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Kempf

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[54] **WHEELCHAIR LIFT WITH LINKAGE ASSEMBLY AND HINGED CONNECTION JOINT**

[75] Inventor: **Dale Kempf**, Clovis, Calif.

[73] Assignee: **Lift-U, division of Hogan Mfg., Inc.**, Escalon, Calif.

[21] Appl. No.: **09/094,424**

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Related U.S. Patent Documents

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Issued: **Feb. 8, 1994**
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[51] **Int. Cl.**⁷ **B60P 1/46**

[52] **U.S. Cl.** **414/545**; 414/540; 414/541; 414/921; 187/222; 14/71.1

[58] **Field of Search** .... 414/921, 539, 414/540, 541, 542, 680, 543, 495, 544, 545, 546, 556, 557, 558, 140.1, 430; 187/222; 254/2 R, 2 C; 14/69.5, 71.3, 71.7, 71.1

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Primary Examiner—Frank E. Werner
Attorney, Agent, or Firm—Christensen 'Connor Johnson & Kindness PLLC

[57] **ABSTRACT**

A linkage assembly **(20)** for use with a platform or step lift **(22)** for transmitting force from a linear actuator **(228)** to a ramp **(40)** pivotally attached to the outer edge of the platform **(26)** of the lift so as to cause the ramp to travel through a rotational path of at least 180 degrees. The linkage assembly is designed so that no portion thereof extends more than about 0.25 inch above the upper surface **(28)** of the ramp and the top surface **(48)** of the platform, and so that the ramp is driven downwardly toward the extended position with a force insufficient to cause serious injury to a person's feet positioned in the path of travel of the ramp. Additionally, a hinge structure **(700)** is provided for use with a step lift for coupling the platform with its vertical extensions **(66, 68)** so as to permit the latter to pivot relative to the platform as the extensions move up and down within the vertical guides **(80, 82)** in which the vertical extensions are slidably received.

18 Claims, 6 Drawing Sheets

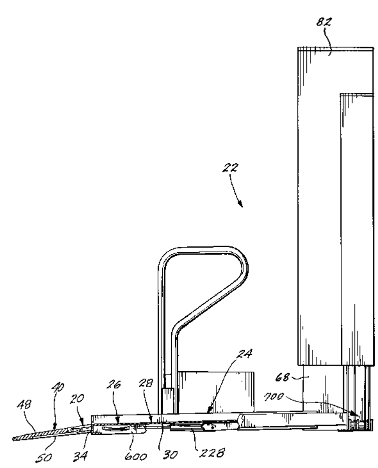


Fig. 1.

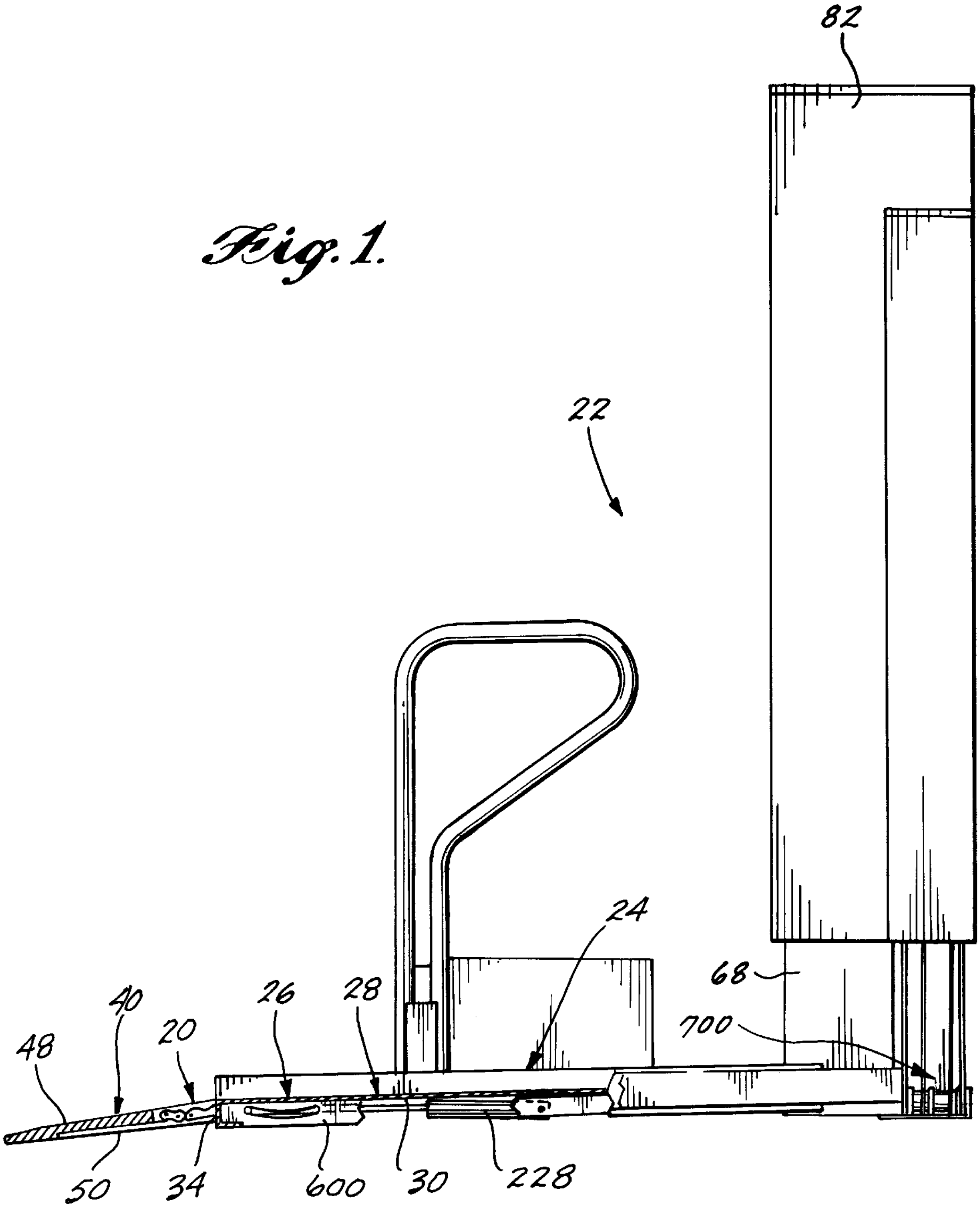


Fig. 2.

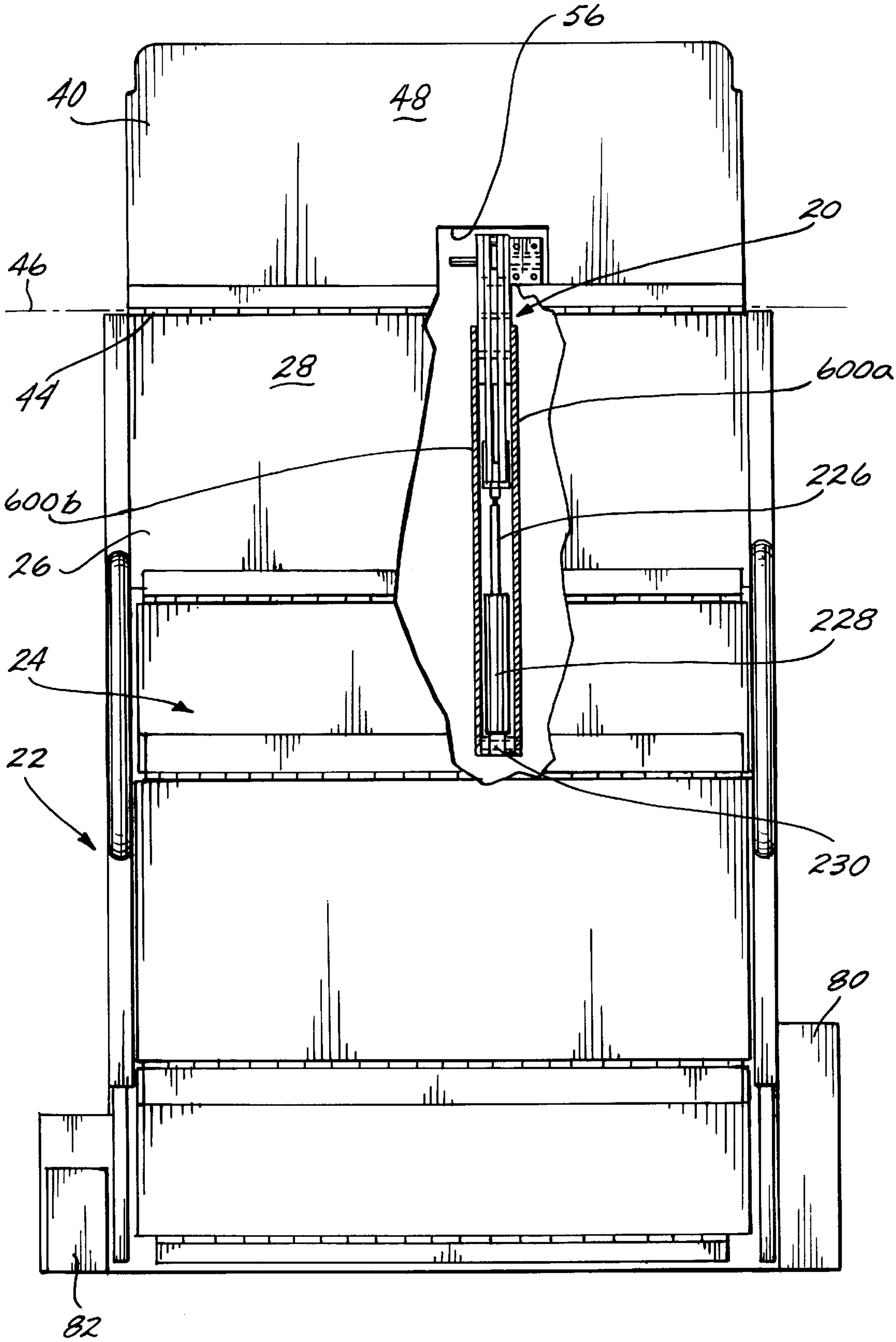
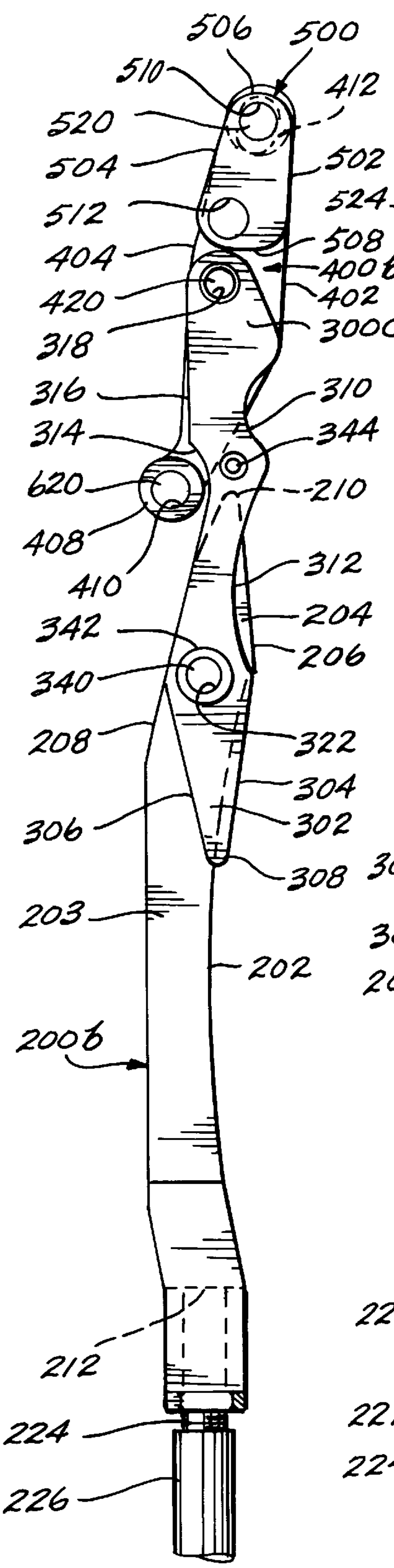


Fig. 3.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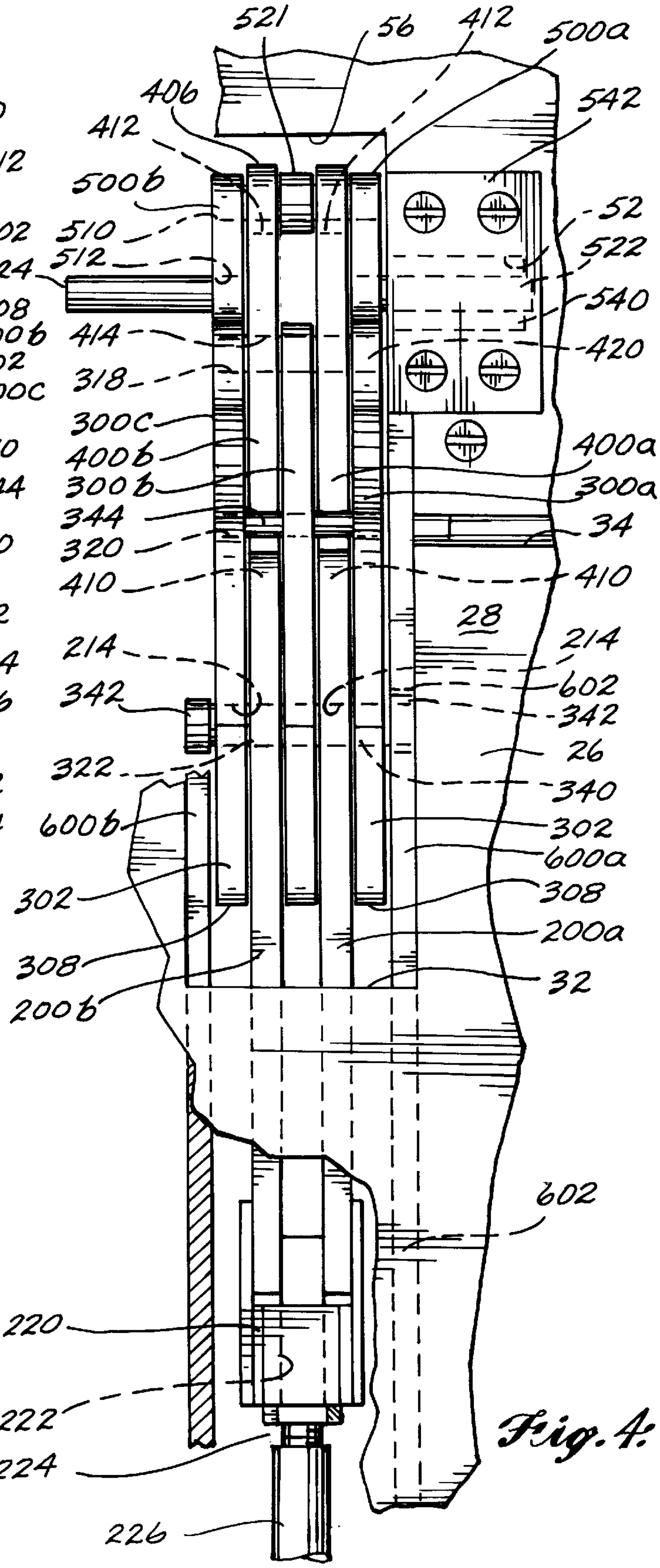
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Fig. 4.

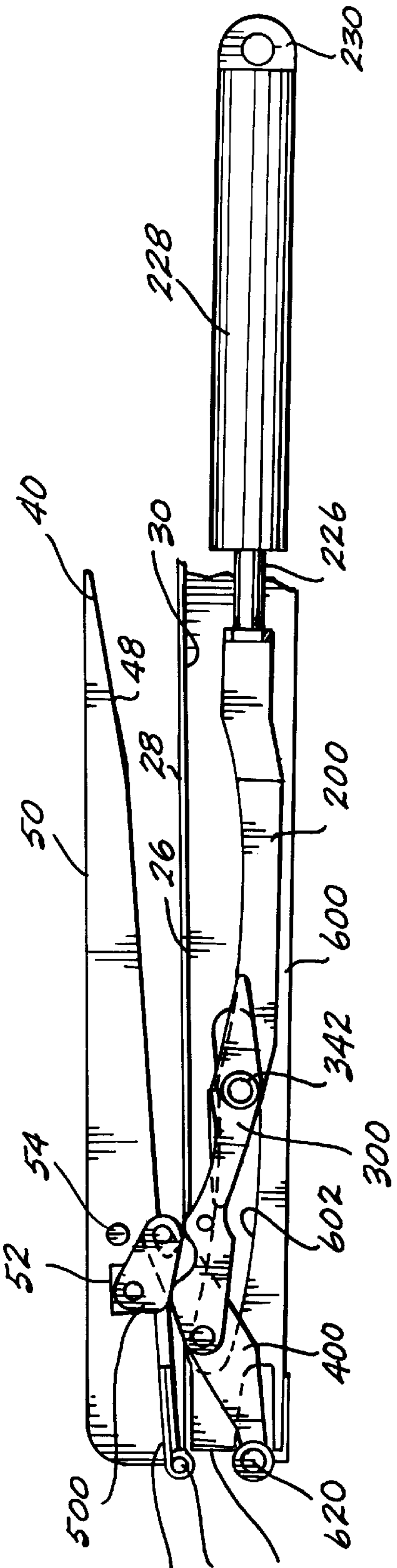
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Fig. 5.

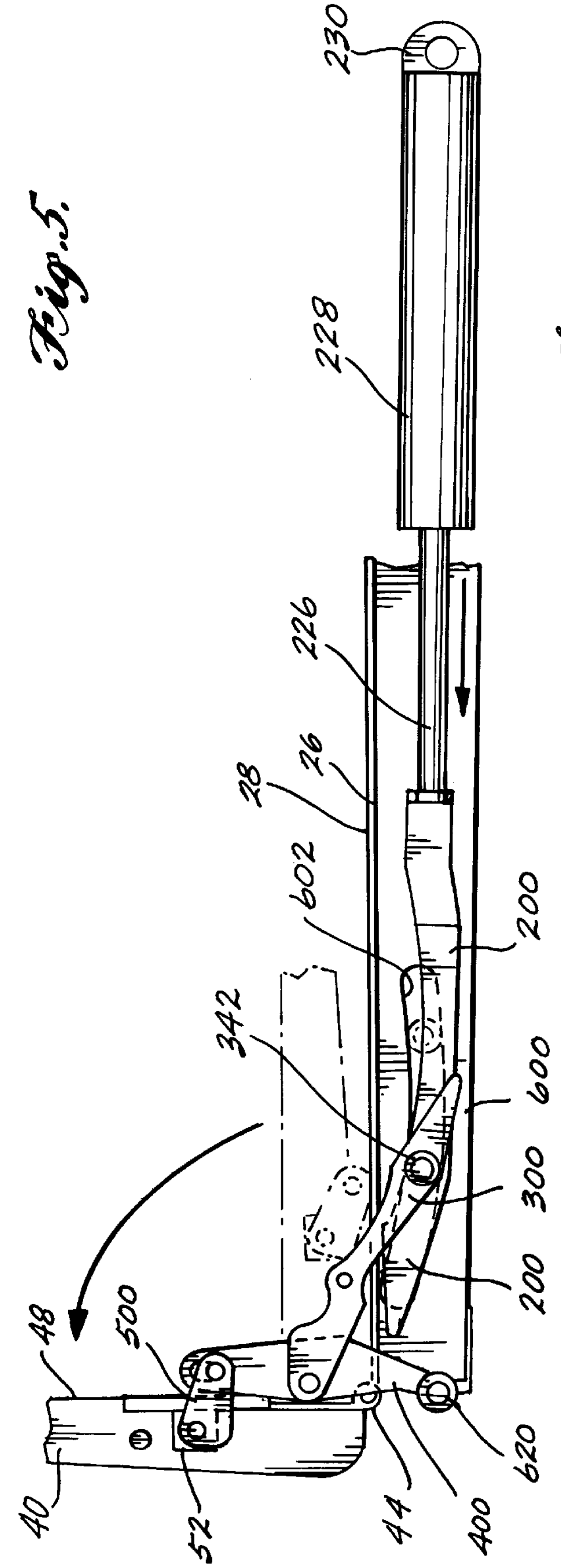
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Fig. 6.

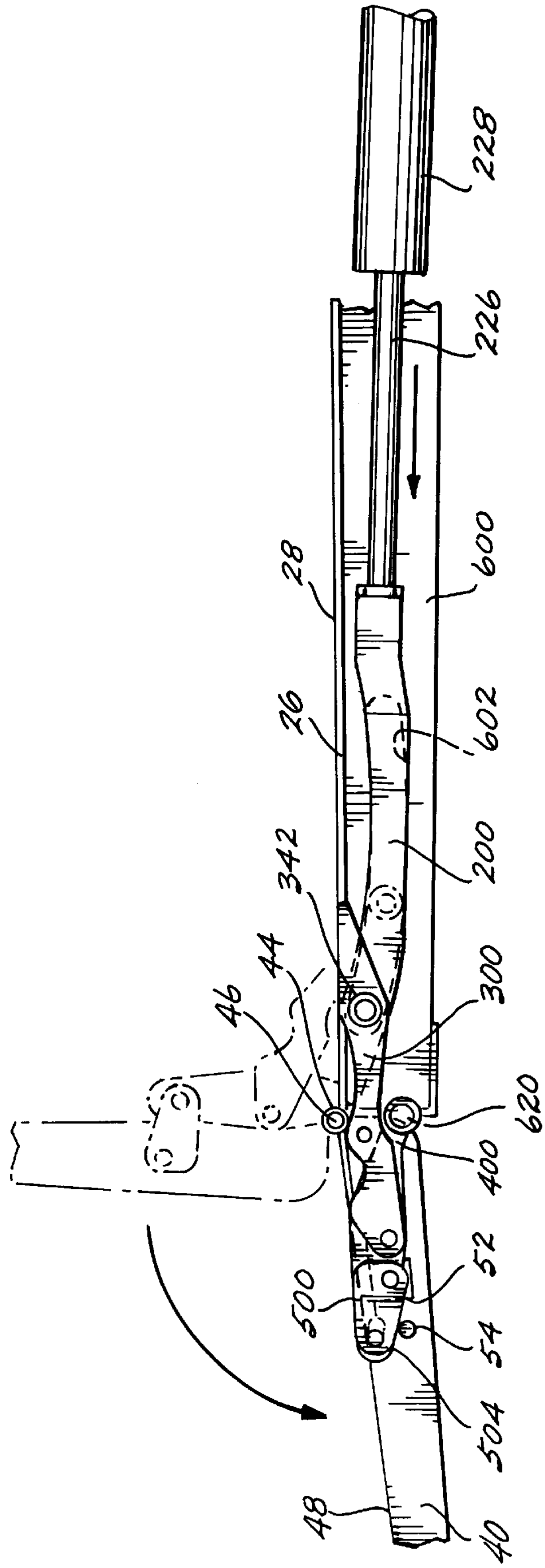

Fig. 7.

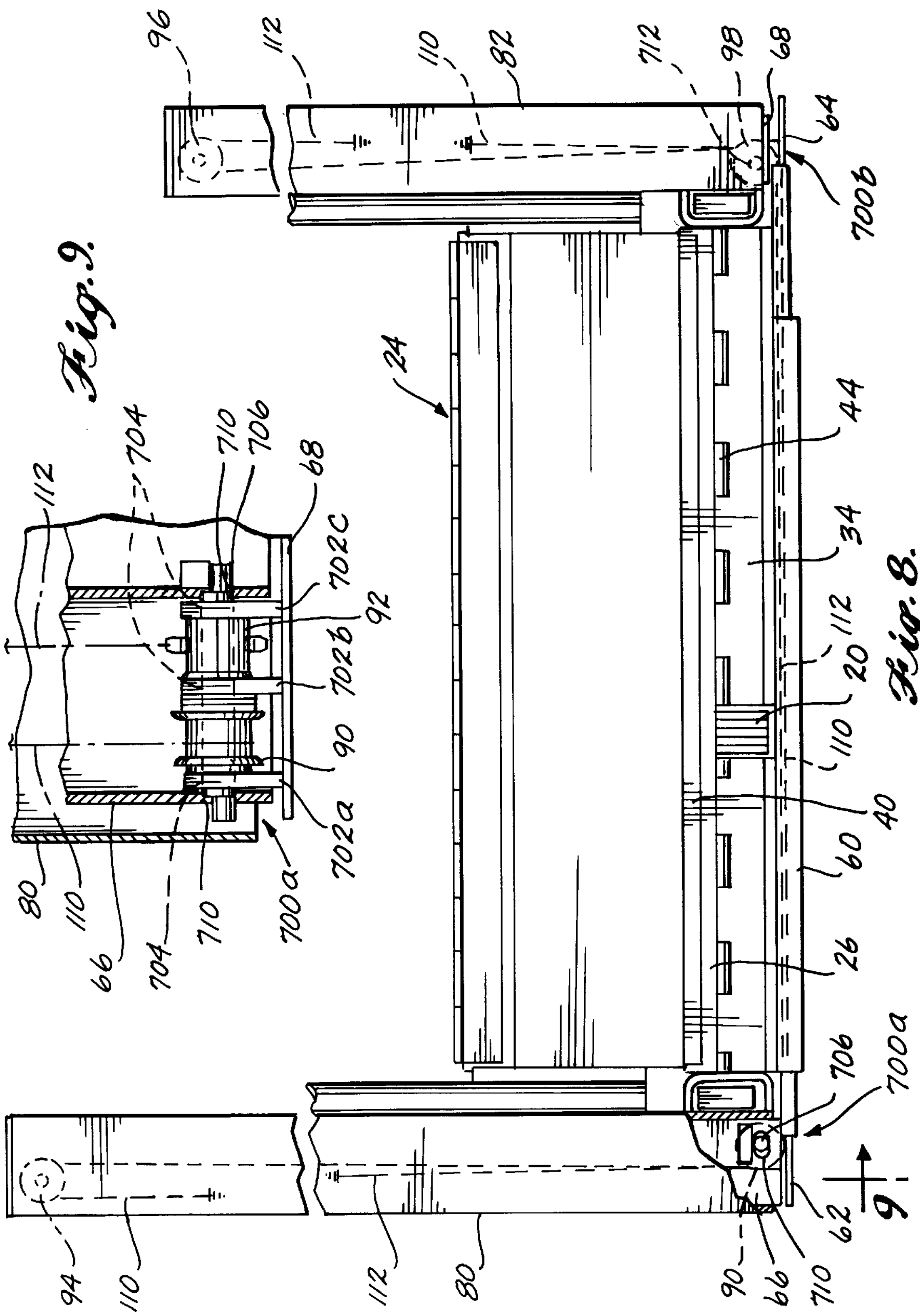

Fig. 9.

Fig. 8.

WHEELCHAIR LIFT WITH LINKAGE ASSEMBLY AND HINGED CONNECTION JOINT

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

The present invention relates to wheelchair lifts, and, more particularly, to linkage assemblies for causing the outer barrier of the lift to move between extended and retracted positions, and to hinge assemblies for pivotally coupling selected horizontal and vertical components of a lift.

BACKGROUND OF THE INVENTION

Wheelchair lifts of the type installed in the stairwell of transit vehicles, such as intra-city buses, are well known. One type of wheelchair lift, commonly referred to as a "step lift," is illustrated in U.S. Pat. No. 4,466,771 to Thorley et al. (the "'771 patent"). Another type of wheelchair lift, commonly referred to as a "platform lift," is illustrated in U.S. Pat. No. 4,058,228 to Hall (the "'228 patents").

Step lifts and platform lifts typically comprise a ramp or barrier plate which is pivotally mounted to the platform of the lift so as to be rotatable through an arc of about 180 degrees between a retracted position where the ramp confronts and extends parallel to the platform and an extended position where the ramp projects outwardly from the platform and is substantially coplanar with the platform. The ramp provides a planar surface between the ground and the platform when the latter is in the lower position, and acts as a vertically extending barrier (when in an intermediate position midway between the retracted and extended positions) for preventing a wheelchair from rolling off the platform when the platform is being moved between lower and upper positions.

Lifts of the type disclosed in the '771 patent typically include a linkage assembly for transmitting force from a hydraulic actuator to the ramp so as to cause the ramp to move between the retracted and extended positions. One portion of the linkage assembly is pivotally attached to the ramp, another portion of the linkage assembly is pivotally attached to the platform, and a third portion of the linkage assembly is attached to the hydraulic actuator. Generally, the linkage assembly is positioned in the center of the ramp and platform, i.e., midway between the left and right sides of the ramp and platform as viewed from the road looking into the stairwell in which the lift is positioned.

Linkage assemblies of the type used in the '771 patent project above the surface of the ramp and platform more than is desired, e.g., as much as one inch. As a consequence of the central placement of the linkage assembly and its projecting configuration, a hump is formed which tends to interfere with a wheelchair occupant's use of the lift. Governmental regulations regarding the design of wheelchair lifts now prohibit structure which projects above the upper surface of the ramp and platform more than 0.25 inch. Clearly, linkage assemblies of lifts of the type disclosed in the '771 patent do not comply with this regulation.

Furthermore, the design of linkage assemblies of the type used on the lift of the '771 patent typically include undesirably large openings or gaps between the various elements making up the linkage assembly and between the linkage assembly and the apertures in the ramp and platform in

which the linkage assembly is received. These gaps open out to the upper surfaces of the platform and the ramp and are sufficiently large that the heel of a high-heeled shoe, an end of a cane, or a child's foot could possibly become lodged within a gap between linkage elements. To avoid such an occurrence, flexible covers have been used to block gaps between elements of linkage assemblies. Such covers add to the cost of the linkage assembly, can adversely affect the operation of the linkage assembly, and tend to require frequent maintenance. Absent the use of such covers, the gaps between elements of known linkage assemblies do not comply with current governmental regulations which permit gaps up to only 0.625 inch wide.

The construction of linkage assemblies of the type used in the '771 lift is such that the various components thereof are formed by various machining operations. These operations tend to be relatively time consuming, and hence expensive. Consequently, the total cost of a linkage assembly of the type disclosed in the '771 patent is typically more expensive than is desired.

Linkage assemblies of the type disclosed in the '771 patent are generally designed so that access to the attachment point of the end of the linkage assembly coupled to the ramp is via the bottom surface of the ramp. Because such bottom surface is typically covered with a tread that covers the attachment point, and the process for removing and reinstalling the tread is relatively time consuming, removal of the linkage assembly for maintenance or replacement tends to be more difficult and time consuming than is desired.

The design of linkage assemblies of the type disclosed in the '771 patent is such that the ramp is driven downwardly toward the extended position with a relatively large force. This force is sufficiently great that if a person's feet are positioned underneath the ramp, the possibility exists that the person's feet could be crushed. To avoid the possibility of such an accident, a relief valve for limiting the pressure of the hydraulic fluid supplied to the actuator is provided. Such a relief valve adds to the cost of the lift.

Yet another problem with linkage assemblies of the type disclosed in the '771 patent is that the various components thereof require frequent lubrication, thereby adding to the cost of maintaining the linkage assembly. Furthermore, the design of the components of such known linkage assemblies is such that the components tend to corrode, thereby adversely affecting the free operation of the portions of the lift coupled to the linkage assembly and increasing the stresses applied to various components of the linkage assembly and the lift.

Consequently, a need exists for a linkage assembly for a step of the type disclosed in the '771 patent, or for a platform lift of the type disclosed in the '228 patent, that does not project more than 0.25 inch above the upper surfaces of the platform and ramp and that does not include gaps of more than 0.625 inch. A need also exists for such a linkage assembly that can be serviced without removing the tread on the bottom surface of the ramp and that does not require periodic lubrication. A need further exists for a linkage assembly that is designed to drive the ramp downwardly toward the extended position with a force such that a person's feet inadvertently positioned in the path of travel of the ramp will not be crushed. A need additionally exists for a linkage assembly that is made from parts which can be fabricated quickly and inexpensively, preferably without the need for extensive machining operations.

Wheelchair lifts of the type disclosed in the '771 patent typically comprise a horizontal support for supporting the platform and vertically extending members attached, typically by welding, to the ends of the horizontal member. The vertically extending members are slidably received in vertically extending guides attached to the sidewalls of the stairwell in which the lift is installed. The vertically extending members coact with the guides to ensure the platform travels up and down along a predetermined path. Because space constraints permit the hydraulic actuator that raises and lower the step lift to be positioned only adjacent the rear side of the platform assembly, a chain drive assembly is provided for ensuring the front side of the platform assembly moves together with the rear side.

Unfortunately, under certain circumstances the guides do not extend parallel to one another and perpendicular to the surface of the platform. Such misalignment may occur as a consequence of improper installation of the guides, either originally or after maintenance, or can occur due to an accident of the vehicle in which the lift is installed. Furthermore, occasionally the chains of the chain drive assembly will become maladjusted.

Because the vertically extending members are rigidly attached to the horizontal member so as to extend perpendicular thereto, misalignment of the guides or maladjustment of the chains can cause the vertically extending members to bind as they travel up and down in the guides. Such binding can, in certain circumstances, cause the vertically extending members to break where they are attached to the horizontal member. Repair and/or replacement of the broken vertically extending members can be relatively time consuming because it requires the disassembly of a substantial portion of the lift. Space constraints prevent the addition of material to the junction of the vertical extensions and the horizontal support which could increase the strength of such junction sufficiently to prevent breakage.

Although arising in a different technological context, U.S. Pat. No. 4,579,500 to Robinson discloses a truck lift gate comprising a pair of vertical rails, a pair of elongate runners slidably received in the rails, and a platform, the outboard ends of which are pivotally attached to bottom portions of the runners. As a consequence of this construction, the platform is free to pivot slightly with respect to the runners.

The Robinson system differs significantly from lifts of the type disclosed in the '771 patent in that with the Robinson system forces for raising and lowering the platform are simultaneously applied to both ends of the platform. Furthermore, the Robinson system includes a pair of flat equalizer plates positioned adjacent the attachment point of the runners and the platform for causing the top surface of the platform to remain perpendicular to the long axes of the runners during vertical movement of the platform. Unfortunately, space constraints in the environment in which known step lifts are used prohibit the use of such equalizer plates, and prevent the application of the vertical drive force directly to both sides of the platform.

Thus, a need exists for a system for mounting the vertically extending members of a step lift to the horizontal member such that the vertically extending members do not bind or break during vertical movement in the guides in which they are received. A solution to this problem needs to be designed for incorporation into the chain drive system used for ensuring both sides of the step lift platform move together.

SUMMARY OF THE INVENTION

The present invention is a linkage assembly designed for use with a wheelchair lift comprising a platform and a ramp pivotally attached to an outer edge of the platform so as to be rotatable through at least a 180 degree arc between retracted and extended positions. In the retracted position the upper surface of the ramp confronts and extends substantially parallel to the top surface of the platform and in the extended position the ramp extends forwardly of the platform and its upper surface is substantially coplanar with the top surface of the platform. The linkage assembly is designed to transmit force from a linear actuator to the ramp so as to cause the latter to move between the retracted and extended positions.

The linkage assembly comprises a plurality of flat linkage members that are designed so as not to project more than about 0.25 inch above the upper surface of the ramp and the top surface of the platform. The linkage assembly is further designed to provide a structure within the apertures in the ramp and platform through which the linkage assembly extends when the ramp is in the extended position. This structure comprises an upper surface that is substantially coplanar with the upper surface of the ramp and the top surface of the platform. Also, the structure is designed to fill in the apertures such that no gaps exist having a width greater than 0.625 inch.

The linkage assembly is designed to transmit the actuation force provided by the linear actuator to the ramp such that the linkage assembly applies a significantly greater actuation force to the ramp when the latter extends perpendicular to the top surface of the platform than when the ramp is in the retracted or extended positions. As a consequence of this feature, the ramp is driven downwardly toward the extended position with a force which is insufficient to crush a person's feet positioned in the path of travel of the ramp. As an additional consequence of this feature, the force which must be applied to the ramp to move the latter from the perpendicular position toward the extended position is sufficient to strongly resist the force applied by a wheelchair rolling against the ramp.

The present invention also comprises a hinge structure designed for use with a step lift for pivotally coupling the vertical extensions of the platform with the latter so as to permit the vertical extensions to pivot about axes extending perpendicular to the vertical path of travel of the platform as the vertical extensions travel up and down within the guides in which they are slidably received. Furthermore, one of the vertical extensions is coupled with the platform so as to permit one end of the extension to move horizontally with respect to the corresponding end of the other vertical extension as the extensions move up and down with the associated guides. As a consequence of this design, the possibility of the vertical extensions binding within the guides is minimized and the possibility of the vertical extensions breaking free of the platform is avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view of a step lift incorporating the linkage assembly and hinge structure of the present invention, with a portion of the lift being illustrated in cross section to reveal the linkage assembly, and with the lift being illustrated in the platform position;

FIG. **2** is a plan view of the step lift illustrated in FIG. **1**, with a portion of the platform being cut away to illustrate the linkage assembly and associated hydraulic actuator;

FIG. **3** is a side elevational view of the linkage assembly;

FIG. **4** is a top view of the linkage assembly illustrated in FIG. **3**;

FIG. **5** is a cross-sectional view of the ramp and platform illustrating in side elevation the linkage assembly and the associated hydraulic actuator, with the ramp being shown in the fully retracted position where the top surface of the ramp confronts and extends substantially parallel with the upper surface of the platform;

FIG. **6** is similar to FIG. **5**, except that the ramp is shown in the barrier position where the top surface of the ramp extends substantially perpendicular to the upper surface of the platform;

FIG. **7** is similar to FIG. **6**, except that the ramp is shown in the fully extended position where the ramp projects from the platform and the top surface of the ramp extends substantially parallel to the upper surface of the platform;

FIG. **8** is a front elevational view of the lift illustrated in FIG. **1**, with a portion of one of the guides being broken away to reveal (a) the vertical extension received therein and (b) a portion of the hinge structure for coupling the vertical extension with the horizontal member supporting the platform; and

FIG. **9** is a cross-sectional side elevational view, taken along line **9—9** in FIG. **8**, showing the bottom most portion of the rear guide and the associated vertical extension, and the rear end of the horizontal member.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. **1**, **2**, and **8**, the present invention is a linkage assembly **20** and a hinge structure **700** designed for use in a step lift **22** of the type illustrated in U.S. Pat. No. 4,466,771 to Thorley et al. (the "'771 patent "), which patent is incorporated herein by reference, or in a platform lift (not shown) of the type illustrated in U.S. Pat. No. 4,058,228. Lift **22** comprises a platform assembly **24** which is designed to be translated between (1) a platform position, as illustrated in FIGS. **1** and **2**, where the various components of the platform assembly together define a platform, and (2) a step position, as illustrated in FIG. **8**, where the various components of the platform assembly together define a stairway. As discussed in detail in the '771 patent, lift **22** comprises structure for causing platform assembly **24** to move between the platform and step positions. Lift **22** also comprises structure for causing the platform assembly **24** to move between a lower position, where the platform is positioned at ground level, and an upper position, where the platform is positioned at the level of the floor of the transit vehicle in which the lift is installed. Platform assembly **24** includes an outer platform member **26** having a planar upper surface **28** and a bottom surface **30**. Platform member **26** also includes a rectangular aperture **32** extending therethrough which begins adjacent outer edge **34** of the member and extends away from the front edge a predetermined distance.

Referring to FIGS. **1** and **5–7**, a ramp **40** is pivotally attached to the outer edge of platform member **26** via hinge **44** so as to be rotatable about a pivot axis **46** which preferably extends along the plane of the upper surface of member **26**. Ramp **40** comprises a planar top surface **48**, a bottom surface **50**, and a pocket **52** (FIG. **5**) which opens up to top surface **48**. Pocket **52** is aligned with aperture **32** in platform member **26** and is positioned adjacent hinge **44**. Ramp **40** includes two studs, one of which is identified at **54** in FIGS. **5–7**, positioned adjacent pocket **52**. Studs **54**, as described hereinafter, lie in the path of travel of drag links **500**. Ramp **40** also includes an aperture **56** (FIG. **2**) adjacent the end of the ramp attached to hinge **44** and is aligned with aperture **32** in platform member **26**.

As a consequence of the pivotal attachment of ramp **40** to platform member **26**, the ramp may be moved from a retracted position, as illustrated in FIG. **5**, through a barrier position, as illustrated in FIG. **6**, and to an extended position, as illustrated in FIG. **7**. In the retracted position, top surface **48** confronts and extends substantially parallel to upper surface **28**. In the barrier position, top surface **48** extends perpendicular to upper surface **28**. In the extended position, ramp **40** projects forwardly of platform member **26** such that the top surface **48** of the ramp is substantially coplanar with upper surface **26** of platform member **26**. Thus, ramp **40** may be rotated about pivot axis **46** through an arc of more than 180 degrees.

Referring to FIG. **8**, lift **22** includes a horizontal support **60** positioned beneath and attached to platform member **26**. Support **60** includes a rear end **62** and a front end **64**. As used herein in conjunction with the description of life **22**, "rear" means those portions of the lift to the left of center, as viewed in FIG. **8**, and "front" means those portions of the lift to the right of center. This terminology is used because when lift **22** is installed in the stairwell of a transit vehicle, the portions of the lift to the left of center are closer to the rear of the vehicle and the portions of the lift to the right of center are closer to the front of the vehicle. Lift **22** also includes a rear vertical extension **66** that is attached to rear end **62** of support **60** and a front vertical extension **68** that is attached to front end **64** of support **60**. Vertical extensions **66** and **68** have a U-shaped configuration, when viewed in cross section, and are attached to support **60** via hinge structure **700** of the present invention, as discussed hereinafter.

As illustrated in FIGS. **1**, **2** and **8**, lift **22** also comprises a rear guide **80** and a front guide **82**. Guides **80** and **82** are hollow columns which are sized to receive vertical extensions **66** and **68**, respectively, with a sliding fit. Thus, guides **80** and **82** define elongate pathways along which vertical extensions **66** and **68** travel as platform assembly **24** is being raised and lowered. Guides **80** and **82** are attached to rear and front sidewalls (not shown), respectively, of the stairwell of the transit vehicle in which lift **22** is installed so as to extend parallel to one another, and perpendicular to upper surface **28** of platform member **26**.

As described in greater detail in the '771 patent, lift **22** comprises a hydraulic actuator (not shown) positioned in rear guide **80** for causing platform assembly **24** to move between ground and floor level positions. One end of the actuator is attached to guide **80** and the other end of the actuator is attached to the rear side platform assembly **24** such that when the piston rod of the actuator is extended and retracted the platform moves between the ground and floor level positions. Thus, the raising and lowering force provided by the actuator is directly applied to only one side of the platform assembly **24**.

Lift **22** includes a chain drive assembly, which is also described in greater detail in the '771 patent, for causing the front side of platform assembly **24**, i.e., the end attached to front vertical extension **68**, to move together with the rear side of the platform assembly. Thus, the chain drive assembly causes platform assembly **24** to remain perpendicular to the long axes of guides **80** and **82** as the platform is moved between the ground and floor level positions.

Referring to FIGS. **8** and **9**, the chain drive assembly comprises three sheaves and three sprockets. Sheave **90** (FIG. **9**) is paired with sprocket **92** (FIG. **9**), both of which are pivotally mounted adjacent the junction of vertical extension **66** and rear end **62** of support **60**, as described in greater detail hereinafter. Sheave **94** is mounted adjacent the upper end of guide **80**, sprocket **96** is mounted adjacent the upper end of guide **82**, and sprocket/sheave pair **98** is mounted adjacent the junction of vertical extension **68** and front end **64** of support **60**. Sprocket/sheave pair **98** comprises a sheave and a sprocket (not shown) which are identical, respectively, to sheave **90** and sprocket **92**. A leaf chain **110** is attached to guide **80** below sheave **94**, extends around sheave **94** and downwardly to sheave **90**, around the latter and across support **60** to the sheave of pair **98**, around the latter and upwardly to an attachment point on guide **82** positioned below pair **96**. A roller chain **112** is attached to guide **82** below sprocket **96**, extends around sprocket **96** and downwardly to the sprocket of pair **98**, around the latter and across support **60** to sprocket **92**, around the latter and upwardly to an attachment point on guide **80** positioned below sheave **94**.

Referring to FIGS. **3** and **4**, linkage assembly **20** comprises elongate clevis links **200**a and **200**b. The latter have an identical configuration and are preferably made from flat plates of steel having a thickness of about 0.31 inch. Clevis links **200** each have a gradually curving concave upper surface **202**, a flat bottom surface **203** and a triangularly shaped outer portion **204** having a flat upper surface **206** and a gradually curving bottom surface **208** which join at an outer end **210**. Surfaces **206** and **208** extend transversely relative to one another such that an angle of about 15 degrees is included between the surfaces. Clevis links **200**a and **200**b each terminate at an inner edge **212** which extends substantially perpendicular to the long axes of the links. Clevis links **200**a and **200**b each include a bore **214** (FIG. **4**) extending therethrough, positioned beneath the junction of surfaces **206** and **202** and approximately centered within the width of the clevis link.

In one embodiment of the present invention (hereinafter referred to as the "exemplary embodiment"), clevis links **200**a and **200**b each have a length of 7.84 inches, as measured between outer end **210** and inner edge **212** along an axis extending parallel to bottom surface **203**. In the exemplary embodiment, the center of bore **214** is spaced 6.00 inches from rear edge **212**, as measured along an axis extending parallel to bottom surface **203**, and upper surface **206** has a length of about 1.75 inches.

The portions of clevis links **200**a and **200**b adjacent inner edges **212** are attached to a U-shaped bracket **220** having a threaded bore **222** therein for receiving threaded end **224** of rod **226** of hydraulic actuator **228**. The latter is positioned underneath platform assembly **24**, and an inboard end **230** of actuator **228** is pivotally attached to the platform assembly, as illustrated in FIG. **2**. Bracket **220** is designed to support clevis links **200**a and **200**b in spaced relation such that a predetermined space is provided between the links. In the exemplary embodiment, hydraulic fluid is provided to hydraulic actuator **228** at about 1200 psi, piston rod **226** has a diameter of 0.625 inch and actuator **228** has an internal diameter of 1.00 inch.

Linkage assembly **20** also comprises connecting links **300**a, **300**b, and **300**c. The latter are identical in configuration and are preferably made from steel plate having a thickness of about 0.31 inch. Each of the connecting links **300** includes a triangularly shaped inner portion **302** having a flat upper surface **304** and a flat bottom surface **306**, which surfaces join at inner end **308** and include an angle of about 15 degrees. Each connecting link **300** includes a first concave depression **310** in the upper surface thereof and a second concave depression **312** in the upper surface inwardly of the first depression (i.e., to the right of the first depression, as viewed in FIG. **3**). Each of the connecting links **300** also include a concave depression **314** in the bottom surface thereof. The outermost portion **316** of the bottom surface of connecting links **300** is flat. Furthermore, each of the links **300** include a bore **318** (FIG. **3**) extending therethrough adjacent the outer end thereof, a bore **320** (FIG. **3**) extending through an intermediate portion thereof and positioned between depressions **310** and **312**, and a third bore **322** (FIG. **3**) positioned at the junction of triangular inner portion **302** with the remainder of the connecting link.

In the exemplary embodiment, connecting links **300** have a length of 6.03 inches, as measured between the outermost portion and the innermost portion of the connecting links. Also, the center of bore **318** is spaced 3.87 inches from the center of bore **322**, and the center of bore **318** is spaced 1.78 inches from the center of bore **320**. Also, as measured along axes extending perpendicular to flat bottom surface portion **316**, bore **318** is positioned 0.125 inches below bore **320**, and bore **318** is positioned 0.187 inches above bore **322**.

The outer portion **204** of clevis link **200**a is positioned between inner portions **302** of connecting links **300**a and **300**b, and the outer portion **204** of clevis link **200**b is positioned between inner portions **302** of connecting links **300**b and **300**c. The clevis links **200** are pivotally attached to the connecting links **250** via a pin **340** (FIGS. **3** and **4**) extending through bores **214** in the clevis links and bores **322** in the connecting links. Pin **340** is sized to project outwardly of the outer side surfaces of connecting links **300**a and **300**c, and wheels **342** are attached to the projecting ends of the pin so as to rotate with the pin and prevent the clevis links and connecting links from moving laterally away from one another. Connecting links **300** are also held together by a pin **344** received in bores **320** with an interference fit.

Linkage assembly **20** also comprises control levers **400**a and **400**b. The latter have an identical configuration and are preferably made from steel plate having a thickness of about 0.31 inch. Control levers **400**a and **400**b each comprise a flat upper surface **402**, a flat bottom surface **404** which extends transversely to the upper surface such that an angle of about 11 degrees is included between the surfaces. Surfaces **402** and **404** join one another at curved outer end **406** (FIG. **3**). Control levers **400**a and **400**b taper to small inner portion **408** having a bore **410** extending therethrough. Each of the control levers **400**a and **400**b includes an oval slot **412** extending through the outer portion thereof, and a bore **414** extending through a central portion thereof. Slot **412** is aligned so that its long axis extends parallel to upper surface **402**.

In the exemplary embodiment of linkage assembly **20**, control levers **400** have a length of 4.36 inches, as measured between outer end **406** and the innermost surface of inner portion **408** along an axis extending parallel to upper surface **402**. The center of oval slot **412** is spaced 3.70 inches from the center of bore **410**, and the center of bore **414** is spaced 2.08 inches from the center of bore **410**. The center of slot **412** is positioned 0.306 inches above the center of bore **414**, and the center of bore **410** is positioned 0.389 inches below the center of bore **414**, as measured along axes extending perpendicular to upper surface **402**.

The inner half of control lever **400**a is positioned between the outer portions of connecting links **300**a and **300**b, and the inner portion of control lever **400**b is positioned between the outer portions of connecting links **300**b and **300**c. Control levers **400** are pivotally attached to connecting links **300** via a pin **420** which is received in bores **318** in connecting links **300** with a sliding fit and is received in bores **414** in control levers **400** with an interference fit.

Linkage assembly **20** further comprises drag links **500**a and **500**b. The latter have an identical configuration and are preferably made from steel plate having a thickness of about 0.31 inch. Drag links **500**a and **500**b each include a flat upper surface **502**, a flat bottom surface **504**, which surfaces join at curved outer end **506** and include an angle of about 15 degrees, and a flat inner surface **508**. Bore **510** extends through each drag link adjacent the front end **506** thereof, and bore **512** extends through each drag link adjacent the inner end thereof.

In the exemplary embodiment, drag links **500** have a length of 1.54 inches, as measured between front end **506** and rear surface **508** along an axis extending parallel to upper surface **502**. The centers of bores **510** and **512** are spaced 1.00 inch apart.

The outermost portions of control levers **400** are received between drag links **500**, with drag link **500**a being positioned next to control lever **400**a and drag link **500**b being positioned next to control lever **400**b. Drag links **500** are pivotally attached to control levers **400** via pin **520** which is received in bores **510** in the drag links with an interference fit and which is received in slots **412** in control levers **400** with a free sliding fit. A spacer **521** is provided between control levers **400**a and **400**b. Spacer **521** (FIG. **4**) is rotatably mounted on pin **520**.

Linkage assembly **20** includes elongate pivot shafts **522** and **524**. One end of shaft **522** is received in bore **512** in drag link **500**a with an interference fit and projects outwardly from the drag link a predetermined distance, e.g., 2 inches, and one end of shaft **524** is received in bore **512** in drag link **500**b with an interference fit and projects outwardly from the drag link a similar predetermined distance.

Linkage assembly **20** additionally comprises a pair of bushing blocks, one of which is identified at **540** in FIG. **4**, for receiving shafts **522** and **524** such that the shafts are free to rotate about their axes within the bushing blocks. Bushing blocks **540** are received in pocket **52** in ramp **40** such that the axes of rotation of shafts **522** and **524** are coaxial and extend parallel to the rotational axis of hinge **44**. By this attachment of shafts **522** and **524** to ramp **40**, drag links **500**a and **500**b are pivotally mounted to ramp **40**. Bushing blocks **540** are held in place in pocket **52** by a plate **542**.

Referring to FIGS. **1**, **4** and **5**, linkage assembly **20** also includes identical support plates **600**a and **600**b. The latter are attached to bottom surface **30** of platform member **26** such that plate **600**a is positioned adjacent the outer sides of clevis link **200**a and connecting link **300**a and plate **600**b is positioned adjacent the outer sides of clevis link **200**b and connecting link **300**c. Plates **600**a and **600**b begin at front edge **34** and extend inwardly from the front edge of a suitable distance, e.g., about 2 feet. Each of the plates **600**a and **600**b includes an inclined, arcuate slot **602** extending therethrough adjacent the front portion of the plate. The width of slots **602** is slightly greater than the outside diameter of wheels **342** so that the wheels may roll freely within the slots, as discussed hereinafter. The outer end (i.e., the left end, as viewed in FIG. **5**) of each slot **602** is positioned adjacent the upper edge of the support plate **600** and the inner end of the slot is approximately centered within the support plate. In the exemplary embodiment, slots **602** have a length of about 5.5 inches and extend along an arc having a radius of about 12 inches.

In connection with the following discussion of the manner in which linkage assembly **20** is attached to lift **22** and the manner in which linkage assembly **20** operates, reference should be made to FIGS. **2**–**7**. Because shafts **522** and **524** are pivotally attached to ramp **40**, as discussed above, drag links **500**, spacer **521**, the majority of control levers **400**, and the outer portions of connecting links **300** are received in aperture **56** in ramp **40** when the latter is in the extended position illustrated in FIGS. **3**, **4** and **7**.

As best seen in FIGS. **5**–**7**, small inner portion **408** of control levers **400** is pivotally attached to platform member **26** adjacent the outer edge **34** thereof via a pin **620** (FIGS. **5**–**7**). Pin **620** is sized to pivot freely within bores **410** in inner portions **408** and is non-rotatably affixed to platform member **26** such that the longitudinal axis of the pin extends parallel to the axis of rotation of hinge **44**. Pin **620** is preferably attached to platform member **26** below hinge **44**. In the exemplary embodiment of the present invention, the longitudinal axis of pin **620** is positioned 1.125 inches below the pivot axis **46** of hinge **44** and is vertically aligned with the pivot axis of hinge **44**.

When ramp **40** is in the fully extended position (FIGS. **3**, **4** and **7**), the majority of connecting links **300** and the outer portions of clevis links **200** are positioned in aperture **32** in platform assembly **26**. Also in this position, wheels **342** are received in the outermost portions of slots **602** in support plates **600**. The inner portions of clevis links **200** extend underneath platform member **26** adjacent its bottom surface **30**, and are attached via U-shaped bracket **220** to rod **226** of hydraulic actuator **228**.

Assuming ramp **400** is initially in the retracted position illustrated in FIG. **5**, the ramp is caused to move toward the extended position by causing hydraulic actuator **228** to operate such that its piston rod **226** is extended. As piston rod **226** moves toward outer edge **34**, it drives clevis links **200** toward the outer edge. This outward movement of the clevis links is transmitted via pin **340** to connecting links **300**, thereby causing the latter to move outwardly and upwardly. Wheels **342** roll within slots **602** during this movement of the clevis links and connecting links.

The outward and upward movement of connecting links **300** is transmitted to control levers **400** via pin **420** causing the control levers to initially move toward a vertically extending position, as illustrated in FIG. **6**. This movement of control levers **400** is transmitted via pin **520** to drag links **500** which, in turn, cause ramp **40** to move upwardly from the retracted position illustrated in FIG. **5** toward the barrier position illustrated in FIG. **6**.

Connecting links **300** and control levers **400** together provide a moment arm which becomes increasingly large as the ramp **40** approaches the vertically extending position it assumes in the barrier position. Thus, the linkage assembly **20** transmits a smaller portion of the force provided by actuator **228** to ramp **40** when the ramp is in the retracted position than when the ramp is in the barrier position. An important aspect of this change in the mechanical advantage provided by linkage assembly **20** is that when ramp **40** is in the barrier position, the position to which it is moved when a wheelchair and occupant are being raised and lowered, a relatively large force is required to drive the ramp **40** outwardly toward the extended position. As a consequence, linkage assembly **20** and actuator **228** strongly resist the tendency of ramp **40** to pivot outwardly when a heavily loaded wheelchair rolls against ramp **40**.

Additional extension of piston rod **226** causes the elements of linkage assembly **20** to drive ramp **40** toward the extended position illustrated in FIG. **7**. As ramp **40** approaches the extended position, the axes of pin **520**, pin **420**, and pin **340** begin to nearly line up, i.e., lie on a common plane. In fact, during the last few degrees of downward travel of ramp **40**, the axis of pin **520** drops below the plane on which pins **340** and **420** lie, i.e., pin **520** moves to an "over center" position. As a consequence of this alignment of pins **340**, **420** and **520**, the length of the moment arm provided by connecting links **300** and control levers **400** is reduced significantly such that the force applied to ramp **40** as it approaches the extended position is much less than the force applied to the ramp when it is in the barrier position.

With the exemplary embodiment, the magnitude of the force provided by linkage assembly **20** to ramp **40** when the latter is in the barrier position (i.e., when ramp **40** is at about the halfway point in its travel through the 180° arc) is at least four times the magnitude of the force provided by the linkage assembly to the ramp during its last few degrees of travel toward or away from the extended position. Similarly, the magnitude of the force the linkage assembly applies to the ramp as the latter approaches the retracted position is about one quarter or less the magnitude of the force the linkage assembly applies to the ramp when the latter is in the barrier position.

As a consequence of this design of the exemplary embodiment of linkage assembly **20**, ramp **40** is urged downwardly during the last few inches of travel toward the extended position such that the outermost edge of the ramp provides a downwardly extending force of only about 40 pounds. Thus, a person's feet inadvertently positioned in the path of travel of ramp **40** will not be crushed by the ramp.

An important advantage of the design of linkage assembly **20** responsible for ramp **40** being urged to the extended position with minimal force is that extra controls in the hydraulic circuitry associated with hydraulic actuator **228** are not required. As noted above, known lifts utilize pressure limiting valves in conjunction with the actuator for limiting the pressure of hydraulic fluid provided to the actuator, thereby limiting the actuation force the actuator can generate.

During the last few degrees of downward travel of ramp **40**, bottom surface **504** of drag links **500** will engage studs **54** which projects outwardly so as to lie in the path of travel of the drag links. As a consequence of this engagement, drag links **500** urge studs **54**, and ramp **40** attached thereto, downwardly to the fully extended position. Studs **54** are provided because under certain circumstances hinge **44** will resist rotation as a consequence of high frictional forces caused by corrosion of the hinge or other factors. This resistance to rotation coupled with the relatively small actuation force applied to ramp **40** by linkage assembly **20** as the ramp approaches the extended position may be insufficient to drive ramp **40** to the fully extended position.

The elements of linkage assembly **20** are designed and are coupled to ramp **40** and platform member **26** so as to form a four-bar linkage. The latter consists of (1) the portion of platform member **26** adjacent its outer edge **34** between the pivot axis **46** of hinge **44** and the longitudinal axis of pin **620**, (2) the portion of ramp **40** between the pivot axis of hinge **44** and the longitudinal axis of shafts **522** and **524**, (3) drag links **500**, and (4) control levers **400**. As noted above, the pivot axes where the four links in the four-bar linkage are attached approach coplanar alignment when ramp **40** is in the extended position. In fact, during the last few degrees of downward travel of ramp **40** pin **520** moves to an "over-center" position, with the result that the above-described four-bar linkage cannot urge ramp **40** to the fully extended position. By providing studs **54** adjacent drag links **500**, the latter will drive ramp **40** downwardly through the last few degrees of travel to the fully extended position, thereby overcoming the above-noted limitation in the ability of the four-bar linkage to transmit drive forces to the ramp when approaching the fully extended position.

As ramp **40** approaches the extended position, wheels **342** begin to travel upwardly as a consequence of the inclined configuration of the slots **602** in which they are received. This upward movement drives triangular inner portion **302** of connecting links **300** upwardly in aperture **32** in platform member **26** until the flat upper surfaces **304** of the triangular portions are approximately coplanar with upper surface **28** of the platform member. Similarly, triangular outer portions **204** of clevis links **200** are driven upwardly into aperture **32** until the flat upper surfaces **206** of the outer portions are approximately coplanar with surface **28**. When in this position, surfaces **206** and **304** together define a planar structure which fills in aperture **32** in platform member **26** such that no gaps of greater than 0.625 inch exist between elements of linkage assembly **20** or between the edges of aperture **32** and the linkage assembly. Furthermore, the upper surface of such structure is substantially coplanar with top surface **28** of platform member **26**.

Furthermore, when ramp **40** is in the extended position, flat upper surface **402** of control levers **400**, upper surface **502** of drag links **500**, and the high portions of connecting links **300** on either side of concave depression **310** in the top surface of the connecting links are positioned in aperture **56** in ramp **40**. Together, these elements define a planar structure which fills in aperture **56** in ramp **40** such that no gaps greater than 0.625 inch in width exist between the elements of the linkage assembly or between the edge of aperture **56** and the linkage assembly. Furthermore, the upper surface of such structure is substantially coplanar with the top surface **48** of ramp **40**.

Concave depressions **314** are provided in the bottom surface of connecting links **300** so that when the linkage assembly is in the fully extended position the bottom surface of the connecting links will not engage projecting portions of pin **620**. Concave depressions **312** are provided in the upper surface of connecting links **300** so that as the connecting links are moving outwardly and upwardly or inwardly and downwardly, the upper surface will not contact the inner edge of aperture **32** in platform member **26**. Concave depressions **310** are provided in connecting links **300** to receive portions of the drag links **500** when ramp **40** is in the retracted position, as illustrated in FIG. **5**.

Linkage assembly **20** causes ramp **40** to move from the extended position to the retracted position in exactly the reverse manner in which the linkage assembly deploys the ramp.

Clevis links **200**, connecting links **300**, control levers **400**, and drag links **500** are designed so that when ramp **40** is in the extended position, no portion of these elements projects more than 0.25 inch above top surface **48** of the ramp and upper surface **28** of platform portion **26**.

For ease of description, the extended position of ramp **40** has been described as the position where top surface **48** of ramp **40** is "substantially" coplanar with upper surface **28** of platform member **26**. More precisely described, however, top surface **48** extends slightly downwardly with respect to upper surface **28**. Linkage assembly **20** is designed to drive ramp **40** to such an "over center" position so as to minimized the effort required to move a wheelchair up onto platform member **26**. That is, in the extended position ramp **40** provides a substantially continuous surface from ground level to upper surface **28** of platform member **26**.

During the travel of ramp **40** from the retracted position to the extended position, pin **520** positioned in oval slot **412** in control levers **400** will move from the outer end of the slot to the inner end of the slot. Then as ramp moves past the barrier position toward the extended position pin **420** will move within slot **412** to the outer end of the slot. Slot **412** is provided for two reasons. First, the manufacturing tolerances required to produce linkage assembly **20** are reduced by providing a slot instead of a bore. For instance, if the length of one of the elements of linkage assembly **20** is slightly longer than intended, or the placement of one of the bores in the elements is inaccurate, pin **420** is free to shift slightly within slot **412** to accommodate such manufacturing errors. Second, when ramp **40** is being raised from both the retracted position and the extended position, linkage assembly **20** will move independently of ramp **40** a small amount before it begins raising the ramp as pin **520** moves from one end to the other of slot **412**. As a consequence of this movement of pin **520**, the linkage assembly moves to a position where the mechanical advantage it provides is sufficiently great that ramp **40** is easily raised.

Because clevis links **200**, connecting links **300**, control levers **400**, and drag links **500** are all made from flat plates of steel, the linkage assembly may be manufactured very inexpensively using conventional laser burning processes. When manufactured in this manner, substantially the only machining required in the fabrication of linkage assembly **20** is the drilling of the bores and slots discussed above.

Because the pins used to pivotally attach the various elements of the linkage assembly are preferably made from hardened steel, because clevis links **200**, connecting links **300**, control levers **400** and drag links **500** are preferably made from cadmium-coated steel plate, and because the diameter of wheels **342** is less than, e.g., 0.027 inches less than, the width of slots **602** in support plates **600**, the linkage assembly will operate freely without lubrication. As a consequence, the cost of maintaining the present linkage assembly is far less than the cost of maintaining its prior art counterparts.

As a consequence of the design of linkage assembly **20**, it is relatively easy to install and remove the latter. More specifically, by attaching the outer end of the linkage assembly to ramp **40** such that access to the linkage assembly is obtained via upper surface **48** of the ramp, the need to remove the tread (not shown) which is typically attached to bottom surface **50** of the ramp is avoided.

turning now to FIGS. **1**, **2**, **8**, and **9**, the present invention also comprises a hinge structure **700**a for attaching vertical extension **66** to rear end **62** of horizontal support **60**, and hinge structure **700**b for attaching vertical extension **68** to front end **64** of the horizontal support. Hinge structures **700**a and **700**b are nearly identical in construction except as noted below.

As illustrated in FIG. **9**, hinge structure **700**a comprises plates **702**a, **702**b and **702**c. These plates are identical in configuration and are attached to the upper surface of rear end **62** so as to project upwardly therefrom in parallel, equally spaced relation. Plates **702**a–**702**c each include a bore **704** extending therethrough, with the bores of each of the plates being coaxially aligned. A pivot rod **706** is received in bores **704** with a sliding fit. Rod **706** is sized to extend a predetermined distance outwardly of plates **702**a and **702**c. Sheave **90** is rotatably mounted on the portion of rod **706** positioned between plates **702**a and **702**b, and sprocket **92** is rotatably mounted on the portion of rod **706** positioned between plates **702**b and **702**c. Thus, plates **702**a, **702**b and **702**c together define a bracket for supporting sheave **90** and sprocket **92**.

Rear vertical extension **66** includes opposed oval slots **710** in the inner and outer sidewalls thereof. The long axes of slots **710** are positioned so as to extend perpendicular to the long axis of vertical extension **66** and parallel to the long axis of horizontal support **60**. Slots **710** are positioned adjacent, e.g., about 1 inch up from, the bottom of vertical extension **66**.

Vertical extension **66** is positioned relative to plates **702**a–**702**c such that the plates are received within the U-shaped space defined by cross-sectional configuration of the extension. The outwardly projecting ends of rod **706** are pivotally received in slots **710**, whereby the bottom end of vertical extension **66** is pivotally attached to rear end **62** of horizontal support **60** so as to be pivotable about an axis extending perpendicular to the long axis of the vertical extension and perpendicular to the long axis of horizontal support **60**.

Hinge structure **700**b is identical to hinge structure **700**a, except that pivot rod **706** is pivotally received in opposed bores **712** instead of opposed slots **710**.

By pivotally attaching vertical extensions **66** and **68** to horizontal support **60** via hinge structures **700**a and **700**b, the vertical extensions are free to assume paths of travel up and down inside guides **80** and **82**, respectively, which extend in parallel to the long axes of the guides. Consequently, if the chains of the chain drive assembly become maladjusted, causing the front side of platform assembly **24** to droop slightly, the vertical extensions **66** and **68** will pivot slightly relative to horizontal support **60** about the axes of rods **706** so as to permit the vertical extensions to slide freely up and down inside the guides.

Oval slots **710** are provided in vertical extension **66** so as to permit the horizontal spacing between the bottom ends of vertical extension **66** and **68** to vary slightly. If guides **80** and **82** are misaligned, i.e., do not extend in parallel, the bottom end of vertical extension **66** will move horizontally slightly so as to permit the vertical extensions to realign themselves during their travel up and down guides **80** and **82**. Such horizontal adjustment, together with the pivotal movement of the vertical extensions **66** and **68** about the axes of rods **706**, permits the vertical extensions to slide freely during their travel within guides **80** and **82**.

Even in the case of severe misalignment of guides **80** and **82**, or severe maladjustment of the chains of the chain drive mechanism, vertical extensions **66** and **68** will only bind within guides **80** and **82**, respectively. The ends of the vertical extensions **66** and **68** will not break free of the horizontal support **60**. This design feature is an important advantage over prior art lifts having vertical extensions which are integrally attached to the horizontal support. When such vertical extensions break free of the horizontal support, difficult and time-consuming repairs are required.

Since certain changes may be made in the above-described apparatus without departing from the scope of the present invention, the foregoing description and accompanying drawings are intended to be interpreted in an illustrative, and not in a limiting, sense.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A wheelchair lift, comprising:

a platform movable between a raised position and a lowered position, said platform having top and bottom surfaces, an outer edge, and an aperture extending through said platform adjacent said outer edge;

a ramp having an upper surface and a lower surface, said ramp being pivotally attached to said platform adjacent said outer edge so as to be rotatable about a pivot axis through an arc between (1) a retracted position in which said upper surface of said ramp confronts and extends substantially parallel to said top surface of said platform, (2) an intermediate position in which said ramp projects vertically from said platform, and (3) an extended position in which said ramp projects from said platform and said upper surface is substantially coplanar with said top surface;

actuator means adjacent said bottom surface of said platform, for providing extension force when said ramp is to be moved toward said extended position and retraction force when said ramp is to be moved toward said retracted position; and

a linkage assembly that cooperates with said actuator means to transmit said extension force from said actuator means to said ramp so as to cause said ramp to move from said retracted position toward said extended position and to transmit said retraction force from said actuator means to said ramp so as to cause said ramp to move from said extended position toward said retracted position wherein said linkage assembly transmits force to said ramp such that (1) when said ramp is in said intermediate position said ramp acts as a safety barrier to prevent a wheelchair passenger on said platform from rolling off said platform and (2) when said ramp downwardly approaches said extended position said ramp is unlikely to injure a bystander who inadvertently may be in the path of travel of said ramp, said linkage assembly being operatively connected to said actuator means and said ramp and no part of said linkage assembly projecting more than 0.25 inch above said top surface of said platform and said upper surface of said ramp when said ramp is in said extended position whereby said linkage assembly is unlikely to interfere with passenger access to said platform and said ramp.

2. A lift according to claim **1**, wherein said linkage assembly is designed so as to provide a structure within said aperture, when said ramp is in said extended position, which substantially fills said aperture and which includes a surface that is coplanar with said top surface of said platform.

3. A lift according to claim **2**, wherein said linkage assembly includes a plurality of linkage members, further wherein said linkage assembly is designed so that no gaps having a width greater than about 0.625 inch exit (a) between adjacent ones of said linkage members and (b) between said linkage assembly and edges of said aperture when said ramp is in said extended position.

4. A lift according to claim **1**, wherein said ramp includes a tread attached to its lower surface, further wherein said linkage means includes attachment means for attaching and removing a first end of said linkage assembly from said ramp without removal of said tread.

5. A lift according to claim **1**, wherein said linkage means transmits said extension force to said ramp, such that said ramp is driven toward said extended position during a final portion of its travel through said arc, with a force having a magnitude that is less than the magnitude of the force provided to said ramp by said linkage means as said ramp moves through said intermediate position.

6. A lift according to claim **5**, wherein said extension force is such that said ramp is driven toward said extended position, during a final portion of its travel through said arc, with a force such that an outermost edge of said ramp generates a downwardly extending force of no more than 40 pounds.

7. A lift according to claim **1**, wherein said linkage means includes a plurality of linkage members, each comprising first and second planar side surfaces which extend in parallel, further wherein said linkage members are attached to one another so that said first surfaces of all of said linkage members extend in parallel.

8. A wheelchair lift, comprising:

a platform movable between a raised position and a lowered position, said platform having top and bottom surfaces, an outer edge, and an aperture extending through said platform adjacent said outer edge;

a ramp having an upper surface and a lower surface, said ramp being pivotally attached to said platform adjacent said outer edge so as to be rotatable about a pivot axis through an arc between (1) a retracted position in which said upper surface of said ramp confronts and extends substantially parallel to said top surface of said platform, and (2) an extended position in which said ramp projects from said platform and said upper surface is substantially coplanar with said top surface;

an actuator adjacent said bottom surface of said platform, for providing extension force when said ramp is to be moved toward said extended position and retraction force when said ramp is to be moved toward said retracted position; and

a linkage assembly that cooperates with said actuator to transmit said extension force from said actuator to said ramp so as to cause said ramp to move from said retracted position toward said extended position and to transmit said retraction force from said actuator to said ramp so as to cause said ramp to move from said extended position toward said retracted position; wherein said linkage assembly comprises:

a plurality of clevis links, each having a planar configuration;

a connector for coupling said plurality of clevis links with said actuator;

a connector of connecting links pivotally attached to said plurality of clevis links to as to be rotatable about a first axis relative to said plurality of clevis links, each of said plurality of connecting links having a planar configuration;

a plurality of control levers pivotally attached to said plurality of connecting links so as to be rotatable about a second axis relative to said plurality of connecting links, said plurality of control levers additionally being pivotally attached to said platform adjacent its outer edge so as to be rotatable about a third axis relative to said platform, each of said plurality of control levers having a planar configuration; and

a plurality of drag links pivotally attached to said plurality of control levers so as to be rotatable about a fourth axis relative to said plurality of control levers, said plurality of drag links additionally being pivotally attached to said ramp so as to be rotatable about a fifth axis, each of said plurality of control levers having a planar configuration;

wherein no part of said linkage assembly projects more than 0.25 inch above said top surface of said platform and said upper surface of said ramp when said ramp is in said extended position whereby said linkage assembly is unlikely to interfere with passenger access to said platform and said ramp.

9. A lift according to claim **8**, wherein said pivot axis, said first axis, said second axis, said third axis, said fourth axis, and said fifth axis all extend parallel to said outer edge of said platform.

10. A lift according to claim **8**, wherein said linkage means is designed so that said second axis, said third axis, said fourth axis, and said fifth axis are substantially coplanar when said ramp is in said extended position.

11. A lift according to claim **8**, wherein (a) said pivot axis, said first axis, said second axis, said third axis, said fourth axis, and said fifth axis are positioned relative to one another and (b) said plurality of drag links and said plurality of control levers are sized and configured, so as to define a four-bar linkage consisting of:

a portion of each of said plurality of drag links between said fourth and fifth axes;

a portion of said ramp between said fifth axis and said pivot axis;

a portion of each of said plurality of control levers between said third and fourth axes; and

a portion of said platform between said pivot axis and said third axis.

12. A wheelchair lift, comprising:

a platform movable between a raised position and a lowered position, said platform having top and bottom surfaces and an outer edge;

a ramp having an upper surface and a lower surface, said ramp being pivotally attached to said platform adjacent said outer edge so as to be rotatable about a pivot axis through at least an arc between (1) a retracted position in which said upper surface of said ramp confronts and extends substantially parallel to said top surface of said platform, (2) an intermediate position in which said ramp projects vertically from said platform, and (3) an**[**d**]** extended position in which said ramp projects from said platform and said upper surface is substantially coplanar with said top surface;

actuator means adjacent said bottom surface of said platform, for providing extension force when said ramp is to be moved toward said extended position and retraction force when said ramp is to be moved toward said retracted position; and

a linkage assembly that cooperates with said actuator means to transmit said extension force from said actuator to said ramp so as to cause said ramp to move from said retracted position toward said extended position and to transmit said retraction force from said actuator means to said ramp so as to cause said ramp to move from said extended position toward said retracted position, said linkage assembly being operatively connected to said ramp and said actuator means, wherein said linkage assembly transmits said extension force to said ramp such that said ramp is caused to move through said barrier position with a force having a magnitude *at least about four times* greater than the magnitude of the force applied to said ramp as said ramp approaches said extended position whereby when said ramp is in said intermediate position said ramp acts as a safety barrier to prevent a wheelchair passenger on said platform from rolling off said platform and when said ramp downwardly approaches said extended position said ramp is unlikely to injure a bystander who inadvertently may be in the path of travel of said ramp.

13. A lift according to claim **12**, wherein said linkage means is designed so that no portion thereof projects more than 0.25 inch above said upper surface of said ramp and said top surface of said platform when said ramp is in said extended position.

14. A linkage mechanism for transmitting actuation and retraction forces from an actuator to a first plate having an upper surface, a lower surface, and an outer edge, said first plate being pivotally attached adjacent said outer edge to a second plate having an upper surface and a lower surface so as to be rotatable about a first axis between a retracted position wherein the upper surface of the first plate confronts and extends substantially parallel to the upper surface of the second plate to an extended position wherein the first plate projects from the second plate and the upper surface of the first plate is substantially coplanar with the upper surface of the second plate, so as to cause the first plate to move at least through an arc between the retracted and extended positions, said linkage mechanism comprising:

first and second linkage assemblies which are pivotally attached to one another and are pivotally attachable to the first and second plates so as to form, together with portions of the first and second plates, a four-bar linkage which will cause the first plate to move (a) from the retracted position toward the extended position when an actuation force is applied to a predetermined portion of said first linkage assembly and (b) from the extended position toward the retracted position when a retraction force is applied to said predetermined portion of said first linkage assembly; and

a third linkage assembly, pivotally attached to said predetermined portion of said first linkage assembly and coupleable with the actuator, for converting a first force provided by the actuator into said actuation force and for providing said actuation force to said predetermined portion of said first linkage assembly and for converting a second force provided by the actuator into said retraction force and for providing said retraction force to said predetermined portion of said first linkage assembly;

wherein no part of said first, second and third linkage assemblies projects more than 0.25 inch above the upper surface of the first plate and the upper surface of the second plate when the first plate is in the extended position whereby said first, second, and third linkage assemblies are unlikely to interfere with access to the upper surface of the first plate and the upper surface of the second plate when the first plate is in the extended position.

15. A linkage assembly according to claim **14**, wherein the first plate includes a first aperture adjacent the first axis and the second plate includes a second aperture adjacent the first axis which is aligned with the first aperture, further wherein:

said first and second linkage assemblies include portions which, when the first plate is in the extended position, form a structure having a surface (a) that is substantially coplanar with the upper surface of the first plate and (b) that fills the second aperture such that no gaps having a width greater than 0.625 inch exist within the second aperture; and

said third linkage assembly includes portions which, when the first plate is in the extended position, form a structure having a surface (a) that is substantially coplanar with the top surface of the second plate and (b) that fills the first aperture such that no gaps having a width greater than 0.625 inch exist within the first aperture.

16. A lift according to claim **14**, wherein said first, second and third linkage assemblies are designed to transmit the first and second forces from the actuator to the first plate such that a greater force is applied to the first plate when the upper surface thereof extends approximately perpendicular to the top surface of the second plate than when the first plate approaches the extended position.

17. A linkage mechanism for transmitting actuation and retraction forces from an actuator to a first plate having an upper surface, a lower surface, and an outer edge, said first being pivotally attached adjacent said outer edge to a second plate having an upper surface and a lower surface so as to be rotatable about a first axis between a retracted position wherein the upper surface of the first plate confronts and extends substantially parallel to the upper surface of the second plate to an extended position wherein the first plate projects from the second plate and the upper surface of the first plate is substantially coplanar with the upper surface of the second plate so as to cause the first plate to move at least through an arc between the retracted and extended positions, said linkage mechanism comprising:

a first linkage assembly, which is pivotally attachable to the first and second plates, for causing the first plate to move (a) from the retracted position toward the extended position when an actuation force is applied to a predetermined portion of said first linkage assembly and (b) from the extended position toward the retracted position when a retraction force is applied to said predetermined portion of said first linkage assembly;

a second linkage assembly, pivotally attached to said predetermined portion of said first linkage assembly and coupleable with the actuator, for converting a first force provided by the actuator into said actuation force, and for providing said actuation force to said predetermined portion of said linkage assembly, and for converting a second force provided by the actuator into said retraction force, and for providing said retraction force to said predetermined portion of said first linkage assembly; and

wherein said first and second linkage assemblies transmit the first and second forces provided by the actuator to the first plate such that the magnitude of the force provided to the first plate when the first plate is positioned about midway between the retracted and extended positions is *at least about four times* greater than the magnitude of the force provided to the first plate when the first plate is in the extended position whereby when the first plate is in the intermediate position the first plate strongly resists outward movement to the extended position and when the first plate downwardly approaches the extended position the first plate is unlikely to injure an object that inadvertently may be in the path of travel of the first plate.

18. A wheelchair lift, comprising:

a platform movable between a raised position and a lowered position, said platform having top and bottom surfaces, an outer edge, and an aperture extending through said platform adjacent said outer edge;

a ramp having an upper surface and a lower surface, said ramp being pivotally attached to said platform adjacent said outer edge so as to be rotatable about a pivot point between (1) a retracted position in which said upper surface of said ramp confronts and extends substantially parallel to said top surface of said platform, (2) an intermediate position in which said ramp projects vertically from said platform, and (3) an extended position in which said ramp projects from said platform and said upper surface is substantially coplanar with said top surface;

actuator means adjacent said bottom surface of said platform, for providing extension force when said ramp is to be moved toward said extended position and retraction force when said ramp is to be moved toward said retracted position; and

linkage means that cooperates with said actuator means for transmitting said extension force and said retraction force from said actuator means to said ramp so as to cause said ramp to move from said retracted position toward said extended position, wherein said linkage means transmits force to said ramp such that (1) when said ramp is in said intermediate position said ramp acts as a safety barrier to prevent a wheelchair passenger on said platform from rolling off said platform and (2) when said ramp downwardly approaches said extended position said ramp is unlikely to injure a bystander who inadvertently may be in the path of travel of said ramp, wherein said linkage means includes a first link coupled to said ramp, a second link coupled between said first link and said actuator means, and means for rotating said first link such that no part of said linkage means projects more than 0.25 inch above said top surface of said platform and said upper surface of said ramp when said ramp is in said extended position whereby said linkage means is unlikely to interfere with passenger access to said platform and said ramp.

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