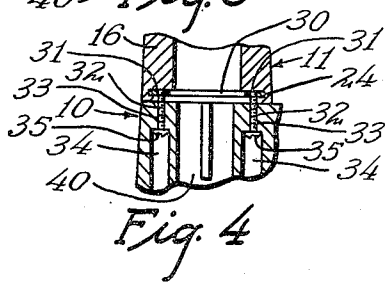


Fig. 4

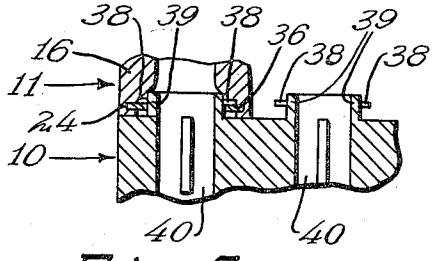


Fig. 5

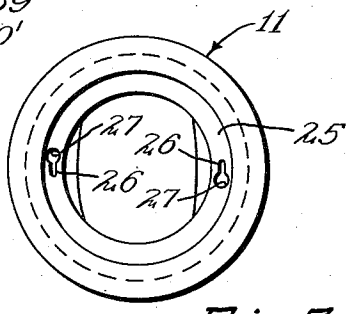


Fig. 7

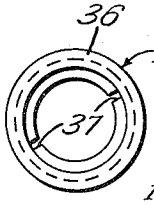


Fig. 6

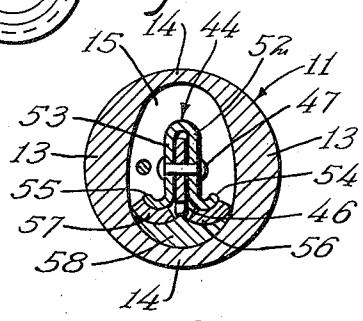


Fig. 8

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Nov. 11, 1958 D. B. BECKER 2,859,450

ARTIFICIAL FINGERS AND HAND MECHANISM

Filed Jan. 7, 1955 2 Sheets-Sheet 2

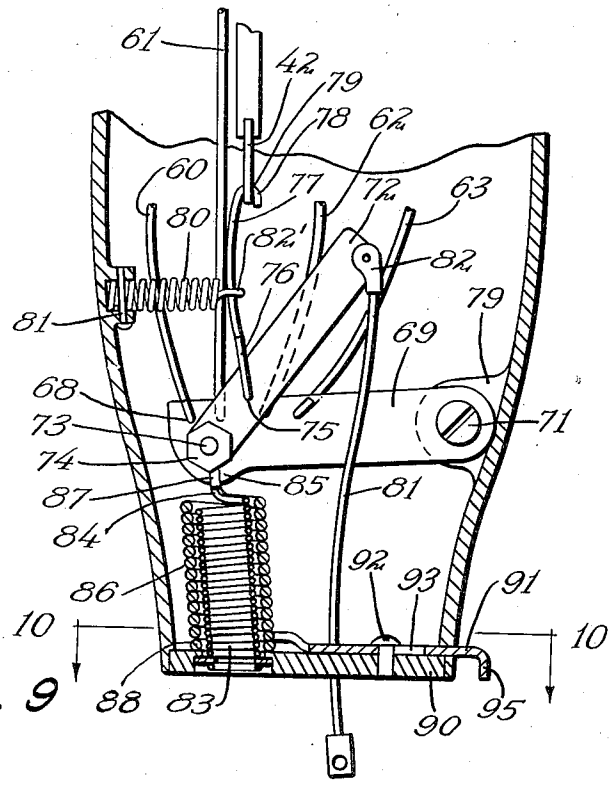


Fig. 9

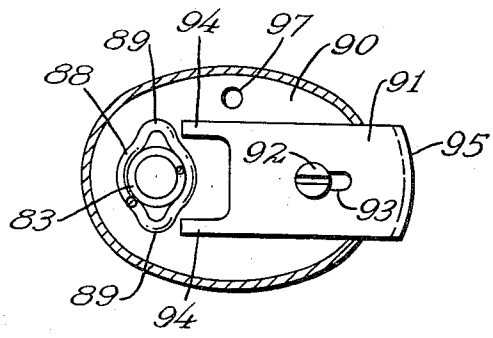


Fig. 10

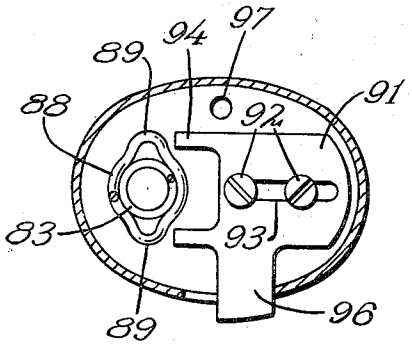


Fig. 11

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ARTIFICIAL FINGERS AND HAND MECHANISM

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13 Claims. (Cl. 3—12.7)

This invention relates to an improvement in artificial fingers and an improvement in finger operating mechanism. More particularly, this improvement in the art concerns plastic flexible fingers and their independent attachment and operation as bending fingers to artificial hands.

Flexible artificial fingers having the appearance and seeming action of normal or natural finger movement has long been the aim of the industry which makes artificial hands. While flexible skin appearing plastic coverings for the fingers and hands are known, the spiral spring finger has most nearly approached this objective. Otherwise artificial fingers are stiff jointed and bend from the one knuckle only depending upon a permanent curvature of the finger for any clasping or grasping action. In any event the only known successfully made and operating artificial fingers have not been of a relatively soft or resilient character resembling the natural flesh, bone, action and appearance of a normal finger. In addition it has heretofore not been possible to successfully control the finger operating pressure in combination with a flexible holding pressure of the finger structure.

Accordingly it is an object of this improvement in the art to provide a flexible artificial finger basically consisting of flesh colored resilient plastic which is independently attachable to an artificial hand for controlled independent and cooperative movement.

Another object of this improvement in the art is to provide plastic fingers which may be straightened out but are normally and naturally held in a natural relaxed hand appearing position and can be bent and flexed at the principal knuckle joints in a manner resembling the normal motion and action of the natural fingers.

Another object of this improvement in the art is to provide a flexible plastic artificial finger stock mounted upon an improved flexing reinforcing structure about which the plastic bends to give the artificial finger a more natural appearance and natural action with normal appearing flexibility at the points of greatest bend.

A further object of the improvement in the art is to provide a flexible plastic artificial finger in combination with a flexible reinforced bending knuckle and internal reinforcing flexing structure.

An additional object of this improvement in the art is to provide a flexible plastic finger stock detachably mounted on an artificial hand, the hand mechanism providing a control for varying the holding pressure of the finger or fingers.

Further objects and advantages will be apparent from the following description of the accompanying drawings, wherein:

Finger 1 is a cross sectional top view through the finger and a portion of the knuckle section of the hand to show its attachment thereto;

Figure 2 is a cross sectional side view of Figure 1 with the finger in a partially bent position;

Figure 3 is a partial cross sectional view showing an attachment of the fingers to the knuckle section of the hand;

Figure 4 is a modification of Figure 3;

Figure 5 is another modification of Figure 3;

Figure 6 a sectional view of a locking ring for attaching the finger structure to the partial knuckle section of the hand shown in Figure 5;

Figure 7 is a plan view of the finger locking ring taken on line 7—7 of Figure 2;

Figure 8 is a sectional view of the finger section on line 8—8 of Figure 2;

Figure 9 is a partial sectional view through the portion of the finger control and operating mechanism in the main body or knuckle section of the hand.

Figure 10 is a sectional view on line 10—10 of Figure 9, and

Figure 11 is a modification of the structure shown in Figure 10.

In the following description like parts will be similarly indicated. The partial knuckle section of the hand is indicated by the numeral **10**. The plastic finger **11** is, for example, a molded rubbery plastic produced in a mold impression of a normal life size finger. The molding stock while preferably latex, with or without pigmentation, may be either a resilient flexible synthetic rubbery material as vinyl, vinyl acetate copolymer, neoprene, isobutylene, isoprene, Buna N, Buna S, and many other synthetic rubbery materials, or natural vulcanized rubber, all of which have characteristics of plasticity and moldability with retention of resiliency and having a resistance to deterioration as required under conditions of use of an artificial hand.

As illustrated more clearly by Figures 1 and 2 taken in conjunction with Figure 8, the plastic molded finger is of a particular design having thickened side body portions **13** and thinner top and bottom portions **14** with a hollow substantially oval center aperture **15** open at the butt end **16** of the finger and closed at the fingernail end **17** with a normal natural appearing finger nail **18**. The solid end **17** is provided with a narrow slot or opening **19** for mounting therein a finger moving structure, as hereinafter described.

The outside surface of this plastic finger **11** is of a flesh colored cast and molded with the usual normal appearing creases or wrinkles and fold lines **20**, **21** and **22** of the hand. Also the principal finger joint contour **23** appears normal and is provided with natural surface wrinkles which give the effect of stretching when the finger is bent.

There is molded internally of the butt end **16** a circumferential groove **24** within which is mounted a holding ring **25**. This ring **25** may be inserted into the groove **24** after the finger **11** is molded or may otherwise be molded therein simultaneously with molding of the finger. The inner surface of ring **25** which extends from the edge of groove **24** is provided, for example, with a pair of diametrically opposed locking slots **26** having enlarged entry apertures **27**.

The finger **11** is mounted on the knuckle portion **10** of the hand by, for example, a pair of diametrically opposed pins, bolts or screws **28** having beads **29** spaced from the hand portion **10** an approximate distance equal to the thickness of ring **25**. The heads **29** fit through the apertures **27** and the finger is turned slightly to straighten onto the hand section **10** and turn the body of the pin **28** into slots **27**, thereby locking the ring **25** under the heads **29**.

Various modifications of this finger securing and locking arrangement may be provided. As illustrated in Figure 4, the ring **30** secured to finger **11** in the manner as indicated for ring **25**, is provided with threaded apertures **31** within which the screw bolts **32** are turned to draw

the fingers 11 tight against the body of the hand section 10. The hand section 10 is provided with apertures 33 which will fit the size of the body of screw bolts 32 and an enlarged aperture portion 34 for entry and turning of the heads 35.

The preferred manner of attaching the plastic finger is illustrated in Figure 5 wherein solid rings 38 are provided on lugs 39 and the plastic finger end providedwith internal groove 24, filled with a suitable plastic to metal cement, and into which the rings 38 are seated. This provides a dust tight seal to the finger mechanism, and also provides, in conjunction with the modifications, a means whereby worn or damaged fingers can be replaced, as needed, without other metal fastening devices.

Another modification may be provided by the structure illustrated in Figure 6 taken in conjunction with Figure 5 wherein the ring 36, secured to finger 11 in the manner as indicated for ring 25, is provided with slots 37 through which, by interpreting the projections on lug 39 as pins 38, the pins 38 are passed and the ring 36 turned to straighten the finger 11 onto the hand portion 10 and lock pins 38 behind the ring 36.

The knuckle section 10 of the hand, as heretofore indicated, is a body portion containing the mechanism, for example, as described in my co-pending application, Serial No. 460,738 for Artificial Hand, of which this application is a continuation-in-part. As more specifically shown therein, this hand body portion 10 contains a series of openings 40 provided with a pair of grooves or slots 41 designed to accommodate or mount finger anchoring plates 42 which form the base or support for pivoting each finger operating mechanism. As shown in Figure 2 the plates are mounted in the slots 41 and held in place by one or more pins 43, in each of the plates 42, extending transversely through the hand body to hold the plates 42 and the balance of the finger plates which are likewise mounted on the section 10 of the hand.

Each of the finger operating mechanisms are formed with an intermediate linkage 44 connected to the plate 42 by pivot pin or rivet 45, and end linkage 46 connected to the intermediate linkage 44 by pivot pin or rivet 47. The pivotal ends of plate 42, linkage 44 and linkage 46 are rounded interfitting hinges which are designed to fold under or inwardly of the palm portion of the hand and to straighten out in the normal fashion of natural fingers with raised edges 48 and 49 abutting against ends 50 and 51, respectively, to avoid any backward bend of linkages 44 and 46.

The intermediate linkage 44, as more clearly illustrated in Figure 8, is a U-bend piece having the ends of the opposite sides 52 and 53 turned out and upwardly in reverse U-bends 54 and 55 respectively. The under surfaces of the reverse U-bends 54 and 55 are provided with a felt or other paddings 56 and 57, respectively. These paddings 56 and 57 provide for a cushion effect against which the finger body 11 is compressed in a hand or finger grasping and holding movement. A further cushioning body 58 is cemented under the pivotal juncture of linkages 44 and 46 at the fold line 22 of finger body 11. This cushioning body 58 may be molded as an integral portion of finger body 11 but is preferably a relatively less resilient plastic or less flexible vulcanized rubber piece which will withstand and resist the brunt of finger lifting pressure at the fold line 22 of the artificial finger. This insert 58 can extend the full inner length of the finger, so that a cushioning effect against the length of the finger sections 44 and 46 is provided or otherwise this entire lower portion of the finger may be molded to a thickness extending under the sections 44 and 46 as appears from considering Figure 8 as an end view through the length of the finger. Therein cushion 58 forms an integral portion of the plastic finger and consequently the base of the finger is of substantially the thickness of, or thicker than, the finger sides. Otherwise the thickened under finger portion 58 and padding 57, as shown by considering Figure 8 as an end view, can be considered as one or more integral cushions cemented, by a plastic to metal bond to the finger linkage portions 44 and 46 partially or throughout the length thereof.

In order to more securely fasten the artificial flexible finger onto the finger operating mechanism the linkage 46 is provided with a flattened rounded end 59 which is held by a rubber or other cement 60' in the slot or socket 19 in the finger end 17.

The operating mechanism which controls finger movement is more fully described in my above mentioned application. However, as illustrated by Figure 1 taken in conjunction with Figure 9, the connecting rods 60 for the one finger and 61, 62 and 63 for the balance of the fingers are connected or hooked into the end linkages 44 in, for example, an aperture 66 and the opposite hook end 67 is secured in an aperture 68 in plate or lever 69. The additional finger operating rods 61, 62 and 63 are likewise secured in similar relationship between the other finger end linkages and the lever 69, as described in the above mentioned application. The thumb action and connecting linkage therefore is not described herein. The lever 69 is pivotally connected to a suitable boss 70 forming a portion of the hand section 10. A screw, pin or rivet 71 pivotally secures lever 69 to the boss 79. Pivotally connected to the opposite end of lever 69 is a pull lever 72. The lever 69 and lever 72 are pivotally mounted on a suitable rivet, pin or bolt 73. In this case the levers 69 and 72 are pivoted on a threaded bolt 73 provided with a locking nut 74. Intermediate the ends of lever 72 there is provided an aperture 75 through which a hooked end 76 of linkage 77 is fastened with the opposite hooked end 78 fastened through a suitable aperture in the end of the second finger fastening plate 42. A spring 80 extends between the side of the hand body 10 fastened thereto by pin 81 and to the link 77 by hook end 82' so as to hold the link 77 in position with fingers normally relaxed. The link end 75 serves as a pivot point so that lever 72 actuates the lever 69 to open the fingers when pull cord 81 is under tension. Pull cord 81 is of a conventional pivotally connected type attached to pull lever 72 by pivot pin or rivet connection 82.

In order to obtain an adjustable variation of holding pressure by the fingers there is provided a first spring 83 secured at one end to butt plate 90 of hand section 10 and at the opposite end by integral hook end 84 extending through a suitable aperture in the lug or ear 85 at the end of the lever 69 connected to the thumb control rod, for example 73, and finger rods 60, 61, 62 and 63. A second spring 86 overrides the spring 83 having its one integral hook end 87 secured in a suitable aperture in ear 85 and its opposite end 88 unfastened and ordinarily freely slidable over spring 83. The end 88 of spring 86, i. e. the end ring, is provided with a pair of ears or similar projections 89 at opposite diametrical sides. These ears 89 may be provided, for example, by bending or stretching the spring end 88 on diametrically opposite sides as at 89. On the butt plate 90 of the wrist section of the 91 fastened to plate 90 by screw 92 secured through the hand portion 10 there is provided a slidable locking key slot 93 of key 91. The inner end of key 91 is provided with the spaced ears or dogs 94 which slidably fit over spring 86 and engage or lock the ears 89 and the end 88 of spring 86 substantially to the plate 90. The plate 90, as illustrated in Figures 9 and 10, extends outwardly through a slot in the side of the wrist sectiond and is provided with a finger flange 95 by which the locking key 91 is moved to lock and free the end 88 of spring 86, as described.

As illustrated in Figure 11, the locking key 91 is fastened to plate 90 by a pair of screws 92 extending through slot 93 and the operating flange 96 extends through a suitable slot in the underside of the wrist portion of hand section 10. The locking key 91, in this instance, is thereby moved from underneath the wrist section rather than

from the side. A suitable aperture 97 is provided in the butt plate 90 for the pull cord 81. This aperture may be in alignment with the slot 93 if desired. Accordingly, the closing and holding forces of the fingers are dependent upon whether the tension of spring 86 is applied simultaneously with the tension of spring 83. As provided for by the resilience of the plastic fingers, when required or desirable, a very strong holding pressure may be used to grasp relatively fragile articles without breakage. In making up the artificial hand the thumb and one or more of the fingers may be of the flexible plastic character as herein disclosed and the balance either structures of the prior art or of the character of a spring structure provided with a partial plastic, e. g. vinyl, coating as shown in my above mentioned application. Further the plastic fingers may be constructed, as illustrated for example without pigmentation or flesh coloring, and then covered with the thin flexible material.

In accordance with the patent statutes, I have described the principles of construction and operation of my improvement in artificial fingers and hand mechanism, and while I have endeavored to set forth the best embodiment thereof, I desire to have it understood that obvious changes may be made within the scope of the following claims without departing from the spirit of my invention.

I claim:

1. A replaceable flexible plastic artificial finger capable of grasping fragile objects under different and variable pressures including in combination a hollow plastic body provided with flexible side wall sections and relatively flexible top and bottom wall sections, an open end section, a solid closed end section, and said open end section provided with locking ring and collar securing means for mounting said plastic finger in abutting relationship to the knuckle section of an artificial hand.

2. The structure of claim 1 wherein the separable plastic hollow body contains operating mechanism fastened to the said closed end section, and an operating lever extending from said open end section.

3. The structure of claim 2 wherein said operating lever is provided with control means for varying the moving force of said finger operating mechanism.

4. The structure of claim 3 wherein said control means comprises a variable spring force of adjustable resistance.

5. An artificial hand including in combination a plurality of separable resilient fingers anchored to the knuckle section of the hand and variable finger pressure operating mechanism, said resilient fingers comprising hollow rounded plastic bodies having relatively flexible side wall sections and flexible top and bottom sections, an open end secured in separable abutting relationship to said knuckle section and a relatively solid closed end section, pivotal finger operating linkages connected to said closed end section, lever means connected to said operating linkages, and adjustable spring means connected to said lever means for controlling the operating tension applied to said linkages, said adjustable spring means comprises one spring member permanently attached between said lever means and the knuckle section of said hand and a second adjustable tensioning means mounted on said knuckle section for varying the operating tension on said linkages.

6. The structure of claim 5 wherein the second adjustable tensioning means is a second spring adapted to be attached to and detached from the said knuckle section to increase the relative operating tension of said linkages and release the increase of relative operating tension respectively.

7. In combination in an artificial hand provided with a flexible finger section, a knuckle section and a wrist section operating mechanism for changing the relative operating tension of said flexible finger section comprising linkage means in said finger section, an operating lever connected to said linkage means, a pull lever connected to said operating lever, primary tensioning means connected between said operating lever and said knuckle section, and secondary tensioning means for increasing the relative operating tension of said flexible finger section.

8. In the structure of claim 7 a locking means for controlling said secondary tensioning means.

9. In the structure of claim 7 said primary tensioning means comprising a spring means permanently attached between said operating lever and said knuckle section and said secondary tension means comprising an auxiliary spring means having at least one end free of any attachment during the absence of any increase in operating tension and both ends secured when the operating tension is increased.

10. An artificial hand structure provided with flexible fingers including in combination operating mechanism for flexing said fingers, said operating mechanism comprising finger linkage means secured at one end in the finger structure and at the opposite end to finger flexing levers under spring tension, spring means for controlling the flexing tension of said finger operating mechanism, auxiliary spring means for increasing the operating tension of said finger linkage means, and locking means for detachably securing the auxiliary spring means during an increase of operating tension.

11. An independently replaceable finger structure for an artificial hand capable of grasping objects at different pressures in combination with a hand body comprising a flexible and resilient hollow body having flexible tubular walls and a solid closed end provided with a fingernail, and cooperable detachable connecting means on the other end of said hollow body and said hand including a ring and groove means.

12. An independently replaceable finger structure for an artificial hand in combination with a hand body comprising a flexible and resilient hollow body having flexible tubular walls and a solid closed end, cooperable detachable connecting means on the other end of said body and on said hand for detachably connecting the same, the closed end of said hollow body having an internal socket therein, finger actuating mechanism on said hand body extending into said hollow body, and means releasably anchoring the end of said finger actuating mechanism in said socket.

13. An independently replaceable finger structure for an artificial hand in combination with a hand body comprising a flexible and resilient hollow body having flexible tubular walls and a solid closed end, cooperable detachable connecting means on the other end of said body and on said hand for detachably connecting the same, finger actuating mechanism including an anchoring member secured to said hand body, link means pivotally connected to said anchoring member extending into said hollow body, and link actuating means connected to said link means, and means releasably connecting the end of said link means to said hollow body adjacent to the closed end thereof.

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