VETERANS ADMINISTRATION PROSTHETICS CENTER RESEARCH REPORT

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I. DEVELOPMENT AND EVALUATION

A. Prosthetics

1. *Lower Limb*

a. *Knee Joint for Below-Knee Prosthesis.* Efforts continue to find a suitable plastic knee joint to replace the steel knee joint still being used in below-knee prostheses. The previously described efforts to use polypropylene demonstrated that this material lacks the rigidity required in a knee joint by most thigh-corset wearers (BPR 10-26, p. 216).

b. *Graphite-Epoxy Knee Joint for Below-Knee Prosthesis.* Efforts with graphite-epoxy composite were also unsuccessful, since it has been impossible to shape this material to the contours required.

c. *Nylon Knee Joint.* Currently being evaluated is the use of nylon for this purpose. Initial investigation demonstrated that this material can be shaped at room temperature to the desired contours, and it seems to possess the required rigidity. Nylon knee joints are currently being fabricated and patients will be selected as pilot wearers.

d. *U.S. Manufacturing Co. Four-Bar-Linkage Knee.* This device, developed by the U.S. Manufacturing Co., Glendale, California, makes use of a polycentric four-bar system installed in an endoskeletal prosthesis, with a machine-contoured foam cover. The knee uses mechanical constant-friction to control swing phase. An elastic extension aid is provided. The unit is comparatively light in weight, provides good knee stability, and allows relatively greater knee flexion. It can be fitted to amputations at the knee-disarticulation and above-knee levels.

The knee was fitted to an above-knee amputee who has a fairly long residual limb and evaluated for 1 year. No special problems were encountered by the prosthetist during fitting and fabrication, and time and cost factors were within the allowable range for

standard above-knee prosthesis. The patient's reaction to the unit was favorable: his gait improved due to better knee stability, and it required less effort to maintain a stable knee, as compared to his previous (single-axis) unit.

The knee still functioned satisfactorily after the year of use. The only maintenance required during the evaluation period was the need to replace the worn-out elastic extension aid after 6 months.

B. Orthotics

1. *Plastic Knee Orthosis.* Although we have been successfully fitting polypropylene knee orthoses with suprapatellar strap suspension for more than 2 years (BPR 10-23, p. 225), it has been felt that polypropylene side bars provided inadequate medial-lateral knee-joint support.

Another shortcoming was that, during ambulation, the calf and thigh cuffs slipped slightly up and down the patients' legs: this was due to the fact that the orthotic knee joint did not match the position of the anatomical knee joint. Although the knee orthoses were fabricated to fit closely to the knee, patients misjudged the placement of the joint when donning the device.

To improve fitting and joint placement, a new polypropylene orthosis has been designed and fabricated using a double-axis knee joint with a sliding action limited by two stops. This joint's movement closely resembles anatomical knee movements. The mechanical joint allows movement of the anatomical knee and does not cause up-and-down motions of the calf and thigh cuffs.

Fabrication was similar to that used for the previous orthosis (BPR 10-23, p. 225) except for two drape moldings; no joints were added. An aluminum disc was added between the moldings to provide a flat surface to construct the new joint. And the cast was modified in a manner similar to that of the previous orthosis, except for a build-up at the joint center. This build-up provided an area in which to construct the mechanical knee joint.

Although the new orthosis weighs only 63 grams more (approx. 2.25 oz more) than the older orthosis, it provides a better fit and better appearance. The device is currently being clinically evaluated.

2. *Orthotic Transverse Rotator.* Evaluation has been completed on the transverse rotator for lower-limb orthoses (BPR 10-28, p. 96). Four lower-limb orthosis wearers have used the device both indoors and outdoors for 3 to 6 months.

All patients have agreed that the shoe sole device functioned well. No major improvements in their gaits were noticeable, but they appreciated the additional freedom the rotator allowed them during ambulation. They were especially pleased with the ability to turn on the braced limb: this has not been possible without the rotator.

In limited indoor walking, the device proved fairly durable, but quickly malfunctioned when used outdoors—the rubber cover wore off or came off for all patients, and enough dirt then collected around the device to prevent it from rotating.

The evaluation confirms the theory that the addition of a transverse rotator to the sole of the shoe of a lower-limb-orthosis wearer is beneficial to the patient. But the present device is durable enough only for indoor use, and requires redesigning if it is to be suitable for outdoor activities.

C. Spinal-Cord-Injury Rehabilitation

1. *Environmental Control Systems*

a. *Stanley Silent Swing Door Operator.* The Stanley Silent Swing Door Operator (Fig. 1) is supplied by the Stanley Works Tool and Door Co., Farmington, Connecticut, and the Prentke Romich Co., Shreve, Ohio.

FIGURE 1.—Stanley Silent Swing Door Operator.

This electromechanical device for the home-living disabled can be mounted on a door transom to operate a light-duty interior swing-door. The door must be butt hung or swing-clear-hinge hung, with

maximum width of 42 in. (106.68 cm) and 50-lb (68.04 kg) maximum weight. A stallable, slow-speed, rotary-field drive motor, employing a built-in gear box with a 160-deg non-adjustable spindle output, is used. Two internal resilient stops stall the motor; no limit switches or return springs are used, and the motor remains energized in the open and closed positions. Although the closing motor windings remain energized, the door can be manually opened against the closing motor torque. The number of pounds of force, initial force and continuous force, required to open the door against the closing motor torque, depends upon the distance between the door hinge and the applied force.

Two Silent Swing Door Operators were submitted for evaluation. They will undergo tests in controlled conditions, and will then be installed in the homes of two disabled veterans for clinical trials.

2. *Communications Aids*

a. *Saltus Reading System.* The Saltus Reading System (Fig. 2), previously identified as the Ealing Reader (BPR 10-27, pp. 102-104), is a portable reading-assist machine intended for the severely paralyzed. Manufactured by the Ealing Corp., South Natick, Mass., the device incorporates a spool of sleeve-insert tape with clear plastic window pockets which accept pages from magazines or books. These can then be viewed. The reader can be clamped on the over-the-bed table included in the package, or on any table.

Several prototypes were evaluated for safety, effectiveness, and usefulness. Engineering tests and clinical trials were conducted in three VA hospitals and an outpatient's home.

Several modifications were instituted by the manufacturer after the device was evaluated. These are as follows:

1. Each plastic scroll pocket is split lengthwise to make it easier to insert reading material when the spool is in motion, without removing the cassette from the main frame.

2. The battery can now be charged while the unit is being operated from a 115-V a.c. source.

3. The original hand switch was replaced by several additional switch controls:

(a) Mouth Switch—Sensitive switches at the top and bottom of the mouth switch can easily be touched by the tongue, lips, or chin. Touching the bottom of the mouth switch causes the reading material to move forward; touching the top produces a reverse movement. The mouth switch attaches to a gooseneck on the device.

(b) Built-in Hand Switch—A hand switch on the upper center portion of the recessed control panel moves the material

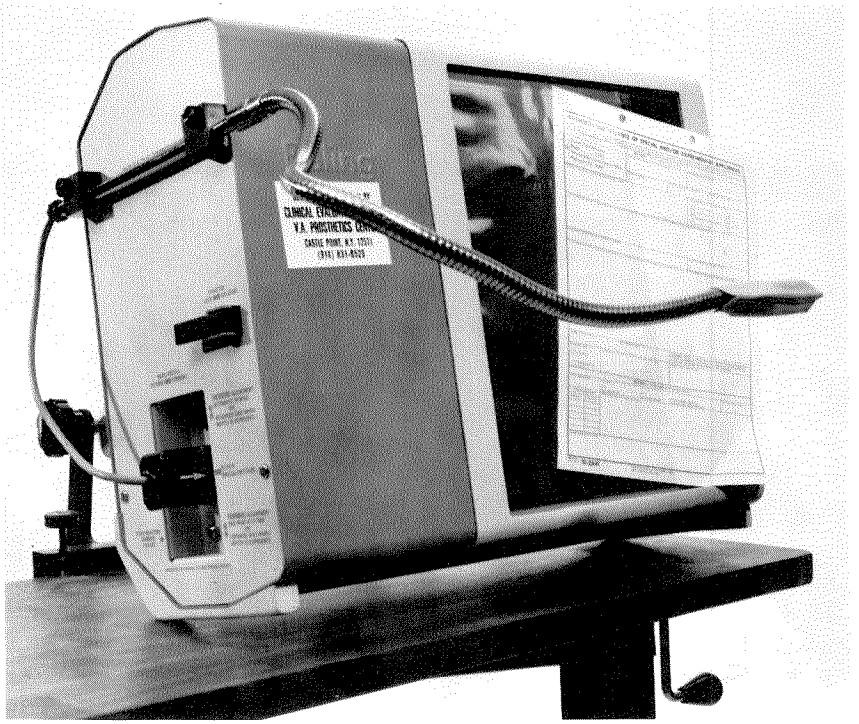

FIGURE 2.—Saltus Reading System. Lengthwise split in the transparent scroll pocket makes it easier to insert reading material.

forward and backward.

(c) Forward Adjustment Double-Throw Switch—A switch on the lower right-hand corner of the recessed control panel operates the spool either one page at a time or continuously while the switch is depressed.

(d) Reverse Adjustment Double-Throw Switch—A switch in the upper right-hand corner of the recessed control panel either automatically rewinds one page at a time or continuously while the switch is depressed.

4. The Saltus Reading System is now available in blue, yellow, green or rust.

The changes made in the Saltus Reading System should reduce loading time considerably, and its optional mouth switch should be

of practical value for independent use by high-level quadriplegics.

The Saltus Reading System is mechanically and electrically safe. It offers those with upper-limb paralysis a degree of reading independence. Its advantages over some page-turning devices are that it operates reliably once it is set up, and it can be easily adapted to various user controls, including interfacing with an environmental control system.

These advantages are achieved at the expense of considerable loading time and the necessity to purchase publications in duplicate. It is therefore recommended that the device be approved for general use by interested veterans and institutions where its advantages as well as its disadvantages are recognized.

3. *Mobility Aids*

a. *Freewheeler Power Wheelchair.* The Freewheeler Power Wheelchair (Fig. 3), manufactured and marketed by the American Stair-Glide Corp., Grandview, Missouri, (BPR 10-26, pp. 228-229) is a portable, lightweight, aluminum, power wheelchair for paraplegics and low-level-injury quadriplegics.

One unit was evaluated for safety, effectiveness, and usefulness. Engineering tests and clinical trials were conducted at two VA hospitals. The Freewheeler Power Wheelchair was unstable outdoors (on some level surfaces as well as on inclines) and it failed to meet proposed VA safety, dimension, and operation standards for wheelchairs.

b. *Electronic Power Conversion Kit For Wheelchairs.* The Electronic Power Conversion Kit for Wheelchairs (Fig. 4 and 5) can convert most American manual wheelchair models to electrically powered wheelchairs (BPR 10-26, p. 246, and BPR 10-28, p. 102). The device is manufactured and marketed by Solo Products, West Sacramento, California. It consists of left-side and right-side drive assemblies, battery case with attached electronics compartment, hand-operated proportional-control joystick on an adjustable bracket, and battery charger.

One Mark II model was evaluated for safety, effectiveness, and utility as an add-on system to power manual wheelchairs. During the evaluation, the charging circuitry malfunctioned and the company replaced the original Mark II model with their Mark III model. Both models underwent performance tests, and clinical trials of both models were conducted at the VA Hospital, Castle Point, New York, and in the home of an outpatient. While the power package performed adequately, the joystick control was jerky during high-speed acceleration and the dynamic braking of the

FIGURE 3.—Freewheeler power wheelchair.

drive system caused the chair to stop abruptly.

The device was returned to the manufacturer for modifications.

c. *Electric Back-Recliner Kit.* The Electric Back-Recliner Kit (Fig. 6 and 7), manufactured and marketed by General Teleoperators, Inc., Downey, California, converts all electrically powered wheelchairs with semi-reclining backs. After conversion the chair has an electrically powered full-reclining back (BPR 10-28, p. 103).

Two units were evaluated: one by the Dental Service at the Castle Point, New York, VA Hospital and one by a quadriplegic with a disability level of C4,5 who needed the reclining features of a wheelchair to relieve pressure under the buttocks.

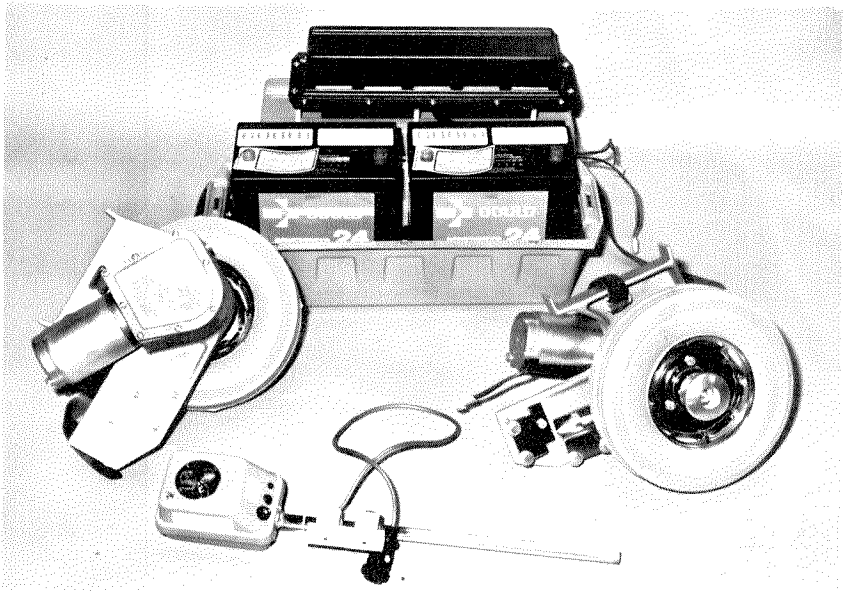

FIGURE 4.—Electronic Power Conversion Kit for wheelchairs.

Both units performed unsatisfactorily. While the back of the wheelchair reclined, the legs remained unraised, thereby producing poor posture. In addition, the control switch for activating the reclining process was overly sensitive, with the result that any degree of carelessness by the user in manipulating the switch caused the recliner back to move in the opposite direction from that desired. This makes it extremely difficult for most quadriplegics to operate the control independently and requires that an attendant be on hand to effect reclining. The Electric Back-Recliner is therefore not recommended for veteran beneficiaries.

d. *Icarus Easy Transfer Wheelchair Attachment.* The Icarus Easy Transfer Wheelchair Attachment (Fig. 8, 9, and 10), manufactured by Icarus Health Aids Ltd., Netanya, Israel, is a permanently attached wheelchair transfer board. The device is unique because, when mounted in its folded position (not in use), it replaces the wheelchair's skirtguard. (The skirtguard must be removed to accommodate the device.)

The device can be used on all standard wheelchairs with removable armrests *except* amputee chairs. It cannot be used on amputee chairs because the brake on the retractable unit cannot reach the wheel on an amputee wheelchair, as the wheelchair's drive wheels

FIGURE 5.—Manual wheelchair converted to electrically powered wheelchair with addition of electronic power conversion kit.

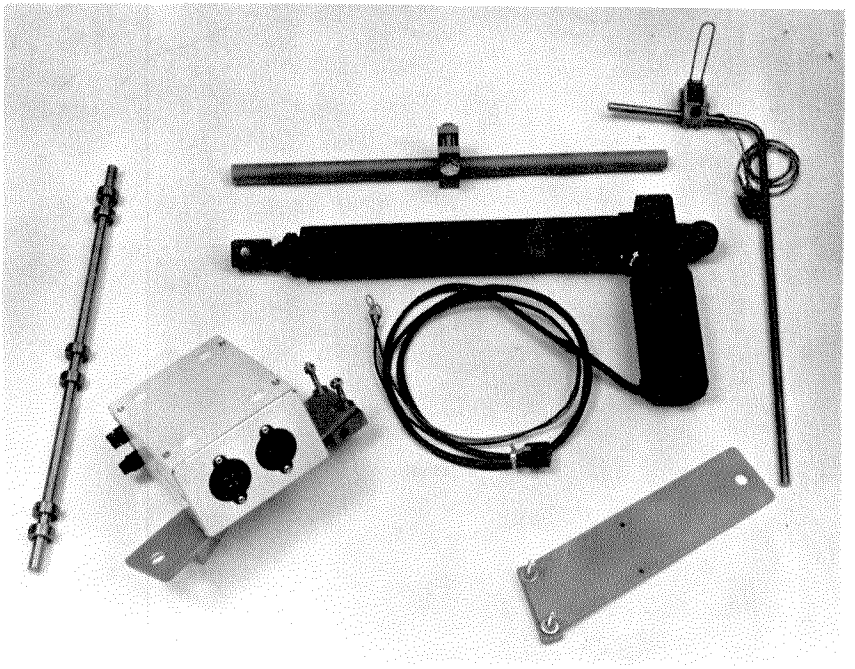

FIGURE 6.—Electric back-recliner kit components.

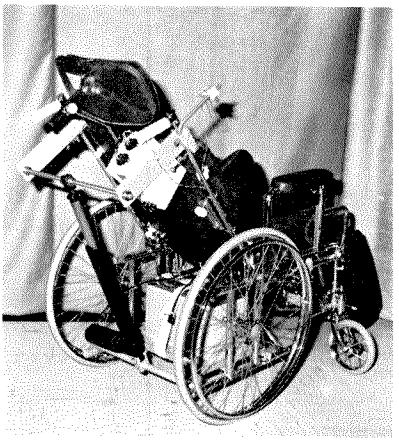

FIGURE 7.—Powered wheelchair converted to full recliner with addition of Electric Back-Recliner Kit.

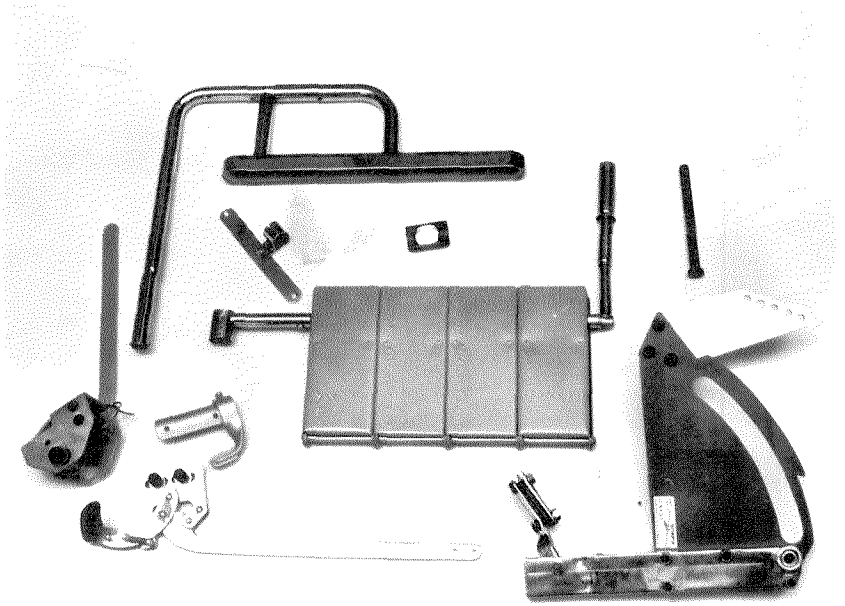

FIGURE 8.—Components of Icarus Easy Transfer Wheelchair Attachment.

are set back too far. Also if the tubular member at the lower rear frame (tipping aid) projects out by more than 4.5 in. (11.43 cm), it would require shortening, thereby permanently altering the chair.

If the user is required to transfer from his wheelchair to an automobile with the device, this can only be accomplished with extensive maneuvering.

The device is currently undergoing clinical evaluation.

e. *Arrow Wheelchair.* The Arrow Wheelchair (Fig. 11) is manufactured by the Erie City Manufacturing Co., Erie, Pennsylvania. It is an inexpensive, manually operated wheelchair. It has a chrome-plated tubular steel frame, with a double-cross flat steel brace structure that is riveted at all joints and welded to the outer tubular frame.

Two Arrow Wheelchairs (Model No. 632) were evaluated for safety, effectiveness and utility. They were checked in accordance with current "V.A. Proposed Standards for Wheelchairs, Self-Propelled, Folding, Multipurpose," and clinical trials were conducted at the VA Hospital, Castle Point, New York. They were returned to the manufacturer with recommendations for improvement.

FIGURE 9.—Icarus Easy Transfer Wheelchair Attachment mounted in folded position.

FIGURE 10.—Icarus Easy Transfer Wheelchair Attachment in transfer position.

FIGURE 11.—Arrow Wheelchair.

FIGURE 12.—Rigal Walker Tray.

f. *Rigal Walker Tray*. The Rigal Walker Tray (Fig. 12) is a folding walker, much lighter in weight than conventional walkers, which can be quickly and easily folded and unfolded. It incorporates a self-contained tray. The device was submitted by its inventor, Mr. Waldo Rigal, Mount Pulaski, Illinois.

The walker underwent supervised clinical trials and laboratory compliance testing, and it did not meet acceptable standards throughout both of these tests (BPR 10-27, pp. 105-106). It was used by several patients at the Castle Point, New York, VA Hospital: these patients unanimously rejected the walker because its design prevented them from walking with proper ambulation techniques. They were required to exercise extreme care in preventing their knees or legs from hitting the device when in use, and the concept of carrying objects on the tray was far from ideal since they tended to concentrate more on the contents of the tray than on their ambulation.

In addition, the Walker Tray was subjected to laboratory tests for compliance with VA Specifications No. X-1460, dated November 27, 1967: it failed to meet specifications on a number of points.

4. *Body Support Systems*

E-Z Patient Turning System. The E-Z Patient Turning System, Model 520 (Fig. 13, 14, and 15), is commercially available from Physical Aids, Inc., El Cajon, California. It is an inflatable, two-section air mattress that is designed to turn a bedridden patient gently from a center, supine, position in the bed to a maximum angle of approximately 45 deg, to prevent decubitus ulcers.

The system employs a laminated air mattress of vinyl and nylon that is sealed down the center to create two halves. A small 20-lb (9.07 kg) air pump that plugs into a standard 110-V a.c. wall socket is used to inflate or deflate the air mattress: each half of the mattress is independently inflated or deflated. The pump shuts off automatically when the mattress is fully inflated.

The device was evaluated in the Spinal Cord Injury (SCI) Service at the Castle Point, New York, VA Hospital. The patient, who was obese, was uncomfortable when the mattress was inflated because his area for movement was limited. In addition, the mattress, which is covered with a heavy material, prevented the air from circulating under the patient, causing him to sweat and develop a skin abrasion.

The device was then evaluated by the VA Hospital, Castle Point, Medical Service staff. One of two participating patients used the device for nine 24-hour days, and the other patient used it for sixty 24-hour days. While the mattress was useful and provided good support for the back, the nursing staff recommended that it should be lengthened to cover the bed completely, and that a timer be incorporated to activate the inflate-deflate cycle at set intervals. This feature would be useful when the nursing staff is busy because it would turn the patient automatically. A patient-operated control

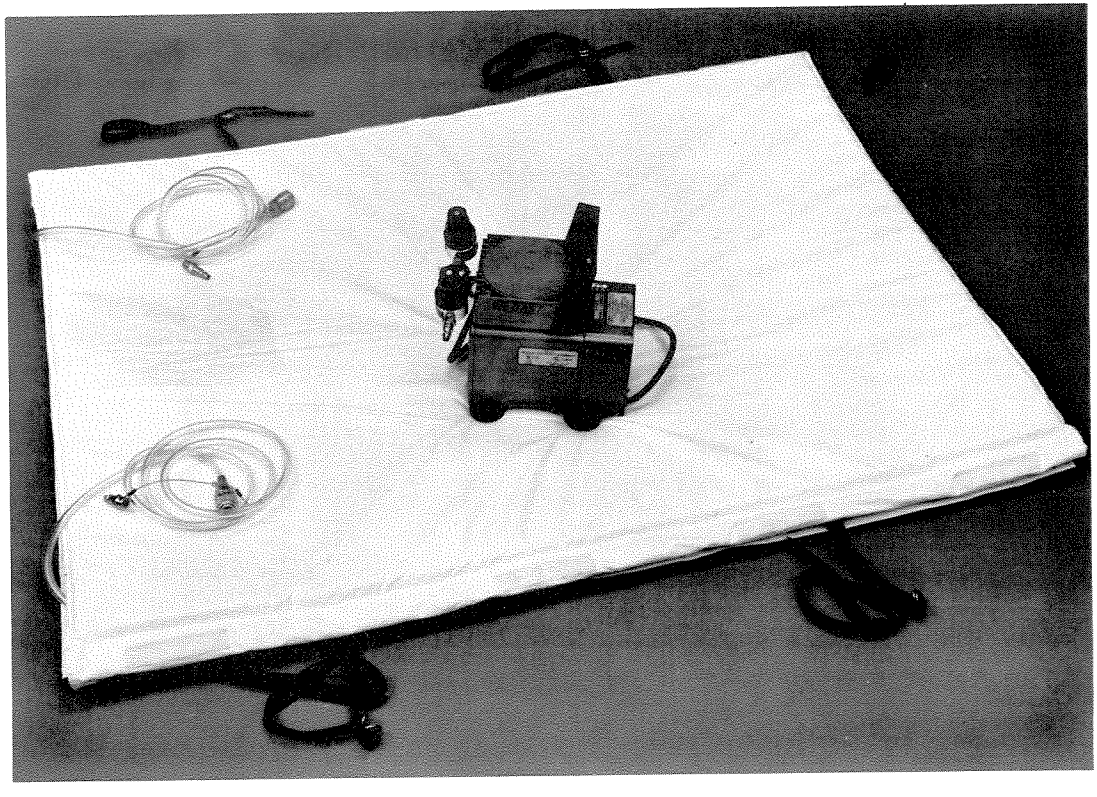

FIGURE 13.–E-Z Patient Turning System components.

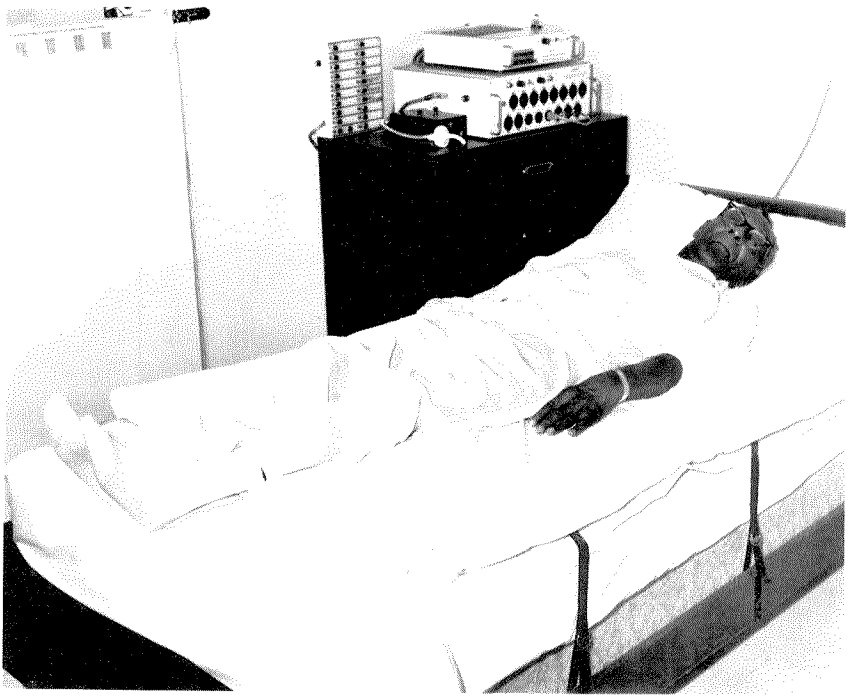

FIGURE 14.—E-Z Patient Turning System, patient in center (supine position).

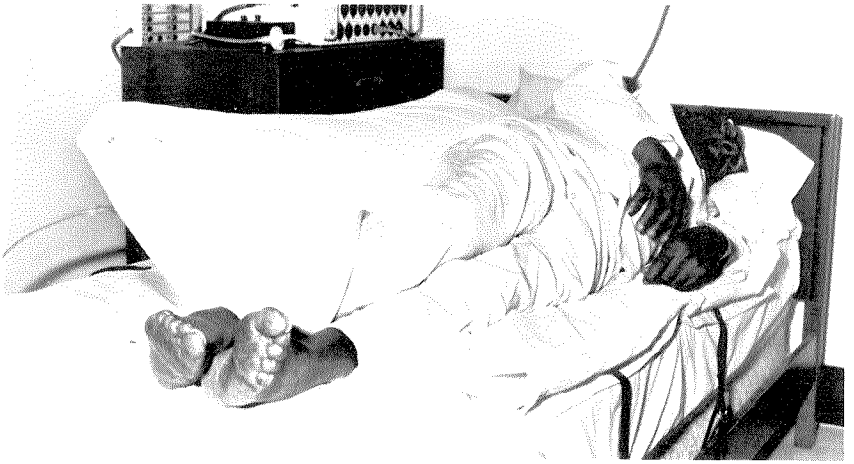

FIGURE 15.—One section of E-Z Patient Turning System inflated to turn patient to maximum of 45 deg.

would also greatly enhance the usefulness of the device.

In each case, the patient had experienced severe pain when turned manually by the staff. By contrast, the slow turning movement of the E-Z Patient Turning System eliminated most of this pain. However, when the device was tried with a multiple sclerosis patient with contractures, it proved to be ineffective.

II. COMPLIANCE TESTING

A. Standards Development

The third draft of "Standard Functional Requirements For Lower Limb Prosthetic Assemblies & Components," incorporating the recommendations of the Philadelphia ISPO Conference, has been reviewed by the participants (see BPR 10-18).

The draft, including comments and corrections from the conferees, was forwarded to the ASTM Committee on Orthotics and External Prosthetics (F-19). This committee, a peer group including VAPC personnel, was chartered to promulgate American standards that are arrived-at by consensus.

B. Compliance Testing

Corset Material

Four manufacturers submitted coutil fabric samples (3 each) for shrinkage tests: Camp International, Jackson, Michigan; Kellogg Industries, Inc., Jackson, Michigan; Medipedic Surgical Supply Co., Warrior, Alabama; and ATCO Surgical Co., Cuyahoga Falls, Ohio. All of the samples complied with the specifications contained in Solicitation No. 5244-11-78.

III. THE VAPC CLINIC TEAM

The breakdown in Table 1, of the veterans treated by the VAPC Clinic Team for the latter half of 1977, represents a typical 6-month case load that is similar to those presented in previous issues of BPR. Of the total number treated, 5 were World War I veterans, 386 were World War II veterans, 10 were Korean War veterans, 142 were Vietnam War veterans; 465 were treated for effects of service-connected injuries and 78 for non-service-connected problems. In addition, there were 5 Israeli, 1 Australian, and 1 Ex-Imperial veterans, and 2 non-veterans on an experimental basis.

TABLE 1. *Breakdown of Patient Disabilities July 1 to December 31, 1977*

Amputation		
Area of involvement	Specific level of involvement	Number of patients
Lower-limb unilateral	Below-Knee	175
	Above-Knee	122
	Transmalleolar (Syme's)	3
	Hip (Disarticulation)	7
Lower-limb bilateral	Below-Knee	18
	Above-Knee/Below-Knee	5
	Above-Knee	11
	Transmalleolar (Syme's)	2
	Below-Knee/Transmalleolar (Syme's)	1
Upper-limb unilateral	Below-Elbow	10
	Above-Elbow	4
Upper-limb bilateral	Above-Elbow	5
Lower-limb and Upper-limb	Above-Knee/Above-Elbow	2
	Above-Knee/Shoulder (Disarticulation)	1
Triple	Above-Knee/Below-Knee/Below-Elbow	1
	Above-Knee/Above-Elbow/Below-Elbow	1
	Below-Knee/Below-Knee/Below-Elbow	1
		369 Total
Neuromuscular or Skeletal Impairment		
Lower-limb unilateral	Ankle-Foot	111
Lower-limb bilateral	Ankle-Foot	8
	Knee-Ankle-Foot	10
Upper-limb unilateral	Arm-Elbow-Forearm; Wrist-Hand	9
Trunk	Lumbosacral spine	5
Miscellaneous	Varied (wheelchairs, shoes, etc.)	34
		177 Total

ERRATUM

The illustration used to depict the E-Z Way Chair Lift in BPR 10-28, p. 126, is in error. The illustration shown is that of the Compass Van.