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UPPER-LIMB PROSTHETICS CURRENT STATUS AND FUTURE NEEDS

Maurice A. LeBlanc, C.P.

This paper is an attempt not so much to give the current status of upper-limb prosthetics but to develop the direction where research and development efforts should be pointed in the next few years to solve the most pressing clinical needs for patients.

Current Status

The history (Figure 1 and Reference 1) and development of upper-limb prosthetics is presented in the *Orthopaedic Appliances Atlas* of 1960 and will be updated by the revision to that volume now in progress and expected in 1978. In addition to the 1960 *"Atlas,"* the *Manual of Upper Extremity Prosthetics* (2) and *Prosthetic Principles—Upper Extremity Amputations* (3) have been used as teaching manuals and resource books to provide state-of-the-art service to amputees.

Background

The 1971 report *Rehabilitation Engineering—A Plan for Continued Progress* (4) made specific recommendations for future research and development in arm prosthetics. Subsequent efforts since that time also have tried to answer the question "What research work should we be doing to best help arm amputees?" (5, 6, 7) Past recommendations centered mostly on the areas listed below:

- Restudy of body powered prostheses
- Continuation of development of externally powered prostheses
- Improvement in appearance of hooks, hands, and arms
- Surveys of the upper-limb amputee population
- Formation of specialized centers for severely disabled arm amputees
- Increased emphasis on control and sensory feedback

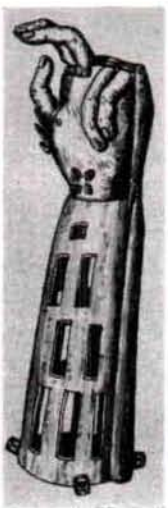

Fig. 1. The Alt-Rupin Hand.

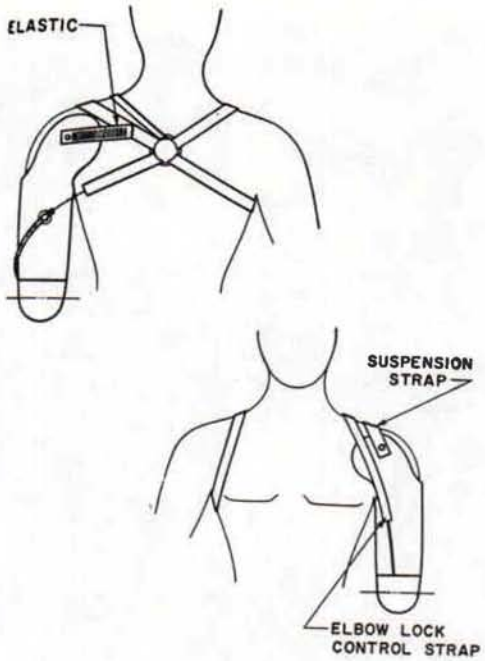

Fig. 2. The Ontario Crippled Children's Centre Open-Shoulder Above-Elbow Socket.

Recent Progress

In the last several years, accomplishments have been made in the following areas:

- Sockets: OCCC[1] open shoulder socket for above-elbow amputees (Figure 2 and Reference 8). Northwestern University self-suspension socket for below-elbow amputees (Figure 3 and Reference 9). Northwestern University atmosphere-pressure suspension socket for above-elbow amputees (Figure 4 and Reference 10).
- Components: Externally powered hands and hooks (Figure 5 and Reference 11). Externally powered elbows (Reference 12). Otto Bock wrist rotator (Figure 6).
- Control: EMG Control (Reference 13 and 14). Hybrid body/electric control (Reference 15). Sensory feedback (Reference 16).
- Cosmesis: Endoskeletal prostheses (Figure 7 and Reference 17).
- High Bilaterals: Coordinated feeder arms (Figure 8).

1.) Ontario Cripple Children's Centre, Toronto, Canada

Fig. 3. The Northwestern University Self-Suspension Socket for Below Elbow Amputees.

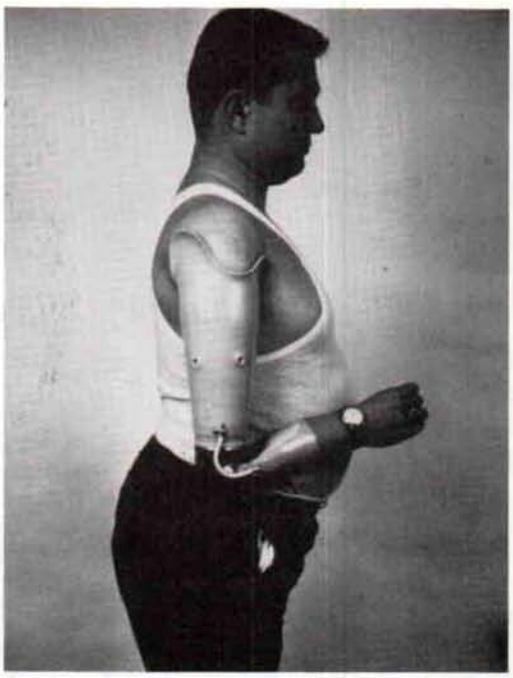

Fig. 4. The Northwestern University Atmosphere-Pressure Suspension Socket.

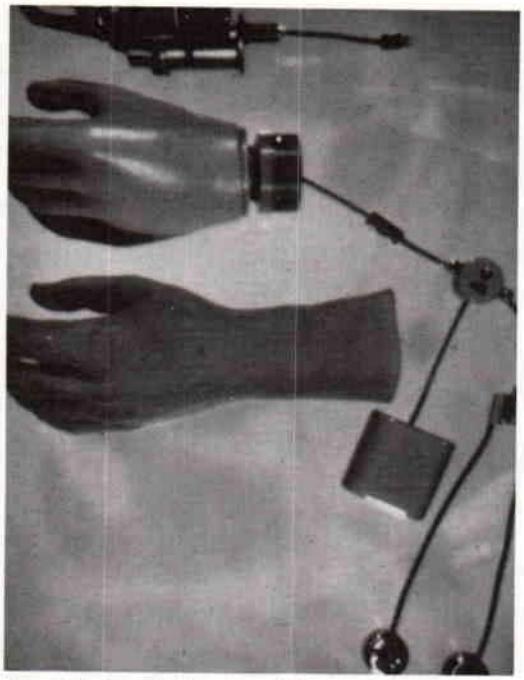

Fig. 5. Externally Powered Terminal Devices.

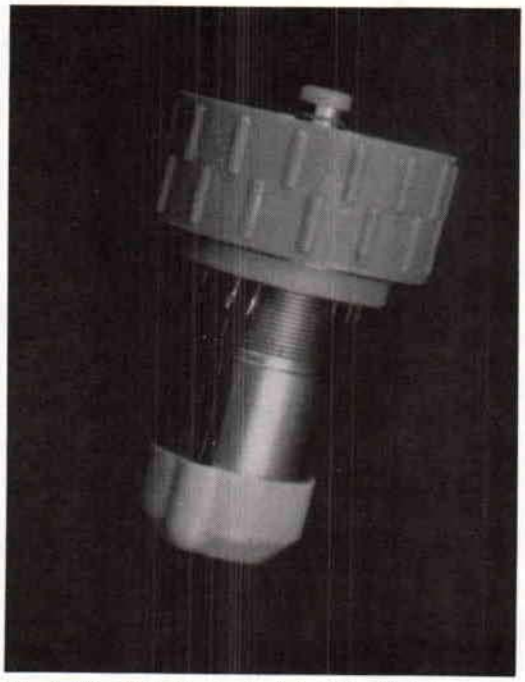

Fig. 6. The Otto Bock Electric Wrist Rotator.

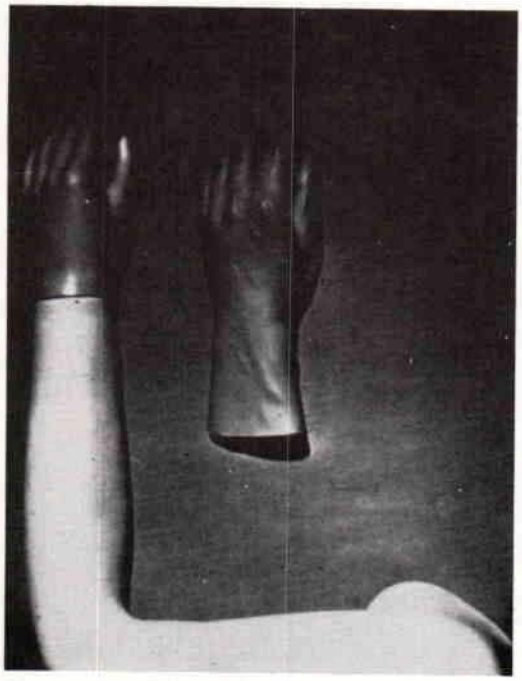

Fig. 7. The Otto Bock Endoskeletal Upper-Limb Prosthesis.

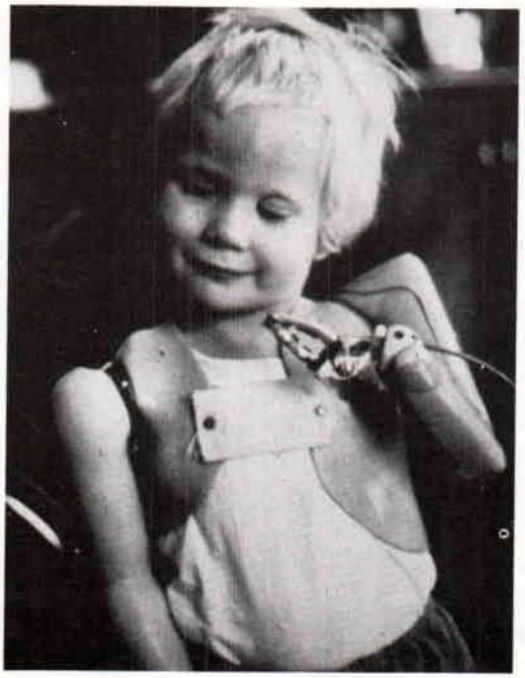

Fig. 8. Electrically Powered Prosthesis With Coordinated Motion Between Wrist and Elbow.

Future Needs

There are several old but good and yet undone ideas for improvement of upper-limb prostheses. Considering recent accomplishments as well, I see future needs for the field as falling into two major items:

- Packaging: Only an estimated 50 percent of arm amputees wear prostheses. Ned Sharples' study (20) revealed that whatever we can do mechanically (functionally) for unilateral arm amputees is not nearly as important as what we can do for them cosmetically (socially). With this in mind, it seems to me that we have to "package" prostheses better to achieve greater amputee acceptance. This includes work 1) on improved prosthetic skin material, 2) self-suspension, 3) self-containment, and 4) general aesthetics.
- High Bilateral Prostheses: It is readily acknowledged that high bilaterals—children and adults—present a most serious and difficult problem. In contrast to unilateral arm amputees and some low level bilateral amputees, the challenge to increase function of these people is a large one. I see future needs including 1) assistance in enabling them to use their feet wherever possible, 2) increase in function of components, 3) increase in control capability without added encumbrance in mental work necessary by the amputee, and 4) commercial availability of components and systems.

Goals

It seems to me that the goals are difficult to achieve, but can be stated simply as:

- For unilateral arm amputees: making them feel good about themselves!
- For bilateral arm amputees: giving them a measure of independence!

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