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ARTIFICIAL ARM

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Fig. 1.

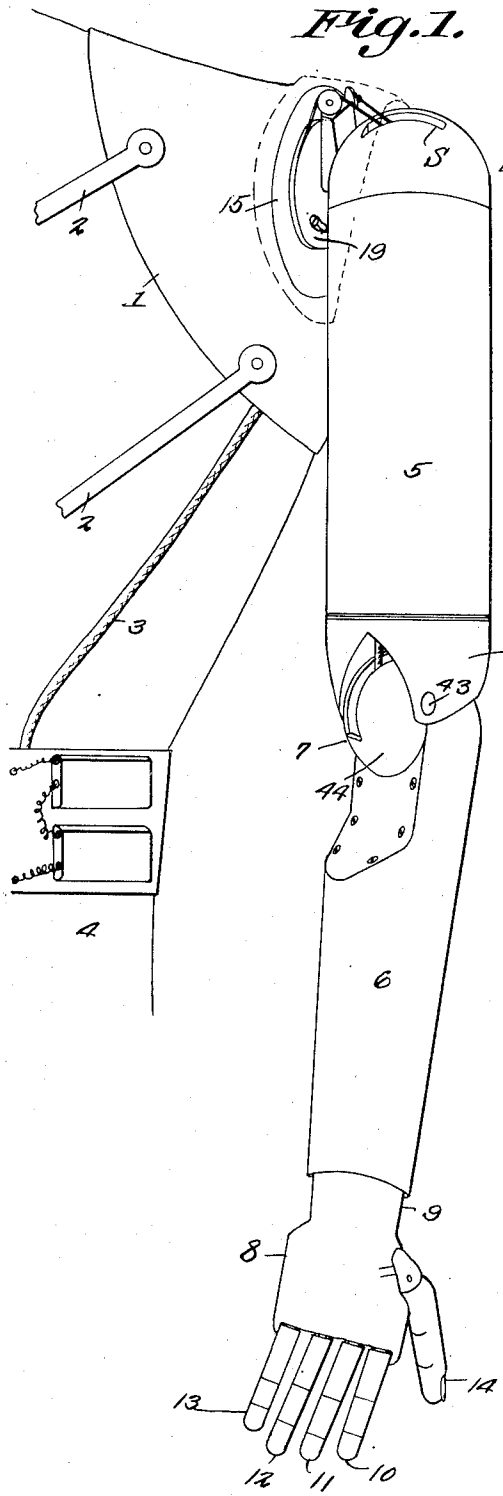

Fig. 2.

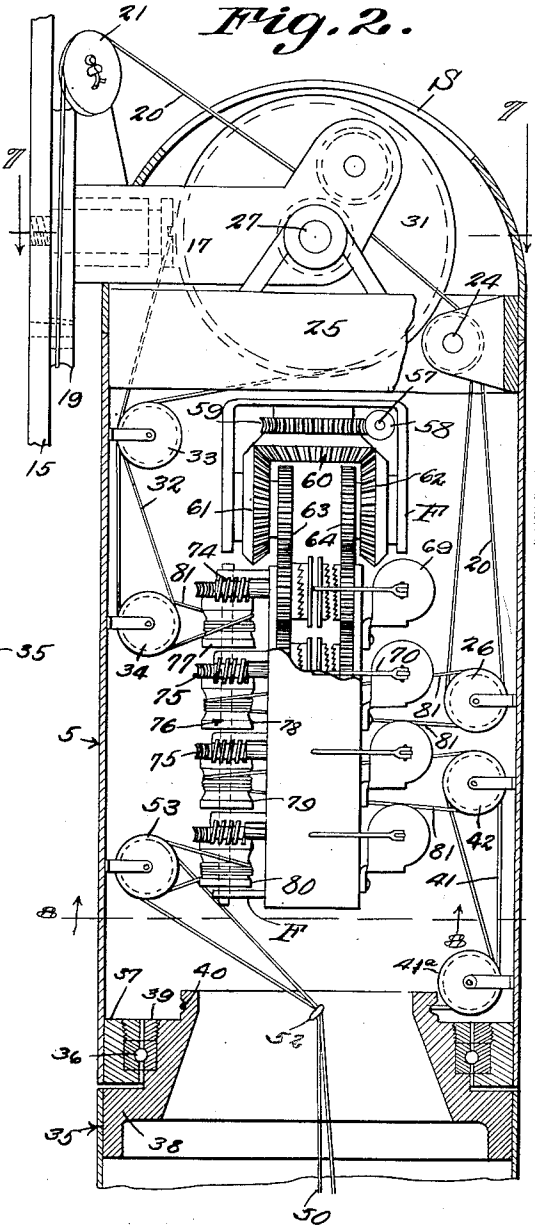

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Fig. 3.

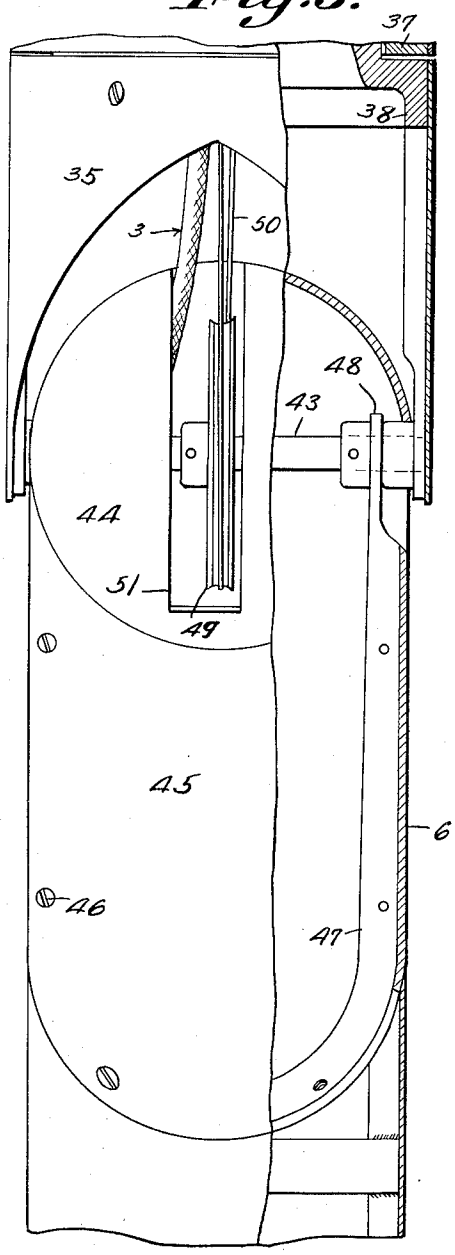

Fig. 4.

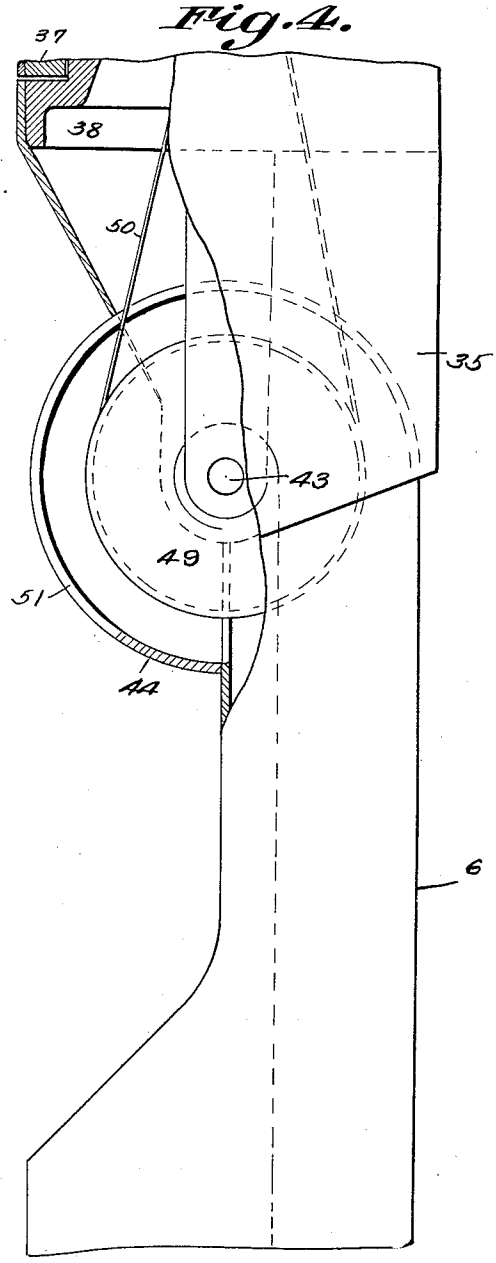

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Fig. 5.

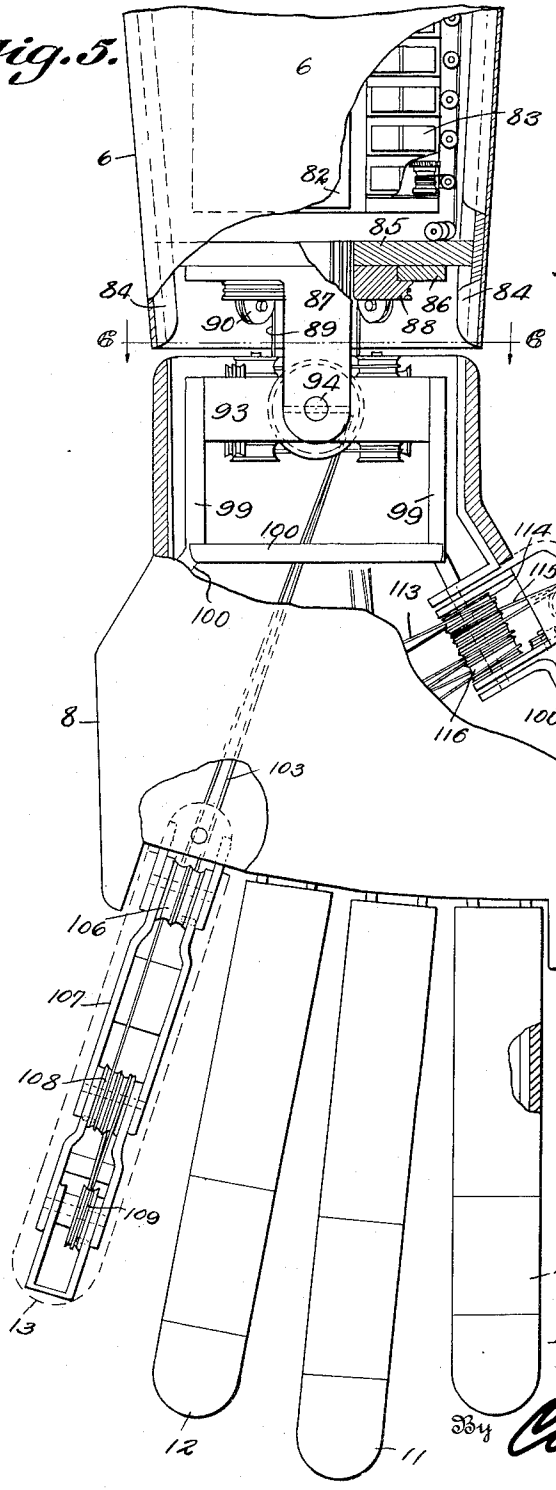
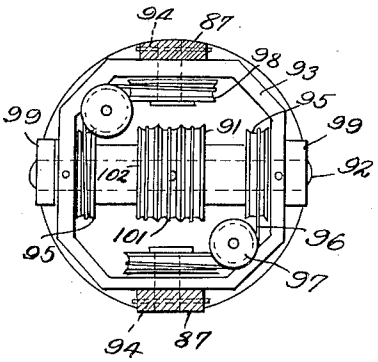


Fig. 6



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ARTIFICIAL ARM

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Fig. 7.

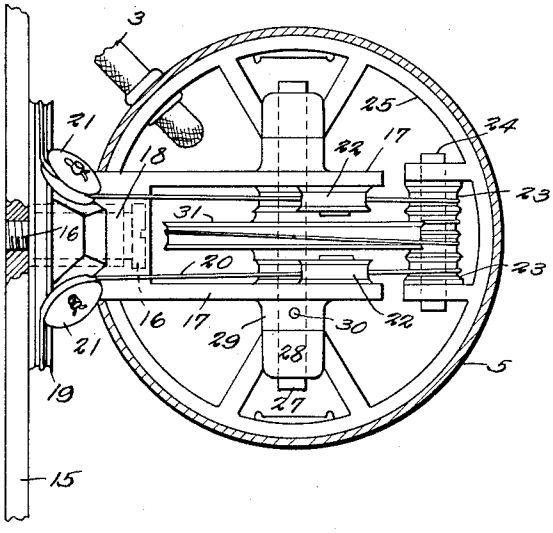
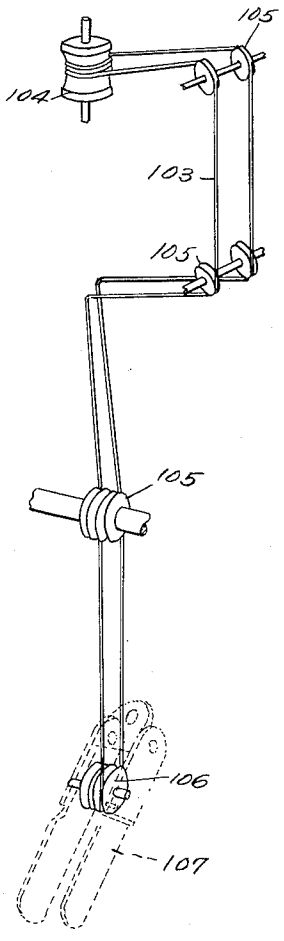


Fig. 9.



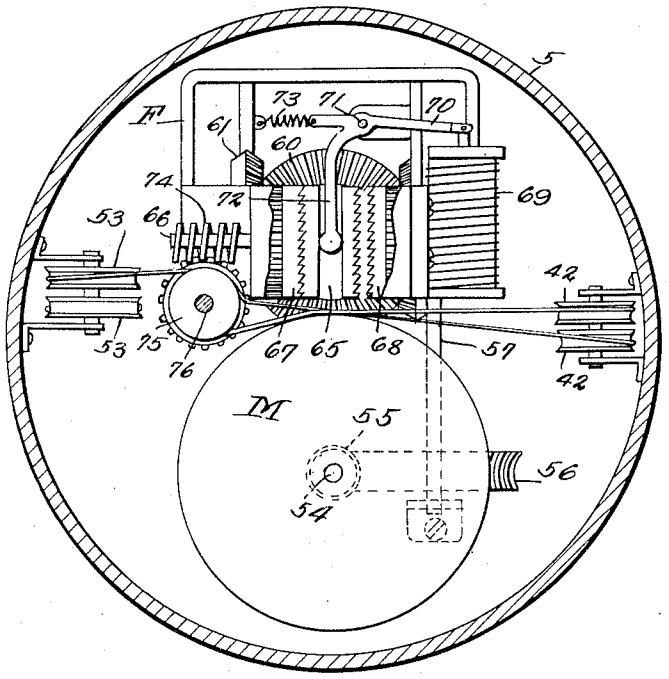


Fig. 8.

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UNITED STATES PATENT OFFICE

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ARTIFICIAL ARM

Harold T. Edwards, Los Angeles, Calif.

Application March 5, 1947, Serial No. 732,509

3 Claims. (Cl. 3—12)

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The present invention relates generally to the class of artificial body members, and more specifically to an improved artificial arm structure that includes a shoulder joint, the wrist joint, and the hand, together with the fingers and thumb of the hand.

The primary object of the invention is the provision of a comparatively light-weight arm structure that may be manipulated with facility, and which is composed of jointed and articulated parts forming either an artificial right arm, or a left arm as herein described and illustrated; and in which the parts are flexibly connected in order to simulate the movements of natural members. The minimum number of parts employed in the structure may with facility be manufactured at comparatively low cost of production, and assembled with convenience to house or contain compactly arranged electro-mechanical power-operated mechanisms for selectively and reversibly transmitting power and motion to the desired parts of the arm.

The arm structure as a whole is constructed of sections or units having suitable and separate electrical control devices for use by the wearer of the arm, and while I have disclosed a complete and unitary arm structure, it will be understood that separated sections of the whole structure are available for separate use.

The invention consists in certain novel features of construction and combinations and arrangements of parts including endless cables and accessories together with self-contained operating means as will hereinafter be described in detail, and more specifically pointed out in the appended claims.

In the accompanying drawings I have illustrated a complete example of a physical embodiment of my invention in which the parts are combined and arranged in accord with one mode I have devised for the practical application of the principles of my invention. It will, however, be understood that various changes and alterations are contemplated and may be made in these exemplifying drawings and mechanical structures, within the scope of my claims without departing from the principles of the invention.

Figure 1 is a front view of an artificial left arm shown as mounted upon a natural shoulder, and in which my invention is physically embodied, and indicating also the electrical control devices carried at the waistline of the wearer.

Figure 2 is an enlarged vertical sectional view of the upper arm structure, showing the shoulder joint together with the self-contained electro-mechanical mechanism for activating various parts of the arm.

Figure 3 is an enlarged front view partly in section of the casings for the upper arm and the fore arm, at the elbow joint; and Figure 4 is a side view partly in section of the same structure.

Figure 5 is an enlarged front view partly in section showing the hand with fingers and thumb, together with the wrist joint, and also

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showing part of the self-contained electro-mechanical mechanism in the wrist end of the fore arm.

Figure 6 is a transverse detail sectional view at line 6—6 of Fig. 5.

Figure 7 is a transverse detail sectional view at line 7—7 of Fig. 2, showing part of the shoulder joint.

Figure 8 is a cross sectional view at line 8—8 of Fig. 2 looking up into the upper arm.

Figure 9 is a diagrammatic view of one of the cable mechanisms for the fingers.

In the general assembly view Fig. 1 where the left arm structure is suspended from a shoulder plate 1, this concavo-convex or truncated cone-shaped plate of light-weight metal, is fashioned to fit neatly over the shoulder with braces or straps 2, 2 connected to other supports carried on the body of the wearer of the artificial arm.

An electric cable 3 composed of various electric wires or circuits extends from a battery 4, or other source of energy, which may be supported upon a waistline belt, passes upwardly and then under the shoulder plate, and the various circuit wires are distributed to the different electrical appliances enclosed in the casings of the members of the arm.

The upper arm structure includes a tubular casing 5 of metal or other light and strong material suitable for the purpose; the parts of the forearm are enclosed within a tubular casing 6 having an elbow joint at 7, and the palm 8 of the hand includes a hollow structure flexibly connected by the wrist joint 9 to the lower end of the forearm. The hand is equipped with four tubular fingers 10, 11, 12, and 13, and the thumb 14, and these tubular or hollow casings enclose the supporting frames upon which the activating and operating devices are mounted.

For suspending the arm structure on the truncated shoulder plate 1 a vertically disposed circular base plate 15 is utilized and the arm structure is swiveled in a horizontal axis to swing forward and backward simulating the swing of a natural arm. For this purpose a horizontally disposed swivel bolt 16 is threaded in the base plate of the shoulder plate or shoulder cap, and a two-arm yoke 17 having a hub 18 is journaled to swivel on the bolt. The hub of the yoke is fashioned with a vertically disposed swivel pulley 19 that oscillates with the swinging movement of the arm structure, and a taut endless cable 20 is looped under the pulley with its two flights passing upwardly and over a pair of spaced guide pulleys 21, 21 journaled in bearings rigid with the yoke, and from these direction-changing pulleys the cable passes through an arcuate slot S in the rounded upper end of the upper arm casing. Within the upper end of the upper arm the cable 20 is guided by pulleys 22, 22 mounted in bearings on the yoke arms to a pair of direction changing pulleys 23, 23 on shaft 24 mounted in bearings within the upper arm casing 5. The shaft 24 is mounted in a horizontally

disposed frame-ring 25 fixed within the tubular casing 5 of the upper arm, and from pulleys 23, 23 the swivel cable 20 extends to a pair of power pulleys 26, 26, journaled in bearings within the casing and actuated as will be described.

The arm structure is also capable of swinging in a vertical plane laterally toward and from the body of the wearer, and to accomplish this movement a spindle 27 is journaled in bearings 28 of the frame 25, and the spindle passes through bosses 29 of the yoke arms and is pinned at 30 so that the arm may swing on its bearings 28 of the spindle.

The spindle is equipped with a large operating pulley 31 mounted between the arms of the yoke 17, and an operating cable 32 extends around the pulley 31 with both flights guided by a pair of direction-changing pulleys 33, 33, journaled in bearings fixed within the casing 5, and thence to a pair of power pulleys 34, 34 within the casing.

At the lower end of the tubular casing 5, and just above the elbow joint 7, the forearm, together with the elbow joint 35 is suspended and swiveled on a vertical axis that includes an annular ball bearing 36 which is mounted between a bearing ring 37 fixed within the lower end of the upper arm casing 5, and a stepped open-center bushing 38 fixed in the upper end of the elbow joint 35, screw rings 39 being provided to retain the bearing members in place. The upper end of this truncated or stepped bushing 38 is fashioned with an exterior annular grooved flange 40 which forms an operating pulley for an operating cable 41 that passes around a direction changing pulley 41*a*, and from there the cable is wound upon a pair of power pulleys 42, 42 journaled in bearings fixed within the casing 5.

The articulated elbow joint 35, below the swivel joint is hinged or pivotally connected by a cross pin 43 with a rounded head 44 integral with an attaching plate 45 that is fastened by screws 46 to a U-shaped frame 47 that closes an opening in the front wall of the forearm casing 6, and the pin 43 passes through bearings in the upper end 48 of the U-shaped frame for suspending the forearm.

For lifting and lowering the forearm on its pivot pin 43, an operating pulley 49 is rigidly mounted on the pin and a cable 50 passing through an arcuate slot 51 in the head 44 is guided through eye-bolt 52 to a pair of power pulleys 53, 53 journaled in bearings within the casing 5.

The four mechanical structures with pulleys and cables above noted and employed in flexing or manipulating the shoulder joint, the upper arm, the elbow joint, and the forearm, are activated by force or power from an electrical motor M (Fig. 8) to which the electric cable 3 is connected.

The motor is mounted within the casing 5 of the forearm on a suitable box frame F adjacent the four power pulleys 26, 34, 42, and 53, and separate cable drives to these power pulleys operate them, under electrical control, to transmit motion and power to the operating pulleys of the articulated parts of the arm.

Speed reduction in the transmission of power is attained from the motor shaft 54 through worm 55 (dotted lines Fig. 8), a worm gear 56, through a second worm 58 and worm gear 59 that revolves with the bevel gear 60. From gear 60 power is transmitted in opposite directions through bevel gear couples 61 and 62 to the two opposed trains of gears 63 and 64.

Between these laterally spaced oppositely rotating trains of gears are arranged four clutch units for shifting power from one train to the other train, and each clutch unit includes a central shiftable clutch member 65 mounted upon a clutch shaft 66 for alternate co-action with the spaced driven members 67 and 68 of the clutch.

Each clutch is electro-magnetically controlled and operated by means of a solenoid 69 with its core of armature pivotally connected with a clutch lever 70 pivoted at 71 on the frame F, and the fork 72 of the lever straddles the shiftable clutch member 65, to move the latter against tension of spring 73.

Each clutch shaft 66 is provided with a worm 74 that meshes with a worm gear 75 mounted on a drum shaft 76 journaled in the frame F, and four drive drums 77, 78, 79 and 80 are each provided with a drive cable 81. One of these cables 81 revolves the pair of reversible power pulleys 26, 26; another drives the power pulleys 34; a third cable operates the power pulleys 42, 42; and the fourth cable 81 drives the power pulleys 53; for operating the four described articulated parts of the arm. Suitable electrical control devices and circuits are provided for operating the motor and for operating the several electro-magnetically operating parts including the clutch units, for the transmission of power and motion to the respective driving drums, power pulleys, and operating pulleys.

At the wrist joint 9 the hand 8 is firmly secured to the forearm by means of a universal joint mechanism which permits a swiveling twist of the wrist, lateral flexing of the hand, and an up and down flexion of the hand with relation to the forearm.

The mechanism for operating the wrist joint, and for flexing the articulated knuckle joints of the fingers and thumb, includes another electrical motor and electrical controls, therefor, together with power and motion transmission mechanism including clutches drums and cables and pairs of power pulleys as above described; and this operating mechanism is mounted within the forearm casing 6.

In Fig. 5 an electric motor is indicated at 82, with some of the electrical controls and power transmission shown at 83 as mounted upon a frame 84 rigidly secured in the tubular casing of the forearm 6. For the swivel twisting movement of the wrist joint on a vertical axis a transversely arranged open-center suspending plate 85 forms part of the supporting frame 84 for a swivel ring 86 that is provided with yoke arms 87 and journaled between the suspending plate 85 and a complementary fixed supporting plate 88. An operating cable 89 passes around a pair of guide pulleys 90, and thence around a central drum 91 mounted upon a horizontal spindle 92 that is journaled in an octagonal swivel ring 93 of the hand 8.

For lateral movements of the hand, the yoke arms 87 of the swivel ring 86 are pivotally mounted in the octagonal swivel ring by means of radially alined trunnions 94, 94 and pulleys 95, 95, cables 96 and guide pulleys 97 with operating pulleys 98, are turned by the motor operated cables for accomplishing these lateral movements.

For up and down movements of the hand of the octagonal swivel ring 93 is pivoted by the

spindle 92 in a pair of bearings 99, 99 which form part of the hand frame 100 which is rigidly mounted within the casing 8 of the hand.

The pulley mounts and cable arrangements for moving the joints of the articulated fingers provides for transmission of power and motion, simultaneously, to each joint of the fingers, and the method of pivoting the fingers on frames within the finger casings permits the knuckle joints to spread in a natural manner when the hand is closed.

In Fig. 6 operating cables passing around the three center pulleys 91, 101 and 102 extend to rotary drive drums in the hand operating mechanism, one of which mechanisms includes the cable 103 that transmits power and motion to the little finger. In the diagram Fig. 9 the fingers are each separately controlled from an individually operated motor driven drum as 104 mounted in the forearm, and the operating cable passes around pairs of guide pulleys 105 to the operating pulleys 106 that are journaled in the flexible finger frame 107, and thence around the joint pulleys 108 and 109 within the finger casing 13. A separate and individual pulley, cable and finger frame series identical to that shown in Fig. 9, for each of the four fingers 10, 11, 12 and 13 is provided.

In Fig. 5 the construction and operation of the flexibly jointed thumb is indicated by the use of a frame 110 having two joint pulleys 111 and 112. The operating cable 113 for the thumb is driven from the motor operated drum, and from thence passes around guide pulleys 114 to impart a limited lateral movement to the thumb structure. The cable is looped for operating the joints of the thumb in manner similar to the operating cables of the fingers, the outer joint of the thumb being moved more rapidly than the inner knuckle joints, as at a ratio of one to two, and cable 116 operates the thumb on a hinge 117 relatively to the palm of the hand 8. The differential ratio of operation of the outer joint or tip section of the thumb relative to the intermediate joints is achieved by making the pulley 112 of a different size than the pulley 111, so that said pulley 112 will rotate twice to each rotation of the pulley 111. This ratio can of course be varied as desired.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In an artificial limb a shoulder support; a first pulley mounted on said support for rotation in a vertical plane; a yoke extended laterally from and rigid with said first pulley; a second pulley rotatably mounted on the yoke in a plane perpendicular to that of the first pulley; an upper arm casing pinned to the second pulley to swing laterally towards and away from said shoulder support on rotation of the second pulley, said casing being supported upon and engaged by the yoke to swing in a plane perpendicular to said plane of lateral swinging movement on oscillation of the yoke responsive to rotation of the first pulley; a drive motor in said upper arm casing; and independent clutch controlled driving connections extending separately from said motor to the first and second pulleys respectively.

2. In an artificial limb a shoulder support; a first pulley mounted on said support for rotation in a vertical plane; a yoke rigid with said first pulley for oscillation on a horizontal axis responsive to rotation of said first pulley; a second pulley mounted on said yoke for rotation in a plane intersecting the plane of rotation of the first pulley at right angles; an upper arm casing pinned to the second pulley so as to be swung laterally towards and away from said shoulder support responsive to rotation of the second pulley, said casing being supported upon and engaged by the yoke to swing forwardly and backwardly relative to said shoulder support responsive to oscillation of the yoke; a forearm casing connected to said upper arm casing for swivelling on a vertical axis; a forearm hinged to said forearm casing; third and fourth pulleys respectively rigid with the forearm casing and forearm respectively; a motor mounted in the upper arm casing; a pair of oppositely rotating gear trains mounted in said upper arm casing and driven by the motor; and a plurality of driving connections extended from said gear train to said first, second, third and fourth pulley respectively, said driving connections being independently clutch controlled for independent shifting of said driving connections to either gear train.

3. In an artificial limb a shoulder support; a first pulley mounted for rotation upon said shoulder support; a hinge yoke rigid with said first pulley; a second pulley mounted for rotation upon said hinge yoke; an upper arm casing pinned to the second pulley for swinging in one direction responsive to rotation of the second pulley, said upper arm casing being engaged by the yoke for swinging in another direction responsive to yoke oscillation on rotation of the first pulley; a forearm casing swivelly connected to the upper arm casing; a third pulley rigid with said forearm casing; a forearm hinged to the forearm casing; a fourth pulley pinned to the forearm and rotatably mounted in the forearm casing; a driving motor mounted in the upper arm casing; a pair of oppositely rotating trains of gears mounted in said upper arm casing; a driving connection between said motor and said trains of gears for continuously rotating the gears of the train, said gear trains including a plurality of opposed pairs of oppositely rotating gears; a driving connection extending from each of said pairs to a different one of said first, second, third and fourth pulleys, said driving connections being independent of each other; and a separate double clutch mounted between the gears of each pair of gears and shiftable to either gear of a pair for engaging the driving connection extending to each pulley with a selected gear.

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