PLOWSHARES #3

Breaking New Ground Technical Report

Prosthetic and Worksite Modifications for Farmers with Upper Extremity Amputations

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Introduction and Background

Upper extremity amputations have historically been a serious problem for agricultural workers. The "farmer's hook" is an all-too-frequent sight at many farm meetings. Over the years, lack of financial and technical resources and isolation from comprehensive rehabilitative services have resulted in many farmers making modifications to their arm prosthetic devices or worksites in order to complete essential farm tasks. This paper, based on interviews/surveys of active farmers using upper limb prosthetic devices, looks at the problems they have experienced and some of the solutions they have developed to overcome these problems.

Scope of the Problem

Even though there is not specific data on the number of farmers with upper extremity amputations, the scope of the problem is partly reflected from several sources. According to the National Safety Council, agriculture was the second most dangerous occupation in the United States in 1984[1]. Farmers are more than four times more likely to experience a disabling injury than the average American worker[2]. The National Center for Health Statistics reports that a higher proportion of farmers are missing entire fingers or toes due to amputations than the non-farm population (14.8/1000 versus 8.8/1000)[3]. A recent Purdue University study on the nature and proportion of physical impairments among Indiana farm operators indicated that 5.1 percent of the operators surveyed had experienced an amputation[4]. Records at Purdue also revealed that for a 25-year period, when corn pickers were the predominate type of harvester in the state, over 100 farmers per year lost a hand or arm due to corn picker accidents alone. Similar findings have also been reported from other Corn Belt states. The corn picker has now been replaced by augers and round balers as leading causes of hand amputations.

BNG Project Study of Farmers with Arm Amputations

The Breaking New Ground Project at Purdue University, which provides technical assistance to farmers with physical disabilities, interviewed 20 farmers with arm amputations to obtain information on the problems they experienced in completing essential farm-related tasks and the solutions they had developed to overcome these problems. The farmers came from 11 states; 17 were primarily grain producers and three operated dairy farms.

Nature of Interviewee's Amputations

Of the farmers interviewed, ten had below-the-elbow amputations (seven right arm, three left arm). Five had experienced an above-the-elbow amputation (three right arm, two left arm). One farmer had an above-the-shoulder left arm amputation, and the remaining four had amputations of both arms.

Terminal Devices Currently Being Used

Of those interviewed, 17 were using the "Dorrance Hook" and two were using the "Prehensile Hand". One farmer was not using any prosthetic device.

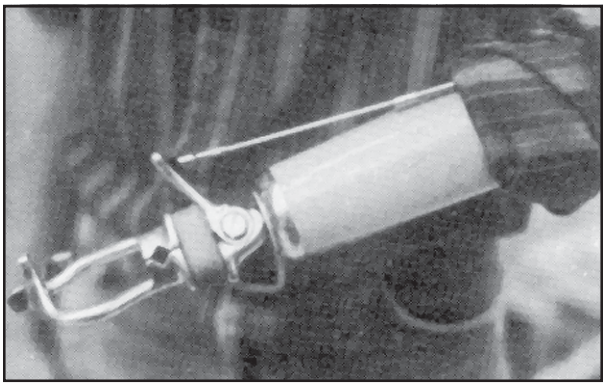

Figure 1. Dorrance Hook.

Traditionally, the most frequently prescribed terminal device for farmers has been the "Standard" or "Dorrance Hook" *(Fig. 1)*. Many have referred to it as the "farmer's hook". The Dorrance Hook operates on the principle that the hand remains closed when the muscles are relaxed and open when making use of the muscles.

The "Prehensile Hand' *(Fig. 2)*, invented by Robert Radocy (Therapeutic Recreation Systems, Boulder, CO) relies on the wearer's muscle use for its gripping strength—it is open when the muscles are relaxed and closed when the muscles and mind coordination cause it to close.

Common Prosthetic Problems and Modifications or Solutions to Alleviate Them

The most common problems that the surveyed farmers experienced were in regard to obtaining their prosthesis, learning how to use it to perform various farm tasks, and servicing the device when failure occurred. Isolation from comprehensive rehabilitation services and service personnel was a major problem for most. In some cases, the farmer was several hundred miles from the nearest rehabilitation hospital. As a result, many relied on local craftsmen and their own ingenuity to make the necessary repairs and modifications.

Following are the specific technical problems most often mentioned, along with suggested solutions.

Cable Breakage

The technical problem most frequently expressed by farmers using either a Dorrance Hook or the Prehensile Hand was frequent cable breakage. To overcome this problem, three farmers with below-the-elbow amputations replaced the cable with nylon rope, which slides through metal loops riveted to the socket and tricep cuff. This arrangement does require an adjustment period to get used to using a rope instead of a cable *(Fig. 3)*. Heavier 1/8-inch cable has also been successful in some instances.

Harness Comfort

Another frequently expressed problem with the prosthetic device was harness comfort. Seven farm-

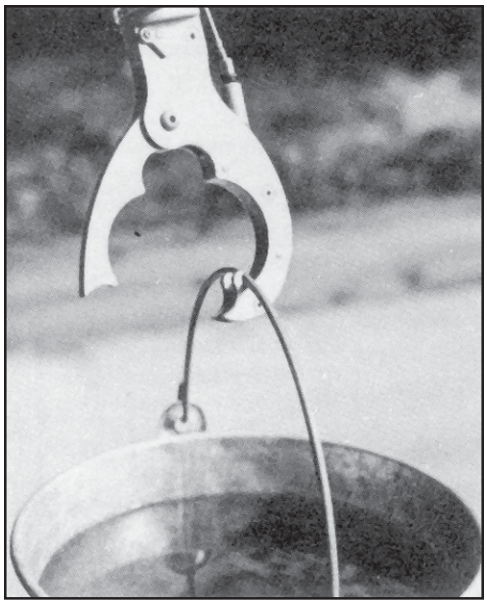

Figure 2. Prehensile Hand.

Figure 3. Replacing cable with nylon rope.

Figure 4. Modifications made by Beverly Dailey.

ers stated that the harness caused irritation, particularly under the arm. Other complaints related to reaching limitations and the need for a quick-release harness, for when the terminal device became caught on something and the wearer needed to let go. One farmer stated that a cow's tail had once gotten caught between the cable and the prosthesis. He reported that he made several revolutions around the cow before he was able to free himself; fortunately, he was only a little shaken.

To overcome both of the above mentioned problems, Beverly Dailey, of Stapleton, NE, uses a very comfortable quick-release harness, constructed with the help of her husband and a local saddle maker. The harness was made out of machine washable Dacron webbing, sheepskin material for underarm comfort, velcro, and part of a bib overall buckle for front attachment and quick release. The harness strap extends behind the back and under the arm, slides through the buckle, is pulled to the desired tension, then folds back and is fastened using velcro material. To quickly release the prosthesis, Beverly simply pulls up on the end strap *(Fig. 4)*.

Exposure to Cold

The need for a heated or insulated socket has also been indicated by most farmers with below-elbow amputations working in cold weather. Since amputees usually experience a decreased blood flow and decreased sensation in their stump, there is a greater danger of frostbite occurring in the stump without them noticing it.[5]

One farmer reported using a heating pad to wrap his stump in and re-warm it following exposure. Other methods used to cope with the problem included: an electric hairdryer to warm up the prosthetic device; knee-length nylons pulled on before the stump sock to keep perspiration away from the skin; and a tube sock pulled over the top of the prosthesis. One farmer stated that he tried an electric (battery operated) hunting sock, but found that the stump perspired more, resulting in his stump becoming colder.

Work done by Eickman and Mathsen at the University of North Dakota found that the bulk of the heat loss from the prosthesis occurred around the upper-socket region[6]. One of their recommendations was the use of an insulated band around the top of the prosthesis to limit heat loss around the outer polyester cover.

Limitations of Terminal Device

Numerous limitations in the ability of the terminal device to perform certain tasks were reported by those interviewed. Here are some, with solutions that have been used.

1. Gripping door knobs or other smooth objects with some terminal devices can sometimes be difficult, due to the slippage that can occur. Some farmers wrap electrical tape or rubber hose ma-

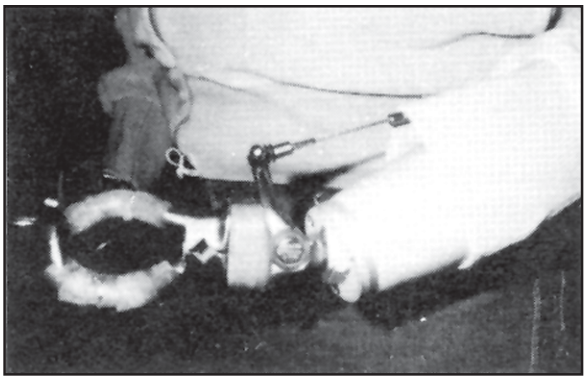

Figure 5. Rubber hose slipped over jaws to improve traction.

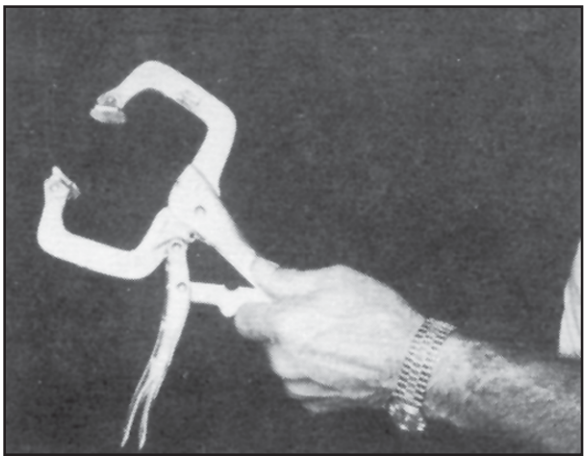

Figure 6. Locking pliers can expand gripping capabilities.

terial around the jaws to provide better traction *(Fig. 5)*. Many jaws on standard hooks are serrated on the inside or coated with Neoprene, a tough rubber-like material, to reduce slippage. Chisels and punches that have larger diameter shanks can be difficult to grip with the terminal device. Rubber hose material slipped over the shank can provide a better gripping surface.

Locking pliers ("vise grips") with a C-clamp gripping end may be used to lock onto an item whose diameter is too large for a conventional hook to grasp *(Fig. 6)*. Radocy's 'Prehensile Hand" is reportedly quite effective in solving gripping problems; it has a 70-pound gripping strength. Features include a "thumb," an internal hook by which a pail handle can be carried, and three gripping diameters, enabling the user to handle items ranging from a slender paintbrush handle to a sledge hammer *(Figs 7 and 8)*.

2. The knife holder on some standard hooks has been found to catch on clothing; therefore, five of the interviewed farmers had removed it. One farmer stated that he sharpened the knife holder to cut twine on bales of hay. He said it works well for cutting open bags of feed, silage, and milk replacer, but warned that if it is too sharp it will cut too many things. "A little dull and a quick pull works best."

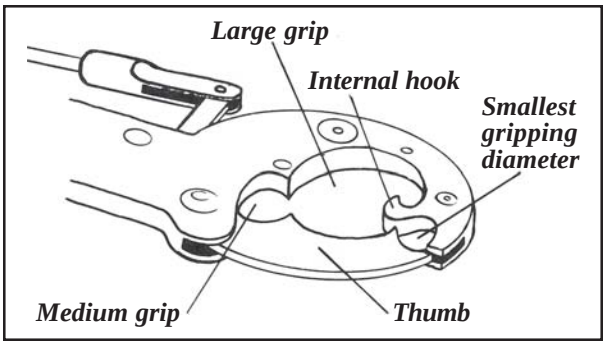

Figure 7. Note the three gripping diameters of the Prehensile Hand.

3. Strength and quality of terminal devices was also raised as a concern. Certain parts were refabricated to enable them to withstand the more abusive uses found on the farm. One farmer interviewed reported that the wrist unit continued to strip out, so he had taken the unit to a local machine shop where the machinist had fabricated a new one out of stainless steal. He felt that the stainless steel was much more durable than the original material.

4. Innovative farmers have discovered techniques to help them perform some tasks that challenge amputees. To start a nail, Marvin Miller of Kalona, IA, holds the head of the hammer sideways, placing a nail between the ring and middle fingers of his good hand and holding it against the hammerhead. He uses the side of the hammerhead

Figure 8. Prehensile Hand holding a hypodermic needle.

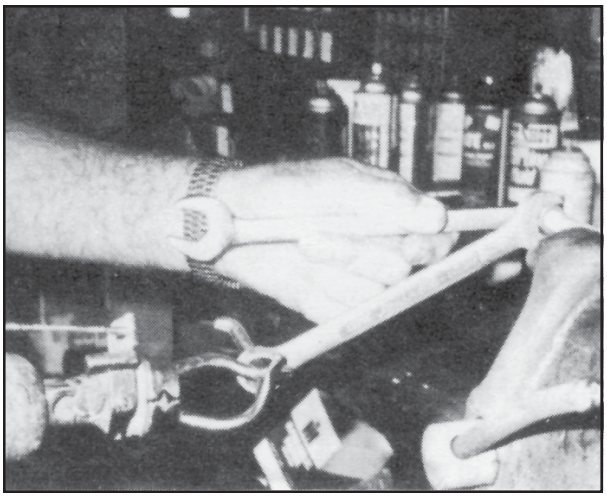

Figure 9. Nut and bolt tightening technique.

to drive the nail into the desired object. He can then pound the nail in the normal fashion.

Tightening or loosening a nut and bolt can be a problem. Les Freed of Loda, IL, uses two sets of open-end/box-end wrenches. With his prosthesis, he places the open-end wrench on the nut or bolt. Then he slides the hook of his terminal device into the box-end wrench and holds the wrench in place while turning the other wrench with his opposite hand *(Fig. 9)*.

Removing hydraulic couplings can sometimes be difficult with two strong hands. Lavern Truby of Randolph, NE, has figured out a way to do it with only one hand and a Dorrance Hook. First, the in-line flow valve is closed to reduce pressure on the internal components of the coupling. Next, a pair of locking pliers is clamped to the male fitting on the hydraulic hose. The sliding locking collar on the female portion of the coupling is held open with the good hand, while the hook is used to push or pull on the locking pliers to couple or uncouple the hose *(Fig. 10)*. (Some manufacturers advertise one-handed couplers; even these, however, are sometimes difficult to connect and disconnect.)

No easy solutions were identified in the survey for connecting and disconnecting the PTO driveline to the tractor. Due to the weight of newer drivelines and close tolerances, this essential activity has proven to be a major barrier for many upper limb amputees. It often requires assistance from a co-worker to complete. A well used push-pin-type coupler appears to be the easiest to use, as compared to the spring-loaded sliding collar. One manufacturer of PTO drivelines states that work is being done to develop a sliding collar coupler that requires only one hand.

5. Some hand tools have been found useful to aid in doing tasks that are normally difficult to do one-handed. They include ratchet screwdrivers, the "One Touch Wrench" (from Great Neck Saw Manufacturers), the "Jaw Locker" (an adjustable jaw-locking end wrench from Tru-Grip Corporation), and one-handed grease guns *(Fig. 11)*.

Modifications to Tools and Worksites

In many cases, the terminal device currently being used was not sufficient to enable the prosthetic user to complete essential tasks. Therefore, modifications were made to tools, equipment and buildings as needed. This section discusses some modifications mentioned.

Modifications to Hand Tools

Many farmers have expressed some difficulty in

Figure 10. Attaching a hydraulic coupling.

Figure 11. One-handed grease gun.

using hand tools to complete work-related tasks. To overcome this problem, several modifications have been made.

Richard Juergens, adaptive equipment consultant, Des Moines, IA, designed and fabricated a wrench adapter for one farmer. This adapter fits into a standard "Dorrance Hook" terminal device *(Fig.12)*. A ratchet wrench will also fit into this adapter.

Charles Bengston of El Paso, TX, has designed a special tool holder and a set of modified hand tools for use with a prosthesis. The user unscrews his terminal device and screws in the specially designed

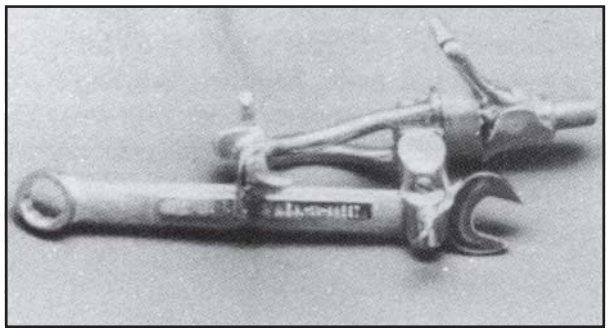

Figure 12. Prosthetic wrench adapter.

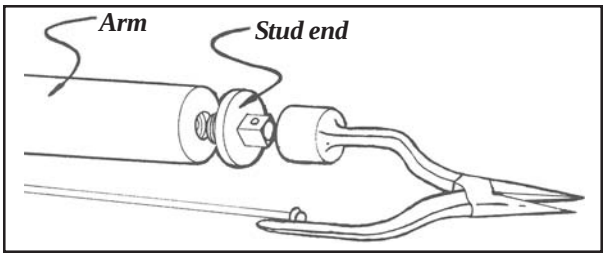

Figure 13. Tool holder attachment to terminal device. (Cable used on plier and scissor attachments.)

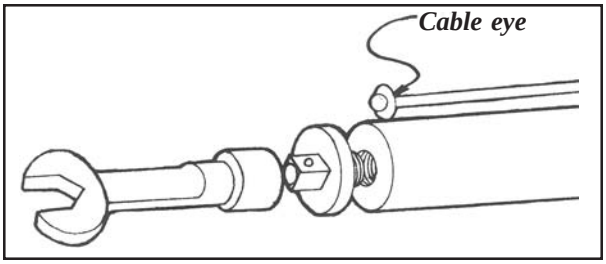

Figure 14. Tool holder with stationary tool.

stud end. Tool handles that have been fitted with socket end pieces fit over the stud end. For pliers and scissors, a cable eye had been mounted to the free handle, which is then activated by cable action *(Fig. 13)*. For other hand tools such as wrenches, the socket has been drilled and tapped for the cable eye to hold the cable while it is inactive *(Fig. 14)*. Hand tools accompanying the tool holder include wrenches, pliers, magnetic nail holder with four different size magnets for holding various size nails, hammer, drafting tool, lug wrench holder, socket holder with wrist action ball joint, ratchet screwdrivers, ratchet wrenches and pipe wrenches.

During haying season, handling the bales can be dif-

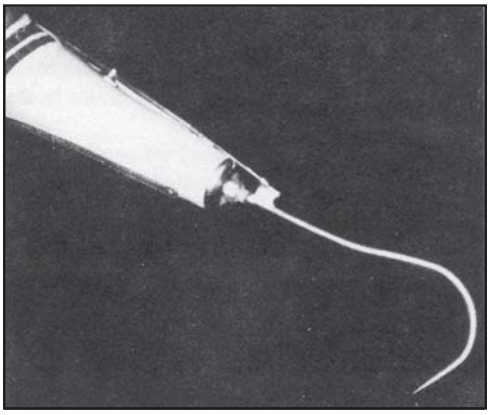

Figure 15. Banker's hay hook.

Figure 16. Milker support arm allows one-handed attachment of teat cups.

ficult for a farmer with a prosthetic device. Rick Banker of Black Creek, WI, uses a hay hook that was fabricated by a local machinist *(Fig. 15)*. Rick unscrews his terminal device and screws the hay hook into the threaded shaft on his socket. He notes that he must use extra caution with his hook when working around others.

Modified Milking Equipment

Dairy farmers using a prosthesis reported difficulty grasping the claw of a milker unit with the prosthesis while using the good hand to attach the teat cups. Surge makes available a flat C-shaped handle that can be welded to the air divider of the milker unit. This handle can be grasped with the terminal device. For milking parlors, the Surge Randel milker support arm allows the operator to attach the teat cups using only one hand *(Fig. 16)*. The milker support arm holds the claw and can be adjusted with one hand at any position under the udder. (Other manufacturers may make similar equipment.)

Modified Vehicle Controls

The many controls on tractors and combines are very difficult to grasp with a prosthetic terminal device. In some instances, these controls can be relocated so they can be easily reached with the operator's good hand. The Department of Agricultural Engineering at the University of Nebraska-Lincoln relocated the hydraulic control for the hydraulic lift arms on Larry Streff's tractor. This allows Larry to actuate the control using his good left hand rather than with his right prosthesis.

Lever extensions can also be used on existing controls to allow for easier gripping. For example,

Figure 17. Truby's lever extension.

Figure 18. Kayhart's steering ring.

Lavern Truby has made a longer lever for the throttle on his tractor to make grasping it easier *(Fig. 17)*.

Bilateral arm amputee Lee Kayhart uses a steering ring mounted on the tractor steering wheel *(Fig. 18)*. The ring swivels 360° and can be easily grasped with the prosthetic hook.

Murray Bedel from Lebret, Saskatchewan, also designed and constructed a steering-assist ring which can be easily connected and disconnected from any steering wheel. The adjustment shaft is constructed with one piece of square steel tubing and a solid piece of barstock, which slides in and out of the tubing. A spring is placed on the inside of the tubing to provide the needed tension against the steering wheel to hold the steering ring in place *(Figs. 19 and 20)*.

Merv Copeland from Tomahawk, Alberta, uses a leg brace extension to operate a hydraulic control on his combine with his thigh *(Fig. 21)*.

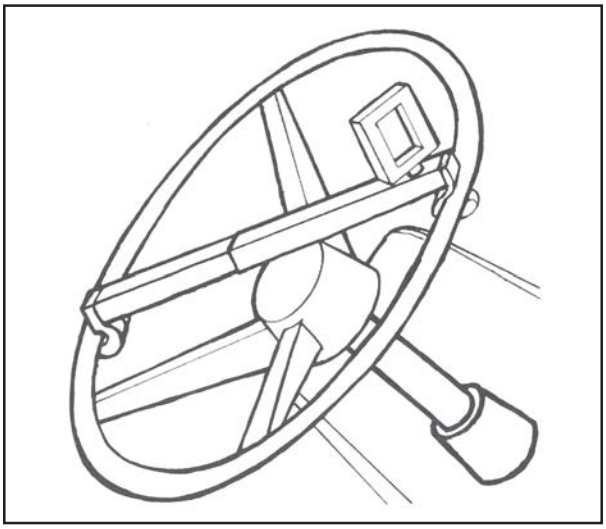

Figure 19. Bedel's steering ring is on a spring shaft, which is easily inserted or removed from the steering wheel.

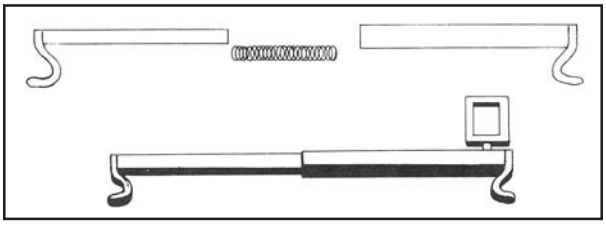

Figure 20. Schematic of the steering ring device.

Building Modifications

Opening and closing gates can sometimes be difficult for farmers with the use of only one arm. Mike Meierhenry of Hoskins, NE., uses a one-handed gate latch, constructed of channel iron attached to a stationary post. The channel iron acts as a gate stop to allow the gate to swing in either direction. To open the gate, Mike raises one or the other gate stop using only one hand. Commercially made one-handed gate latches are also available.

Climbing grain bins can also be difficult. Larry Streff

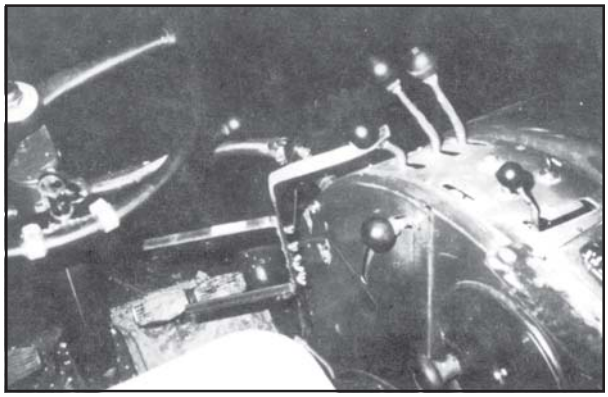

Figure 21. Leg brace that Copeland uses to operate the hydraulic control.

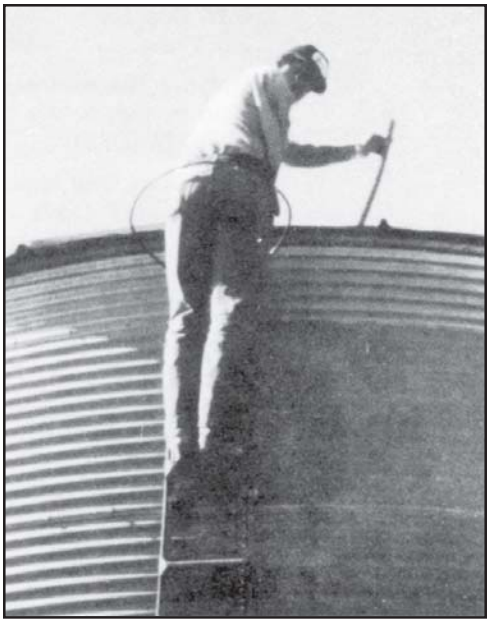

Figure 22. Support ring aids Streff in climbing grain bin ladder.

uses a back support loop around the ladder of his grain bin. He rests his back against the loop while he uses his good hand to open the bin lid *(Fig. 22)*. Grain bin stairs are also useful and safer in overcoming this problem. The user can maintain better balance climbing steps than he can climbing a vertical ladder.

Other Resources

Accent Special Publications, the publisher of *Accent on Living* magazine, has a booklet on devices and aids for one-handed individuals. It lists the names and addresses of 54 product sources and five pertinent publications aside from its own publications.

Amputees may also wish to consult magazines and catalogues that offer assorted tools and aids. They may order these items or perhaps get ideas for modifications that they can implement themselves.

The Breaking New Ground Project at Purdue has recently published a resource manual entitled, *Agricultural Tools, Equipment, Machinery and Buildings for Farmers and Ranchers with Disabilities*. It contains over 300 ideas currently being used by farmers with physical disabilities which enable them to remain active in their operations. Some of the ideas pertain to farmers with upper extremity amputations. Photographs and detailed descriptions of each modification appear in the manual.

Conclusions

The various modifications and solutions discussed in this paper are only some of the many attempts that have been tried by farmers and professionals to overcome various problems associated with completing essential farm tasks using a prosthesis. Many of the modifications are homemade to meet one person's need and may not necessarily be effective for another person. They are presented only as ideas to assist farmers, professionals and manufacturers who seek solutions to overcome their specific problems through new designs of prosthetic devices, tools and equipment for use by farmers with upper extremity amputations.

Breaking New Ground welcomes other suggestions from farmers or rehabilitation professionals on how to overcome problems that still confront upper extremity amputees in the farm setting. Please forward your ideas to:

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5. Eickman, L. and Mathsen, D.V. "Rural Prosthetic/Orthotic Device Development —A Cooperative Venture", Proceedings of the International Conference on Rural Rehabilitation Technologies, Grand Forks, ND, 1984.
6. Ibid.

Sources of Products for Farmers with Arm Amputations

Companies

Name	Selected Items Available
Abbey Medical/Abbey Rents 3216 El Segundo Blvd. Hawthorne, CA 90250	wide variety of aids
Adapative Fashions, Inc 5641 Bartlett Blvd Mound, MN 55364	clothing
AliMed 68 Harrison Ave. Boston, MA 02111	wide vareity of aids
Amputee Golfers Association Lakeview Terrace Wachtung, NJ 07060	adaptive aids for golfing
Crescent Tool Co. Subsidiary of Cooper Industries P.O. Box 728 Apex, NC 27502	gripping tool that can be used as pliers, wrench or clamp and can be operated with one hand
Drive-Master 16 Andrews West Paterson, NJ 07424	driving aids and steering rings
FashionAble Box S Rocky Hill, NJ 08553	clothing
Fred Sammons Box 32 Brookfield, IL 60513	wide variety of aids
Gardens for All 180 Flynn Avenue Burlington, VT 05401	special gardening tools
Gardener's Eden P.O. Box 7307 San Francisco, CA 94120	special gardening tools

Grayline Housewares, Inc. 1616 Berkley St. Elgin, IL 60120	wide variety of aids
Great Neck Saw Manufacturers, Inc. Mineola, NY 11501	One Touch Wrench
Gresham Driving Aids 30800 Wixom Road P.O. Box 405A Wixom, MI 48096	driving aids
Modern Farm 1825 Big Horn Avenue Cody, WY, 82414 (800) 443-4934	one-handed wire gate close, One-Touch Speed Wrench
National Amputee Golf Association 5711 Yearling Court Bonita, CA 92002	adaptive aids for golfing
National Amputees Golf Foundation Warm Springs, GA 31830	adaptive aids for golfing
Nelson Medical Products 5690 Sarah Avenue Sarasota, FL 33583	wide variety of aids
Prentke Romich 8769 Township Rd. 513 Shreve, OH 44676	electronic devices
P.R.I.D.E. Foundation 1159 Poquonnock Road Groton, CT 06340	clothing
Roy Dodgen Shop Blue Eye, MO 65611	housewares
Sears Roebuck & Co. Dept. 608 Sears Tower Chicago, IL 60684	wide vareity of aids

Sendak Kitchen Products Box 1592 N. Springfield, VA 22151	soldering iron that automatically feeds in the solder and flux
Smith & Hawken 25 Corte Madera Mill Valley, CA 94941	special gardening tool
Surge Milking Equipment Babson Brothers 2100 South York Road Oakbrook, IL 60521 (312) 654-1600	C-shaped handle for milker unit, Randel milker support
Therapeutic Recreation Systems, Inc. 1280 28th Street, Ste. 3 Boulder, CO 80303	Prehensile Hand
Toys for Dad Northern Hydraulics, Inc. P.O. Box 1499 Burnsville, MN 55337	vise C-clamp, one-handed grease gun
Tru Grip Corporation 9550 E. Groh Road Grosse Ile, MI 48138	Adjustable Jaw Locking End Wrench
United Pacific Corporation 245 Roosevelt Road West Chicago, IL 61085	one-handed hammer
Vargas Fishing-Aid Rodholder Co. 10550 Dunlap Crossing Rd., #117 Whittier, CA 90606	outdoor equipment
Walter F. Nicke Box 667-8G Hudson, NY 12534	special gardening tools
Western Amputee Golf Association 118 W. Swain Road Stockton, CA 95207	adaptive aids for golfing

Other Resources

Accent Special Publications Box 700 Bloomington, IL 61701	*Single-Handed: Devices and Aids for One Handers and Sources of these Devices*
American Journal of Occupational Therapy 1383 Piccard Drive Rockville, MD 20850	"Adaptive Living Aids for a Bilateral Shoulder Disarticulation," M.A. Marker (#9, 584, 1977)
Bannerstone House Publishing Co. 301-327 E. Lawrence Avenue Springfield, IL 62703	*Prostheses and Rehabilitation after Arm Amputation*, L.F. Bender, C.C. Thomas, 1974
Charles N. Bengston 4614 Atlas, #225 El Paso, TX 79904	tool adapter for artificial arm
Breaking New Ground Dept. of Agricultural Engineering Purdue University West Lafayette, IN 47907	*Agricultural Tools, Equipment, Machinery and Buildings* (resource manual for farmers and ranchers with physical disabilities)
Disabled Sportsman of America P.O. Box 26 Vinton, VA 24179	*Hunting & Fishing*
Farm Family Rehabilitation Management Services Box 37 Ankeny, IA 50021	"Farming with an Arm Amputation: Adaptive Equipment and Techniques" (videotape featuring farmers D. Offerman, B. Dailey, H. Hilton, L. Streff, and R. Banker)
Federation of the Handicapped 211 West 14th Street New York, NY 10011	*Handbook for One-Handers*, A.L. Danzig
Harper and Row Publishers 10 E. 53rd Street New York, NY 10022	*The One-Hander's Book: A Basic Guide to Activities of Daily Living*, Veronica Washam
Medical Center Rehabilitation Hospital University of North Dakota Box 8202, University Station Grand Forks, ND 58202	"Prosthesis Plus Technique Equals Independence" (videotape on prostheses)

National Institute for Rehabilitation Engineering 97 Decker Road Butler, NJ 07405 (201) 838-2500	customized devices of all kinds
Veterans Administration Washington, D.C. 20420	*Guide for the Arm Amputee*

Breaking New Ground does not endorse, recommend, or certify any of the modifications, devices, or commercial products mentioned in this article as being safe or functional. Nor has BNG intentionally excluded products or services supplied by companies not cited in this article.

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