TECHNICAL NOTES

"Technical Notes" in the Journal of Rehabilitation R&D most often originate when an investigator, in the course of his research, pauses to record the details of a device and/or procedure which has contributed materially to furthering the scientific purposes of his research. We publish them in the hope that they will become part of the universal exchange of scientific instrumentation and device "shop talk."

"Technical Notes" found in the Journal will usually lack controlled comparison studies vis-à-vis alternate ways of accomplishing similar ends; they are clearly not complete reports of scientific research. Nevertheless, they are thoughtfully reviewed by members of our editorial board and by such ad hoc reviewers as may seem appropriate, in order to assure you of their originality, technical correctness, medical appropriateness, etc.

Multistate Myoelectric Control: The Feasibility of 5-State Control[a]

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Introduction *— From the earliest publication on myoelec-*control (1), there has been sustained interest in achieving control of more than one active function from a single muscle remnant. The Bio-Engineering Institute of the University of New Brunswick has concentrated its development efforts almost exclusively upon multistate myoelectric control. In its 3-state control system (2), function selection is dependent upon the magnitude of the processed myoelectric signal. This technique has been used as well by Schmidl (3) and by Childress (4). Surprisingly, there is no evidence that this "unphysiological" control technique is more difficult for the patient to learn than the more "natural" control in which each muscle remnant activates a single function. Indeed, it has been reported that some young patients have found it easier to learn to use this system than the more conventional two-muscle system*. Another technique for controlling two functions from a single muscle makes selection dependent upon the rate of increase of the signal. That method was employed originally by Reiter (1), and more recently by Sörbye**, and is now available in a system developed by Otto Bock.

Encouraged by the clinical success of 3-state systems, the Bio-Engineering Institute began in 1977 to investigate the feasibility of 5-state control (providing selection of 4 active functions plus an inactive or "off" state). As with the 3-state system, anticipated clinical need is primarily in applications where the amputee has few muscle remnants available as control sites—for example, in interscapulothoracic amputation. The system may be used as well in less extreme cases to provide, for example, control of prehension and wrist rotation for a short below-elbow amputee having only a single control site.

An initial laboratory investigation of operator error in a 5-level pursuit tracking task, with continuous visual feedback, yielded equivocal results (5). However, further research with modified decision boundaries yielded much more encouraging data (6).

In contrast with a 3-state system, in which the operator can achieve error-free control without any feedback other than observation of the controlled device, a 5-state system requires some "state feedback" to indicate to the operator, prior to activation, which function has been selected. In the research mentioned above, the feasibility of 5-state control without continuous visual feedback, and the value of electrocutaneous feedback to identify selected states, were demonstrated. While in that research electrocutaneous feedback was used to confirm two of the active states, further studies indicated that provision of feedback for the 2nd active state only might be adequate (although not necessarily optimal). This arrangement was chosen for initial testing, and a 5-state control system constructed.

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*M. Marshall; private communication concerning patients trained at Ontario Crippled Children's Centre; 1980.

**Rolf Sörbye; private communication concerning current research in Örebro, Sweden; 1982.

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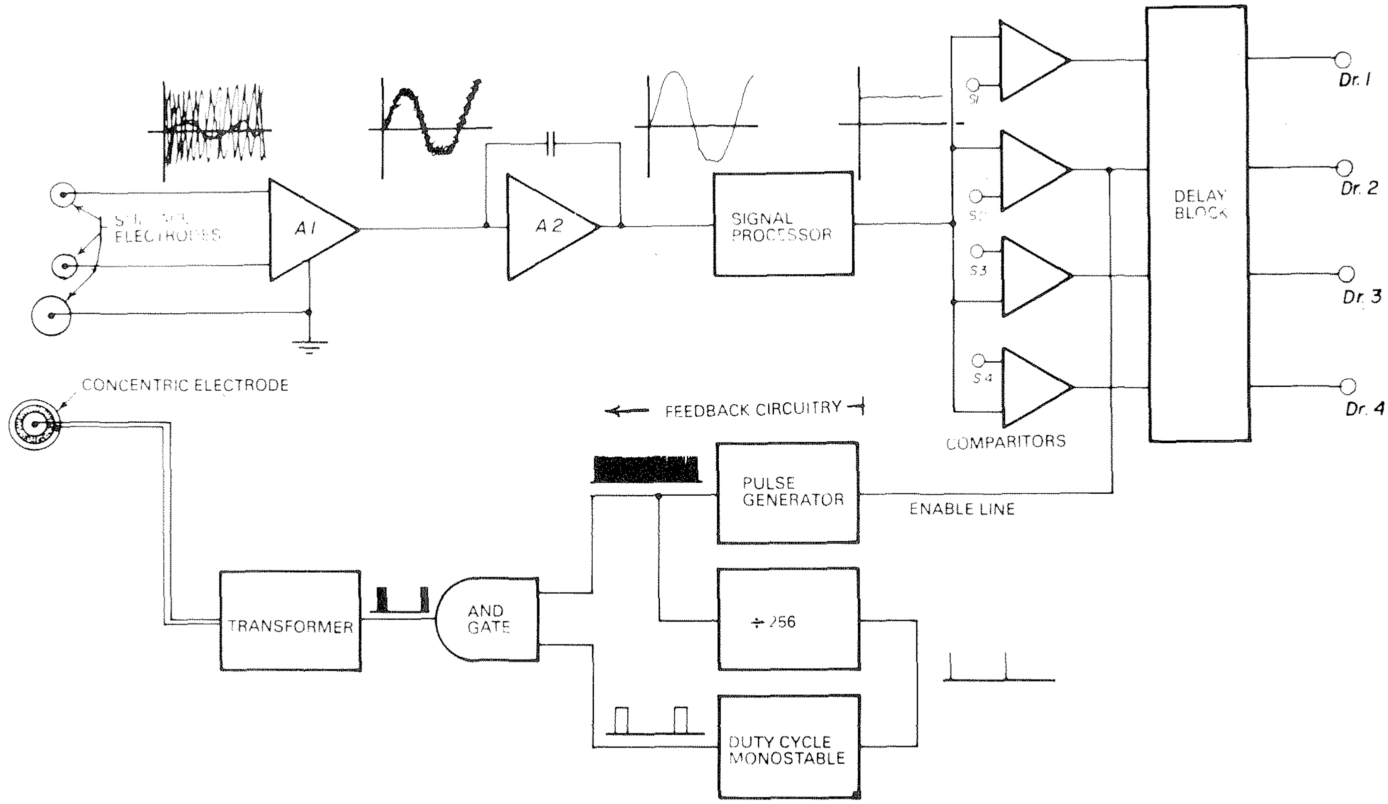

FIGURE 1.
Block diagram shows major components of the 5-state myoelectric control system (at top) and below it the feedback circuitry. State feedback provided by this circuit supplies an electrocutaneous stimulus which informs the wearer immediately whenever drive enable line 2 is selected. The delay provided in the system's activation response gives the operator time to react to the feedback and alter the myoelectric signal level, if necessary, prior to activation of the prosthesis.

A 5-State Control System

The Circuit—Figure 1 is a block diagram showing the major components of the 5-state myoelectric control system. The myoelectric signal is amplified and processed through a full-wave rectifier and low-pass filter, giving the mean absolute value of the myoelectric signal. The rectifier has a very small dead zone, (10 mV), and the low-pass filter time constant is 150 ms.

The d.c. output from the processor is compared to four exponentially distributed switching levels, S1—S4. These switching levels are selected according to the method developed by Parker et al (7) and subsequently modified slightly (6), to use optimally the dynamic range between resting "noise" level and the myoelectric signal at a firm contraction level. The active states are assigned as shown in Table 1 on the basis of expected frequency of use and probability of error in state selection as determined from the tracking measurements.

A drive enable line is selected when the processor output exceeds the corresponding switching level and maintains a value less than the next switchng level. Activation of the drive enable line is delayed by 300 ms, to allow the operator to move from one state to another without activating those states lying between.

The delay in activation is essential also in the use of electrocutaneous stimuli for state feedback, which in this system is provided for the second active state only. When drive enable line two is selected, the feedback stimulus is turned on immediately. The delay in activation gives the operator time to react to the feedback and alter the myoelectric signal level (if necessary) prior to activation of the prosthesis.

The feedback circuitry consists of a pulse generator, a divide-down register and a monostable multivibrator. The pulse generator runs at a rate of 3.3 kHz which is subsequently divided down to a rate of 13 pulses per second. The resultant pulse widths are then set to a duration of 10 ms by the monostable multivibrator. The output of the monostable is then gated with the pulse generator output. The result is modulation of the 3.3 kHz carrier, yielding 13 pulse bursts per second with each burst having a duration of 10 ms, consistent with earlier studies of acceptable stimulus characteristics (8). Transformer coupling of the stimulus to the patient, and use of a concentric stimulating electrode, provide isolation from the myoelectric signal-detection circuitry.

Operation

Setup involves measuring the dynamic range of the operator's myoelectric signal at the control site and setting the switching levels as discussed. The intensity of the electrocutaneous feedback is set at a comfortable level.

The following explanation is provided to new operators, to help them locate the desired states.

All functions may be turned off by relaxing the muscle. The first active state (Table 1) is found by contracting the muscle slowly until the hand starts to close. The hand will continue to move as long as the contraction level is maintained. The second active state is found by increasing the contraction until the stimulus comes on and then holding that level. The third is found by contracting up to just beyond the point where the stimulus turns off. The fourth is found by contracting the muscle firmly.

Operators are encouraged to return to the off state before attempting to enter another active state. This helps to reduce operator error (6) and reduces frustration in early training.

Testing

Seven normals have been trained on the prototype 5-state control in the laboratory. Training periods were one hour per day for one week. All could operate the hand and wrist rotator with reasonable skill after two days of training. By the end of the training period, errors (defined as activation of undesired functions) were typically 5%–10% of commands. Accidental activation of the wrist rotator was the most common error.

The single amputee to evaluate the system in the laboratory has a congenital left terminal transverse hemimelia, short below-elbow, and was 48 years of age at the time of testing. She had been fitted in 1975 with a UNB-designed 3-state system and is considered to be a good wearer but a moderate user of her prosthesis.

The evaluation involved seven half-hour sessions over four consecutive days. On the first day, myoelectric signal levels were determined and a demonstration was given of the feedback stimulator. For the (six) subsequent sessions, myoelectric control electrodes were affixed temporarily at the sites used for her accustomed control system, and the stimulating electrode was affixed near the ground electrode on the opposite side of the stump. No prosthesis was worn; instead, a dummy prosthesis consisting of an Otto Bock electric hand and wrist rotator was used, on the bench, for the 5-state system evaluation.

This patient noticed immediately that the response of the 5-state system was slower than that of her normal myoelectric prosthesis, a fact caused by a longer filter time constant and a greater activation delay. After some empirical adjustment of switching levels on the second day of training, reasonably good performance was achieved. By the end of training she seemed to be utilizing the electrocutaneous feedback effectively, and did not require excessive concentration to control the system, being able to carry on a conversation while operating the system without significant degradation of performance. Her error rate at the end of training was 5%–10%.

One significant problem encountered by this amputee subject was a tendency for the control muscle to change position relative to the electrodes in response to a strong contraction. This had not been noted as a problem with her 3-state system, either because the socket provided significant stabilization or because her 3-state system is not so sensitive. (However, the observation may contribute some evidence of the potential value of muscle fixation by myodesis or myoplasty in amputation surgery.)

TABLE 1.
Assignment of active states

Active State	Function
1	Hand Closing
2	Hand Opening
3	Pronation
4	Supination

Conclusion

This work is at a very early stage, and is reported primarily to inform other investigators, who may have related interests, of the early findings in this laboratory.

In these investigations it has become evident that additional tracking studies must be carried out in order to refine the optimization of switching levels. The present technique is based upon the assumption of zero operator error in generating the control signal (7); the necessity of tampering with the resulting settings in order to improve performance (as noted above) is evidence that this assumption is inadequate to meet the demands of the 5-state system. This had been noted previously by the authors (6). As well, before further work is attempted with patients, some improvements should be made to the experimental apparatus, and it is intended to fit the control system into a complete prosthesis for such evaluation studies.

Nevertheless, these results do show that 5-state myoelectric control is feasible, and that it may prove to be of clinical value.■

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Locomotion via Paralyzed Leg Muscles: Feasibility Study for a Leg-Propelled Vehicle[a]

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Abstract — Functional electrical stimulation has been used to restore some degree of controllable movement to paralyzed muscle. The purpose of this study was to demonstrate the feasibility of using electrically stimulated paralyzed leg muscles to propel a wheelchair-type vehicle. For this, a conventional manual wheelchair was modified by the addition of a drive system which permits forward propulsion by reciprocating movements of the legs. A battery-powered electrical stimulator using surface electrodes over the quadriceps muscles controls locomotive characteristics. This vehicle has been successfully operated by paraplegic and quadriplegic test subjects. Advantages of using paralyzed leg muscles for locomotion may include improvement in locomotive capability, circulation in the lower extremities, cardiovascular and respiratory fitness, strength and size of the exercised muscles and bones, and self-image.

Introduction

Since skeletal muscle paralysis is often considered permanent, a major philosophy in the rehabilitation of paralyzed individuals urges efforts to make compensatory use of functional muscles. Thus, in cases of lower-limb paralysis, wheelchairs which are propelled by the upper-body musculature are frequently prescribed. The conventional handrim-operated wheelchair, however, has been reported to be inefficient and stressful to the muscular, cardiovascular and respiratory systems (1,2,3,4). These stresses could discourage locomotion, which is undesirable because the sedentary lifestyle of many wheelchair-dependent individuals can contribute to a further loss of physical fitness (5,6). Furthermore, wheelchair confinement can lead to other problems, including the following: poor circulation of blood in the lower extremities which may in turn result in thrombus formation and decubitus ulcers; wasting of paralyzed limbs (due to muscle atrophy and bone demineralization) which may increase the likelihood of injuries; and deterioration of one's self-image.

FIGURE 1
Leg-propelled vehicle during use by a paraplegic individual.

To improve the rehabilitation of paralyzed individuals, recent research has been aimed at restoring some degree of function to paralyzed muscles via electrical stimulation (7). Functional electrical stimulation (FES) has been used to exercise paralyzed muscles (8,9,10) and permit them to perform rudimentary tasks to assist in ambulation (11,12,13). Ultimately, use of paralyzed muscles for free walking should be possible if many technological and physiological problems could be solved relating to: fitness of muscles, bones and joints; fine control and coordination of multiple muscles; obtaining necessary motor (efferent) and sensory (afferent) signals for regulating activity and maintaining posture and equilibrium; and miniaturization and implantation of required electronic circuits (7).

Because of the extensive problems involved in using paralyzed muscles for free walking, it seems reasonable to develop an **intermediate** system in which electrically stimulated paralyzed muscles could be used for locomotion—in a sitting position. It was therefore the purpose of this project to develop a wheelchair-type vehicle which could be propelled via simple movements of electrically stimulated paralyzed legs. This leg-propelled vehicle (LPV) system could, potentially, alleviate many of the problems associated with conventional arm-propelled wheelchairs, while helping to develop and maintain fitness of the paralyzed legs.

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Subjects

College-age paraplegic (N=4) and quadriplegic (N=2) volunteers have been used to evaluate capability of using electrically stimulated paralyzed leg muscles to operate the LPV. These subjects were relatively free of lower motoneuron damage, and did not suffer from cardiovascular, pulmonary or other impairments which would contraindicate participation. This project has been approved by the Human Subjects Research Committees of Wright State University and Miami Valley Hospital.

Methods

Leg Propelled Vehicle — The LPV during use by a paraplegic individual is illustrated in Fig. 1. To facilitate construction of the LPV, an Everest and Jennings "Universal" model wheelchair was modified. This permitted use of the original frame, hammock seat, large handrim operated drive wheels, and the swivel casters. The casters were moved; the LPV is essentially a three-wheeled system with the weight distributed between the two drive wheels and a centered front swivel caster. The second swivel caster, now centered in the rear, usually remains about 2 cm above the ground and prevents backward tipping with forward acceleration. The primary additions to the wheelchair were two moveable footplates which were coupled to the drive wheels via ratchet-type transmissions. (Figure 2 provides a close-up view of the modified wheelchair and the ratchet drive system.) With forward extension of the legs, the pawls of the ratchet systems engage, causing forward rotation of the drive wheels. With backward movement of the legs, the pawls of the ratchet systems disengage, permitting the drive wheels (and vehicle) to coast forward. Since a separate ratchet transmission is used for each drive wheel, forward locomotion can be accomplished with synchronous or asynchronous reciprocating movements of the legs. Large-radius steering can be accomplished by consecutive movements of a single leg.

Figure 3 provides a line drawing of the LPV ratchet drive system. Illustrated are the following: (A) moveable footplate which slides along two steel rods by way of linear ball bearings; (B) pivotally mounted drive levers; (C) ratchet pawl; and (D) drive gear which is attached to the drive wheel. The top view shows the foot in the resting (backward) position. In that position, the ratchet pawl is disengaged from the drive gear and the vehicle will roll freely. This permits coasting, as well as retaining the use of the conventional handrim drive system for forward or backward locomotion. The bottom view shows the foot as its moves forward during electrical stimulation of the quadriceps muscle group. The foot's initial forward movement engages the pawl into the drive gear. Then, the pivotally mounted drive levers cause circular movement of the pawl mounting lever, which results in rotation of the drive gear for forward propulsion of the vehicle. When electrical stimulation ceases, the foot returns to the resting position by way of gravity, because of the slight upward angle of the footplate. Thus, only stimulation of the leg extensor muscle is required to operate this LPV. As

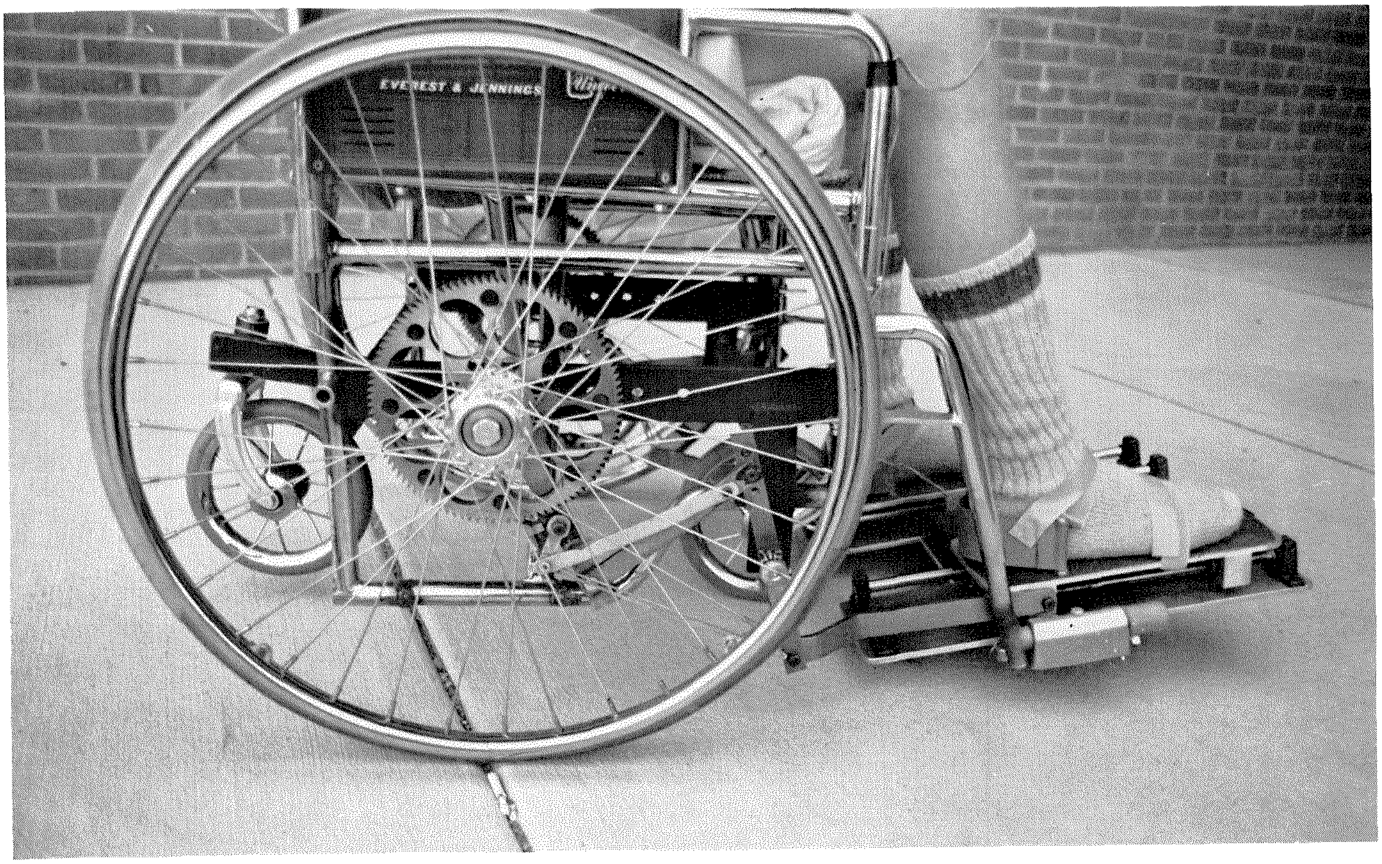


FIGURE 2
Close-up view of the modified wheelchair and the ratchet drive system.

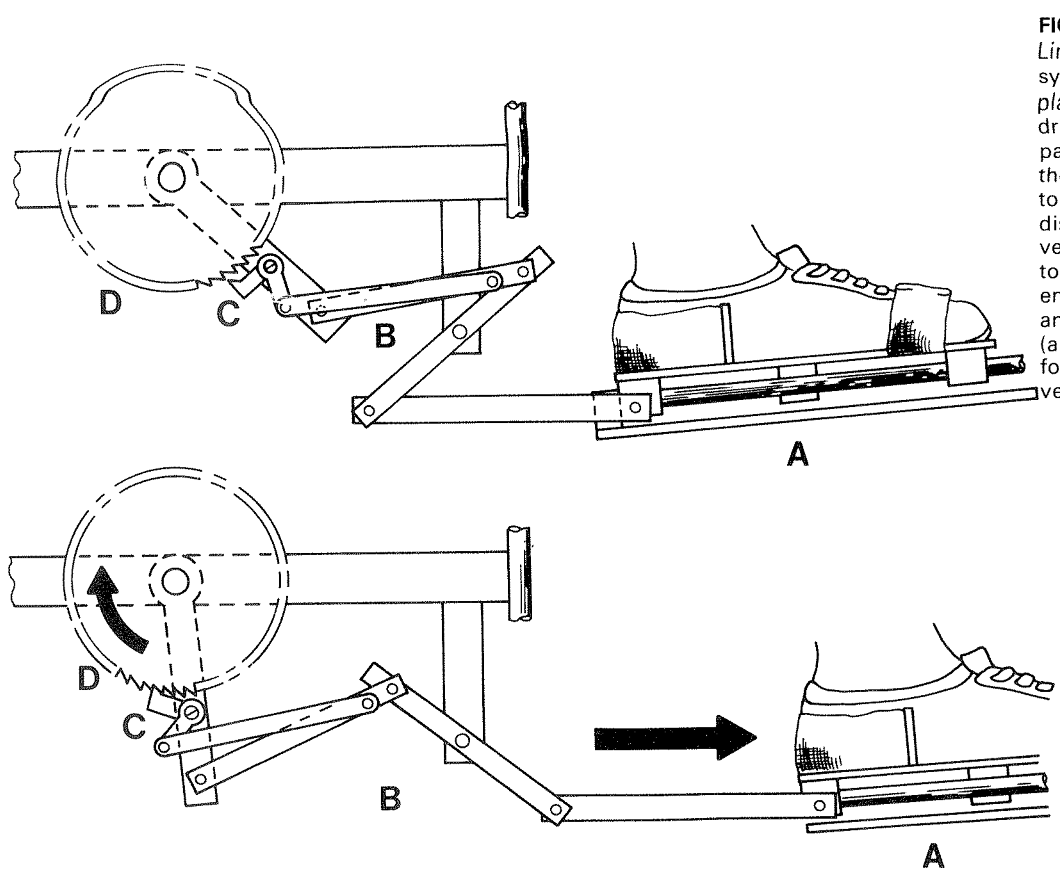


FIGURE 3
Line drawing of ratchet drive system. (A) moveable foot*plate; (B) pivotly mounted* drive levers; (C) ratchet pawl; (D) drive gear. At top, the foot is in the resting positon and the ratchet pawl is disengaged permitting the vehicle to roll freely. At bottom, the foot moves forward, engaging the ratchet pawl, and causing the drive gear (and drive wheel) to rotate for forward movement of the vehicle.

a precaution against ankle injury with powerful muscle contractions, foot-ankle and/or knee orthoses are worn during operation of this vehicle when appropriate.

Electrical Stimulator System — A two-channel, battery powered electrical stimulator, which mounts upon the LPV (Fig. 1), was constructed. This stimulator was designed to permit independent manual control of stimulus amplitude (0 to 150 milliamperes at 67.5 or 135 volts) and of pulse width (10 to 1000 microseconds) for each leg at a common frequency which can range from 20 to 125 Hz. Three skin-surface electrodes (3M Company) are provided at each stimulator channel output—an anode (common) and two cathodes (active). The anode is placed just proximal to the patella. The cathodes are placed over separate motor points of the quadriceps muscle group, which elicit desired movements at the lowest threshold voltage levels. Although the frequency of muscle stimulation may be set between 20 and 125 Hz (typically 60 Hz), voltage application to the pair of cathode electrodes sequences back and forth. Therefore, individual muscle fibers are being stimulated at one-half of this rate, which may delay the onset of fatigue while maintaining smooth contractions (14,15).

Figure 4 provides a functional block diagram of the LPV electrical stimulator system. The circuitry employs CMOS digital logic and single supply operational amplifiers which operate from a small 9-V battery. Small radio "B" batteries provide the high voltage output. The stimulator consists of three basic sections: pulse generation, high-voltage output, and control. For pulse generation, a clock whose output is adjustable from 40 to 250 Hz is used. This clock feeds into a divided-by-four counter which provides four sequential pulses. Outputs 0 and 2 are used for the right leg stimulator channel, whereas outputs 1 and 3 are used for the left leg stimulator channel. The pulses for each channel are 180 deg out of phase. Because of the similarity in circuitry for these channels, only the right leg channel is illustrated.

To generate pulses of the desired width, an OR gate at the counter output pair feeds into a monostable multivibrator. By ANDing the multivibrator output with the original counter pulses, two alternating pulses, 180 deg apart and of the desired width, are generated. The stimulator output amplitude is controlled by a dual potentiometer between the AND gates and voltage-follower operational amplifiers. The voltage followers drive high-voltage switching transistors through analog switches. Thus, control of stimulator output occurs at this point. Also in series with these drive lines are high-voltage protection diodes (to protect against a back flow of current from the high-voltage to the low-voltage circuitry) and output current-limiting resistors (150 milliamperes max). The collector of each output transistor is connected to an active cathodal electrode which is placed over a motor point of the quadriceps, whereas the common anodal electrode is connected to the positive terminal of the battery high-voltage source. Thus, activating the analog switches causes the high-voltage switching transistors to conduct, which completes the circuit between the high-voltage battery and the electrodes. This results in a stimulatory current flow through the skin and underlying tissues. Note that the stimulator "ground" must be kept isolated from the subject and from all other electrical circuitry to prevent potentially hazardous electric shocks. At a typical pulse width of 200 microseconds, using 30 cm^2 electrodes, the peak transcutaneous current density will be 5 milliamperes/cm^2, and the average current density (at 30 Hz per electrode) will be only 30 microampere/cm^2. No electrode burns have been encountered with this system.

The stimulator control system consists of manual and automatic circuits for regulating the period of stimulation to each leg. The manual section uses three pushbutton switches to activate either the right leg, the left leg, or both legs together. These switches feed into OR gates which in turn activate the analog switches to enable stimulator output. Microswitches mounted near the end of the forward travel of the LPV footplates deactivate these pushbutton switches and cut off stimulation: this protective circuit prevents impacting of the feet at the end of the footplate travel. Using the manual pushbuttons, either synchronous or asynchronous propulsion patterns can be achieved, as well as multiple movements of a single leg for turning the vehicle.

In the automatic mode, the legs can be stimulated either synchronously or asynchronously. A Schmitt trigger, flip flop and AND gates comprise this circuit. The frequency rate of leg extension is set by the time constant of the potentiometer (R_1) and capacitor (C_1) (Fig. 4). Again, protective switching circuitry prevents over-extension of the legs and impacting of the feet.

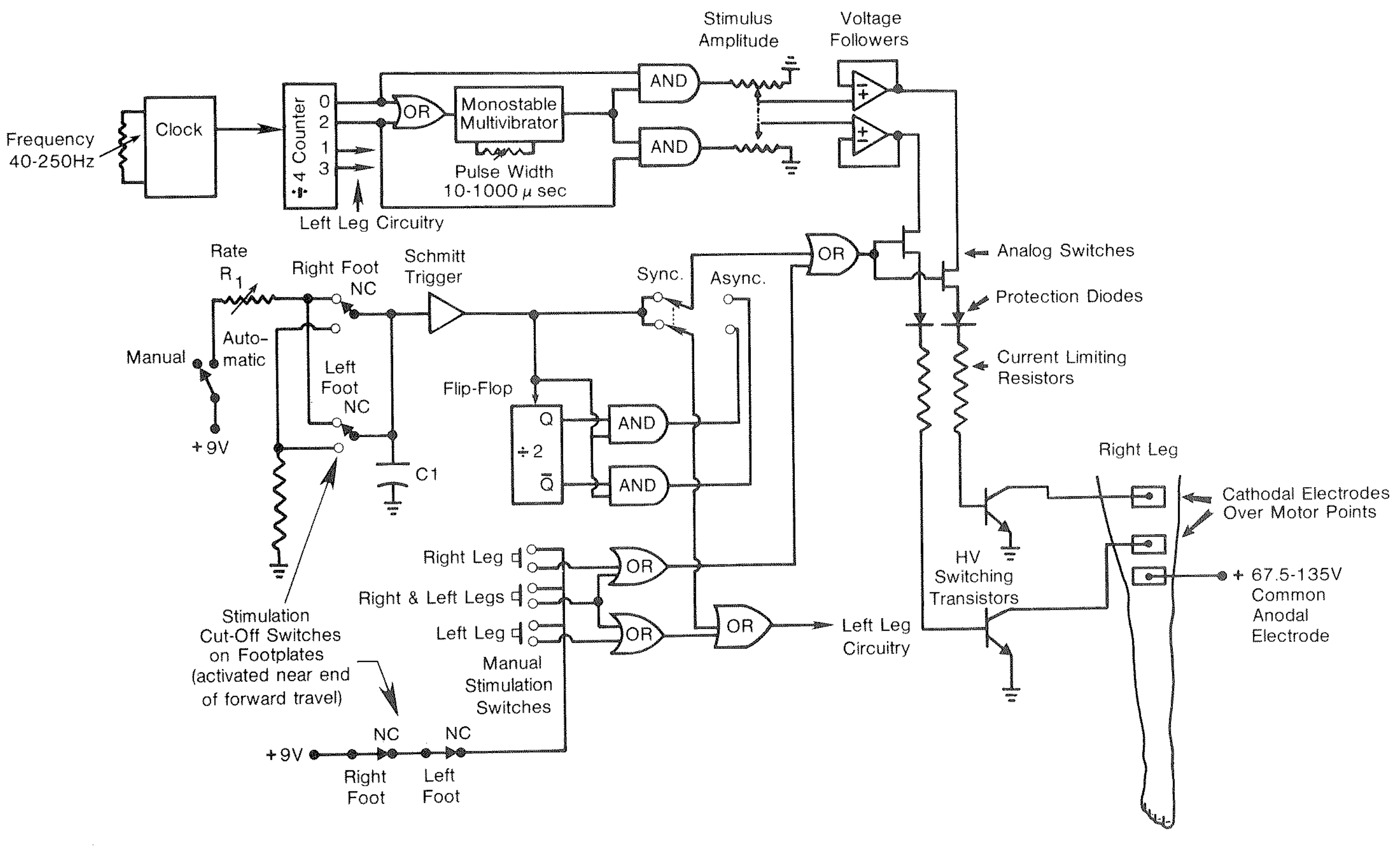
Results and Discussion

A prerequisite for successful FES is that motor units are intact (7). If there is extensive denervation of the muscles, electrical stimulation via skin surface electrodes would not be feasible because of the high current levels required to elicit contractions. Denervation of the quadriceps muscles tends to occur with injuries to the lumbar region of the spinal cord. Therefore, the LPV could potentially be used by the majority of spinal-cord-injured patients since they have higher-level injuries. Most of these individuals will not perceive the electrical impulses, due to disruptions of sensory pathways ascending to the brain. However, even those subjects with sensation do not report serious discomfort using the indicated stimulus parameters.

For a 70-kg individual operating the LPV on a smooth, level surface, about 1.5 kg of force is required to move the footplates forward. Essentially all of the spinal-cord-injured patients that we have evaluated during electrically induced exercise of the quadriceps muscles (more than 25) can easily generate this force—even if they have been paralyzed for as long as 13 years. The current LPV design permits alterations in the drive ratio by changing the pivot points of the ratchet drive levers (Fig. 3B) via multiple mounting holes. Thus, it is possible to adjust the force/velocity relationship in the propulsion system of this vehicle to the capability of the individual user.

Prior to using the LPV, evaluation of the strength and endurance of the electrically stimulated paralyzed quadriceps muscle groups is advisable. In many cases, an exercise

FIGURE 4
Functional block diagram of the LPV electrical stimulator system. Only the right leg channel is illustrated.



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program to condition deteriorated muscles will be required. Recent development of an LPV simulator-ergometer in our laboratories enables this evaluation and conditioning (16). Recent data indicate that conditioning programs for these muscles which incorporate progressive intensity and duration of the exercise result in marked increases in strength and endurance (16). Once sufficient strength and endurance is developed so that the LPV can be used regularly, chronic operation of the LPV may in itself provide exercise conditioning benefits.

During use of the LPV, the level of stimulation is set for each leg so that forward propulsion is achieved without hesitation of the legs. The rate at which the legs are stimulated controls the velocity of movement. As expected, when the LPV requires greater force to operate, or when muscles fatigue during prolonged operation, higher stimulation currents are needed to recruit additional muscle fibers in an attempt to accomplish the task. When the muscles cannot perform the locomotive task at maximal stimulatory current, they are considered fatigued, and will then undergo a rest period. There does not seem to be any adverse effect in regularly exercising these muscle to fatigue.

The LPV as described was designed to test the feasibility of using paralyzed leg muscles for locomotion. **Initial testing with two quadriplegic and four paraplegic subjects** clearly indicates that this concept of restoring movement to paralyzed muscles for the purpose of propelling a vehicle is achievable, and may be desirable considering the potential beneficial effects. In addition to improving locomotive capability, use of the LPV may also do the following: improve circulation of blood in the lower extremities which could reduce the occurrence of thrombus formations and decubitus ulcers; improve cardiovascular and respiratory fitness; increase the size and strength of the exercising muscles and bones which could improve appearance and decrease the risk of injury; and improve self-image.

Design improvements, broader application, considered — The present design of the LPV does not permit small radius steering, reverse operation, or braking when using the legs for propulsion. For these maneuvers, the handrims must be used. Future LPV designs should provide for greater maneuverability. It is conceivable that a microprocessor-based stimulator system (15), with a joystick type controller and feedback sensors on the drive mechanism, could be incorporated to enable a greater degree of muscle control for more precise locomotive tasks. Such a system could automatically compensate for fatiguing muscle fibers, and changes in the terrain.

Another advantage of retaining the handrim system on the LPV is that both the arms and legs may be used to operate this vehicle simultaneously. Such propulsion could reduce the stresses of locomotion, because greater muscle mass could be brought into use than when using the arms or legs alone. This may also be helpful in maintaining total body fitness.

The LPV may be beneficial for patients who have voluntary leg function, but cannot walk effectively because of weakness, lack of coordination, or orthopedic or other medical problems (17). Many of these non-paralyzed individuals propel conventional wheelchairs with their arms or legs (in the latter case by removing the footrests and either pushing or pulling the wheelchair along the floor with their feet). To determine any advantages of using the LPV for such individuals, we tested several geriatric (up to 95 years old) nursing home patients. Most of these individuals found the LPV to be easier to propel than their usual wheelchairs. We are, however, unaware of commercially available wheelchair-type vehicles designed for leg (or arm and leg) propulsion.

In order to objectively determine locomotive and health benefits for using the LPV, much future research and development needs to be performed. This should be directed toward: (i) improving LPV design; (ii) determining metabolic and cardiopulmonary stresses for operating the LPV via electrically stimulated paralyzed leg muscles in comparison with operating a conventional handrim-operated wheelchair with the functional arms; (iii) determining benefits of simultaneously using both the arms and legs for locomotion; and (iv) determining physical and psychological benefits of using paralyzed muscles for locomotion.

In conclusion: the concept of using electrically stimulated leg muscles for propulsion of a specially constructed vehicle appears to be quite feasible. In addition to greater locomotive capability, many health benefits may be derived from the exercise. The LPV may even substitute, in some instances, for motorized wheelchairs; in these cases, paralyzed muscles would take the place of the electric motor and metabolism would provide the energy instead of a battery ▪

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Traction for the Bilateral Lower Extremity Amputee: A World War II Improvisation

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When skin traction is indicated after first-stage open amputation at double leg or thigh levels, rope traction, utilizing a large paint bucket or similar device rigged as shown in the Figure, enables the patient to freely turn, unassisted, without interruption of the traction forces.

Rigging each stump separately causes the ropes to twist together as the patient turns, compromising traction and requiring assistance, without which the patient is obliged to remain in one position until assisted, and to accept the undesirable consequences of such a confining position. Also, with traction release during assistance there is often attendant stump pain.

In 1944 at the Lawson General Hospital, Atlanta, Ga. (one of the then five WW II Army Amputation Centers) the traction problem became apparent to the writer. It occurred to him that conversion of the two traction lines into a single line of force by interposition of some swivel device could provide a remedy. A handy 2-gallon (7.504 liter) paint bucket readily and effectively lent itself to the purpose. This traction set-up for the double lower-extremity amputee was thereafter routinely used at the Center.

In 1946 one of the writer's colleagues reported (1) our traction experience at the Center, featuring use of a turning device (Inset of Figure) crafted after the bucket prototype, which besides having a somewhat utilitarian appearance had also been somewhat heavy. (The report was made in a publication limited to the military at that time).

In 1950 this traction concept was presented, along with some other innovations, in a scientific exhibit (2) of orthopedic devices at the annual meeting of the American Academy of Orthopaedic Surgeons (AAOS) in New York City.

In this connection it was observed, at a scientific exhibit (3) at the annual meeting of the AAOS in 1973, that photographs of lower extremity double amputee casualties of the Viet Nam War showed them in traction at a U.S. Army Hospital with each stump rigged separately, without the benefit of the above-described traction modification.

Today, one might expediently use a plastic water pail, which would require only the removal of the handle and the making of a hole, centrally, in its bottom, the opening being reinforced with a metal washer on the interior surface of the pail to counter pressure from the rope's knot. If a fabricated device were desired, light, flat stock of aluminum rather than steel could be used.

Although occasion for use of bilateral stump traction sel-

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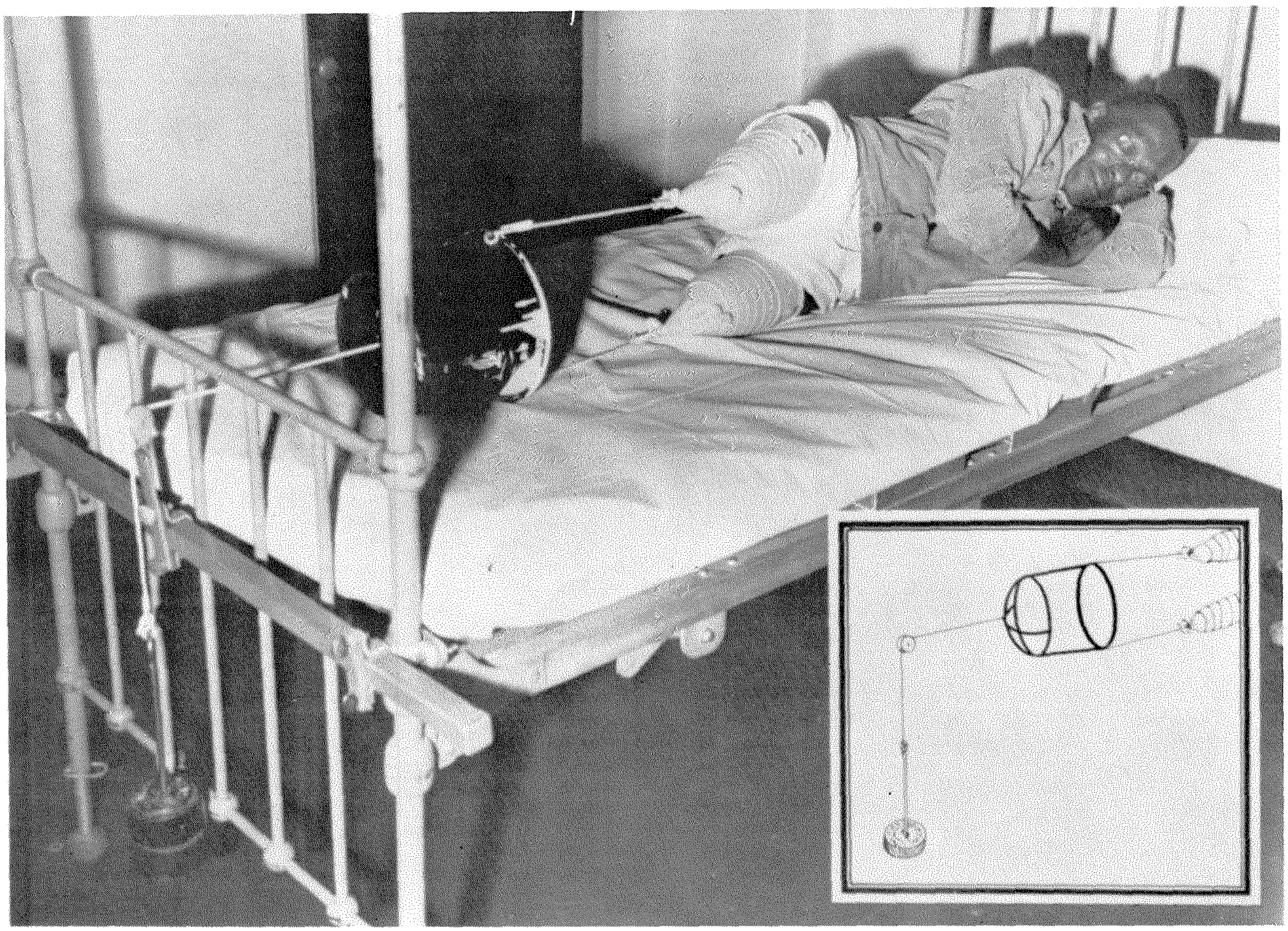

FIGURE 1
Double thigh amputee in stockinette, "Ace-adherent", skin traction. Note paint-bucket swivel device, which converts the double stump traction lines into a single line, allowing the patient free turning without rope-twisting or traction interruption.
Note, too, ventral slits made per routine in the stockinette to permit dressing of the terminal wounds without release of traction.
Inset: Diagram of appliance crafted after paint bucket.

dom arises outside of military or civilian trauma centers, the traction set-up recommended is simple of application in any hospital and it can afford considerable benefit in the early phase of patient reablement ■

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Editorial Comment

Dr. Edward C. Holscher, who contributed this brief paper reminding us of a useful, commonsense way of handling a problem, is a well-known orthopedic surgeon with long experience in amputation surgery and prosthetics. As a Colonel in World War II he commanded an Army amputation center at a time when Surgeon General Kirk had flatly ordered the use of primary amputation and skin traction, followed by later secondary revision and closure. The Surgeon General was, of course, anxious to prevent the gas gangrene that had been so tragically common after previous wartime (or civilian traumatic) surgery.

Although Dr. Holscher clearly intends only to provide a reminder of a useful idea that was at risk of being forgotten, his article was sent out for review in the usual manner. As often happens, the four (orthopedist) reviewers tended to diverge somewhat in their responses, but all produced quotable remarks and it seemed worthwhile to present some of these.

One reviewer, who said he had not used Ed Holscher's method in bilateral amputations, was pleased to discover the idea and said "I think I would use it... if the situation arose again. Another said: "I find the described traction turning device to be a very simple arrangement which may be very easily applied as described in the paper. Indeed, this device may provide the geriatric patient greater mobility to move about in bed."

Two reviewers could not bring themselves to recommend publication of so simple a reminder of a gadget: one of these urged instead the preparation of a more scientific paper reviewing the role of traction in modern amputation practice, justifying its use and specifying the circumstances under which it still is required in the present modern setting... and the description of the device could be included in such a paper.

The other's comment was: "I do find it important to stress frequently the value of, and the need of, appropriate skin traction for open amputations. Many of our young surgeons are not aware of the effectiveness of traction in obtaining sufficient skin for closure with good sensation, subcutaneous fat, etc. This point does need to be continually emphasized."

We also discovered that readers interested in reconciling the concept of early self-care and mobility (using a temporary prosthesis) with the use of skin traction, should refer to Dr. Holscher's Reference No. 3.

The Editors

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