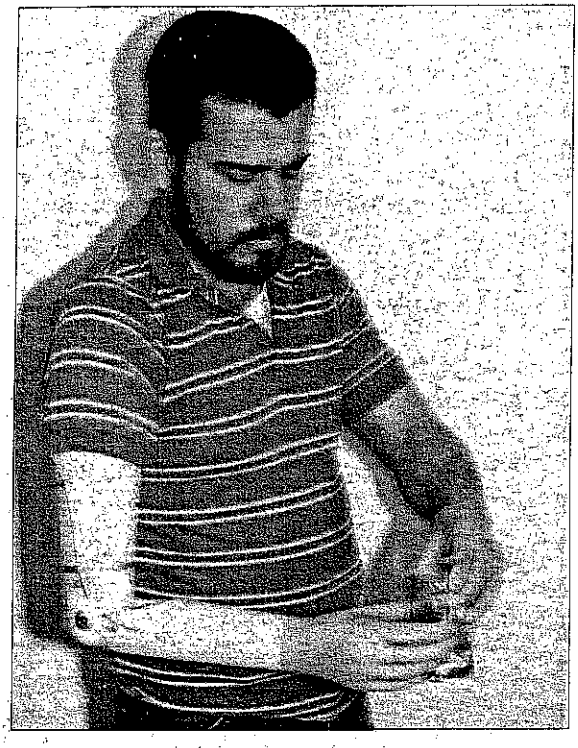
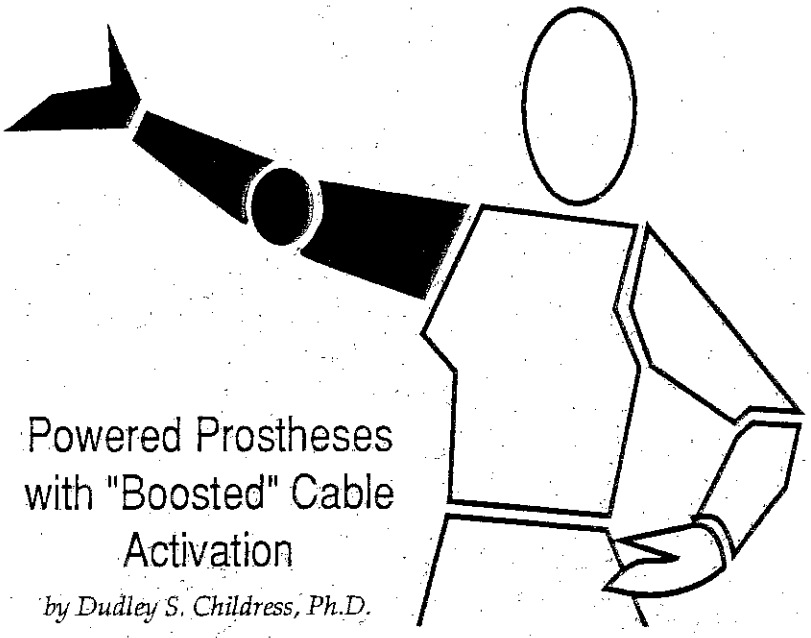
Capabilities

Communicating the Science of Prosthetics and Orthotics

VOLUME 1 NUMBER 2, JULY 1991





Powered Prostheses with "Boosted" Cable Activation

by Dudley S. Childress, Ph.D.

For several years we have been working on the development of powered prosthesis control systems that are based on the concepts of extended physiological proprioception (e.p.p.), a concept originally formulated in the early 1970s by D.C. Simpson at the University of Edinburgh. Recently has it been possible for us to begin clinical trials of an electric elbow controller based on this concept (see photo above). This control approach attempts to use the body's own proprioception to provide information concerning forces, position, and velocity of a prosthesis joint being controlled. Body-powered, cable-actuated prostheses exemplify a kind of e.p.p. system because the body's own joints determine where the prosthesis is positioned in space and how fast it is moving. Also, forces active on the prosthesis are coupled through it and/or the cable to the user. We believe systems based on e.p.p. control can be used easily and somewhat subconsciously (low mental loading) because the approach captures and uses the body's own natural proprioception as part of the control process. The e.p.p. control system we have developed for electric elbows, and which we have fitted clinically, uses a cable to control the electric elbow in essentially the same way a non-powered elbow is controlled and actuated. Therefore, the user of the electric elbow can operate it in a traditional way, but with powered assistance. Consequently, the force and excursion required to operate the elbow can be set to match the user's own capabilities for force and excursion. We might say that we have used electric power to "boost" the cable so that it can be operated with little force or with small excursion, as compared the purely body-operated situation.

The e.p.p. system has been implemented on three clinical fittings (Rehabilitation Institute of Chicago) for control of a NY-Hosmer elbow. One above-elbow wearer has an above elbow amputation (photo), and he uses flexion of

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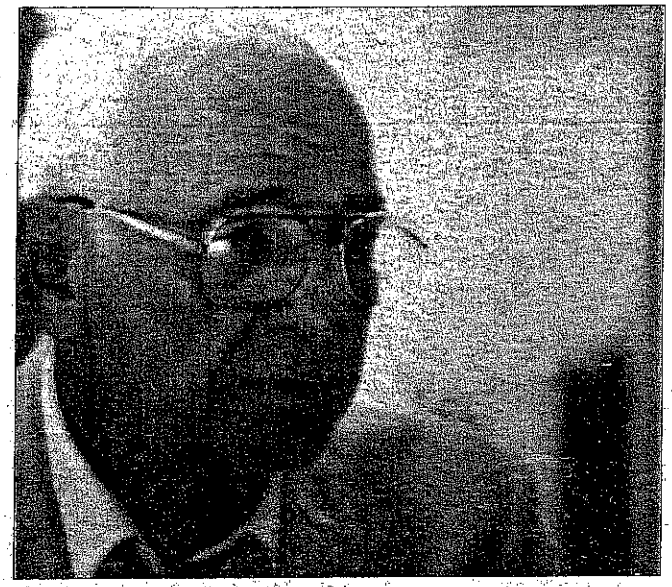
S.O.A.



(Dr. Compere, father of Northwestern University's Prosthetics Research Laboratory and Rehabilitation Engineering Program, believed in "state-of-the-art." This issue's S.O.A. column is dedicated to him.)

Dr. Clinton C. Compere died on Sunday, May 26, 1991 in his home in Tucson, Arizona. He was 80 years old. The medical engineering laboratories on the 14th floor of the Rehabilitation Institute of Chicago (RIC) are his direct legacy, as is the Northwestern University Prosthetics-Orthotics School on the 17th floor. He organized the Northwestern University Prosthetics Research Laboratory in 1957 when he hired Colin McLaurin and Fred Hampton from Sunnybrook Hospital in Toronto. He initiated the Prosthetics-Orthotics Education Program in 1958, and brought Blair Hangar in to lead prosthetics education. In 1972 he was behind the establishment of Northwestern University's Rehabilitation Engineering Program, which at that time concentrated on total joint replacement research and the development of assistive aids for profoundly disabled individuals. This led to the establishment of the Rehabilitation Engineering Clinical Services Department of the RIC in 1981. Dr. Compere was always very supportive of prosthetists and orthotists, and his early influences helped them in developing their professional identity. In a similar way, he supported the new field of rehab engineering.

The research and education programs are only a small part of Dr. Compere's many contributions to medicine. First and foremost, he was an outstanding orthopaedic surgeon. Highly respected nationally, he held many of the top positions of orthopaedic societies in the United States. For example, in 1963 he was the president of the American Academy of Orthopaedic Surgeons (AAOS). In Chicago, he was Chief-of-Staff of Chicago Wesley Memorial Hospital from 1963 to 1965. He was chairman of the Department of Orthopaedic Surgery of Northwestern University Medical School from 1978 to 1980. Dr. Compere was director of the Bone and Joint Pathology Laboratory in the Department of Orthopaedic Surgery from 1946 to 1966. This was his primary personal area of research. Active on national committees in Washington, D.C., he was instrumental in helping initiate many of the programs that are so important today in rehabilitation.

The RIC began with Dr. Clinton's (as he was affectionately called) amputee clinic and with Hildegarde Myers, who established the physical therapy department. Dr. Clinton brought Ms. Myers to the RIC from the West Side VA Hospital (Chicago) and she played an important role in its survival during those early years. In 1957 Dr. Compere was Vice-Chairman of the Board of Directors of the RIC and member of the Founder's Group. He served on its board of directors until his death. He was one of the people responsible for bringing Dr. Henry Betts to the RIC, which caused it to flourish. In many academic institutions there was a bias against the relatively new field of physical medicine and rehabilitation. This was never the case at Northwestern, primarily because of Dr. Compere.

Compere was a surgeon's surgeon, and he was a *teacher*. He was mentor to many physicians and researchers. He lives on in their work and in their programs. In this age of extensive litigation in medicine, he never had a law suit. Perhaps he was lucky; perhaps it was because of his excellent skills in the operating room and his way with patients. He was one of the few orthopaedic surgeons in the country who could also give a person an "adjustment" of the spine. He was tough; curmudgeon-like some would say, but beneath the external shell was a heart of goodness and caring that was somehow communicated to his patients. He always took plenty of time with them. Care was his primary goal. He was not in medical practice to make money.

Orthopaedic Surgery has lost one of its great surgeons. Prosthetics, Orthotics, and Rehabilitation Engineering have lost one of their great advocates. We have lost a great friend and father.◆ *by Dudley S. Childress, Ph.D.*

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Resource Unit

As project director of the Resource Unit, I talk to people every day who need information on p&o, and find out why they need it. Giving out information is a privilege, knowing someone will benefit from it—and a responsibility. I want to give the best information we have. Sometimes, though, I'm in a position to receive information myself. Some of the best kind of information is the human kind—stories about people. Like about Donna Lynn Hall.

In 1964, Donna Lynn benefitted from her parents' insistence on asking questions until they got the information and answers they needed. When a lump on Donna's leg wouldn't go away, and with that instinctive knowledge that "*someone* knows what's going on", her parents kept asking questions until they were directed to Dr. Clinton Compere. The lump was diagnosed as cancer, and Donna's leg was amputated above the knee. He respected their questions—and their fears—going the extra mile to talk to a young teenaged girl with all her concerns about appearance ("I want to wear mini skirts like the other girls") and instilling confidence that allowed Donna to continue living her life to the fullest after the amputation; ice skating, horseback riding, sailing, and camping. "God directed us to Dr. Compere," said Mrs. Hall, "Donna had total confidence in Dr. Compere, and they were very good friends. He made extra visits to her in the hospital, and she trusted his decisions completely. She once said, 'If he wanted to cut off my head, I'd know it was the right thing for me.' And Dr. Compere's character was reflected in the hospital staff. Their care for Donna was terrific."

The openness and caring of Donna's parents and of Dr. Compere surely gave her the motivation to learn to walk again. A spirit-filled Christian, she knew she could do it, with God and her friends' and parents' help. "Being an amputee was hard back then, " Mrs. Hall said, "Amputation was shocking to some people. But Donna's acceptance of it—and success despite it—plus the support of schoolfriends and everyone, made all the difference." Donna was determined. She didn't want to limp, and discarded her cane before becoming a summer camp counselor in 1965. Her campers, or "bunnies", often wondered what she would do about the leg in various camping situations. Who knows what acceptance of persons with disabilities she instilled in them as a result of her own attitude and experience.

Donna's story continues beyond her death in 1966 from returning cancer. This year, Donna's parents donated her prosthesis to the Prosthetics Research Laboratory. "We thought someone could use it," said Donna's mother. "It represents all the determination Donna had to walk again."◆ *by Else M. Tennessen, M.S.*

ISPO Update

The International Society for Prosthetics and Orthotics (ISPO) cordially invites you to be an exhibitor in Chicago at the Seventh World Congress of ISPO, June 28 to July 3, 1992. This triennial event offers a unique opportunity for manufacturers and distributors of prosthetic and orthotic products to show these products to a worldwide audience of prosthetists, orthotists, therapists, physicians, surgeons, engineers, nurses, rehabilitation specialists, and others. Over 1200 attendees are expected.

The exhibition will run from Sunday, June 28, 1992, to Thursday, July 2, 1992. Exhibits will be open from 9:30 am to 5:00 pm most days.

Chicago is the leading convention city of the United States and the Hyatt Regency Chicago is the leading hotel for large meetings like the Congress. Wacker Hall is directly adjacent to all the Congress meeting rooms, ensuring an excellent flow of participants through the exhibit hall. Generous exhibit space means you can have all the space you require. Empty booth space, as well as furnished booths, will be available. Booth prices start at $960.

The exhibit reservation deadline is November 15, 1991. For more information, contact Moorevents, Inc., 400 North Michigan Ave., Suite 2300, Chicago, IL 60611 USA.◆

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Controller, from page 1

his remaining limb to control flexion of the artificial elbow. In the two other fittings, both shoulder disarticulations, rounding of the two shoulders is used to control elbow flexion. Only one powered joint is being controlled while the clinical merits of the system are examined. It is our opinion that the greater benefits of e.p.p. control will become apparent when the user needs to control several prosthetic joints simultaneously and in a coordinated manner. It is then, we believe, that the proprioceptive feedback available to the user through his or her own physiological joints will have opportunity to be used to its greatest advantage.

The field of artificial limbs is not the only one to use cable-actuated control to provide effective feedback to the user. The actuation of wing and tail control surfaces on airplanes was controlled directly by cables for many years. Pilots liked the "feel" (e.p.p.) this provided them. As planes became larger the direct cable controls gave way to a "boosted" kind of cable control, similar in concept to the system we have developed for the elbow controller. In a somewhat similar manner, albeit without cables, steering mechanisms of automobiles are now mostly "powered," and this makes parking easy because the force and excursion requirements can accommodate the capabilities of a wide range of drivers.

This research was performed by Dudley S. Childress, Ph.D., Craig W. Heckathorne, M.S., John S. Strysik, and Edward C. Grahn. For more information see the following:

Simpson, D.C. (1974), "The Choice of Control System for the Multimovement Prosthesis: Extended Physiological Proprioception (e.p.p.)," *The Control of Upper-Extremity Prostheses and Orthoses*, P. Herberts et al. (eds.); New York: Charles C. Thomas, pp. 146-150.

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Childress, D.S. (1989), "Control Philosophies for Limb Prostheses," *Progress in Bioengineering*, J.P. Paul et al. (eds.); New York: Adam Hilger, pp. 210-215.

Heckathorne, C.W., Strysik, J.S. and Grahn, E.C. (1989), "Design of a Modular Extended Physiological Proprioception Controller for Clinical Applications in Prosthesis Control," *Proceedings of the 12th Annual RESNA Conference*, pp. 226-227.

Heckathorne, C.W. (1990), "Manipulation in Unstructured Environments: Extended Physiological Proprioception, Position Control, and Arm Prostheses," *Proceedings of the International Conference on Rehabilitation Robotics*, pp. 25-40.◆

What is E.P.P.?

Key Concepts

proprioception (proh•pree•oh•sep•shun)
The awareness of posture, movement, and changes in equilibrium and the knowledge of position, weight, and resistance of objects in relation to the body.

extended physiological proprioception (e.p.p.)
The awareness of the action of a *prosthesis* using the intact proprioceptive senses of the controlling, human joint to which the prosthesis is attached. The movement of the human joint both directs and reflects the movement of the prosthetic joint.

Capabilities
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Northwestern University
Rehabilitation Engineering Program
345 E. Superior St., Room 1441
Chicago, IL 60611-4496

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