

March 15, 1949.

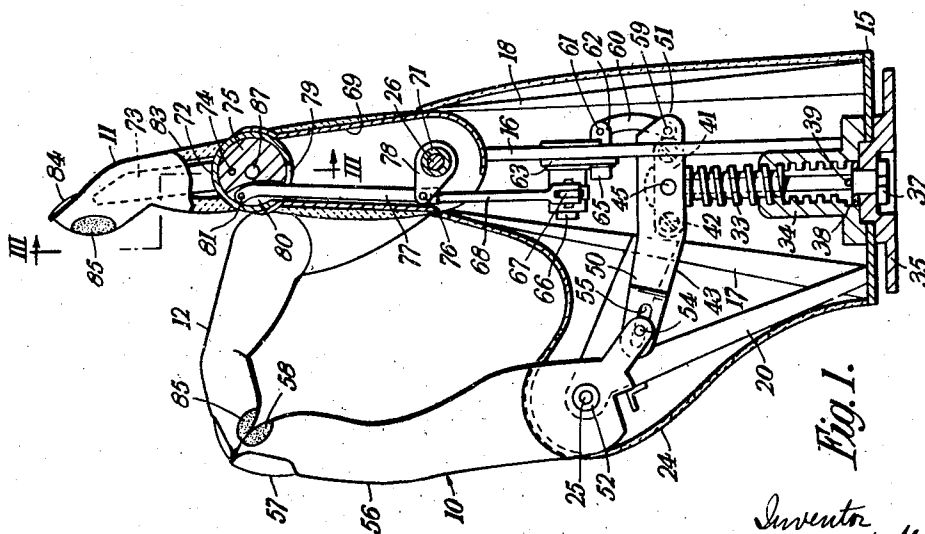
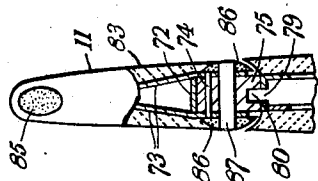
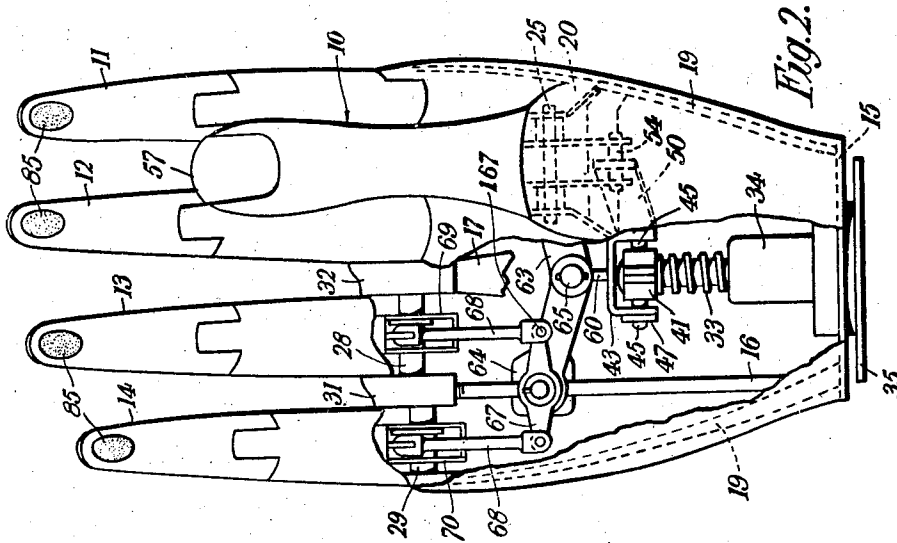
E. W. HOBBS

2,464,577

ACTUATING MECHANISM FOR ARTIFICIAL HANDS

Filed Jan. 31, 1946

4 Sheets-Sheet 1



Inventor
Edward Walter Hobbs
By Messrs. Mott, Burns & Berry
Attorneys

March 15, 1949.

E. W. HOBBS

2,464,577

ACTUATING MECHANISM FOR ARTIFICIAL HANDS

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4 Sheets-Sheet 2

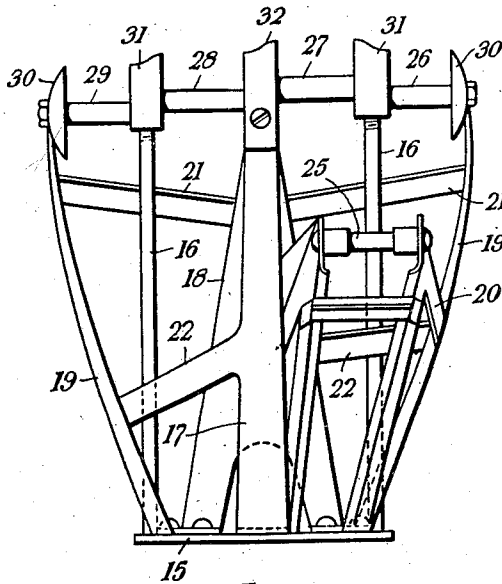


Fig. 4.

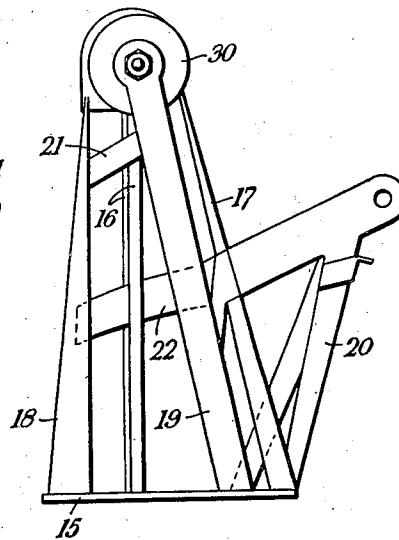


Fig. 5.

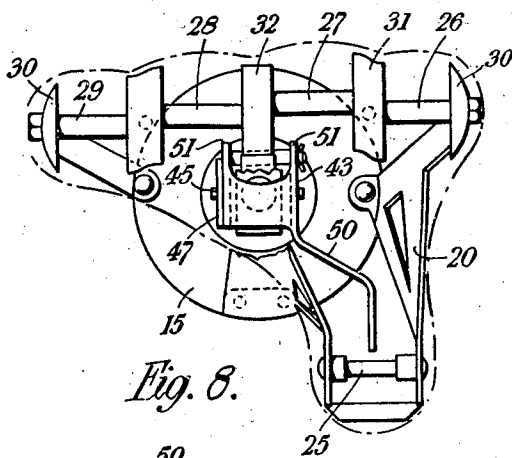


Fig. 6.

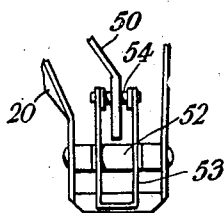


Fig. 7.

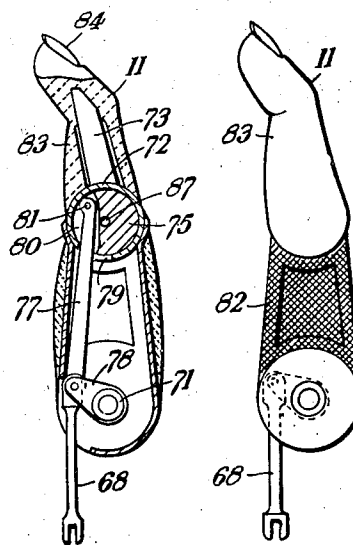


Fig. 8.

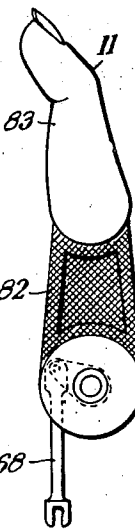


Fig. 9.

Inventor
Edward Walter Hobbs
By Messrs. North, Cross & Berry
Attorneys

March 15, 1949.

E. W. HOBBS

2,464,577

ACTUATING MECHANISM FOR ARTIFICIAL HANDS

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4 Sheets-Sheet 3

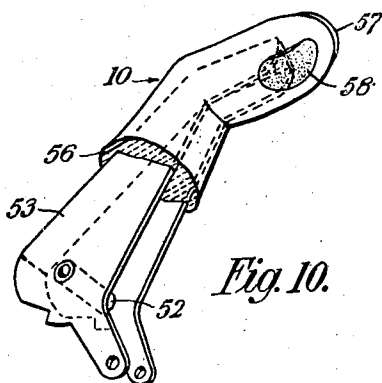


Fig. 10.

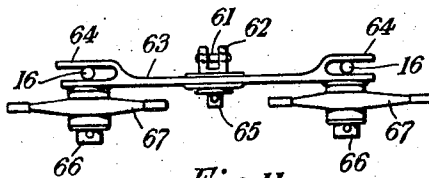


Fig. 11.

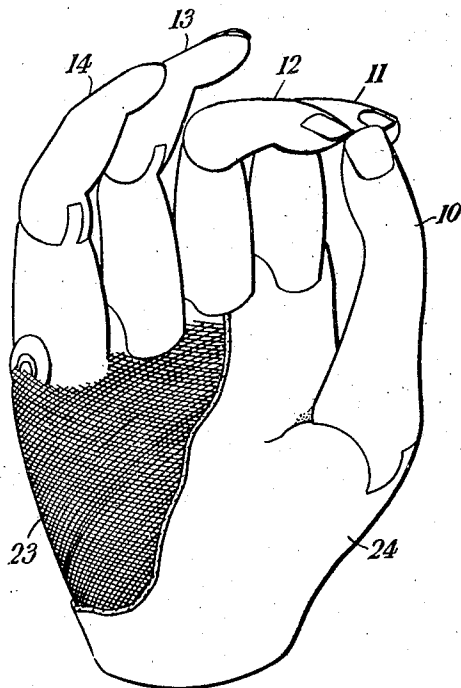


Fig. 12.

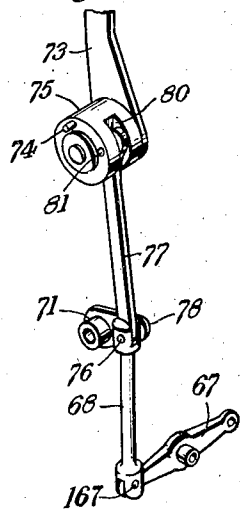


Fig. 13.

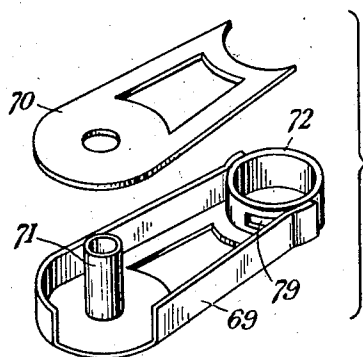


Fig. 14.

Inventor
Edward Walter Hobbs
By Max, Holt, Cress & Berry
Attys.

March 15, 1949.

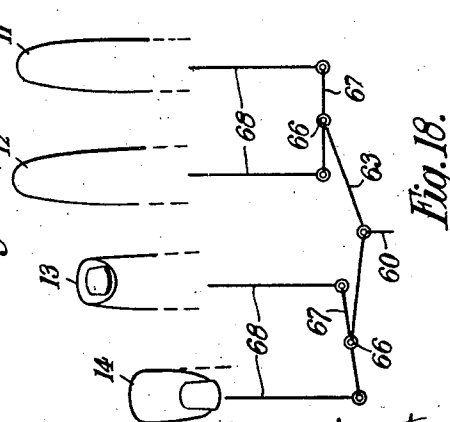
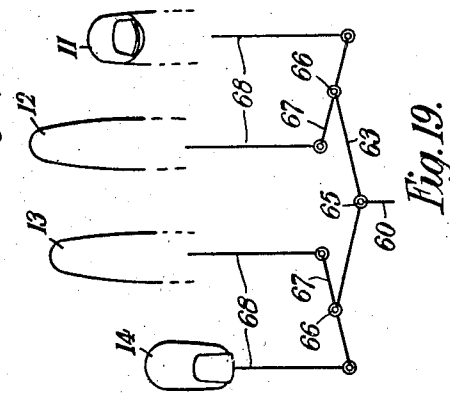
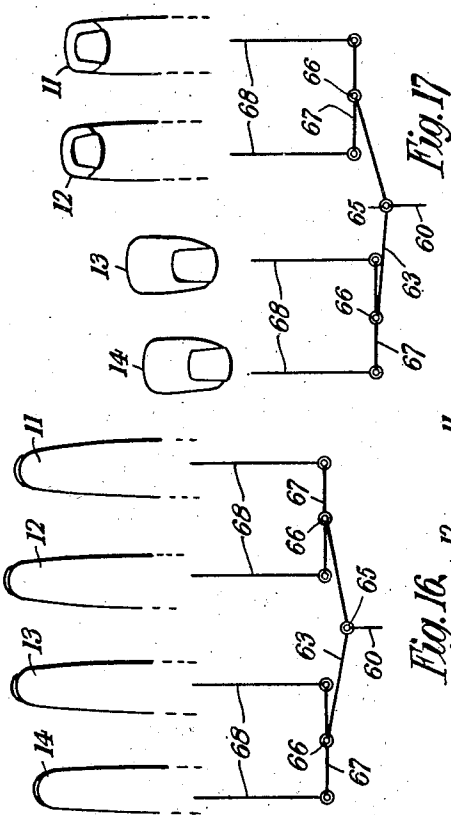
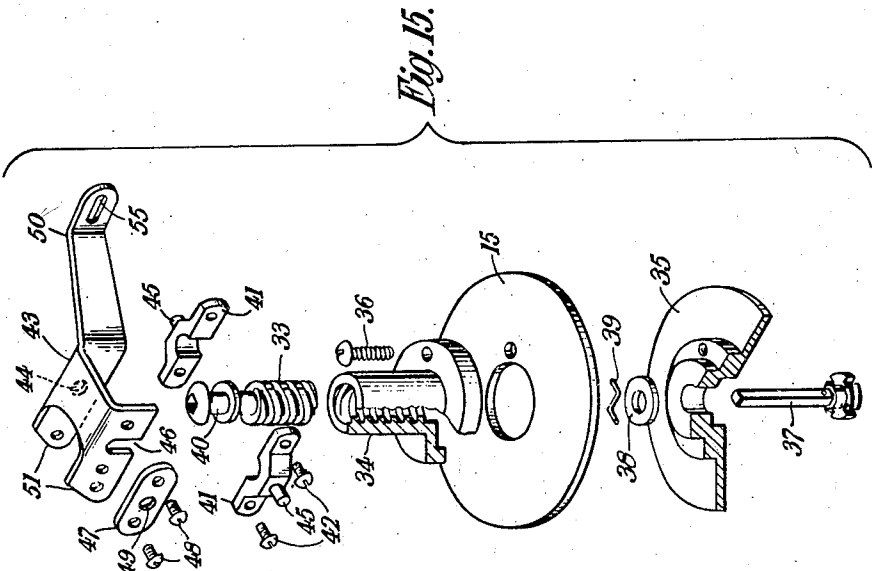
E. W. HOBBS

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ACTUATING MECHANISM FOR ARTIFICIAL HANDS

Filed Jan. 31, 1946

4 Sheets-Sheet 4



Inventor
Edward Walter Hobbs
By Moses, Holtz, Cress & Berry
attys.

UNITED STATES PATENT OFFICE

2,464,577

ACTUATING MECHANISM FOR ARTIFICIAL HANDS

Edward Walter Hobbs, Rickmansworth, England

Application January 31, 1946, Serial No. 644,498
In Great Britain October 19, 1945

10 Claims. (Cl. 3-12)

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This invention relates to mechanical artificial hands for use by persons who have suffered amputation. These, as are well known are operated to grasp or to release objects by a flexion cord, wire or the like actuated by shoulder movement, chest movement or pedal movement of the wearer.

The artificial hands at present available are primitive, enable a narrow range only of objects to be grasped and do not permit of the object being securely held. Thus one form embodies a pivoted and spring loaded thumb which co-operates with fixed fingers, being opened against the action of the spring by the pull of the flexion cord. In another form four fingers are pivoted to close as a unit against a fixed thumb under spring pressure. In yet another the four fingers again pivot as a unit to open and close against a fixed thumb, being operated from the flexion cord through a worm drive which acts to lock the fingers in the closed position.

In all these constructions the first and second fingers only co-operate with the thumb, the third and fourth fingers closing only to the same extent as the first and second fingers and contributing but little towards effective holding of the grasped article.

The invention provides an artificial hand comprising a base member, a plurality of digits pivotally mounted on the base member for opening and closing movement in relation thereto; a common operating member for the digits which operates positively on them to open and close them and is self-locking against reverse operation by the digits, and a compensating linkage connecting the operating member and the digits and serving to impart collective movement to the digits from the operating member, said linkage permitting, after any of the digits has been arrested, continued movement of the remaining digit or digits on continued movement of the operating member.

With this form of hand an object can be grasped much more effectively than with the artificial hands at present available, since any of the digits not arrested by an object to be grasped can continue to close until they either reach a limiting position or themselves make contact with the article.

An important advantage of the hand according to the invention is that it dispenses with the use of springs, the digits being moved positively both in the opening and closing directions by the operating member. It will be understood that only a limited amount of power can be developed by the use of the shoulder or chest muscles or by a

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pedal movement, for the purpose of operating the hand and when a spring is employed to move the digits of the hand in one direction a substantial proportion of this small available power is used up in overcoming the spring.

In the preferred form of hand according to the invention, four fingers and a thumb are arranged to share pivotal movement derived through the compensating linkage from the operating member. They thus all close together around an object and the hand can therefore pick up a wide range of objects, for example a pin, a cricket ball, an electric light bulb or a cigarette package.

I do not however exclude the possibility of employing a rigid thumb and compensated pivotal fingers operating in conjunction therewith. Again one or more of the fingers may be maintained rigid if desired. I may further provide for an additional manual adjustment of any of the digits in relation to the base member by the other hand. Thus, in the case of a rigid thumb this could be made settable into two or more positions by such manual adjustment. Such manual adjustment may also be provided, if desired, in the case of the compensated pivoted digits.

In the preferred form of hand according to the invention, each finger is pivoted to the base member at the base of the finger and consists of two parts pivoted together at a point corresponding to the middle knuckle joint, the compensating linkage being connected to the upper portion of each finger so as to cause pivotal movement thereof about both joints as the finger opens and closes, while the thumb is pivoted to the base member at its lower end and has no knuckle joint. I prefer moreover to offset the pivots at the lower ends of the finger to correspond with the anatomical arrangement of the lower knuckles of a normal hand. As hereinafter explained in more detail, this is achieved by placing the pivots of the first and third fingers in alignment and at the same level above the base member, the pivots for the second and fourth (or little) fingers being respectively above and below this level, and being respectively behind and in front of the line joining the pivots of the first and third fingers. In this way I simplify the construction of the hand since all the fingers, except the fourth (or little) finger, can be made of the same length. Also, by so making the fingers of the same length the compensating action is improved.

While I prefer to keep the pivotal axes of all the fingers parallel they may be set slightly askew,

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should it be desired that the finger tips should approach or splay apart as the fingers close.

The hand according to the invention is especially suitable for use in conjunction with the artificial arm described in U. S. application of Joyce Otterman Serial No. 646,133, filed February 7, 1946, which serves to convert the pull of the flexion cord into rotary movement.

The preferred form of operating member, in a hand according to the invention, is a screw and nut mechanism, one member of which (preferably the screw) is adapted to receive rotary driving movement and the other of which is fixed to the base member, the compensating linkage being operated by axial movement of the drive-receiving member.

The screw and nut mechanism is an efficient operating member, since the screw can be made of small diameter and will therefore turn at low peripheral speed, thus dissipating far less of the input energy in friction than in the case of a worm drive which necessarily turns at a much higher peripheral speed. The screw and nut mechanism is moreover self-locking against reverse operation by forces applied to the fingers, provided the tangent of the pitch angle of the thread does not exceed $1/6$. Furthermore it enables a light or firm contact pressure to be applied at will by the user, according to the degree of effort exerted, giving firm and positive locking both in the light pressure and in the firm pressure positions. Also, by further operation of the flexion cord, the user can, should he wish, increase or diminish the gripping pressure of the fingers after the object has been grasped.

One specific form of artificial hand according to the invention, will now be described in detail, by way of example with reference to the accompanying drawings in which:

Fig. 1 is a side elevation of the hand, partly in section, showing one of the fingers closed,

Fig. 2 is a corresponding part-sectional front view, showing all the fingers open,

Fig. 3 is a section on the line III—III in Fig. 1,

Fig. 4 is a front elevation of the skeleton structure constituting the base of the hand,

Fig. 5 is a left hand side view of the structure shown in Fig. 4,

Fig. 6 is a vertical section through one of the fingers and its associated operating link,

Fig. 7 is a corresponding side elevation,

Fig. 8 is a top plan view of the structure shown in Fig. 4, with the screw and nut mechanism fitted therein,

Fig. 9 is a detail view showing the connection between the thumb and the screw and nut mechanism,

Fig. 10 is a perspective view of the thumb, with its covering partly broken away,

Fig. 11 is a plan view of the main link of the compensating linkage,

Fig. 12 is a perspective view of the hand with the covering partly broken away and showing the hand in a partly closed position,

Fig. 13 is a detail view of one of the finger-operating links,

Fig. 14 is a perspective view of the two components of the inner structure of one of the fingers,

Fig. 15 is an exploded view showing the various components of the screw and nut mechanism and

Figs. 16-19 are diagrams showing the positions assumed by the compensating linkage under different operating conditions.

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Like reference characters designate like parts throughout the figures.

The hand comprises a base, constituted by the skeleton structure shown in Figs. 4 and 5, to which the thumb 10 and the fingers 11, 12, 13 and 14 are pivoted.

The skeleton structure is built up of an annular base, plate 15 a pair of upstanding tie rods 16, a front upright 17, a rear upright 18, side members 19, a thumb-supporting buttress 20, and bracing members 21, 22. All these parts are made of light metal alloy strip and they are welded or riveted together. This skeleton structure is, of itself, sufficiently strong to take all loads which are likely to be imposed on the hand, but it is reinforced to provide a factor of safety by wrapping it externally with metal gauze 23 (see Fig. 12). After assembly within the skeleton structure of the operating mechanism and the mounting thereon of the thumb and fingers, the skeleton structure is given an external coating 24 (Fig. 12) of plastic material and is afterwards pressed in a mould to shape the plastic material and to cause the same to penetrate into the interstices of the gauze.

A length of rod 25 (Figs. 4 and 8) carried by the buttress 20 serves as the pivot for the thumb 10, while lengths of rod 26-29 serve as the pivots for the lower ends of the fingers 11-14 respectively. These extend between metal blocks 30 fitted to the upper ends of the side members 19 of the skeleton, metal blocks 31 fitted to the upper ends of the tie rods 16, and a metal block 32 uniting the upper ends of the front and rear members 17, 18 of the skeleton.

As will be observed from Figs. 4 and 8 the pivots 26, 28 for the first and third fingers 11, 13 are coaxial, while the pivot 27 for the second finger 12 lies above and behind this common axis, while the pivot 29 for the fourth finger 14 lies below and in front of this common axis. The arrangement of the pivots which constitute the lower knuckle joints thus corresponds with the anatomical arrangement of the hand in nature, thus enabling the fingers 11, 12, 13 to be made of the same length, the fourth finger 14 being somewhat shorter.

The opening and closing movements are communicated to the fingers and thumb by a screw and nut mechanism shown in Figs. 1 and 2 and in detail in Fig. 15. The screw 33 turns in a nut 34 fixed to the base plate 15 and to an end ring 35 by a screw 36. The end ring 35 is arranged to fit on to the wrist plate of an artificial arm as described in U. S. application Serial No. 646,133 and rotary movement is communicated to the screw 33 by a driver 37 which receives a rotary movement from the flexion cord through the elbow mechanism of the arm likewise as described in U. S. application Serial No. 646,133. The driver 37 has a squared end fitting into a square hole in the screw 33, so that the screw 33 can move up and down relatively to the driver 37 as it turns in the nut 34. The driver 37 is prevented from falling out of the screw by a washer 38 and pin 39.

Rotatably mounted on a circular part 40 at the top of the screw 33 is a trunnion block 41. This, as shown in Fig. 15, is formed in two parts united together by screws 42. On top of the trunnion block 41 rests a saddle piece 43, having at one side a hole 44 to fit over one of the trunnions 45 and at the other a slot 46 to embrace the other trunnion 45. The saddle piece 43 is held in position on the trunnion block 41 by a plate 47 and

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screws 48, the plate 47 having a hole 49 fitting over the trunnion 45.

Integral with the saddle piece is a cranked arm 50 for communicating pivotal movement to the thumb and a forked extension 51 for communicating pivotal movement to the fingers.

As shown in Figs. 9 and 10, the thumb is constituted by a skeleton structure constituted by a light metal channel 53, the flanges of which are joined by a tube 52 mounted on and free to turn on the bearing rod 25. The flanges of the channel are also joined by a pin 54 engaging a slot 55 in the arm 50. As therefore the screw 33 moves up and down, the saddle piece 43 will rise and fall communicating pivotal movement to the thumb through the agency of the arm 50 and pin 54.

The thumb is enclosed by a preformed plastic structure 56, carrying a cellulose acetate nail 57 and rubber gripping pad 58, which is slipped over the metal skeleton and bonded thereto by adhesive or liquid plastic material. The forked rearward extension 51 of the saddle piece 43 is pivoted by a pin 59 to the lower end of a lever 60 (Fig. 1), the upper end of which is pivoted by a pin 61 to a fork 62 (Fig. 11) pivoted centrally by a pin 63 to a V-shaped lever 63 (see also Fig. 2). This lever 63 has at its ends forked portions 64 which embrace the tie rods 16 and so confine the movements of the lever 63 to an up and down movement or a rocking movement about the pivot pin 65. At each end the lever 63 is provided with a forwardly extending pin 66 on which is centrally pivoted a lever 67. To the opposite ends of the levers 67 are pivoted links 68 for imparting pivotal movement to the fingers, each link 68 being forked at its lower end, see Figs. 6 and 13, to embrace the associated end of lever 67 to which it is attached by a pin 167.

As shown in Figs. 6, 7, 13 and 14 the lower part of each finger comprises a light metal box formed of two members 69, 70 which are suitably united together and support between them a tube 71 mounted to turn on the associated bearing rod, i. e. 26 in the case of the first finger 11, and a tubular bearing 72 for permitting the upper part of the finger to turn relatively to the lower part. The upper part of each finger comprises a pair of metal strips 73 united by a pin 74 to a barrel 75 mounted to turn in the bearing 72 (see also Fig. 3). The upper end of each link 68 is pivoted by a pin 76 to the lower end of a link 77 and also to a steadying link 78 rotatably mounted on the tube 71. The upper end of the link 77 passes through a slot 79 in the bearing 72 and into a slot 80 in the barrel 75, being secured to the barrel by a pin 81.

As the link 68 moves up and down therefore the finger is caused to open and close, pivoting both about the axis of barrel 75—which corresponds to the middle knuckle joint—and about the bottom pivot which corresponds to the lower knuckle joint.

The lower part of each finger is encased in metal gauze 82 (Fig. 7) and subsequently covered with plastic material, as in the case of the base. The upper part of each finger is encased by a preformed plastic sheath 83, carrying a nail 84 and rubber pad 85, which corresponds exactly to that employed for the thumb and is secured to the metal structure in similar fashion. The lower end of each plastic upper sheath rests against buttons 86 of plastic material attached to the outer ends of the barrel 75 by a pin 87 (Fig. 3).

The saddle piece 43 and levers 63, 67 constitute

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a compensating linkage by which collective opening and closing movement is communicated to the fingers and thumb from the screw 33, but which permits of continued movement after any one or more digits have been arrested of any digits which have not been arrested. The action of the linkage insofar as differential movement of the fingers is concerned, will be clear from Figs. 16—19.

In Fig. 16 the parts are shown in the position they occupy with the fingers fully open. In Fig. 17, the first two fingers have been arrested in a partly closed position, and the third and fourth have moved on, the lever 63 having turned about its central pivot 65. In Fig. 18 the first two fingers have been arrested in the fully open position, and there has been differential movement as between the third and fourth fingers, the left hand lever 67 having rocked about its central pivot to permit this. In Fig. 19, both levers 67 have rocked about their central pivots.

Differential movement as between the fingers and thumb is permitted by virtue of pivotal movement of the saddle piece 43 on the trunnions 45. Thus, if the fingers are arrested, the saddle piece can turn about the rear pin 59, as the trunnion block moves up and down, to effect pivotal movement of the thumb. Similarly, if the thumb is arrested, the saddle piece can turn about the forward pin 54 to move the fingers.

It will be understood that the screw 33 need not derive rotary movement from the elbow mechanism described in U. S. application Serial No. 646,133. This could, if desired, be provided by attachment of a disc to the outer end of the screw which could be turned by the wearer by moving it against the surface of a table or other convenient object, or rotated by the other hand. What I claim as my invention and desire to secure by Letters Patent is:

1. An artificial hand, comprising a base member, a plurality of digits, consisting of four fingers and a thumb, all pivotally mounted on the base member for opening and closing movement in relation thereto, a screw and nut mechanism, one member of which is fixed to the base member and the other of which is adapted to receive rotary driving movement, a trunnion block rotatably mounted on said other member, and a compensating linkage connecting said other member and the digits, and serving to impart collective pivotal movement to said digits on axial movement of said other member, said compensating linkage comprising a saddle piece pivotally mounted on the trunnion block and having a forward extension pivoted to the thumb, a main lever pivoted intermediately to a rearward extension of the saddle piece, an end lever pivoted intermediately to each end of said main lever and finger-operating links pivoted at their opposite ends to the fingers and to the ends of said end levers.

2. An artificial hand, comprising a base member including a skeleton metal structure and a stiffening wrapping of wire gauze surrounding said metal structure, a plurality of digits pivotally mounted on the base member for opening and closing movement in relation thereto, a common operating member for the digits which operates positively on them to open and close them and is self-locking against reverse operation by the digits and a compensating linkage connecting the operating member and the digits and serving to impart collective movement to the digits from the operating member, said linkage permitting, after any of the digits has been arrested, continued movement of any other of the digits

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on continued movement of the operating member.

3. An artificial hand, comprising a base member including a skeleton metal structure, a stiffening wrapping of wire gauze surrounding said metal structure and an outer layer of plastic material applied to said wire gauze, a plurality of digits pivotally mounted on the base member for opening and closing movement in relation thereto, a common operating member for the digits which operates positively on them to open and close them and is self-locking against reverse operation by the digits and a compensating linkage connecting the operating member and the digits and serving to impart collective movement to the digits from the operating member, said linkage permitting, after any of the digits has been arrested, continued movement of any other of the digits on continued movement of the operating member.

4. An artificial hand, comprising a base member, a plurality of digits pivotally mounted on the base member for opening and closing movement in relation thereto, each digit comprising a hollow lower section pivoted at its lower end to the base member and constituted by a metal frame, a layer of wire gauze surrounding said frame, and an outer layer of plastic material applied to said wire gauze, and a hollow upper section pivoted to said lower section and comprising a metal frame and a preformed plastic sheath encasing said frame, a common operating member for the digits which operates positively on them to open and close them and is self-locking against reverse operation by the digits and a compensating linkage connecting the operating member and the digits and serving to impart collective movement to the digits from the operating member, said linkage permitting, after any of the digits has been arrested, continued movement of any other of the digits on continued movement of the operating member.

5. An artificial hand, comprising a base member, four fingers pivotally mounted on the base member for opening and closing movement in relation thereto, and an axially movable operating member for the fingers which operates positively on them to open and close them and is self-locking against reverse operation by the digits, and a compensating linkage connecting said operating member and said fingers, said compensating linkage comprising a main lever mounted centrally for pivotal movement in relation to the operating member, said main lever having forked ends which engage and are slidable in relation to fixed parts of the base member, an end lever pivoted intermediately to each end of said main lever and finger-operating links pivoted at their opposite ends to the fingers and to the ends of said end levers.

6. An artificial hand comprising a base member, a plurality of digits consisting of four fingers and a thumb all pivotally mounted on said base member for opening and closing movement in relation thereto, a screw and nut mechanism on said base member, means operable by the wearer of the hand for causing relative rotation between the members of said screw and nut mechanism and thereby for causing one of the same to reciprocate relative to the other, a lever extending across said reciprocating member and pivotally mounted intermediate its ends thereon to be rockable about an axis transverse to the axis of said reciprocating member, means pivotally connected to one end of said lever for rocking said

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thumb digit to open and close the same as said reciprocating member reciprocates, and means connecting the opposite end of said lever with said four finger digits for imparting opening and closing movement thereto as said reciprocating member reciprocates.

7. An artificial hand comprising a base member, a plurality of digits consisting of four fingers and a thumb all pivotally mounted on said base member for opening and closing movement in relation thereto, an operating member mounted on said base member for reciprocation relative thereto, means operable by the wearer of the hand for reciprocating said operating member positively forward and back, a lever extending across said operating member and pivotally mounted intermediate its ends thereon to be rockable about an axis transverse to the axis of said member, means providing a pivotal connection between one end of said lever and said thumb digit for rocking said digit to open and close the same as said operating member reciprocates, and lever and linkage connection means between the opposite end of said lever and said four finger digits for opening and closing said finger digits upon reciprocating movement of said operating member and for continuing the closing movement of those finger digits which are free from closing obstructions, upon continued movement of said operating member in digit closing direction, while permitting the other finger digits to be arrested against further closing movement when reaching an obstruction.

8. An artificial hand comprising a base member, a plurality of digits consisting of four fingers and a thumb all pivotally mounted on said base member for opening and closing movement in relation thereto, an operating member mounted on said base member for reciprocation relative thereto, means operable by the wearer of the hand for reciprocating said operating member positively forward and back, a lever extending across said operating member and pivotally mounted intermediate its ends thereon to be rockable about an axis transverse to the axis of the said member, means for rocking said thumb digit to open and close the same as said operating member reciprocates including a pivotal connection between one end of said lever and said thumb digit about which said lever will rock whenever closing movement of said digit is arrested by said digit striking an obstruction, and connections between the opposite end of said lever and said four finger digits for imparting opening and closing movement to the latter as said operating member reciprocates, said connections including a link, a pivotal connection between said link and the opposite end of said lever about which said lever will rock whenever closing movement of any of said finger digits is arrested by said digit striking an obstruction, a second lever, connections between said link and said second lever for imparting movements of translation to said second lever as said link reciprocates with said operating member, said connections including a pivot intermediate said second lever about which the same can oscillate, and connections from opposite ends of said second lever and said finger digits including levers and links arranged to cause continued closing movement of all unobstructed ones of said finger digits upon continued movement of said operating member, after any of said digits has been arrested by striking an obstruction.

9. An artificial hand, comprising a base member, a plurality of digits consisting of four fingers

and a thumb all pivotally mounted on said base member for opening and closing movement in relation thereto, an operating member mounted on said base member for reciprocation relative thereto, means operable by the wearer of the hand for reciprocating said operating member positively forward and back and for self-locking said operating member in operated position, a main lever extending across said operating member and pivotally mounted intermediate its ends for rockable movement about an axis transverse to the direction of reciprocation of said operating member, means connecting the pivot mounting of said main lever to said operating member for reciprocating movement with said operating member; lever and linkage connection means between said main lever and all of said finger digits for opening and closing said digits upon reciprocating movement of said operating member and for continuing the closing movement of those finger digits which are free from closing obstructions, upon continued movement of said operating member in digit closing direction, while permitting the other finger digits to be arrested against further closing movement when reaching an obstruction, and a linkage between said operating member and said thumb digit separate from said main lever, for positively opening and closing said thumb digit upon reciprocating movement of said operating member, said linkage comprising a lost motion connection permitting the continued closing movement of the unobstructed finger digits, upon obstruction of said thumb digit against further closing movement.

10. An artificial hand comprising a frame structure including a pair of substantially parallel tie rods extending lengthwise of the hand, a plurality of digits mounted on said structure for opening and closing movement in relation thereto, an operating member mounted on said structure for bodily rectilinear movement lengthwise of said hand, means for bodily moving said oper-

ating member under control of the wearer, a main lever pivotally mounted on said operating member intermediate its ends for bodily moving said main lever with said operating member along said hand and for pivotally moving said main lever with respect to said operating member about the pivotal axis, said axis being transverse to the length of said lever, said main lever having means guiding its ends along said tie rods during movements thereof, end levers each pivoted intermediate of its ends respectively to an end of said main lever, and a digit operating linkage mechanism between each end of each of said end levers and a corresponding digit for imparting opening and closing movement to said digits as said operating member moves and for causing continued closing movement of all unobstructed digits upon continued closing movement of said operating member in digit closing direction, after any of said digits has been arrested by striking an obstruction.

EDWARD WALTER HOBBS.

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