# United States Patent [19]

**Berthelsen**

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[54] **ADJUSTABLE BED**


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[52] **U.S. Cl.** ..... **5/62;** 5/81

[51] **Int. Cl.**[2] ..... **A61G 7/10**

[58] **Field of Search** ..... 5/61, 62, 66, 81



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 3,200,416 | 8/1965 | Warrick | 5/62 |
| 3,579,671 | 5/1971 | Kotter | 5/62 |
| 3,724,003 | 4/1973 | Ellwanger et al. | 5/66 |
| 3,724,004 | 4/1973 | Behrens | 5/66 |



*Primary Examiner*—Casmir A. Nunberg

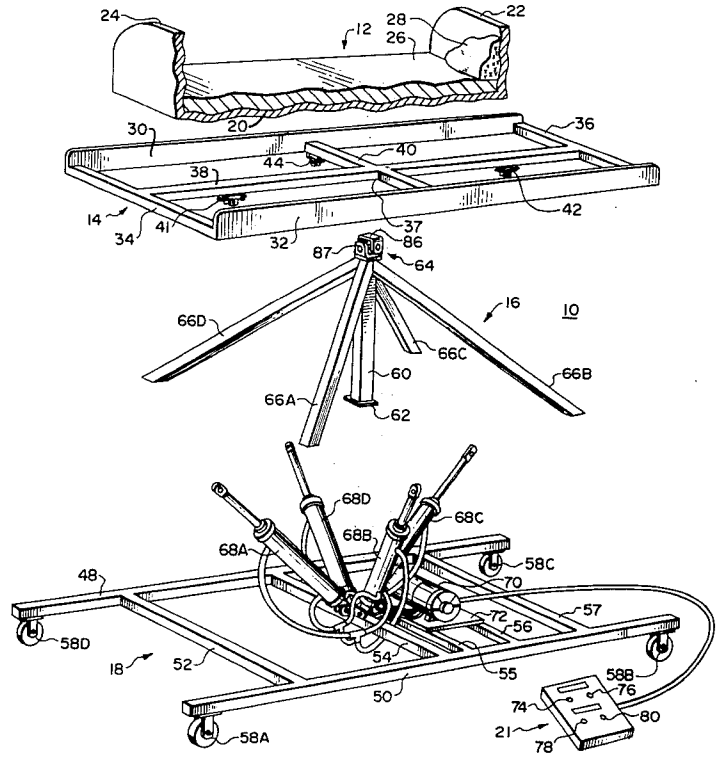
*Attorney, Agent, or Firm*—Vincent L. Carney



[57] **ABSTRACT**

To adjust a bedstead to any angle with respect to the floor without raising one edge to an excessive height, two corresponding pairs of hydraulic cylinders of an adjustable bed are connected to a movable frame along the pitch axis and roll axis of the movable frame by universal joints to permit pivoting in any direction about a stationary center point. As a first piston, connected at a location along the roll axis, is extended, a corresponding second piston, located a distance from the first piston along the same axis, is retracted by an equal amount, so that the foot of the bedstead moves in the opposite direction from the head of the bedstead, with a point on the movable frame centered between the two end connections of the piston rods rotating through an angle but not moving vertically. Third and fourth hydraulic cylinders operate in the same manner along the pitch axis to change the roll position of the bedstead, with the roll axis and the pitch axis having coincident midpoints.


**14 Claims, 4 Drawing Figures**



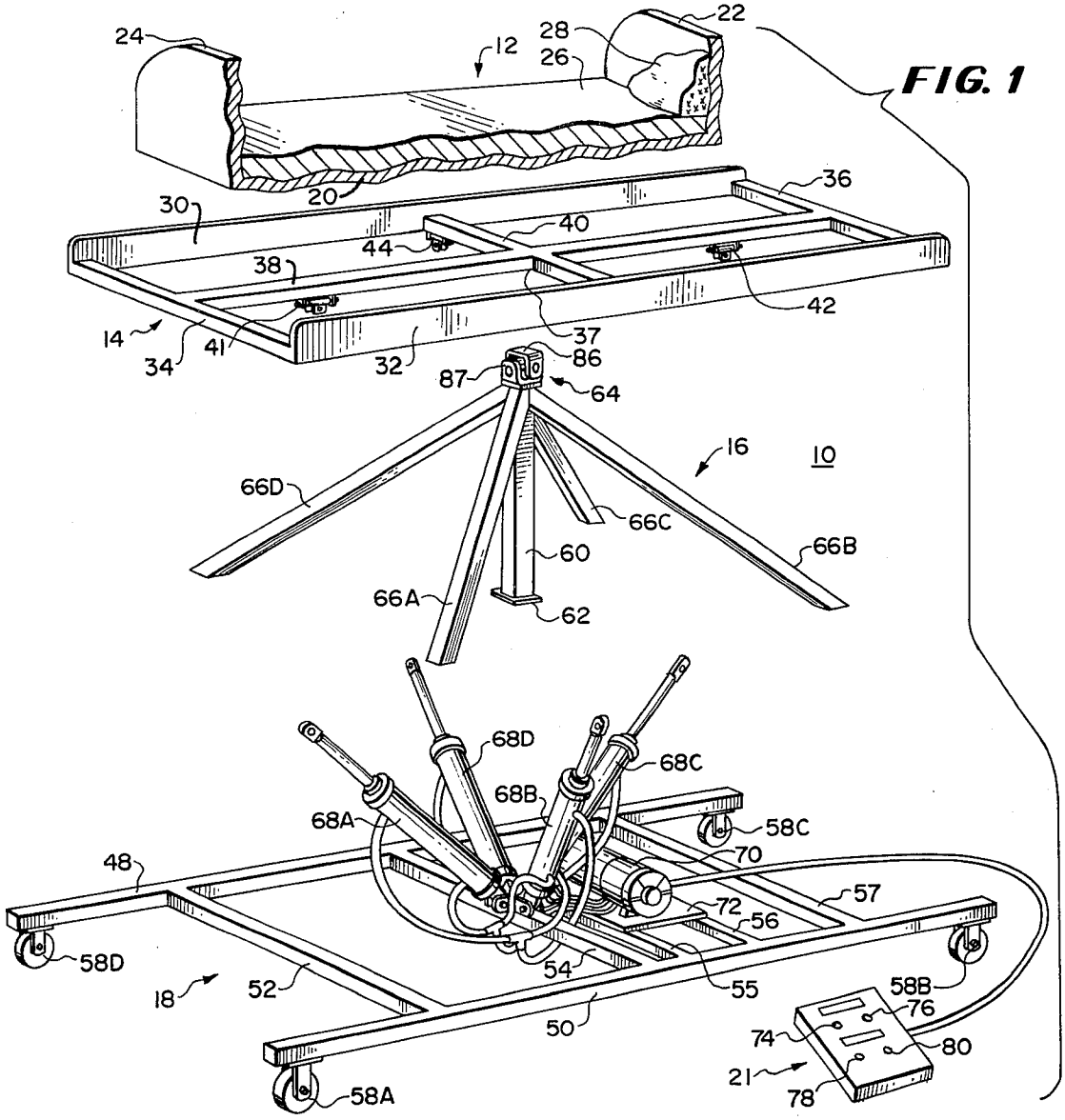

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12
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32
86
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64
16
10
66D
66C
66B
60
66A
62
68D
68C
68B
68A
58C
70
48
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72
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58D
18
52
54
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58B
76
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74
80
21
78
58A

FIG. 1

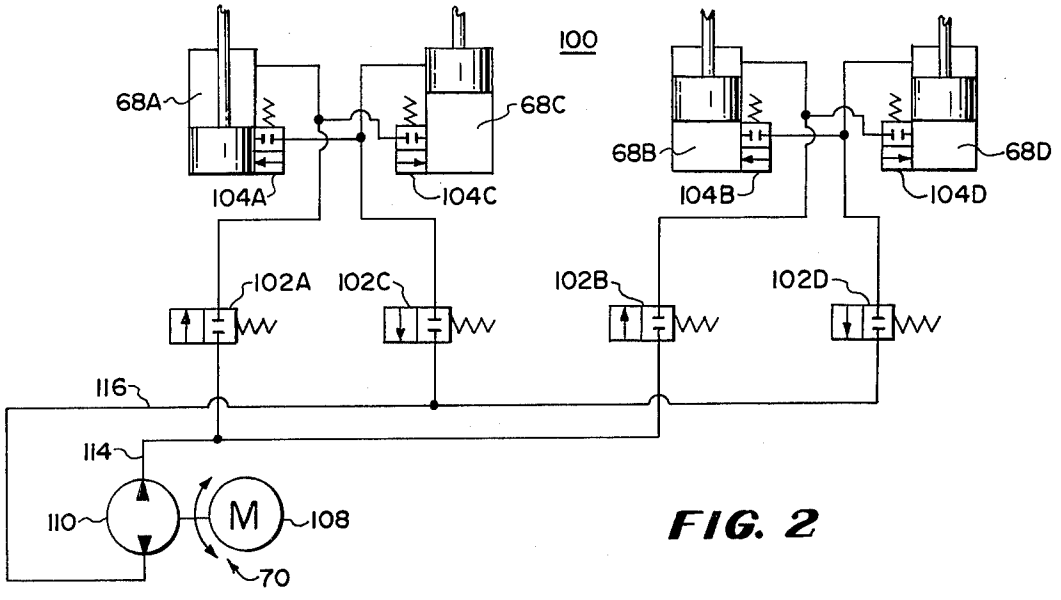

100
68A
68C
68B
68D
104A
104C
104B
104D
102A
102C
102B
102D
116
114
110
M
108
70

FIG. 2

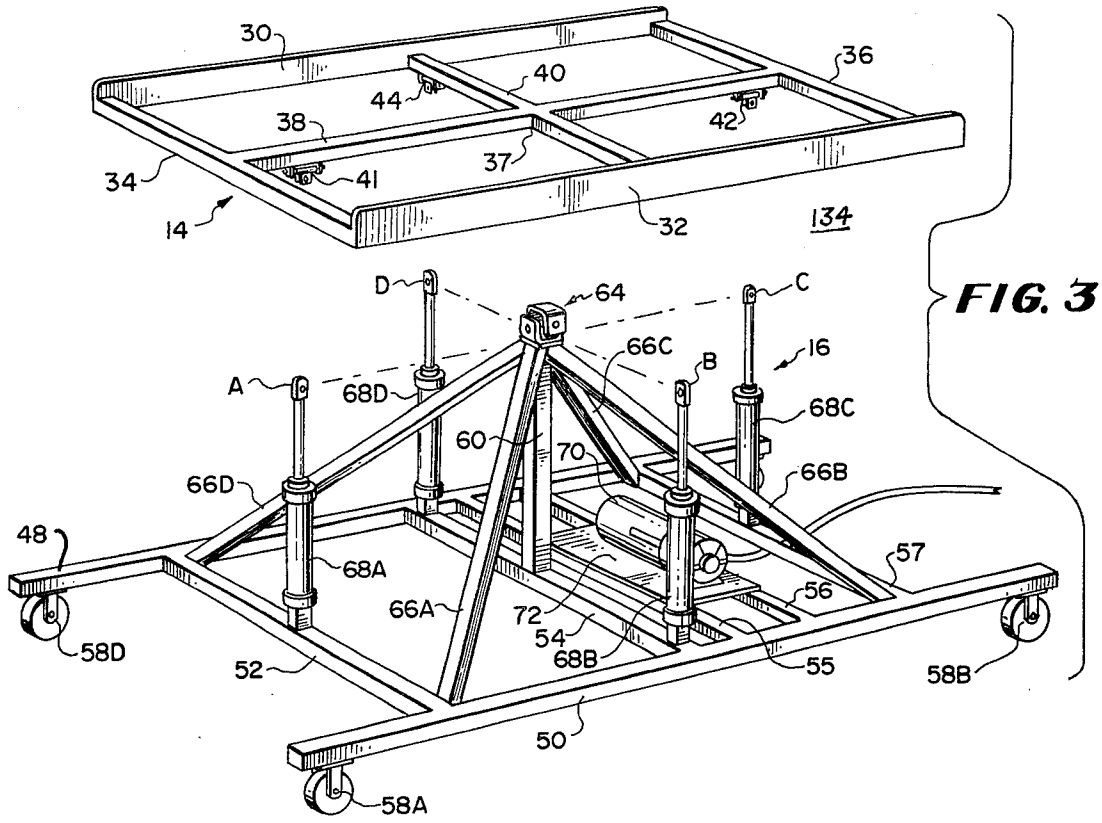

30
36
40
44
42
38
37
41
34
14
32
134
D
64
C
66C
16
B
A
68D
68C
60
70
66B
66D
48
68A
57
66A
56
72
54
68B
55
58D
52
58B
50
58A

FIG. 3

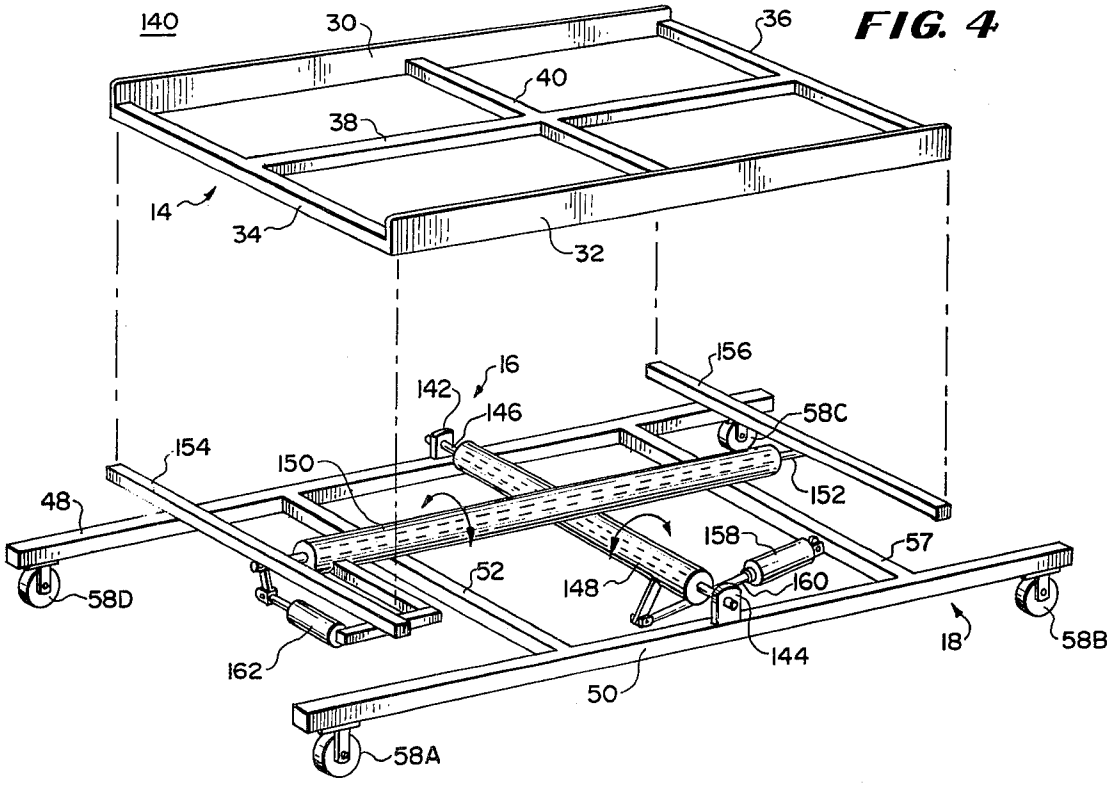

140
30
36
40
38
14
34
32
16
156
142
146
58C
154
150
152
48
158
57
52
148
160
58D
18
58B
162
144
50
58A

FIG. 4

# ADJUSTABLE BED

This invention relates to adjustable beds.

In one class of adjustable bed, the bedstead is adjustable in attitude by changing the relative elevations of the head and foot of the bed and in roll position by changing the relative elevations of the two sides of the bed. This class of adjustable bed has an advantage over other classes of adjustable beds in that the patient may be positioned in a variety of different positions rather than just in positions having different attitudes with his head lower or higher than his feet.

In a prior art type of this class of adjustable bed, the bed includes a first frame which remains parallel to the floor of the room in which the bed is located and second and third frames, the angles of which can be adjusted. The second frame is adjustably mounted to the first frame and carries the third frame, with the roll position of the second frame with respect to the first frame being adjustable by a first mechanical linkage and the attitude or pitch of the third frame being adjustable with respect to the second frame by a second mechanical linkage to adjust the angle of the bedstead in both roll and pitch positions.

The prior art type of adjustable bed has several disadvantages, which are: (1) it is excessively expensive; (2) it is relatively heavy because of the requirement of two separate movable frames and one stationary frame; (3) it is relatively slow and clumsy to adjust since the frames, for best results, must be adjusted one at a time; (4) the adjustment in pitch direction raises an edge to an undesirable height since the mechanism for pitch adjustment is carried by the frame for roll adjustment and is therefore elevated to some extent during the roll adjustment with the pitch adjustment increasing the elevation further.

Accordingly, it is an object of this invention to provide a novel adjustable bed.

It is a further object of the invention to provide an adjustable bed which may be adjusted both in pitch and roll positions without requiring that any edge be raised to an excessive height.

It is a still further object of the invention to provide a novel adjustable bed which is adjustable both in pitch and roll positions without placing strain upon the frame of the bed.

It is a still further object of the invention to provide a novel adjustable bed in which the adjusting mechanisms need move only one frame in either or both of two directions with respect to the base of the bed to achieve the different positions desired.

It is a still further object of the invention to provide an adjustable bed which is relatively simple to control.

It is a still further object of the invention to provide an adjustable bed which may be supported at more than three points with respect to a fixed base or floor.

It is a still further object of the invention to provide an adjustable bed in which one side is moved upwardly as the other side is moved downwardly about either or both a pitch axis or a roll axis.

It is a still further object of the invention to provide an adjustable frame for a bed which can receive and support different designs of bedsteads such as for example, articulated bedsteads in which the head or foot of the bedstead can be adjusted in position with respect to the rest of the bedstead.

It is a still further object of the invention to provide a hydraulically-controlled adjustable bed in which the possibility of leakage of hydraulic fluid is remote, which can be locked in position with relatively few valves and which remains locked even though the hydraulic lines are opened.



In accordance with the above and further objects of the invention, an adjustable bed, table or other apparatus used in hospitals to change the position of a patient includes a base frame, a movable frame and a tilting apparatus positioned between the stationary base frame and the movable frame to position the movable frame with respect to the base frame.

The base frame is mounted on rollers to move it to any location in the hospital and remains stationary with respect to the floor once in position. The movable frame supports a bedstead or a table upon which the patient rests and is adjustable in attitude or roll position with respect to the base frame to position the patient at a selected angle for treatment. The bedstead may be any of a number of differently designed bedsteads including some articulated bedsteads in which the head and foot of the bedstead are adjustable.

To adjust the position of the movable frame with respect to the base frame, the tilting apparatus includes two pairs of hydraulic cylinders with each hydraulic cylinder having its base connected to the base frame of the adjustable bed. The distal end of each piston rod of the hydraulic cylinders is connected to the movable frame through a universal joint, with the piston rod ends of the first pair of hydraulic cylinders being connected in a first line along the movable frame to form a pitch axis about which the head and foot of the bed rotate in an arc during pitch adjustment and the piston rod ends of the second pair of hydraulic cylinders being connected along a second line of the movable frame to form a roll axis about which the sides of the bed rotate in an arc during roll position adjustment, the pitch and roll axes being perpendicular to each other and intersecting at their midpoints to form a stationary point about which the head, foot and sides of the adjustable bed rotate during adjustment.

The cylinders in each of the first and second pairs of cylinders are double-acting cylinders with their ports connected through valves to a source of hydraulic pressure so that fluid, when adjusting the bed, is applied to one port of one of the cylinders and to the opposite port of the other cylinder of a pair of cylinders, forcing the one cylinder to extend its piston rod, while the other cylinder retracts its piston rod or forcing the one cylinder to retract its piston rod while the other cylinder extends its piston rod, thus causing rotation in an arc about an axis of the adjustable bed. Valves in the base of each of the cylinders can be closed to lock the cylinders without danger of leakage and will hold the cylinders in locked position even though the hydraulic lines are open.

With this arrangement, the axes are independent of each other and the pivoting of one axis in adjusting the pitch or roll position of the bed does not affect the angle of the other axis even though the other axis may be adjusted at the same time, thus permitting the bed to be changed in pitch or roll position either simultaneously or separately.

In the preferred embodiment, a center post has one end connected to the center beam of the stationary base of the adjustable bed and the other end connected to the point of intersection of the pitch and roll axes of

the movable frame through a universal joint to add support to the frame.

From the above description, it can be understood that the adjustable bed of this invention has the advantages of: (1) being of relatively simple structure, requiring few parts and being relatively economical to construct; (2) being adjustable in pitch and in roll without requiring any side to be raised to an excessive height; (3) being relatively easy to adjust in angle with an uncomplicated automatic control; (5) being constructed so that different designs of bedsteads can be mounted to the movable frame of the adjustable bed; (6) being relatively free from leakage of hydraulic fluid; (7) requiring relatively few valves; and (8) remaining locked in position even if the hydraulic lines are opened.

The above-noted and further features of the invention will be better understood from the following detailed description when considered with reference to the accompanying drawings, in which:

FIG. 1 is a fragmentary, exploded, perspective view of an adjustable bed in accordance with an embodiment of the invention.

FIG. 2 is a schematic drawing of the hydraulic power system of an adjustable bed in accordance with an embodiment of the invention.

FIG. 3 is a fragmentary, exploded, perspective view of another embodiment of adjustable bed in accordance with the invention.

FIG. 4 is a fragmentary, exploded, perspective view of still another embodiment of adjustable bed in accordance with the invention.

In FIG. 1, there is shown an exploded perspective fragmentary view of an adjustable bed **10** having a bedstead **12**, a movable supporting frame **14**, a frame pivoting section **16**, a horizontal base frame **18**, and a control box **21**, connected to each other in the order named from top to bottom, with the control box **21** controlling the frame pivoting section to adjust the movable supporting frame **14** and bedstead **12** with respect to the horizontal base frame **18** at a selected attitude and a selected roll position.

To support a patient, the bedstead **12** includes a base **20**, a headboard **22**, and a footboard **24**, adapted to support conventional bedding such as a mattress **26** and a pillow **28**. While a conventional bed structure has been shown for the bedstead, other structures such as tables and the like may be included instead and the bedstead may include side rails or be free from side rails.

To support the bedstead or a patient table, the movable supporting frame **14** includes an outer rectangular frame and an inner cruciform frame, with the outer rectangular frame including first and second longitudinally-extending parallel side beams **30** and **32** connected at their ends by parallel transversely-extending end beams **34** and **36** to which they are welded. The two end beams **34** and **36** are formed of square steel tubing and extend orthogonally to and between the ends of the longitudinal side beams **30** and **32** which are steel angles.

Within the rectangular outer frame, the cruciform inner frame includes a longitudinal center beam **38** and a transverse center beam **40**. The longitudinal center beam **38** is a square tubular steel beam that extends parallel to and midway between the longitudinal side beam **30** and **32** so as to lie along the roll axis of the movable supporting frame **14**, being welded at each of its ends to a different one of the transverse end beams **34** and **36**, and the transverse center beam **40** is a square tubular steel beam that extends parallel to and is midway between the transverse end beams **34** and **36** so as to lie along the pitch axis of the movable frame, being welded to the longitudinal side beams **30** and **32** at its two ends and intersecting the longitudinal center beam **38** at its center, with the transverse center and longitudinal center beams **40** and **38** having a common midpoint to form the inner cruciform frame.

The bottom sides of the cruciform frame are flush with the bottom sides of the rectangular outer frame and the top sides are flush with the transverse side beams **34** and **36** but, the longitudinal side beams **30** and **32** are of greater height than the end beams and the beams forming the cruciform inner frame to provide retaining sides for the bedstead. Many different designs of bedsteads can be mounted to the movable frame **14** including many types of articulated bedsteads in which the head and foot are adjustable in angle with respect to the center portion of the bedstead.

To enable the movable supporting frame **14** to be mounted to the frame pivoting section **16**, the cruciform inner section has welded or fastened by other means to its bottom side a universal joint **64** at the junction **37** of the longitudinal center beam **38** and transverse center beam **40**. The longitudinal beam **38** has, fastened to its bottom surface, a first universal joint **41** between the junction **37** and the side transverse beam **34** and a second universal joint **42** spaced between the junction **37** and the transverse beam **36** for mounting piston rods of the frame pivoting section **16**. Similarly, the center transverse beam **40** has first and second universal joints, one being shown at **44**, each being spaced between a different one of the side longitudinal beams **30** and **32** and the center junction **37**.

To support the adjustable bed, the horizontal base frame **18** includes first and second longitudinally-extending steel beams **48** and **50** connected in parallel relationship to each other by five transverse beams **52**, 54, 55, 56 and **57**, with each of the transverse beams being parallel to each other and being welded at its opposite ends to different ones of the two longitudinally-extending beams **48** and **50**. To permit the bed **10** to be moved from position to position, four casters **58A-58D** are mounted to the longitudinally-extending beams **48** and **50**, with a different caster being mounted to each different end of the beams.

To pivotally support the movable supporting frame **14** with respect to the base frame **18**, the frame pivoting section **16** includes a center post **60** mounted firmly by a bracket **62** at its bottom end to the center of the center transverse beam **54** and having the universal joint **64** at its upper end for connection to the movable supporting frame **14** at the junction **37**.

The universal joint **64** includes a top yoke **86** that is fastened at the junction **37** of the beams **38** and **40** and a bottom yoke **87** connected to the top of the post **60**, with the first yoke **86** being rotatably connected to the second yoke **87** by a needle bearing spider to permit the movable supporting frame **14** to move in the roll or pitch directions about the post **60**. This type of universal joint is a type commonly used in automobiles and provides very little free play, permitting only motion in the rotational directions along the needle bearings so that the frame **14** has substantially no lateral motion and provides tilting motion.

To support the center post **60**, four tubular struts **66A-66D** are each fastened at one of its ends to the top portion of the post **60** near the universal joint **64** and at its other end to a different location on the base frame **18** to form a rigid pyramidal supporting structure about the center post **60**. Each of the lower ends of the struts **66** is fastened to a different intersection of one of the longitudinally extending beams **48** and **50** and the transversely-extending beams **52** and **57**.

To tilt the movable mattress supporting frame **14** and hold it in a selected position, the frame pivoting section **16** includes four hydraulic cylinders **68A-68D**, each having one end pivotally connected to a central portion of the transverse beam **54** at the base of the post **60** with its piston rod positioned to extend outwardly and upwardly therefrom and connected to a different one of the four universal joints on the center cruciform frame of the movable supporting frame **14** (three of the universal joints **41, 42** and **44** being shown in FIG. **1**).

With this arrangement, two of the hydraulic cylinders **68A** and **68C** have their piston rods connected to two different positions along the longitudinal center beam **38** equal distances from the universal joint **64** and two others of the hydraulic cylinders **68B** and **68D** have piston rods connected to the center transverse beam **40** equal distances from the universal joint **64** so that: (**1**) to change the attitude of the movable supporting frame **14**, one of the piston rods in one of the hydraulic cylinders **68A** or **68C** is extended and the piston rod in the other of these two hydraulic cylinders is retracted by the same distance that the first one is extended; and (**2**) to change the roll position of the movable supporting frame **14**, the piston rod in one of the hydraulic cylinders **68B** and **68D** is extended and the piston rod in the other of these two cylinders is retracted an equal amount.

Because the hydraulic cylinders **68A** and **68C** that adjust the movable frame **14** in pitch have their piston rods connected to the movable frame along the roll axis, it is not necessary for them to change their amount of extension as the roll position of the movable frame is changed. Similarly, the hydraulic cylinders **68B** and **68D** do not have to change their amount of extension as the pitch is changed since their rods are connected along the pitch axis. Moreover, each pair of cylinders can independently change the angle of the movable frame along its own axis, either at the same time or at a different time from the time the other pair is changing the angle of the movable frame along its axis.

To provide power to the hydraulic cylinders **68A-68D**, a hydraulic pump assembly **70** is mounted to a plate **72** which is mounted to the two transverse beams **55** and **56**, with the hydraulic pump assembly **70** supplying fluid through valves under the control of the control box **21**.

The control box **21** includes switches actuated from its front panel through push buttons **74, 76, 78** and **80**, to control the hydraulic pump assembly **70** and open and close the solenoid valves that change the attitude and roll positions of the movable frame **14** or lock in position and unlock the movable frame in a manner described more completely hereinafter with respect to FIG. **2**.

More specifically, these push buttons are connected so that: (**1**) to raise the headboard **22** of the bedstead **12**, the push button **74** is depressed; (**2**) to lower the headboard, the push button **76** is depressed; (**3**) to lower the right side of the bedstead, the push button **78** is depressed; and (**4**) to raise the right side of the bedstead, the push button **80** is depressed. With these connections, one of the two buttons **74** and **76** can be depressed at the same time as one of the two buttons **78** and **80** to change the attitude and roll positions of the bedstead simultaneously.

In FIG. **2**, there is shown a schematic diagram of a hydraulic system **100**, having its hydraulic pump assembly **70**, the four hydraulic cylinders **68A-68D**, and eight solenoid-controlled valves **102A-102D** and **104A-104D**.

To provide fluid pressure for the operation of the hydraulic cylinders **68A-68D**, the hydraulic pump assembly **70** includes an electrically-driven reversible motor **108** and a hydraulic pump **110**, having hydraulic lines **114** and **116**, with the direction of the motor determining the direction of flow of the fluid through the hydraulic lines **114** and **116**.

To pivot the mattress supporting frame **14**, the hydraulic cylinders **68A-68D** are double-acting hydraulic cylinders, each with a corresponding one of the normally-closed solenoidcontrolled valves **104A-104D** within and communicating with its base to form a controllable piston-rod extending port.

To permit fluid to flow into and from the hydraulic cylinders while the bed is being adjusted, the pump **110** communicates with: (**1**) the valve **104A** and piston rod retracting port of hydraulic cylinder **68C** through line **116** and the normallyclosed, solenoid-controlled valve **102C**; (**2**) the valve **104C** and the piston rod retracting port of hydraulic cylinder **68A** through line **114** and the normally-closed solenoid-controlled valve **102A**; (**3**) the valve **104B** and the piston rod retracting port of hydraulic cylinder **68D** through line **116** and the normally-closed, solenoid-controlled valve **102D**; and (**4**) the valve **104D** and the piston rod retracting port of hydraulic cylinder **68B** through the normally-closed line **114** and solenoid-operated valve **102B**.

Each pair of piston rod retracting ports and valves **104** are connected to the appropriate hydraulic line through different branches of a T-connector so that, as the piston rod of one of the hydraulic cylinders **68A** and **68B** moves in one direction, the piston rod of the respective hydraulic cylinder **68C** and **68D** is moved in the opposite direction by the hydraulic fluid.

With these connections, when one of the four sides of the supporting frame **14** is raised by one hydraulic cylinder, the opposite side is lowered by the other hydraulic cylinder of the pair of hydraulic cylinders along one of the two axes to pivot the frame about the other of the two axes, with the piston rods of the other pair of cylinders being connected along the other axis. Since the pivoting of one axis does not change the elevation of any part of the other axis, either pair of hydraulic cylinders can pivot the frame **14** about one axis or both can pivot the frame **14** about their respective axis.

To extend and retract the pistons in a corresponding pair of the hydraulic cylinders **68A-68D**, the normally-closed solenoidoperated valves **102A-102C** and **104A-104D** that communicate with that pair of the hydraulic cylinders are opened and the pump **110** is driven by the reversible motor **108** in a direction to force fluid into the piston rod extending port of the hydraulic cylinder that is to raise one end of the bedstead and to receive fluid from the hydraulic cylinder that is to lower one end of the bedstead.

In FIG. 2, the hydraulic cylinders are shown in the position they have when adjusting the supporting frame 14 (FIG. 1) in both attitude and roll (all valves open) and being temporarily in a position where the foot of the bed is downward, its head is upward and there is no roll position with the valves being ready to move the bed out of this position. This is shown by the hydraulic cylinder 68A having its pistion completely retracted to the lowest position and the hydraulic cylinder 68C having its pistion fully extended to the highest position. The hydraulic cylinders 68B and 68D, which control the roll position of the bed, have their pistons positioned intermediately in the cylinder so as to position the bed in its neutral roll position.

While a hydraulic system is disclosed in the preferred embodiment, other moving systems, such as electrically driven screws, can be used instead. Moreover, it is possible to omit the valves 102 entirely in the embodiment of FIG. 2 since the valves 104 each lock one cylinder against one direction of motion and the pairs of cylinders work against each other so that each pair of valves controls one of the directions of motion. However, if one of each of the cylinders in each of the pairs of cylinders is omitted, then the valves 102 must be included, but since there are only two cylinders in such an embodiment, only four valves 102 are required.

There is less danger of leakage if the valves 102 are omitted from the embodiment of FIG. 2 since external valves are subject to leakage and the valves 104 are inside the cylinders. Moreover, if the hydraulic lines are opened, the cylinders remain locked since they are held by fluid trapped between the pistons and the closed valves 104 in an embodiment having four cylinders and not including the valves 102.

In FIG. 3, there is shown a portion of another embodiment of an adjustable bed 134 similar to the adjustable bed 10, differing in that the hydraulic cylinders are mounted substantially vertically to the transverse beams 52, 54 and 57. In FIG. 3, parts of the adjustable bed 134 are the same and are numbered the same as parts of the adjustable bed 10 in FIG. 1, and other parts, not necessary to explain in this embodiment, are omitted from FIG. 3 altogether.

In the embodiment of FIG. 3, the hydraulic cylinders 68A and 68C are mounted substantially vertically to the center of the parallel cross beams 52 and 57 and the hydraulic cylinders 68B and 68D are mounted substantially vertically to opposite ends of the cross beam 54, which is parallel and centered between the cross beams 52 and 57, so that an imaginary roll axis, shown by the dotted line A-C, and an imaginery pitch axis, shown by the dotted line D-E, pass through the ends of the piston rods of the hydraulic cylinders, intersecting each other orthogonally near the center of the movable supporting frame 14.

The hydraulic cylinders 68A–68D are connected for operation in the manner shown in FIG. 2 which is identical to the connection used to extend and retract the pistons of the hydraulic cylinders in the embodiment of FIG. 1. With these connections, the attitude of the movable supporting frame 14 is changed by pivoting the frame 14 about the pitch axis D-B without requiring a change in the vertical or horizontal position of the piston rods of the hydraulic cylinders 68D and 68B as the attitude of the movable frame 14 changes. Similarly, when the roll position of the supporting frame 14 is changed, the roll axis A-C rotates but does not move vertically or horizontally as the pitch axis D-E pivots its end points.

The pistons are locked as shown and explained in connection with FIG. 2 once a desired position is obtained. Both attitude and roll position of the frame 14 can be changed simultaneously, in which case, the intersecting point of the axes A-C and D-E remains fixed except for rotating while the end points of the roll and pitch axis move horizontally as the movable supporting frame 14 changes attitude and roll positions.

Prior to operating the adjustable beds 10 or 134, a patient on the bedstead 12 can be moved to any location by rolling the adjustable bed to that particular location. For example, the patient can be placed on the adjustable bed in a hospital ward and moved to a treatment room.

In operating the adjustable bed, the position of the patient can be adjusted by changing the attitude, the roll, or both the attitude and the roll positions of the movable supporting frame 14. This is accomplished through the control box 21 (FIG. 1) which controls the pivoting section 16 to tilt the bedstead 20 (FIG. 1) into any selected position.

To change the attitude of the movable supporting frame 14 so that the head of the bed is lower than the foot of the bed, the push button 76 (FIG. 1) on the control box 21 is depressed, causing the motor 108 to rotate (FIG. 2) to operate the pump 110 and opening valves 102A and 104C to force fluid through line 116, valve 102A, into the hydraulic cylinder 68A, valve 104C of cylinder 68C and from the valve 104C into the cylinder 68C, with fluid returning to the pump 110 through valve 102C and line 116 so that the piston rod of the hydraulic cylinder 68C is extended, thus causing the bed to pivot about the beam 40.

Similarly, to lower the foot 24 with respect to the head 22 of the bed, the push button 74 on the control box 21 is depressed to cause the motor to operate in the reverse direction and to open valves 102A and 102C in which case the pump 110 forces fluid through line 116 and valve 102A to move the piston rods in the opposite directions with the fluid returning to the pump through valve 102C and line 116, thus extending the piston rod in the cylinder 68A and retracting the piston rod in the cylinder 68C.

To adjust the roll position of the bed by pivoting about the roll axis while resting on the universal joint 64, the push button 78 is depressed to lower the right side and the push button 80 is depressed to lower the left side of the supporting frame 14. Depressing the push button 78 causes fluid to be pumped through line 114 and valve 102B to the hydraulic cylinder 68B and to the valve 104D from which it enters the hydraulic cylinder 68D, thus extending the piston rod in the cylinder 68D and retracting the piston rod in the cylinder 68B to cause the right side of the bed to lower. Depressing the push button 80 causes fluid to flow in the other direction by reversing the motor 108 and opening the same valves to pivot the bed in the opposite direction.

When none of the push buttons 74, 76, 78 or 80 are depressed, valves 102A–102D and 104A–104D are closed and the pistons firmly locked in position to prevent further motion. With this mechanization, the bed is held firmly from motion except when its position is being changed. Of course, both the pitch and the roll positions may be changed simultaneously if desired.

If FIG. 4, there is shown a portion of another embodiment of adjustable bed 140 which is similar to the adjustable bed 10 shown in FIG. 1 except for the frame pivoting section 16. Parts of the embodiment of FIG. 4 that are identical to parts of the embodiment of FIG. 1 have the same reference numerals.

As shown in FIG. 4, the frame pivoting section 16 includes two upstanding bearing supports 142 and 144 each mounted to the center of a different one of the two longitudinally-extending beams 48 and 50 in the base frame 18. To permit changes in pitch of the bed, an elongated rod 146 serving as a center bearing is mounted on the two supports 142 and 144, thus lying parallel midway between the two end beams 52 and 57, with an outer tubular pitch axle 148 being positioned for rotation upon the elongated bearing 146. To permit adjustment in the roll position of the frame 14, an outer cylindrical tubular bearing 150 is welded orthogonally to the pitch axle 148 and extends along the longitudinal axis of the adjustable bed 140 midway between the two longitudinally-extending beams 48 and 50. An inner roll axle 152 fits within the tubular bearing 150, with each of two bed frame supports 154 and 156 being welded to a different end of the roll axle for movement therewith.

To change the attitude or pitch of the bed, the hydraulic cylinder 158 has its base mounted to the end transverse support 57 and its piston rod 160 mounted by a lever to the tubular pitch axle 148 to rotate the pitch axle as the piston rod 160 is extended or retracted. To change the roll position of the bed, a second hydraulic cylinder 162 has its piston rod mounted by a lever to the roll axle 150 and its base to the tubular bearing 150 by another lever to pivot the roll axle 150 with respect to the bearing 162 and thus change the roll position of the bedstead.

The hydraulic cylinders can be locked and controlled in a manner directly analogous to the manner in which the hydraulic cylinders of the embodiments of FIGS. 1 and 3 are controlled and locked, except that only two cylinders cooperate with four valves to control the roll positions and the pitch positions instead of four cylinders and four or eight valves.

In the embodiments of FIGS. 1 and 3, two pairs of cylinders are included, with the two cylinders in each pair having equal strokes. However, it is possible to use two cylinders only or to space the cylinders at different distances from the intersection of the axis and compensate for the differences in this distance by including cylinders having different strokes. Moreover, the stationary point at the intersection of the pitch and roll axes need not be centered on the bed although this provides the lowest maximum elevation of an edge of the bed for each angle. It is also possible to mount the frame pivoting section 16 to a movable support member that can be altered in elevation with respect to the base frame 18 so that the base support for the movable frame 14 is the movable support member rather than the base frame 18 to permit changes in elevation of the entire movable frame.

From the above description, it can be understood that the adjustable bed of this invention had the advantages of: (1) being of relatively simple structure, requiring few parts and being relatively economical to construct; (2) being adjustable in pitch and in roll without requiring any side to be raised to an excessive height; (3) being relatively easy to adjust in angle with an uncomplicated automatic control; (5) being constructed so that different designs of bedsteads can be mounted to the movable frame of the adjustable bed; (6) being relatively free from leakage of hydraulic fluid; (7) requiring relatively few valves; and (8) remaining locked in position even if the hydraulic lines are opened.

Although a preferred embodiment has been described with some particularity, many modifications and variations of the preferred embodiment may be made without deviating from the invention. It is therefore to be understood that, within the scope of the appended, the invention may be practiced other than as specifically described.

What is claimed is:

1. An adjustable patient support apparatus, comprising:
- a base support;
- said base support including a support member;
- a movable frame adapted to support said patient in an adjustable position having a first axis of rotation and a second axis of rotation;
- said first and second axes crossing substantially at a point of intersection;
- means for moving at least portions of said movable frame with respect to said support member;
- said means for moving said movable frame including means for selectively pivoting said movable frame about the first axis of rotation and about the second axis of rotation without substantially changing the elevation of said point of intersection with respect to said support member, whereby said movable frame is pivoted in either or both of two directions;
- said means for moving said movable frame including first movable means for pivoting said movable frame about the first axis and second movable means for pivoting said movable frame about the second axis;
- said first movable means including a first base mounted stationary with respect to said support member and a first driven arm connected to one point on one of said axes a first distance from said point of intersection;
- said second movable means including a second base mounted stationary with respect to said support member and a second driven arm connected to the other of said axes at a second point a second distance from said point of intersection.

2. An adjustable patient support apparatus in accordance with claim 1 in which said base support further includes:
- a universal joint; and
- a stationary frame;
- one portion of said support member being adapted to be supported on said stationary frame and another portion being connected to said point of intersection by said universal joint.

3. An adjustable patient support apparatus in accordance with claim 1 in which said first movable means further includes a third base mounted stationary with respect to said support member and a third driven arm connected to said one of said axes at a third point a third distance from said point of intersection on the opposite side of said point of intersection from said one point.

4. An adjustable patient support apparatus in accordance with claim 3 in which said second movable means includes a fourth base mounted stationary with

respect to said support member and a fourth driven arm connected to said other of said axes at a fourth point a fourth distance from said point of intersection on the opposite side of said point of intersection from said second point.

**5.** An adjustable patient support apparatus in accordance with claim **3** in which said means for moving said movable frame includes means for moving said first driven arm in a first direction a fifth distance and said third driven arm a sixth distance in a second direction with the product of said first and sixth distances being equal to the product of said third and fifth distances, whereby pivoting about said axis is provided.

**6.** An adjustable patient support apparatus in accordance with claim **4** in which said means for moving said movable frame includes:

means for moving said first driven arm in a first direction a fifth distance and said second driven arm a sixth distance in a second direction with the product of said first and sixth distances being equal to the product of said third and fifth distances, whereby pivoting about said one axis is provided; and

means for moving said second driven arm in a third direction a seventh distance and said fourth driven arm an eighth distance in a fourth direction with the product of said second and eighth distances being equal to the product of said fourth and seventh distances, whereby pivoting about said other axis is provided.

**7.** An adjustable patient support apparatus in accordance with claim **4** in which:

said first and second movable means includes first, second, third and fourth hydraulic cylinders each having a different housing and piston rod;

said first, second, third and fourth bases each comprising a hinge means connecting the housings of said hydraulic cylinders to said base support;

said first, second, third and fourth driven arms being the piston rods of said cylinders.

**8.** An adjustable patient support apparatus according to claim **7** in which said first and third distances are equal.

**9.** An adjustable patient support apparatus in accordance with claim **7** in which said base support further includes:

a universal joint; and

a stationary frame;

one end of said support member being adapted to be supported on said stationary support frame and the other end being connected to said point of intersection by said universal joint.

**10.** An adjustable patient support apparatus in accordance with claim **9** in which said base support further includes means for elevating said support member with respect to said stationary frame whereby the elevation of said movable frame is changed.

**11.** An adjustable patient support apparatus in accordance with claim **2** in which said universal joint includes needle bearings.

**12.** An adjustable patient support apparatus in accordance with claim **2** in which said base support further includes means for elevating said support member with respect to said stationary frame whereby the elevation of said movable frame is changed.

**13.** An adjustable patient support apparatus in accordance with claim **12** in which said bases and driven arms are lockable with respect to each other.

**14.** An adjustable patient support apparatus in accordance with claim **7** in which said first movable means includes:

a source of hydraulic pressure having first and second ports for the application of pressure through one of said first and second ports and the venting of hydraulic pressure through the other of said first and second ports; and

first conduit means for selectively bringing one of said first and second hydraulic cylinders into communication with one of said ports and the other hydraulic cylinder into communication with said other of said ports;

second conduit means for selectively bringing one of said second and fourth hydraulic cylinders into communication with said second hydraulic cylinder to one of said ports and said base of said fourth hydraulic cylinder to the other of said ports.

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