"HELPING HAND"

A HYDRAULICALLY OPERATED MECHANICAL HAND*

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Rehabilitation of the quadriplegic patient is difficult and often discouraging to both patient and physician. Paralysis of the hands resulting from injuries to the spinal cord at the cervical level results in complete helplessness. Many frustrating attempts to design an apparatus to regain functional use of the hands preceded the development of the present hydraulically operated mechanical hand.

First, an attempt was made to determine the number of patients in need of a mechanical device to provide hand function. No such data could be found. We then estimated the total quadriplegic population of the country, based on statistics obtained from local hospitals.

Seven quadriplegic patients are treated yearly in the four general hospitals in Wilmington, Delaware, which serve an area of approximately 400,000 population. Thus, traumatic quadriplegia occurs locally at a rate of 1 in 57,000 population. Assuming this to be average for the entire country, approximately 3,000 persons become quadriplegic yearly. Due to modern methods of treatment, most of them survive for a number of years. This results in an increasing number of such patients. It is then probably safe to assume that several thousand persons could be benefitted by the use of a mechanical hand. The figures quoted above do not include quadriplegia resulting from cervical cord tumors, poliomyelitis, and other diseases.

Having demonstrated the need for a device to regain partial use of paralyzed hands, the idea was presented to the management and engineering staff of All American Engineering Company, Wilmington, Delaware. Project "Helping Hand" was then instituted, and preliminary investigation begun. It was decided that a properly functioning mechanical hand should meet the following specifications:

1. The weight of the complete unit must be kept at a minimum due to weakness and paralysis of the hand and the arm. Total weight should not exceed eight ounces.
2. A three-jaw chuck type grasp was to be provided the patient when the hand was in use. The wrist was to be held in the cock-up or functional position. Figure 1A and B show the hand closed and opened. Figure 1C illustrates the activating mechanism.
3. Operation of the hand should be mechanically simple and require little muscle force by the patient. The activating mechanism was so constructed that it could be placed in various locations depending upon the remaining functional muscle groups, *i.e.*, shoulder adductors or cervical muscles. Figure 2A and B is a palmar view of the closed and opened hand.

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4. The cost of the hand was to be kept as low as possible, using commercially available components that could easily be replaced if worn or broken.
5. The hand must be comfortable and cosmetically acceptable to the patient.

After weeks of study and consultations with plastics experts, metallurgists, and latex engineers, a prototype was constructed, and preliminary testing done. Numerous areas for improvement were found in the first model. These were incorporated into the final hand which we believe will more than meet the specifications mentioned above.

A hydraulic system was found to be most efficient. The use of tap water as the hydraulic fluid lowered the cost and eliminated the hazard of fire inherent in nearly all other hydraulic fluids.

The use of a plastic splint, nylon activating cylinders, and nylon tubing reduced weight and provided long component life. The complete hand, ready for use, weighs six ounces. The portion of this unit attached to the patient weighs only four and one-half ounces: thus, the earlier weight specification was reduced by nearly one-half.

The hand, voluntary opening in type, is held closed by a beryllium alloy C-spring which is chromium plated. The spring after heat treatment will not change shape or lose its holding force and will last a lifetime unless crushed by the application of great force.

The finger grips are made of 0.021-inch thick latex. They are permanently attached to the finger wires with a special cement.

The durability of the hydraulic system was tested in a cycling machine for a period equivalent to 26 years of patient-use. At the end of this test there was no fluid loss, and the cylinder operation was improved in smoothness.

Cosmetically the hand is acceptable to the patient. When used for such activities as writing or working at a desk, only the latex finger grips are exposed. The splint lies on the volar aspect of the forearm and is held in place by contouring its upper end to fit the arm and attaching the lower end at the wrist with a wrist watch strap so arranged that the watch can be worn on the anchoring strap.

A measuring splint (Fig. 3) also was designed for use by the orthotist. The measurements of the patient's hand and arm taken from this splint make possible the rapid fabrication of a well-fitting hand without repeated adjustments. This technique reduces the cost by decreasing the fitting time. Figure 4 illustrates the complete fitting kit with detailed fitting instructions.

Specifications of the Hand Components

1. Weight of complete hand (hydraulic system filled with water)—6 ounces
2. Weight of the unit lifted by patient—4½ ounces
3. Hydraulic cylinders made of nylon
   - Cylinder capacity—5 milliliters
   - Cylinder bore—½ inch
   - Cylinder stroke—1 inch maximum
   - Cylinder leakage prevented by rubber "O" rings
4. Hydraulic fluid—tap water
   - Total volume of water in system—25 milliliters
   - Volume of water moved in maximum operation—5 milliliters
5. C-spring made of special beryllium alloy extruded bar stock
   - Spring specially wound, heat treated, and chromium plated
   - Ball sockets on spring to receive and retain cylinder-end ball joints

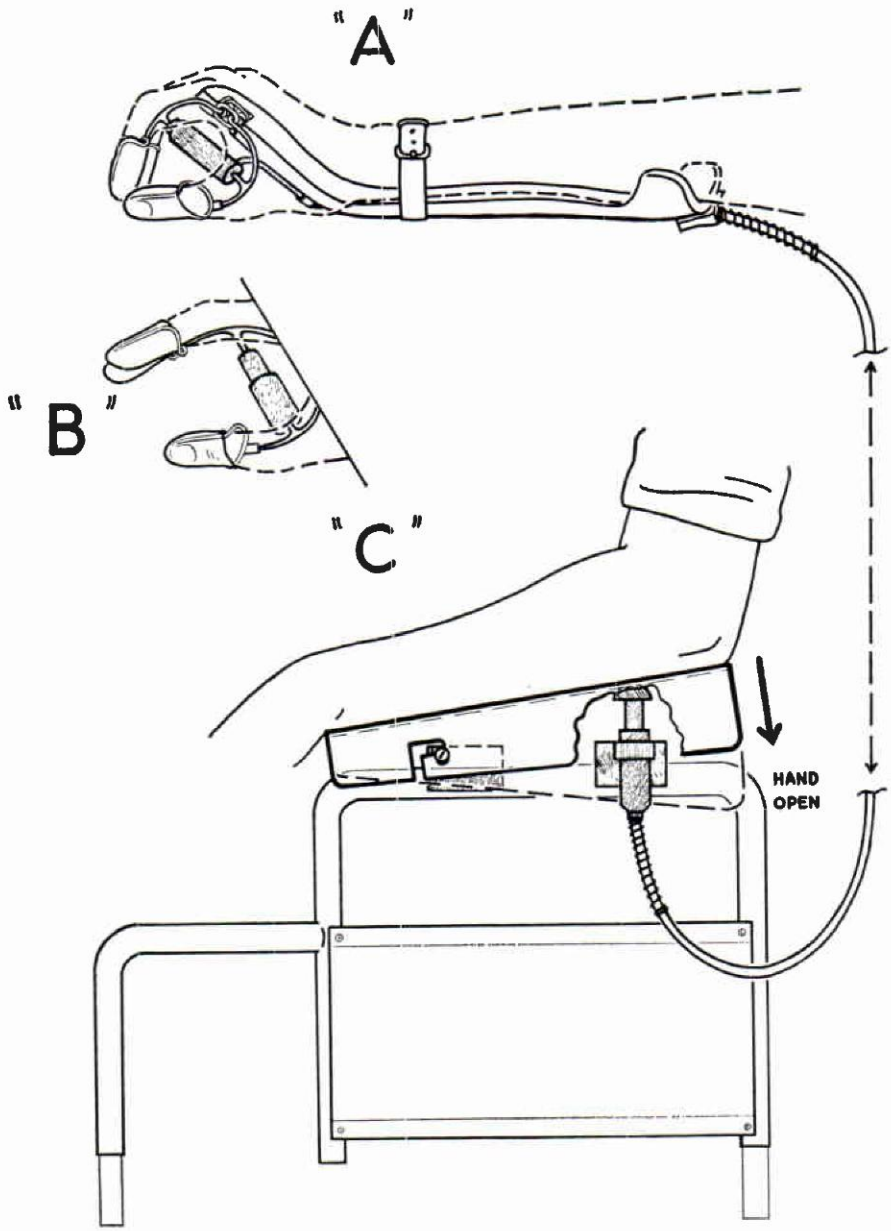

Fig. 1

Hand opened by depressing shoulder or leaning on chair arm.

6. Tubing (nylon)
   Inside diameter—0.125 inches
   Tubing has safe working pressure of 150 pounds per square inch
   Tubing permits flow of 400 milliliters of water per minute
7. Hydraulic System
   The system handles 75-pound forces continually with ease
8. Finger Caps (Latex)
   Thickness—0.021 inches
   Caps attached to finger wires with cement
9. Anchoring Wrist Strap
   Same type as used on wrist watch and so designed that watch can be worn on same strap
10. Splint (Acrylic Plastic)
    Contoured to upper forearm
    Retains shape permanently
11. Sizing Device
    Makes possible correct and speedy assembly of components to fit the patient
    Fits either hand by attaching to right or left hand splint

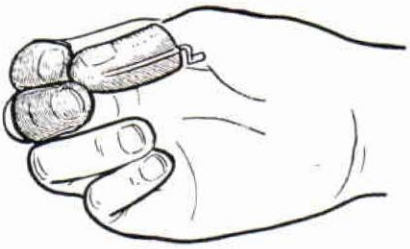

Fig. 2A. Three-jaw chuck grasp.

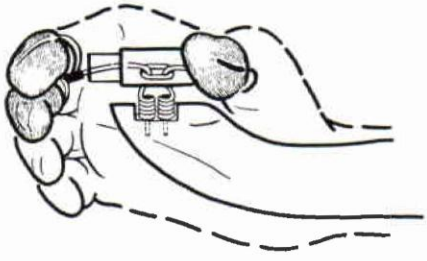

Fig. 2B. Hand open.

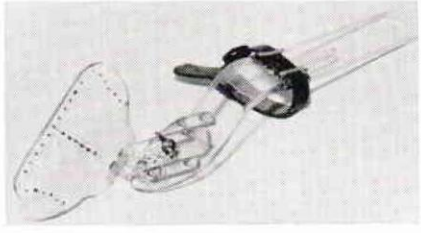

Fig. 3

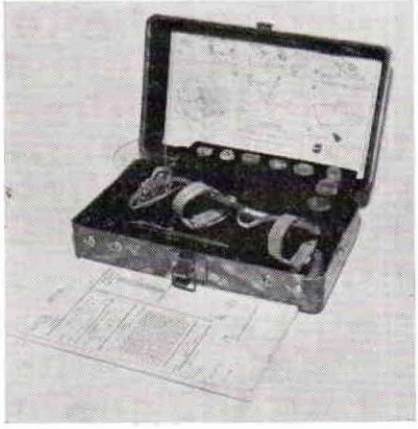

Fig. 4

Summary

A lightweight, hydraulically operated mechanical hand was developed and tested on quadriplegic patients. This apparatus provides the patient with three-jaw chuck type grasp and enables him to perform many activities otherwise impossible. It is recommended that any patient fitted with the "helping hand" receive training similar to that given the upper extremity amputee. This instruction assures maximum benefit from the use of the hand.

The development of the hydraulic hand is an illustration of the improved instrumentation possible from the combined efforts of the engineering and the medical professions.

"REHABILITATION AND WORLD PEACE" THEME OF WORLD CONGRESS

A World Congress with the theme, "Rehabilitation and World Peace," meets in New York City in the Waldorf Astoria immediately before the National Assembly of the Limb and Brace Profession. The Congress is the Eighth to be held by the International Society for the Welfare of Cripples. Its sessions in the Waldorf Astoria Hotel in New York City run from August 28 to September 2. Immediately thereafter the National Assembly of the Limb and Brace Profession, sponsored by The American Orthotics and Prosthetics Association, will open in the same rooms (the World Congress Supply Exhibits will be in the Jade, Basildon and Astor Rooms of the Waldorf Astoria on the third floor and the same rooms will be used by AOPA).

The Congress is open to persons from all the countries who are interested in the field of rehabilitation and wish to attend. The U. S. National Society for Crippled Children and Adults is the host society.

Dr. Howard A. Rusk, President of the World Congress, will preside at the opening session. Other speakers of special interest to the limb and brace profession include Dr. Henry H. Kessler of West Orange, New Jersey, and the Honorable Arthur S. Fleming, Secretary of Health, Education, and Welfare.

Of special interest will be the session on "Industrial Medicine and Rehabilitation," to be held on August 30. Dr. John Lauer of Pittsburgh will discuss "Modern Rehabilitation As Seen By An Industrial Physician." Speakers in other sections include Dr. Michael M. Dasco of New York on "Rehabilitation Program for the Aging."

Advance reservations for the Congress should be sent to the Eighth World Congress, 2023 W. Ogden Ave., Chicago 12, Illinois. ($15.00 per person). Information about exhibits at the Congress may be obtained by writing Mr. Ronald B. Almack, Exhibits Manager, International Society for the Welfare of Cripples, 101 Memorial Hall, Medical College of Virginia, Richmond 19, Virginia.