United States Patent [19]

Anderson

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[54] **UNIVERSAL WHEELCHAIR FOR THE SEVERELY DISABLED**

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[73] Assignee: **Government of the United States,** Washington, D.C.

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[21] Appl. No.: **307,202**

[52] **U.S. Cl.**..... **180/8 A;** 180/DIG. 3; 280/5.3; 280/36 B; 280/DIG. 10; 280/242 WC; 297/345; 297/DIG. 4

[51] **Int. Cl.**..... **B62d 63/02**

[58] **Field of Search**... 280/36 B, 5.3, 5.32, DIG. 10, 280/242 WC; 180/DIG. 3, 8 A; 297/DIG 4, 330, 345, 353

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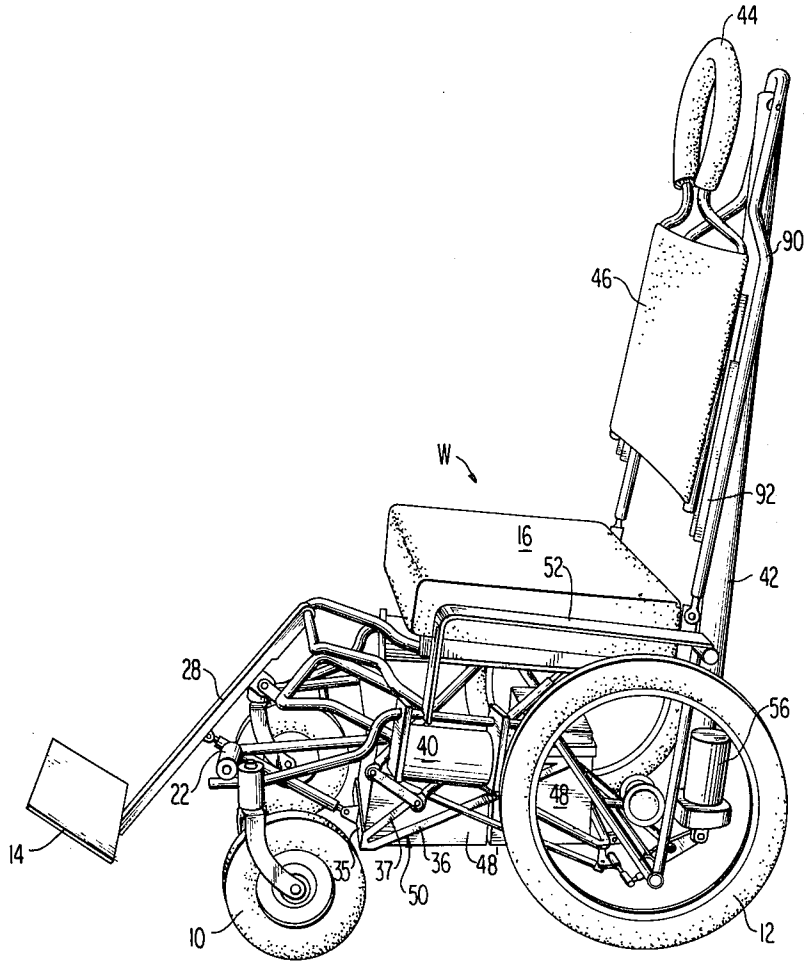
Primary Examiner—David Schonberg
Assistant Examiner—Michael J. Forman
Attorney, Agent, or Firm—Browdy and Neimark

[57] **ABSTRACT**

A universal, adjustable-height powered wheelchair is disclosed for the severly disabled, such as quadriplegic, driver. The wheelchair has a powered elevating mechanism capable of raising the seat and occupant from a height of 6 inches to 26 inches above the ground. It is capable of climbing a 12 inch high curb and may be used while driving any standard-sized two door sedan.

36 Claims, 19 Drawing Figures



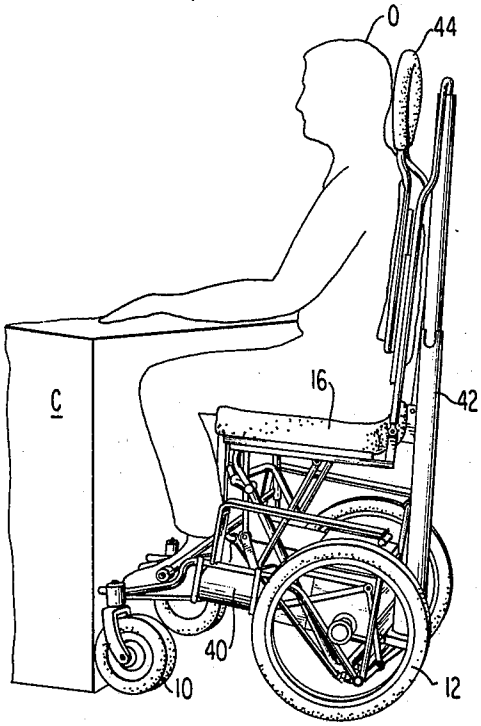


FIG.2

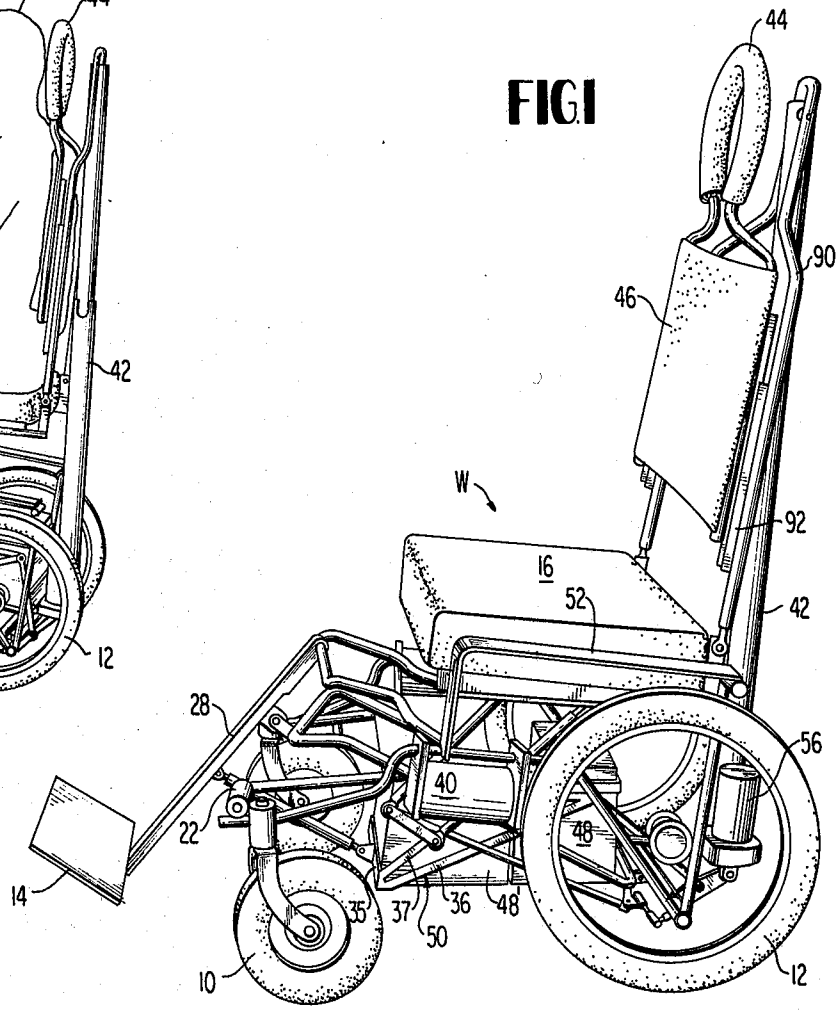
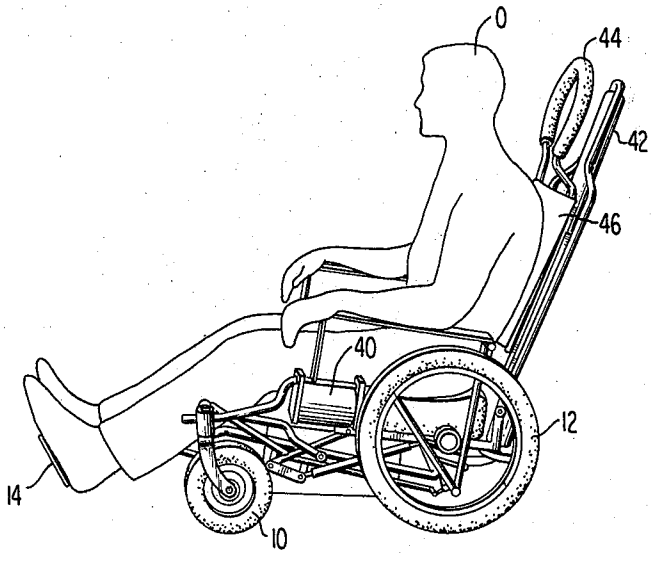


FIG.1



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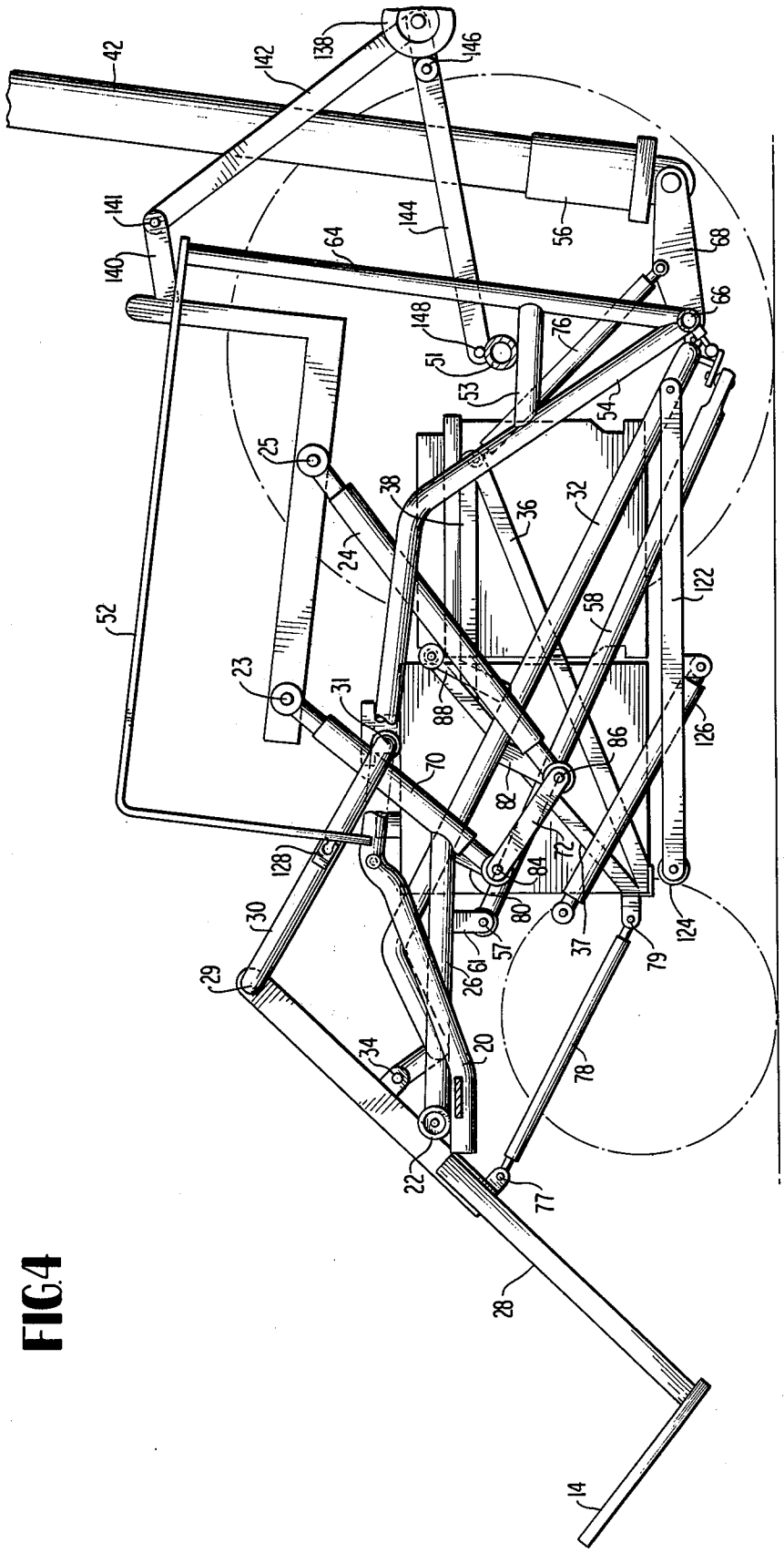
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FIG.4

FIG.5

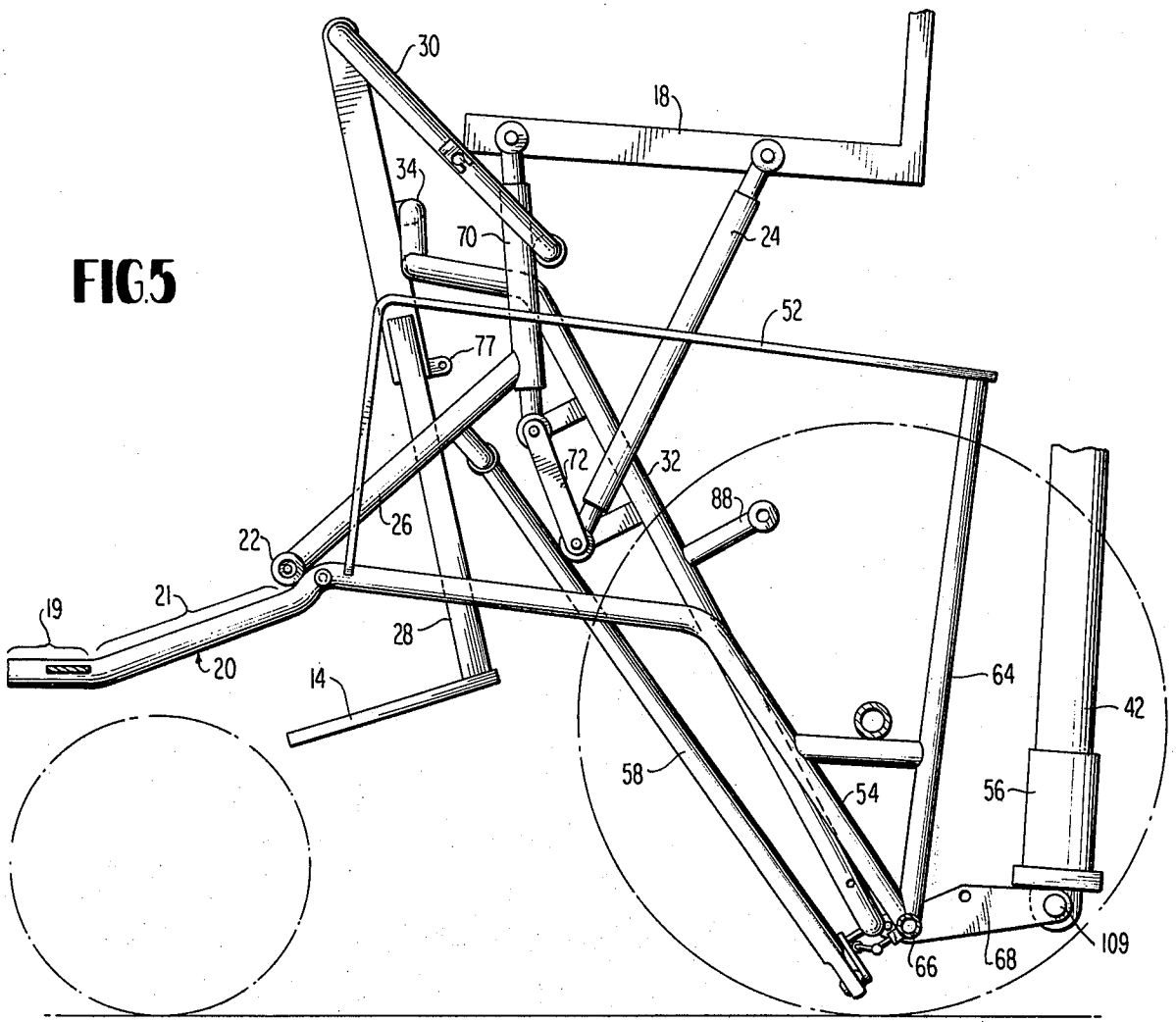
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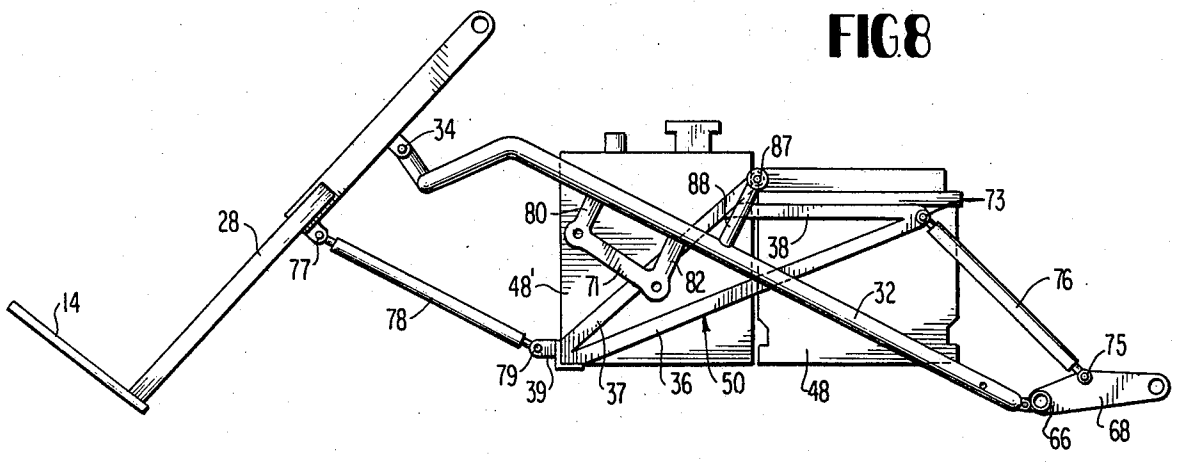
FIG.8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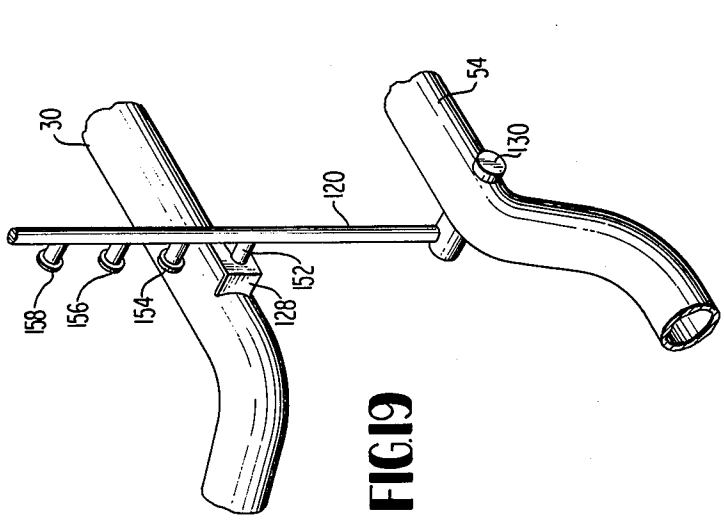


FIG19

FIG6

FIG7

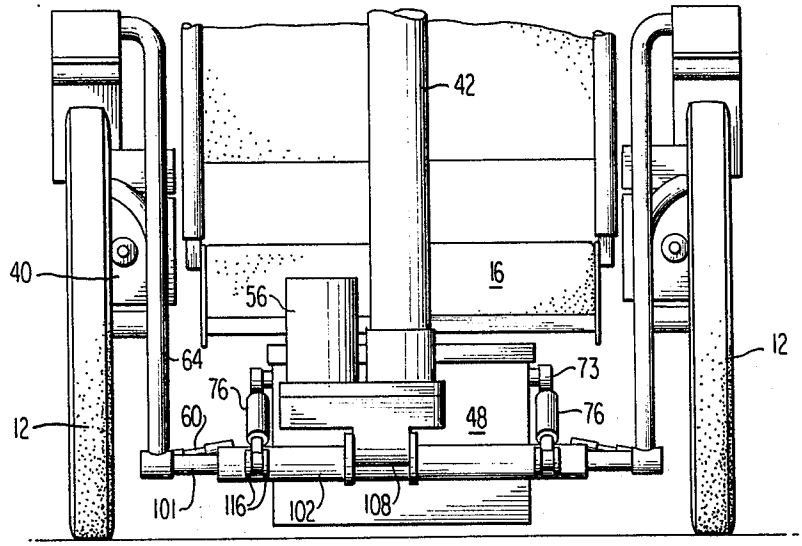
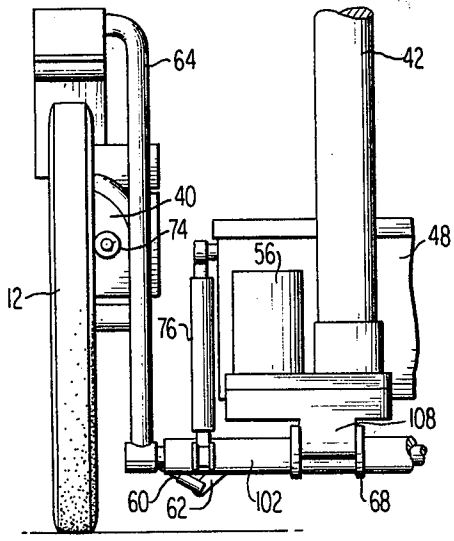


FIG.9



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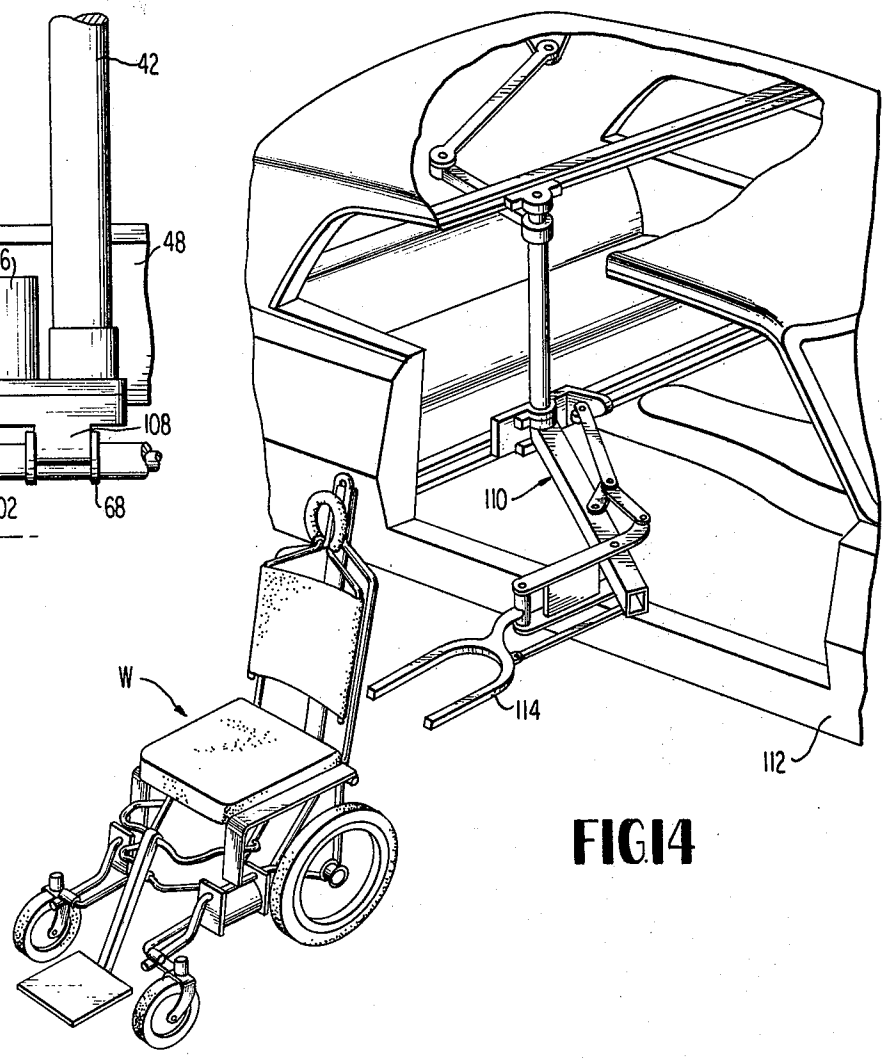

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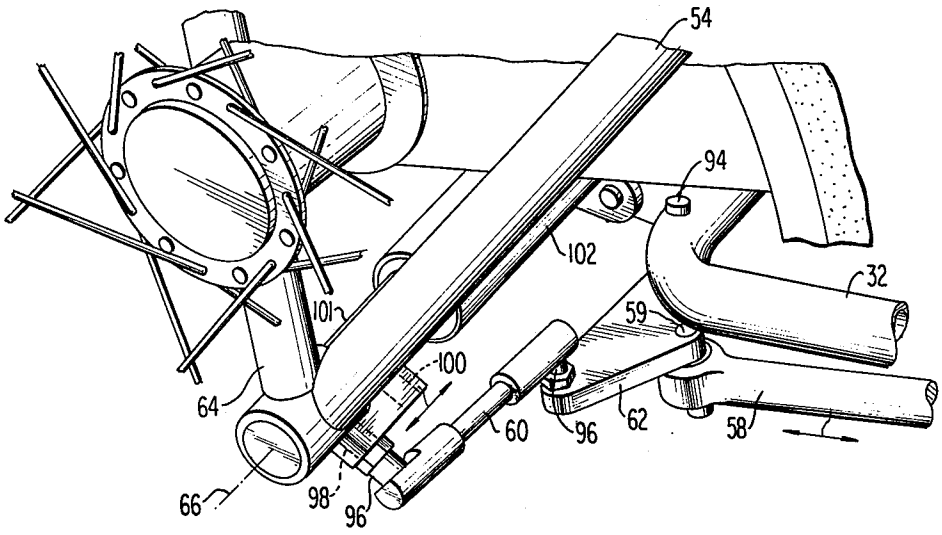

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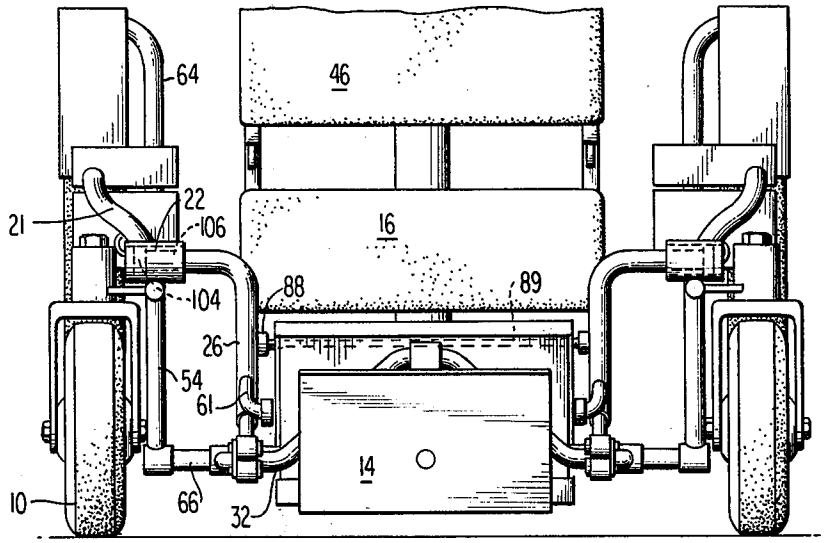


FIG.12

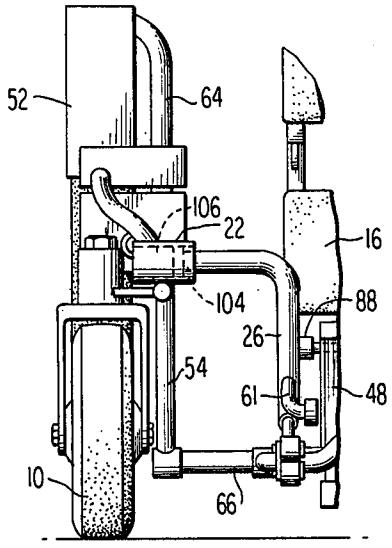


FIG.13

FIG.15

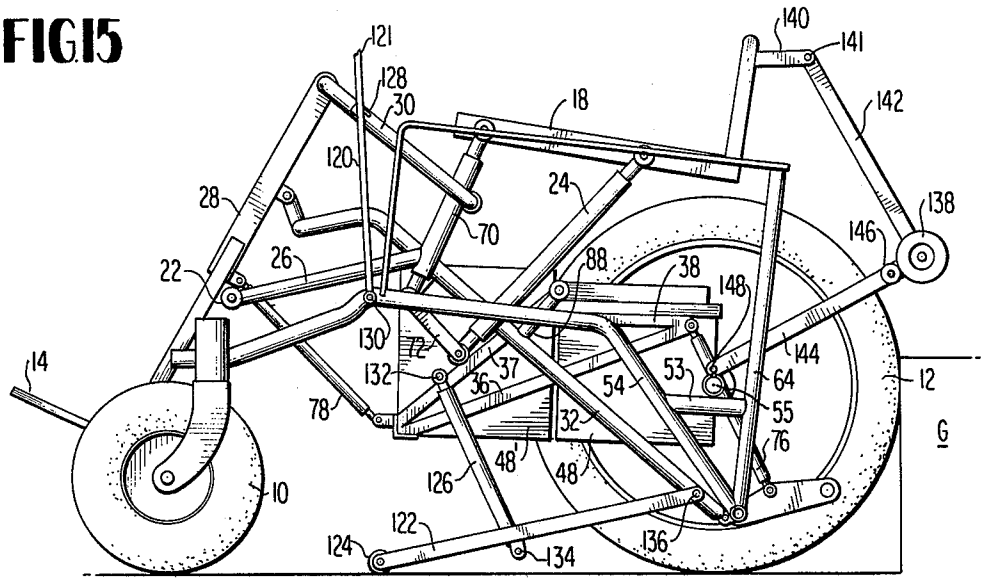


FIG.16

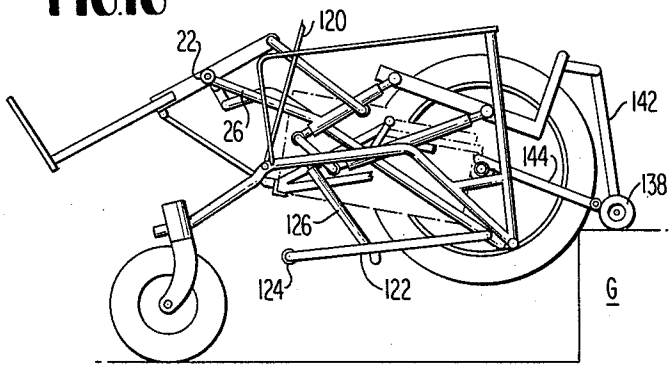
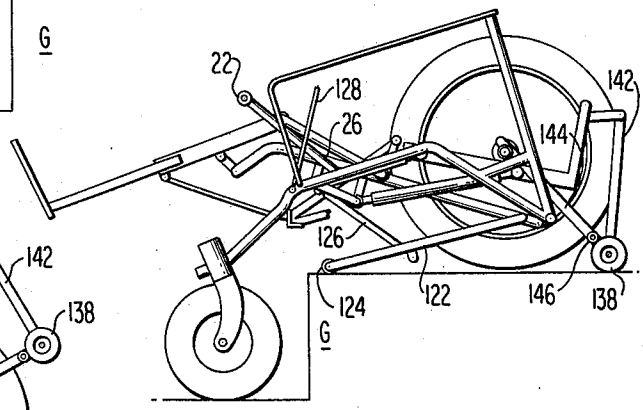


FIG.17



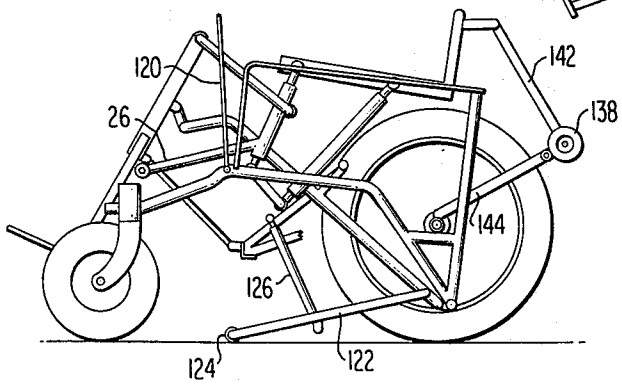


FIG.18

UNIVERSAL WHEELCHAIR FOR THE SEVERELY DISABLED

FIELD OF THE INVENTION

The present invention relates to a universal wheelchair for the severely disabled person and more particularly to an adjustable-height powered wheelchair capable of use with an automobile, capable of climbing curbs and being free from any protuberances above the seat or leg rest surfaces to make transfer of the occupant into and out of the wheelchair as unencumbered as possible.

BACKGROUND OF THE INVENTION

In the period since World War II, medical science has made great progress in the areas of sustaining and rehabilitating severely handicapped persons. As a result, many quadriplegics, for example, are alive, relatively healthy and well-adjusted, leading useful lives with a near normal life expectancy. It is a paradox of our times, however, that many of the disabling conditions of the physically handicapped are not necessarily inherent in the conditions themselves, but are consequences of the lack of help they need over and above the norm. Despite the image of helplessness, the only real "handicap" of the severely disabled is mobility.

It appears that the group of disabled persons most in need of aid to achieve mobility are those afflicted by the worst form of paralysis: the loss of control and sensation of the legs, torso, and part of the arms. There are many diseases and accidents that cause this condition, the most common of which is quadriplegia (lesion of the spinal cord in the region of the cervical vertebrae). Manual wheelchair operation and wheelchair to auto transfer is possible by normal weight young low-level (trauma at sixth or seventh cervical vertebrae) quadriplegics, although with some difficulty. High level (trauma at fourth or fifth cervical vertebrae) quadriplegics have required a powered wheelchair and other human or mechanical assistance in transferring to automobile, bed or commode. Most quadriplegics can drive an automobile equipped with hand controls, power steering and brakes and automatic transmission.

Quadriplegics with trauma higher than the fourth cervical vertebrae either do not live long or, lacking autonomic breathing, require mechanical breathing assist apparatus. Also these very high level traums quadriplegics have even less arm and shoulder function and their auto and wheelchair controls must by much more automated.

DESCRIPTION OF THE PRIOR ART

Until the present invention the mobility of the physically disabled was almost exclusively limited to the use of the "conventional" folding wheelchair. Manual propulsion (using the hands to pull on the wheel rim to make it turn) is feasible only for paraplegics or the equivalent, who have normal upper extremities. Although quadriplegics may be able to propel themselves for short distances, this is tiring and runs the risk of developing sores on the hands (since the hands do not have full sensation in quadriplegics).

The quadriplegics need a powered drive system which, in the prior art, has been provided by merely bolting a motor/battery unit onto the back of a folding wheelchair. Of course the wheelchair is then no longer able to fold, and this represents the key obstacle to

quadriplegic driving. Some quadriplegics can manage to pull themselves from a wheelchair to car seat using a "sliding board" which bridges the gap between the wheelchair and car seat. However, even if the quadriplegic could accomplish this strenuous feat, he would need an attendant to disassemble the wheelchair and then store the folded wheelchair and battery in the trunk. Thus, when using the present powered folding wheelchairs, quadriplegics are precluded from driving automobiles unassisted, although it is possible to modify a step-van so that a wheelchair can enter on an elevating tailgate lift and then roll over a specifically modified flat floor to the driving position.

Since quadriplegics are capable of driving (with hand controls, automatic transmission, power steering, and power brakes), their main problem is that of automobile entry. This problem is generally ignored in prior art wheelchairs.

Many other deficiencies exist with regard to prior art wheelchairs. With respect to the activities of daily living, a "standard" powered wheelchair is only barely adequate around the house, office or on the sidewalk. The standard wheelchair does not accommodate itself very well to the transfer processes, e.g., from chair to bed or commode, and into and out of an automobile; it is not capable of negotiating an ordinary curb without a ramp or driveway. It can furnish no change in sitting position (important in the prevention of decubitus ulcers). It is compatible with only one table or desk height. The standard seat height precludes the user from reaching high shelves and make it awkward for the user to converse with standing non-disabled persons. The position of the footrests made it difficult to approach a kitchen counter or bookcase, both of which lack leg "cut outs." Also, the head height of the occupant of a standard wheelchair is much too great for entry into a standard automobile while seated in the wheelchair.

When a battery is added to a folding wheelchair, it must be placed behind the rear axle, because the folding mechanism precludes mounting anywhere else. This placement shifts the center of gravity so far to the rear that quadriplegics run the risk of tipping over backwards on uphill slopes, especially while accelerating uphill.

Finally, overall dimensions preclude the use of a conventional wheelchair in many houses not specifically designed for the handicapped, unless a second normal person (attendant) is available to carry the quadriplegic through narrow doors or procure articles out of his reach. As the quadriplegic's weight, age, and/or loss of motor functions increases, transferring becomes even more difficult.

A variation of the folding wheelchair is the manually-reclining wheelchair, which is based on a folding wheelchair undercarriage. The back rest is attached in such a way that it can be unlocked by an attendant, repositioned, and then locked back in place. Usually this feature is used for quadriplegics with poor trunk muscles who need to be somewhat reclined all the time for stability. If the quadriplegic wants to recline, he must have assistance from an attendant.

There is a less common type of wheelchair that deserves mention here: the one-man golf-cart type wheelchair. These are distinguished from the folding wheelchairs and from the present invention in that they steer through a direct, mechanical linkage, similar to that of an automobile. The principal disadvantage of this sys-

tem is the inherent large turning radius which is typically 40 inches (80 inches wall to wall). Thus the golf-cart type wheelchair is usually limited to use as an outdoor wheelchair. Also the manual tiller steering demands more range of motion and arm force than the purely electronic switch controls of the caster type wheelchairs. However, as an outdoor wheelchair, the golf-cart type wheelchair has some definite advantages. Since it is not based on the lightweight folding wheelchair principle, it can use more rugged components like heavy duty wheels, bearings and motors. Since it is designed to be a powered vehicle, it usually has space set aside for two or more batteries; this results in a greater range. The seat is supported by a solid frame; this provides better support for a cushion than the suspended fabric of a folding wheelchair, which was designed for use without a cushion. Finally, it has a low center of gravity, which makes it more stable on hills and under accelertion. This feature fits in well with its higher speed and greater hill climbing ability.

The golf-cart type wheelchair is usually "streamlined" with a fiberglass body which may appear attractive to some people. However, quadriplegics accustomed to tubular frame wheelchairs may feel that the streamlined body makes them look more conspicuous.

The advantages and disadvantages of these two types of wheelchairs serve as an excellent departure point point for formulating the specific constraints for a universal wheelchair. In order for the wheelchair to be competitive with these two wheelchair types, it must incorporate the best features of both classes with the addition of some very important new features to correct their deficiencies.

A comprehensive review of this problem and all previous work in the same area has already been published in the open literature by Bray et al "Vehicles for the Severely Disabled," Rehabilitation Literature, Vol 28, No. 4, 1967, pp. 98–109. There have been several van-type solutions to the wheelchair-bound driver problem where a standard wheelchair enters via a ramp or tailgate lift and is wheeled over and locked down in driving position. This has also been accomplished by a 5 foot tall woman using an undersized wheelchair in a Checker Auto.

A full-sized adult in a standard non-adjustable wheelchair simply will not fit in any commercially-available sedan, even if it has a rear engine or front wheel drive (no drive shaft tunnel). The head clearance is simply not great enough. A Swedish scheme included an adjustable-height wheelchair which could be lowered and placed in a sedan by an attendant using a ramp. A post-polio in California drove a 1954 sedan from a standard wheelchair substituted for the right front seat. It was necessray, in addition to special right-side hand controls, to completely alter the auto frame and floor to achieve head clearance and a ramp entrance; auto ground clearance was only three inches.

Other quadriplegic driver solutions involve dismembering the wheelchair and/or some assistance by an attendant to place the handicapped person or wheelchair in the auto.

A retractable-frame wheelchair has been devoloped by Professor Muhlemann in Switzerland that fits in many small European automobiles and enables driving from the wheelchair. Muhlemann, "Rollstuhl Fabresito", Motor-Rundschau, No. 17, 1968, p. 698. This wheelchair is not powered and involves manually removing the drive wheels and retracting the frame during loading. Thus, it is primarily a paraplegic solution and would not be useful for quadriplegics.

One significant wheelchair has been designed since the 1966 Bray report: the self reclining Rugg wheelchair, named after its inventor Donald Rugg. Stantor, "The Rugg Chair", Tooney J. Gazette, 1969; 80–82. This powered wheelchair incorporates a mechanism that will recline the back rest under power while at the same time raising the foot rests to form a flat bed-like surface. The motivation for building the wheelchair was to re-distribute the user's body weight over long periods of sitting. Although the wheelchair does not have an adjustable seat height, the user reclines the back seat slightly in order to lower his overall height for entry into an Econoline Ford Van.

The research done in the past has been mostly concerned with driving while seated in a conventional wheelchair. Until the present invention, no one has attempted a comprehensive design of a wheelchair that considers the special needs of quadriplegia and incorporates automatic loading into an automobile.

SUMMARY OF THE INVENTION

The present wheelchair was designed for all of the daytime activities of an almost completely paralyzed person. Said paralysis could include legs, trunk and most of the arms such as in the case for a C5 to C7 traumatic quadriplegic or the equivalent. These daytime activities are inclusive of curb climbing and driving an automobile while seated in the wheelchair. Basically, the powered wheelchair of the present invention is designed for the use of any person who cannot operate a standard manual wheelchair and who cannot easily transfer from wheelchair to automobile.

The most unique feature of the wheelchair is its powered elevating mechanism which raises the seat and occupant from a height of 5 – 8 inches to about 24 – 27 inches above the ground — keeping it level at all times. In the low position, the occupant can operate a standard two door American sedan with the front seat removed. An intermediate position can be used for most daily activities. At the highest position the foot rests retract and the chair allows reaching high shelves, etc. or conversing at eye level with a standing person. A single elevating actuator, in addition to seat raising, also provides for powered seat back reclining or tipping back of the whole chair. Also by engaging a simple stop lever on each side of the seat and running the actuator, the wheelchair will climb curbs up to **12** inches high while keeping the seat substantially level. Four wheel brakes, swing-away armrests and freedom from any protuberances above seat or legrest surfaces make transfer of the occupant in and out as unencumbered as possible. Two DC motors, one on each **16** inch rear wheel, will enable wheelchair and occupant to travel on the level for several miles at 7 miles per hour or to climb a 10 percent grade at low speed; a gear changer providing the extra torque for hill climbing. Being somewhat shorter and no wider than existing standard manual wheelchairs, the wheelchair of the present invention can maneuver or turn around in the small space of 19½ inches. The wheelchair can be collapsed in a simple way for shipment or auto trunk transport.

The wheelchair of the present invention results in independent mobility in order to provide the disabled with an independent life. This is important not only in

saving the cost of attendant care but also to overcome feelings of helplessness and despair.

Accordingly, it is an object of the present invention to eliminate the deficiencies of prior art wheelchairs.

It is another object of the present invention to combine all of the desirable features of prior art inventions.

It is still another object of the present invention to provide a wheelchair which provides greater comfort, range and stability than prior art wheelchairs.

It is still another object of the present invention to provide a wheelchair with variable seat height that locks in any position allowing compatibility with any height table top.

It is yet another object of the present invention to provide a wheelchair with a reclining back to alter sitting pressure.

It is still another object of the present invention to provide a wheelchair having no obstacles or protuberances to inhibit transferring into or out of the wheelchair.

It is still another object of the present invention to provide a wheelchair of proper size to be operable inside buildings in addition to being able to fit with occupant inside a car.

It is yet another object of the present invention to provide a powered wheelchair with a great range of travel and which is stable under all conditions of road slope and acceleration.

It is still another object of the present invention to provide a wheelchair which is compatible with all size and weight persons and with allowance for padding.

It is another object of the present invention to provide a wheelchair compatible with a mechanism to load the wheelchair and occupant into a standard sized two door sedan.

It is still another object of the present invention to provide a wheelchair which has the capability of climbing curbs up to twelve inches high.

It is yet another object of the present invention to help the physically handicapped overcome horizontal obstacles such as narrow doorways, curbs, steep hills and very large distances.

It is still another object of the present invention to help the physically handicapped to overcome vertical obstacles such as those features of a "standing" world that exclude the seated.

These and other objects will become more clear upon a consideration of the following description of a preferred embodiment and the drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the wheelchair in accordance with the present invention at normal height.

FIG. 2 is a perspective view of the wheelchair with occupant in its raised position.

FIG. 3 is a perspective view of the wheelchair with occupant in its lowered position.

FIG. 4 is a side elevation showing details of the linkage used in the wheelchair of the present invention when at normal height.

FIG. 5 is a side elevation showing details of the linkage when in the highest position.

FIG. 6 is a side elevation of the wheelchair in a fully reclined position and showing the actuator mechanism at a normal position in phantom.

FIG. 7 is a side elevation of the wheelchair in a fully folded position.

FIG. 8 is a detailed view of the battery support means.

FIG. 9 is a rear elevation of the wheelchair at the lowered position.

FIG. 10 is a detailed rear elevation of a portion of the wheelchair in the raised and narrowed position.

FIG. 11 is a detailed perspective view of the narrowing mechanism.

FIG. 12 is a front elevation of the wheelchair at normal width.

FIG. 13 is detailed front end elevation of a portion of the wheelchair in the heavyweight mode.

FIG. 14 is a perspective view of an automobile lift which may be used with the wheelchair of the present invention.

FIG. 15 is a side elevation of the wheelchair of the present invention in the curb climbing mode in the first step of climbing a twelve inch curb.

FIG. 16 is a side elevation of the present wheelchair showing a further step in the process of climbing a twelve inch curb.

FIG. 17 is a side elevation of the present wheelchair showing a still further step in the process of climbing a twelve inch curb.

FIG. 18 is a side elevation of the present wheelchair upon completion of the curb climbing function.

FIG. 19 is a perspective view of a detail of the present wheelchair showing the connection of the stop lever for use in the curb climbing mode.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The wheelchair in accordance with the present invention is shown in FIG. 1 at its normal height. The chair includes drive wheels **12**, caster wheels **10**, a seat **16**, foot rest **14**, head rest **44** and back rest **46**. The seat and the occupant may be raised to the position shown in FIG. 2 or lowered to the position shown in FIG. 3. When in the position shown in FIG. 2, the foot rest **14** is pulled in below the knee so that the occupant O may pull up close to a vertical object such as a counter C.

In the lowered position as shown in FIG. 3, the wheelchair is in a very stable configuration for long or high speed local travel and the chair and occupant may be placed into a standard sized two door sedan with the front seat removed.

The linkage of the present wheelchair is specifically designed to provide one degree of freedom such that seat height, leg rest position, battery frame position, narrowing, reclining and curb climbing are all responsive to the lengthening and shortening of actuator **42**. It is further designed to offer no obstruction to body motion in and out of the wheelchair and to have its relative center of rotation (pivot) right at the human knee joint. This linkage will now be discussed in more detail.

FIGS. **4**, **5** and **6** show the linkage of the present wheelchair in the normal, raised and lowered positions, respectively. The seat frame **18** is supported by front support link **70** and rear leg **24** which are connected thereto at front support link bearings **84** and rear leg bearing **86**. A connecting plate **72** connects rod ends **80** and **82** which may be fixedly connected together by bar **71** as is shown in FIG. **8**.

The subframe **32** is pivotally connected to leg rest **28** at subframe bearing **34**. Lateral leg link **30** connects the leg rest **28**, at leg link bearing **29**, with front support

link 70, at bearing 31. A front leg link 26 fixedly extends from front support link 70.

Side frame 54 provides a fixed reference as it is connected to all four wheel axles. The fixed frame includes side frame 54, wheel frame 64, fender 52 and axle support 53.

To raise the front of subframe 32 with respect to the ground as the seat 16 rises, in order for footrest 14 to avoid hitting the ground, a roller or cam follower 22 is attached to front leg 26 and rolls on the front or cam portion 20 of side frame 54. The cam 20 has two slopes, a near horizontal slope 19 near its front end and in inclined slope 21 of about 20° just to the rear of the horizontal slope (see FIG. 5). Another advantage of the roller/cam arrangement is that it allows for the addition of a curb climbing feature to the wheelchair which will be discussed hereinbelow. The curb climbing concept requires that the cam follower 22 be able to separate from the cam 20.

One of two batteries 48 and 48' may be used to run the wheelchair. Standard automobile lead-acid batteries are preferably used because of their initial low cost, rechargeabiltiy and availability of replacement. The batteries are supported beneath the seat and themselves are raised and lowered along with the raising and lowering of the seat since they are connected to the wheelchair linkage. FIG. 8 shows a detailed view of the battery linkage.

Battery support frame 50 comprises L-shaped element 35 supporting the front of battery 48' (as seen in FIG. 1) and side elements 36, 37 and 38 on both sides of the batteries 48 and 48'. The top ends of elements 37 are connected by a battery frame rod 89 which can be seen in FIG. 12. Frame element 38 connects elements 36 and 37 and supports the rim or flange of battery 48. Thus battery 48' is fully supported by frame element 35 and rod 89, while battery 48 is supported by frame elements 38.

The battery frame 50 is connected to the wheelchair by means of front battery support link 78, rear battery support links 76 and rod ends 88 connected to subframe 32. Front battery support link 78 is pivotally connected to tubes 39 in the center of frame elements 35, by bearing 79 and to leg rest 28 by bearing 77. Rear battery support link 76 is pivotally connected to frame 50 at the intersection of elements 36 and 38 by bearing 73. One link 76 is placed at each side of battery 48 as can be seen in FIG. 9. Links 76 are pivotally connected to transverse axis 66 by bearing 75 and tabs 116 connected to central tube support 102. Rod ends 88 attached to subframe 32 are pivotally connected to each end rod 89 by by means of a bearing 87.

This linkage causes the batteries to fit under the knees of the occupant when the seat is in the low position so that there is only seven inches between the seat and the floor. This is very important with respect to driving a passenger car while seated in the wheelchair. For very tall quadriplegic patients who want to drive a passenger car, the seat may be lowered even more to obtain extra head room by removing the forward battery 48' and moving the rear battery 48 to fit beneath the knees. This allows the seat to come to rest two inches lower.

When in the low position as seen in FIG. 3, the wheelchair is still operable and the casters 10 will swivel completely. Raising the seat another couple of inches will raise the battery high enough for adequate ground clearance in order to provide a very stable configuration for "high speed" wheelchair travel on hard surfaces and virtually eliminates the possibility of tipping over sideways or backwards while accelerating, turning, or negotiating hilly paths.

The variable height function of the present wheelchair is extremely significant since the user of this device has limited arm function and it is very important that he be able to position the height of his body at the work area. The method now used by quadriplegics is to modify the height of desks to fit a fixed height wheelchair. The present universal wheelchair can be raised under power to any seat height and locked in place when the power is turned off.

It can be seen from FIG. 1 that there are no obstructions to transferring into and out of the wheelchair. All guiding and supporting linkages are below the body. If possible, it is desirable for the quadriplegic to perform this transferring using his own muscles, however limited, in order to decrease his dependence on attendants or mechanical devices. The fender 52 is part of the frame which includes side frame 54, wheel frame 64 and axle support 53. Accordingly, fender 52 can carry the full weight of the wheel user. Quadriplegics can transfer across a level surface by lifting up their bodies with their arms. The present wheelchair makes this motion possible by virtue of the load carrying fender 52 which is approximately the same height above the floor as a commode, bathtub, or bed (almost all transfers are to one of these three). The seat 16 can be set at the fender height 52 or it can be set slightly above or below to take advantage of gravity.

Another departure from conventional wheelchair design is apparent from FIG. 1. The foot rest 14 is supported by a single central support 28. This has the advantage of improving maneuverability by eliminating members normally found at the front corners of the wheelchair.

FIG. 2 shows the highest seat height position. It can be seen that the wheelchair occupant O is almost as high as a normal standing person. This feature provides an important psychological advantage in that the wheelchair user will not be forced to "look up" at the non-handicapped world. As discussed hereinabove, in the high position the feet are directly below the knees and do not protrude beyond the wheelchair frame. This feature greatly improves maneuverability. The overall length (including feet) is 32 inches as compared to 46 inches for the conventional wheelchair. Similarly, the plan diagonal is 39 inches compared to a standard 49 inches. This means that the universal wheelchair can turn around in a 39 inch wide hallway which is fairly standard. Also, with the feet tucked in below the knees, the quadriplegic can frontally approach laboratory tables and kitchen counters as designated by C in FIG. 2 which were designed for use by standing persons with no leg "cut-outs". With the present wheelchair, the quadriplegic is able to use both hands on a countertop istead of approaching sideways with only one hand available. Since quadriplegics generally do not have a good hand grasp, they depend on pushing one arm against the other for grasping objects. The wheelchair in this position also protects the user's feet and legs from collisions with walls which can result through careless manipulation of the controls. The raised position of the wheelchair gives the user access to many phases of life normally denied to the "seated" handi-

will also narrow under power to 23 inches by the narrowing mechanism discussed hereinabove. As can be seen from FIG. **11**, the ball joint link **60** attaches to side frame **54** by means of ball joint stud **96** which screws into hole **98**. FIG. **11** shows stud **96** bolted to outermost hole **98**. In order to convert to the heavyweight mode, the stud **96** is threaded into the innermost hole **100**. Thus, the lateral translation shaft **101** will slide farther out of central frame **102**. A comparison of FIGS. **12** and **13** shows the changeover from the normal width (FIG. **12**) to the heavyweight mode (FIG. **13**).

One further change that has to be made, as can be seen in FIGS. **12** and **13**, is to invert cam followers **22**. Each cam follower contains bearing **104** and **106** which are assymmetrically mounted. Thus, unbolting the two cam followers **22** and flipping them over moves them out one inch on each side. Thus, the cam followers are still firmly centered on cam **20** in either mode.

The heavyweight mode may be used routinely in hospitals and rehabilitation centers where all doors are wide enough for the two inch width increase. The advantage would be to add seat room for extra padding, braces, or other medical equipment. Quadriplegics that are fitted with casts (for fractures) would benefit from the extra room.

The actuator unit **42** powered by motor **56** is known in the prior art and may utilize a recirculating ball screw and nut to efficiently convert the gear motors rotary output into linear thrust. Such an actuator is manufactured as "Power Pak" by the Saginaw Steering Gear Division of General Motors, Inc. The screw preferably has a "No-Bak" device to prevent reverse driving; thus, the linkage "locks" whenever the power is turned off. Also the actuator unit has an overrunning clutch to provide protection from overload and limit motion at the end of the stroke. The ratchet type clutch also provides audio feedback to the user indicating that he has reached the end of the stroke. In addition, the overrunning clutch eliminates the need for limit switches (at the end of each stroke) and the accompanying wiring and relaying they require. In the preferred, a 22 inch stoke is necessary. It should be clear that any other mechanical, electromechanical, hydraulic or pneumatic mode of operation for the actuator can be used without departing from the concept of the present invention.

Another asset of the present wheelchair is its capability of easy folding without the use of tools. This facilitates lower shipping costs from the factory and is important on those occasions that require folding of the wheelchair as for instance if a quadriplegic is transported by automobile without the aid of a loading mechanism. He would then be lifted into the car while the wheelchair is folded and placed in the trunk or in back of a station wagon or truck. Although this loading procedure is awkward, it may be adopted when automobile travel is infrequent and attendants are strong.

A quick release pin **109** (see FIG. **5**) is released from the lower actuator bearing **108** (FIGS. **9** and **10**) which is pivotally attached to central frame **102** by means of tabs **68** fixedly attached thereto, and two quick release pins are removed from bearings **77** and **34** on the leg rest assembly. The leg rest **28** and back rest **46** are then free to converge. The leg rest **28** fits between the fabric back rest **46** and the actuator **42**. Continuing this motion results in the fully folded position as shown in FIG. **7**. The overall size of the folded envelope is 25 inches by 33 inches by 19 inches. It is important to note that the wheelchair can still be operated under power in this position so that it can be easily moved by someone walking alongside.

The wheelchair is designed to be compatible with a fully powered automobile loading mechanism that will automatically place the quadriplegic and his wheelchair into either the driver or passenger side of a passenger car. Such a lift mechanism is shown in FIG. **14**. The wheelchair W will back up to the car **112** as shown and the fork structure **114** will attach to the seat frame **18**. The user will then shorten the actuator **42** which will raise the wheels and frame. It should be noted that although the name "lift" is given to the mechanism, this is realy a misnomer since the wheelchair itself does all the vertical lifting. After the entire wheelchair is above the door sell height, the lift mechanism **110** will guide and completely support the wheelchair until it is in either the driver or passenger position. It should be noted that the wheelchair loads on the curb side of the car **112** which is much safer than having to load on the street side.

The importance of automobile driving and riding to the handicapped person cannot be over-emphasized. It affords him a personal freedom that is highly satisfying, and it provides a means to get to work. This is usually a major problem for quadriplegics, who are generally able to drive with hand controls but are restricted to driving vans because of the large size of conventional wheelchairs. Quadriplegics as a rule, cannot transfer themselves from wheelchair to automobile seat, as paraplegics can.

For optimal maneuverability, the mode of power of the present wheelchair is applied independently to each rear wheel **12** with the front two wheels **10** free to swivel on casters. The drive motors **40** and the drive system are the same as are now used on virtually all powered wheelchairs and may be Rae brand units. The motor shafts may be fitted with 1 inch diameter steel pinion gears **74** (see FIGS. **9** and **10**) which are in contact with the side wall of the pneumatic tire **12**. Preferably, however, a metal motor pinion gear is used meshing with a plastic bevel gear mounted on the rear rim (not shown). Positive engagement of the gear sets will prevent slippage as is the case with the friction drive. The wear properties of a self-lubricating plastic gear are much better than that of a metal pinion on soft rubber.

For ease of rolling plus large contact area for traction and lower loading pressures on the ground, a large drive wheel is important. The preferable size for such a drive wheel is 16 inches diameter in order to avoid elbow interference in the automobile driving mode. The two drive motors **40** are controlled by an infinitely variable solid state proportional control lever (not shown) which are well known in the art of powered wheelchairs. The control is placed in any desired location on the wheelchair for easy accessibility. It is preferably attached to arm rests which are not shown in the drawings.

The chair may be equipped with arm rests (not shown) connected to back rest **46** or actuator-seat link **90**. It is important that the arm rests be capable of moving out of position so that no impediments to transferring are included. The arm rests may fold upward out of the way or swing outwards and slide behind back rest **48**. Means for accomplishing this function would be readily apparent to those of ordinary skill in the art.

capped. Examples where standing height is a valuable asset are telephone booths, bookcases, bulletin boards, lecture podiums, blackboards, file cabinets, light switches, elevator controls, door locks, etc. Another advantage in a high seated height is improved visibility at lecture halls and theaters where wheelchair users are usually relegated to the rear, for lack of open floor space. Note that all four wheels **12** and **10** are at the extreme corners of the wheelchair "envelope" for maximum stability.

FIG. **6** shows the wheelchair in the reclined position. Reclining is a desirable feature from the standpoint of altering the pressure distribution of skin tissue on which the body weight rests. Some quadriplegics can do this by lifting themselves up with their hands and shifting their positions. However, those with limited strength or sensitive skin can easily alter their pressure distribution by reclining periodically. In addition, the ability to recline to any back angle provides a welcome change from upright sitting for relaxing, watching television, reading, riding in an automobile, etc. The reclining capability of the present wheelchair is powered by the actuator **42** and the back rest **46** can be locked in any angle of reclining. This is made possible by attaching the actuator-seat link **90** at a position between the seat frame **18** and the top of the back rest **46.** This connecting point is seat pivot **93.** Since the back rest **46** is only upright in those positions where the actuator **42** is raising the seat or holding it in a raised position, it may be seen that in the lowered position when the seat is stopped by the frame, a continued shortening of the actuator **42** will cause a reclining of back rest **46.** Seat pivot **93** contains a stop thereon for setting the normal angle of back rest **46.** This stop will come into play when the actuator is lengthening from the reclined position and the back rest **46** is being raised to the normal position. Once the stop on pivot **93** is reached, the actuator will cause the seat **16** to be raised. By adjusting this stop, the upright angle of the back rest can be set to suit each individual. Generally, the higher the level of spinal cord lesion, the more reclined the user will want to be for daily activities. This feature alone makes the wheelchair available for very high (C-4) quadriplegics who have no trunk muscles and thus must be slightly reclined at all times for stability. It should be noted that the back and head rest unit **46** and **44** can slide on slides **92** attached to the actuator-seat link **90.** Accordingly, the back rest **46** and head rest **44** slide toward the seat upon reclining. This ensures that the back rest pivots effectively at the hips, even though no pivot is physically located there. Therefore, the position of the person on the seat is not shifted, nor is the clothing "bunched up" by the operation.

Because of the forward position of the two batteries **48** and **48'**, the wheelchair is stable in the reclined position and can even be driven under suspended obstacles such as chains across roadways. Many entrances to public land now feature chains to keep cars out and turnstiles to keep motorcycles out; such an arrangement ironically exludes wheelchair users that cannot bend under the chain. Almost all supermarkets have installed turnstiles at all entrances which would also block regular wheelchairs. However, in the reclined position, the present wheelchair could fit under the horizontal pipe that is designed to exclude people but still admit shopping carts.

The present wheelchair also has the capability to narrow its overall width. Commercially available wheelchairs normally have an overall width of about 25 inches which prevent the user from entering bathrooms with the minimum dimension of 22 inches.

FIG. **9** shows a rear view of the wheelchair in the low position. It should be noted that the seat **16** of the wheelchair is between the wheels **12.** With a standard width seat, the wheelchair cannot be any narrower than **25** inches in this position. A **25** inch width does have an advantage over narrower widths with respect to stability at high speeds or on steep side slopes.

The present wheelchair, however, has the capability to automatically narrow to a width of 21 inches when the seat is raised to its highest position. The narrowing function is fully powered and is automatically coupled to the seat raising function so that it is driven by the actuator **42.** It can be seen from a comparison of FIGS. **4** and **5** that the cam roller **22** rides along the angled portion **21** of cam **20** as the seat is being raised to its highest position. Accordingly, this portion of the cam **20** is angled outward so that as the side frame **54** narrows, the cam follower **22** remains securely centered over the cam **20** as can be seen more clearly in FIGS. **12** and **13.** Portion **21** of the cam **20** is also angled upward to provide proper guidance for the seat motion as discussed hereinabove. The cam follower **22** rides on portion **21** of the cam **20** at the seat height range of 23 inches to 27 inches from the floor.

In order to control the narrowing of the chair so that it occurs automatically only when the seat has reached a certain height above the floor a control link **58** is added. As can be seen from FIGS. **4** and **5,** control link **58** is connected to front leg **26** by means of front leg extension tabs **61** which are fixedly attached to front leg **26** and pivotally attached to control link **58** at front control link bearing **57.** As can be seen more clearly from FIG. **11,** the control link **58** is attached to side frame **54** by means of a bell crank **62** and ball joint link **60.** The control link **58** is pivotally attached to bell crank **62** at pivot **59.** The bell crank **62** is also pivotally attached to subframe **32** at pivot point **94.** The crank **62** is pivotally attached to ball joint link **60** at pivot point **96.** In operation, as can be seen from a comparison of FIGS. **4** and **5,** when the seat is raised, the cam follower **22** passes rearwardly up portion **21** of cam **20** causing control link **58** to move rearwardly and cause a rotation of bell crank **62** about fixed width pivot **94.** As can be seen from a comparison of FIGS. **9** and **10,** this rotation of the bell crank **62** about the fixed width pivot **94** pulls the ball joint link **60** toward the center of the wheelchair and the ball joint link **60** in turn pulls the wheel frame **64** side frame unit which slides along the lateral translation axis **66** causing a narrowing of the wheelchair by two inches on each side. The lateral translation axis **66** consists of a shaft **101** sliding inside a central tube support **102** which supports the seat-raising linkage. Shaft **101** preferably slides on polytetrafluoroethylene (Teflon) bearings within central tube support **102.**

In order to fit those who feel uncomfortable in the normal seat width of 18 inches (measured at the hips) and would prefer the increased seat width of 20 inches, the present wheelchair is capable of widening to a heavyweight mode by means of four simple adjustments. Although the overall width increases by two inches (from 25 inches to 27 inches) the 27 inch width

The effectiveness of the present wheelchair is also enhanced by the presence of brakes on all four wheels. Standard wheelchairs have only rear brakes that are essentially static brakes. Even if they could be applied dynamically, the weight transfer inherent under braking could unload the rear wheels enough to cause unstable skidding. Accordingly, dynamic braking is applied to the front caster wheels **10** as well as the rear drive wheels **12.** As dynamic braking systems and methods of applying them to wheeled vehicles are extremely well known in the art, a specific mode of such a dynamic braking system is not specifically shown in the drawings. It should be noted however that braking does occur when the drive motor **40** is turned off.

FIGS. **15** to **19** are specifically directed toward the curb climbing capability of the wheel chair of the present invention. In order to adapt the basic wheelchair linkage discussed hereinabove to a curb climbing capability, three items need be added on each side of the wheelchair.

The first item is a stop lever **120** which can be seen more clearly in FIG. **19.** The stop lever **120** is attached to side frames **54** at pivot **130.** A bracket **128** is permanently attached to lateral leg link **30.** The stop lever **120** has a plurality of settings to accommodate for different curb heights. Setting **152** represents the setting of a 3-inch curb, **154** is a 6-inch curb, **156** is a 9-inch curb, and **158** is a 12-inch curb. It should be noted that the 3-inch setting (as shown engaged in FIG. **19**) will climb curbs from 0 to 3 inches high. Likewise the 6-inch setting will climb curbs from 3 to 6 inches, etc. Stop lever **120** has a portion **121** extending above 12-inch setting **158** which acts as a handle so that the lever may be engaged or disengaged by the occupant of the wheelchair. For operation in the heavyweight mode a spacer (not shown) may be added to the pivot bolt **130.**

A second mechanism which must be added are back-up wheels **138.** Back-up wheel **138** is attached to seat frame **18** by means of link **142** which is attached to rod end **140** at bearing **141.** Rod end **140** is fixedly attached to seat frame **18.** Another link **144** connects back-up wheel **138** with drive wheel hub **55.** A pivot point **148** of link **144** with drive wheel hub **55** is preferably slightly above the wheel axis so that back-up wheel **138** is not permanently in contact with drive wheel **12** but is only engaged when needed. A small transmission wheel **146** is positioned between back-up wheel **138** and drive wheel **12.**

The third function necessary for curb climbing are idler wheels or rollers **124.** Idler wheel link **122** connects to subframe **32** at the pivot **136.** A supporting brace **126** connects the idler wheel link **122** with battery frame element **37** at pivot point **132.** Support brace **126** is pivotally connected to idler wheel link **122** at bearing **134.** It is preferable that pivot **132** be movable so that idler wheel **124** may move away from the ground when the wheelchair is in normal operations. Accordingly, pivot **132** may be mounted on the swinging arm of a "Destaco" toggle action clamp mounted on battery brace **37** and actuated either remotely or directly.

The sequence of operation of the curb climbing mode of the present invention will now be explained with reference to FIGS. **15** thru **18.** First, the stop lever **120** must be engaged. The height of the wheelchair is adjusted so that the appropriate setting **158** of stop lever **120** may engage bracket **128** on lateral leg link **30.** The height of the chair is then lowered to just below the narrowing range of its height and backed up to curb G. It should be noted that the curb climbing mechanism only operates in the lower two-thirds of the seat height range. The narrowing mechanism operates in the upper one-third. Therefore, the wheelchair does not narrow while climbing. The cam follower **22** rolls on the level portion **19** of cam **20** during curb climbing, when engaging the cam **20** at all. It is also important that the curb climbing sequence start with the caster wheels **10** pivoted forward so that the wheelchair has the longest wheel base possible. Preferably the caster axes are locked to prevent rotating during the curb climbing sequence.

After the wheelchair is backed up to curb G the main actuator **42** is shortened which causes the back-up wheels **138** to engage the curb surface and accept the full weight of the rear of the wheelchair (FIG. **16**). Drive wheels **12** and the rear of side frame **54** and wheel frame **64** continue to move upward. Front leg **26** and cam follower **22** depart from side frame **54** because of the action of stop lever **120.** This also causes lifting of leg rest **28** and a slight tipping back of seat frame **18.** At this point the drive wheel **12** actuates the back-up wheel **138** via transmission wheel **146** in order to cause the wheelchair to continue backwards to the position shown in FIG. **17.** This action begins as soon as the drive wheels **12** clear the curb surface. The drive motors **40** provide the power for said backwards motion.

When the wheelchair has moved back until caster wheels **10** touch the curb G the function of idler wheels **124** becomes apparent. These idler wheels **124** must support the weight of the wheelchair while caster wheels **10** are brought up onto the curb. At this point the actuator is lengthened to raise the seat and simultaneously level the side frame **54** which causes caster wheels **10** to rise. Once caster wheels **10** clear the surface of the curb the wheelchair is powered backwards on the surface of the curb to the position shown in FIG. **18.** The wheelchair is now in the same position as its initial position shown in FIG. **15.** It should be noted that if a 6-inch high curb had been negotiated, the seat would have been raised to ½ this height and the stop lever **120** set at a shorter length. Once the chair is able to roll on a level surface the stop lever can be disengaged and the idler wheels **124** lifted out of engagement with the ground and the seat **18** can be reset to any height.

Descending a curb may be accomplished by performing the opposite sequence of climbing a curb described hereinabove. To accommodate narrowing it it is preferable that the links **142** and **144** to the back-up wheels **138** be capable of flexing or be equipped with self-aligning bearings at **141** and/or **148.** There is no axle between back-up wheels **138** which are cantilevered on links **144.**

Another feature that comes with the curb climbing mechanism is a tilt-back reclining mode. This tilt-back is achieved by going through the curb climbing sequence without the curb. Stop lever **120** will cause the seat to tilt back. Since the batteries **48** and **48'** will also tilt back, precautions should be taken to retain the battery fluid with, for example, spill-proof caps. The back-up wheels **138** prevent the wheelchair from tipping over.

Obviously many modifications and variations of the present invention are possible in the light of the above

teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A universal wheelchair for the severely disabled, comprising:
four wheels;
a frame connecting said wheels;
a seat;
raising and lowering means connected to said frame and said seat for causing the height of said seat to be continuously adjusted between a lowered position 8 inches above ground and a raised position about 24 inches above ground, said raising and lowering means comprising an actuator, connecting said frame and said seat, and power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat;
power means connected to said frame for propelling the wheelchair; and
curb climbing means connected thereto for causing the powered climbing of the wheelchair onto and off of curbs while keeping said seat substantially level, said curb climbing means being powered by the lengthening and shortening of said actuator.

2. A wheelchair in accordance with claim 1 further including heavyweight means on said frame for accepting the manual adjustment of the width of the wheelchair.

3. A wheelchair in accordance with claim 1 further including narrowing means connected to said frame for causing powered narrowing and widening of the width of the wheelchair in response to the motion of said actuator.

4. A wheelchair in accordance with claim 3 wherein:
said narrowing means causes powered narrowing of the wheelchair automatically in the top portion of travel of said actuator during the raising of said seat and causes powered widening in said seat from the uppermost position thereof.

5. A universal wheelchair for the severely disabled, comprising:
four wheels;
a frame connecting said wheels;
a seat;
raising and lowering means connected to said frame and said seat for causing the height of said seat to be continuously adjusted between a lowered position eight inches above ground and a raised position about 24 inches above ground;
a foot rest; and
linkage means connected to said foot rest and said seat for causing said foot rest to extend without contacting ground when said seat is in a lowered position and to retract to a position such that no portion of the occupant's foot positioned on said foot rest protrudes farther forward than the knee of the occupant when said seat is in a raised position, said linkage means being responsive only to the height of said seat.

6. A wheelchair in accordance with claim 5 further including power means connected to said frame for propelling the wheelchair.

7. A wheelchair in accordance with claim 6 wherein said raising and lowering means comprises:
an actuator connecting said frame and said seat, and
power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat,
the wheelchair further including curb climbing means connected thereto for causing the powered climbing of the wheelchair onto and off of curbs while keeping said seat substantially level, said curb climbing means being powered by the lengthening and shortening of said actuator.

8. A wheelchair in accordance with claim 6 further including:
a seat back connected to said seat; and
tilting means connected thereto for causing the powered tilting of said seat without a concomitant total reclining of said seat back.

9. A wheelchair in accordance with clain 6 further including heavyweight means on said frame for accepting the manual adjustment of the width of the wheelchair.

10. A wheelchair in accordance with claim 6 wherein said linkage means is located under said seat and said foot rest whereby in at least the raised position there are no encumbrances to hamper the transfer of the occupant to and from the wheelchair.

11. A wheelchair in accordance with claim 6, further including:
a seat back connected to said seat; and
reclining means connected to said seat back for causing the powered reclining of said seat back with respect to said seat when said seat is in the lowermost position thereof.

12. A wheelchair in accordance with claim 4 wherein said reclining means is responsive only to the motion of said raising and lowering means.

13. A wheelchair in accordance with claim 5 wherein said raising and lowered means comprises:
an actuator connecting said frame and said seat, and
power means connected to said actuator for lengthening and shortening said acutator thereby raising and lowering said seat;
the wheelchair further including narrowing means connected to said frame for causing the powered narrowing and widening of the width of the wheelchair in response to the motion of said actuator.

14. A wheelchair in accordance with claim 13 wherein:
said narrowing means causes powered narrowing of the wheelchair automatically in the top portion of travel of said actuator during the raising of said seat and causes powered widening in said top portion during the lowering of said seat from the uppermost position thereof.

15. A wheelchair in accordance with claim 13 wherein;
said narrowing means causes powered narrowing of the wheelchair automatically in the top portion of travel of said actuator during the raising of said seat and causes powered widening in said top portion during the lowering of said seat from the uppermost postion thereof.

16. A wheelchair in accordance with claim 13, further including:
a seat back connected to said seat and to said actuator; and
reclining means connected to said back for causing the reclining of said seat back when said power

means shortens said actuator beyond said lower position.

17. A wheelchair in accordance with claim **16**, further including:

curb climbing means connected thereto for causing the powered climbing of the wheelchair onto and off of curbs while keeping said seat substantially level, said curb climbing means being powered by the lengthening and shortening of said actuator.

18. A universal wheelchair for the severely disabled comprising:

four wheels;

a frame connecting said wheels;

a seat;

raising and lowering means connected to said frame and said seat for causing the height of said seat to be continuously adjusted between a lowered position eight inches above ground and a raised position about 24 inches above ground;

a seat back connected to said seat; and

reclining means connected to said seat back for causing the powered reclining of said seat back with respect to said seat when said seat is in the lowermost position thereof.

19. A wheelchair in accordance with claim **18** further including power means connected to said frame for propelling the wheelchair.

20. A wheelchair in accordance with claim **19**, further including a back rest slidably mounted on said seat back whereby said back rest slides down said seat back upon reclining to avoid sliding between the seat back and the back of the occupant of the wheelchair.

21. A wheelchair in accordance with claim **19** further including heavyweight means on said frame for accepting the manual adjustment of the width of the wheelchair.

22. A wheelchair in accordance with claim **19** further including:

tilting means connected to said seat back for causing the powered tilting of said seat without a concomitant total reclining of said seat back.

23. A wheelchair in accordance with claim **19** wherein said raising and lowering means comprises:

an actuator connecting said frame and said seat and

power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat;

the wheelchair further including curb climbing means connected thereto for causing the powered climbing of the wheelchair onto and off of curbs while keeping said seat substantially level, said curb climbing means being powered by the lengthening and shortening of said actuator.

24. A wheelchair in accordance with claim **19** wherein said reclining means is responsive only to the motion of said raising and lowering means.

25. A wheelchair in accordance with claim **24** wherein said raising and lowering means comprises:

an actuator connecting said frame and said seat back; and

power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat and for causing the reclining of said seat back when the shortening of said actuator is continued beyond said lowered position.

26. A wheelchair in accordance with claim **19** wherein said raising and lowering means comprises:

an actuator connecting said frame and said seat and

power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat;

the wheelchair further including narrowing means connected to said frame for causing the powered narrowing and widening of the width of the wheelchair in response to the motion of said actuator.

27. A wheelchair in accordance with claim **26** wherein:

said narrowing means causes powered narrowing of the wheelchair automatically in the top portion of travel of said actuator during the raising of said seat and causes powered widening in said top portion during the lowering of said seat from the uppermost position thereof.

28. A universal wheelchair for the severely disabled, comprising:

four wheels;

a frame connecting said wheels;

a seat;

raising and lowering means connected to said frame and said seat for causing the height of said seat to be continuously adjusted between a lowered position eight inches above ground and a raised position about 24 inches above ground;

a seat back connected to said seat; and

tilting means connected thereto for causing the powered tilting of said seat without a concomitant total reclining of said seat back.

29. A wheelchair in accordance with claim **28** further including power means connected to said frame for propelling the wheelchair.

30. A wheelchair in accordance with claim **29** wherein:

said tilting means is powered by the motion of said raising and lowering means.

31. A wheelchair in accordance with claim **29** wherein said raising and lowering means comprises:

an actuator connecting said frame and said seat and

power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat;

the wheelchair further including narrowing means connected to said frame for causing the powered narrowing and widening of the width of the wheelchair in response to the motion of said actuator.

32. A wheelchair in accordance with claim **31** wherein:

said narrowing means causes powered narrowing of the wheelchair automatically in the top portion of travel of said actuator during the raising of said seat and causes powered widening in said top portion during the lowering of said seat from the uppermost positon thereof.

33. A wheelchair in accordance with claim **29** wherein said raising and lowering means comprises:

an actuator connecting said frame and said seat and

power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat;

the wheelchair further including curb climbing means connected thereto for causing the powered climbing of the wheelchair onto and off of curbs while keeping said seat substantially level, said curb climbing means being powered by the lenthening and shortening of said actuator.

34. A universal wheelchair for the severely disabled, comprising:

four wheels;

a frame connecting said wheels;

a seat;

raising and lowering means connected to said frame and said seat for causing the height of said seat to be continuously adjusted between a lowered position eight inches above ground and a raised position about 24 inches above ground, said raising and lowering means comprising an actuator, connecting said frame and said seat, and power means connected to said actuator for lengthening and shortening said actuator thereby raising and lowering said seat;

narrowing means connected to said frame for causing powered narrowing and widening of the width of the wheelchair in response to the motion of said actuator.

35. A wheelchair in accordance with claim 34 further including power means connected to said frame for propelling the wheelchair.

36. A wheelchair in accordance with claim 35 wherein:

said narrowing means causes powered narrowing of the wheelchair automatically in the top portion of travel of said actuator during the raising of said seat and causes powered widening in said top portion during the lowering of said seat from the uppermost postion thereof.

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