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(54) MUSCULAR STRENGTH ASSISTING DEVICE

(57) A conventional muscular strength assisting instrument may give assisting force to prevent an action of a user who is trying to evade a dangerous situation when the user is in such a dangerous situation. A muscular strength assisting instrument comprises: an assisting unit that assists muscular strength of a user by using assisting force due to extension or contraction; a detection unit that detects a predetermined dangerous situation; and a control unit that adjusts the assisting force of the assisting unit when the dangerous situation is detected by the detection unit.

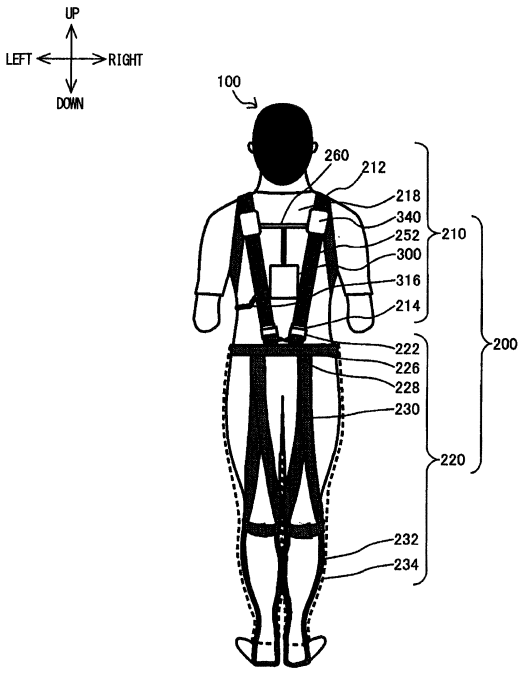

FIG. 1

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Description

BACKGROUND

1. TECHNICAL FIELD

[0001] The present invention relates to a muscular strength assisting instrument.

2. RELATED ART

[0002] A muscular strength assisting instrument has been known, and such a muscular strength assisting instrument assists muscle of a user by means of a resilient member or the like (for example, please see Patent Literature 1).

[Patent Literature 1] Japanese Patent Application Publication No. 2003-153928

[0003] Such a muscular strength assisting instrument may give assisting force to prevent an action of a user who is trying to evade a dangerous situation when the user is in such a dangerous situation.

SUMMARY

[0004] A first aspect of the present invention provides a muscular strength assisting instrument comprising: an assisting unit that assists muscular strength of a user by using assisting force due to extension or contraction; a detection unit that detects a predetermined dangerous situation; and a control unit that adjusts the assisting force of the assisting unit when the dangerous situation is detected by the detection unit.

[0005] The summary clause does not necessarily describe all necessary features of the embodiments of the present invention. The present invention may also be a subcombination of the features described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Fig. 1 is a rear schematic view of a muscular strength assisting instrument worn by a user.
Fig. 2 is a side schematic view of a muscular strength assisting instrument worn by a user.
Fig. 3 is a perspective view of a coupling instrument and an attachment instrument.
Fig. 4 is a functional block diagram of a control box.
Fig. 5 is a cross-sectional view of a release unit.
Fig. 6 is a cross-sectional view of the release unit.
Fig. 7 is a cross-sectional view of another unleashing unit.
Fig. 8 is a cross-sectional view of another unleashing unit.
Fig. 9 is a rear schematic view of another muscular strength assisting instrument worn by a user.
Fig. 10 is a cross-sectional view of a pump.
Fig. 11 is a schematic view of a resilient portion with a low filler content.
Fig. 12 is a schematic view of the resilient portion with a high filler content.
Fig. 13 is a side schematic view of another muscular strength assisting instrument worn by a user.
Fig. 14 is a side view of a shoe.
Fig. 15 is a view illustrating an operation of a shoe.
Fig. 16 is a rear schematic view of another muscular strength assisting instrument worn by a user.
Fig. 17 is a front schematic view of another muscular strength assisting instrument worn by a user.
Fig. 18 is a functional block diagram of the control box.
Fig. 19 is a view illustrating an operation of a muscular strength assisting instrument.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0007] Hereinafter, (some) embodiment(s) of the present invention will be described. The embodiment(s) do(es) not limit the invention according to the claims, and all the combinations of the features described in the embodiment(s) are not necessarily essential to means provided by aspects of the invention.

[0008] Fig. 1 is a schematic view of a muscular strength assisting instrument 200 worn by a user 100 as seen from the back. The upward, downward, leftward and rightward directions indicated with arrows in Fig. 1 are defined as the upward, downward, leftward and rightward directions of the muscular strength assisting instrument 200. Fig. 2 is a schematic view of the muscular strength assisting instrument 200 worn by the user as seen from a side. The upward, downward, forward and backward directions indicated with arrows in Fig. 2 are defined as the upward, downward, forward and backward directions of the muscular strength assisting instrument 200.

[0009] In Fig. 1 and Fig. 2, the muscular strength assisting instrument 200 comprises an upper attachment portion 210 and a lower attachment portion 220. The upper attachment portion 210 has upper assisting belts 212, lower assisting belts 252, coupling instruments 214, a jacket portion 218, a control box 300, a measuring unit 310, and release units 340. Pairs of the upper assisting belts 212, the lower assisting belts 252, the coupling instruments 214, and the release units 340 are provided on the left and right.

[0010] The lower attachment portion 220 has attachment instruments 222, coupling belts 226, a fixation belt 228, knee belts 230, heel belts 232, and a pants portion 234. Pairs of the attachment instruments 222, the coupling belts 226, the knee belts 230, and the heel belts 232 are provided on the left and right.

[0011] The right upper assisting belt 212 is provided outside the jacket portion 218 and slidably at a part on the right shoulder. One end side of the right upper assisting belt 212 is attached by being wrapped around a right shoulder part and an armpit part of the user 100,

and the right upper assisting belt 212 is joined with itself at the shoulder part by a hook and pile fastener. The other end side of the right upper assisting belt 212 is coupled to one end side of the right lower assisting belt 252 by the release unit 340.

[0012] The right lower assisting belt 252 extends to a waist part on the back side of the user 100. The other end side of the right lower assisting belt 252 is provided with the coupling instrument 214. The left upper assisting belt 212 and lower assisting belt 252 also have similar configuration on the left side of the user 100. The coupling instruments 214 are connected to a corresponding one of the attachment instruments 222 in the lower attachment portion 220 so that they can be attached to and detached from the corresponding attachment instrument 222.

[0013] These upper assisting belts 212 and lower assisting belts 252 are formed by covering, with an elastic synthetic resin, elastic belt-like cloth into which natural or synthetic rubber fibers are woven. The upper assisting belts 212 and the lower assisting belts 252 assist muscular strength of a waist part of the user 100 by using assisting force due to extension or contraction. The upper assisting belts 212 and the lower assisting belts 252 are one example of an assisting unit.

[0014] The jacket portion 218 covers the upper body of the user 100. Arm portions of the jacket portion 218 are not limited to a certain form, and may be short sleeves, long sleeves, sleeveless, etc.. A material of the jacket portion 218 is not particularly limited, and for example, textiles, webs, or the like are used.

[0015] The fixation belt 228 is attached by being wrapped on a lower side part of a waist part of the user 100. The two left and right coupling belts 226 are connected to upper parts of the fixation belt 228. Furthermore, the two left and right pairs of the knee belts 230 are connected to lower parts of the fixation belt 228.

[0016] Upper edges of the coupling belts 226 are each provided with the attachment instrument 222. The right attachment instrument 222 is connected with the right coupling instrument 214 of the upper attachment portion 210 so that it can be attached thereto and detached therefrom, and fixes the right lower assisting belt 252 to the fixation belt 228. The left attachment instrument 222 has similar configuration.

[0017] The measuring unit 310 is attached to the fixation belt 228, and is arranged so that it is at the center of a belly part of the user 100. The measuring unit 310 has a ultrasonic sensor 312, an angular adjustment section 314, and a cable 316.

[0018] The ultrasonic sensor 312 has a transmitter that transmits ultrasonic waves, and a receiver that receives sound waves reflected on the ground. The ultrasonic sensor 312 measures the length of time from transmission of ultrasonic waves by the transmitter to acquisition of reflected waves by the receiver. The ultrasonic sensor 312 outputs the measured length of time to the control box 300 through the cable 316.

[0019] The angular adjustment section 314 is configured with two members that can pivot relatively on an axis extending leftward and rightward. The ultrasonic sensor 312 is attached to one of the members, and the fixation belt 228 is attached to the other member. By causing the angular adjustment section 314 to pivot, the direction to which ultrasonic waves of the ultrasonic sensor 312 are transmitted can be changed according to the user 100. Thereby, for example, the muscular strength assisting instrument 200 can direct the oscillation of ultrasonic waves toward an area ahead the tiptoes of the user 100 according to the step or height of the user 100.

[0020] The control box 300 is electrically connected with the left and right release units 340 by the cable 260, and is retained by the left and right release units 340. Thereby, the control box 300 is arranged at the center on a back part of the user 100. The control box 300 judges whether or not the user 100 is in a dangerous situation. When the control box 300 judges that the user 100 is in a dangerous situation, the release unit 340 releases the resilience being generated by the upper assisting belts 212 and the lower assisting belts 252. To release the resilience is one example of adjustment of the assisting force by the control box 300.

[0021] The right knee belt 230 has two belts. These two belts intersect at a part that is below the front side of a knee after passing through left and right parts of a waist part, a buttock part, and a thigh part of the right leg of the user 100, and attached by being joined with each other at a part that is below the back side of the knee by a hook and pile fastener. Both the edges of the right heel belt 232 are connected to left and right parts of a knee part of the right knee belt 230. The heel belt 232 is attached from the left and right side surfaces of a lower thigh part at which the heel belt 232 is attached to the knee belt 230, to a heel part. The left knee belt 230 and heel belt 232 have similar configuration on the left leg side of the user 100.

[0022] The knee belts 230 and the heel belts 232 are non-elastic, and formed by covering, with a synthetic resin or the like, non-elastic, belt-like cloth into which natural or synthetic fibers are woven. A synthetic resin sheet or leather may be used as the knee belts 230 and the heel belts 232.

[0023] The pants portion 234 covers both the legs of the user 100 down to parts around the ankles. A material of the pants portion 234 is not particularly limited, and for example, textiles, webs, or the like are used. The fixation belt 228 is wrapped outside an upper part of the pants portion 234, and the knee belts 230 and the heel belts 232 are sewed inside the pants portion 234. Thereby, upward movement of the fixation belt 228 is restricted by the knee belts 230 and the heel belts 232.

[0024] Fig. 3 is a perspective view of the coupling instrument 214 and the attachment instrument 222. The coupling instrument 214 has: two engaging projections 215 that each have an inclined surface on one side; and two resilient claws 216. The attachment instrument 222

has a fitting portion 223 and engaging holes 224. When the coupling instrument 214 is inserted to the fitting portion 223, the engaging projections 215 are deformed inward due to the resilience of the resilient claws 216 and the inclined surfaces of the engaging projections 215. When the coupling instrument 214 is further inserted to the fitting portion 223 in the state, the engaging projections 215 engage with the engaging holes 224 due to fitting of the engaging projections 215 and the engaging holes 224, and the coupling instrument 214 and the attachment instrument 222 are connected.

[0025] In contrast, the connection between the coupling instrument 214 and the attachment instrument 222 can be released by bending the engaging projections 215 inward through the engaging holes 224 of the attachment instrument 222. If they are separated in this state, the connection between the coupling instrument 214 and the attachment instrument 222 can be released.

[0026] Fig. 4 illustrates a functional block diagram of the control box 300. The control box 300 has a detection unit 324 and a control unit 326.

[0027] The detection unit 324 detects whether or not the user 100 is in a predetermined dangerous situation based on distance. In the present embodiment, the detection unit 324 detects, as one example of a dangerous situation, whether or not there is a step with predetermined height or higher in an area onto which the user 100 steps.

[0028] In this case, the detection unit 324 acquires the length of time output by the measuring unit 310, and calculates the distance by multiplying the length of time by the speed of sound. When the calculated distance is equal to or longer than predetermined distance, or equal to or shorter than predetermined distance, the detection unit 324 judges that there is a step with predetermined height or higher. The detection unit 324 may detect that the muscular strength assisting instrument 200 is worn by the user 100, calculate the above-mentioned distance, stores the calculated distance as the reference distance, and compare distance calculated thereafter with the reference distance, and when their difference exceeds a predetermined value, may judge that there is a step with predetermined height or higher.

[0029] When having detected that there is the above-mentioned step, the detection unit 324 outputs a release signal to the control unit 326. In contrast, when having not detected that there is the above-mentioned step, the detection unit 324 does not output a release signal. When having acquired the release signal from the detection unit 324, the control unit 326 outputs a drive signal for driving the release unit 340 to the release unit 340.

[0030] Fig. 5 and Fig. 6 are cross-sectional views of the release unit 340. Fig. 5 illustrates a state where the upper assisting belt 212 and the lower assisting belt 252 are coupled by the release unit 340. In contrast, Fig. 6 illustrates a state where the upper assisting belt 212 and the lower assisting belt 252 are uncoupled by the release unit 340.

[0031] The release unit 340 has an engaging claw 342, an engaging plate 344, a support unit 346, a biasing member 348, a rod 350, a housing 352, and a drive unit 354. The housing 352 is a hollow rectangular parallelepiped having a rectangular opening on its one surface. The support unit 346 and the biasing member 348 are provided inside the housing 352. The drive unit 354 and the upper assisting belt 212 are fixed to the outer surface of the housing 352.

[0032] The lower assisting belt 252 is fixed to one end side of the engaging claw 342. Two saw blade-like claws are provided to the other end side of the engaging claw 342.

[0033] A central portion of the engaging plate 344 is supported pivotably by the support unit 346. One end of the engaging plate 344 is biased downward as seen in the figure by the biasing member 348. Also, the other end of the engaging plate 344 abuts on the rod 350.

[0034] The rod 350 penetrates the housing 352. One end side of the rod 350 is connected to the drive unit 354, and the other end side abuts on the engaging plate 344.

[0035] In the state as illustrated in Fig. 5, a drive signal has not been input to the drive unit 354, and the rod 350 is withdrawn toward to the drive unit 354. Because the biasing force of the biasing member 348 is in action in this state, the engaging plate 344 pivots counterclockwise as seen in the figure, and the above-mentioned one end of the engaging plate 344 is positioned at a lower part as seen in the figure.

[0036] Accordingly, the engaging plate 344 engages with the engaging claw 342, and restricts movement of the engaging claw 342. Thereby, the upper assisting belt 212 and the lower assisting belt 252 are coupled, and the transmission path of assisting force of the upper assisting belt 212 and the lower assisting belt 252 is established.

[0037] In Fig. 6, due to a drive signal from the control unit 326 being input to the drive unit 354, the drive unit 354 is pushing the rod 350 downward. Thereby, the rod 350 pushes down the above-mentioned other end of the engaging plate 344 against the biasing force of the biasing member 348.

[0038] Accordingly, the engaging plate 344 pivots clockwise as seen in the figure, the above-mentioned one end of the engaging plate 344 is lifted, and engagement between the engaging plate 344 and the engaging claw 342 is released. Thereby, the upper assisting belt 212 and the lower assisting belt 252 are physically uncoupled, and the transmission path of the assisting force is physically blocked. In this manner, the assisting force for the user 100 is unleashed.

[0039] The muscular strength assisting instrument 200 shown in the present embodiment unleashes the assisting force of the muscular strength assisting instrument 200 when a dangerous situation of the user 100 is detected by the detection unit 324. Thereby, the muscular strength assisting instrument 200 can prevent an action of the user 100 to evade a dangerous situation from being

obstructed.

[0040] In the above-mentioned embodiment, the detection unit 324 detects a step with predetermined height or higher as a dangerous situation. That is, the detection unit 324 judges that it is a dangerous situation in both a case that a step is an upward step relative to the current position of the user 100 and a case that a step is a downward step relative to the current position of the user 100. Instead of this, the detection unit 324 may judge that it is a dangerous situation in either of the cases, in particular when a step is a downward step relative to the current position of the user 100, and may not judge that it is a dangerous situation when a step is an upward step relative to the current position of the user 100. When the ground onto which the user 100 is about to step is low, and the user 100 does step onto the ground, it is more likely for the user 100 to lose the balance of his/her body. In this case, unnecessary assisting force is not given to the user 100, and falling can be prevented. In contrast, when the ground onto which the user 100 steps is high, the assisting force is given to the user 100, and a load on the muscle is reduced.

[0041] Also, the detection unit 324 may detect that it is a dangerous situation when a prerecorded safety condition is not met. A safety condition is prerecorded in the detection unit 324, and the detection unit 324 detects whether the prerecorded safety condition is not fulfilled. When the detection unit 324 judges that a detected result does not fulfill the safety condition, the detection unit 324 judges that the user 100 is in a dangerous situation.

[0042] Note that in the above-mentioned embodiment, the coupling instrument 214 and the attachment instrument 222, and the release unit 340 are provided separately. Instead of this, the release unit 340 may perform both coupling and uncoupling of the upper assisting belt 212 and the lower assisting belt 252 in wearing and removal of the muscular strength assisting instrument 200.

[0043] Fig. 7 and Fig. 8 are cross-sectional views of another unleashing unit 360. Fig. 7 illustrates a state where the assisting force of the upper assisting belt 212 and the lower assisting belt 252 is in action. In contrast, Fig. 8 illustrates a state where the assisting force of the upper assisting belt 212 and the lower assisting belt 252 is unleashed. The unleashing unit 360 has a rotary body 362, engaging projections 364, adjustment belts 366, 368, an engaging claw 370, a biasing member 372, a rod 374, a support unit 376, a housing 378, and a drive unit 380.

[0044] The rotary body 362 is retained by a rotation axis so that it is rotatable. The saw blade-like engaging projections 364 are provided to the outer circumference of the rotary body 362.

[0045] A central portion of the engaging claw 370 is supported by the support unit 376 so that it is pivotable. One end of the engaging claw 370 is provided with a projection to engage with the engaging projections 364 of the rotary body 362. The one end of the engaging claw 370 is biased by the biasing member 372 upward from below as seen in the figure. The other end of the engaging claw 370 abuts on the rod 374.

[0046] The adjustment belts 366, 368 are non-elastic. One end of the adjustment belt 366 is fixed to the rotation axis. The other end of the adjustment belt 366 is connected to the lower assisting belt 252.

[0047] One end of the adjustment belt 368 is fixed to a central portion of the rotary body 362, and the fixed portion rotates integrally with the rotary body 362. Furthermore, the adjustment belt 368 is wrapped around the fixed portion. The other end of the adjustment belt 368 is connected to the upper assisting belt 212.

[0048] In the state as illustrated in Fig. 7, a drive signal has not been input to the drive unit 380, and the rod 374 is withdrawn toward to the drive unit 380. Because the biasing force of the biasing member 372 is in action in this state, the engaging claw 370 pivots counterclockwise as seen in the figure, and the above-mentioned one end of the engaging claw 370 is positioned at an upper part as seen in the figure.

[0049] Accordingly, the projection of the engaging claw 370 engages with any one of the engaging projections 364 to restrict rotation of the rotary body 362. Thereby, extension of the upper assisting belt 212 is restricted, and the assisting force of the upper assisting belt 212 and the lower assisting belt 252 are acting on the user 100.

[0050] In Fig. 8, due to a drive signal from the control unit 326 being input to the drive unit 380, the drive unit 380 is pushing the rod 374 upward. Thereby, the rod 374 pushes up the above-mentioned other end of the engaging claw 370 against the biasing force of the biasing member 372.

[0051] Accordingly, the engaging claw 370 pivots clockwise as seen in the figure, the above-mentioned one end of the engaging claw 370 is pulled downward, and engagement between the engaging claw 370 and the engaging projections 364 is released. Thereby, it becomes possible for the rotary body 362 to rotate counterclockwise, and the adjustment belt 368 wrapped around the rotary body 362 is pulled out by the resilience of the upper assisting belt 212 and the lower assisting belt 252. Due to the adjustment belt 368 being pulled out, there is no longer tension strength of the upper assisting belt 212 and the lower assisting belt 252, and the assisting force for the user 100 is unleashed. Thereby, the muscular strength assisting instrument 200 can prevent an action of the user 100 to evade a dangerous situation from being obstructed.

[0052] Fig. 9 is a schematic view of another muscular strength assisting instrument 202 worn by the user 100 as seen from the back. The upward, downward, leftward and rightward directions indicated with arrows in Fig. 9 are defined as the upward, downward, leftward and rightward directions of the muscular strength assisting instrument 202. In the muscular strength assisting instrument 202 illustrated in Fig. 9, the configuration of members other than assisting belts 213, resilient portions 242, a

control box 302, and a pump 304 is the same as that of the muscular strength assisting instrument 200 illustrated in Fig. 1, and explanation of the same configuration is omitted.

[0053] The assisting belts 213 are non-elastic. One end of the assisting belt 213 on the back side is connected to a corresponding one of the resilient portions 242.

[0054] The resilient portions 242 are arranged on left and right parts of a back part of the user 100. One end of the resilient portion 242 is connected to a corresponding one of the upper assisting belts 212, and the other end is fixed to a corresponding one of the attachment instruments 222 via the coupling instrument 214.

[0055] The resilient portions 242 are coupled with the pump 304 via a coupling tube 262. The pump 304 is retained at the center of the back of the user 100 by the coupling tube 262.

[0056] When a dangerous situation of the user 100 has been detected, the control box 302 outputs a drive signal for driving the pump 304. In contrast, when a dangerous situation of the user 100 is not detected, the control box 302 does not output a drive signal for driving the pump 304.

[0057] The resilient portion 242 is formed with a resilient material, and its cross-sectional shape is rectangular and hollow. The inside of the resilient portion 242 is filled with fluid 217.

[0058] Fig. 10 illustrates a cross-sectional view of the pump 304. The pump 304 has a cylinder 390, a piston 392, and an actuator 394. The pump 304 controls the filler content of the fluid 217 in the resilient portion 242 by: moving the piston 392 upward by the actuator 394; feeding the fluid 217 in the cylinder to the resilient portion 242; moving the piston 392 downward; and causing the fluid 217 to return from the resilient portion 242 into the cylinder 390.

[0059] Fig. 11 illustrates a state where the filler content of the fluid 217 in the resilient portion 242 is low, and Fig. 12 illustrates a state where the filler content of the fluid 217 in the resilient portion 242 is high. In Fig. 11, because the filler content of the fluid 217 in the resilient portion 242 is low, the cross-sectional shape of the resilient portion 242 remains rectangular, and the flexural rigidity is low. In contrast, in Fig. 12, because the filler content of the fluid 217 in the resilient portion 242 is high, the cross-sectional shape of the resilient portion 242 is deformed to become elliptical, and the flexural rigidity is high. Thereby, the higher the amount of the fluid 217 filling the resilient portion 242, the higher the assisting force for the user 100. Note that any of gas and liquid, or a mixture of them can be used as the fluid 217.

[0060] Upon acquisition of a drive signal from the control unit 326, the pump 304 drives the actuator 394 to move the piston 392 downward. By moving the piston 392 downward, the fluid 217 is caused to return from the resilient portion 242 into the cylinder 390. By reducing the filler content of the fluid 217 in the resilient portion 242, the resilience of the resilient portion 242 can be reduced.

[0061] In this manner, when the detection unit 324 has detected a dangerous situation of the user 100, the muscular strength assisting instrument 202 can reduce the resilience of the resilient portion 242. Because of this, the muscular strength assisting instrument 202 can avoid giving the user 100 assisting force that obstructs an action of the user 100 to evade a dangerous situation.

[0062] Although an example in which the measuring unit 310 in the present embodiment uses the ultrasonic sensor 312 has been shown, laser reflection may be used. Furthermore, instead of them, an image of an area onto which the user 100 steps may be captured by using a camera, the image in front of the user 100 may be analyzed, and it may be detected whether or not there is a step in the area onto which the user 100 steps.

[0063] Fig. 13 is a schematic view of another muscular strength assisting instrument 204 worn by the user 100 as seen from a side. In the muscular strength assisting instrument 204 illustrated in Fig. 13, the configuration of members other than a shoe 330 is the same as that of the muscular strength assisting instrument 200 illustrated in Fig. 1, and explanation of the same configuration is omitted. The shoe 330 detects the center of gravity of the user 100, and based on this, the detection unit 324 detects a dangerous posture of the user 100 as one example of a dangerous situation.

[0064] Fig. 14 is a side view of the right shoe 330. The shoe 330 is worn on a foot of the user 100 in a manner similar to that for a normal shoe. The shoe 330 has a first load sensor 332, a second load sensor 334, and a cable 336.

[0065] The first load sensor 332 is provided to the shoe 330 on the tiptoe side on the back side of the foot, and detects a load on the tiptoe side of the user 100. The second load sensor 334 is provided to the shoe 330 on the heel side of the backside of the foot, and detects a load on the heel side of the user 100. Load detection values of both the load sensors are output to the control box 306 through the cable 336. A left shoe has the same configuration.

[0066] Fig. 15 illustrates a state where the body weight of the user 100 is applied onto the heel side. When the body weight is applied onto the heel side of both the feet as illustrated in Fig. 15, it is inferred that the user 100 is bending backward. If the user 100 bends forward in this posture, the muscular strength assisting instrument 204 gives the user 100 force to return from the forward-bent posture, so the user 100 may fall backward. Accordingly, in the backward-bent posture of the user 100, the muscular strength assisting instrument 204 desirably does not give the user 100 the assisting force of the upper assisting belt 212 and the lower assisting belt 252.

[0067] The detection unit 324 acquires load detection values of the first load sensor 332 and the second load sensor 334 from both the left and right shoes 330. When, for both the left and right shoes 330, a ratio of a load indicated by the second load sensor 334 relative to a load

indicated by the first load sensor 332 becomes larger than a predetermined ratio, the detection unit 324 judges that the center of gravity of the body weight of the user 100 has moved backward.

[0068] When having judged that the center of gravity of the body weight of the user 100 has moved backward, the detection unit 324 outputs a release signal to the control unit 326. When having not judged that the center of gravity pf the body weight of the user 100 has moved backward, the detection unit 324 does not output a release signal to the control unit 326. Upon acquisition of a release signal from the detection unit 324, the control unit 326 outputs a drive signal for driving the release unit 340. Then, the release unit 340 that has acquired the drive signal releases engagement of the engaging claw 342 to unleash the assisting force of the upper assisting belt 212 and the lower assisting belt 252.

[0069] The muscular strength assisting instrument 204 may comprise a triaxial acceleration sensor in the control box 302, in addition to two load sensors of the shoe 330. When comprising the triaxial acceleration sensor, the muscular strength assisting instrument 204 can detect, in detail, a dangerous situation that is related to a posture of the user 100 because a posture of a waist part of the user 100 relative to the gravitational direction can also be detected. Instead of or in addition to the acceleration sensor, the muscular strength assisting instrument 206 may use a muscle potential sensor to detect a dangerous situation of the user 100. Because when the user 100 falls down, a part of the body of the user 100 stiffens instantly, the muscle potential sensor may judge that the user 100 is in a dangerous situation when the stiffening force has exceeded a predetermined threshold.

[0070] Fig. 16 is a schematic view of another muscular strength assisting instrument 206 worn by the user 100 as seen from the back. The upward, downward, leftward and rightward directions indicated with arrows in Fig. 16 are defined as the upward, downward, leftward and rightward directions of the muscular strength assisting instrument 206. Fig. 17 is a schematic view of the other muscular strength assisting instrument 206 worn by the user 100 as seen from the front. The upward, downward, leftward and rightward directions indicated with arrows in Fig. 17 are defined as the upward, downward, leftward and rightward directions of the muscular strength assisting instrument 206.

[0071] The muscular strength assisting instrument 206 is worn on the upper body and the lower body of the user 100, and assists the muscular strength of a waist part of the user 100. The muscular strength assisting instrument 206 has: a jacket portion 400 and a pants portion 402; a wiring portion 404; a waist part actuator 410, a leg part actuator 420; a control box 500; an action detection unit 508; and a power source switch 510.

[0072] The jacket portion 400 is formed to cover the upper body of the user 100. Arm portions of the jacket portion 400 are not limited to a certain form, and may be short sleeves, long sleeves, sleeveless, etc.. The jacket portion 400 is formed with elastic chemical fibers, etc. The jacket portion 400 constricts the upper body of the user 100 with a certain degree of constraining force to contact closely thereto. Thereby, it becomes hard for the jacket portion 400, when it is worn, to slip on the upper body of the user 100.

[0073] The pants portion 402 is formed to cover the lower body of the user 100. The pants portion 402 may be short pants that cover halves of leg parts, or may be long pants that cover the leg parts entirely. The pants portion 402 is formed with elastic chemical fibers, etc.. The pants portion 402 constricts the lower body of the user 100 with a certain degree of constraining force to contact closely thereto. Thereby, it becomes hard for the pants portion 402, when it is worn, to slip on the lower body of the user 100.

[0074] The waist part actuator 410 has a first actuator 412 and a second actuator 414. The first actuator 412 is formed like a belt, and is provided on the right side of the user 100 and from a back part to a waist part. The first actuator 412, over its entire length, contacts the jacket portion 400 closely by being pasted to the jacket portion 400.

[0075] The first actuator 412 includes a polymer material that extends and contracts when voltage is applied. When voltage is applied, the first actuator 412 extends or contracts in the longitudinal direction. The first actuator 412 extends or contracts to provide the assisting force to the user 100.

[0076] One example of a polymer material is a polyrotaxane crosslinked body. The first actuator 412 is produced by winding a sheet member that is formed by sandwiching both surfaces of a planar polyrotaxane crosslinked body with elastic electrodes. Here, the longitudinal direction of the first actuator 412 is parallel with the axial direction of the wound sheet member. Because the first actuator 412 is pliable, it is possible to reduce the sense of discomfort that is felt by the user when she/he walks with the first actuator 412 on.

[0077] Another example of a polymer material is a non-ionic gel. In this case, the first actuator 412 has a pair of outer electrodes, a mesh-like mesh electrode that is arranged between the pair of outer electrodes, and a non-ionic gel that is provided between the mesh electrode and each of the outer electrodes. One example of a non-ionic gel is polyvinyl alcohol gel containing dimethylsulfoxide as a solvent. In this first actuator 412, when voltage that is higher than voltage applied to the outer electrodes is applied to the mesh electrode, negative electric charges are introduced from the outer electrodes to the non-ionic gel, and the outer electrodes are attracted toward the mesh electrode. As a result, the distance between the pair of outer electrodes contracts. Conversely, when voltage application is terminated, the distance of the pair of outer electrodes returns to the original state, and extends due to the elastic force of the non-ionic gel. By laminating a plurality of the combination of the outer electrodes, the mesh electrode, and the non-ionic gel, the

extension-contraction amount can be increased.

[0078] Another example of a polymer material is a polypyrrole film. A polypyrrole film immersed in an electrolyte expands or contracts when voltage is applied. For example, when positive voltage is applied, a polypyrrole film expands. When negative voltage is applied, a polypyrrole film contracts. Because the first actuator 412, when containing a polypyrrole film, requires an electrolyte, the first actuator 412 needs to be sealed.

[0079] The second actuator 414 is provided on the left side of the user and from a back part to a waist part. Because the other configuration of the second actuator 414 is similar to that of the first actuator, explanation of the similar configuration is omitted.

[0080] The leg part actuator 420 has a third actuator 422, a fourth actuator 424, a fifth actuator 426, and a sixth actuator 428. The third actuator 422 is provided from the upper right to the lower left of the front surface of the pants portion 402 that covers a thigh part of the right leg. The third actuator 422 is formed like a belt. The third actuator 422, over its entire length, contacts the pants portion 402 closely by being pasted to the pants portion 402.

[0081] The third actuator 422 includes a polymer material that extends and contracts when voltage is applied, and when voltage is applied, extends or contracts in the longitudinal direction. The third actuator 422 extends and contracts to assist raising and lowering of the right leg of the user 100 at a time of walking. Because the other configuration of the third actuator is similar to that of the first actuator 412, explanation of the similar configuration is omitted.

[0082] The fourth actuator 424 is provided from the upper left to the lower right of the front surface of the pants portion 402 that covers the thigh part of the right leg. Accordingly, the third actuator 422 and the fourth actuator 424 intersect on the front surface of a thigh part of the right leg. The fifth actuator 426 is provided from the upper left to the lower right of the front surface of the pants portion 402 that covers a thigh part of the left leg. The sixth actuator 428 is provided from the upper right to the lower left of the front surface of the pants portion 402 that covers the thigh part of the left leg. The fifth actuator 426 and the sixth actuator 428 intersect on the front surface of a thigh part of the right leg. The other configuration of the fourth actuator 424, the fifth actuator 426, and the sixth actuator 428 is similar to that of the third actuator 422, and explanation of the similar configuration is omitted.

[0083] The wiring portion 404 applies voltage separately to a power source of the control box 500, the waist part actuator 410, and respective actuators of the leg part actuator 420 (hereinafter, referred to as the respective actuators). The control box 500 is provided on an upper portion on the front side of the pants portion 402. The control box 500 has a control apparatus 502, a power source unit 504, and an electric leakage sensor 506.

[0084] The control apparatus 502 is in charge of the overall control of the muscular strength assisting instrument 206. The power source unit 504 applies voltage separately to the respective actuators through the wiring portion 404. The electric leakage sensor 506 detects electric leakage of the wiring portion 404 and the respective actuators.

[0085] The action detection unit 508 is provided on a back part of the user 100, and detects an action of the upper body of the user 100. One example of the action detection unit 508 is a triaxial acceleration sensor. When the user 100 bends forward, the action detection unit 508 detects inclination of the upper body, and outputs inclination information about the upper body to the control apparatus 502.

[0086] The power source switch 510 is provided at a central portion of a belly part of the user 100. By using the power source switch 510, the user 100 switches turning on and off of a main power source of the muscular strength assisting instrument 206.

[0087] Fig. 18 is a functional block for explaining control of the control box 500. As illustrated in Fig. 18, the control apparatus 502 has a control unit 518 and a storage unit 514.

[0088] The control unit 518 acquires the inclination information from the action detection unit 508. Furthermore, the control unit 518 acquires a power source signal from the power source switch 510. By referring to the storage unit 514 based on the acquired inclination information, the control unit 518 controls the power source unit 504 based on the relationship between the inclination information stored in the storage unit 514 and power source control, and assists the muscular strength by applying voltage separately to the respective actuators.

[0089] Fig. 19 is a view illustrating an operation of the muscular strength assisting instrument 206. As illustrated in Fig. 19, when voltage is applied to the second actuator 414, the second actuator 414 contracts. Due to the contraction of the second actuator 414, the assisting force for raising the upper body is given to the user 100.

[0090] Upon acquisition of a first power source signal from the power source switch 510, the control unit 518 turns on the main power source of the muscular strength assisting instrument 206. Upon acquisition of a next power source signal, the control unit 518 turns off the main power source of the muscular strength assisting instrument 206.

[0091] The electric leakage sensor 506 detects, as one example of a dangerous situation, electric leakage at the wiring portion 404 and the respective actuators. In this case, when electric current that is higher than the electric current that is supposed to flow under control of the control unit 518 flows, the electric leakage sensor 506 judges that there has been electric leakage, and outputs, to the control unit 518, a notification indicating detection of electric leakage.

[0092] When the notification indicating that there has been electric leakage has been input from the electric leakage sensor 506, the control unit 518 forcibly turns off

the main power source, and terminates supply of energy for extending or contracting the respective actuators. Thereby, when it is a dangerous situation due to electric leakage, the muscular strength assisting instrument 206 turns off the main power source, and the dangerous situation of the user 100 is avoided.

[0093] Instead of or in addition to this, also in the muscular strength assisting instrument 206 provided with the respective actuators, a dangerous situation of the user 100 may be detected by using the measuring unit 310 shown in Fig. 1 or the shoe 330 shown in Fig. 14, and the control unit 518 may turn off the main power source. Also, when a dangerous situation of the user 100 is detected, the muscular strength assisting instrument 206 may give the user 100 the assisting force from the respective actuators for avoiding the dangerous situation. To give the assisting force for avoiding a dangerous situation is one example of adjustment of the assisting force by the control unit 518.

[0094] When a large dented step is detected in a forward area, the muscular strength assisting instrument 206 may apply voltage to the leg part actuator 420 and give the assisting force to obstruct raising of legs for a purpose of not allowing the user 100 to move forward. The muscular strength assisting instrument 206 can prevent the user 100 from falling into the large dent by not allowing the user 100 to move forward.

[0095] In another example, when it is detected that the user 100 stumbles on a downward slope, the muscular strength assisting instrument 206 may apply voltage to the leg part actuator 420 and the waist part actuator 410, give the user 100 the assisting force to cause legs to stretch out further forward and the assisting force for raising the upper body, and give the assisting force to prevent falling. Furthermore, by providing, to the muscular strength assisting instrument 206, an actuator to assist muscular strength of an arm portion, the muscular strength assisting instrument 206 may give the arm portion of the user 100 force to assist an action to keep balance for preventing falling. In this manner, the muscular strength assisting instrument 206 can avoid a dangerous situation of the user 100 by adjusting the assisting force for the user 100.

[0096] Also, instead of or in addition to turning off the main power source, by providing the release unit 340 shown in Fig. 5 to one end of each of the respective actuators, the respective actuators may be uncoupled from the jacket portion 400 by driving the release unit 340 when a dangerous situation of the user 100 is detected. Although in the examples illustrated in Fig. 16 and Fig. 17, a dangerous situation of the user 100 is detected by the action detection unit 508, instead of or in addition to this, the muscular strength assisting instrument 206 may detect a dangerous situation of the user 100 by using a muscle potential sensor. Because when the user 100 falls down, a part of the body of the user 100 stiffens instantly, the muscle potential sensor may judge that the user 100 is in a dangerous situation when the stiffening force exceeds a predetermined threshold.

[0097] In a dangerous situation, instead of or in addition to turning off the main power source, the control unit 504 may cause the respective actuators to return to their natural length actively. In this case, a discharge circuit may be provided to an actuator to be driven electrically, such as the first actuator 412. In a dangerous situation, in addition to termination of power supply from the power source unit 504 to the actuators, the control unit 504 may cause the actuators to return to their natural length actively by discharging electrical charges accumulated in the actuators by means of the discharge circuit. Thereby, when the actuators are caused to return to their natural length rapidly and the user avoids a danger, it becomes possible to surely prevent the actuators from obstructing an action of the user.

[0098] A dielectric elastomer actuator formed by gluing elastic sheet-like electrodes onto both the surfaces of an elastomer film such as silicone and acryl may be used as the first actuator 412 and the like. The actuator extends in the planar direction by sandwiching and squashing the elastomer film with the Coulomb's force generated by voltage application to the electrodes. In a dangerous situation, in addition to controlling voltage to the actuator, the control unit 504 may physically block the transmission path for the assisting force of the actuator by using the release unit 340 shown in Fig. 5 to Fig. 8.

[0099] The first actuator 412 and the like are preferably deformable due to external force at least when power is not being supplied. In this case, the rigidity or resilience at a time of non-supply of power is preferably lower than those at a time of supply. Thereby, because the first actuator 412 is easily deformed due to force received from the user when power supply is terminated in a dangerous situation, obstruction of an action of the user is prevented. When an actuator is a rotary motor, an oil hydraulic cylinder, or the like, a mechanism to free an action of the actuator, such as a clutch mechanism or an oil removing mechanism, in a dangerous situation is provided, but such a mechanism needs not be provided in a case of the above-mentioned actuator. Furthermore, due to the pliability of an actuator itself, the actuator can serve as a buffer material in a case of falling or the like.

[0100] Furthermore, as another example of a dangerous situation, the assisting force of the muscular strength assisting instrument 200 and the like may be unleashed or reduced upon detection of pouring of water over the user 100. Note that pouring of water over the muscular strength assisting instrument 206 can be detected by detecting an electric current value, detecting an electric leakage amount, or detecting humidity around the respective actuators by a hygrometer. Thereby, when the user 100 falls into water or in other cases, an electric shock of the user 100 due to electric leakage of electric equipment such as an actuator can be prevented. Also, an electric leakage breaker may be provided to the control box 500, and power supply to the respective actuators may be blocked when electric leakage has occurred.

[0101] Among the detection unit 324 and the control units 326, 518, a part that performs control for reducing the assisting force based on a dangerous situation may be performed by a CPU reading out a software program or may be formed as hardware by an ASIC or the like. Note that, in addition to adjustment of the assisting force, the control units 326, 518 may give a warning by sound, vibration or the like to notify that it is a dangerous situation.

[0102] Also, when the action detection unit 508 of the muscular strength assisting instrument 206 comprises an acceleration sensor, the acceleration sensor outputs, to the control unit 504 via wiring, an acceleration signal about three directions from a waist part of the user.

[0103] When it has been detected that output from the acceleration sensor corresponds to a state where the user is falling down, a state signal indicating that the user is falling down is output to the control unit 504. Upon acquisition of the state signal, the control apparatus 502 controls the power source unit 504 to discontinue aid to walking by actuators such as the first actuator 412 and the second actuator 414. That is, a free state where there is no aid of the muscular strength assisting instrument 206 to the user is provided. Note that instead of discontinuation of aid to walking, the control apparatus 504 may lower output of the respective actuators by lowering applied voltage, thereby restricting the aid to walking.

[0104] The action detection unit 508 acquires, from the acceleration sensor, an acceleration signal about three directions from a waist part of the user. The action detection unit 508 calculates acceleration based on the acquired acceleration signal, and creates a profile of acceleration changes in predetermined length of time. Note that one example of the predetermined length of time is two seconds.

[0105] It has been known that when a human falls down, a characteristic acceleration change is observed at his/her waist part. Accordingly, as a reference profile, a profile of acceleration changes measured when the user intentionally falls down is stored in advance in the storage unit 514. The action detection unit 508 detects that the user who is using the muscular strength assisting instrument 206 is falling down by comparing the reference profile stored in the storage unit 514 and a profile calculated based on output from the acceleration sensor.

[0106] When the created profile and the reference profile match about a predetermined condition, the detection unit such as the detection unit 324 that detects a dangerous situation judges that the user is falling down, and outputs, to the control apparatus 502, a state signal indicating that the user is falling down. Upon acquisition of the state signal, the control apparatus 502 terminates voltage control processing. The control apparatus 502 stops aid to walking by the respective actuators by terminating the voltage control processing.

[0107] In contrast, when a predetermined condition is not met, the detection unit judges that the user is falling down, and outputs, to the control apparatus 502, a state signal indicating that the user is not falling down. Upon acquisition of the state signal, the control apparatus 502 performs voltage control processing.

[0108] In this manner, the muscular strength assisting instrument 206 stops walking aid when the detection unit has detected that the user is falling down. Thereby, when the user is falling down, it is possible to prompt the user to take an action to protect himself/herself by discontinuing the aid and allowing the user to be in a natural bodily state.

[0109] Also, instead of an acceleration sensor, a pressure sensor may be provided as the detection unit to the waist or a buttocks part of the user, and detect that the user has sat down as a predetermined state. In this case, the detection unit acquires, from the pressure sensor, a signal about pressure applied to a waist part or a buttocks part of the user. The detection unit calculates pressure based on the acquired pressure signal, and when the calculated pressure exceeds a predetermined pressure threshold, judges that the user has sat down. Thereby, the detection unit detects that the user wearing the muscular strength assisting instrument 206 has sat down, and is not in a dangerous state.

[0110] When having detected that the user has sat down, the detection unit outputs, to the control apparatus 502, a state signal indicating that the user has sat down. Upon acquisition of the state signal, the control apparatus 502 performs muscular strength aid to the user without performing control that is to be performed when a dangerous situation has occurred.

[0111] Furthermore, instead of or in addition to a pressure sensor, an angular sensor that can detect the angles of knees may be provided to knee parts of the user. In this case, the detection unit acquires, from the angular sensor, a knee bending angle signal about the user. The detection unit calculates the knee bending angle based on the acquired knee bending angle signal, and when the calculated angle exceeds a predetermined angular threshold, or when length of time during which the knee bending angle is exceeding a predetermined angular threshold has exceeded predetermined length of time, judges that the user has sat down. Thereby, the detection unit may detect that the user who is using the muscular strength assisting instrument 206 has sat down.

[0112] Also, when a ultrasonic sensor whose transmission direction is oriented to the ground onto which the user steps is provided instead of an acceleration sensor, as a predetermined state, presence of a step with predetermined height or higher in front of the user may be detected. In this case, the detection unit acquires length of time until reception of ultrasonic waves transmitted from the ultrasonic sensor to the ground after being reflected on the ground. The action detection unit 508 calculates the height of a step on the ground by measuring the distance by multiplying the acquired length of time by the speed of sound. When the calculated height is equal to or higher than a threshold, the detection unit judges that there is a step with predetermined height or

higher in front of the user. Thereby, the detection unit detects presence of a step with predetermined height or higher in front of the user who is using the muscular strength assisting instrument 206.

[0113] When having detected presence of a step with predetermined height or higher in front of the user, the detection unit outputs, to the control apparatus 502, a state signal indicating presence of a step with predetermined height or higher in front of the user. Upon acquisition of the state signal, the control apparatus 502 terminates voltage control processing and stops walking aid. In this manner, by aiding walking in the presence of a step with predetermined height or higher in front of the user, it becomes possible to guide the user to the step and prevent the user from falling down due to the step.

[0114] Furthermore, in the presence of a step with predetermined height or higher in front of the user, the detection unit may judge that there is a step with predetermined height or higher in front of the user based on whether or not the ground onto which the user step is low. When the ground onto which the user steps has a downward step, it becomes more likely for the user to fall down due to the step. Accordingly, by aiding walking in a state where the ground onto which the user steps is low, it becomes possible to guide the user to the step and prevent the user from falling down due to the step.

[0115] Furthermore, instead of or in addition to a ultrasonic sensor, an image capturing apparatus may be used. In this case, the detection unit acquires an image of an area in front of the user that is captured by the image capturing apparatus. The detection unit may analyze the acquired image, and judge whether or not there is a step with predetermined height or higher in front of the user. Thereby, the detection unit detects presence of a step with predetermined height or higher in front of the user who is using the muscular strength assisting instrument 206.

[0116] Also, the muscular strength assisting instrument 206 may comprise an atmospheric pressure sensor 72 instead of an acceleration sensor. In the muscular strength assisting instrument 206, the detection unit detects that the user is going up stairs as a predetermined state. When the user holds a handrail while going up stairs, indication of intention from any of or both the right input unit 26 and the left input unit 28 cannot be input.

[0117] In contrast, because a load on the leg parts is large when going up stairs, many users want to have walking aid. For this reason, when having detected that the user is going up stairs, the detection unit outputs, to the control apparatus 502, a state signal indicating that the user is going up stairs. Upon acquisition of the state signal, the control apparatus 502 controls the power source unit 504 and aids walking by means of the respective actuators even when indication of intention has not been input from any of the right input unit 26 and the left input unit 28. Thereby, walking of the user who is holding a handrail and going up stairs can be assisted.

[0118] The detection unit acquires an atmospheric pressure signal from the atmospheric pressure sensor 72. The detection unit calculates altitude of the user based on the acquired atmospheric pressure signal. The detection unit creates a profile of altitude changes of the user based on the calculated altitude. The detection unit judges that the user is going up stairs when the profile of altitude changes indicate gradual rises. Thereby, the detection unit detects that the user who is using the muscular strength assisting instrument 206 is going up stairs.

[0119] When the control apparatus 502 judges that the user has input a power source signal by means of the power source switch 29, the action detection unit 508 acquires an atmospheric pressure signal from the atmospheric pressure sensor. The detection unit calculates altitude of the user based on the atmospheric pressure signal, and creates a profile of altitude changes. The detection unit judges whether or not the user is going up stairs based on the profile of altitude changes.

[0120] When the profile of altitude changes indicates that the user is going up stairs, for example when the altitude of the user is gently rising, the detection unit judges that the user is going up stairs, and is not in a dangerous state, and outputs, to the control apparatus 502, a state signal indicating that the user is going up stairs. Upon acquisition of the state signal, the control apparatus 502 performs voltage control processing.

[0121] Furthermore, in addition to the atmospheric pressure sensor, an angular sensor to measure the angle of the hip joint of the user may be provided. In this case, the detection unit acquires a bending angle signal of the hip joint of the user from the angular sensor. The detection unit for example calculates an angular change of the hip joint based on the angle signal, and acquires timing of bending and straightening of the legs of the user. When going up stairs, the legs are bent at the hip joint and reach a stair, and then the hip joint is straightened to go up by the one stair; therefore, it may be detected that the user is going up stairs by comparing the timing of straightening of the hip joint and the timing of altitude changes of the user.

[0122] While the embodiment(s) of the present invention has (have) been described, the technical scope of the invention is not limited to the above described embodiment(s). It is apparent to persons skilled in the art that various alterations and improvements can be added to the above-described embodiment(s). It is also apparent from the scope of the claims that the embodiments added with such alterations or improvements can be included in the technical scope of the invention.

[0123] The operations, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the claims, embodiments, or diagrams can be performed in any order as long as the order is not indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as "first" or "next" in the claims, embodiments, or diagrams, it does not necessar-

ily mean that the process must be performed in this order.

Explanation of Reference Number

[0124]

100 user, 200, 202, 204, 206 muscular strength assisting instrument, 2 1 0 upper attachment portion, 2 1 2 upper assisting belt, 2 1 3 assisting belt, 2 1 4 coupling instrument, 2 1 5 engaging projection, 216 resilient claw, 2 1 7 fluid, 2 1 8 jacket portion, 2 2 0 lower attachment portion, 2 2 2 attachment instrument, 2 2 3 fitting portion, 2 2 4 engaging hole, 2 2 6 coupling belt, 2 2 8 fixation belt, 2 3 0 knee belt, 2 3 2 heel belt, 2 3 4 pants portion, 2 4 2 resilient portion, 2 5 2 lower assisting belt, 2 6 0 cable, 2 6 2 coupling tube, 300, 302, 306 control box, 3 0 4 pump, 3 1 0 measuring unit, 3 1 2 ultrasonic sensor, 314 angular adjustment section, 316, 336 cable, 3 2 4 detection unit, 3 2 6 control unit, 3 3 0 shoe, 3 3 2 first load sensor, 334 second load sensor, 3 4 0 release unit, 3 4 2,3 7 0 engaging claw, 344 engaging plate, 3 4 6,3 7 6 support unit, 348, 372 biasing member, 350, 374 rod, 352, 378 housing, 354, 3 8 0 drive unit, 3 6 0 unleashing unit, 3 6 2 rotary body, 3 6 4 engaging projection, 366, 368 adjustment belt, 3 9 0 cylinder, 3 9 2 piston, 394 actuator, 4 0 0 jacket portion, 4 0 2 pants portion, 4 0 4 wiring portion, 4 1 0 waist part actuator, 4 1 2 first actuator, 414 second actuator, 4 2 0 leg part actuator, 4 2 2 third actuator, 4 2 4 fourth actuator, 4 2 6 fifth actuator, 4 2 8 sixth actuator, 5 0 0 control box, 5 0 2 control apparatus, 5 0 4 power source unit, 506 electric leakage sensor, 508 action detection unit, 5 1 0 power source switch, 514 storage unit, 518 control unit

Claims

1. A muscular strength assisting instrument comprising:

   an assisting unit that assists muscular strength of a user by using assisting force due to extension or contraction;
   a detection unit that detects a predetermined dangerous situation; and
   a control unit that adjusts the assisting force of the assisting unit when the dangerous situation is detected by the detection unit.

2. The muscular strength assisting instrument according to Claim 1, wherein the control unit unleashes the assisting force of the assisting unit.

3. The muscular strength assisting instrument according to Claim 2, wherein the control unit unleashes the assisting force by terminating supply of energy of extension or contraction by the assisting unit.

4. The muscular strength assisting instrument according to Claim 3, wherein the control unit unleashes assisting force so that length of the assisting unit becomes natural length.

5. The muscular strength assisting instrument according to Claim 2, wherein the control unit unleashes the assisting force by physically blocking a transmission path of the assisting force between the assisting unit and the user.

6. The muscular strength assisting instrument according to any one of Claims 2 to 5, wherein the assisting unit is deformable due to external force in a state where at least assisting force is unleashed.

7. The muscular strength assisting instrument according to any one of Claims 1 to 6, wherein the detection unit detects water being poured, as the dangerous situation.

8. The muscular strength assisting instrument according to any one of Claims 1 to 6, wherein the detection unit detects a step with predetermined height or higher, as the dangerous situation.

9. The muscular strength assisting instrument according to Claim 8, wherein the detection unit detects the step based on whether or not the ground onto which the user steps is low.

10. The muscular strength assisting instrument according to Claim 9, wherein the detection unit judges presence or absence of the step by measuring distance to the ground onto which the user steps.

11. The muscular strength assisting instrument according to Claim 8, wherein the detection unit judges presence or absence of the step by analyzing an image of an area in front of the user.

12. The muscular strength assisting instrument according to any one of Claims 1 to 6, wherein the detection unit detects a predetermined dangerous posture of the user, as the dangerous situation.

13. The muscular strength assisting instrument according to Claim 12, wherein the detection unit detects backward movement of the center of gravity of body weight of the user, as the dangerous posture.

14. The muscular strength assisting instrument according to Claim 12 or 13, wherein the detection unit has at least one of a load sensor, a myoelectricity sensor, and an acceleration sensor.

15. The muscular strength assisting instrument according to Claim 14, wherein the detection unit judges whether or not the center of gravity of the body weight of the user has moved backward based on a load output by the load sensor.

16. The muscular strength assisting instrument according to any one of Claims 1 to 15, wherein the detection unit judges that it is the dangerous situation when a prerecorded safety condition is not met.

17. The muscular strength assisting instrument according to any one of Claims 1 to 16, wherein the control unit provides, by the assisting unit, assisting force for avoiding the dangerous situation.

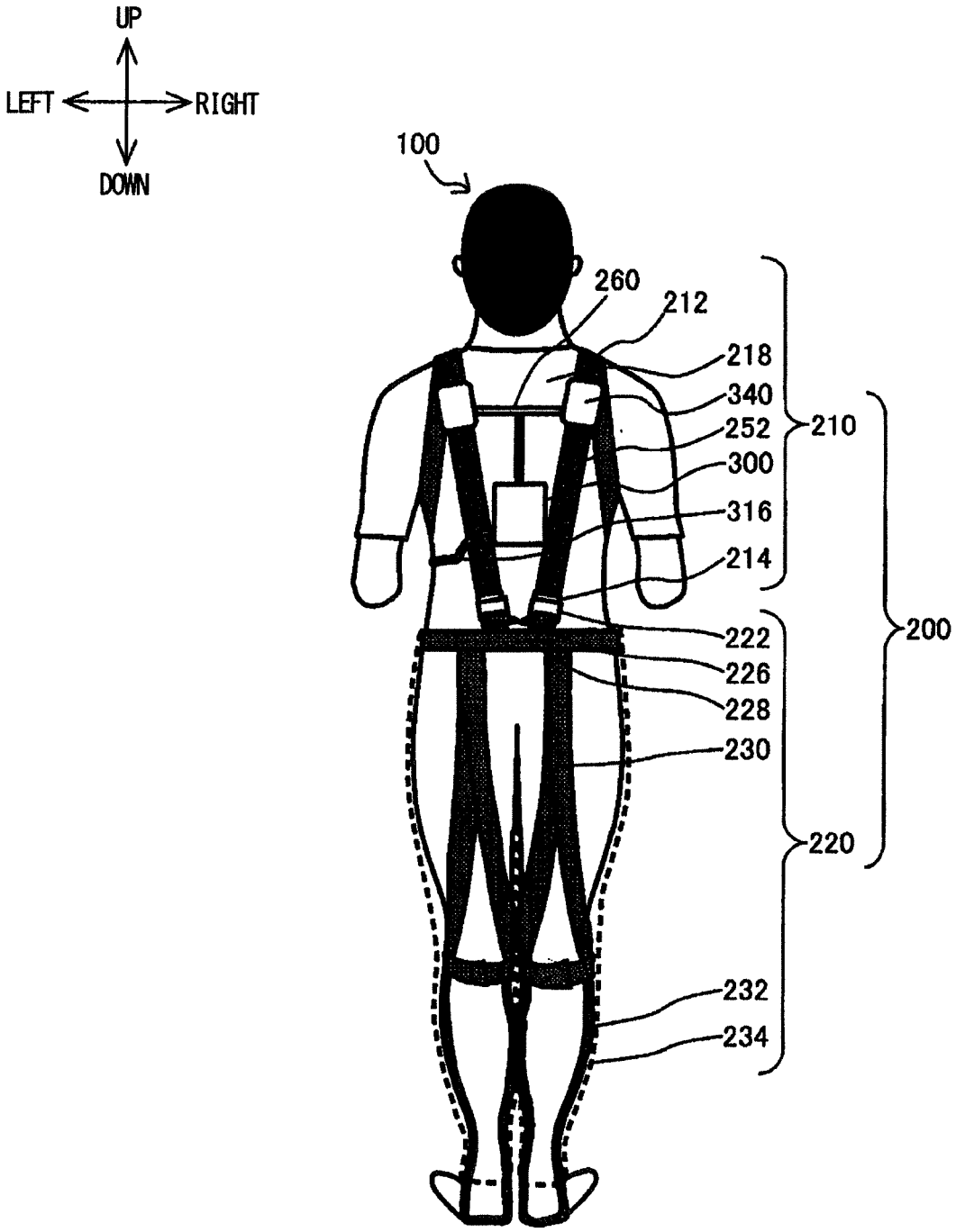
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FIG. 1

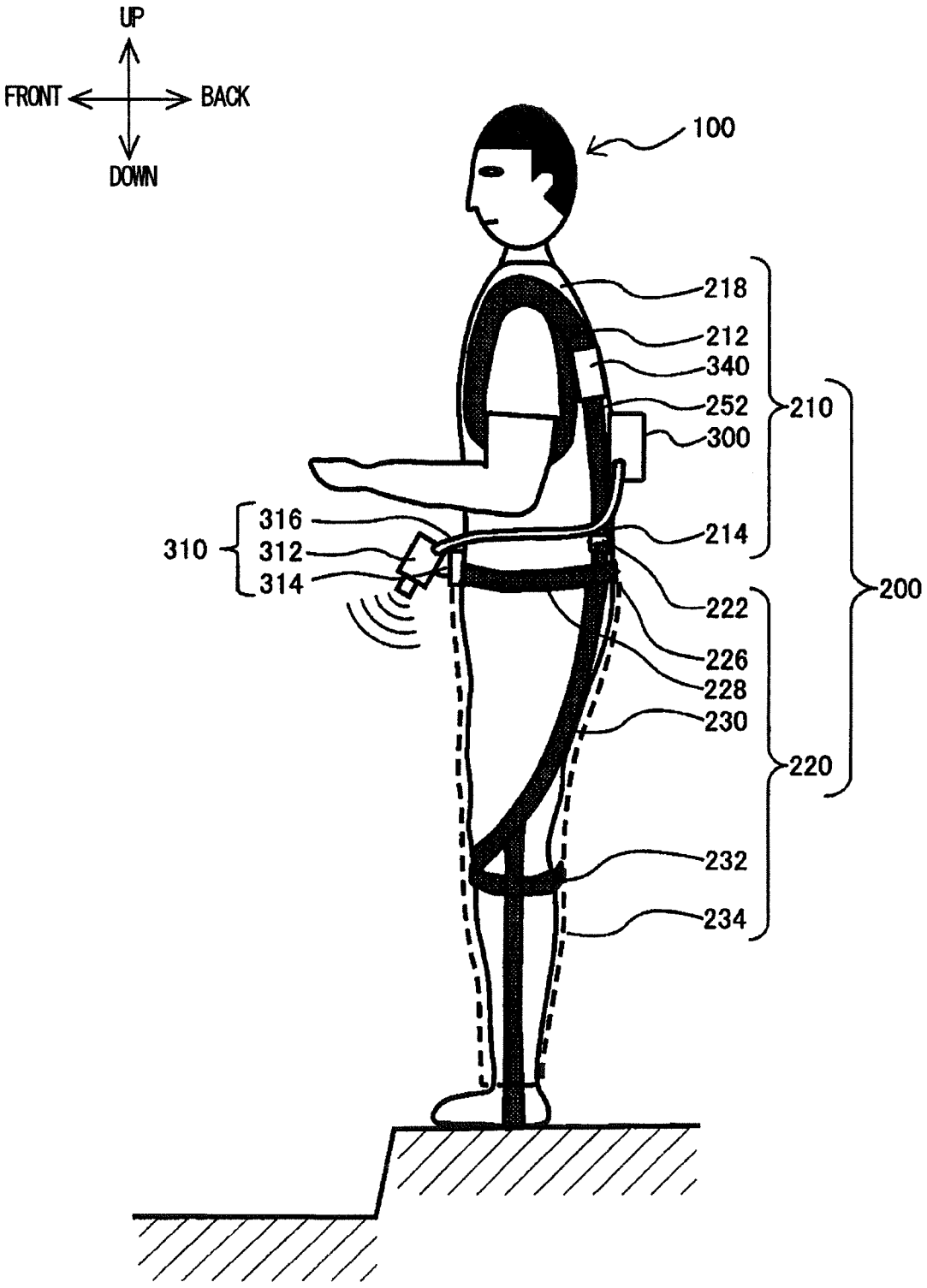
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FIG. 2

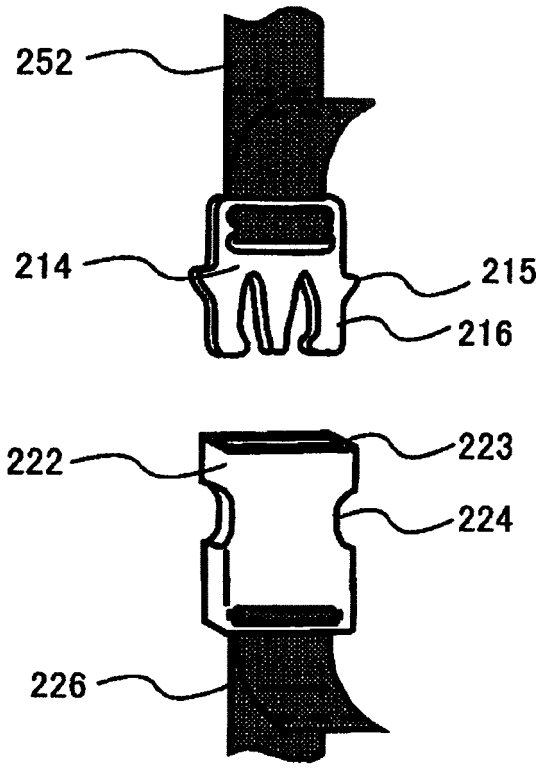
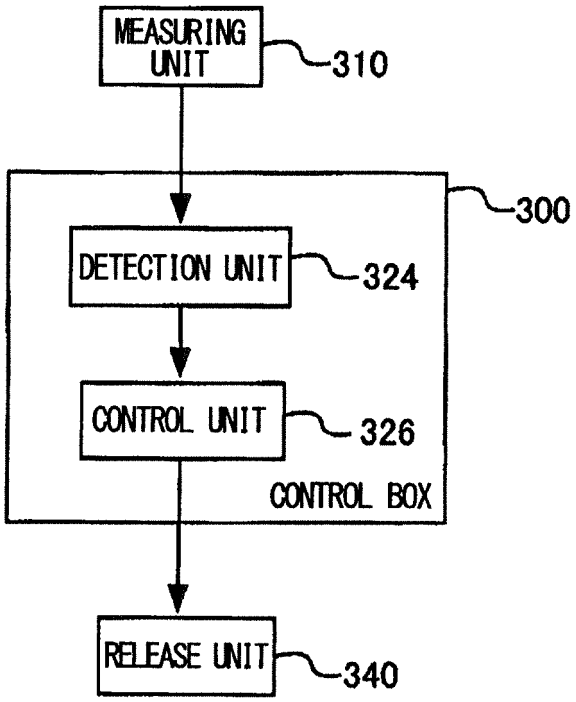


FIG. 3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DETECTION UNIT
324
CONTROL UNIT
326
CONTROL BOX
RELEASE UNIT
340

FIG. 4

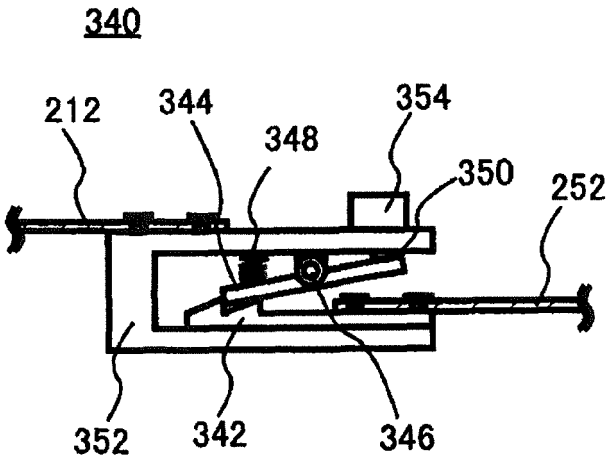

FIG. 5

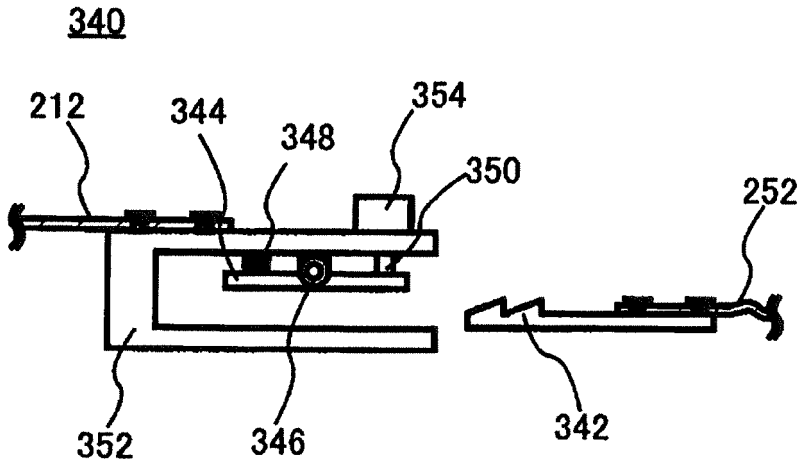

FIG. 6

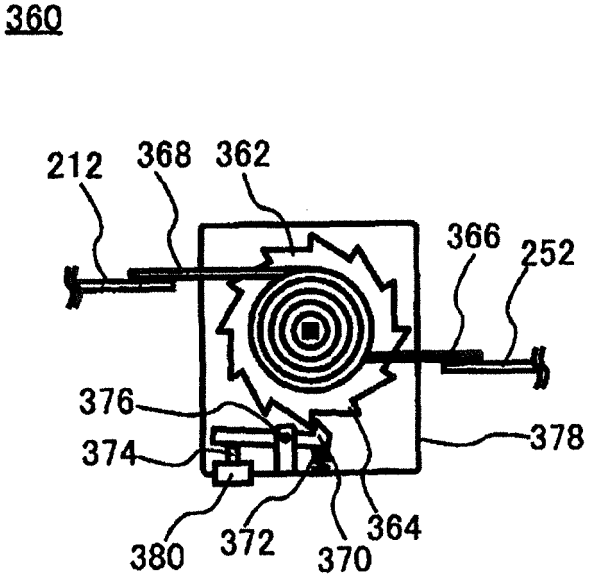

FIG. 7

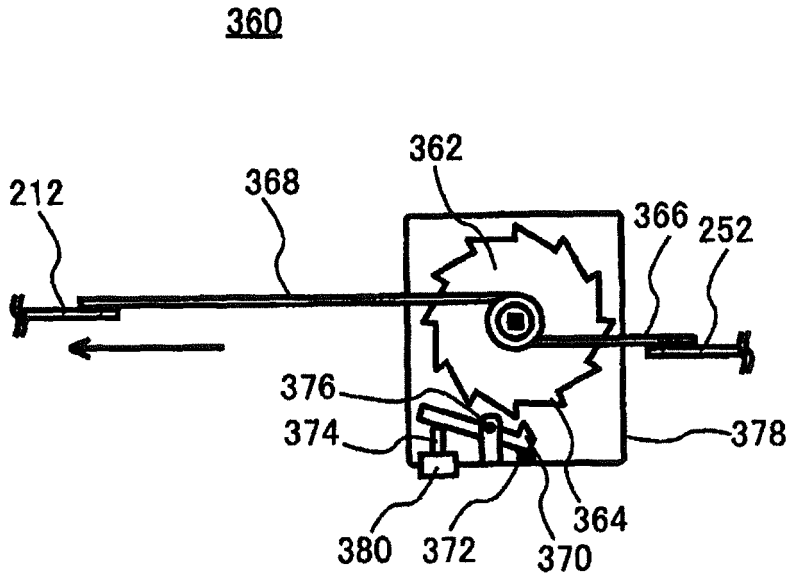

FIG. 8

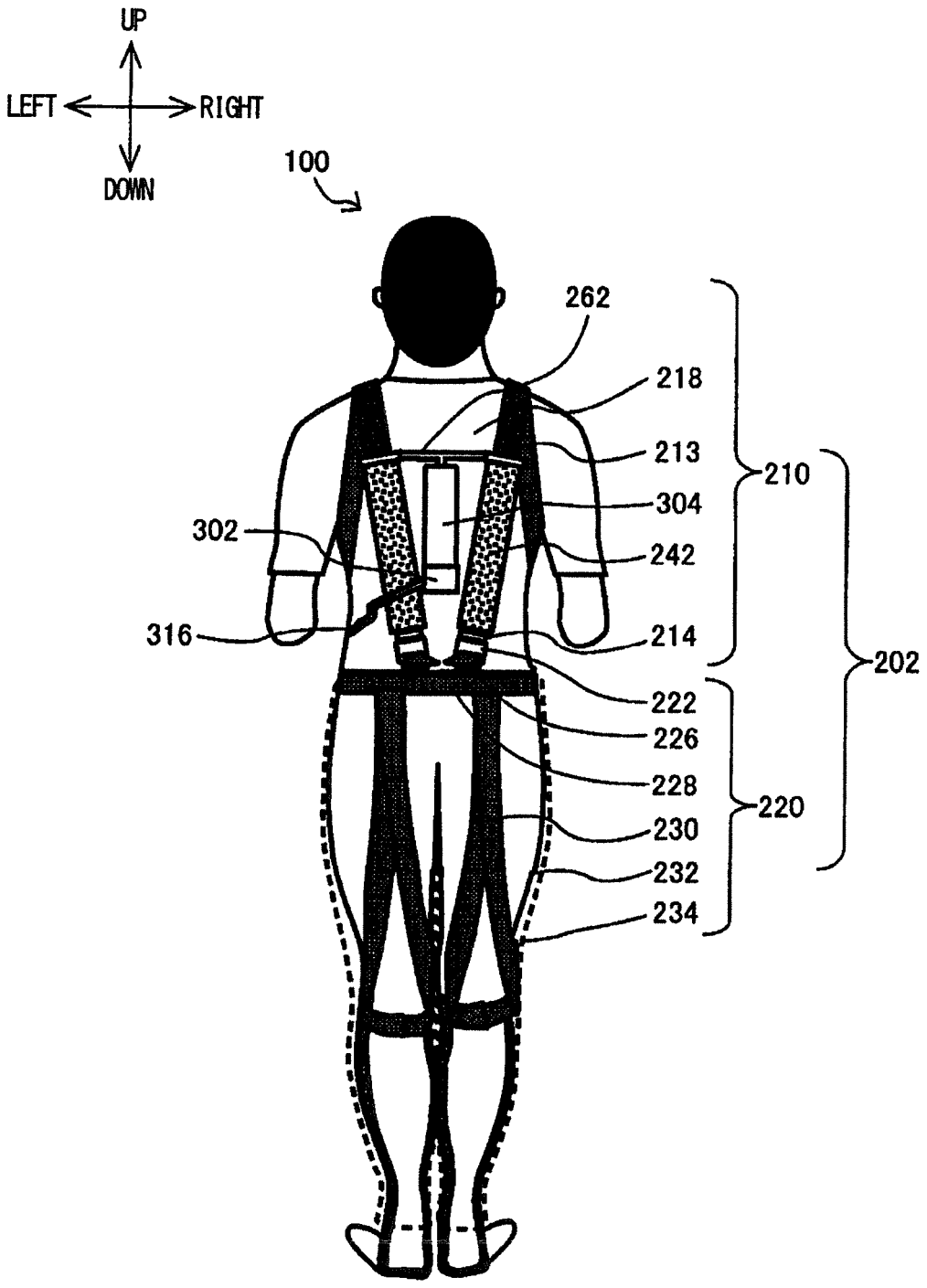
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FIG. 9

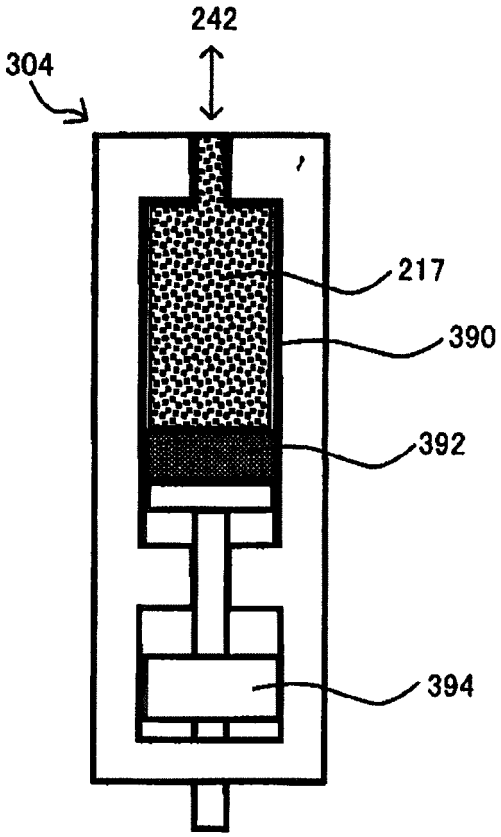


FIG. 10

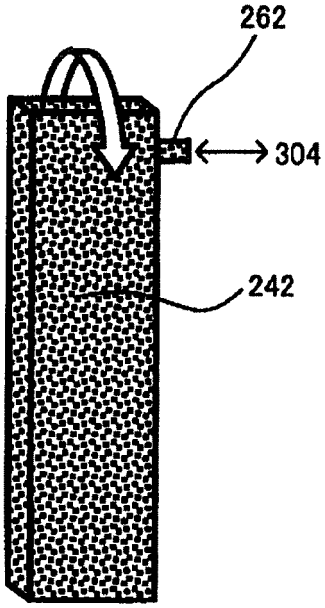


FIG. 11

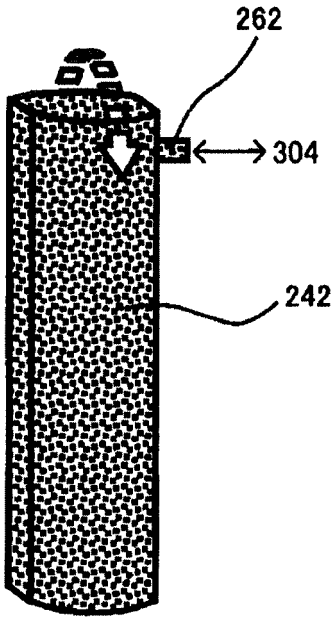
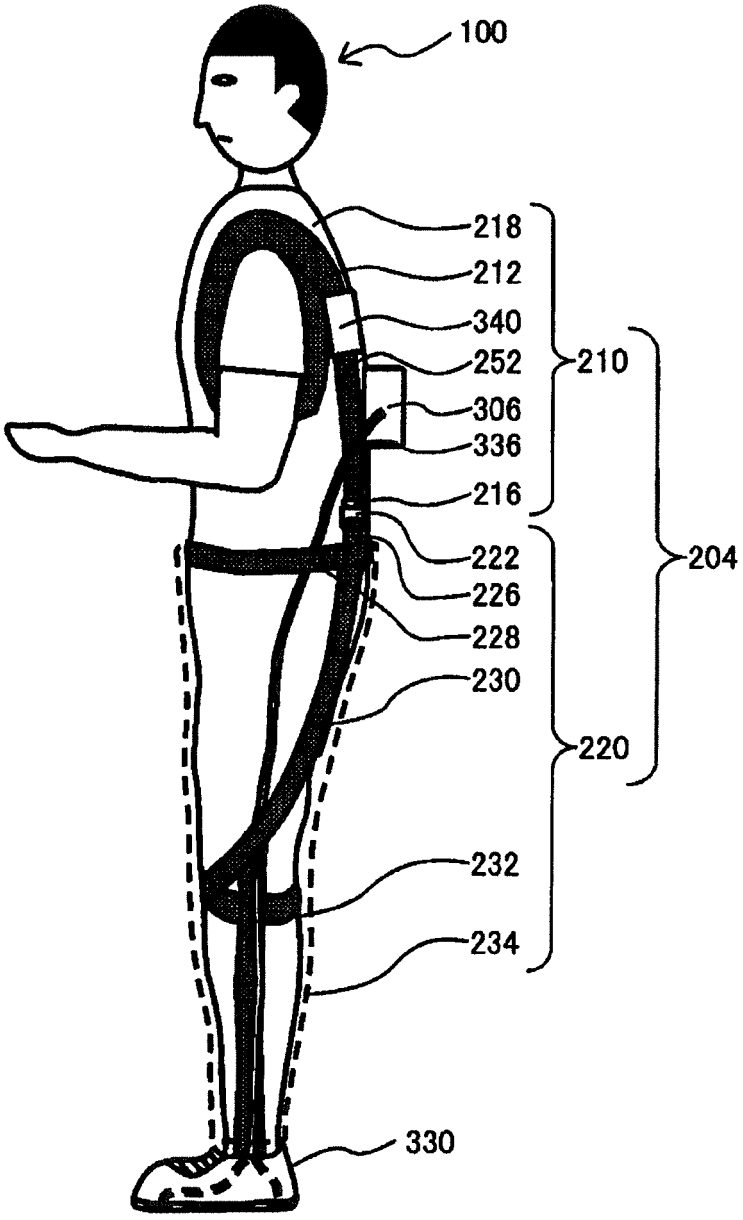


FIG. 12


100
218
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340
252
306
336
216
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222
226
228
230
220
204
232
234
330

FIG. 13

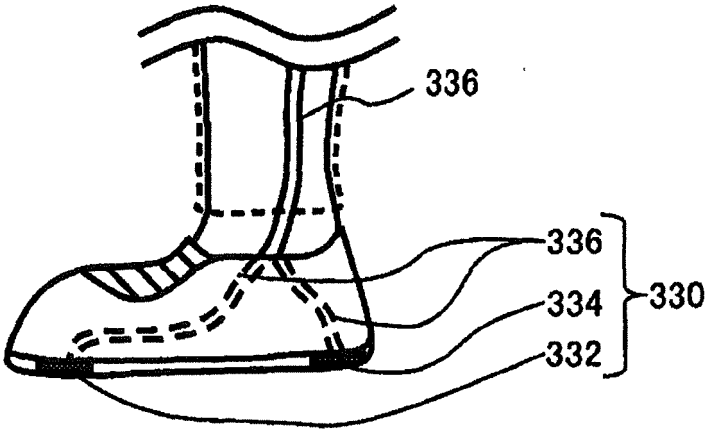

FIG. 14

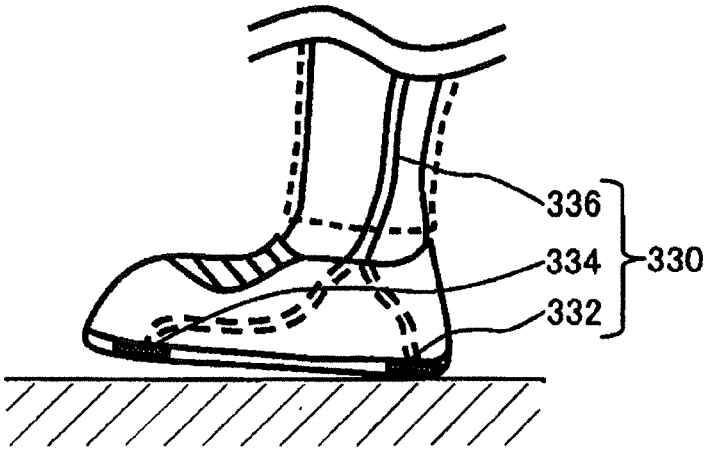

FIG. 15

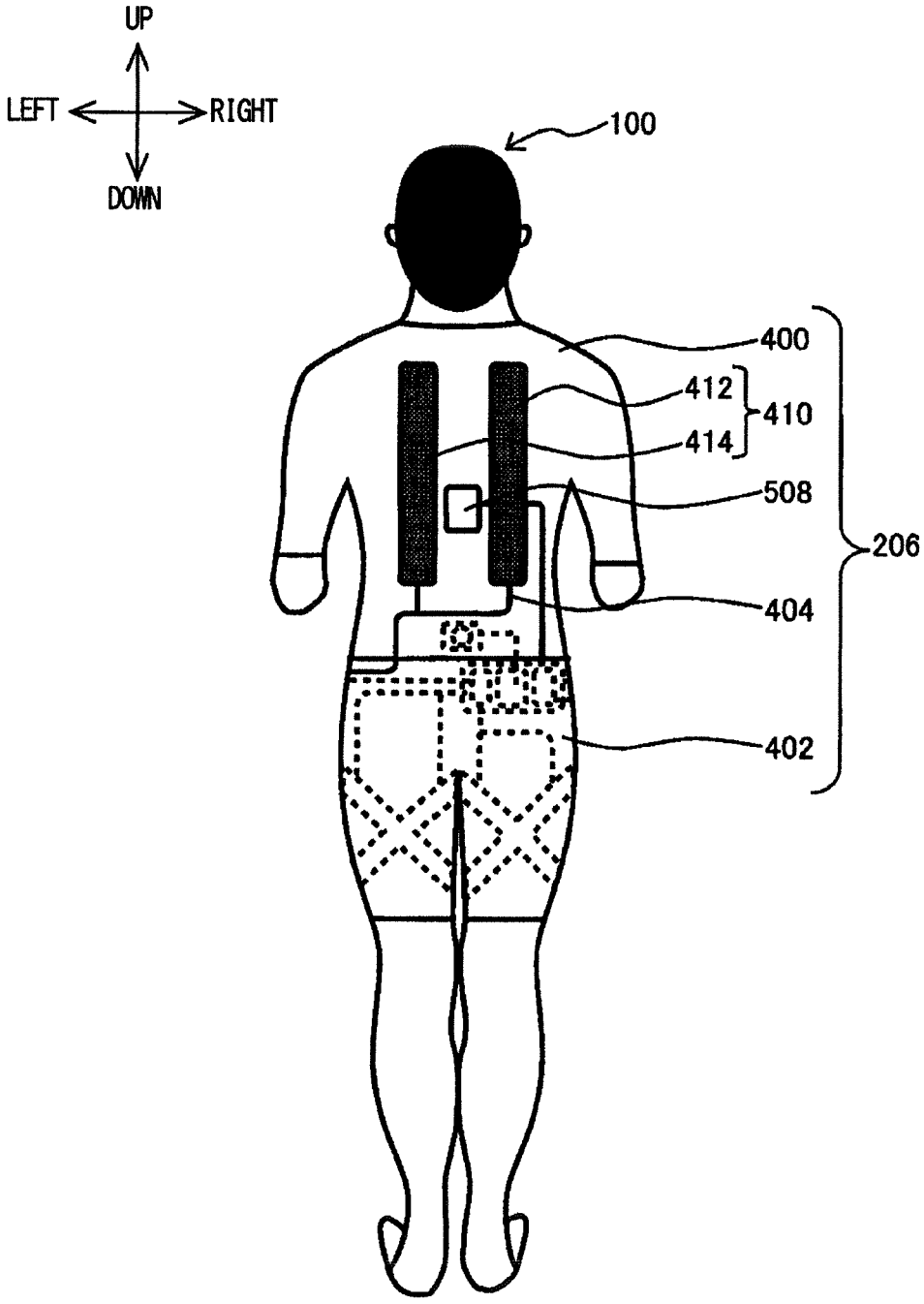

FIG. 16

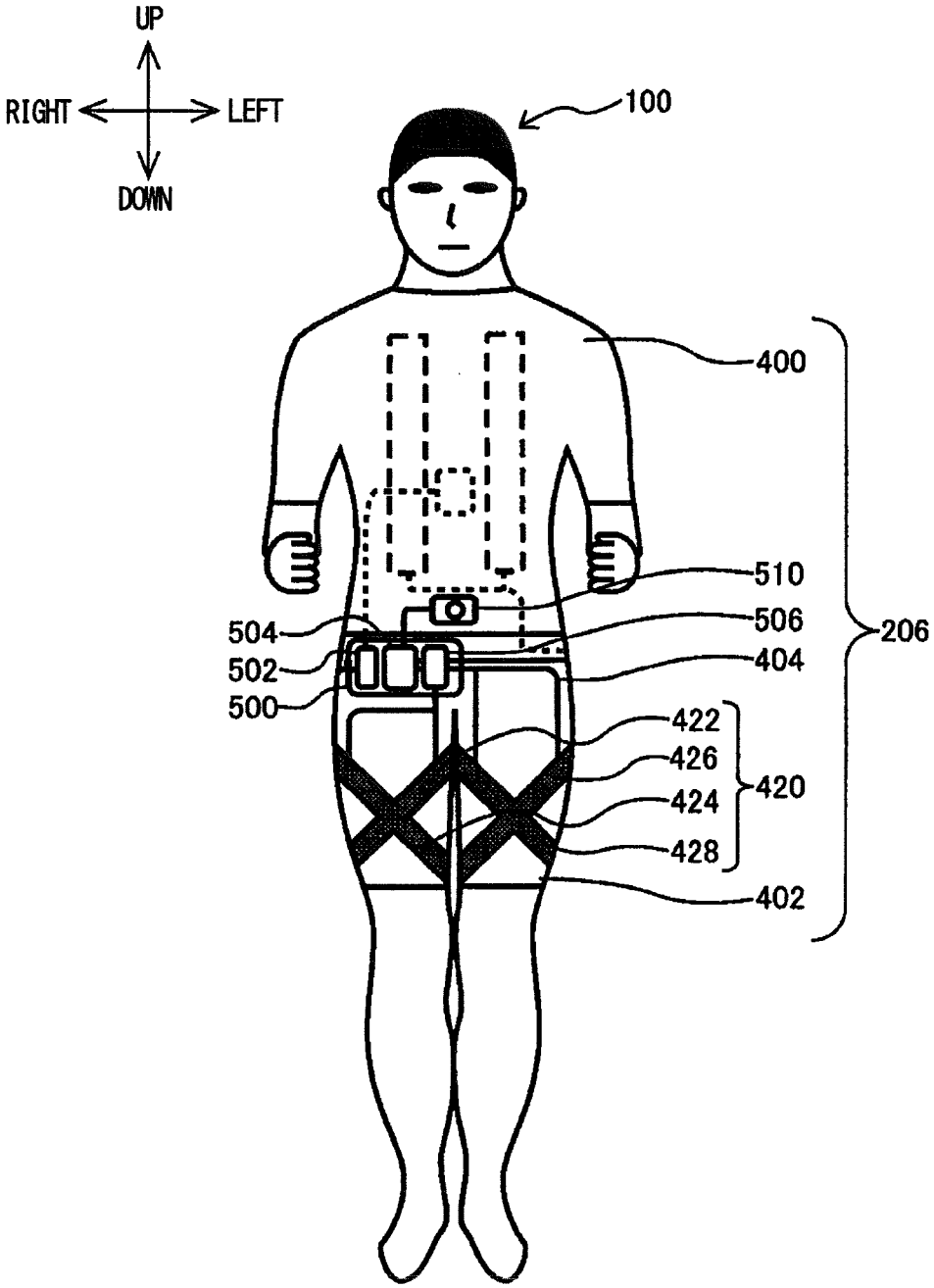
UP
RIGHT
LEFT
DOWN
100
400
510
504
506
206
502
404
500
422
426
420
424
428
402

FIG. 17

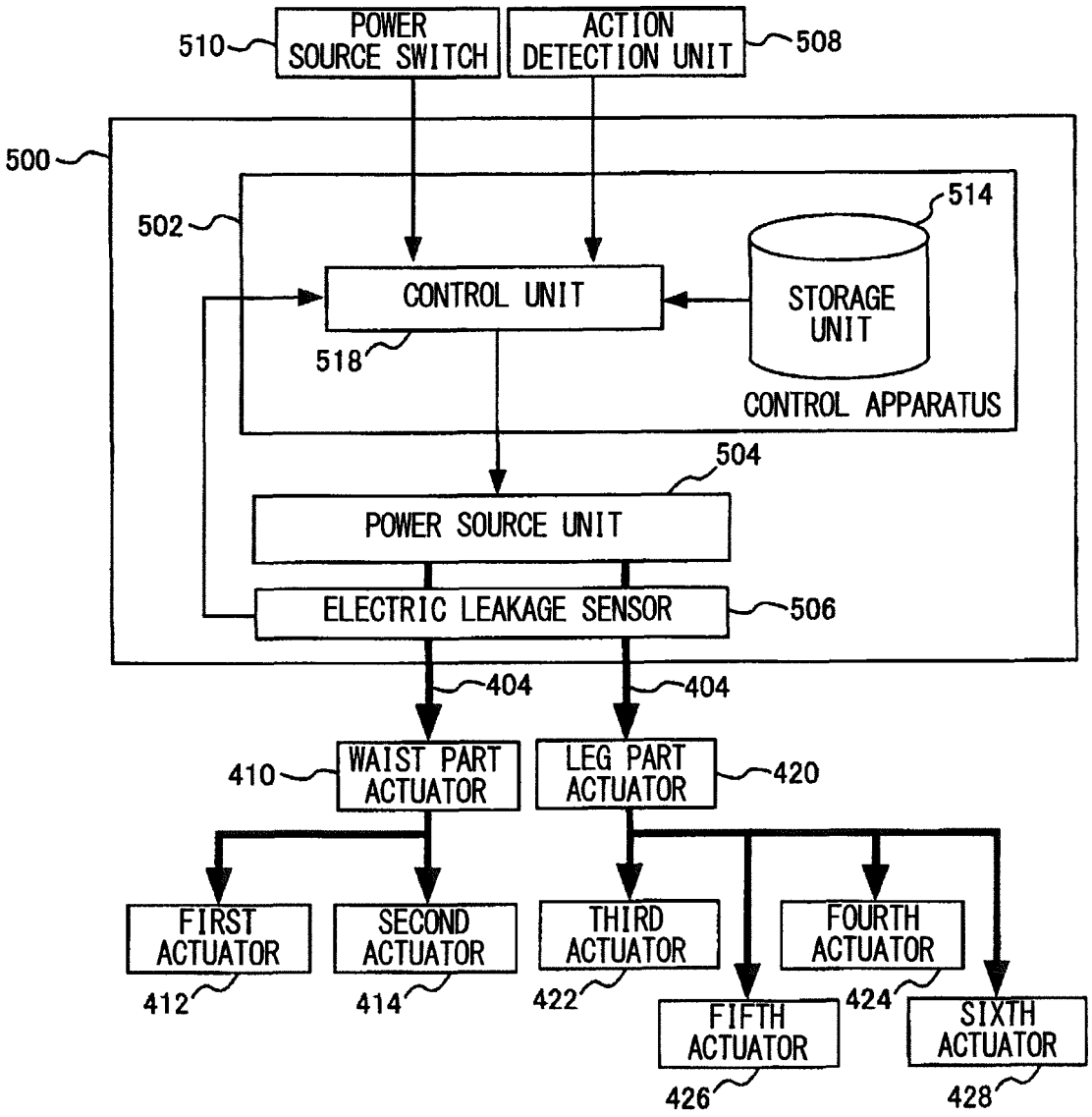
POWER SOURCE SWITCH
510
ACTION DETECTION UNIT
508
500
502
514
CONTROL UNIT
518
STORAGE UNIT
CONTROL APPARATUS
504
POWER SOURCE UNIT
ELECTRIC LEAKAGE SENSOR
506
404
404
410
WAIST PART ACTUATOR
LEG PART ACTUATOR
420
FIRST ACTUATOR
412
SECOND ACTUATOR
414
THIRD ACTUATOR
422
FOURTH ACTUATOR
424
FIFTH ACTUATOR
426
SIXTH ACTUATOR
428

FIG. 18

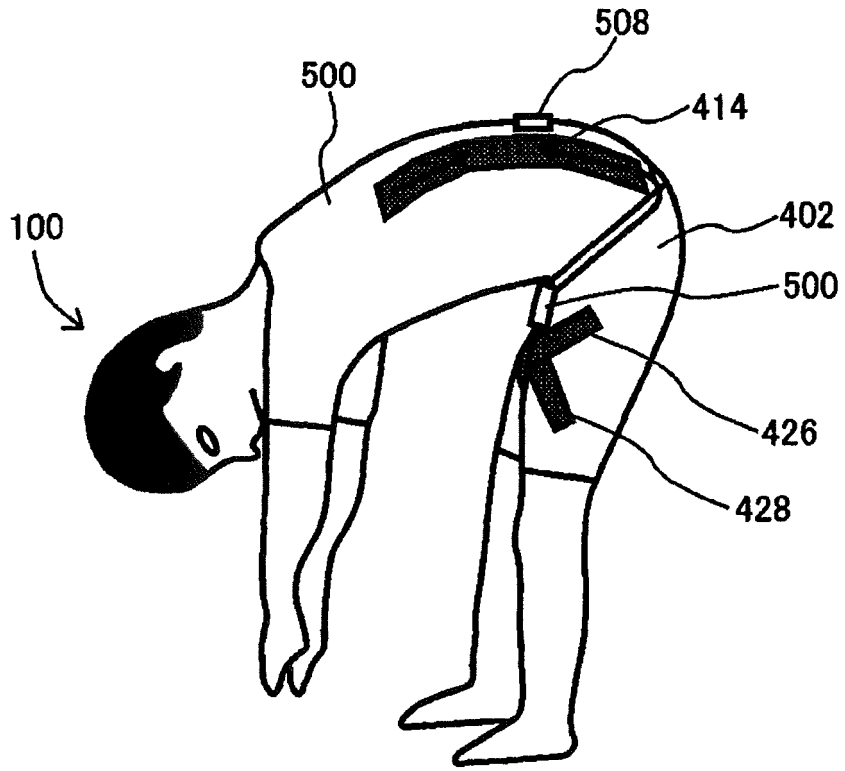

FIG. 19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/006137

A. CLASSIFICATION OF SUBJECT MATTER
A61H3/00(2006.01)i, *B25J11/00*(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)
A61H3/00, B25J11/00

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 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
Y	JP 4424269 B2 (Casio Computer Co., Ltd.), 03 March 2010 (03.03.2010), entire text; all drawings (Family: none)	1-17
Y	JP 2011-193901 A (Toyota Motor Corp.), 06 October 2011 (06.10.2011), paragraphs [0028] to [0065]; all drawings (Family: none)	1-17
Y	JP 2007-130234 A (Matsushita Electric Industrial Co., Ltd.), 31 May 2007 (31.05.2007), paragraph [0051]; all drawings (Family: none)	1-17

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

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"P" document published prior to the international filing date but later than the priority date claimed
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 November, 2013 (01.11.13)	19 November, 2013 (19.11.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/006137

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2006/022057 A1 (Honda Motor Co., Ltd.), 02 March 2006 (02.03.2006), paragraphs [0021] to [0024]; all drawings & EP 1792597 A1	1-17
Y	JP 2012-115314 A (Equos Research Co., Ltd.), 21 June 2012 (21.06.2012), paragraphs [0013] to [0066]; all drawings (Family: none)	1-17
Y	JP 2009-112447 A (Tokai Rika Co., Ltd.), 26 May 2009 (26.05.2009), paragraphs [0018] to [0026]; all drawings (Family: none)	1-17
Y	JP 2-136023 A (Matsushita Electric Works, Ltd.), 24 May 1990 (24.05.1990), page 1, lower right column, lines 9 to 11 (Family: none)	7
Y	JP 2010-110381 A (Toyota Motor Corp.), 20 May 2010 (20.05.2010), paragraph [0024]; fig. 2 (Family: none)	10
A	JP 2012-100722 A (Toyota Motor Corp.), 31 May 2012 (31.05.2012), paragraph [0005] (Family: none)	7

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Patent documents cited in the description

- JP 2003153928 A **[0002]**