(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 798 429 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.10.1997 Bulletin 1997/40

(51) Int. Cl.[6]: **E04G 1/00**, E04G 3/00

(21) Application number: **97104753.5**

(22) Date of filing: **20.03.1997**

(84) Designated Contracting States:
DE FR

(30) Priority: **25.03.1996 JP 94870/96**

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(54) Wire rope supply path length adjusting device and suspension support device for an outer wall working machine utilizing the same

(57) A wire rope supply path length adjusting device (80) for adjusting change in length of a wire rope supply path caused by pivoting of a pivotable arm (20) pivotably supported on a base member (10) for suspending an object to be supported by means of wire ropes includes a pair of fixed pulleys (81) of the same diameter provided rotatably about axes of rotation parallel to a rotation axis of the pivotable arm across the wire rope supply path at positions which are spaced from the rotation axis (second axis) of the pivotable arm on the side of said base member, and a pair of movable pulleys (82) of the same diameter provided rotatably about axes of rotation parallel to the rotation axis of the pivotable arm across the wire rope supply path at positions which are spaced from the rotation axis of said pivotable arm on the side of the pivotable arm. The wire ropes (4) are caused to engage on the pulleys on the pivoting side among the respective pairs of pulleys and the diameters of the respective pairs of pulleys and the distances of the respective pairs of pulleys from the rotation axis of said pivotable arm are selected at values at which length of the wire rope supply path between the respective pairs of pulleys is maintained substantially constant regardless of change in an angle of rotation of said pivotable arm.

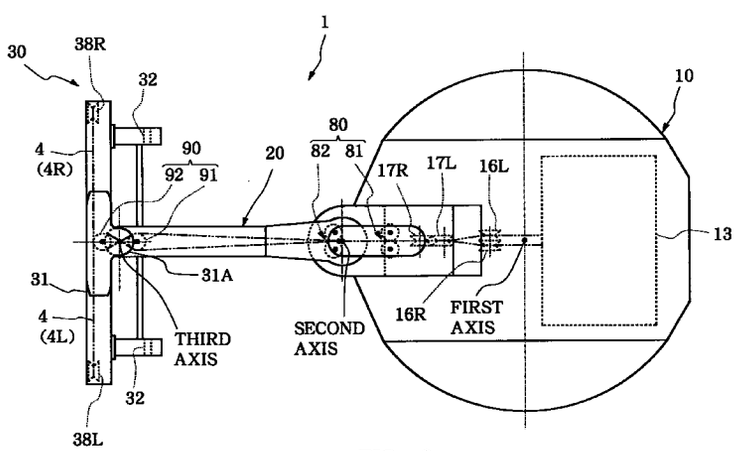

FIG. 2

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Description

This invention relates to a device for adjusting change in length of a wire rope supply path caused by pivoting of a pivotable arm in in a pivotable arm structure in which the pivotable arm is pivotably supported on a base member for suspending and supporting an object to be suspended by means of wire ropes supplied from the base member throught the pivotable arm such, for example, a pivotable arm structure in a suspension support device for suspending outer wall working machines such as an automatic work unit and a manned cage working on an outer wall of a building from the roof of the building by means of wire ropes.

In performing work such as new building work, repair and cleaning on an outer wall surface of a building, it is known to lift and lower an automatic machine or a manned cage suspended from the roof by means of wire ropes along the outer wall surface and perform the work by the automatic machine or a workman in the cage.

There is an outer wall working device which has fitting and moving members which are fitted in guide grooves of a channel steel configuration extending vertically, i.e., in the moving direction of the working machine. By sliding of the fitting and moving members along the guide grooves, lifting and lowering of the outer wall working machine are guided and moving off of the working machine from the outer wall surface of the building can be prevented. The suspension support device has an arm extending from a main body of the device outwardly of the outer wall surface of the building and the outer wall working machine is suspended by wire ropes which are suspended from the foremost end portion of the arm. For enabling the suspended working machine to move to a desired position on the building, the suspension support device has a holding unit provided at the foremost end portion of the arm in which the fitting and moving members of the working machine can be fittedly engaged and the main body of the device can move along rails laid along the outer wall surface on the roof of the building.

In the schematic side elevation of Fig. 9, a support device 70 is provided movably along rails 3 laid along an outer wall on the roof of a building 2. In a main body 71 of the device 70 is provided a winder (not shown) for taking up and feeding out ropes 4 for suspending an outer wall working machine 40. A holding unit 72 is also provided in the main body 71 through an arm 73 for holding the working machine 40.

The holding unit 72 includes a pair of holding guide members 72A provided with an interval equal to interval between a pair of guide grooves 5 formed on the building 2 (i.e., interval between the fitting and moving members 41 of the working machine 40). By lifting the working machine 40 up to the location of the holding unit 72 and causing the fitting and moving members 41 to engage fittedly in the holding guide members 72A, the working machine 40 is held stably by the holding unit 72.

The holding guide members 72A has the same cross section as the guide grooves 5 of the building 2 and is long enough to receive the fitting and moving members 41. The lower end portions of the holding guide members 72A are formed so as to have a predetermined interval between the upper surface of the building 2 and are provided with connecting members 72C which are driven by drive means 72B such as a motor cylinder to project from and withdraw into the holding guide members 72A.

In the projecting state, the connecting members 72C connect the holding guide members 72A with the guide grooves 5 of the building 2 and thereby guide the fitting and moving members 41 to move smoothly between the guide grooves 5 and the holding guide members 72A.

The ropes 4 suspending the outer wall working machine 40 extend from the winder in the main body 71 to the holding unit 72 via the arm 73 and are suspended from the upper portion of the holding unit 72.

According to this support device 70, the outer wall working machine 40 is lowered and lifted by feeding out and taking up of the ropes 4 by the winder and, as shown in Fig. 10, the working machine 40 is held by the holding unit 72 by causing the fitting and moving members 41 of the working machine 40 to engage in the holding guide members 72A whereby an area in which the working machine is lowered and lifted (i.e., a working area of the working machine 40) can be changed with the working machine held by the holding unit 72.

More specifically, the working machine 40 is lifted from the state in which the fitting and moving members 41 are fittedly engaged in the guide grooves 5 to the state in which the fitting and moving members 41 are engaged in the holding guide members 72A of the holding unit 72. Then, the support device 70 is moved along the rails 3 to a position where the holding guide members 72 of the holding unit 72 oppose desired guide grooves 5 while holding the working machine 40 in the holding unit 72. The working machine 40 is lowered to shift the fitting and moving members 41 from the holding guide members 72A to the guide grooves 5 whereby the working machine 40 can be lowered along the guide grooves 5.

There are cases where it is difficult to provide rails along the outer wall surface of a building due to the structure of the building with the result that location of the suspension support device is restricted and where it is difficult to place the holding unit of the suspension support device at a position corresponding to guide grooves formed on the building due to an obstacle existing on the building. It is desirable to provide a suspension support device which, even in such situation, can move its holding unit freely to a desired position and can change the position of the outer wall working machine held by the holding unit without moving the main body of the suspension support device too frequently.

For this purpose, it is conceivable to provide a sup-

port arm for supporting a holding unit rotatably about a vertical axis of rotation. In such structure, a wire rope arrangement enabling bending of a wire rope at the axis of rotation is required. For example, as shown in the schematic view of Fig. 11A, by providing pulleys 75 and 76 of the same diameter across the rotation axis 77 rotatably about an axis which is parallel to the rotation axis 77 and stretching a wire rope 4 obliquely between the pulleys 75 and 76, the wire rope supply path of the wire rope 4 will be maintained even if the support arm is pivoted leftwardly or rightwardly as shown in Figs. 11B and 11C.

In such structure, however, length of the wire rope supply path changes with pivoting of the support arm (pivotable arm) with the result that the outer wall working machine suspended an supported by means of wire ropes is lifted or lowered with the pivoting of the support arm. More specifically, as the angle of rotation of the support arm increases, the amount of engaging (winding) of the wire ropes on the pulleys increases to pull up the wire ropes so that the suspended outer wall working machine is lifted. Conversely, when the angle of rotation of the support arm decreases, the amount of engaging (winding) of the wire ropes on the pulleys decreases so that the working machine is lowered due to its self-weight. Such lifting and lowering of the outer wall working machine take place during holding of the working machine by the holding unit of the suspension support device and therefore are quite undesirable.

It is, therefore, an object of the invention to provide a wire rope supply path length adjusting device capable of preventing change in the wire rope supply path length caused by pivoting of a pivotable arm in in a pivotable arm structure in which the pivotable arm is pivotably supported on a base member for suspending and supporting an object to be suspended by means of wire ropes supplied from the base member throught the pivotable arm.

It is also an object of the invention to provide a suspension support device for an outer wall working machine employing such wire rope supply path length adjusting device.

For achieving the above described objects of the invention, there is provided a wire rope supply path length adjusting device for adjusting change in length of a wire rope supply path caused by pivoting of a pivotable arm in in a pivotable arm structure in which the pivotable arm is pivotably supported on a base member for suspending and supporting an object to be supported by means of wire ropes supplied from the base member throught the pivotable arm comprising, a pair of fixed pulleys of the same diameter provided rotatably about axes of rotation parallel to a rotation axis of said pivotable arm across the wire rope supply path at positions which are spaced from the rotation axis of said pivotable arm by a predetermined distance on the side of said base member, and a pair of movable pulleys of the same diameter provided rotatably about axes of rotation parallel to the rotation axis of said pivotable arm across the wire rope supply path at positions which are spaced from the rotation axis of said pivotable arm by a predetermined distance on the side of said pivotable arm, the wire ropes being caused to engage on the pulleys on the pivoting side among the respective pairs of pulleys and the diameters of the respective pairs of pulleys and the distances of the respective pairs of pulleys from the rotation axis of said pivotable arm being selected at values at which length of the wire rope supply path between the respective pairs of pulleys is maintained substantially constant regardless of change in an angle of rotation of said pivotable arm.

According to the invention, the wire rope supply path length is not changed by pivoting of the pivotable arm and, therefore, undesirable lifting and lowering of the object to be suspended and supported by the wire ropes due to pivoting of the pivotable arm will be effectively prevented.

In one aspect of the invention, said object to be supported is suspended and supported at end portions thereof by said wire ropes, said wire ropes consist of two wire ropes arranged vertically and each of said pairs of fixed pulleys and movable pulleys respectively consists of two pulleys provided vertically corresponding to the two vertically arranged wire ropes.

In another aspect of the invention, there is provided a suspension support device for an outer wall working machine comprising a movable base capable of moving on an upper surface of a building, a main body provided rotatably about a vertical first axis on said movable base, a winding device provided in the main body for taking up and feeding out wire ropes, a pivotable arm provided rotatably about a vertical second axis on said main body, a holding unit for holding an outer wall working machine provided rotatably about a vertical third axis in the foremost end portion of said pivotable arm, said holding unit suspending the wire ropes supplied from said winding device through said pivotable arm to suspend and support the outer wall working machine, and a wire rope supply path length adjusting device described above provided in a wire rope supply path between said main body and said pivotable arm.

According to this aspect of the invention, the outer wall working device suspended and supported by the wire ropes will not be lifted or lowered by pivoting of the pivotable arm and, therefore, the outer wall working machine can be held stably by the suspension support device and moved to a desired position with a greater degree of freedom.

Preferred embodiments of the invention will be described below with reference to the accompanying drawings.

In the accompanying drawings,

Fig. 1 is perspective view showing an embodiment of a suspension support device for an outer wall working machine in a state suspending an outer wall working machine incorporating the wire rope supply path length adjusting device according to

the invention ;

Fig. 2 is a plan view of the device of Fig. 1;

Fig. 3 is a right side elevation of the device;

Fig. 4 is a sectional view of a pivotable arm;

Fig. 5 is a schematic plan view of a state of wiring arrangement of wire ropes in the pivotable arm;

Fig. 6 is a schematic plan view of length adjusting pulleys;

Fig. 7 is a schematic plan view of the length adjusting pulleys showing a state of the pulleys in action;

Fig. 8 is a plan view showing an action of the suspension support device;

Fig. 9 is a schematic view showing a prior art suspension support device;

Fig. 10 is a schematic view showing the suspension support device of Fig. 9 in a state holding an outer wall working machine in its holding unit; and

Figs. 11A, 11B and 11C are schematic views showing an example of wire rope arrangement permitting bending of a wire rope at an axis rotation.

A suspension support device 1 has a movable body 10 which is movable along rails 3 laid on a roof (upper surface 2A) of a building 2, a holding unit 30 connected to a pivotable arm 20 which constitutes the arm structure. An outer wall working machine 40 is suspended and supported by wire ropes 4 which are suspended vertically from the holding unit 30.

The outer wall working machine 40 in this embodiment is an automatic machine for automatically performing a window cleaning work. Although illustration of details of the working machine 40 is omitted, the working machine 40 has fitting and moving members 41 having plural rollers arranged in parallel on left and right end portions of a surface opposite to an outer wall surface 2B of the building 2. These fitting and moving members 41 can be fittedly engaged in vertical guide grooves 5 formed on the outer wall surface 2B of the building 2. As the rollers of the fitting and moving members 41 are rotated, the outer wall working machine 40 suspended by the wire ropes 4 is lifted or lowered, being guided along the guide grooves 5.

The pair of the guide grooves 5 have an interval which is equal to a lateral interval of the pair of fitting and moving members 41. The guide grooves 5 have a generally rectangular cross section with one side thereof opened outwardly like channel steel bars buried in the surface portion of the outer wall and the fitting and moving members 41 of the outer wall working machine 40 can be fittedly engaged in the guide grooves 5 in such a manner that the fitting and moving members 41 cannot move forward and rearward or leftward and rightward but can move vertically.

The suspension support device 1 will now be described more in detail.

The movable body 10 has a wheel unit 11A which engages with the rails 3 laid on the upper surface 2A of the building 2, movable base 11 including a drive mechanism (not shown) for driving the wheel unit 11A, and the rotary body 12 of a columnar configuration including the winding device 13 for taking up and feeding out the wire ropes 4. The rotary body 12 is mounted on the movable base 11 rotatably about a vertical axis (i.e., first axis).

The rotary body 12 is driven and rotated by a first axis motor 14 such as a servo motor including position and speed detection sensors which constitutes the drive means. Driving of this first axis motor 14 is controlled by an unillustrated control system and, therefore, driving of the rotary body 12 is conttrolled by this control system.

Driving of the wheel unit 11A connected to the movable base 11 and the winding device 13 provided in the rotary body 12 are also controlled by the control system and, therefore, the control system controls movement of the movable body 10 along the rails 3 (i.e., movement of the suspension support device 1 along the rails 3) and lifting and lowering of the outer wall working machine 40 by taking up and feeding out of the wire ropes 4.

The pivotable arm 20 is pivotably supported about a vertical axis (second axis) at a portion in the vicinity of the upper peripheral portion of the rotary body 12 and supports the holding unit 20 at the foremost end portion thereof. The base of the pivotable arm 20 is inserted, as shown in Fig. 4, in a holding portion 12A of a generally C-shaped cross section formed in the rotary body 12. A pivotable arm shaft 21 which constitutes the second axis is fixedly secured at the lower surface of the base of the pivotable arm 20 and is rotatably supported through thrust bearings 12D by a bearing housing 12C which is fixedly secured to a lower holding plate 12B of the holding portion 12. The pivotable arm 20 can thereby be pivoted in a horizontal plane about the pivotable arm shaft 21.

Driving of the second axis motor 22 is controlled by the unillustrated control system and, therefore, driving of the pivotable arm 20 is controlled by this control system.

The holding unit 30 includes a lateral arm 31 of a predetermined length and a pair of left and right holding guides 32 which extend vertically downwardly at an interval equal to the interval of the guide grooves 5 of the building 2. The holding unit 30 is supported rotatably about a vertical axis (third axis) at the center of the lateral arm 31 on the foremost end portion of the pivotable arm 20. The holding unit 30 is rotatable by a predetermined angle.

The lateral arm 31 is formed in the central portion thereof with a rearwardly projecting support portion 31A. A holding unit shaft 32 which constitutes the third axis is fixedly secured to the lower surface of the the support portion 31A and this holding unit shaft 32 is rotatably supported through bearings 34 by a bearing housing 33 fixedly secured to the foremost end portion of the pivotable arm 20.

A reduction gear device 35 is connected to the lower end of the holding unit shaft 32 and an input shaft of this reduction gear device 35 is connected by a timing belt 37 to an output shaft of a third axis motor 36 which

is provided in the pivotable arm 20. Therefore, the holding unit shaft 32 (i.e., the holding unit 30) is driven and rotated by the third axis motor 36.

Driving of the third axis motor 36 is controlled by the unillustrated control system and, therefore, the holding unit 30 is rotated by this control system.

The holding guides 32 are of a relatively small thickness and formed in a cross section which can be fittedly engaged in the guide grooves 5 and have a length which is sufficient for receiving the entire fitting and moving members 41. Unillustrated connecting members are slidably provided in the lower end portion of the holding guides 32.

In the foremost end portions of the holding guides 32 are provided unillustrated forward and rearward position detection sensors for detecting the outer wall surface 2B of the building 2 and left and right position detection sensors for detecting the guide grooves 5.

The wire ropes 4 used for suspending the outer wall working machine 40 are fed from the winding device 13 provided in the rotary body 12, supplied through inside of the pivotal arm 20 and inside of the lateral arm 31 of the holding unit 30, suspended from sides of the lateral arm 31 and connected at sides of the outer wall working machine 40 to support the working machine 40. The wiring mechanism of these wire ropes 4 will be described more in detail below. In the present embodiment, one wire rope (4L, 4R) each is connected at each side of the outer wall working machine 40 and, therefore, the working machine 40 is suspended by two wire ropes. Alternatively, two wire ropes may be connected at each side of the working machine 40 so that the working machine 40 will be suspended by four wire ropes. In this case, each of wire rope pulleys to be described later may have two wire receiving grooves.

Left and right wire ropes 4L and 4R supplied from the winding device 13 are brought to a height corresponding to the pivotable arm 20 through a first pulley 16 (16L and 16R) provided with its rotation axis extending in a leftward and rightward direction in a horizontal plane on the front side of the rotary body 12 and second pulleys 17L and 17R provided in front of and at a higher level than the first pulley 16 with its rotation axis extending in a leftward and rightward direction in a horizontal plane. As shown by Fig. 5, the wire ropes 4L and 4R pass through the inside of the pivotable arm 20 through a length adjusting pulley device 80 which maintains length of the supplied wire ropes 4L and 4R constant regardless of pivoting of the pivotable arm 20 and are divided to the left and right by a dividing pulley mechanism 90 provided in the vicinity of the axis of rotation (third axis) of the holding unit 30 to lead to end portions of the lateral arm 31. Subsequently, the wire ropes 4L and 4R are suspended from the end portions of the lateral arm 31 through suspending pulleys 38L and 38R provided in the end portions of the lateral arm 31 with their rotation axis extending in a forward and rearward direction in a horizontal plane.

The first pulley 16 consists of the left and right pulleys 16L and 16R provided adjacent to each other for supporting the left and right wire ropes 4L and 4R. The second pulleys 17L and 17R are offset in a forward and rearward direction and also in their height by predetermined amounts to prevent interference with each other and are aligned with the center line of the pivotable arm 20. By this arrangement, the left and right wire ropes 4L and 4R are supplied with a certain vertical interval through the inside of the pivotable arm 20.

The length adusting pulley device 80 is constructed, as shown in Fig. 6, of a pair of fixed pulleys 81 provided in the rotary body 12 on the side of the winding device 13 from the second axis which is the pivoting axis of the pivotable arm 20 and a pair of movable pulleys 82 provided in the pivotable arm 20 on the side of the holding unit 30 from the second axis. Since the wire ropes 4L and 4R are supplied at a predetermined vertical interval as described above, the pulleys 81 and 82 are respectively provided for each of the wire ropes 4L and 4R so that two pulleys of the same construction are provided vertically for each of the pulleys 81 and 82.

The pair of fixed pulleys 81 consist of fixed pulleys 81A and 81B of a predetermined diameter provided rotatably about vertical axis at locations spaced from the second axis by a predetermined distance on the side of the winding device 13 across the feeding path of the wire ropes 4. Since the pair of fixed pulleys 81 are provided in the rotary body 12, the wire rope feeding path on the side of the winding device 13 from the fixed pulleys 81 can be maintained constant regardless of pivoting of the pivotable arm 20.

The pair of movable pulleys 82 consist of movable pulleys 82A and 82B of the same diameter as the fixed pulleys 81 provided rotatably about vertical axis in the pivotable arm 20 at locations which are spaced by a predetermined distance toward the holding unit 30 from the second axis of the pivotable arm 20 and across the wire rope feeding path. Since the movable pulleys 82 are provided in the pivotable arm 20, these movable pulleys 82 move along a circle whose center is the second axis as the pivotable arm 20 is pivoted thereby maintaining the wire rope feeding path on the side of the holding unit 30 from the movable pulleys 82 along the center line of the pivotable arm 20.

According to this arrangement, in a state where the pivotable arm 20 is not pivoted (i.e., in a straight position to the rotary body 12 as shown in Fig. 2), the wire ropes 4 pass straightly through the pair of pulleys 81 and the pair of pulleys 82 as shown in Fig. 7 without engaging (winding) on any of the pulleys 81 and 82. When, as shown in Fig. 10, the pivoting arm 20 is pivoted from the state of Fig. 9 by an angle θ, the wire ropes 4 engage (wind) on the pulleys 81B and 82B on the pivoting side. Engaging angles $\alpha 1$ and $\alpha 2$ of the wire ropes 4 on the pulleys 81B and 82B caused by pivoting of the pivotable arm 20 are proportional to the pivoting angle θ.

When the pivoting arm 20 is not pivoted, length L of the wire ropes 4 between the pair of fixed pulleys 81 and the pair of movable pulleys 82 is equal to distance l

between the pair of fixed pulleys 81 and the pair of movable pulleys 82, i.e., a sum of distance l between the second axis and the pair of fixed pulleys 81 and distance S between the second axis and the pair of movable pulleys 82. When the pivotable arm 20 is pivoted, the length of the wire ropes 4 between the pair of fixed pulleys 81 and the pair of movable pulleys 82 becomes a sum of straight distance L1 between the center of the fixed pulley 81B and the center of the movable pulley 82B and winding lengths L81 and L82 of the wire ropes 4 on the pulleys 81B and 82B.

Since, as described above, the engaging angles α 1 and α 2 of the wire ropes 4 on the pulleys 81B and 82B are proportional to the pivoting angle θ of the pivoting arm 20, by properly setting the diameters of the pulleys 81 and 82 and positional relations of the pulleys 81 and 82, i.e., the distance l of the pair of fixed pulleys 81 from the second axis and the offset amount S of the pair of movable pulleys 82 from the second axis, a desired correlation between these factors can be obtained. Thus, the diameters of the pulleys 81 and 82 and the positional relations of the pulleys 81 and 82, i.e., the distance l of the pair of fixed pulleys 81 from the second axis and the offset amount S of the pair of movable pulleys 82 from the second aixs are so selected that the length of the wire ropes 4 fed between the the pair of fixed pulleys 81 and the pair of movable pulleys 82 can be maintained constant or substantially constant regardless of variation in the pivoting angle .

According to the length adjusting pulley device 80, length of the wire ropes 4 fed between the pair of fixed pulleys 81 and the pair of movable pulleys 82 is constant or substantially constant regardless of pivoting of the pivotable arm 20 and, therefore, the wire ropes 4 will not be pulled or loosened by pivoting of the pivotable arm 20 and, accordingly, unexpected lifting or lowering of the suspended outer wall working machine 40 and application of an excess load on the pivotable arm drive unit (second axis motor 22) due to pivoting of the pivotable arm 20 can be effectively prevented. Further, occurrence of unequal length between the left and right wire ropes 4L and 4R in the portions on the side of the working machine 40 from the length adjusting pulley device 80 resulting in inclination of the working machine 40 can be prevented.

The dividing pulley mechanism 90 consists of length adjusting pulleys 91 and 92 of the same diameter which are provided rotatably about a vertical axis across the third axis about which the holding unit 30 is rotated. The pulley 91 is provided on the side of the pivoting arm 20 and the pulley 92 is provided on the side of the lateral arm 31 and these pulleys 91 and 92 are arranged symmetrically with respect to a plane crossing the pivotable arm 20 at the third axis. The wire rope 4L is led obliquely from one side of the pulley 91 to an opposite side of the pulley 92 as viewed in Fig. 2 and further led to the suspending pulley 38L provided at one end of the lateral arm 31 whereas the wire rope 4R is led obliquely from the other side of the pulley 91 to an opposite side of the pulley 92 and further led to the suspending pulley 38R provided at the other end of the lateral arm 31. The wire ropes 4L and 4R are supplied symmetrically with respect to a plane crosing the pivotable arm 20 at the third axis and, therefore, in the plan view of Figs. 2 and 5, the left and right wire ropes 4L and 4R cross each other at the third axis.

According to the dividing pulley mechanism 90, as the lateral arm 31 is rotated (i.e., as the holding unit 30 is rotated), the length adjusting pulley 92 on the lateral arm side moves along the circumeference of a circle whose ceter is the third axis and there occur change in the distance between the length adjusting pulley 91 on the pivotal arm side and the length adjusting pulley 92 on the lateral arm side and also change in amounts of engagement of the respective wire ropes 4 on the pulleys 91 and 92. However, a sum of amounts of engagement of the wire rope 4L on the pulleys 91 and 92 is equal to a sum of amounts of engagement of the wire rope 4R on the pulleys 91 and 92 and, therefore, when the holding unit 30 has been rotated, change in the length of the wire rope 4L is the same as change in the length of the wire rope 4R. Accordingly, there is no possibility of inclination of the outer wall working machine 40 due to difference in length between the wire ropes 4L and 4R.

The suspension support device 1 can hold the outer wall working machine 40 with its holding unit 30 and its movable body 10 can move along the rails 3. Further, as shown in Fig. 11, the suspension support device 1 can move the outer wall working machine 40 held by the holding unit 30 to a desired location in a horizontal plane within the reach of the pivotable arm 20 by rotation of the rotary body 12 about the first axis and pivotal motion of the pivotable arm 20 about the second axis and, further, can change the angle of the outer wall working machine 40 in a horizontal plane freely by rotation of the holding unit 30 about the third axis. By the arrangement according to which the holding unit 30 can be moved to a desired location within the reach of the pivotable arm 20, the suspension support device 1 can be used even in a case where the rails 3 are not laid along the outer wall surface 2B of the building 2 or there is an obstacle on the upper surface of the building 2. This broadens the scope of application of the suspension support device 1 made according to the invention.

The rotation drive unit for the rotary body 12 (i.e., the first axis motor 14), the rotation driving unit for the pivotable arm 20 (i.e., the second axis motor 22) and the rotation driving unit for the holding unit 30 (i.e., the third axis motor 36) are controlled by the control system as was previously described. Taking up and feeding out of the wire ropes 4 by the winding device 13 provided in the movable body 10 are also controlled by the control system.

The control system controls the respective drive units in accordance with a predetermined program as described above to cause the fitting and moving members 41 of the outer wall working machine 40 to engage

in the guide grooves 5 of the outer wall surface 2B and lower and lift the working machine 40 along the guide grooves 5 for performing work on the outer wall surface 2B.

The suspension support device 1 holding the outer wall working machine 40 is moved from its stand-by position along the rails 3 by driving the driving unit of the movable body 10 and stopped at a predetermined position. This stopping at a predetermined position is made by detecting a member to be detected provided on either one of the building 2 and the device 1 by a sensor provided on the other of the building 2 and the device 1.

Then the holding unit 30 is moved in a forward and rearward direction and also in a leftward and rightward direction by rotation of the rotary body 12 about the first axis and pivoting of the pivoting arm 20 about the second axis. The holding unit 30 is also rotated about the third axis to align the holding guides 32 with the guide grooves 5 of the building 2. This positioning of the holding unit 30 is performed in response to detection information of the outer wall surface 2B and the guide grooves 5 by the front and rearward position detection sensor and the left and right position detection sensor.

In the state where the holding guides 32 are aligned with the guide grooves 5, the winding device 13 is driven to lower the outer wall working machine 40. At this time, lowering of the outer wall working machine 40 causes unillustrated connecting members to project from the lower end of the holding guides 32 so that the holding guides 32 are connected with the guide grooves 5 in advance to movement of the fitting and moving members 41. By continuous lowering of the outer wall working machine 40, the outer wall working machine 40 reaches a position opposite to the outer wall surface 2B and starts work on the outer wall surface 2B.

As the outer wall working machine 40 continues the work and reaches the lower end of the building 2, the work and lowering by the outer wall working machine 40 are stopped and then the outer wall working machine 40 is lifted and held by the holding unit 30. The holding unit 30 is moved to a next work area by rotation of the rotary body 12, pivotable arm 20 and holding unit 30 and the above described positioning and subsequent processes are repeated to perform work on the outer wall surface 2B. Upon completion of work in an area within the reach of the pivotable arm 20, the entire device 1 is moved by driving of the movable body 11 and the positioning and subsequent processes are repeated.

Claims

1. A wire rope supply path length adjusting device for adjusting change in length of a wire rope supply path caused by pivoting of a pivotable arm in in a pivotable arm structure in which the pivotable arm is pivotably supported on a base member for suspending and supporting an object to be supported by means of wire ropes supplied from the base member throught the pivotable arm comprising:

   a pair of fixed pulleys of the same diameter provided rotatably about axes of rotation parallel to a rotation axis of said pivotable arm across the wire rope supply path at positions which are spaced from the rotation axis of said pivotable arm by a predetermined distance on the side of said base member; and

   a pair of movable pulleys of the same diameter provided rotatably about axes of rotation parallel to the rotation axis of said pivotable arm across the wire rope supply path at positions which are spaced from the rotation axis of said pivotable arm by a predetermined distance on the side of said pivotable arm,

   the wire ropes being caused to engage on the pulleys on the pivoting side among the respective pairs of pulleys and the diameters of the respective pairs of pulleys and the distances of the respective pairs of pulleys from the rotation axis of said pivotable arm being selected at values at which length of the wire rope supply path between the respective pairs of pulleys is maintained substantially constant regardless of change in an angle of rotation of said pivotable arm.

2. A wire rope supply path length adjusting device as defined in claim 1 wherein said object to be supported is suspended and supported at end portions thereof by said wire ropes, said wire ropes consist of two wire ropes arranged vertically and each of said pairs of fixed pulleys and movable pulleys respectively consists of two pulleys provided vertically corresponding to the two vertically arranged wire ropes.

3. A suspension support device for an outer wall working machine comprising:

   a movable base capable of moving on an upper surface of a building;

   a main body provided rotatably about a vertical first axis on said movable base;

   a winding device provided in the main body for taking up and feeding out wire ropes;

   a pivotable arm provided rotatably about a vertical second axis on said main body;

   a holding unit for holding an outer wall working machine provided rotatably about a vertical third axis in the foremost end portion of said pivotable arm, said holding unit suspending the wire ropes supplied from said winding device through said pivotable arm to suspend and support the outer wall working machine; and

   a wire rope supply path length adjusting device as defined in claim 2 provided in a wire rope supply path between said main body and said pivotable arm.

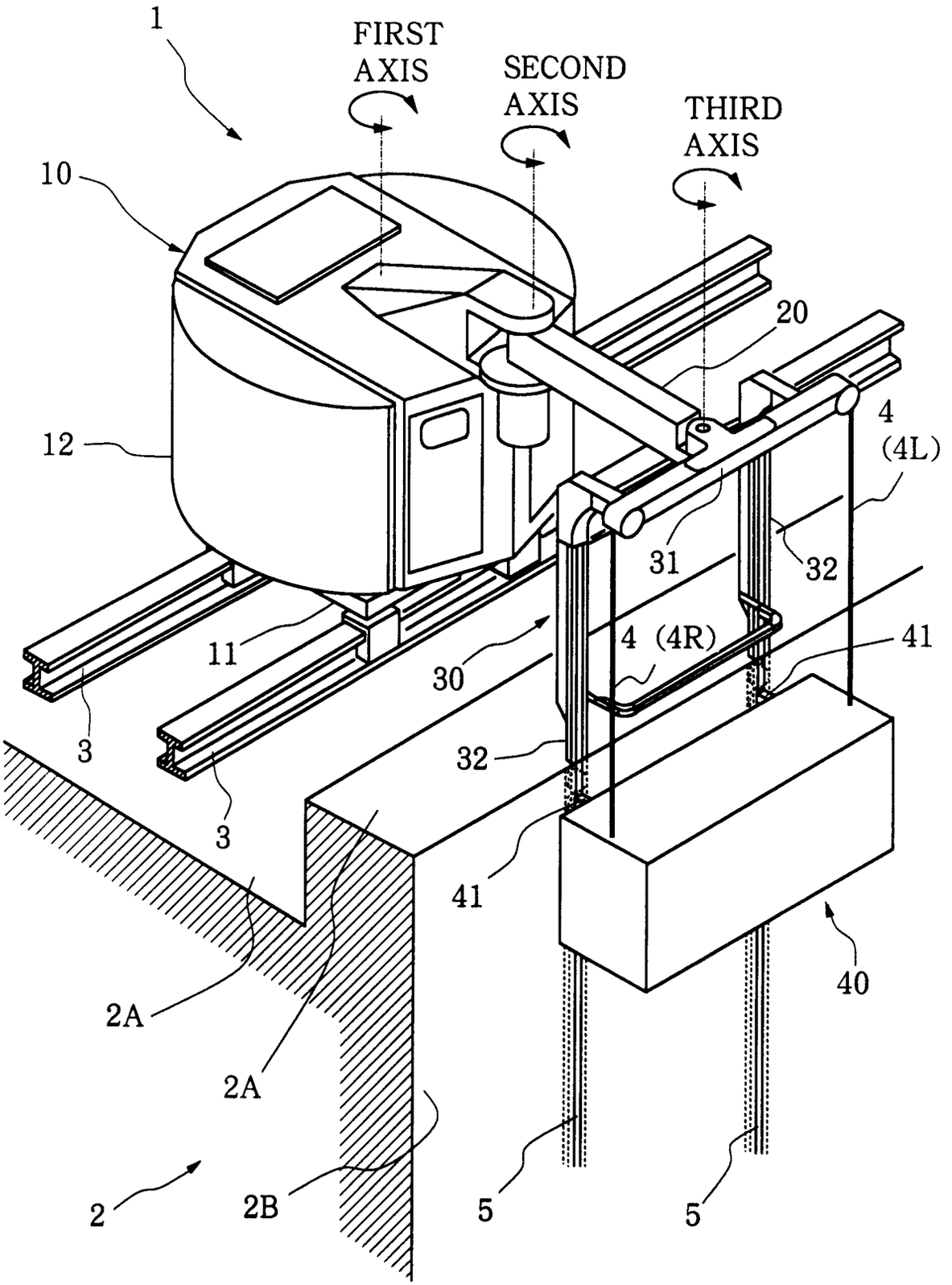
1
FIRST AXIS
SECOND AXIS
THIRD AXIS
10
20
12
4 (4L)
31
32
11
30
4 (4R)
41
3
3
32
41
40
2A
2A
2
2B
5
5

FIG. 1

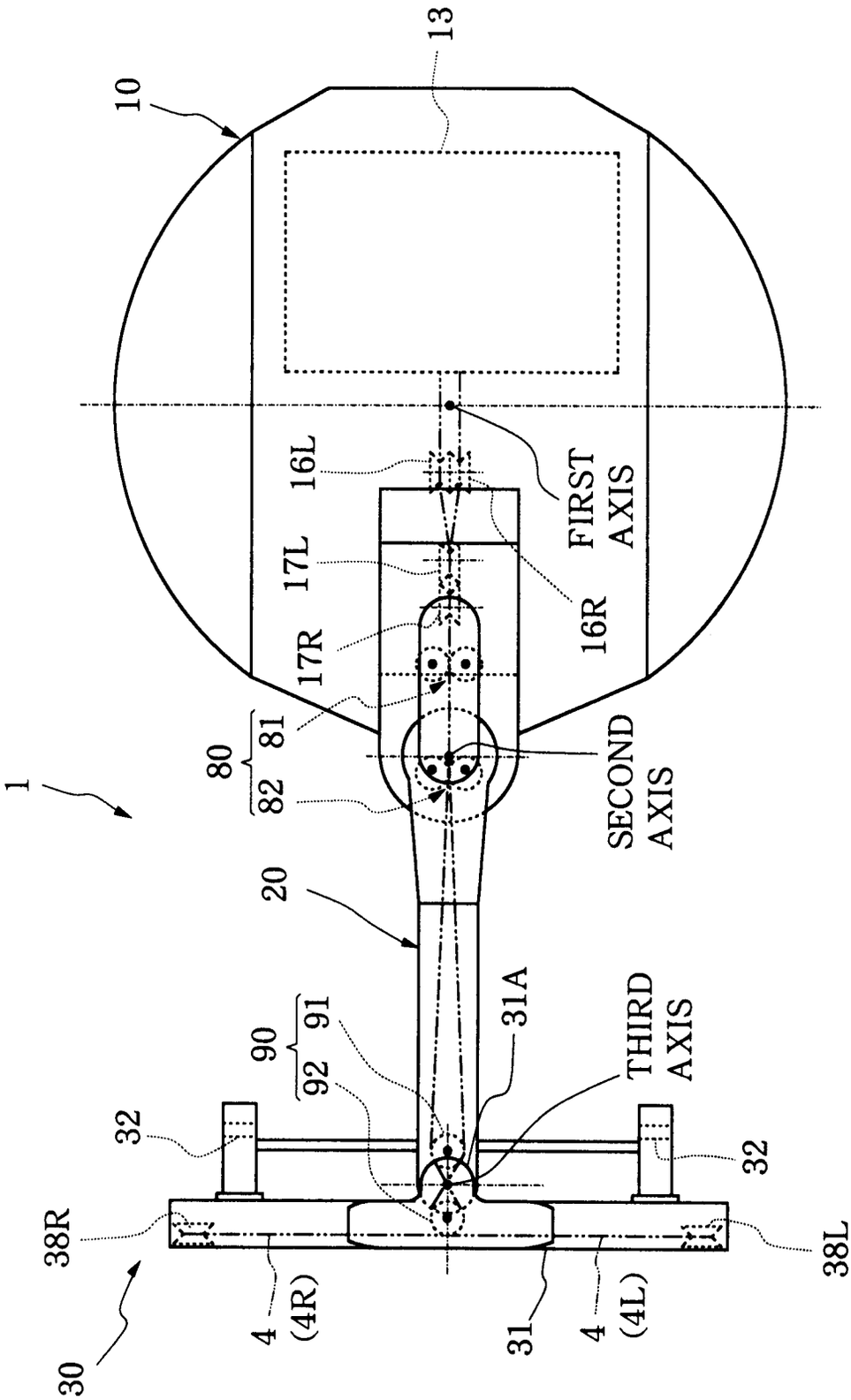
13
10
16L
FIRST AXIS
17L
16R
17R
80
81
82
SECOND AXIS
1
20
90
91
92
31A
THIRD AXIS
32
32
38R
38L
4 (4R)
4 (4L)
31
30

FIG. 2

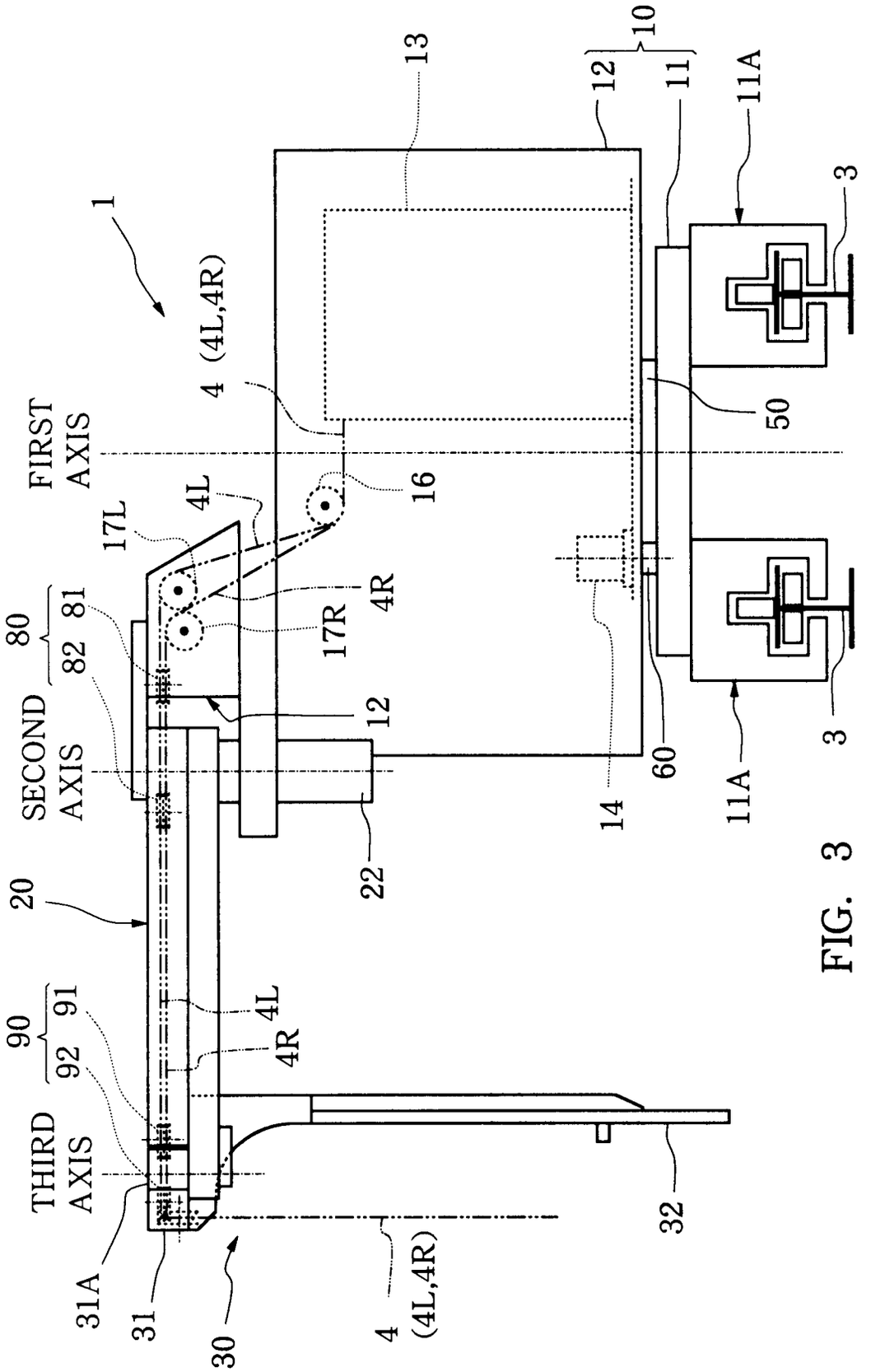
1
4 (4L,4R)
FIRST AXIS
SECOND AXIS
THIRD AXIS
80
81
82
90
91
92
20
30
31
31A
4
(4L,4R)
4L
4R
17L
17R
16
22
12
13
10
11
11A
3
50
60
14
32

FIG. 3

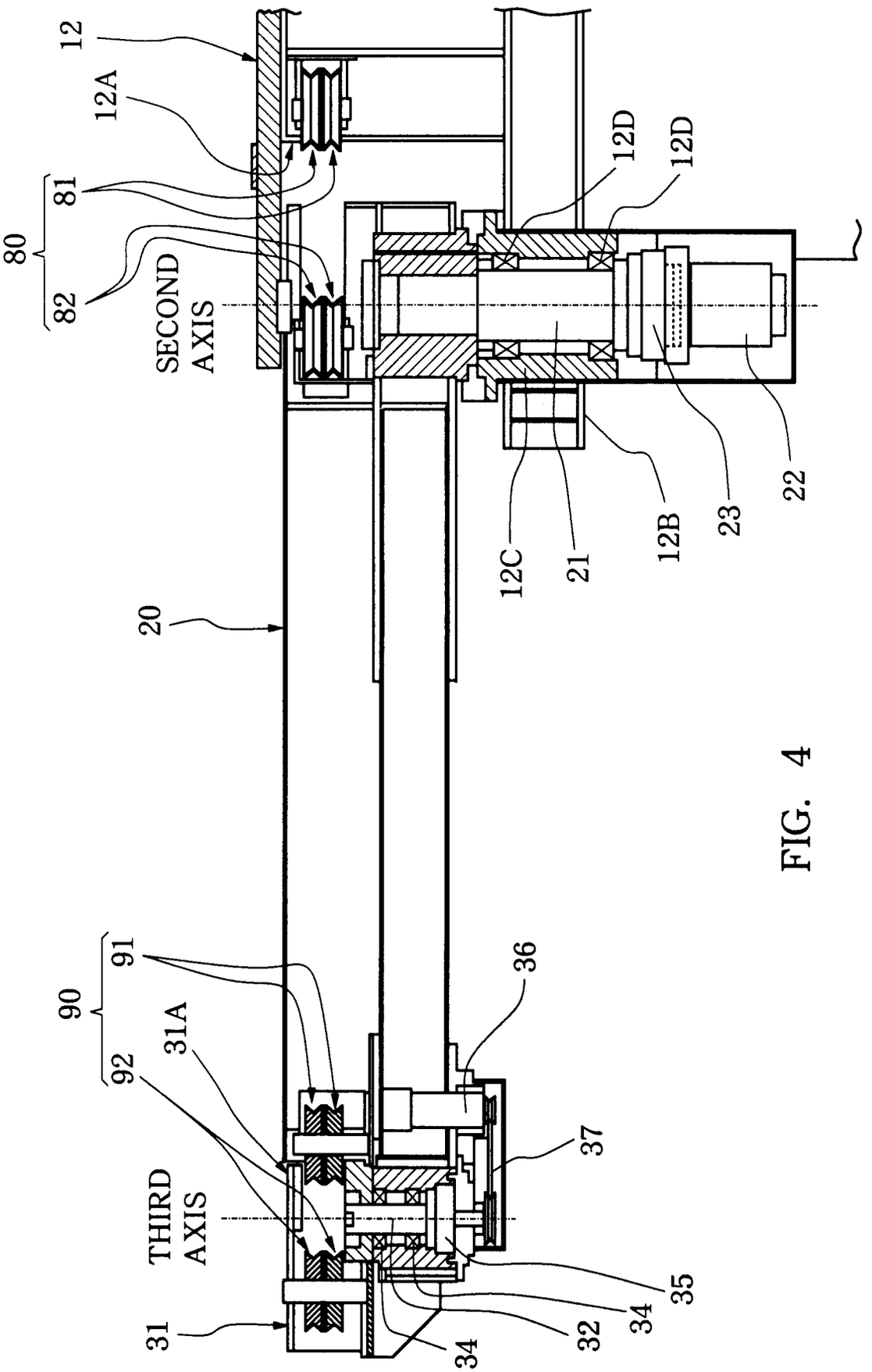
12
12A
81
80
82
SECOND AXIS
12D
12D
22
23
12B
21
12C
20
91
90
92
31A
36
37
THIRD AXIS
35
34
32
34
31

FIG. 4

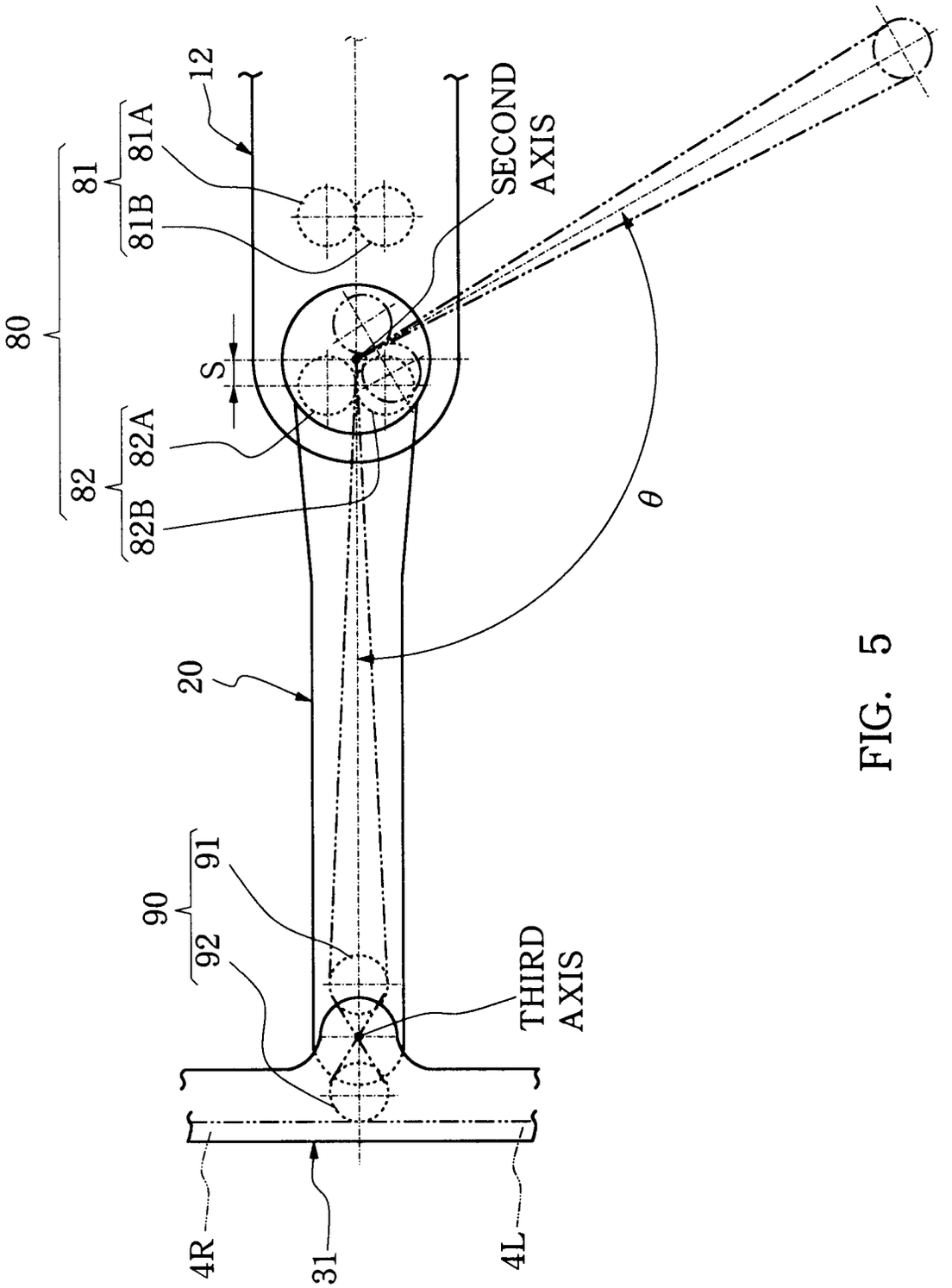
80
81
81A
81B
82
82A
82B
12
S
SECOND AXIS
θ
20
90
91
92
THIRD AXIS
4R
31
4L

FIG. 5

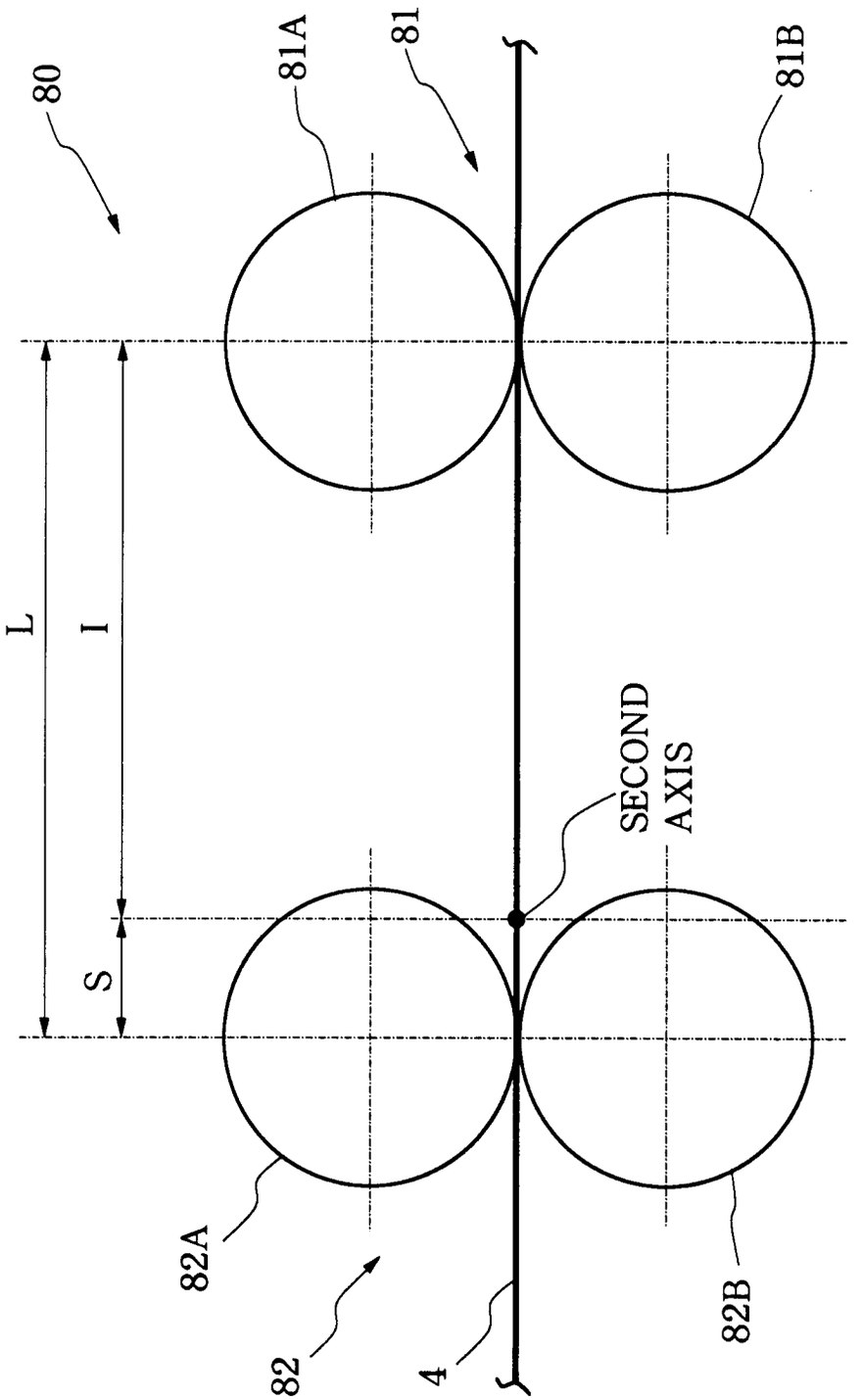

FIG. 6

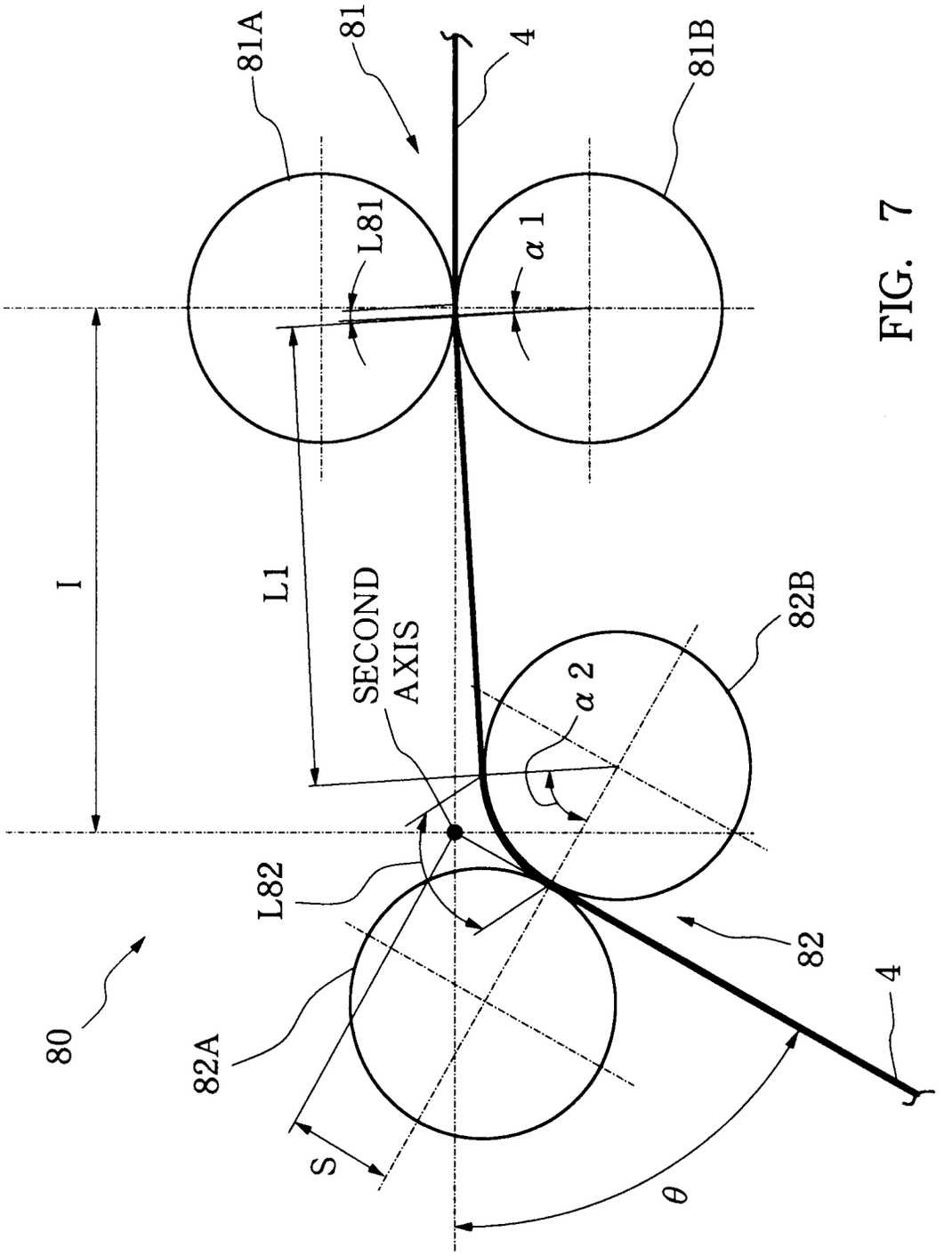

FIG. 7

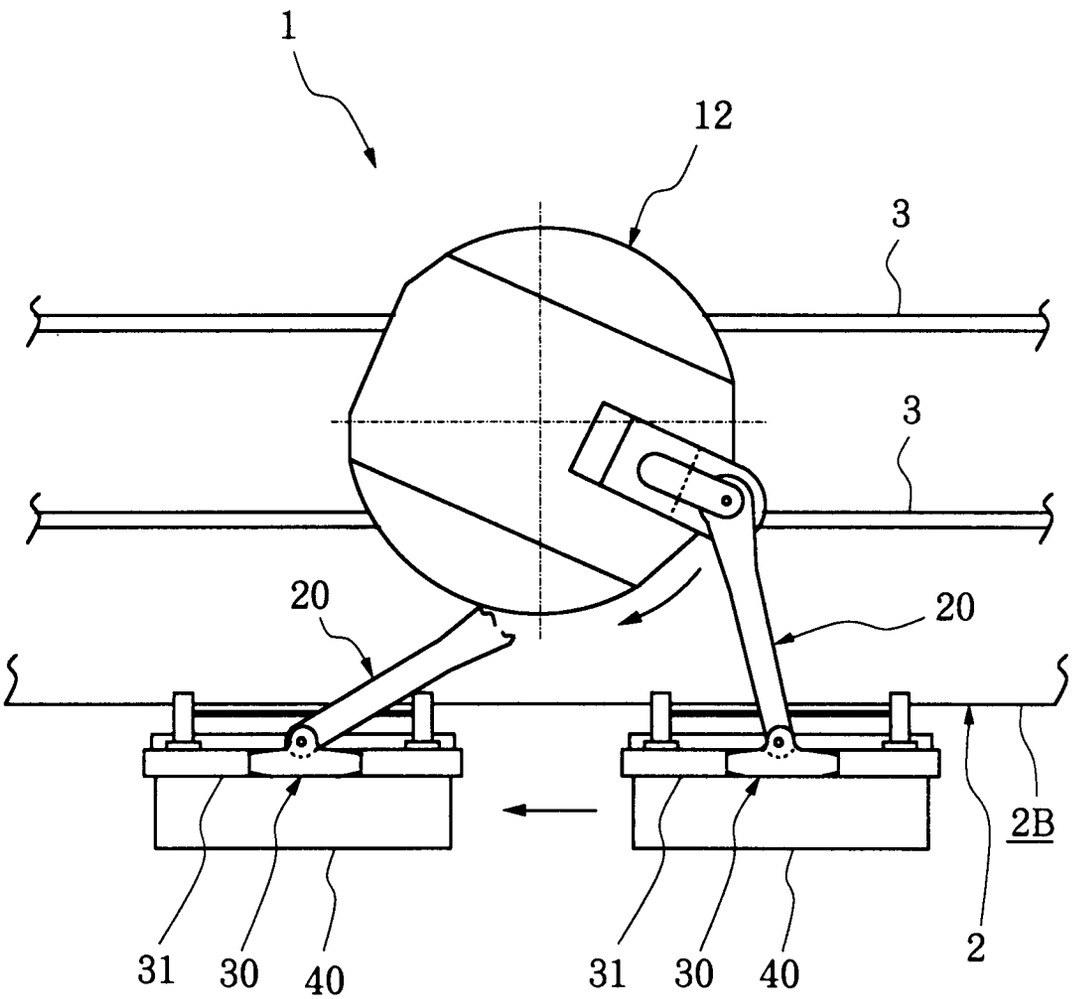

FIG. 8

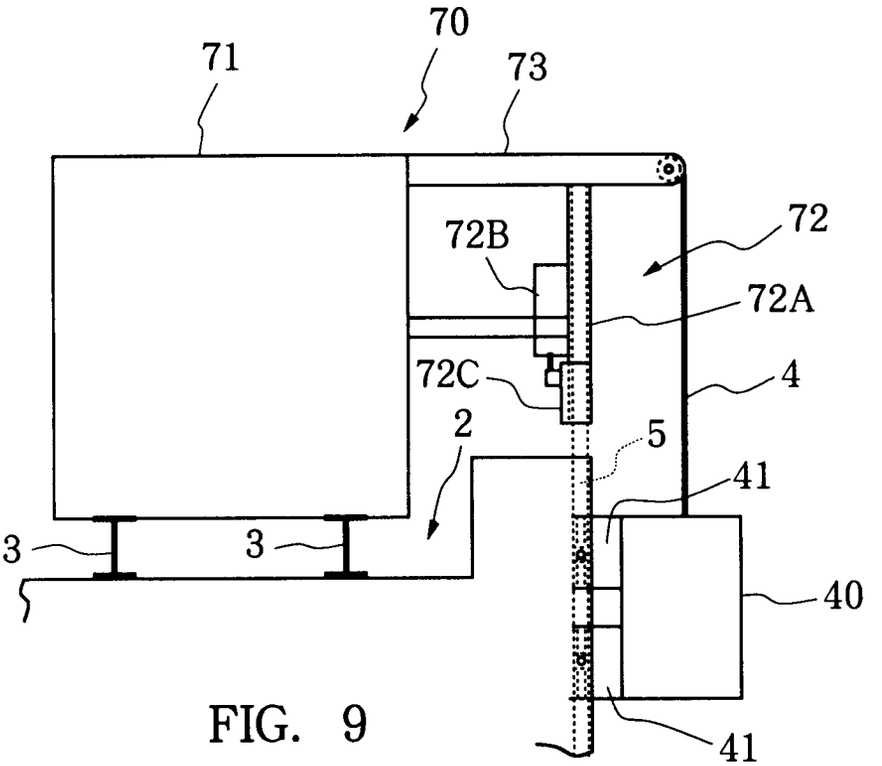

FIG. 9
PRIOR ART

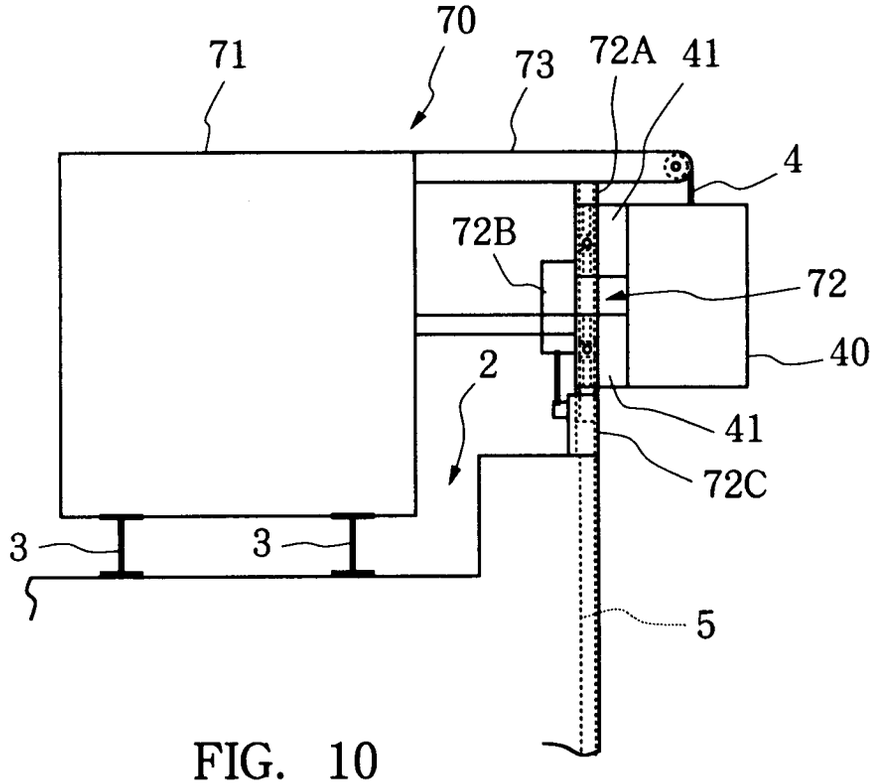

FIG. 10
PRIOR ART

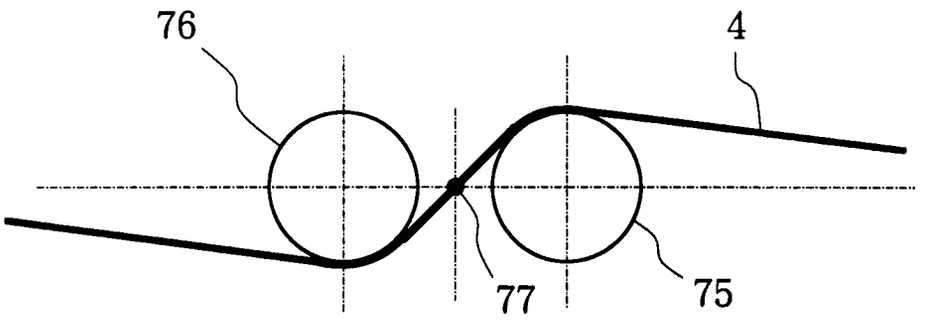

FIG. 11A

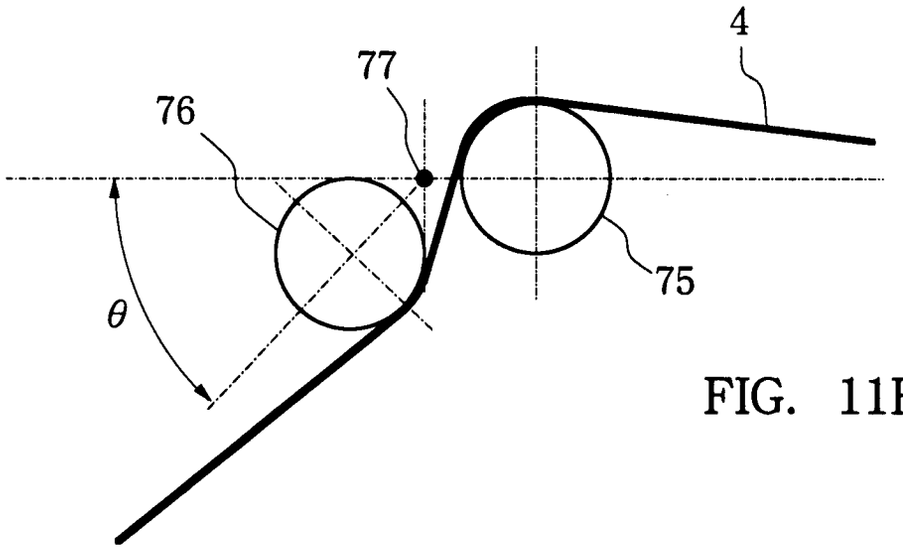

FIG. 11B

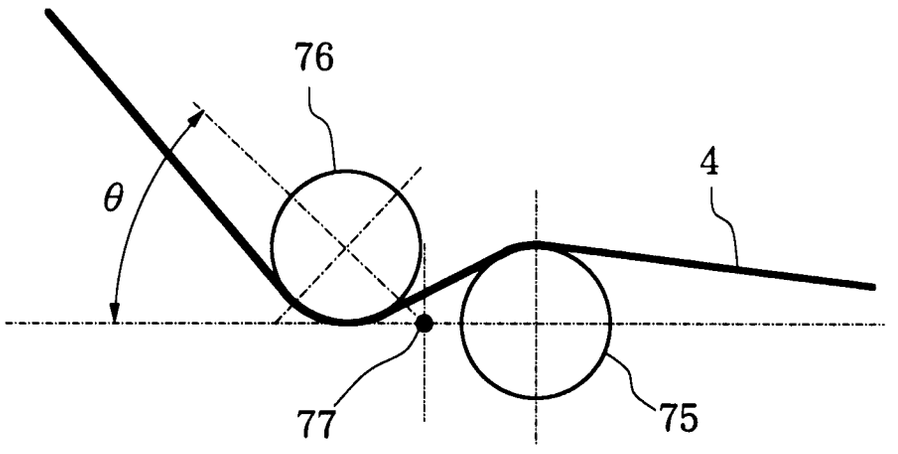

FIG. 11C

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 10 4753

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	FR 2 524 453 A (O ET K ORENSTEIN & KOPPEL) ---		E04G1/00 E04G3/00
A	US 3 803 656 A (HARSCO CORP.) ---		
A	EP 0 574 817 A (NIHON BISO) ---		
A	DE 44 12 681 A (SCHINDEHÜTTE) ---		
A	DE 92 04 034 U (MANNESMANN) ---		
A	DE 91 16 269 U (VOLLATH) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

E04G
B66C
A47L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 June 1997	Vijverman, W

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