A compact and relatively simple artificial hand, which includes hooks pivotally mounted on a first frame to move together and apart, the first frame being rotatably mounted on a second frame to enable "turning at the wrist" movement without limitation, and the second frame being pivotally mounted on a third frame to permit "flexing at the wrist" movement. A hook-driving motor is fixed to the second frame but has a shaft that drives a speed reducer on the first frame which, in turn, drives the hooks. A second motor mounted on the second frame, turns a gear on the first frame to rotate the first frame and the hooks thereon. A third motor mounted on the third frame, turns a gear on a second frame to pivot it.

2 Claims, 6 Drawing Figures
COMPACT ARTIFICIAL HAND

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

BACKGROUND OF THE INVENTION

This invention relates to artificial hand mechanisms. Artificial hands can be utilized not only as prosthetic devices but also to enable unmanned manipulation as on unmanned space vehicles or in radioactive areas. Where such hands are to have a plurality of degrees of freedom of movement, such as turning without restriction at the "wrist" and flexing at the wrist, the prior art mechanisms show only complex and large drive devices. For example, U.S. Pat. No. 2,640,994 shows an artificial hand which can turn at the wrist as well as pivot, but which utilizes a complex and bulky gear train for coupling a motor located far above the wrist to drives that move the fingers, flex the hand at the wrist, and turn the hand at the wrist.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, an artificial hand is provided which is compact and of relatively simple construction, and yet which has large versatility. The hand includes a first frame which pivotally supports a pair of object-engaging members that pivot together and apart, a second frame which rotatably supports the first one in "pivoting at the wrist" movement, and a third frame which pivotally supports the first one in "flexing at the wrist" movement. A first motor for driving the object-engaging members together and apart, is fixed to the second frame and has a shaft extending along the axis of rotation of the first frame on the second, to drive a gear train on the first frame which moves the members. A second motor fixed to the second frame, drives a worm gear on the first frame that is coaxial with the first motor shaft, to rotate the first frame in "turning at the wrist" movement. A third motor fixed to the third frame, drives a worm wheel which is fixed to the second frame and has an axis of rotation coaxial with the longitudinal axis of the motor shaft. The gear segments are portions of worm gears, and are engaged with a worm. The worm is driven by a reversible motor which is mounted on the second frame so that the motor does not rotate about the axis when the first frame is rotated, and this retarding torque could cause rotation of the worm which could cause the hook members to move apart or together. Of course, the fact that the first motor is not mounted on the first frame means that simple wires can be connected to it, even though the first frame is rotated about the axis, only a very small retarding torque is applied by the de-energized first motor. If the speed reducer were mounted on the second frame, then it would apply considerable retarding torque to the worm when the worm and first frame rotated, and this retarding torque could cause rotation of the worm which could cause the hook members to move apart or together. Of course, the fact that the first motor is not mounted on the first frame means that simple wires can be connected to it, even though the first frame is rotated about the axis.

The mechanism for turning the first frame with respect to the second frame includes a second motor which is fixed to the second frame. As shown in FIG. 5, the second motor drives a worm which drives a worm wheel. The worm wheel turns a shaft to which another worm is fixed. The worm drives a worm wheel that is fixed to the first frame, as shown in FIG. 5. The worm wheel is mounted on the first frame, and is coaxial with the first motor shaft and the output shaft of speed reducer. When the motor is energized, it turns the worm wheel to slowly rotate

FIG. 1 illustrates an artificial hand which includes a pair of object-engaging members, or hook members which can move apart (up to 70° apart) and together to grasp objects, the hook members being pivotally mounted on a first frame. The first frame is rotatably mounted about a longitudinal axis and is second frame, to permit movement simulating pivotting of a hand about the wrist, but with the first frame being rotatable by an unlimited number of turns. The second frame is, in turn, pivotable about a lateral axis with respect to a third frame to permit a motion simulating flexing, or up and down movement, of a hand with respect to the forearm. The third frame can be fixed to a support, that may be a controllable rod when the artificial hand is utilized where a man cannot be present, or that may be a forearm where the artificial hand is utilized as a prosthetic device.

As shown in FIG. 5, the first frame is rotatably supported by a bearing and a Teflon bushing on the second frame. The two hook members are pivotally mounted about axes and are fixed to gear segments. The gear segments are portions of worm gears, and are engaged with a worm. The worm is driven by a reversible motor which is mounted on the second frame, so that the motor does not rotate about the axis when the first frame is rotated, and this retarding torque could cause rotation of the worm which could cause the hook members to move apart or together. Of course, the fact that the first motor is not mounted on the first frame means that simple wires can be connected to it, even though the first frame is rotated about the axis.
the first frame 16, the direction of motor energization determining the direction of first frame rotation.

As mentioned above, the second frame 20 can pivot about the lateral axis 22 to simulate flexing of a hand with respect to the forearm up to 90° to either side. As shown in FIGS. 3 and 4, pivoting about the axis 22 is accomplished by the third motor 70 which is fixed to the third frame 24, and which drives a worm 72. The worm 72 is engaged with a worm wheel 74 that is fixed to a shaft 76 that is, in turn, fixed to the second frame 20. Thus, when the motor 70 with a gear box portion 78 is energized, it turns the second frame 20 about the axis 22 to cause the second frame to pivot in a motion simulating flexing of a hand with respect to the forearm. Of course, during such pivoting about the axis 22, the hook members 12, 14 may be turned to any direction with respect to the axis 22.

The three motors 42, 50 and 70 are high efficiency miniature types which are typically elongated along the axis of rotation of the motor shaft. All three of the motors are oriented with their axes parallel to axis 18 about which the first frame rotates on the second one, to limit the width of the artificial hand. As shown in FIG. 2, the first motor 42 is located between the arms 80, 82 of a yoke of the third frame 24. The second frame 20 has a pair of arms 84, 86 that lie outside the yoke arms 80, 82 to leave space for the motor 42.

Thus, the invention provides an artificial hand which is compact and of relatively simple construction. This is accomplished by utilizing three frames, the first frame pivotally supporting a pair of hook members and being rotatable without limit on the second frame, the second frame supporting a first motor that pivots the hook members and a second motor that rotates the first frame on the second, and with the second frame being pivotable on the third frame. The mounting of the hook-pivoting motor on the second frame with its shaft coaxial with the axis of rotation of the first frame on the second, and with the speed reducer which is driven by the first motor mounted on the first frame, results in free rotation of the first frame on the second without significant drag from the first motor. In addition, the first motor does not have to rotate without limit and therefore flexible wires can be utilized to supply current thereto. By mounting the motors close to the elements they drive, complex gearing arrangements are avoided, and yet close control of movements of the arm are effected.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art, and consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. An artificial hand device comprising:
   a first frame;
   a second frame rotatably supporting said first frame for rotation about a predetermined axis;
   means for rotating said first frame about said axis;
   a pair of object-engaging members having inner ends pivotally mounted on said first frame;
   a motor mounted on said second frame, said motor having a motor shaft extending along said axis; and
   a speed reducer gear train connected to said motor shaft, said gear train connected to said object-engaging members to pivot them;
   said gear train mounted on said first frame, whereby the motor applies minimum torque tending to retard rotation of the first frame.

2. The device described in claim 1 including:
   a third frame pivotally supporting said second frame for pivoting about a second axis extending substantially perpendicular to said first axis, said third frame comprising a yoke having a pair of arms and said second frame having a pair of arms lying on opposite sides of said yoke arms and pivotally connected thereto, and said first motor lying between said arms of said yoke.

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