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Technical aids*

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Introduction

The "disabled" represent a population with a wide variety of functional losses. The VA are in complete accord with the idea that each individual has a right to all the help technology can offer at a given time. The range of disability and therefore the needs are enormous; few centres, even in developed countries, have the time or the means to develop technical aids in sufficient quality and quantity to meet all these needs. It is essential to link all centres in the field to avoid costly duplication and repetition of error, to advance development, and improve treatment as rapidly as possible. Some links in this chain of co-operation have already been forged; information about development and evaluations are now being disseminated through such organizations as VA, ISPO and ICTA (ISO).

Technical aids, by which are meant all rehabilitative devices except artificial limbs, are quite different now from what they were perhaps 5 years ago; there are available today an enormous number of devices for the handicapped. Most of the newer ones fall into four major areas:

Mobility aids
Communication devices
Manipulation and control of the environment
Patient handling devices.

Mobility aids

Mobility is one of the fundamental characteristics of the animal kingdom and its loss can be devastating for human beings in modern society. Apart from conventional crutches, canes, walkers, artificial limbs or orthotic devices, there are wheelchairs, licensed vehicles and other mobility aids which are not clearly wheelchairs or licensed vehicles.

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Wheelchairs

Until recently relegation to a wheelchair was an admission of medical failure and so only the most general features of the chair were of concern. Now the wheelchair is looked upon as a rehabilitation tool to replace functional loss. As such, there must be judicious prescription of the most appropriate components from a vast number of options.

Figure 1 (left) shows a manually-propelled wheelchair which represents an archetype of a variety of such devices. Wheelchairs are specially designated as standard, heavy duty, lightweight, amputee chairs, indoor chairs and, more recently, outdoor chairs. Nevertheless all are simply variations on this basic type with special applications based on moderate design changes and a great deal of imagination. The Veterans Administration have developed standards, specifications, and test procedures for manual wheelchairs. These may serve some day as the basis for international standards.

Not too long ago, American medical rehabilitation specialists considered powered wheelchairs too dangerous for use by quadriplegics in hospitals. Today an opposite point of view prevails; their fear of accidents was not well founded. Another philosophical change is the view that a wheelchair is a means of transportation and not principally an exercise device. The basic model upon which most powered wheelchairs have been designed is the joystick controlled type chair.

Many variations of this basic model have been developed for special applications; they feature light weight, foldability, or portability of components. The other end of the scale perhaps is represented in Figure 1 (right), a heavy, expensive "wheelchair" which provides many more functions than the basic type first shown; breath control, joystick control, body

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Fig. 1. Left, typical manually propelled wheelchair. Right, an example of a heavy, multi-purpose wheelchair.

attitude alteration, uneven terrain capability, and a variety of accessories. There is even an increasing demand for wheelchairs capable of travelling at 8 to 11 kilometres per hour. Several such chairs have been designed including a VA version featuring an automatic transmission to achieve high speeds at low power and high power at low speeds.

Perhaps more than anywhere else, standards, specifications, and appropriate test procedures are required to control the safety and quality of electric wheelchairs. Powering conventionally designed wheelchairs may unduly stress them, causing premature structural failure. The most effective types of control systems need to be determined from a range that includes joysticks, breath controls and even eye motion sensors, voice controls and acoustic controls. The VA are developing standards and specifications for these devices and intend to reconcile them with others in the world community.

Multi-purpose mobility aids

Between the wheelchair as a mobility aid and a licensed vehicle such as an automobile or a van, there is yet a third class. These are the devices which provide a number of other functions in addition to the basic one of mobility. Thus we have seen wheelchairs that perform as stretchers and therapeutic aids in enabling a patient to stand erect. Others double as shower chairs and commode seats.

Included in this group are some that are in effect wheelchair transporters. Their underlying use is to enable a wheelchair user to cover distances and speeds beyond the normal ranges and speeds of wheelchairs but short of the ranges and speeds of licensed vehicles. The safety and practicality of these devices must be carefully considered.

Of great significance in this group is a device which enables a wheelchair user to move about in a wheelchair and to stand up independently for activities of daily living, school, or work. Examples of this type are shown in Figure 2. Others enable a patient to move about in a wheelchair, to stand erect independently, and to move about in the erect position independently of the wheelchair.

Licensed vehicles

"Add-on" automotive hand control systems are used by lower limb amputees and those without sufficient upper-extremity strength and range of motion to operate standard motor vehicles. With the exception of mechanical advantage, no form of power augmentation is provided for these systems. The VA have developed standards, specifications and test procedures to govern their quality and safety, which are being adopted by other U.S. agencies. We hope they will also provide some basis for international standards. A new generation of automotive control systems has been developed

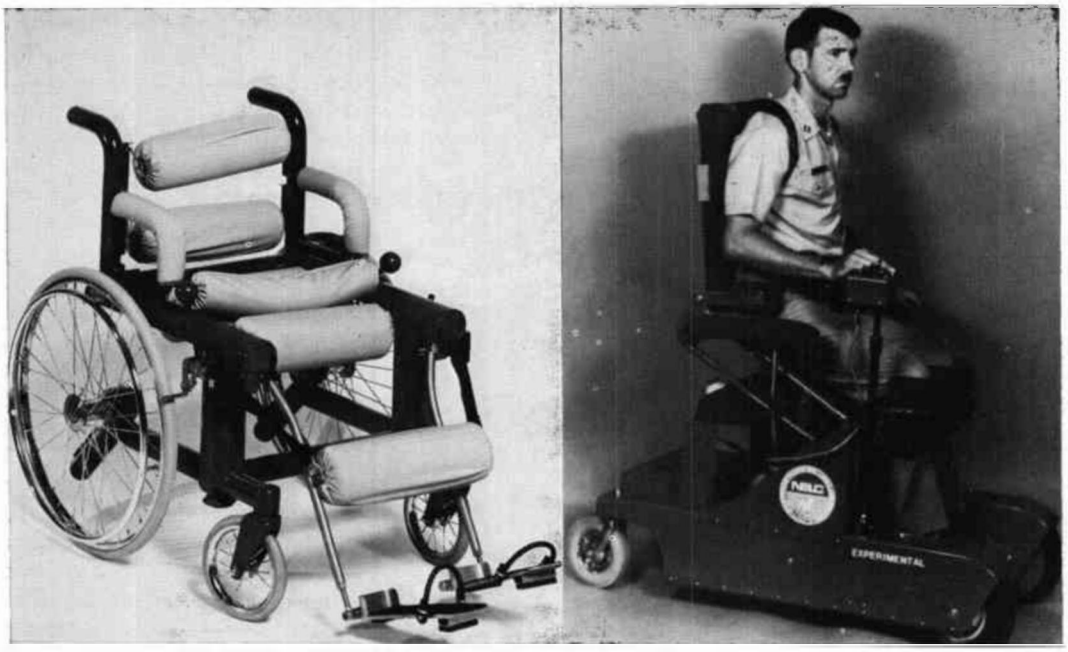

Fig. 2. Left, stand-up wheelchair. Right, powered stand-up mobility system.

to provide alternatives for handicapped drivers unable to use mechanical "add-on" hand controls. Several servo-operated control systems are now being evaluated. One example is the Scott Van; another example is the Lunar Rover (Fig. 3), an adaptation of the joystick controlled vehicle used on the moon. Others are the Sevier Van and a French vehicle controlled by a "fly-by-wire" joystick originally designed for the Mirage jet aircraft.

As persons with increasingly severe disabilities are enabled to drive by means of improved technology, additional problems arise. Among them are designing proper lifts (Fig. 4) to enable wheelchair users to enter and leave a van safely. Another highly important area is the securement of a wheelchair within a van or automobile when used by either driver or passenger in a wheelchair.

Fig. 3. Adaptation of the joystick controlled vehicle used on the moon.

Fig. 4. Automatic wheelchair lift system for a passenger vehicle.

Communication devices

Information transmission

Man alone is characterized by the ability to communicate by speech although he also employs a variety of other means of communication. Inability to communicate by speaking or writing is a catastrophic loss for which little has been done to date. Fundamental research on language disorders due to cerebral dysfunction has not yet led to technological solutions. However, speech disorders not due to cerebral involvement are being helped to some extent by improvement of technical aids. The simplest one presents a picture or symbol to carry a message. A more advanced alphanumeric system and others with a voice output have been developed.

Another communication problem is the inability to read, not because of blindness, but because of paralysis and the inability to handle the material to be read. Figure 5 shows a device to enable such persons to turn the pages of a book. Also available are machines that utilize 35 mm slides to display reading material. Other systems use microfilm and microfiche.

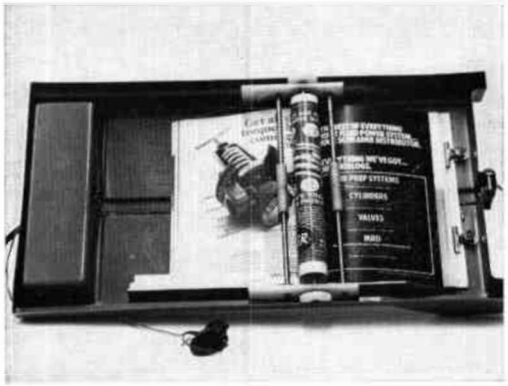

Fig. 5. Page-turning device.

Sensory aids

Apart from long and/or white canes and apart from sound amplifiers for telephones, other devices have been developed to aid both the blind and the deaf.

The Lindsay Russell Pathsounder, a sensory aid for the blind, uses ultrasonic pulses to probe the surroundings. It signals the user by tactile or audible feedback. It must be used with a cane or dog guide.

The C-5 Laser Cane is a VA sponsored mobility aid for the blind. The complete system is self contained. It directs three infra-red beams from a gallium arsenide laser, one upward and ahead, one ahead, and one downward to the ground. Audible indications warn of overhanging obstructions, while objects ahead, discontinuities in the terrain, e.g. curb, are indicated tactiley.

The Sonicguide is an ultrasonic mobility aid for the blind. It should be used with a primary mobility means such as a cane or a guide dog. If objects are present, the user is warned by an auditory signal to an ear-piece (vented to allow transmission of ambient sounds).

The Braille-Output Calculator for the blind was developed by the American Foundation for the Blind. The output is a printout in Braille.

The Speech Plus (Speech+) is a speech output calculator for the blind (Fig. 6). It was developed by Telesensory Systems, Inc.

Fig. 6. Talking output calculator for the blind.

Control of the environment and manipulation

Environmental controls

Amputees and paralytics have lost their ability to grasp, transport, and release objects, the dexterity considered a fundamental human trait such as the large brain, binocular vision, and the apposable thumb. Prosthetic hands or hooks are used as replacements in the case of amputation; splints or other orthotic devices for certain paralytics. The functional loss of limbs compounded by inability to maintain trunk posture and exacerbated by the inability to speak, tragically closes the door to a life limited only by the imagination. New technical

Fig. 7. VAPC Hospital Environmental Control System.

aids may help to replace some of these lost capabilities.

A bed-ridden or wheelchair-bound person still needs to use many common household appliances. The VAPC Environmental Control System, shown in Figure 7, is operated by an actuator which is sensitive to both positive and negative pressures developed in the mouth. The actuator can also be operated by two push-button switches. A monitor, which consists of indicator lamps, displays the appliance under control by the patient. The power and control section completes the system. One model for the home has 20 channels while the one for hospital use has 12 channels. With certain variations there are approximately eight or nine similar systems, some using solid state components. All, however, are grandchildren of the early Possum system.

The state of the art in environmental control systems has been advanced with the recent development of the VAPC Remote Station Environmental Control. It permits a person to move about freely by means of a wireless arrangement.

Patients able to speak may find value in the Voice Operated Typewriter and Environmental Control, developed for VAPC by Scope Electronics, Inc. The system incorporates six interconnected sections or units which permit voice activation of an environmental control and electric typewriter.

Medical manipulators

Remote manipulators were originally developed for handling materials in hostile environments; in nuclear reactors, under the sea or in space. Rehabilitation of the high level quadriplegic person, for example, does not yet include provision for voluntary control of the upper extremities. Orthotic devices are not sufficiently advanced to provide a wide range of useful activities. The most obvious step at the moment is to provide the quadriplegic with a teleoperator or manipulator, e.g. a third arm controllable by whatever residual mechanical motions he can produce such as tongue movement, intra-oral breath pressure or movements of the head. Voice recognition devices are also being used to control the manipulator without physically linking the user to it. Among those developed to date is the VAPC Manipulator (Fig. 8). The basic unit is a telescopic arm which can reach objects within a sphere with a diameter of 2·5 metres while lifting 2 kilogrammes; it is now being modified for control by speech.

As shown, the device is controlled principally by movement of the head or chin. Up to 9 degrees of freedom can be achieved by utilizing a phase shifting lever mounted next to the chin control. The most ingenious element of this system is that the log of input position is proportional to the velocity of the movement of the manipulator terminal device.

The Applied Physics Laboratory of Johns Hopkins University, and the Research Centre for Rehabilitation of Heidelberg, Germany have

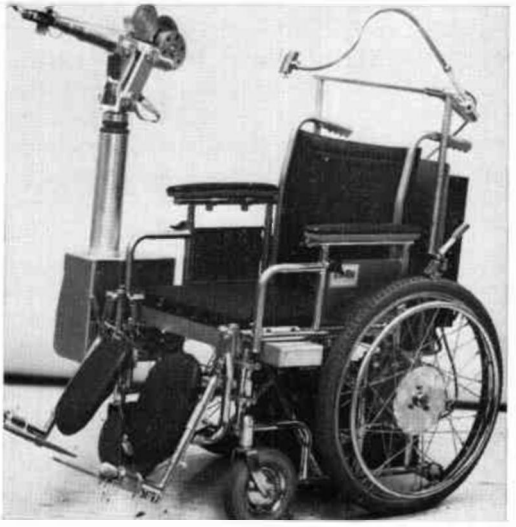

Fig. 8. The VAPC Manipulator.

Fig. 9. Left, the Royalair Fluidized Bed. Right, the Sevier Mobile Bed.

also developed medical manipulators for the seriously disabled person. They are different from the telescoping VAPC design in that both resemble prosthetic arms with jointed segments controlled in a variety of ways.

Patient handling devices

Beds

Several special beds have been developed to prevent decubitus ulcer, improve circulation, and provide mobility.

The Royal Air Fluidized Bed (Fig. 9, left), developed at the University of South Carolina, pumps air through a medium of silicon ceramic beads 74 to 105 millimicrons in diameter, in which the patient is suspended. The whole system is covered by a polyester sheet in which the orifices are smaller than the smallest ceramic bead. Provision is made for temperature and humidity control. A patient sinks in about 100 mm, reducing the maximum pressure on his skin to approximately 10 mm of mercury.

The Egerton Stoke-Mandeville electrically operated Tilt and Turning Bed with Gutman Head Traction Unit permits one attendant to turn a patient on his side, approximately 70 degrees, and to tilt him head or feet down, approximately 15 degrees. Both tilting and turning systems are independent and can be operated at the same time or separately.

The Hess Rotary Bed No. 387, or the Hess "Sandwich" Bed, is a turning frame which simplifies patient care. One person can turn a patient. In addition, the patient can be tilted head or feet down.

The Rancho Flotation Bed is designed to distribute the body weight of an occupant so that it is in effect weightless. The bed contains a mixture of barium and petroleum with a specific gravity twice that of the body which, therefore, floats immersed halfway.

Others of this class are the Steeper CO-RO and the Roto Rest Bed developed in Ireland.

The Sevier Mobile Bed (Fig. 9, right), is designed as a standard hospital or home bed for spinal cord injured and similar patients. It has two other functions: (1) the occupant can adjust it to raise the back and lower the legs while at the same time the sides raise to prevent him from rolling out and narrowing the bed, and (2) the occupant can then drive the bed away as though it were a wheelchair passing through doorways in its narrowed mode. It is not designed to replace a wheelchair but rather for short excursions indoors and outdoors to avoid the need for frequent transfer in and out of a wheelchair with the aid of attendants.

The Mobilizer is an ingenious device which permits one nurse or attendant in the hospital or home to lift patients weighing well over 90 kg out of bed, on to the Mobilizer, and then to transport them to a bath, X-ray, gymnasium and then back to bed. It is designed with a roller system which places the platform under the patient with no danger of pinching the skin.

Our principal needs now are for objective evaluation, standardization, dissemination of information concerning applications throughout the world, and the development of methods for deploying, servicing and replacing the products of this technological surge.