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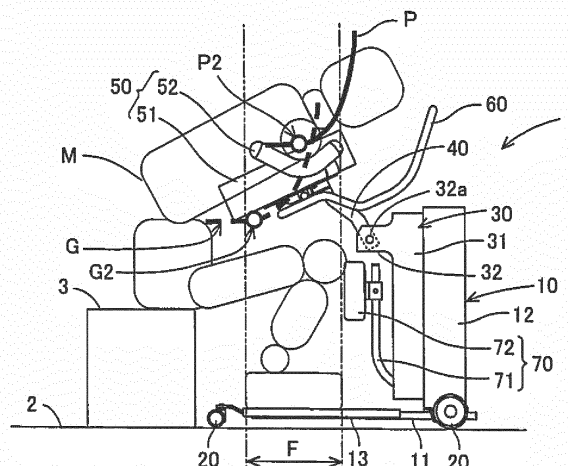
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(54) **ASSISTANCE ROBOT**

(57) An assisting robot (1) that can suppress discomfort to a care receiver (M) during a standing-assistance operation is provided. A control device (80) for the assisting robot (1) executes a first operation that coordinates lowering of an elevator (30) and forward rotation of an arm (40) for at least a part of a period from when

the care receiver (M) is in an initial sitting posture to an intermediate posture. The control device (80) executes a second operation that raises the elevator (30) during a period from time of the intermediate posture to time of a standing posture.

Fig. 3



Description

Technical Field

[0001] The present invention relates to an assisting robot.

Background Art

[0002] PTL 1 discloses an assisting robot that helps a care receiver to stand up. The assisting robot has two drive axes: A shaft, as one of the drive axes, moves linearly in a vertical direction. The other drive axis is a table provided to the upper end of the shaft in a pivotable manner. With the care receiver in a sitting posture having his/her elbows on the table, the assisting robot pivots (forward-rotates) the table and moves the table into an ascension-ready position and thereafter raises the table to make the care receiver stand up.

PRIOR ART REFERENCES

[0003] PTL 1: JP-A-2012-217686

BRIEF SUMMARY OF THE INVENTION

Technical Problem

[0004] The assisting robot first rotates the table forward while the elbows of the care receiver in the sitting posture are placed on the table. Since the table is raised by rotating forward, the upper body of the care receiver is lifted as the table starts rotating forward.

[0005] Here, while in the sitting posture in which the care receiver is seated on a seat surface, the center of gravity of the care receiver is normally separated away from the ground position in contact with feet of the care receiver. When the upper body of the care receiver is lifted by the forward rotation of the table from this state, a force is generated that causes the upper body of the care receiver to separate rearward from the table of the assisting robot. For this reason, the care receiver exerts force to keep from separating away from the table and feels discomfort as a result.

[0006] It is an object of the present invention to provide an assisting robot that can suppress discomfort to a care receiver during a standing-assistance operation.

Solution to Problem

[0007] An assisting robot according to the present invention includes: a base, an elevator for linear movement in a vertical direction with respect to the base, an arm that is pivotable about a predetermined pivot axis on the elevator, a holder provided at the end of the arm for holding the upper body of the care receiver, and a control device that controls vertical movement of the elevator and pivoting of the arm to assist a care receiver in stand-

ing up from a sitting posture to a standing posture.

[0008] The control device executes a first operation that lowers the elevator and forward-rotates the arm in a coordinated manner for at least a part of a period of time from when the care receiver is in the initial sitting posture to the predetermined intermediate posture, and further executes a second operation that raises the elevator in a period from when the care receiver is in the predetermined intermediate posture to the standing posture.

[0009] According to the present invention, the first operation is an operation in which lowering the elevator and forward-rotating the arm are performed in a coordinated manner. The upper body of the care receiver is tilted forward by forward-rotating the arm. Here, in the first operation, the holder is raised with respect to the elevator by forward-rotating the arm, but the elevator is lowered with respect to the base by lowering the elevator. As a result, in the first operation, at least a portion of the raising of the holder with respect to the elevator by forward-rotating the arm is offset by lowering the elevator.

[0010] In this way, when the center of gravity G of the care receiver moves forward from its position during the initial sitting posture, in the case of the first operation described above, the amount the upper body of the care receiver is raised is reduced compared to the amount with just forward-rotating the arm as performed conventionally. Therefore, in the initial stage from the sitting posture to the standing posture, the amount the upper body of the care receiver is lifted is reduced, thereby reducing discomfort to the care receiver.

Brief Description of Drawings

[0011]

[FIG. 1] FIG. 1 is a rear perspective view showing the external appearance of an assisting robot according to the present embodiment.

[FIG. 2] FIG. 2 is a view from the right side showing the structure of the assisting robot in which a care receiver is in an initial sitting posture.

[FIG. 3] FIG. 3 is a view from the right side showing the structure of the assisting robot in which a care receiver is in an initial sitting posture.

[FIG. 4] FIG. 4 is a view from the right side showing the structure of the assisting robot in which a care receiver is in an initial sitting posture.

[FIG. 5A] FIG. 5A shows a trace of the shoulder position P of the care receiver and the angle θ of the trunk receiver at the shoulder positions P1, P2, P3 during a standing operation of the care receiver that uses an assisting robot.

[FIG. 5B] FIG. 5B shows a change in time of the angle of the trunk receiver from the beginning to end of assistance in the standing operation of the care receiver.

[FIG. 6A] FIG. 6A shows, for comparison, a trace of the shoulder position Pa and an angle θ_a of the trunk

at the shoulder positions Pa1, Pa2, Pa3 during a standing operation of a healthy subject.

[FIG. 6B] FIG. 6B shows an angle θ_a of the trunk from the beginning to end of operation in the standing operation of the healthy subject.

DESCRIPTION OF EMBODIMENTS

(1. Configuration of an assisting robot 1)

[0012] An assisting robot 1 assists a care receiver M (shown in FIG. 2) in standing up from a sitting posture to a standing posture, and assists the care receiver M in sitting down from a standing posture to the sitting posture. In particular, the assisting robot 1 according to the present embodiment is primarily targeted to a care receiver M who has difficulty standing up by oneself, and is effectively used, for example, in assisting the pulling down and pulling up of bottoms (i.e., clothes worn on the lower body) of the care receiver M and assisting the care receiver M in performing a bowel movement. With an assisting robot 1 supporting the upper body of the care receiver M in a standing posture, a single caregiver can perform the above-mentioned treatment of the care receiver M. In other words, the standing posture in the present embodiment refers to a state in which at least the lower body of the care receiver M is upright, and does not refer to a state in which both the upper body and the lower body are upright.

[0013] Although the assisting robot 1 of the present embodiment is described for the purpose of assisting in raising only the lower body of the care receiver M to a standing posture, it is also possible for the assisting robot 1 to assist in raising both the lower body and upper body of a care receiver M to the standing posture.

[0014] As shown in FIGS. 1 and 2, the assisting robot 1 has a base 10, wheels 20, an elevator 30, an arm 40, a holder 50, a grip 60, a lower leg contact section 70, and a control device 80. In the following, front, rear, left, right, up, and down, as shown in FIG. 1, are front, rear, left, right, up, and down as seen from the care receiver M. The base 10 includes a frame 11, a support column 12, a footrest 13, and a fixed cover 14. The frame 11 is located slightly apart from and is roughly horizontal with a ground surface 2 (floor, ground).

[0015] The support column 12 is fixed to the frame 11 and erected upward from the front of the upper surface of the frame 11. The support column 12 is disposed at the center in the left-right direction at the front of the frame 11. In the present embodiment, the assisting robot 1 has one support column 12, but two or more support columns 12 may be provided.

[0016] The footrest 13 is fixed to the rear of the top surface of the frame 11. A contact mark 13a for the feet of the care receiver M is marked on the top surface of the footrest 13. That is, the contact mark 13a guides the position of the feet of the care receiver M. As shown in FIG. 1, the fixed cover 14 is fixed to the frame 11 or the

support column 12, and encloses the periphery of the lower portion of an elevator main body 31 of the elevator 30 described later.

[0017] As shown in FIG. 1, the wheels 20 are arranged at the four corners (front, rear, left and right) of the frame 11. The wheels 20 have a locking function for restricting rotation. In the present embodiment, the wheels 20 freely rotate, but the wheels 20 may be provided such that they are driven by a driving device.

[0018] The elevator 30 includes the elevator main body 31, a pivot support 32, and an elevator cover 33. As shown in FIG. 2, the elevator main body 31 has an elongated shape in the vertical direction and is provided to the front face of the support column 12 so as to be linearly movable in the vertical direction. The elevator main body 31 is guided by a guide (not shown) on the front face of the support column 12 and is driven by a linear motion device (not shown). The elevator main body 31 is enclosed by the fixed cover 14.

[0019] The pivot support 32 is provided on the upper end of the elevator main body 31 and has a pivot axis 32a that is parallel to the left-right direction. Specifically, the pivot support 32 protrudes rearward from the upper end of the elevator main body 31. That is, the pivot axis 32a is positioned rearward of the support column 12 and the elevator main body 31.

[0020] As shown in FIG. 1, the elevator cover 33 is fixed to the elevator 30 and encloses the elevator 30. Further, the elevator cover 33 encloses the support column 12 and the fixed cover 14. The elevator cover 33 also overlaps the fixed cover 14 even when the elevator 30 is in a raised position. In the present embodiment, the assisting robot 1 has one elevator 30 because it has one support column 12, but if the assisting robot 1 has two or more support columns 12, the assisting robot 1 will be provided with a number of elevators 30 corresponding to the number of support columns 12.

[0021] The arm 40 is provided so as to be capable of pivoting about the pivot axis 32a of the pivot support 32 of the elevator 30 as a central axis. The arm 40 is pivoted by an arm driving device (not shown). The arm 40 pivots to a position higher than the pivot support 32. That is, the pivot range of the arm 40 spans from the state where the tip of the arm 40 extends to the rear of the pivot support 32 (shown in FIG. 2), to the state where the tip of the arm 40 is in the vicinity above the pivot support 32 or the elevator main body 31 (shown in FIG. 4). When the assisting robot 1 assists in standing, the arm 40 rotates forward from the rear-extended state, and when the assisting robot 1 assists in sitting down, the arm 40 rotates rearward to the rear-extended state.

[0022] The holder 50 is provided at the distal end of the arm 40 and holds the upper body of the care receiver M. In the present embodiment, the holder 50 includes a trunk receiving section 51 that comes into contact with the trunk of the care receiver M and an underarm receiving part 52 that supports both underarms of the care receiver M. Furthermore, the holder 50 may be provided

with only one of the trunk receiving section 51 or the underarm receiving part 52.

[0023] The trunk receiving section 51 supports the trunk of the care receiver M from below. The trunk receiving section 51 has a planar shape and is made of a cushion material. The trunk receiving section 51 has an initial shape corresponding to the body of the standard care receiver M and is flexibly deformed to accommodate the body of each care receiver M. In the present embodiment, the trunk receiving section 51 comes into contact with the chest and abdomen of the care receiver M.

[0024] The underarm receiving part 52 has an arc shape and is disposed on the left and right sides of the trunk receiving section 51 such that an arc opening faces upward. The underarm receiving part 52 supports the upper body of the care receiver M by supporting the underarms of the care receiver M from below. Further, by sandwiching both underarms of the care receiver M from the front and rear direction, the underarm receiving part 52 restricts back and forth movement of the care receiver M. Accordingly, the trunk receiving section 51 and the underarm receiving part 52 can control the shoulder position P of the care receiver M in a state held in place by the holder 50.

[0025] By the arm 40 pivoting with respect to the elevator 30, the center line in the left-right direction of the trunk receiving section 51 is pivoted in the range of 20° to 110° with respect to the vertical line. Within the range of angles 20° to 90° of the center line of the trunk receiving section 51, the trunk receiving section 51 is directed upward and rearward. On the other hand, within the range of angles 90° to 110° of the trunk receiving section 51, the trunk receiving section 51 is directed upward and forward.

[0026] The grip 60 has a U-shape, and both ends of the U-shape of the grip 60 are fixed to the lower surface of the trunk receiving section 51. The central portion of the grip 60 is located in front of the trunk receiving section 51 and gripped by the care receiver M held in the holder 50.

[0027] The lower leg contact section 70 determines the position and posture of the lower body of the care receiver M in the sitting posture by coming into contact with the front part of the lower leg (shin or knee) of the care receiver M in the sitting posture. In particular, the position of the feet is determined to some extent. The lower leg contact section 70 is fixed to the support column 12 of the base 10. The lower leg contact section 70 includes two support members 71 and a lower leg pad 72.

[0028] The support members 71 have an L-shape. One end of the L-shaped support member 71 is fixed to the support column 12, and the other end of the L-shaped support member 71 is positioned behind the support column 12. The lower leg contact main body 72 is fixed to the other end of the support member 71 and is positioned behind the elevator cover 33 and below the pivot support 32. The lower leg pad contact main body 72 is a part that comes in contact with the front part of the lower leg of

the care receiver M, has a planar shape, and is made of the cushion material.

[0029] The control device 80 is fixed to a frame 11 of the base 10 and erected upward from the front top surface of the frame 11. The control device 80 is positioned next to the support column 12. The control device 80 controls vertical movement of the elevator 30 and pivoting of the arm 40 to assist the care receiver M in standing up and sitting down.

[0030] When an operator (the care receiver M or the caregiver) executes an adjustment operation for a standing start height, the control device 80 controls only the vertical movement of the elevator 30 and does not pivot the arm 40 at this time. That is, the control device 80 adjusts the standing start height according to the elongation of the care receiver M.

[0031] Furthermore, a standing-assistance program to be used during a standing-assistance operation is stored in the control device 80 beforehand. As a standing-assistance operation is executed by the operator (the care receiver M or the caregiver), the control device 80 executes the standing-assistance program and controls the vertical movement of the elevator 30 and pivoting of the arm 40. Additionally, a sitting-assistance program to be used during a sitting-assistance operation is stored in the control device 80 beforehand. As a sitting-assistance operation is executed by the operator (the care receiver M or the caregiver), the control device 80 executes the sitting-assistance program and controls the vertical movement of the elevator 30 and pivoting of the arm 40. Further, the control device 80 corrects the standing-assistance program and the sitting-assistance program in accordance with the standing start height.

(2. Standing-assistance operation by the assisting robot 1)

[0032] The standing-assistance operation with respect to the care receiver M by the assisting robot 1 will be described with reference to FIGS. 2 to 4. In FIGS. 2 to 4, the bold solid line shows the trace of the shoulder position P during a standing operation of the care receiver M, and the thick broken line shows the trace of the center of gravity G during the standing operation of the care receiver M. The standing-assistance operation is an operation that moves the assisting robot 1 from an initial state shown in FIG. 2, to an intermediate state shown in FIG. 3, and then to a final state shown in FIG. 4. That is, by way of the standing-assistance operation, the care receiver M moves from an initial sitting posture shown in FIG. 2, to an intermediate posture shown in FIG. 3, and then to a standing posture shown in FIG. 4. That is, the control device 80 conducts the vertical movement of the elevator 30 and forward rotation of the arm 40 so that the shoulder position P moves along the trace shown in FIGS. 2 to 4.

[0033] As shown in FIG. 2, in the initial state of the standing-assistance operation, the care receiver M is

seated on a seat surface 3 (the sitting posture). The assisting robot 1 is set to the initial state of the standing-assistance operation by operation of the care receiver M or a caregiver. In the standing-assistance program, the initial state of the assisting robot 1 is a state in which the holder 50 is positioned furthest to the rear. That is, the initial state of the assisting robot 1 is a state in which the arm 40 extends rearward. The lower body of the care receiver M is disposed in a space below the holder 50. The feet of the care receiver M are positioned on the contact mark 13a. The lower legs of the care receiver M come in contact with the rear surface of the lower leg pad 72.

[0034] In this state, the control device 80 moves the elevator 30 vertically as a result of the care receiver M or the caregiver performing a vertical movement operation of only the elevator 30 according to the height of the upper body of the care receiver M who is in a sitting posture on the seating surface 3. In this way, the front surface of the trunk of the care receiver M comes into contact with a trunk holding surface of the trunk receiving section 51. Further, the care receiver M places the underarms on the underarm receiving part 52, and the care receiver M grips the grip 60. In this initial state, the upper body of the care receiver M is in a slightly forward-leaning posture. However, the position of the center of gravity G1 in the front-rear direction of the care receiver M in the initial state is located behind the front-rear span F of the feet of the care receiver M.

[0035] Subsequently, when the care receiver M or the caregiver starts the standing-assistance operation, the control device 80 lowers the elevator 30 and forward-rotates the arm 40 in a coordinated manner in accordance with the standing-assistance program. Here, the operation from the initial sitting posture to the intermediate posture of the care receiver M is referred to as the first operation. That is, the first operation is an operation in which lowering the elevator 30 and forward-rotating the arm 40 is performed in a coordinated manner for at least a part of a period of time from the initial sitting posture to the intermediate posture.

[0036] In the present embodiment, the coordinated operation of lowering the elevator 30 and forward-rotating the arm 40 is performed for the entire period from the initial sitting posture to the intermediate posture. Of course, coordinated operation can also be executed for only a part of the period. At this time, the arm 40 only forward-rotates and does not rearward-rotate, and the elevator 30 only descends and does not rise.

[0037] As shown in FIGS. 2 and 3, the first operation moves the shoulder position P of the care receiver M forward in a roughly horizontal manner. In the first operation, the holder 50 rises with respect to the elevator 30 by forward rotation of the arm 40. However, as the elevator 30 descends, the shoulder position P moves in a roughly horizontal manner. Here, "roughly horizontal" includes states that are slightly inclined upward or downward with respect to the horizontal.

[0038] Furthermore, in the first operation, by forward rotation of the arm 40, the trunk holding surface of the trunk receiving section 51 tilts forward and moves forward. Therefore, due to the coordinated first operation, the shoulder position P of the care receiver M moves forward and the rear end of the trunk receiving section 51 rises. Accordingly, the upper body of the care receiver M tilts forward and the vicinity of the abdomen of the care receiver M is lifted. As a result of such a first operation, while the buttocks of the care receiver M are kept in contact with the seat surface 3, the back muscles of the care receiver M extend and the pelvis stands upright. In this way, the holder 50 supports the care receiver M having such a posture in a stable manner.

[0039] Additionally, as shown in FIG. 3, in the intermediate posture, the position in the front-rear direction of the center of gravity G2 of the care receiver M enters the front-rear span F of the ground surface in contact with the feet of the care receiver M. Accordingly, although the care receiver M can not stand up on his/her own, in the intermediate posture, the care receiver M is in a posture that makes it easy for him/her to support him/herself in a stable manner with his/her own feet.

[0040] Whether or not the position of the center of gravity G2 of the care receiver M in the front-rear direction is within the front-rear span F of the ground surface in contact with the feet can be predicted by the extension and the weight of the care receiver M. Therefore, by predicting the center of gravity G of the care receiver M in advance and setting vertical movement of the elevator 30 and the angle of forward rotation of the arm 40, the above can be realized.

[0041] Additionally, it is also possible to make the above judgment by measuring the mass on the holder 50 and determining whether or not the mass reaches a predetermined percentage of the mass of the upper body of the care receiver M. Further, the above judgment can be made based on whether or not the rear load received by the holder 50 from the care receiver M has reached a value that is equal to or less than a predetermined value. Furthermore, the above judgment can also be made depending on whether or not the inclination of the upper body of the care receiver M has reached a predetermined value or more.

[0042] Accordingly, the control device 80 switches the operation of the elevator 30 from lowering to raising. In the present embodiment, the control device 80 coordinates upward movement of the elevator 30 and forward rotation of the arm 40 in accordance with the standing-assistance program. Here, the operation from the intermediate posture of the care receiver M to the standing posture is referred to as a second operation. That is, in the second operation, the coordination between raising of the elevator 30 and forward rotation of the arm 40 is performed for at least a part of a period from the intermediate posture to the standing posture.

[0043] In the present embodiment, the coordinated operation of raising the elevator 30 and forward-rotating the

arm 40 is performed for the entire period from the intermediate posture to the standing posture. Of course, coordinated operation can also be executed for only a part of the period. At this time, the arm 40 is only rotating forward and does not rotate rearward, and the elevator 30 only rises and does not descend.

[0044] As shown in FIGS. 3 and 4, the shoulder position P of the care receiver M rises upward in a roughly direct manner while slightly moving forward from the intermediate posture. That is, the holder 50 moves slightly forward due to forward rotation of the arm 40 and rises mainly due to rising of the elevator 30.

[0045] By performing the second operation, the buttocks of the care receiver M moves upward and away from the seating surface 3. In the second operation, by the forward rotation of the arm 40, the trunk holding surface of the trunk receiving portion 51 further tilts forward. The upper body of the care receiver M is raised and further tilted forward. Accordingly, by way of the second operation, when the upper body of the care receiver M rises, a state in which the back muscles of the care receiver M are extended is maintained. Therefore, during the second operation, the holder 50 can support the care receiver M in a stable manner.

[0046] Furthermore, during the second movement, the position (G2 to G3) of the center of gravity G of the care receiver M in the front-rear direction is located within the front-rear span F of the ground surface in contact with the feet of the care receiver M. In this way, the care receiver M feels secure when the upper body of the care receiver M rises.

(3. Position of the pivot axis 32a)

[0047] Next, the position of the pivot axis 32a will be described with reference to FIGS. 2 to 4. The height from the top surface of the footrest 13 to the pivot axis 32a moves up and down within a range of 400 to 1000 mm through the vertical movement of the elevator 30. In the standing-assistance program, when the assisting robot 1 is in the intermediate state shown in FIG. 3, the pivot axis 32a is positioned at the lowest position, and when the assisting robot 1 is in the final state shown in FIG. 4, the pivot axis 32a is positioned at the highest position. However, since the vertical movement of the elevator 30 can be suitably adjusted, the lowest position and the highest position of the pivot axis 32a can be changed according to the elongation of the care receiver M.

[0048] The center in the left-right direction of the trunk receiving section 51 comes into contact with the center in the left-right direction of a front surface of the body of the care receiver M. The distance L (shown in FIGS. 2 and 4) between a line passing through the shoulder position P and parallel to the trunk holding surface, which is provided for the care receiver M by the trunk receiving section 51 of the holder 50, and the pivot axis 32a of the arm 40 is 230 to 290 mm. In particular, the distance L is preferably 250 to 270 mm.

[0049] The pivot axis 32a is located in front of the front-rear span F of the ground surface in contact with the feet of the care receiver M. The pivot axis 32a is located 250 to 450 mm in front of the ground contact position of the heel of the foot of the care receiver M. In particular, the distance between the pivot axis 32a and said ground contact position is preferably 300 to 400 mm.

[0050] During the first operation, the pivot axis 32a descends within the height range of the upper body of the care receiver M, that is, within the range from the lower surface (the seat surface 3) of the buttocks of the care receiver M to the top of the head. In particular, in the present embodiment, the pivot axis 32a descends within the height range of the body (chest and abdomen) of the care receiver M during the first operation.

[0051] Further, as shown in FIG. 2, the pivot axis 32a is located in front of the head of the care receiver M in the initial sitting posture. Further, as shown in FIG. 4, the pivot axis 32a is located behind the head of the care receiver M in the standing posture while the care receiver M is held in the holder 50.

(4. Shoulder position of the care receiver and a healthy subject)

[0052] Next, the trace of the shoulder position P of the care receiver M and the change of the angle θ of the trunk receiving section 51 during the standing-assistance operation will be described with reference to FIGS. 5A and 5B. In FIGS. 5A and 5B, T1, T2, and T3 represent times, and P1(T1), P2(T2) and P3(T3) represent the shoulder positions at T1, T2, and T3, respectively.

[0053] For comparison, the trace of the position Pa of a healthy subject and the trace of inclination angle θ_a of the trunk when a healthy subject performs the standing operation will be described with reference to FIGS. 6A and 6B. In FIGS. 6A and 6B, Ta1, Ta2, Ta3 and Ta4 represent times, and Pa1 (Ta1), Pa2 (Ta2), Pa3 (Ta3), Pa4 (Ta4) represent the shoulder positions at Ta1, Ta2, Ta3, and Ta4, respectively. Further, the trace of the shoulder position P of the care receiver M and the change of the angle θ of the trunk receiving section 51 as well as the trace of the shoulder position Pa of the healthy subject and the change of the angle θ_a of the trunk, are different, for example, depending on the extended length, sitting height, the length of the legs, and the like.

[0054] As shown in FIG. 5A, the shoulder position P of the care receiver M is positioned at P1 at the time T1 when the care receiver M is in the initial sitting posture, at P2 at the time of the intermediate posture T2, and at P3 at the time of the standing posture T3. The shoulder position P moves forward in a roughly horizontal manner from P1 to P2. Thereafter, the shoulder position P moves forward from P2 and rises to reach P3. The shoulder position P rises while moving forward from P1 to P3. P1 is the lowest position, and P3 is the highest position.

[0055] The angle θ of the trunk receiving section 51 (equivalent to the angle of the trunk of the care receiver

M), as shown in FIGS. 5A and 5B, is 35° at time T1 when the care receiver M is in the initial sitting posture, 64° at time T2 of the intermediate posture, and 95° at time T3 of the standing posture. As shown in Figure 5B, the angle θ trends upward.

[0056] On the other hand, as shown in FIG. 6A, the shoulder position Pa of the healthy subject is at position Pa1 at time Ta1 when the healthy subject is in the initial sitting posture and is positioned at the lowest position Pa2 at time Ta2 when the upper body is tilted forward and the buttocks are lifted away from the seating surface 3. After that, the shoulder position Pa of the healthy subject rises and is located at Pa4 at time Ta4 of the standing posture.

[0057] The trunk angle θ_a of the healthy subject at time Ta1 of the initial sitting posture is 5°, and by gradually tilting forward, at time Ta2, the angle θ_a reaches 44°, when the buttocks separates from the seat surface 3. Immediately after that at time Ta3, the trunk angle θ_a is maximized, and then the trunk rises as the angle θ_a becomes small. The trunk angle θ_a is 3° at time Ta4 of the standing posture.

[0058] The shoulder position P of the care receiver M approximately follows the trace of the shoulder position Pa of the healthy subject from the vicinity of Pa2 to somewhere in between Pa3 and Pa4. Therefore, since the care receiver M stands up after sliding the upper body forward like the healthy subject, the care receiver M can comfortably stand up with the center of gravity G on the soles of the feet. However, whereas the trunk angle θ_a becomes small after becoming large in the healthy individuals, the angle θ of the trunk receiving section 51 continues to become large. The reason for this difference is that the final standing posture is different.

(5. Effect)

[0059] The assisting robot 1 described above includes: the base 10, the elevator 30 for linear movement in the vertical direction with respect to the base 10, the arm 40 that is attached in a pivotable manner to the elevator 30 with the predetermined pivot axis 32a, a holder 50 provided at the end of the arm 40 for holding the upper body of the care receiver M, and the control device 80 that controls vertical movement of the elevator 30 and pivoting of the arm 40 to assist the care receiver M in standing up from the sitting posture to the standing posture.

[0060] The control device 80 lowers the elevator 30 and forward-rotates the arm 40 in a coordinated manner for at least a part of a period from when the care receiver M is in the initial sitting posture (T1 in FIG. 5A and FIG. 5B), shown in FIG. 2, to the intermediate posture (T2 of FIG. 5A and FIG. 5B), shown in FIG. 3. Furthermore, the control device 80 executes the second operation that raises the elevator 30 during a period from the intermediate posture shown in FIG. 3 (T2 of FIG. 5A and FIG. 5B) to the standing posture as shown in FIG. 4 (T3 in FIGS. 5A and 5B).

[0061] The first operation by the control device 80 is an operation in which the lowering of the elevator 30 and forward rotation of the arm 40 are performed in a coordinated manner. The upper body of the care receiver M is tilted by the forward rotation of the arm 40. Here, although the first operation raises the holder 50 with respect to the elevator 30 by forward rotation of the arm 40, the elevator 30 is lowered with respect to the base 10. As a result, in the first operation, at least a portion of the raising operation of the holder 50 with respect to the elevator 30 by the forward rotation of the arm 40 is offset by the lowering operation of the elevator 30.

[0062] In this way, when the center of gravity G of the care receiver M moves forward from its position during the initial sitting posture, in the case of the first operation described above, the amount of the upper body of the care receiver M raised is suppressed compared to the amount with just the forward rotation of the arm as before. Therefore, in the initial stage from the sitting posture to the standing posture, the amount of the upper body of the care receiver M lifted is reduced, thereby suppressing discomfort to the care receiver M.

[0063] The holder 50 includes the trunk receiving section 51 which comes into contact with the trunk of the care receiver M. The first operation is an operation that raises the rear end of the trunk receiving section 51 by coordinating the lowering of the elevator 30 and the forward rotation of the arm 40. Through such a first operation, the spine of the care receiver M extends in a state in which the pelvis is upright. In this way, the holder 50 supports the care receiver M having such a posture in a stable manner. Further, in the second operation, the assisting robot 1 stabilizes the care receiver M and moves the care receiver M to a standing posture. In other words, the care receiver M is provided with a sense of security.

[0064] Additionally, for at least a part of a period, by coordinating the lowering of the elevator 30 and the forward rotation of the arm 40, the first operation moves the shoulder position P of the care receiver M held by the holder 50 forward in an approximately horizontal manner. By doing so, from the time T1 of the initial sitting posture to the time T2 of the intermediate posture, the care receiver can get ready to stand up without feeling burdened.

[0065] The first operation and the second operation by the control device 80 include an operation for forward-rotating the arm 40 and do not include an operation for rearward-rotating the arm 40. That is, the angle of the trunk of the care receiver M changes only in one direction. As shown in FIGS. 6A and 6B, in the case of the healthy subject, the angle of the trunk changes direction midway. By performing the first operation and the second operation in the manner described above, the assisting robot 1 is effective in the case in which the objective is to assist in raising only the lower body of the care receiver M to the standing posture.

[0066] Additionally, for at least a part of a period from the time T2 of the intermediate posture to the time T3 of the standing posture, the second operation is an opera-

tion in which the raising of the elevator 30 and the forward rotation of the arm 40 are performed in a coordinated manner. That is, the care receiver M moves into a head forward posture in the second operation. Thus, in particular, the assisting robot 1 is effective in a case in which the objective is to assist in raising only the lower body of the care receiver M to a standing posture.

[0067] Further, the pivot axis 32a of the arm 40 descends within the range of the upper body height of the care receiver M during the first operation. Furthermore, the pivot axis 32a of the arm 40 is positioned in front of the head of the care receiver M in the initial sitting posture and behind the head of the care receiver M in the standing posture. By positioning the pivot axis 32a of the arm 40 in the manner described above, the assisting robot 1 assists in standing without giving discomfort to the care receiver M.

[0068] Additionally, distance L between a line passing through the shoulder position P of the care receiver M held by the holder 50, with being parallel to the trunk holding surface defined by the holder 50 for the care receiver M, and the pivot axis 32a of the arm 40 is 230 to 290 mm. By positioning the pivot axis 32a of the arm 40 in the manner described above, the assisting robot 1 assists in standing without giving discomfort to the care receiver M.

[0069] Also, the time T2 of the intermediate posture of the care receiver M may be any of the following. In the present embodiment, the time T2 of the intermediate posture corresponds to all of the following but correspondence to at least one of the following will suffice.

[0070] The first intermediate posture time T2 of the care receiver M is when the buttocks of the care receiver M starts rising from the seat surface 3. The second intermediate posture time T2 of the care receiver M is when the position in the front-rear direction of the center of gravity G of the care receiver M enters the front-rear span F of the ground surface in contact with the feet of the care receiver M. The third intermediate posture time T2 of the care receiver M is when the mass supported by the holder 50 reaches a value that is equal to or greater than a predetermined percentage of the upper body mass of the care receiver M. The fourth intermediate posture time T2 of the care receiver M is when the rear load on the assisting robot 1 from the care receiver M reaches a value that is equal to or less than the predetermined value. The fifth intermediate posture time T2 of the care receiver M is when the inclination of the upper body of the care receiver M reaches a value that is equal to or greater than a predetermined value.

Reference Signs List

[0071] 1: assisting robot, 3: seat surface, 10: base, 30: elevator, 31: elevator main body, 32: pivot support, 32a: pivot axis, 40: arm, 50: holder, 51: trunk receiving section, 52: underarm receiving part, 80: control device, F: front-rear span of ground surface in contact with the feet, M:

the care receiver, G: center of gravity of the care receiver, P: shoulder position, T1: time of initial sitting posture, T2: time of intermediate posture, T3: time of standing posture, θ : angle of the trunk receiving section

Claims

1. An assisting robot, comprising:

a base;
an elevator that moves linearly in a vertical direction with respect to the base;
an arm which is pivotable about a predetermined pivot axis on the elevator;
a holder provided at an end of the arm that supports an upper body of a care receiver, and
a control device that controls vertical movement of the elevator and pivoting of the arm for assisting the care receiver in standing up from a sitting posture to a standing posture,
wherein the control device executes a first operation that coordinates lowering of the elevator and forward rotation of the arm for at least a part of a period from when the care receiver is in an initial sitting posture to a predetermined intermediate posture, and executes a second operation that raises the elevator in a period from time of the predetermined intermediate posture to time of the standing posture.

2. The assisting robot according to claim 1, wherein the holder includes a trunk receiving section that comes into contact with the trunk of the care receiver, and the first operation is an operation in which the rear end of the trunk receiving section is raised by lowering the elevator and forward-rotating the arm in a coordinated manner.

3. The assisting robot according to claim 1 or 2, wherein, for at least the part of the period, by coordinating lowering of the elevator and forward rotation of the arm, the first operation moves a shoulder position of the care receiver held by the holder forward in an approximately horizontal manner.

4. The assisting robot according to any one of claims 1 to 3, wherein the first operation and the second operation by the control device include an operation for forward-rotating the arm and do not include an operation for rearward-rotating the arm.

5. The assisting robot according to claim 4, wherein the second operation is an operation that coordinates raising of the elevator with forward rotation of the arm for at least a part of a period from the predetermined intermediate posture to the standing posture.

6. The assisting robot according to any one of claims 1 to 5, wherein the pivot axis of the arm descends within a range of the upper body height of the care receiver during the first operation, and the pivot axis of the arm is positioned in front of a head of the care receiver in the initial sitting posture and behind the head of the care receiver in the standing posture. 5

7. The assisting robot according to any one of claims 1 to 6, wherein a distance L between a line and the pivot axis of the arm is 230 to 290 mm, the line passing through the shoulder position of the care receiver held by the holder, with being parallel to a trunk holding surface defined by the holder for the care receiver. 10
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8. The assisting robot according to any one of claims 1 to 7, wherein the time of the predetermined intermediate posture is when the buttocks of the care receiver starts rising from a seat surface. 20

9. The assisting robot according to any one of claims 1 to 7, wherein the time of the predetermined intermediate posture is when the position in the front-rear direction of the center of gravity of the care receiver enters the front-rear span of a ground surface in contact with the feet of the the care receiver. 25

10. The assisting robot according to any one of claims 1 to 7, wherein the time of the predetermined intermediate posture is when the mass supported by the holder reaches a value that is equal to or greater than a predetermined percentage of the upper body mass of the care receiver. 30
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11. The assisting robot according to any one of claims 1 to 7, wherein the predetermined time of the intermediate posture is when the rear load on the assisting robot from the care receiver reaches a value that is equal to or less than a predetermined value. 40

12. The assisting robot according to any one of claims 1 to 7, wherein the predetermined time of the intermediate posture is when the inclination of the upper body of the care receiver reaches a value that is equal to or greater than a predetermined value. 45

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Fig. 1

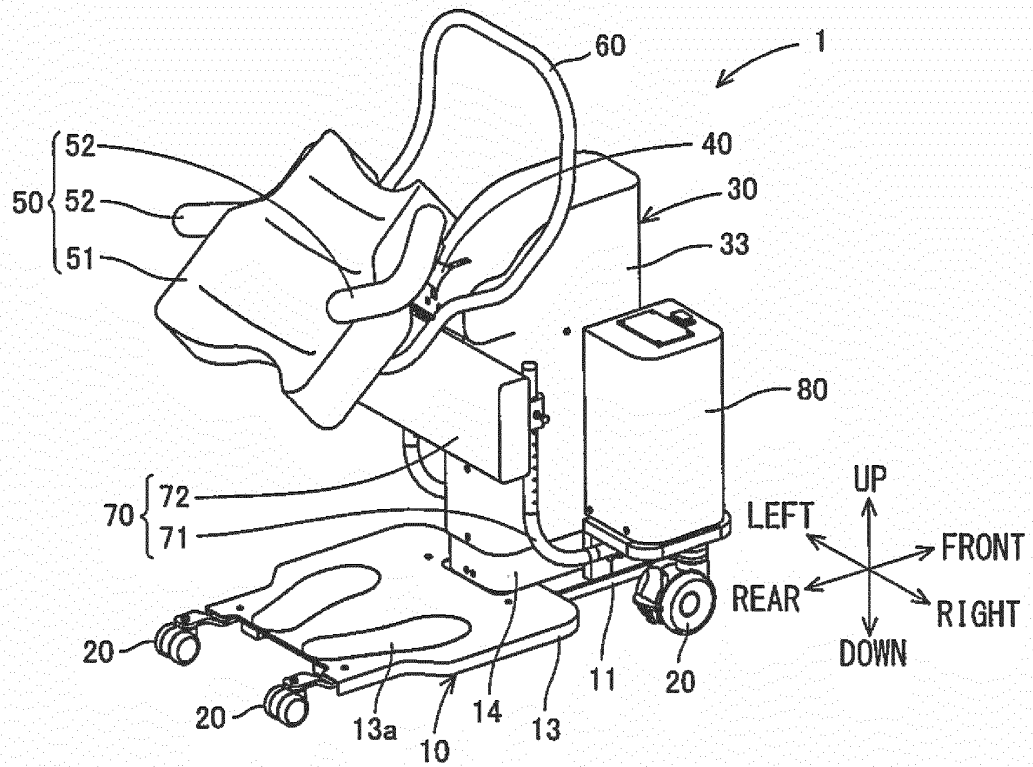


Fig. 2

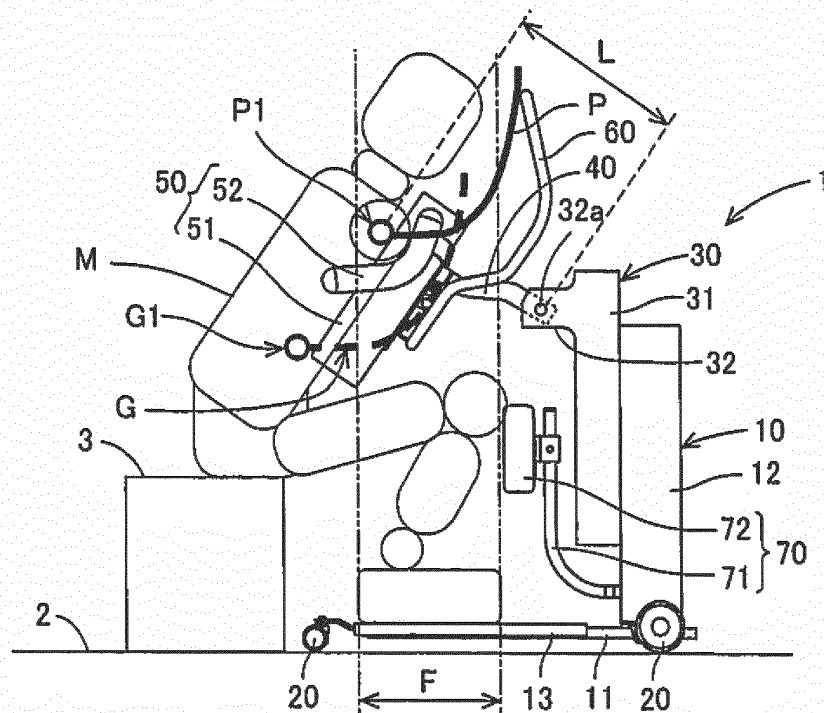


Fig. 3

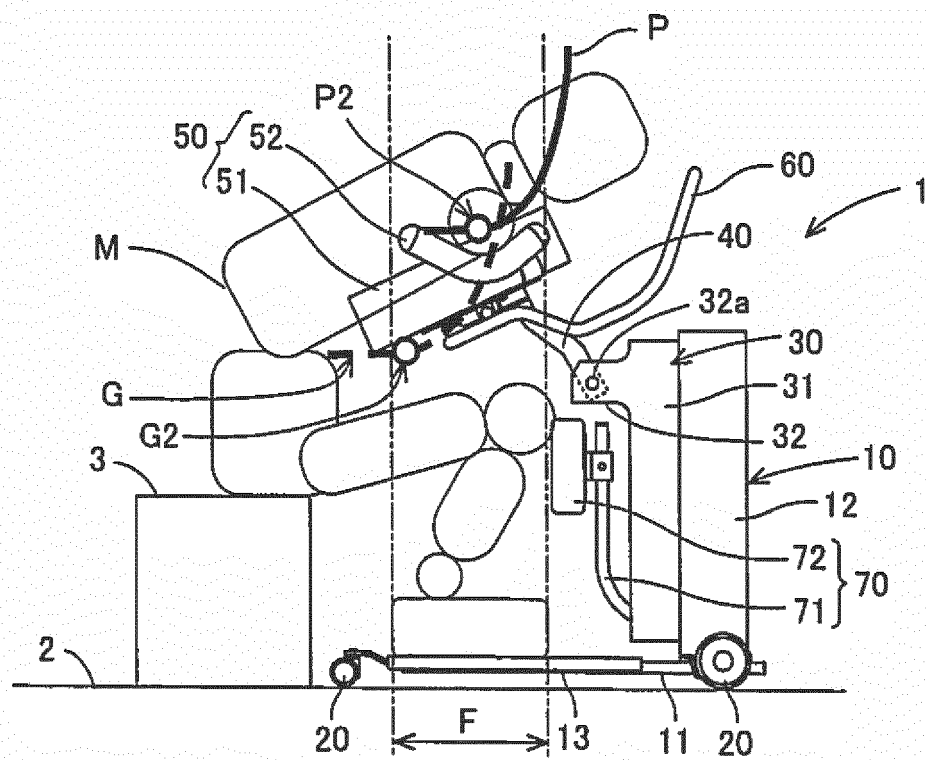


Fig. 4

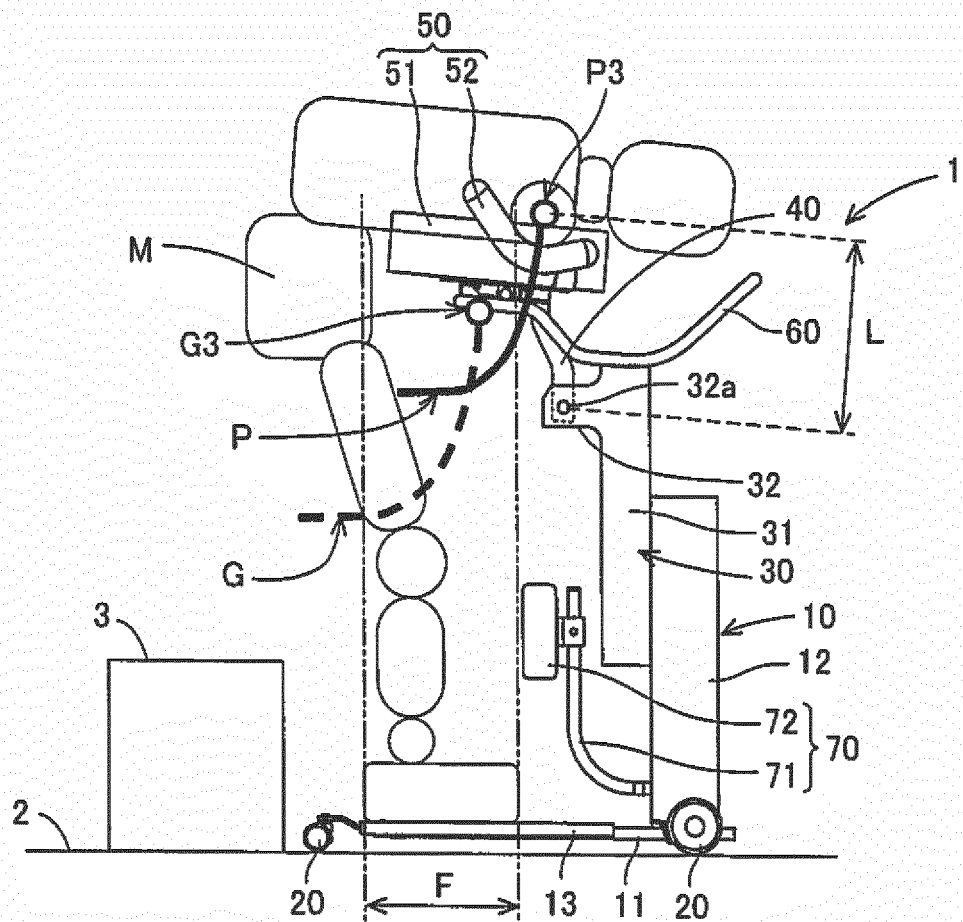


Fig. 5A

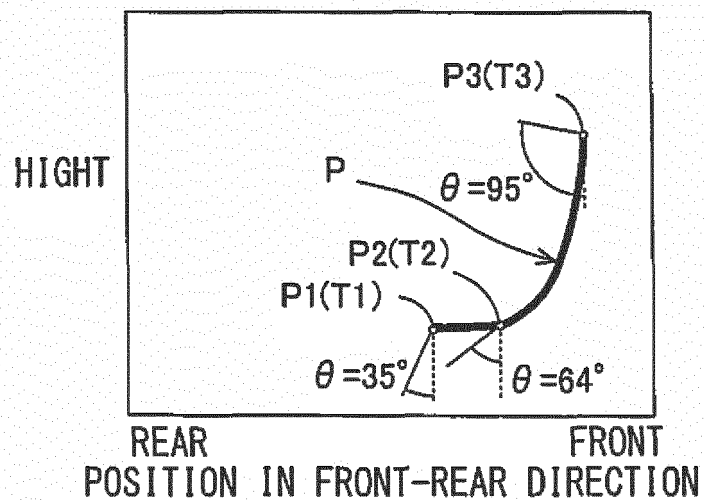


Fig. 5B

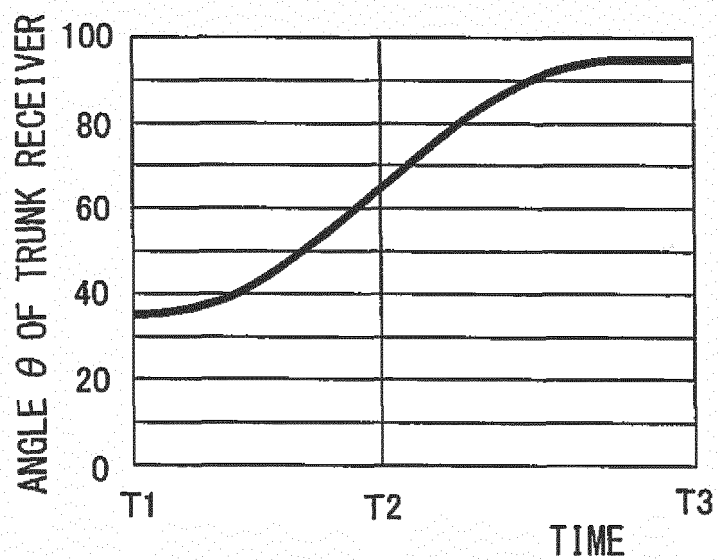


Fig. 6A

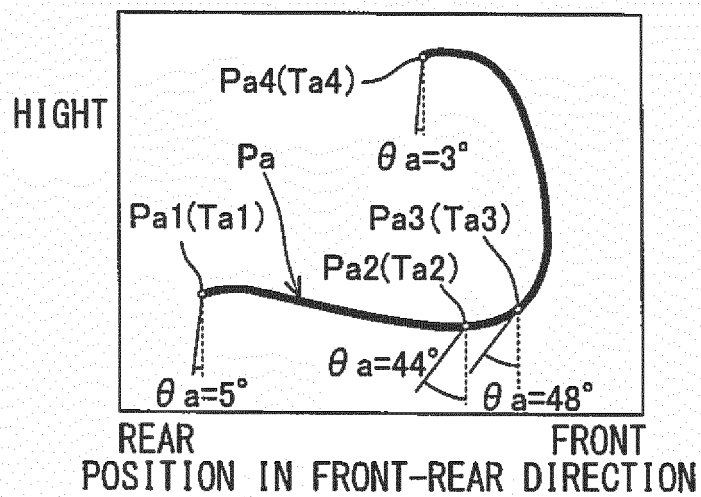
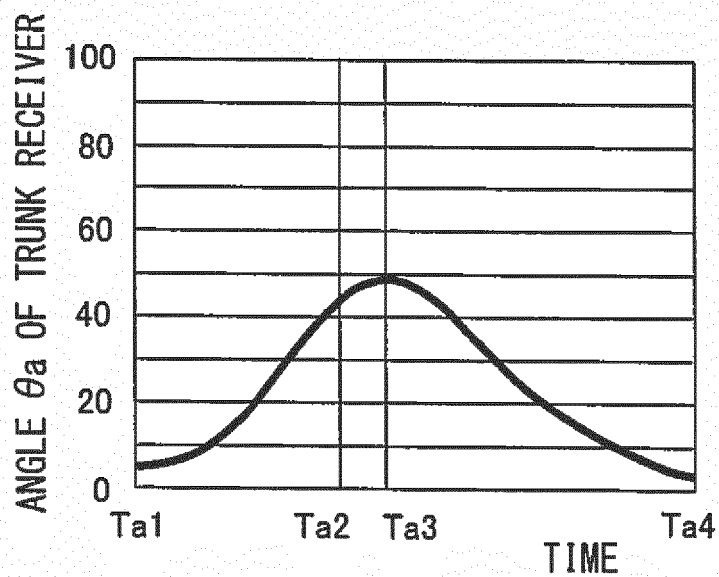


Fig. 6B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/078274

A. CLASSIFICATION OF SUBJECT MATTER

A61G5/00(2006.01)i, A61G7/10(2006.01)i, A61G7/12(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61G5/00, A61G7/10, A61G7/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-307121 A (Paramount Bed Co., Ltd.), 25 December 2008 (25.12.2008), paragraphs [0001] to [0080]; fig. 1 to 22 (Family: none)	1-12
A	JP 2012-217686 A (Fuji Machine Mfg. Co., Ltd.), 12 November 2012 (12.11.2012), entire text; all drawings & CN 102727356 A	1-12
A	JP 2014-61448 A (Fuji Machine Mfg. Co., Ltd.), 10 April 2014 (10.04.2014), paragraphs [0005] to [0007], [0021] to [0023], [0029] to [0036]; fig. 1 to 4, 7 to 15 (Family: none)	1-12

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
27 October 2015 (27.10.15)Date of mailing of the international search report
10 November 2015 (10.11.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/078274

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015-139566 A (Toyota Motor Corp.), 03 August 2015 (03.08.2015), paragraphs [0004] to [0014], [0019] to [0031], [0065] to [0075]; all drawings (Family: none)	1-12

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2012217686 A [0003]