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Trippensee et al.(10) **Pub. No.: US 2006/0087166 A1**(43) **Pub. Date: Apr. 27, 2006**(54) **POWER LIFT AND TILT MODULES****Related U.S. Application Data**(75) Inventors: **Darin J. Trippensee**, Fresno, CA (US);
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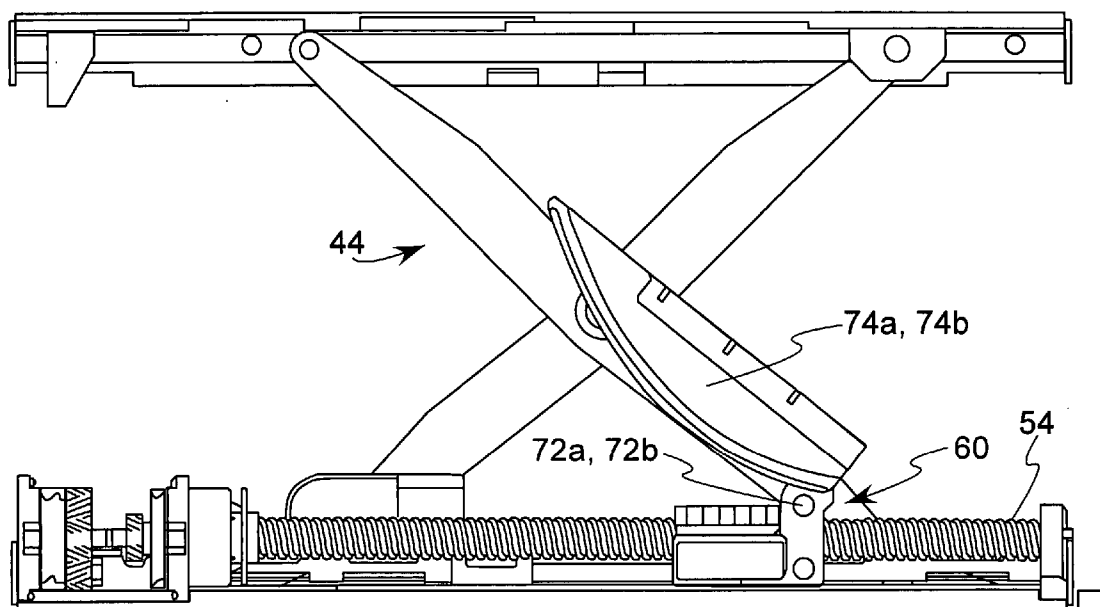
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TOLEDO, OH 43604-1619 (US)(57) **ABSTRACT**

A modular actuator has a combination cam member and scissors mechanism in a compact unit that is capable of lifting heavy loads. A pull member is capable of controlling and combining two different mechanisms that travel at different rates through two ranges of motion. The cam member has a profile that is dimensioned and configured to maintain a constant range of motion.

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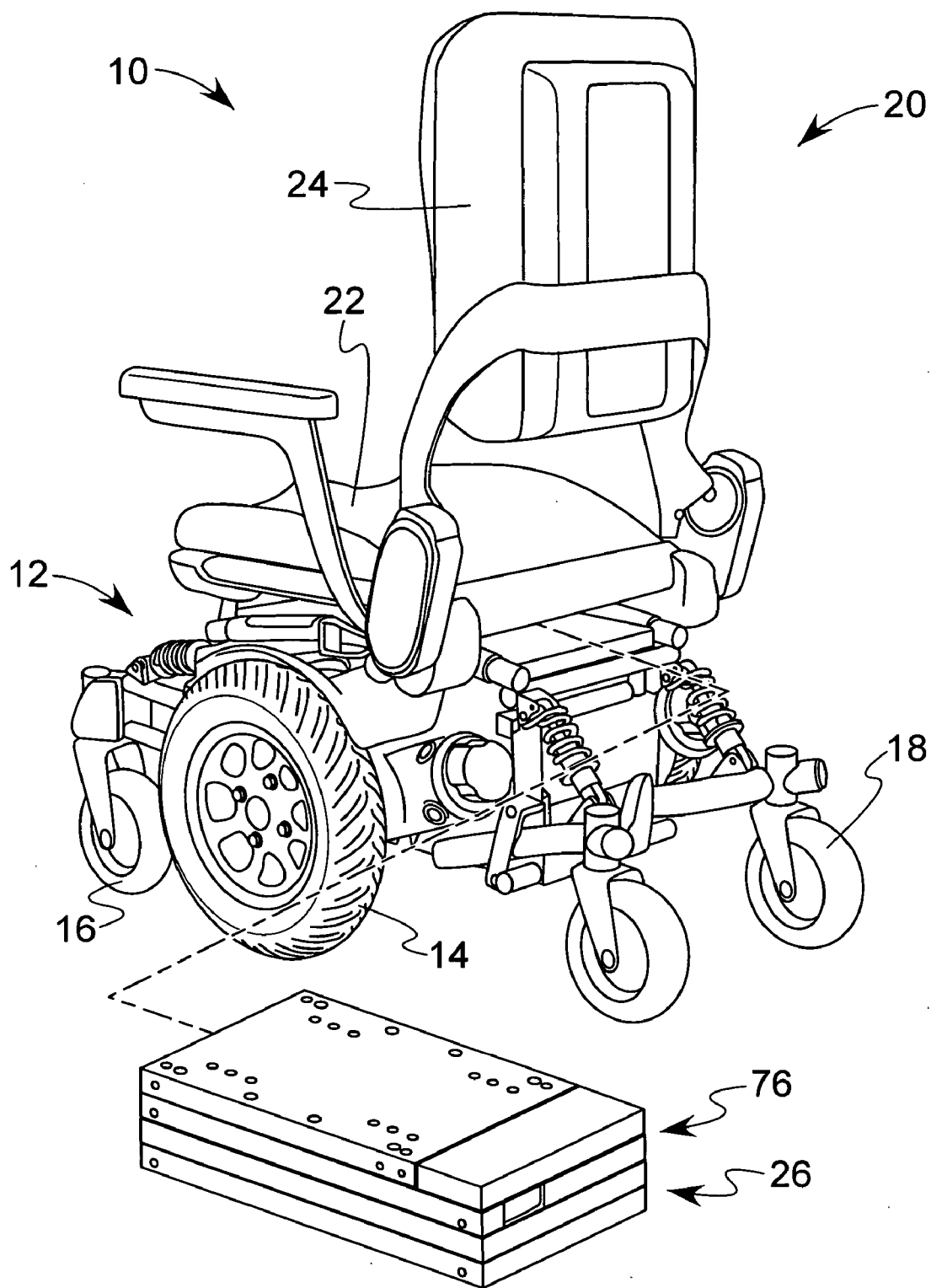
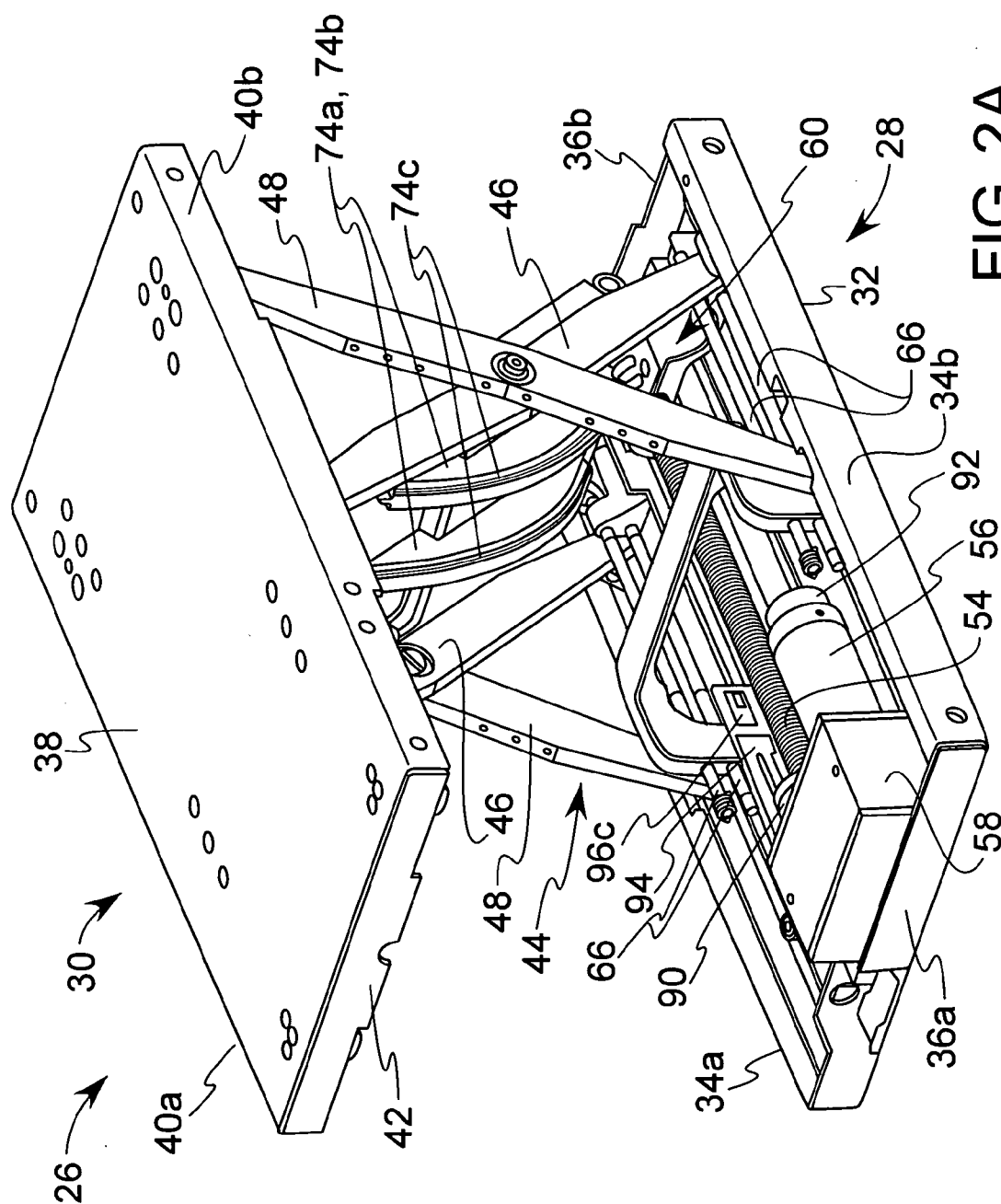


FIG. 1



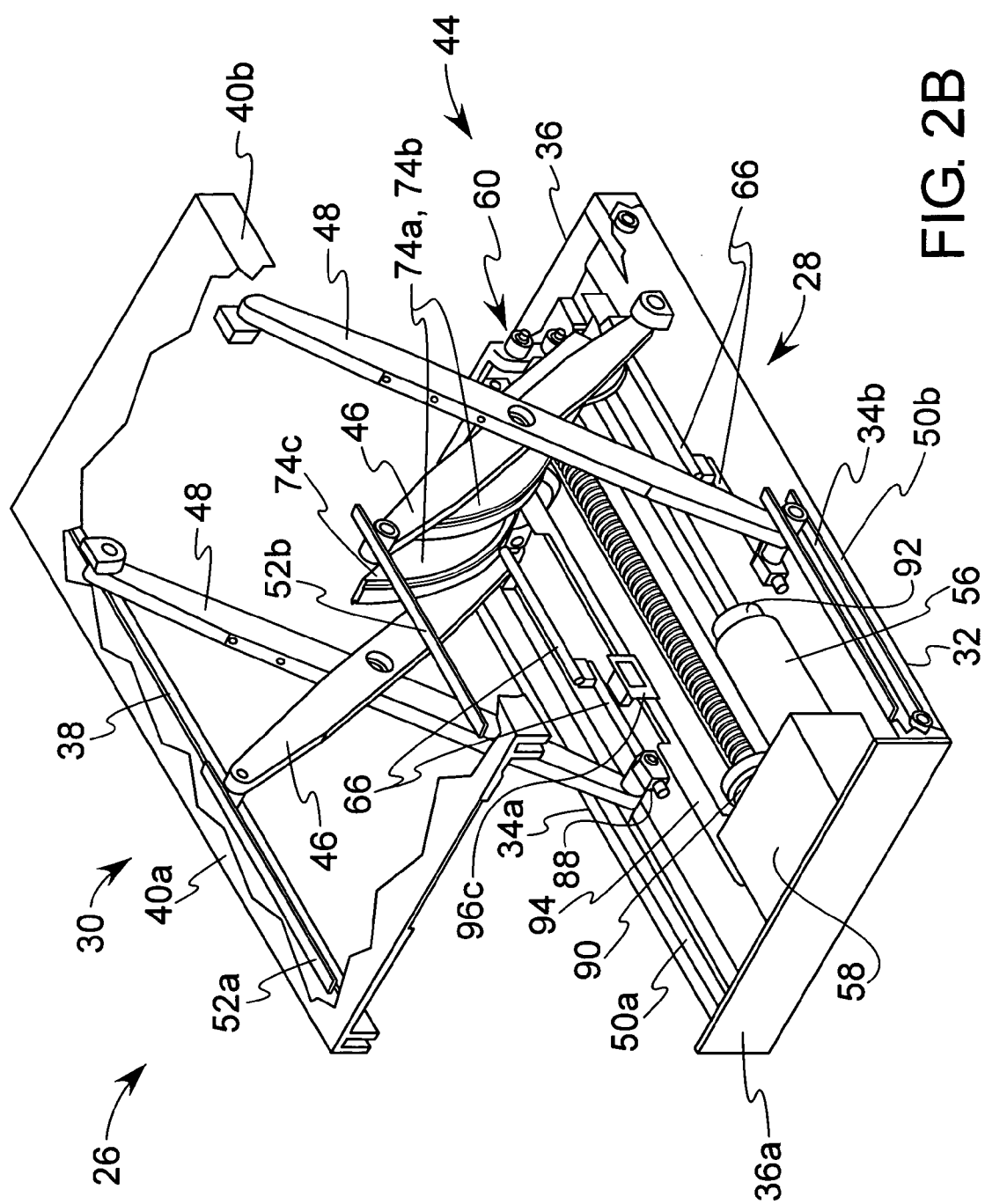


FIG. 2B

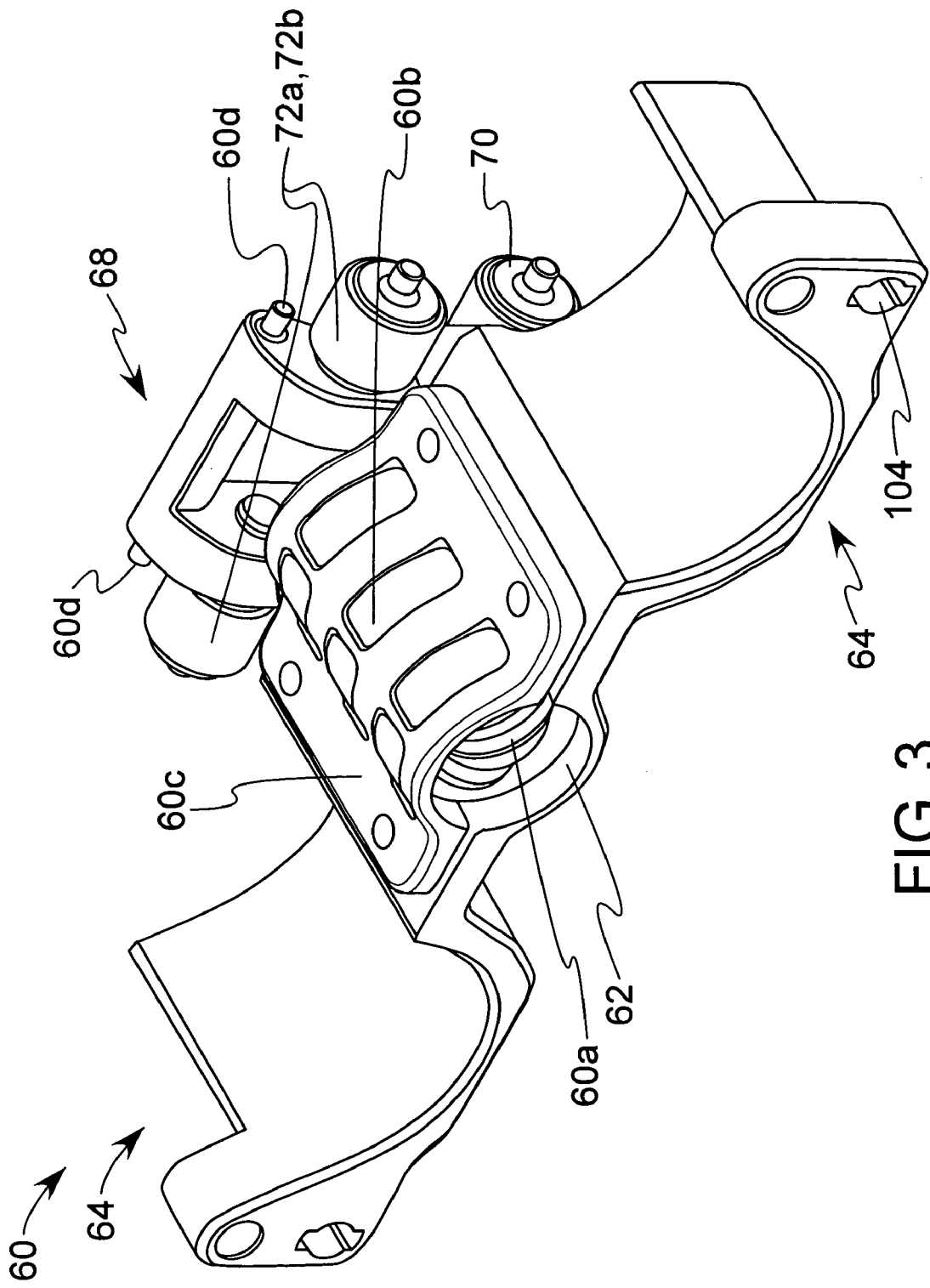


FIG. 3

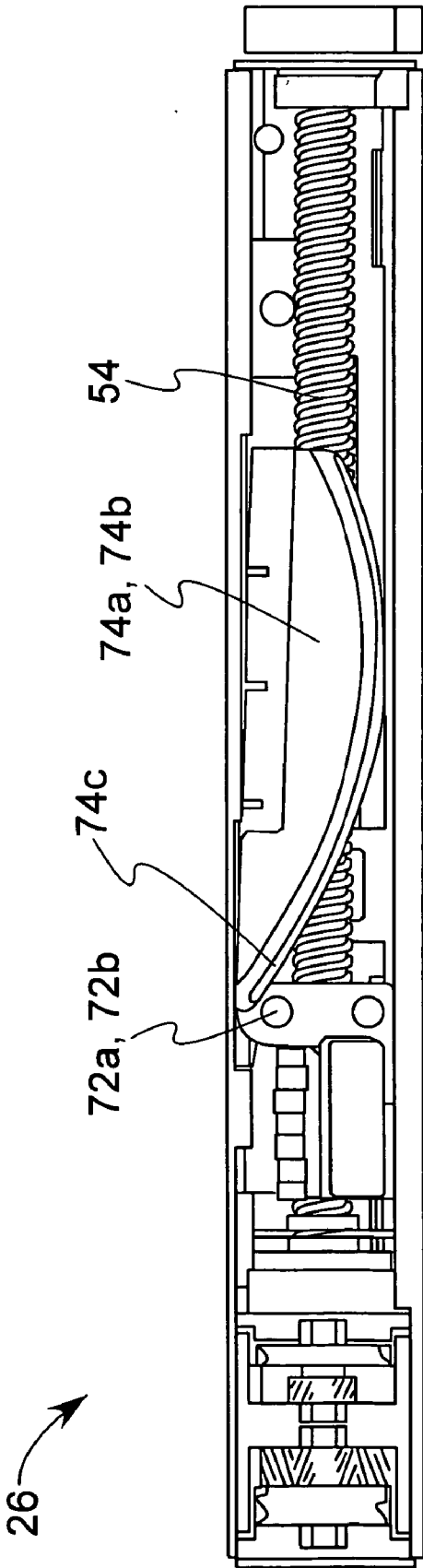


FIG. 4A

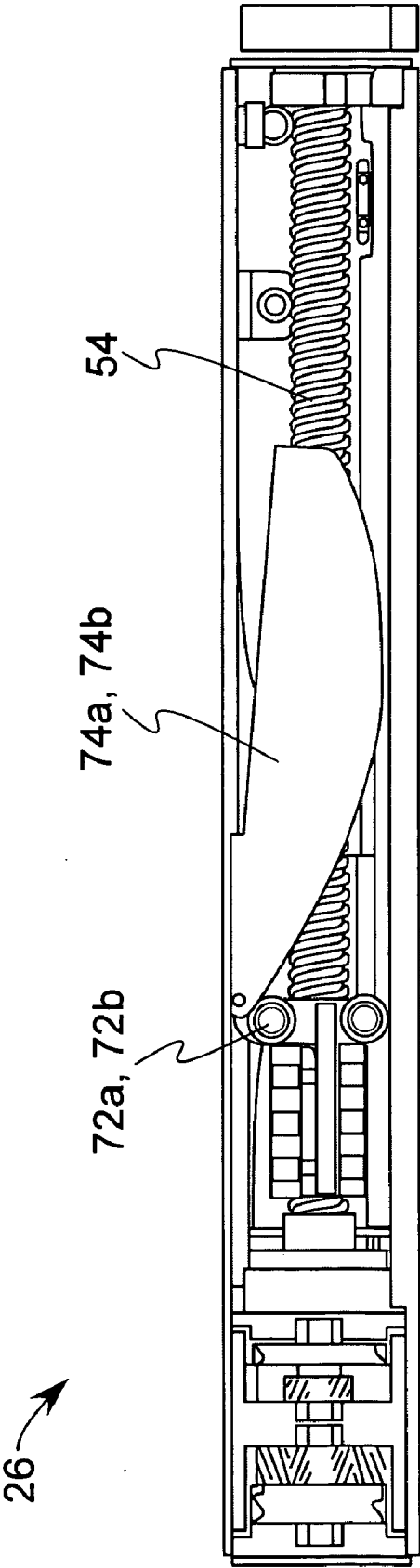


FIG. 4B

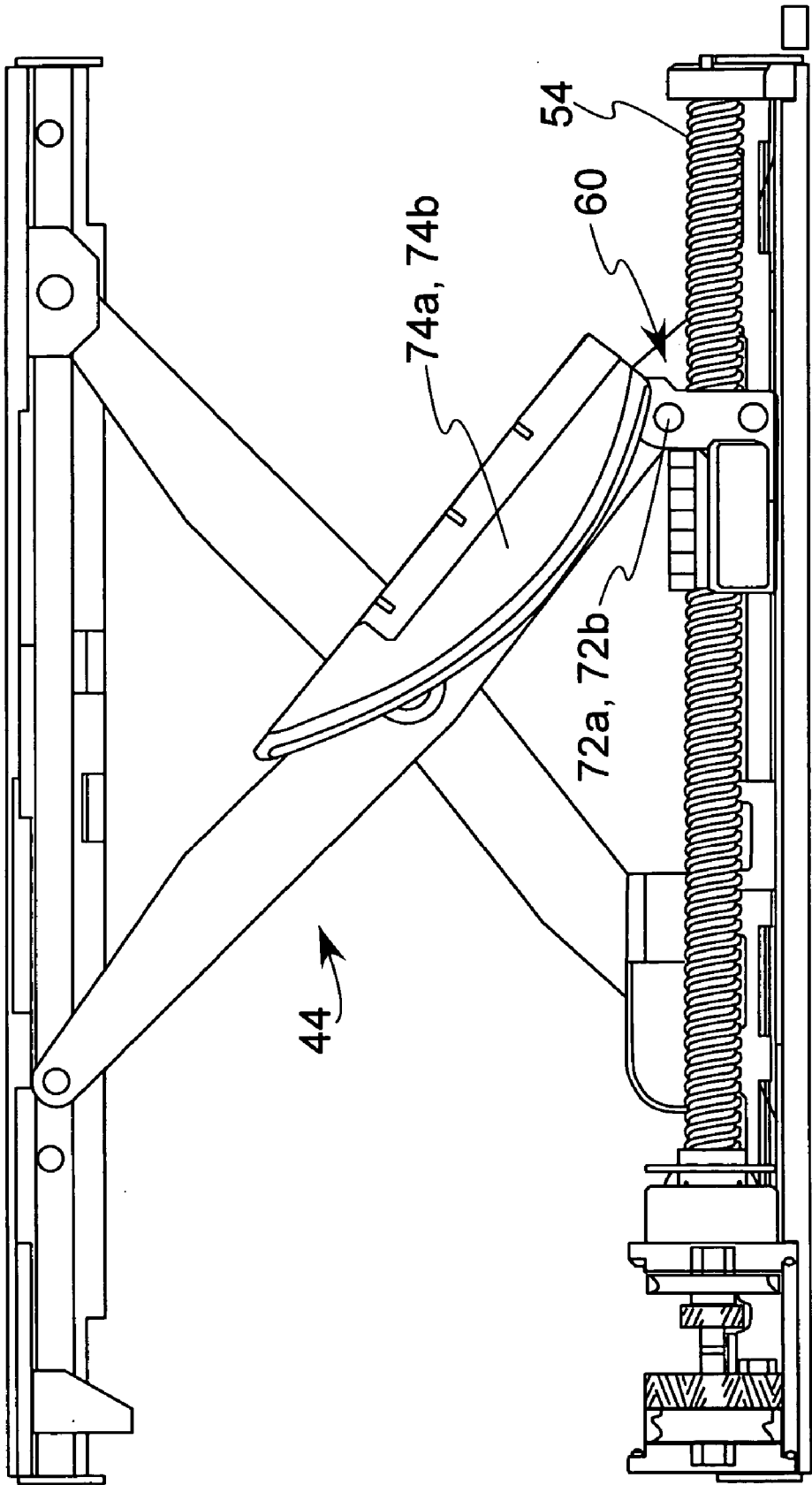


FIG. 5A

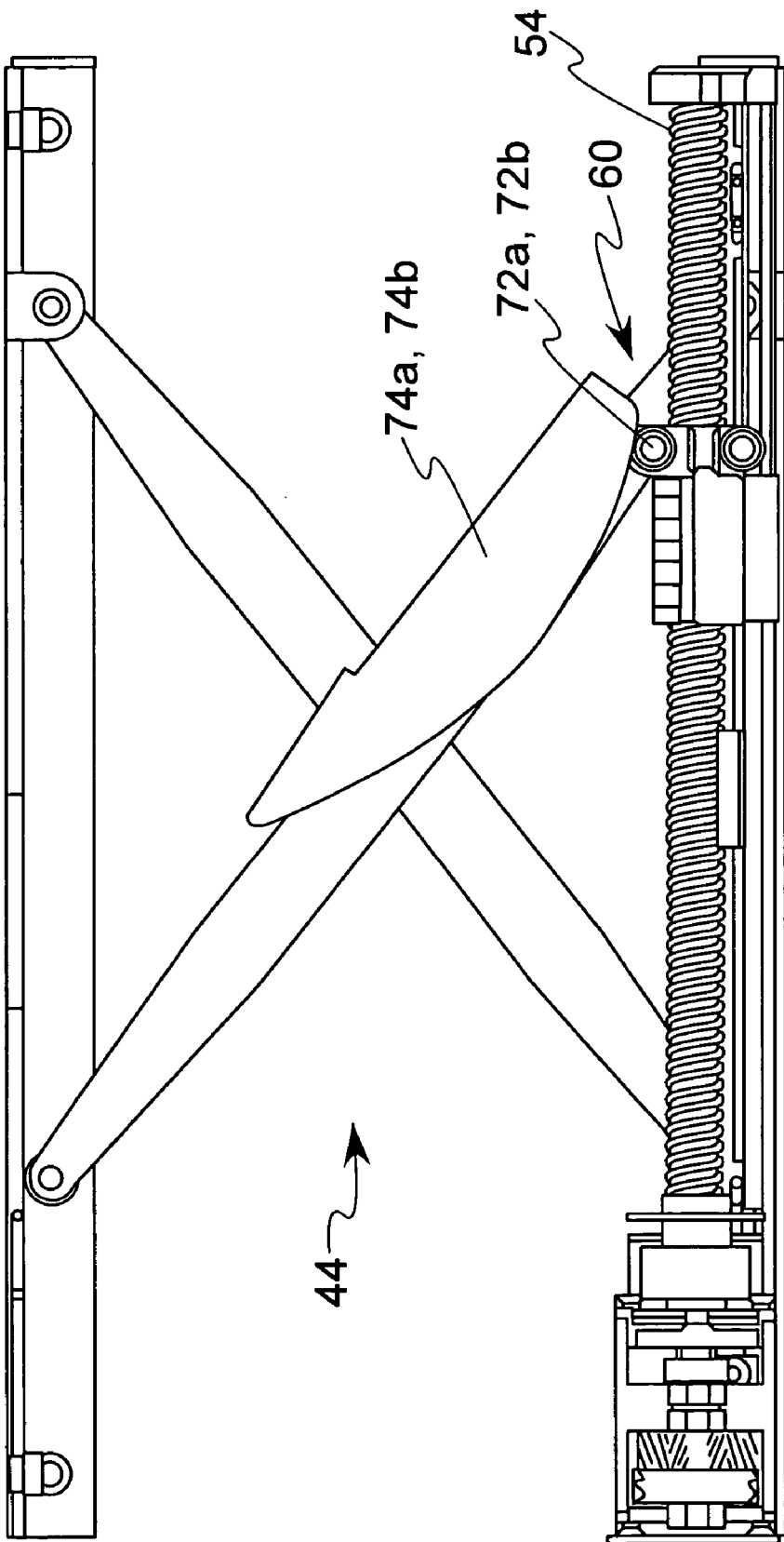


FIG. 5B

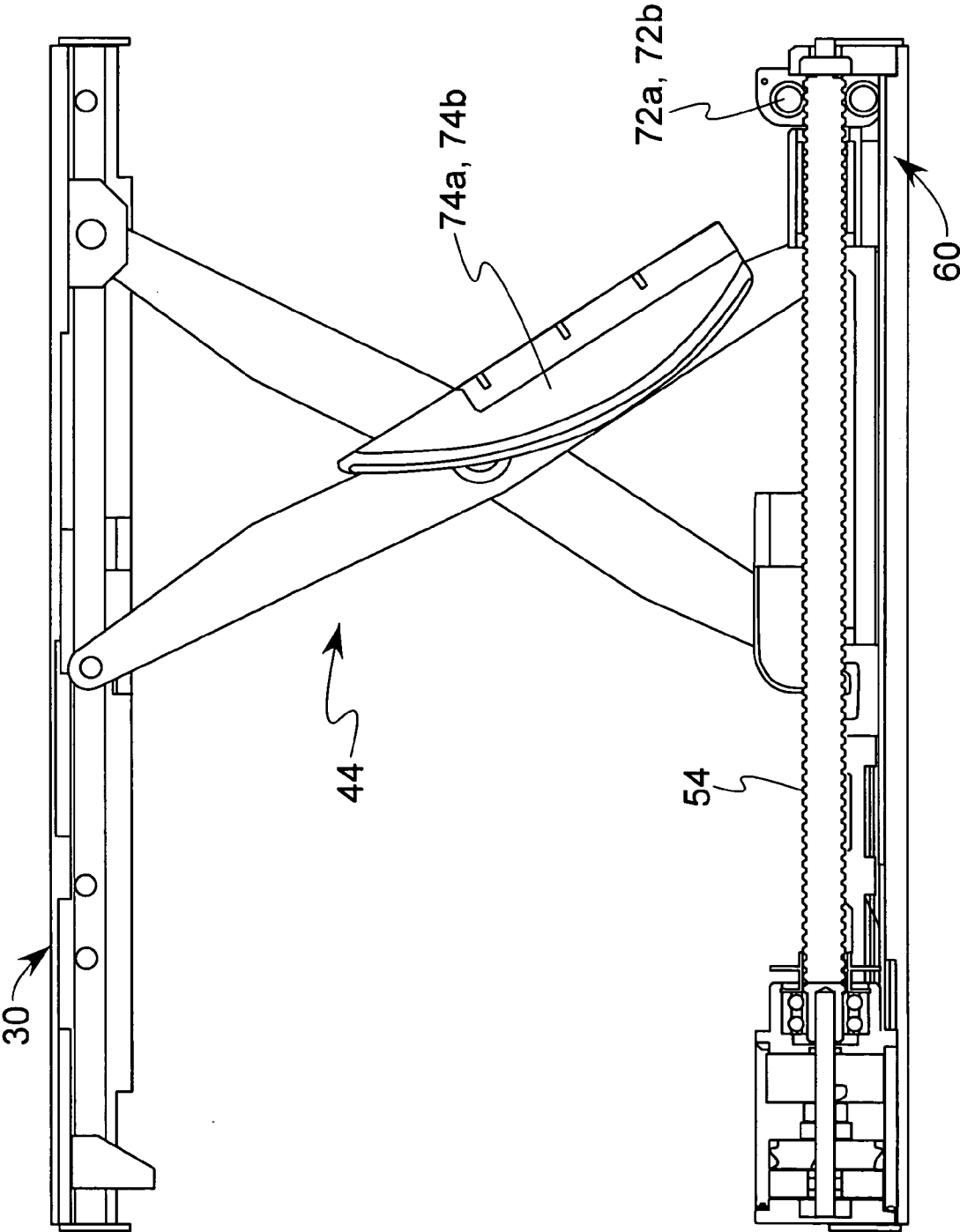
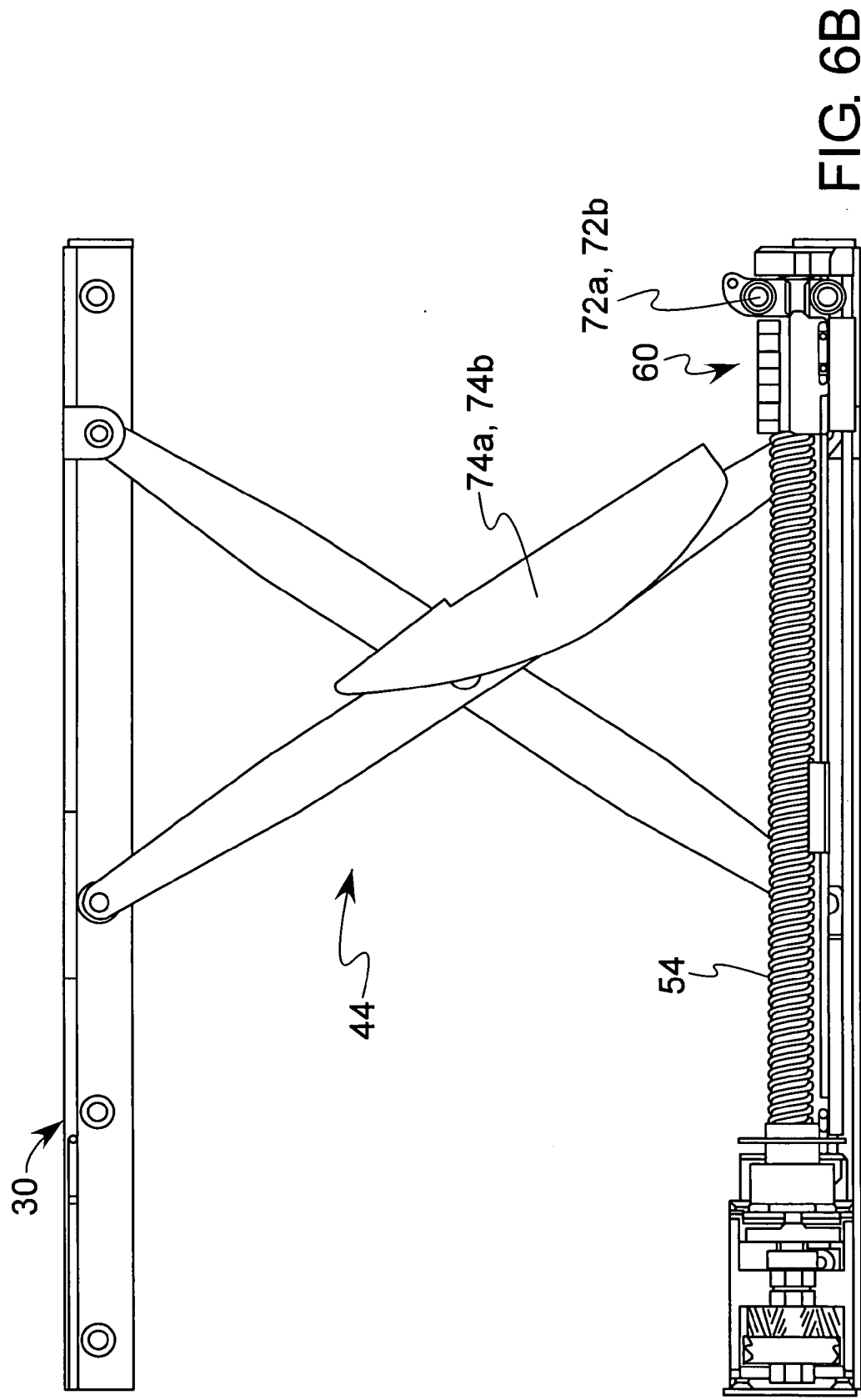
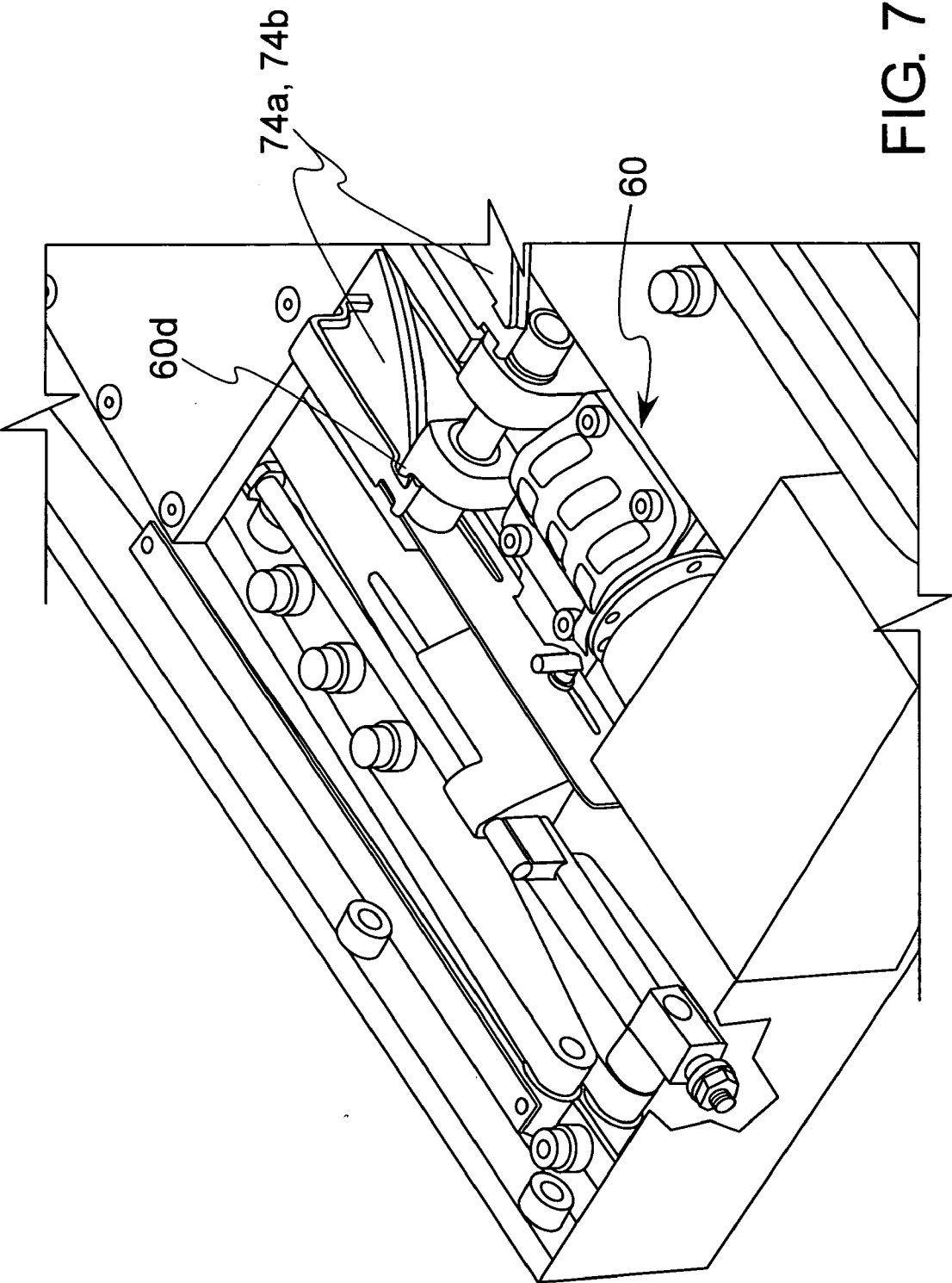
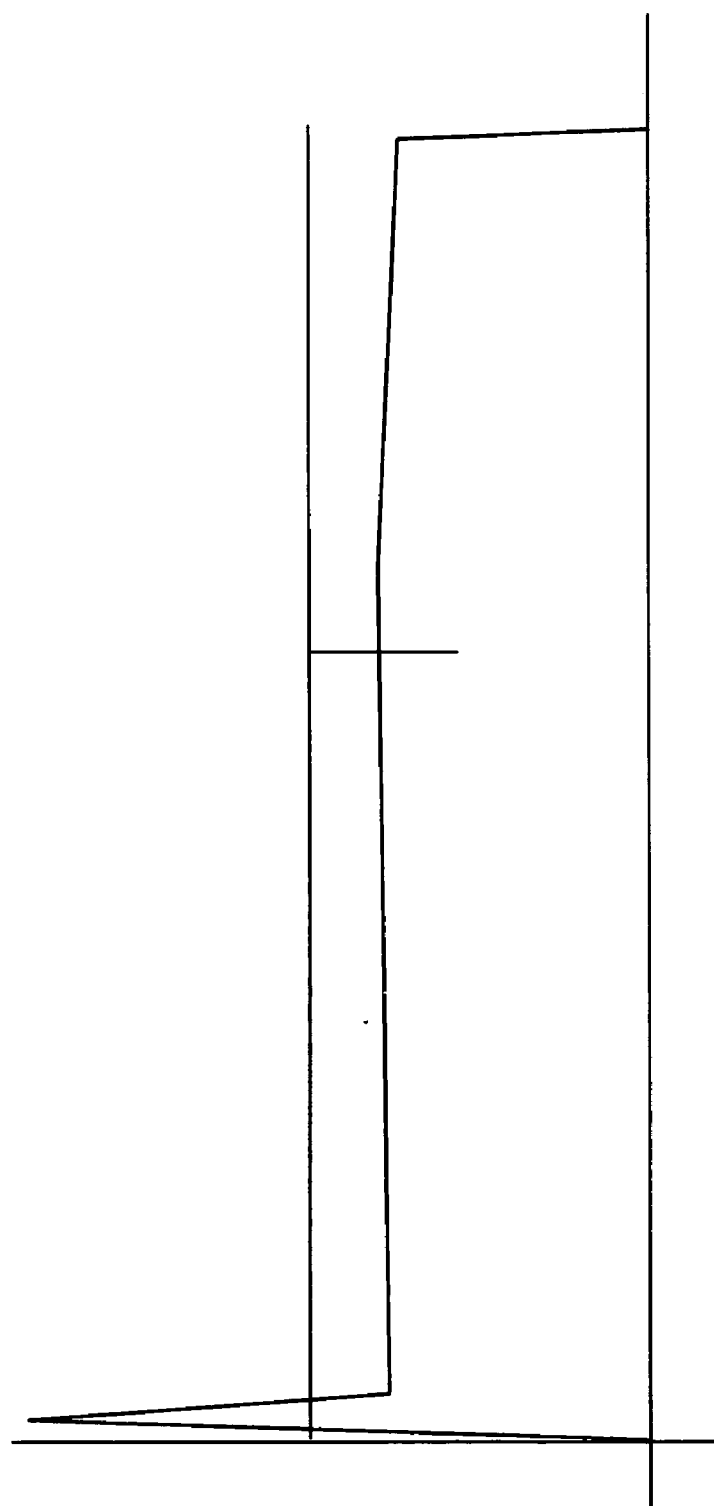


FIG. 6A



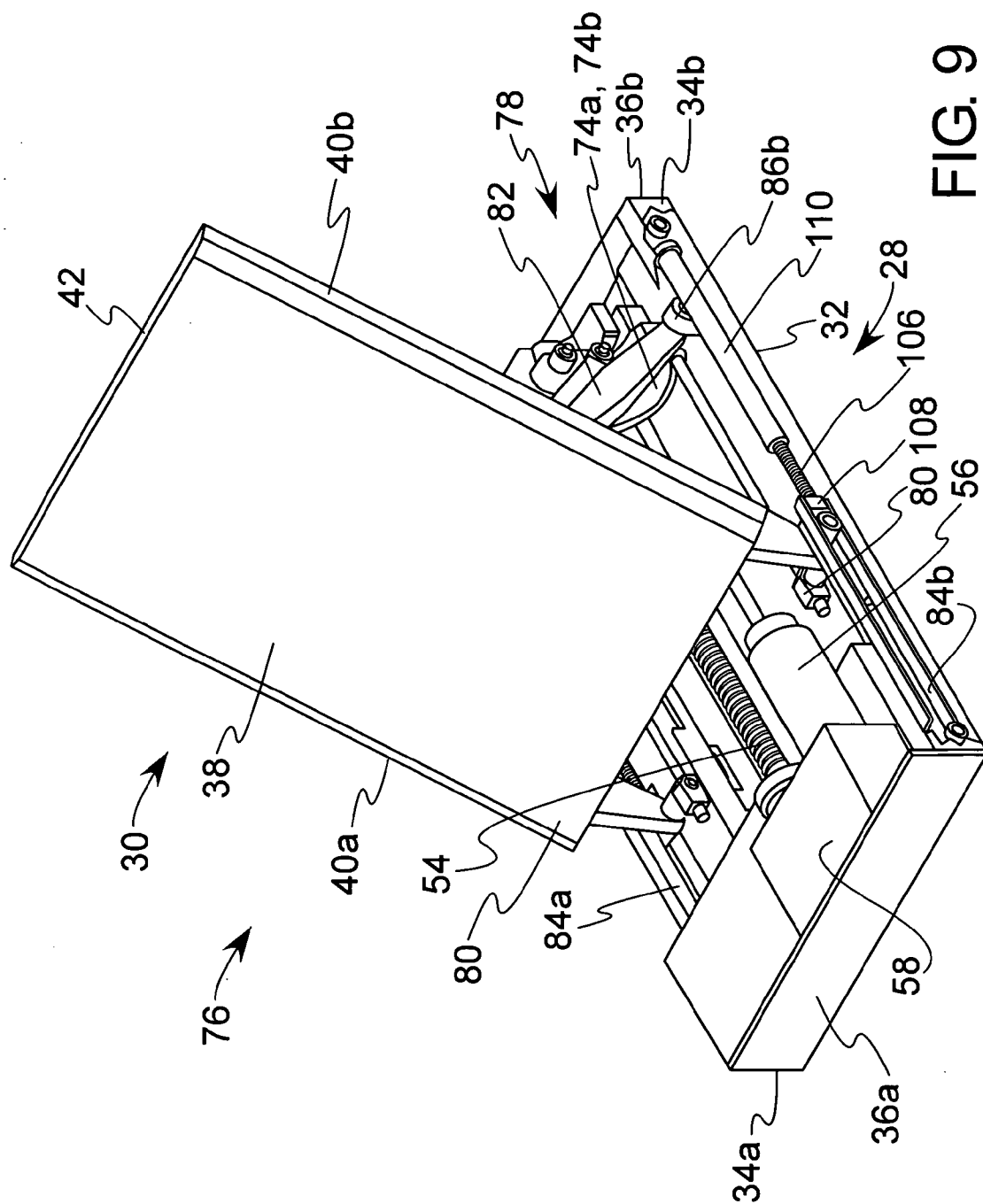




Nut Assembly Travel D

FIG. 8

Motor Control Draw I
(Motor Load)



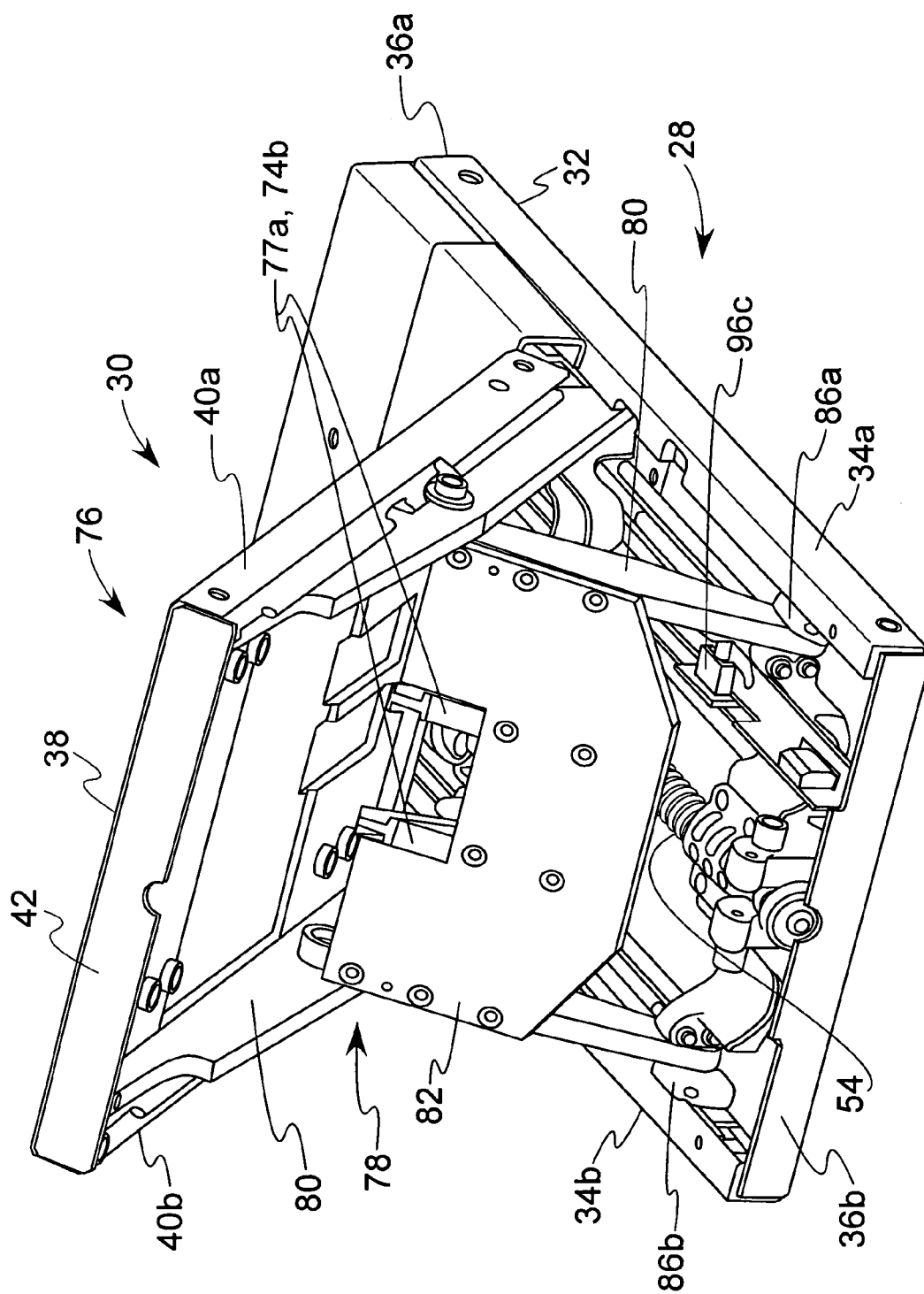


FIG. 10

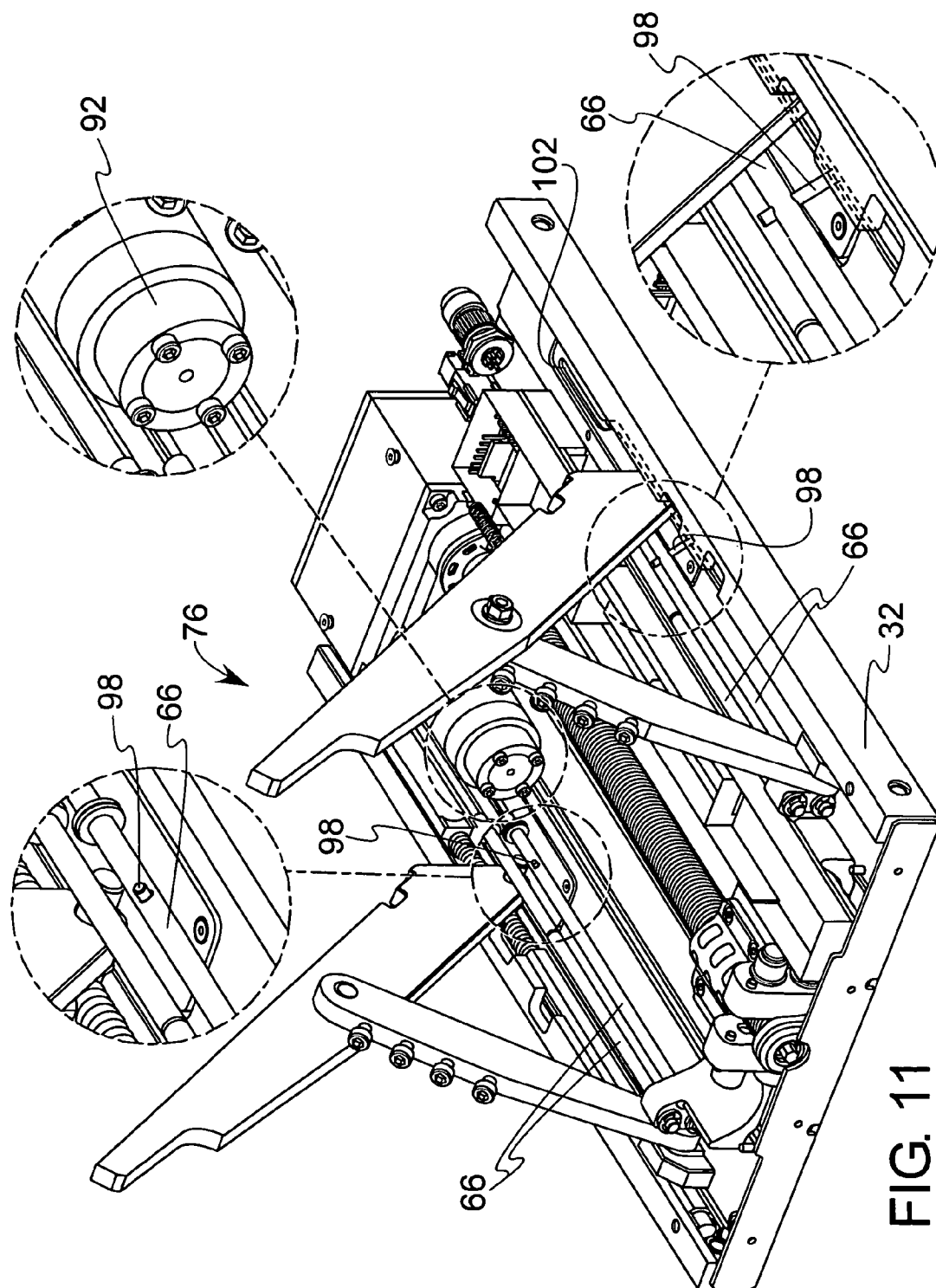


FIG. 11

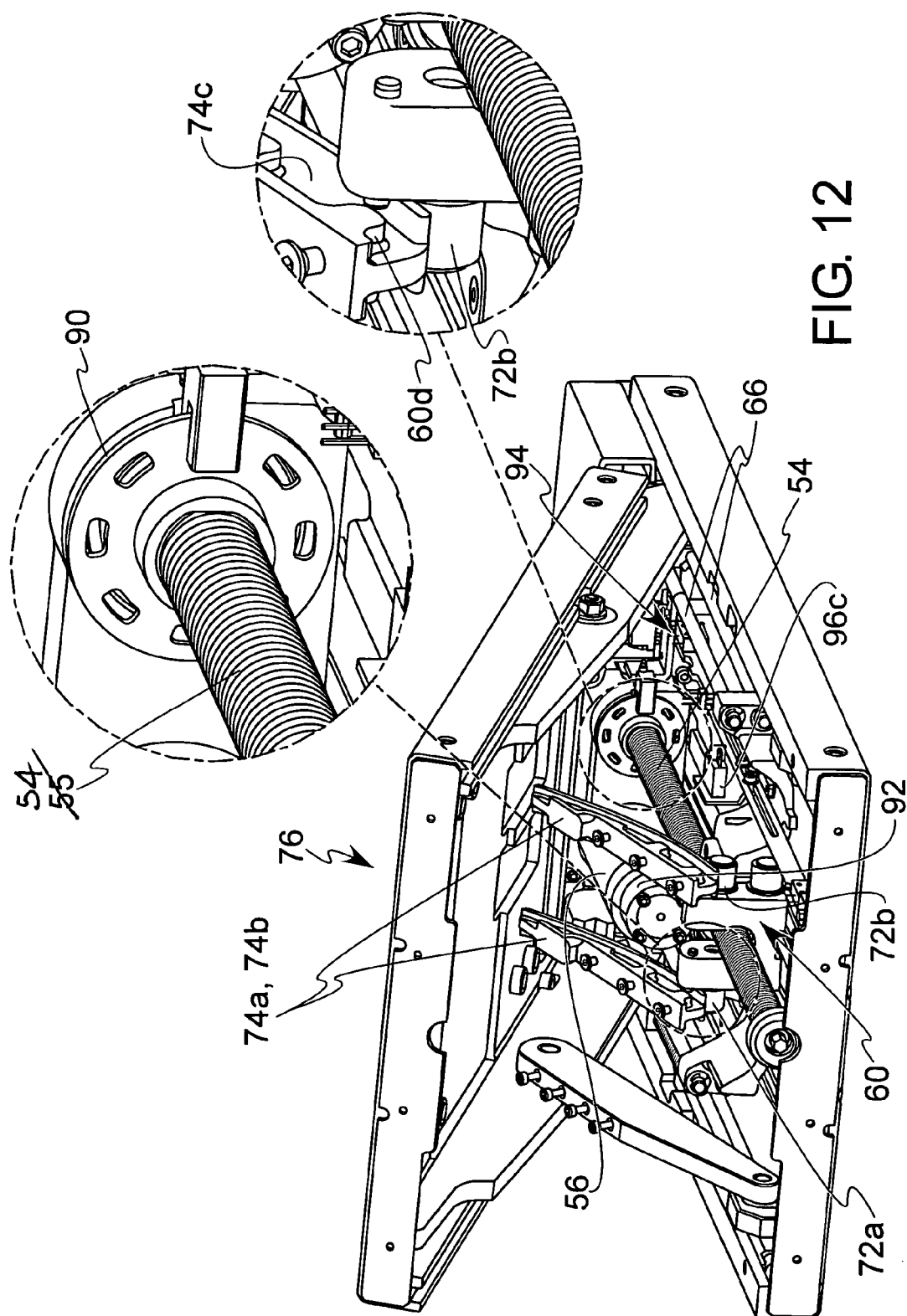


FIG. 12

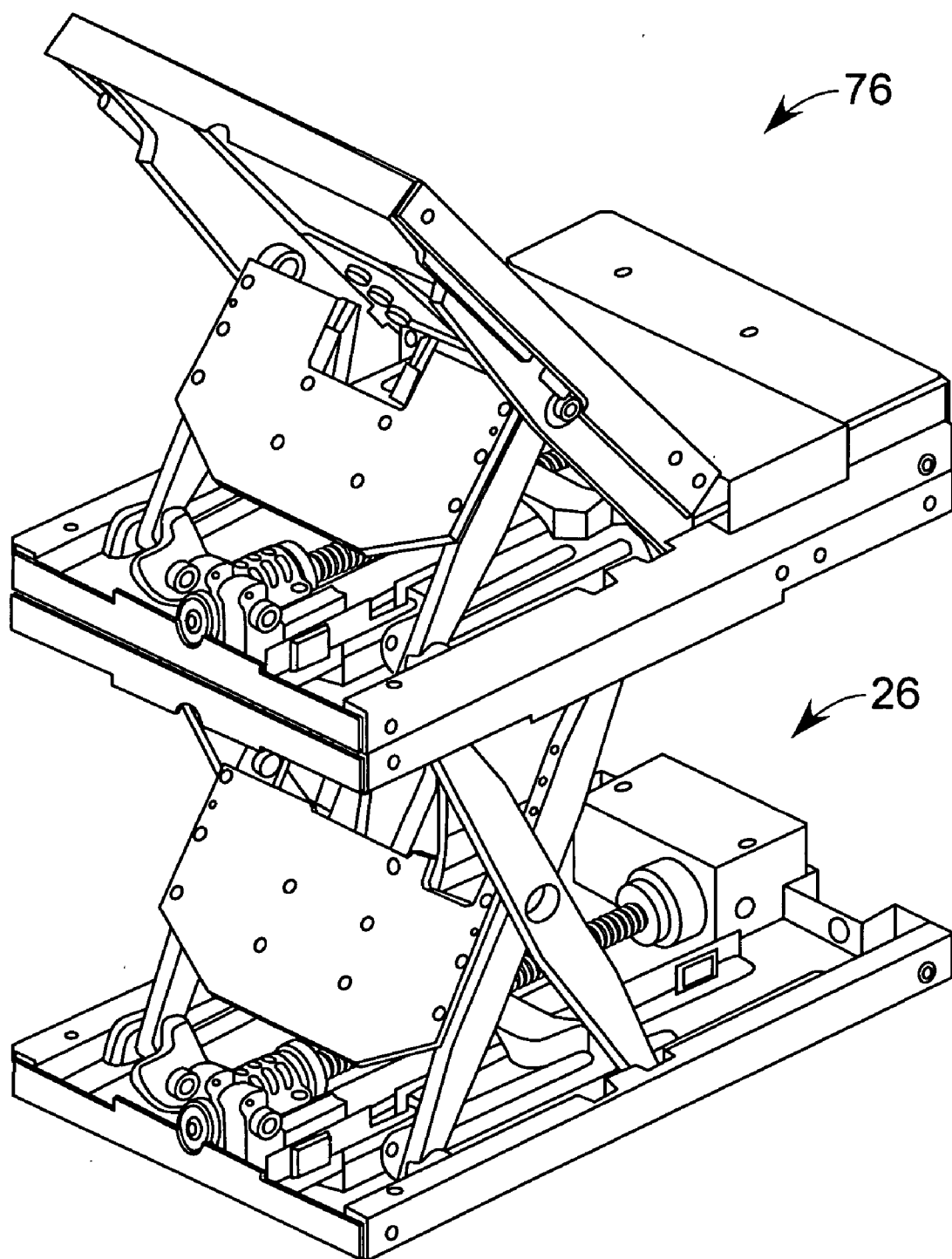


FIG. 13

POWER LIFT AND TILT MODULES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/621,439, filed on Oct. 22, 2004.

BACKGROUND OF INVENTION

[0002] This invention relates in general to personal mobility vehicles and more particularly, to seating systems for personal mobility vehicles. Most particularly, this invention relates to the mechanisms for lifting and/or tilting seat assemblies for wheelchairs and like vehicles.

[0003] Mechanisms for lifting and/or tilting wheelchair seat assemblies are well known. Such mechanisms typically include an actuator (i.e., a lead screw, nut, motor, and gearbox). By convention, parts of the actuator are integrated in the base and parts of the actuator are integrated in the seat assembly. Such actuators encounter a high load from an initial or lowered position. This high load typically causes premature wear of the actuator. A lifting and/or tilting mechanism is needed that is in the form of a compact unit that is capable of lifting heavy loads.

SUMMARY OF INVENTION

[0004] The present invention is directed towards a modular actuator that meets the foregoing needs. According to one embodiment of the invention, the modular actuator has a cam member in combination with a scissors mechanism in a compact unit that is capable of lifting heavy loads. Moreover, the invention is directed towards an actuator having component parts that may be integrated with the base or the seat assembly in such a manner that the parts are not integrated with both the base and the seat assembly. The invention is also directed towards a pull member that is capable of controlling and combining two different mechanisms that travel at different rates through two ranges of motion. The invention is still further directed towards a lifting and/or tilting assembly that includes two different actuator mechanisms that function to apply lifting and/or tilting force throughout different periods of operation, whereby transition from one mechanism to the other mechanism is substantially undetected by one supported by the assembly. The invention is further directed towards a cam member having a profile that is dimensioned and configured to maintain a constant range of motion and keep a constant load on the actuator.

[0005] Various objects and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiment, when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0006] **FIG. 1** is a rear perspective view of a wheelchair and a modular actuator according to the present invention.

[0007] **FIGS. 2A and 2B** are enlarged front perspective views of lift modules according to alternative embodiments of the present invention.

[0008] **FIG. 3** is an enlarged front perspective view of a nut assembly of the lift modules shown in **FIG. 2B**.

[0009] **FIGS. 4A and 4B** are cross-sectional views in elevation of the lift modules shown in **FIGS. 2A and 2B** in lowered positions.

[0010] **FIGS. 5A and 5B** are cross-sectional views in elevation of the lift modules shown in **FIGS. 2A and 2B** in partially raised positions.

[0011] **FIGS. 6A and 6B** are cross-sectional views in elevation of the lift modules shown in **FIGS. 2A and 2B** in fully raised positions.

[0012] **FIG. 7** is an enlarged partial front perspective view of the lift module shown in **FIG. 2B** in a lowered position.

[0013] **FIG. 8** is a graph of the load profile of the lift modules.

[0014] **FIG. 9** is a front perspective view of a tilt module according to one embodiment of the present invention.

[0015] **FIG. 10** is a rear perspective view of a tilt module according to another embodiment of the present invention.

[0016] **FIG. 11** a rear perspective view of the tilt module shown in **FIG. 10** with portions removed to permit viewing of a secondary over-tilt lock and a one-way clutch and further showing enlarged detail views of the secondary over-tilt lock and the one-way clutch.

[0017] **FIG. 12** a front perspective view of the tilt module shown in **FIG. 10** with portions removed to permit viewing of an over-tilt lock and a position sensor and further showing enlarged detail views of the over-tilt lock and the position sensor.

[0018] **FIG. 13** is front perspective view of the lift and tilt modules stacked upon one another.

DETAILED DESCRIPTION

[0019] Referring now to the drawings, there is illustrated in **FIG. 1** a wheelchair **10** and a modular actuator according to the present invention. The wheelchair **10** is a power wheelchair and more particularly, a mid-wheel drive wheelchair, although the invention can be practiced with other suitable drive configurations, such as front and rear wheel drive configurations. The wheelchair **10** comprises a base **12**, which includes a frame supported on a supporting surface by a plurality of wheels, such as drive wheels **14**, front wheels **16**, and rear wheels **18**, as shown in the drawing. The drive wheels **14** can be powered by any suitable power source and can be controlled by any suitable input device, including but not limited to a joystick (not shown). A seat assembly **20** is supported by the base **12**. The seat assembly **20** comprises a seat **22** and a seat back **24**, which may articulate (i.e., recline) relative to the seat **22**. According to the present invention, the seat assembly **20** is adapted to be supported by one or more modular actuators **26**, **76** that may be controlled to tilt and/or lift the seat assembly **20**.

[0020] Modular actuators in the form of lift modules **26** are shown in **FIGS. 2A and 2B**. The lift modules **26** comprise a first member **28**, which is adapted to be secured to the base **12**, and the second member **30**, to which the seat assembly **20** is adapted to be secured, and which is adapted to move relative to the first member **28**. In the illustrated embodiment of the invention, the first member **28** comprises a bottom plate **32** and a plurality of side walls, including

longitudinal side walls **34a**, **34b** and end walls **36a**, **36b**. Similarly, the second member **30** comprises a top plate **38** and a plurality of side walls, including longitudinal side walls **40a**, **40b** and end walls **42**. The first and second members **28** and **30** are configured to form housings for enclosing or otherwise supporting other elements of the lift module **26**. It should be appreciated that the particular configuration of the lift module **26** shown is provided for illustrative purposes and that the invention may be practiced with other configurations.

[0021] The first and second members **28** and **30** are connected together by a lift mechanism, such as the scissors mechanism **44** shown. The scissors mechanism **44** comprise members **46**, **48** that cross and are pivotally connected to one another. In the illustrated embodiment of the invention, forward ends of the cross members **46**, **48** are pivotally connected proximate to forward regions of the longitudinal side walls **34a**, **34b**, **40a**, **40b** of the first and second members **28** and **30**. Rearward ends of the cross members **46**, **48** are slidably and pivotally connected proximate to rear regions of the longitudinal side walls **34a**, **34b**, **40a**, **40b** of the first and second members **28** and **30**. The latter connection may be provided by opposing tracks **50a**, **50b**, **52a**, **52b** (shown in FIG. 2B) proximate the rear regions of the longitudinal side walls **34a**, **34b**, **40a**, **40b** of the first and second members **28** and **30**.

[0022] The scissors mechanism **44** is preferably driven by a lead screw **54**, which in turn can be driven by a motor **56**, or other suitable prime mover. The motor **56** may indirectly drive the lead screw **54** through a gearbox **58**, as shown in the drawings. The lead screw **54** may carry for longitudinal movement a nut assembly **60**, as shown more clearly in FIG. 3. In the illustrated embodiment of the invention, the nut assembly **60** includes an internal thread **62** for engagement with the lead screw **54**. It should be noted that the nut assembly **60** has a nut **60a** therein. Webbing **60b** in a semi-cylindrical portion **60c** of the nut assembly **60** aids in trapping the nut **60a** within the nut assembly **60**. It should be appreciated that the illustrated nut assembly is provided for illustrative purposes and that the invention may be practiced or carried out with other assemblies or configurations.

[0023] As shown in FIG. 3, the nut assembly **60** has means for supporting pull members. Although the supporting means may take on any form, the particular means shown includes support members and more particularly, laterally extending support members **64**. The particular support members **64** shown may be shaped to provide clearance for other elements of the lift module **26**, including but not limited to, for example, the motor **56**. The support members **64** may also be structured to withstand longitudinal forces. The support members **64** cooperate with pull members, such as the pull members **66** shown in FIGS. 2A and 2B. The pull members **66**, as shown in the drawings, may include but are not limited to pull rods, although other pull members may be suitable for practicing the invention.

[0024] A portion of the nut assembly **60**, a medial portion **68** in the illustrated embodiment shown in FIG. 3, may support one or more low friction elements. One or more low friction elements, such as the surface rollers **70** shown, may be provided for engagement with and movement relative to the first member **28** of the lift module **26**. One or more other low friction elements, such as the cam rollers **72a**, **72b**

shown, may be provided for engagement with and movement relative to a cam member **74a**, **74b**, which will be described in greater detail below.

[0025] One or more cam members **74a**, **74b** are adapted to engage the low friction elements **72a**, **72b**. As shown in FIGS. 4A and 4B, when the lift module **26** is in a lowered or initial position, the cam rollers **72a**, **72b** engage the cam members **74a**, **74b**. As the lead screw **54** is driven by the motor **56** (shown in FIGS. 2A and 2B) and gearbox **58**, the lead screw **54** threads the nut assembly (i.e., from left to right when viewing the drawings). The cam rollers **72a**, **72b** push up on the cam members **74a**, **74b**, and the cross member **46** of the scissors mechanism **44** pushes up on the second member **30** of the lift module **26**. The cam rollers **72a**, **72b** and cam members **74a**, **74b** are beneficial to raise the second member **30** when the scissors mechanism **44** has insufficient mechanical advantage. It should be noted that the cam members **74a**, **74b** have slots or grooves **74c** that receive nubs or pins **60d** on opposing sides of the nut assembly **60**, as shown in FIG. 3. The grooves **74c** and pins **60d** function as guides and stops for the cam members **74a**, **74b**. In addition, the pins **60d** and grooves **74c** function to prevent an external force from inadvertently lifting or tilting the scissors mechanism **44** prior to the nut assembly **60** transferring the load from the cam rollers **72a**, **72b** to the pull members **66**, as will be described in greater detail in the description that follows.

[0026] A transition is made from the cam members **74a**, **74b** to the scissors mechanism **44** when the cam rollers **72a**, **72b** reach the end of the profile of the cam members **74a**, **74b**, as shown in FIGS. 5A and 5B. It should be noted that throughout the operation of the cam members **74a**, **74b**, the scissors mechanism **44**, particularly the cross members **46**, is pulled by the pull members **66** (shown in FIGS. 2A and 2B) via the nut assembly **60**. Although the pull members **66** pull the scissors mechanism **44**, the pull members **66** are not in tension. The cross members **46** act to lift the second member **30** of the lift module **26** by virtue of the connection between the cam members **74a**, **74b** and the cross members **46**. At the transition between the cam members **74a**, **74b** and the scissors mechanism **44**, the nut assembly **60** continues to pull the pull members **66**, which are placed in tension, and which in turn pull the cross members **46** of the scissors mechanism **44**. At this transition point, the scissors mechanism **44** has a sufficient mechanical advantage to lift the second member **30** of the lift module **26**. The transition between the cam members **74a**, **74b** and the scissors mechanism **44** should be smooth because the cam rollers **72a**, **72b** reach the end of the profile of the cam members **74a**, **74b** when the mechanical advantage of the scissors mechanism **44** is sufficient to raise the second member **30** under load to a fully raised position, as shown in FIGS. 6A and 6B. The pull members **66** contribute to combine two ranges of motion (i.e., via the cam members **74a**, **74b** and the scissors mechanism **44**) and two rates (i.e., different rates) of motion into one continuous motion. This is graphically illustrated in FIG. 8, which simulates load versus time of the lift module **26**. In the graph, the vertical axis represents motor current draw or motor load and the horizontal axis represents travel of the nut assembly **60**. The relative flat curve is provided to maximize the performance of the motor **56** and gearbox **58** and reduce or eliminate any perceived transfer of function from cam members **74a**, **74b** to pull members **66**. Although

the graph in **FIG. 8** represent an ideal operational characteristic of the invention, actual data may not support a line that is as flat, as represented.

[0027] Another modular actuator according to the present invention is illustrated in **FIGS. 9 and 10**. This modular actuator is in the form of a tilt module 76. The tilt module 76 is similar to the lift module 26 described above in that the tilt module 76 comprises a first member 28, which is adapted to be secured to a wheelchair base, and the second member 30, to which a wheelchair seat is adapted to be secured, and which moves relative to the first member 28. In the illustrated embodiment of the invention, the first member 28 comprises a bottom plate 32 and a plurality of side walls, including longitudinal side walls 34a, 34b and end walls 36a, 36b. Similarly, the second member 30 comprises a top plate 38 and a plurality of side walls, including longitudinal side walls 40a, 40b and an end wall 42. The first and second members 28 and 30 are configured to form housings for enclosing or otherwise supporting other elements of the tilt module 76. It should be appreciated that the particular configuration of the tilt module 76 shown is provided for illustrative purposes and that the invention may be practiced with other configurations.

[0028] The first and second members 28 and 30 are connected together by a modified scissors mechanism, such as the scissors mechanism 78 shown. The scissors mechanism 78 comprises one or more tilt members 80 and struts 82 that are pivotally connected to the tilt members 80. In the illustrated embodiment of the invention, lower ends of the tilt members 80 are slidably and pivotally connected proximate to rearward regions of the longitudinal side walls 34a, 34b of the first member 28. Lower ends of the struts 82 are pivotally connected proximate to forward regions of the longitudinal side walls 34a, 34b of the first members 28. The former connection may be provided by opposing tracks 84a, 84b (shown in **FIG. 9**) proximate the rear regions of the longitudinal side walls 34a, 34b of the first members 28. The latter connection may be provided by opposing pivot bosses 86b (only one shown in **FIG. 9**) proximate the forward regions of the longitudinal side walls 34a, 34b of the first members 28.

[0029] The tilt module 76, like the lift module 26 described above, is preferably driven by a lead screw 54 (shown in **FIG. 9**), which in turn can be driven by a motor 56 (shown in **FIG. 9**), or other suitable prime mover. The motor 56 may indirectly drive the lead screw 54 through a gearbox 58 (shown in **FIG. 9**). The lead screw 54 may carry for longitudinal movement a nut assembly 60, like that shown in **FIG. 3**. In the preferred embodiment of the invention, the nut assembly 60 includes an internal thread 62 for engagement with the lead screw 54. It should be noted that the nut assembly 60 has a nut 60a therein. Webbing 60b in a semi-cylindrical portion 60c of the nut assembly 60 aids in trapping the nut 60a within the nut assembly 60. It should be appreciated that the illustrated nut assembly is provided for illustrative purposes and that the invention may be practiced or carried out with other assemblies or configurations.

[0030] As described above with reference to the lift module 26, the nut assembly 60 has means for supporting pull members. Although the supporting means may take on any form, the particular means shown includes support members

and more particularly, laterally extending support members 64. The particular support members 64 shown may be shaped to provide clearance for other elements of the tilt module 76, including but not limited to, for example, the motor 56. The support members 64 may also be structured to withstand longitudinal forces. The support members 64 cooperate with pull members 66, such as, for example, the pull rods shown in **FIG. 10**, although other pull members may be suitable for practicing the invention.

[0031] A portion of the nut assembly 60, a medial portion 68 in the illustrated embodiment, supports one or more low friction elements. One or more low friction elements, such as the surface rollers 70 shown, may be provided for engagement with and movement relative to the second member 30 of the tilt module 76. One or more other low friction elements, such as the cam rollers 72a, 72b shown, may be provided for engagement with and movement relative to a cam member 74a, 74b.

[0032] One or more cam members 74a, 74b are adapted to engage the low friction elements 72a, 72b. When the tilt module 76 is in a lowered or initial position, the cam rollers 72a, 72b engage the cam members 74a, 74b. As the lead screw 54 is driven by the motor 56 and gearbox 58, the lead screw 54 threads the nut assembly 60. The cam rollers 72a, 72b push up on the cam members 74a, 74b, which push up on the second member 30 of the tilt module 76. The cam rollers 72a, 72b and cam members 74a, 74b are beneficial to push up the second member 28 when the tilt mechanism 44 has insufficient mechanical advantage.

[0033] A transition is made from the cam members 74a, 74b to the tilt members 80 and struts 82 when the cam rollers 72a, 72b reach the end of the profile of the cam members 74a, 74b. At this transition, the tilt members 80 are pulled by the pull members 66 via the nut assembly 60. This transition should be smooth because the cam rollers 72a, 72b reach the end of the profile of the cam members 74a, 74b when the mechanical advantage of the tilt members 80 and struts 82 is sufficient to raise the first member 28 under load to a fully raised position, as shown in the drawings. The pull members 66 contribute to combine two ranges of motion (i.e., via the cam members 74a, 74b and the tilt members 80 and struts 82) and two rates of travel into one continuous motion.

[0034] According to a preferred embodiment of the invention, an over-tilt lock, as shown in **FIGS. 9 and 10**, may be provided. The over-tilt lock locks out the pull members 66 between a minimum and a maximum tilt angle (e.g., between about 0 degrees and about 50 degrees) just prior to when the user's weight shifts and goes from a positive force in a clockwise direction (when viewing **FIG. 9**) to a positive force in a counter clockwise direction (when viewing **FIG. 9**) about the tilt pivot point. This prevents the seat assembly 20 from inadvertently over tilting. Obviously, the affects of shifts in the user's weight are dependent on, for example, the user's weight, the center of gravity of the seat assembly 20 and the user combined, and the relationship between the center of gravity and the tilt axis. Positioning of the module 76 and/or the motor 56 and/or the gearbox 58 could effectively position the center of gravity over the module 76 and the wheelchair base 12 as desired.

[0035] It should be noted that a spring 106 may be provided to function as an over-tilt mechanism to be used in conjunction with or in lieu of the over-tilt lock. As stated

above, a load reversal may occur as the tilt module 76 tilts back beyond a certain threshold, that is, when the user's weight shifts and goes from a positive force in one direction to a positive force in another clockwise direction about the tilt pivot point, or to a negative force. The spring 106 may be provided for positively biasing the load in as this shift occurs to a negative force.

[0036] In addition, the spring functions a load compensating mechanism may be employed to balance the load applied against the motor 56 during operation of the modules 26, 76. For example, in the illustrated embodiments of the invention, one or more helical coil springs 106 cooperate with the scissors mechanisms 44, 78. A spring 106 may be carried by a rigid rod, which is within the spring 106, and which may be present on opposing sides of the modules 26, 76. The rod may be free to move in a longitudinal direction through operation of the modules 26, 76 and prevent the spring 106 from moving radially. In the illustrated embodiment of the invention, a first end of the rod is connected to a movable block 108 while a second end of the rod, opposite the first end, is a free end (i.e., not physical fixed). It should be noted that the spring 106 may be at least partially encased in a sleeve 110, tube, or the like, which further prevents the spring 106 from moving radially. In this way, the spring 106 is maintained along a substantially linear axis coincident with the longitudinal axes of the rod and the sleeve 110. Throughout the operation of the scissors mechanisms 44, 78, the mechanical advantage may not be constant. As a consequence, the load on the motor 56 may be greater during certain periods of operation. During periods when the load on the motor 56 is reduced, the motor 56 may operate at a greater speed. This may be undesirable. That is to say, it may be desirable to operate the motor 56 at a substantially constant rate of motion. In accordance with the invention, the spring 106 may be compressed by the scissors mechanisms 44, 78 during operation of the modules 26, 76. As a consequence, the load applied by the spring 106 increases as the scissors mechanisms 44, 78 gain a greater mechanical advantage. Since the spring 106 is compressed throughout the operation of the modules 26, 76, the spring 106 could offer little to no resistance initially when the modules 26, 76, and more particularly, the scissors mechanisms 44, 78 are first operated (i.e., when the load on the motor 56 is greatest), and offer greater resistance as the load on the motor 56 decreases due to the mechanical advantage of the scissors mechanisms 44, 78. In this way, the motor 56 may be operated at a substantially constant rate of motion.

[0037] The over-tilt lock function of the tilt module 76 is embodied in two separate mechanisms. When the nut assembly 60 is in contact with the cam members 74a, 74b, the over tilt function may be carried out by the pins 60d on the nut assembly 60 engaging the grooves 74c on the cam members 74a, 74b, as shown in FIG. 11. When the cam rollers 72a, 72b disengage from the cam members 74a, 74b, a secondary over tilt lock is engaged. As shown in FIG. 11, there are two pull members 66 per side of the tilting module 76. The lower set of pull members 66 each have a single timing pin 98 and a single locking pin (not shown) extending in a radial direction from the long axis of the pull member 66. The timing pin 98 engages an "S" shaped timing slot 102 in the base 32 of the tilt module 76. The locking pin is housed in a matching slot 104 in the lateral support members 64 of the nut assembly 60 (shown in FIG. 3). As the cam members 74a, 74b transition the length of the bottom plate 32, the nut assembly 60 pulls all the pull members 66. The lower set of pull rods 66 with the timing pin 98 is fully extended between the nut assembly 60 and the pivot connections at the

rearward ends of the scissors mechanism 78. The lower pull rod timing pin 98 is moved through the timing slot 102 in the base 32 while this pull rod 66 is pulled into a tensile load condition. While this transition to a tensile load condition is accomplished, the locking pin in the lower pull rod 66 comes out of the mating slot in the lateral support members 64 of the nut assembly 60 and, through the rotation of the pull rod 66 via the timing pin 98, is now prevented from retreating back into the mating slot 104. With this pull rod 66 now prevented from retreating back into the support arm member 64 in over tilt condition, this pull rod 66 becomes a compression member instead of a tensile member, holding the parts stationary and preventing inadvertent over tilt.

[0038] The present invention may further comprise a position sensor 90, as shown in FIG. 12. The sensor 90, for example, may be in the form of an optical encoder or reader that counts the number of turns or revolutions of the lead screw 54 to determine the position of the actuator. This sensor may be used in conjunction with or in lieu of position switches, such as end switches and the inhibit switches 96c described below, to reduce available tilt angle, adjust the angle at which reduced speed of the wheelchair base will be implemented, or act as a fine tuning adjustment for what is considered a bottom angle or "home" position for the tilt.

[0039] The present invention may further comprise a one-way anti-back drive clutch 92, as shown in FIG. 12, that prevents the weight of the user from closing the actuator. For example, the motor 56 may be free to turn unencumbered by frictional resistance in one direction to raise the user. However, resistance prevents the actuator from creeping down due to the load imposed on the actuator by the weight of the user. This is particularly useful when lead screw 54 is not a self locking thread design and the nut assembly 60 is as low friction as possible to allow a smaller motor per weight. Under conditions where the motor 56 is neither being driven up or down, the weight of the user can be enough to cause the lead screw 54 to be back driven in a downward command direction. The one-way clutch 92 may freewheel when the motor 56 rotates in a direction to increase the tilt angle of the tilt module 76, or to increase the lift height of the lift module 26. When electrical power to the motor 56 is removed or the motor 56 is driven in a direction to reduce the tilt angle, or the lift height, the one way clutch engages and impedes the tendency of the motor 56 to reduce the tilt angle. The motor 56 can overpower the clutch on demand, but the weight of the user is not sufficient to reduce tilt angle, or the lift height. This function can also be accomplished by a conventional electrical brake (not shown) on the motor armature shaft. The clutch is preferred over that of an electrical brake as release of an electrical brake can allow over rapid decrease in tilt angle, or lift height.

[0040] The present invention may also have a switch rail 94, as shown in FIG. 12, or may otherwise support one or more position switches. For example, the switch rail 94 shown may support two end switches (not shown) and an inhibit switch 96c between the end switches. The end switches are threshold switches that prevent further operation of the actuator when the actuator reaches upper and lower operating limits. For example, the end switches may be normally open switched. When the nut assembly 60 reaches one end of the switch rail 94, a support member 64 may engage an end switch to close the end switch at that end of the switch rail 94. The closed switch may produce a signal representing that the nut assembly 60 has been driven a threshold distance in a first direction. A controller could recognize this as a threshold condition and, for example,

prevent the motor **56** from further operating and thus prevent the tilt module **76** from tilting further back. However, the motor **56** remains operable to turn in an opposite direction to return the module **76** forward toward a non-tilted orientation until, for example, the support member **64** of the nut assembly **60** closes the other end switch at the other end of the switch rail **94**. It should be appreciated that the end switches need not be normally open switches. The type of end switch used depending on the design of the electronics. Regardless of the switch orientation, the switches may operate as described above. The inhibit switch **96c** may prevent operation of the wheelchair **10**, or limit performance of the wheelchair **10** under a certain condition. The inhibit switch **96c** may signal the wheelchair base **10** when a certain height of lift, or a certain degree of tilt has been attained. Above a certain amount of lift or degree of tilt, the top operating speed of the wheelchair can or will be reduced to reduce or eliminate the occurrence of accidents resulting from a compromised driving position or compromised stability standpoint. For example, the inhibit switch **96c** may be a mid-travel rocker switch, which may, for example, be a single pole switch, double throw switch that is thrown in a first direction to decrease the motor speed beyond a certain tilt angle, either when raising or lowering the top plate **38**, and that is thrown in a second direction to permit the motor **56** to operate at an increased motor speed below that tilt angle. That is to say the mid-travel rocker switch may function to reduce the available drive motor speed above a certain angle of tilt, via activation by the nut assembly **60**, and restore full drive motor speed below that angle as the nut assembly **60** directs the switch throw back to a full motor speed setting.

[0041] The modular actuators (i.e., the lift and tilt modules **26**, **76**) according to the present invention are compact units that have high load carrying abilities. The actuators are adapted for use in new wheelchairs, or for use in converting existing wheelchairs, to wheelchairs having lift and tilt capabilities. The actuators could integrate with existing wheelchairs in a relatively short time with minimal efforts. The likeness of the lift and tilt modules **26**, **76** would minimize component parts. That is to say, but for the scissors mechanisms **44**, **78**, the component part of the lift and tilt modules **26**, **76** may be substantially identical. Since the lift and tilt modules **26**, **76** use common components to achieve two distinctly different modes of operations (i.e., lifting and tilting operations), economy in inventory and production is achieved. Moreover, the lift and tilt modules **26**, **76** may be removable, reversible, and adjustable. The lift and tilt modules **26**, **76** may function as structural elements of the wheelchair, and have low profiles that are particularly useful for wheelchair seat lifting and center of gravity seat tilting. This also allows lift and tilt wheelchairs to be offered with a low seat to floor height. High load bearing characteristics are achieved through the entire cycle of operation by two working mechanisms. During angles of low mechanical advantage for the scissors mechanism **44**, or the tilt members **80** and struts **82**, the cam members **74a**, **74b** function to push the second member **30** upward. The scissors mechanism **44**, or the tilt members **80** and struts **82**, takes over when enough mechanical advantage is available. The cam members **74a**, **74b** lifts loads in a low profile. These two mechanisms (i.e., cam members **74a**, **74b** and scissors mechanism **44**, or the tilt members **80** and struts **82**) may be tuned (i.e., dimensioned and configured) to keep the load on the motor **56** and gearbox **58** constant to maximize the life of the drive train (i.e., the motor **56** and gearbox **58**).

[0042] It should also be appreciated that the pull members **66** marry the cam members **74a**, **74b** and the scissors mechanism **80**, **82** as well as the scissors mechanism **44** so that the difference in the rate of motion of the two components (i.e., cam members **74a**, **74b** and the scissors mechanism **44**) is not noticeable.

[0043] As shown in FIG. 13, the lift and tilt modules **26** and **76** are adapted to be stacked upon one another. This permits the wheelchair seat assembly **20** to be lifted, tilted, or lifted and tilted, as shown.

[0044] In a preferred embodiment of the invention, each module (i.e., lift and tilt module) is relatively thin and is most preferably about two inches in height to insure that the minimum seat height is maintained.

[0045] The principle and mode of operation of this invention have been explained and illustrated in its preferred embodiment. However, it must be understood that this invention may be practiced otherwise than as specifically explained and illustrated without departing from its spirit or scope.

What is claimed is:

1. A modular actuator for moving a seat of a personal mobility vehicle through two ranges of motion comprising a first mechanism that operates to move the seat through a first one of the ranges of motion and a second mechanism that operates to move the seat through a second one of the ranges of motion.

2. The actuator according to claim 1 wherein the actuator is a lift module and the first mechanism is one or more cam members that are adapted to cooperate with one or more cam rollers and the second mechanism is a scissors mechanism.

3. The actuator according to claim 2 wherein the one or more cam members are dimensioned and configured to maintain a constant load throughout the first range of motion and a load consistent with the second range of motion.

4. The actuator according to claim 1 wherein the actuator is a tilt module and the first mechanism is one or more cam members that are adapted to cooperate with one or more cam rollers and the second mechanism is one or more tilt members that are adapted to cooperate with one or more struts.

5. The actuator according to claim 4 wherein the cam member is dimensioned and configured to maintain a constant load throughout the first range of motion and a load consistent with the second range of motion.

6. A modular actuator for moving a seat of a personal mobility vehicle through two ranges of motion comprising a first mechanism therein that operates to move the seat through a first one of the ranges of motion and a second mechanism that operates to move the seat through a second one of the ranges of motion, the first and second mechanisms being within a compact unit.

7. The actuator according to claim 6 wherein the first and second mechanisms and other component parts thereof are integrated in such a manner so as not to be integrated with both the seat or a base of the personal mobility vehicle.

8. The actuator according to claim 6 wherein the actuator is self contained and readily attachable to existing personal mobility vehicles.

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