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(54) Linear motor elevator.

(57) A linear motor elevator driven by a linear motor and elevated up and down in a hoistway, including a cage, a counterweight, and a hoisting mechanism having two ends by and from which the cage and the counterweight are respectively suspended so as to be alternatingly elevated up and down in the hoistway. the linear motor elevator further includes a secondary conductor pillar secured in the hoistway and a stator member secured to eight one of the cage and the counterweight at a position surrounding a portion of the secondary conductor pillar with a small gap therebetween. The stator member is composed of a plurality of tubular stators vertically linked and constituting a primary conductor of the linear motor. The linear motor elevator also includes a guide member secured to the stator member at the top and bottom thereof for guiding the elevation of the stator member in the hoistway and maintaining the gap. The linear motor is composed of the stator member and the secondary conductor pillar, and the cage and the counterweight are elevated up and down by an electromagnetic force acting between the stator member and the secondary conductor pillar.

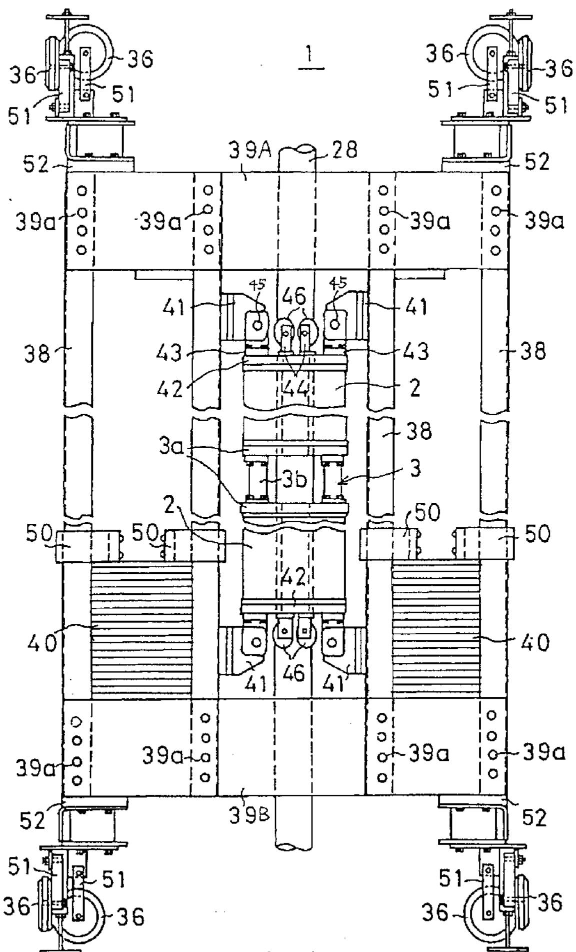

FIG. 1

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This invention relates to elevators, and more particularly to elevators that employ a linear electric motor as drive source.

In buildings equipped with elevators, in some cases, the height of the building is restricted by rights to daylight, so a machine room at the top of the hoistway cannot be allowed to project above the topmost floor of the building. In the case of such buildings, a hydraulic elevator is adopted, since this does not require a machine room at the top of the building.

In recent years however, elevators employing linear motors have been developed and are being practically used to some extent. In comparison with hydraulic elevators, such elevators have smaller power consumption, produce less noise, enable the travel to be increased, and enable the rated speed to be raised.

Fig. 7 of the accompanying drawings is a view showing a prior art elevator using such a linear motor an example of the hoistway on which this elevator is arranged. In Fig. 7, (b) is a side view and (a) is a cross-sectional view along the line A-A of Fig. 7(b).

In Fig. 7, at the top of an hoistway 24, there are arranged two pairs of channel-section steel beams 26. These pairs are arranged in the direction perpendicular to the plane of the paper in Fig. 7(a) and parallel to the plane of the paper in Fig. 7(b). Between each pair of beams 26, there are mounted a pair of sheaves 25, each freely rotatable on a shaft passing through the beams.

Below beams 26, there are arranged a pair of channel-section steel girders 29 larger than beams 26, arranged in the direction parallel to the plane of the paper in Fig. 7(a) and perpendicular to the plane of the paper in Fig. 7(b). A base 34 secured by means of anchor bolts, not shown, is provided in the pit of hoistway 24. Screw rods 33, each formed with a male screw-thread, at the top thereof, are fixed on base 34 such that the bottom ends of screw rods 33 are fixed on the left and on the right of the top face of this base 34 as shown in Fig. 7(a).

In hoistway 24, a cylindrical pillar 28 is erected under the pair of girders 29.

A mounting plate 30 welded to the top of cylindrical pillar 28 is fixed by means of bolts, not shown, to the undersurface of the pair of girders 29. It should be noted that, in Fig. 7, the external diameter of cylindrical pillar 28, is shown exaggerated relative to the other components such as beams 26 and girders 29. The middle of a bracket 31 is welded to the bottom end of cylindrical pillar 28.

The aforementioned screw rods 33 pass vertically through holes formed in the left and right ends of this bracket 31 as shown in Fig. 7(a), and coil springs 32 are freely fitted over the top ends of the screw rods 33. These coil springs 32 are compressed by seats 33b into which the top ends of screw rods 33 are inserted and nuts 33a threaded on to screw rods 33 from above.

As a result a downwardly directed tension force is applied to the lower end of Pillar 28 by means of bracket 31, thereby suppressing the bending that would be caused by a counterweight 22 that ascends and descends the hoistway 24 due to the electromagnetic force acting between itself and cylindrical pillar 28.

A pair of main ropes 23 are wound on respective pairs of sheaves 25 described above. At one end of these main ropes 23 there is suspended a cage 21. At the other ends of main ropes 23 there is suspended a counterweight 22. Guide rollers 36 are arranged, as will be described later with reference to Fig. 8, above and below this counterweight 22. These guide rollers 36 roll along one of the top face and both side faces of each of guide rails 37, respectively, which are arranged vertically along the wall of hoistway 24, facing both sides of counterweight 22.

Guide rollers, not shown, are also arranged above and below cage 21 respectively. These guide rollers roll along one of the top face and both side faces respectively of guide rails, not shown, vertically arranged in hoistway 24, facing both sides of cage 21.

A cylindrical stator 27, shown at the center of counterweight 22, will be described in detail with reference to Fig. 8.

Fig. 8 is a detail view, to a larger scale, showing counterweight 22 shown in Fig. 7. In Fig. 8, four steel uprights 38 are arranged vertically and in parallel. The upper and lower ends of these uprights 38 are fixed by bolts 39a respectively, to crossheads 39A and 39B provided transversely on the outside face of the upper and lower ends of these uprights 38.

In the lower part of counterweight 22, between left-side pair of uprights 38, and between the right-side pair of uprights, there are provided two stacks of weights 40 over crossheads 39B consisting of a plurality of sheets of soft steel plate. The upper ends of these weights 40 are pressed from above by pressing elements 50 each of which is clamped in the middle region of one of uprights 38, respectively.

Thick straps 52 are respectively welded to the central portions of the upper and lower ends of the pair of uprights 38 provided at the left and right ends. In the middle region of each of these straps 52 in the direction perpendicular to the plane of the paper, the bottom ends of three levers 51 are fixed by bolts through mounting bases. At the top ends of these three levers 51, there are respectively mounted three guide rollers 36, described above with reference to Fig. 7.

Cylindrical pillar 28 passes vertically through the central part of a space defined by the two central uprights 38. A cylindrical stator 27 supported by pressing elements 41, to be described later, is freely coaxially fitted over the outside of cylindrical pillar 28 with a predetermined small gap therebetween.

Annular roller bases 42 are fixed by a plurality of bolts to the respective upper and lower end faces of stator 27. U-shaped roller bearings 44 are fixed in radially symmetrical manner in plan view on the outer faces of these roller bases 42. Rollers 46 are freely fitted in these roller bearings 44. Each roller 46 is freely rotatably supported and pressed against cylindrical pillar 28, by means of a roller shaft passing through roller bearings 44 and bearings, not shown, that press on this roller shaft.

A pair of T-shaped fixing elements 43 are symmetrically provided to the left and right respectively on the outer faces of roller bases 42, and are fixed by means of bolts to roller bases 42. The tips of fixing elements 43 are respectively freely fitted with the tips of fixing elements 41 which are fixed to uprights 38, and are respectively fixed to fixing elements 41 by stepped screw-threaded pins 45 passing through fixing elements 41.

These roller bearings 44 and stator 27 are assembled by means of a jig in which a tube is assembled beforehand having the same diameter as that of cylindrical pillar 28 before assembly with counterweight 22. Assembly is effect by find adjustment of the position of rollers 46 along the roller shaft which is inserted into these rollers 46, such that the internal circumference of stator 27 and cylindrical pillar 28 are coaxial.

With a linear motor elevator constructed as above, eddy current flows in the surface of cylindrical pillar 28 due to the magnetic flux generated by excitation of the stator winding, not shown, which is mounted on the inner circumference of stator 27. Stator 27 is driven by the electromagnetic force produced by the magnetic flux of the stator winding and this eddy current, causing counterweight 22, on which the stator 27 is fixed, to be raised or lowered relative to the pillar 28. When this happens, cage 21 is also lowered or raised, so that the elevator is put into operating condition.

However, in the conventional linear motor elevator with the stator constructed in this way, when the rated load to be carried by the elevator is increased, there is a proportionate increase in the length of stator 27. When this happens, there is a risk that a middle portion 28a of cylindrical pillar 28 surrounded by stator 27 flexes due to the electromagnetic force between cylindrical pillar 28 and stator 27. This alters the gap between stator 27 and cylindrical pillar 28 and thereby alters the characteristic of the drive force acting on stator 27, causing impairment of the prescribed running performance, with the possibility that this will obstruct speed control of the elevator.

Consideration has therefore been given to the method of reducing the amount of such flexing due to the electromagnetic force by raising stiffness by increasing the external diameter of cylindrical pillar 28. However, if this is done, both the internal and external diameters of the stator must be increased. Consequently, in order to obtain the desired drive force, the excitation current of the stator must be increased. This increases power consumption and-so reduces the characteristic advantage described above of using a linear motor elevator.

Furthermore, at the inner portion of stator 27, it is very difficult to make a gap between stator 27 and cylindrical pillar 28 exactly to a predetermined value.

Direct visual checking of the gap can be carried out only at the top and bottom portions of stator 27. When there is an increase in the length of stator 27 due to the increase of rated load to be carried, a risk arises that the difference between the actual gap and the predetermined value may increase.

A further aspect is that the propulsive force of the stator has to be designed and manufacture of the stator has to be carried out taking into consideration the rating of the cage every time. This increases the types of stator. Furthermore, the stator has to be manufactured for each order, so that the manufacturing equipment also is individual or corresponds to small lots. Manufacture of the stator therefore takes much time and costs for the manufacture are increased.

For this reason, consideration has therefore been given to the method of decreasing the number of types of stator and applying these stators to cages even in the case that the loading of the cages are below the rated loading determined by the stator. However, if this is done, when a stator is combined with a cage of the minimum rating, efficiency is lowered.

Furthermore, since, if the rated loading is increased and the stator length has to be made longer, there is a risk of difficulties being caused in the assembly operation in respect of transportation and installation.

Accordingly, an object of this invention is to provide a linear motor elevator wherein flexing of a secondary conductor due to the electromagnetic force acting between the secondary conductor and a stator can be avoided.

Another object of this invention is to provide a linear motor elevator wherein the difference between the actual gap between a secondary conductor and stator and a predetermined value can be reduced.

Still another object of this invention is to provide a linear motor elevator which is easy to manufacture without lowering the running efficiency of the elevator.

These and other objects of this invention can be achieved by providing a linear motor elevator driven by a linear motor and elevated up and down in a hoistway, including a cage, a counterweight, and a hoisting mechanism having two ends by and from which the cage and the counterweight are respectively suspended so as to be alternatingly elevated up and down in the hoistway. The linear motor elevator further includes a secondary conductor pillar secured in the hoistway and a stator member secured to either one of the cage ad the counterweight at a position surrounding a portion of the secondary conductor pillar with a small gap therebetween. The stator member is composed of a plurality of tubular stators vertically linked and constituting a primary conductor of the linear motor. The linear motor elevator also includes a guide member secured to the stator member at the top and bottom thereof for guiding the elevation of the stator member in the hoistway and maintaining the gap. The linear motor is composed of the stator member and the secondary conductor pillar, and the cage and the counterweight are elevated up and down by an electromagnetic force acting between the stator member and the secondary conductor pillar.

According to one aspect of this invention there can be provided a linear motor elevator driven by a linear motor and elevated up and down in a hoistway, including a cage, a counterweight, and a hoisting mechanism having two ends by and from which the cage and the counterweight are respectively suspended so as to be alternatingly elevated up and down in the hoistway. The linear motor elevator further includes a secondary conductor pillar secured in the hoistway and a stator member secured to either one of the cage and the counterweight at a position surrounding a portion of the secondary conductor pillar with a small gap therebetween. The stator member is composed of a plurality of tubular stators vertically linked and constituting a primary conductor of the linear-motor. The linear motor elevator also includes a guide member secured to the stator member at the top and bottom thereof and between the tubular stators for guiding the elevation of the stator member in the hoistway and maintaining the gap. The linear motor is composed of the stator member and the secondary conductor pillar, and the cage and the counterweight are elevated up and down by an electromagnetic force acting between the stator member and the secondary conductor pillar.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein;

Fig. 1 is a front view showing a main part of a linear motor elevator according to an embodiment of this invention;

Fig. 2 is a front view showing a main part of a linear motor elevator according to another embodiment of this invention;

Fig. 3 is a front view showing a main part of a linear motor elevator according to a further embodiment of this invention:

Fig. 4 is a front view showing a main part of a linear motor elevator according to still another embodiment of this invention;

Fig. 5 is a front view showing a main part of a linear motor elevator according to a further embodiment of this invention;

Fig. 6 is a front view showing a main part of a linear motor elevator according to another embodiment of this invention;

Fig. 7 is a view showing a prior art linear motor elevator; and

Fig. 8 is a front view showing a main part of a linear motor elevator shown in Fig. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, the embodiments of this invention will be described below.

Specifically, in Fig. 1, between a pair of uprights 38 that are vertically arranged in the central region, of a counterweight 1, a pair of short stators 2 whose length is approximately one half of that of the stator 27 shown in Fig. 8 and whose propulsive force is also approximately one half are fitted freely in a vertically symmetrical manner and coaxially with cylindrical pillar 28.

Before assembly of these stators 2 on uprights 38 of counterweight 1, these stators 2 are assembled such that the axes of the inner circumferences of two stators 2 are on the same axis line, by means of linking elements 3, to be described later.

These linking elements 3 are constituted by annular end plates 3a and a pair of spacing plates 3b. Each of end plates 3a has the same configuration as that of roller base 42. End plates 3a are respectively fixed by a plurality of bolts to the lower and upper end faces of upper stator 2 and lower stator 2. Each of spacing plates 3b is approximately I-shaped with its upper and lower flanges. Spacing plates 3b are arranged between facing planes of these end plates 3a and with their upper and lower flanges fixed to end plates 3a by bolts.

The linear motor elevator constructed as shown in Fig. 1 can be operated the same as the prior art linear motor elevator shown in Figs. 7 and 8. In addition, as two short stators 2 are linked by means of linking elements 3, it is possible to confirm the gap between stator 2 and cylindrical pillar 28 at the lower end of upper stator 2 and at the upper end of lower stator 2. In case of stator 27 shown in Fig. 8, it is impossible to confirm visually the gap between stator 27 and cylindrical pillar 28 at cental portion 28a. So, the assembly of two stators 2 on uprights 38 of counterweight 1 shown in Fig. 1 can be carried out with higher precision than the assembly of stator 27 on uprights 38 of counterweight 22 shown in Fig. 8.

With a linear motor elevator constructed in this way, let us consider the case where a stator is to be assembled in the counterweight, which requires a propulsive force of about one half of counterweight 22 of Fig. 8. In this case, only one of stators 2, for example, lower stator 2 in Fig.1 is used and a roller base 42 is fixed by a plurality of bolts to the upper end face of lower stator 2 instead of end plate 3a. Roller base 42 is fixed to uprights 38 by means of fixing elements 41, fixing elements 43 and pins 45, and also presses cylindrical pillar 28 by means of roller bearings 44 and rollers 46, as described in the prior art. Consequently, the number of types of stators 2 can be decreased according to this embodiment.

Fig. 2 is a front view showing a main part of a linear motor elevator according to another embodiment of this invention. It should be notes that, in Fig. 2, guide rollers 36 shown at the upper and lower ends of Fig. 1 and the mounting portions of these guide rollers 36 are omitted to save space on paper.

Fig. 2 shows the case where this invention is applied to an elevator in which a rating of 1.5 times the propulsive force of balancing weigh 1 shown in Fig. 1 is required. In this case three of stators 2 shown in Fig. 1 are serially linked, and linkage between stators 2 positioned at the upper and lower ends and top and bottom ends of stator 2 positioned in the middle are achieved by linking elements 3, respectively.

In this case also, linkage between each stator 2 and linking elements 3 is performed by means of a jig, not shown, before assembly with the counterweight. After confirming that each stator 2 is coaxial, combination and overlapping positions on assembly of stators 2 with linking elements 3 are marked and the assembly is then dismantled: the counterweight can then be reassembled at the installation site of the elevator. This facilitates transportation of stators 2, and also facilitates the operation of installation of the counterweight within the hoistway. It may be noted that although in Fig. 2 the case was described where three stators 2 were linked together, the number to be linked could be four or five or another number depending on the rating of the elevator cage.

Fig. 3 is a front view showing a main part of a linear motor elevator according to a further embodiment of this invention, and illustrates the case where stators of different length are assembled and linked. In Fig. 3, the length of stator 2A is two times that of stator 2. In this case, the linear motor elevator can be operated the same as that of Fig. 2. Furthermore, there is the advantage that, compared with the counterweight shown in Fig. 2, the centering time can be shortened, by reducing the number of stators.

Fig. 4 is a front view showing a main part of a linear motor elevator according to still another embodiment of this invention. It shows the case where rollers 46 are added between the pair of stators 2, in comparison with the counterweight shown in Fig. 1.

Specifically, in Fig. 4, roller bearings 44 shown in Fig. 8 are arranged hanging down symmetrically and radially from end plate 3a of upper stator 2. Each of rollers 46 that is inserted, through pins, not shown, at the tip of these roller supports 44, contacts the outer circumference of cylindrical pillar 28 in radial fashion. Thus, each roller 46 is freely rotatably supported and is pressed against cylindrical pillar 28. In this case, the linear motor elevator can be operated the same as that of Fig. 1. Furthermore, in this case, flexing of the cylindrical pillar 28 can be further reduced in comparison with the case of the counterweight shown in Fig. 1.

Fig. 5 is a front view showing a main part of a linear motor elevator according to a further embodiment of this invention, and is a view corresponding to Fig. 2. In Fig. 5, three of the stators 2 assembled in Fig. 4 are linked together. Fig. 5 shows the case where the stators are applied to an elevator that requires a propulsive force of 1.5 times that needed for the counterweight shown in Fig. 4.

Thus, irrespective of the load of the cage of the elevator, flexing of the cylindrical pillar 28 can be prevented and transportation and assembly facilitated, by subjecting cylindrical pillar 28 to pressure by rollers 46 mounted on roller bearings 44 provided on linking elements 3.

Fig. 6 is a front view showing a main part of a linear motor elevator according to another embodiment of this invention. This is an example in which flexing of cylindrical pillar 28 within the stators having an increased linkage length is prevented by the addition of rollers 46 between stator 2A and stator 2 of the counterweight shown in Fig. 3.

Thus, when the range over which the electromagnetic force acts becomes long by linkage of stators to deal with increase in cage rating, stators of only a few different types of lengths can cope with cages of many different ratings, by linking stators of different length and inserting rollers at this linkage part. The prescribed propulsive characteristic can therefore be obtained without difficulty.

In the embodiments shown in Figs. 4, 5 and 6, rollers are arranged at the bottom of upper and intermediate stator. But this invention is not limited to these embodiments. Rollers may be arranged at the top of lower and intermediate stator.

It should be noted that, although, in the embodiments described above, the case has been described where a cylindrical pillar and stators are provided on the counterweight side, this invention could likewise be applied in exactly the same way to the case where they are provided on the cage side.

With a linear motor elevator constructed in this way, the propulsive force of the linear motor elevator can be coped with by the number of stators linked vertically.

According to a linear motor elevator of this invention, the assembly of the stators on the uprights can be carried out with a higher precision than the prior art.

According to a linear motor elevator of this invention, rollers for maintaining the gap between the inside face of the stators and the secondary conductor pillar are provided between the stators.

Accordingly, a linear motor elevator that is easy to manufacture without lowering the running efficiency of the elevator can thereby be obtained.

Furthermore, the difference between the actual gap between the secondary conductor pillar and the stator and the predetermined value can be reduced.

As the bending of the secondary conductor pillar can be avoided, so the flexing of the secondary conductor pillar due to the electromagnetic force acting between the secondary conductor pillar and the stators can be prevented.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

Claims

1. An elevator comprising a cage (21) and a counterweight (22) connected together by hoisting means (23) and suspended thereby in a hoistway (24), and a linear electric motor for raising and lowering the cage in the hoistway;

said motor comprising a secondary conductor pillar (28) mounted in the direction of the hoistway,

stator means (27) surrounding the pillar (28) with a small gap therebetween, guide means (46) at the upper and lower ends of the stator means for guiding the stator means relative to the pillar (28) to maintain the gap therebetween and said stator means being secured to either the cage (21) or the counterweight (22) whereby in use electromagnetic forces acting between the stator means and the secondary conductor pillar cause relative movement between the stator means and the cage or counterweight which is secured to it and the pillar in the direction of the length of the pillar;

characterised in that said stator means comprises a plurality of tubular stators (2,2a) connected in end to end relation.

2. An elevator as claimed in claim 1 characterised in that said stator means comprises a plurality of tubular stators (2) of the same configuration.

3. An elevator as claimed in claim 1 characterised in that said stator means comprises tubular stators of at least two different configurations.

4. An elevator as claimed in claim 3 characterised in that the stators are of one unit and two units of length respectively.

5. An elevator as claimed in any preceding claim characterised in that guide means (46) are provided between adjacent tubular stators (2,2a).

6. A linear motor elevator driven by a linear motor and elevated up and down in a hoistway, comprising:

a cage;

a counterweight;

hoisting means having two ends by and from which said cage and said counterweight are respectively suspended so as to be alternatingly elevated up and down in said hoistway;

a secondary conductor pillar secured in said hoistway;

stator means secured to either one of said cage and said counterweight at a position surrounding a portion of said secondary conductor pillar with a small gap therebetween;

said stator means being composed of a plurality of tubular stators vertically linked and constituting a primary conductor of said linear motor; and

guide means secured to said stator means at the top and bottom thereof for guiding the elevation of said stator means in said hoistway and maintaining said gap;

said linear motor being composed of said stator means and said secondary conductor pillar; and

said cage and said counterweight being elevated up and down by an electromagnetic force acting between said stator means and said secondary conductor pillar.

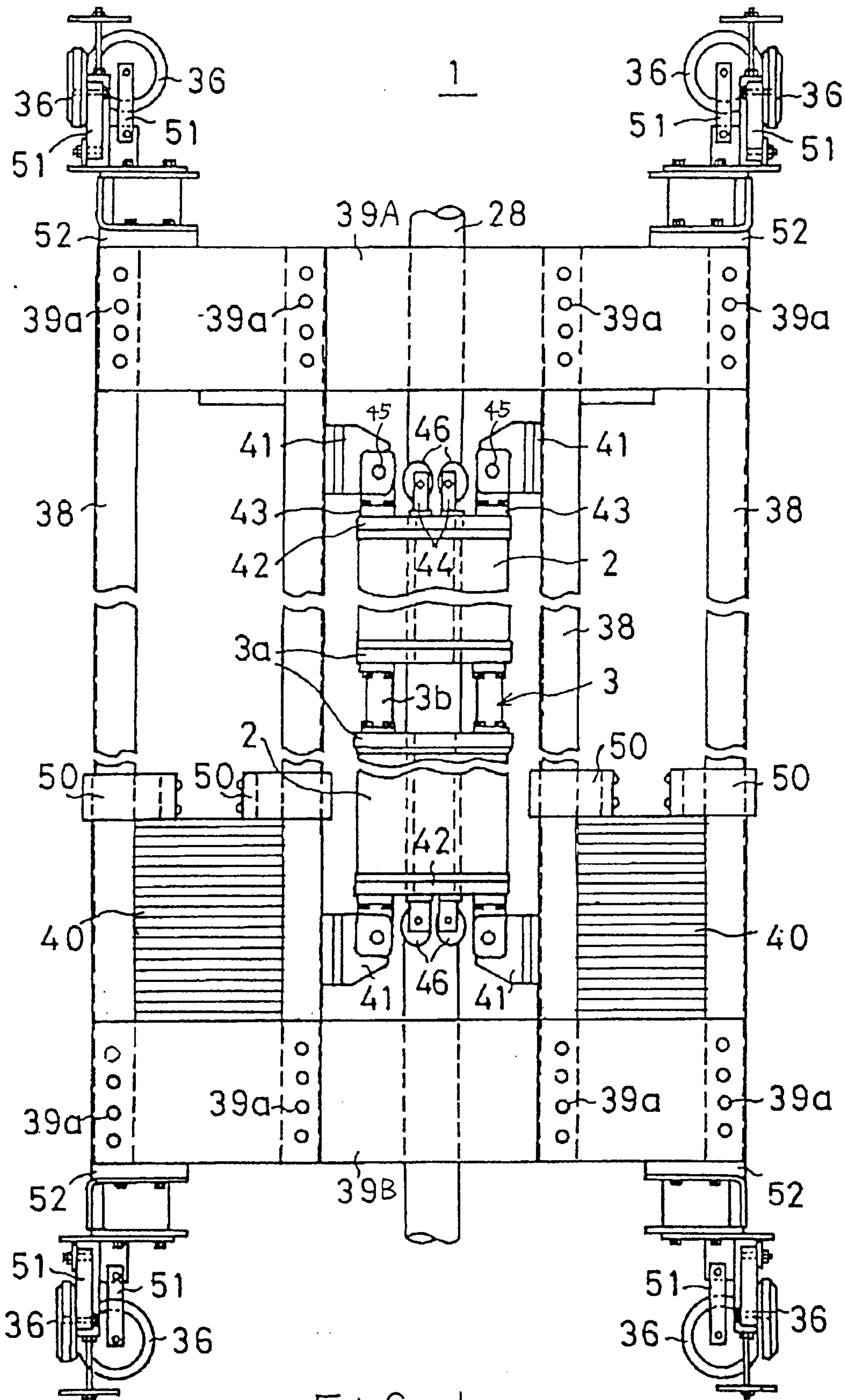
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FIG. 1

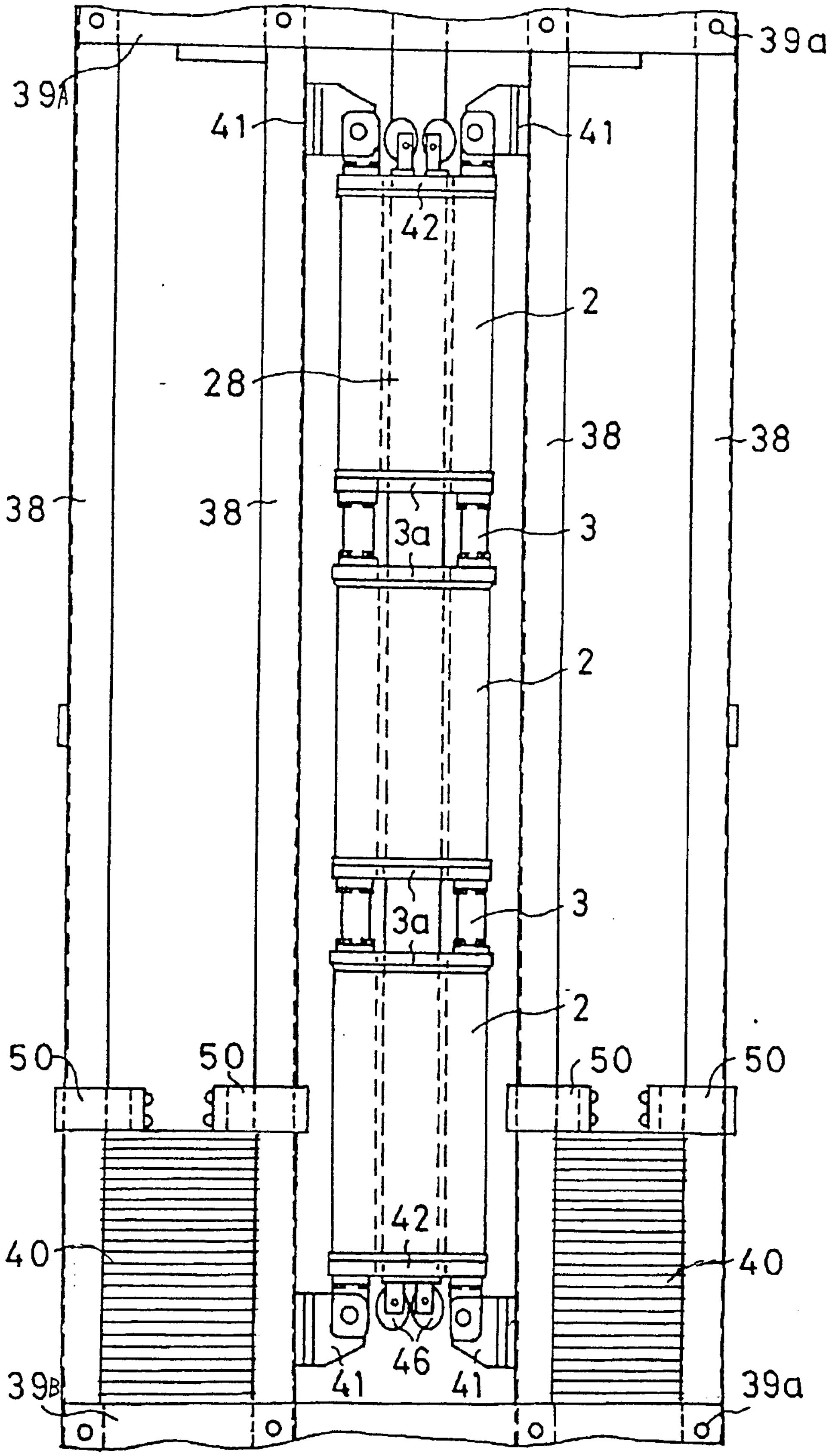
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FIG.2

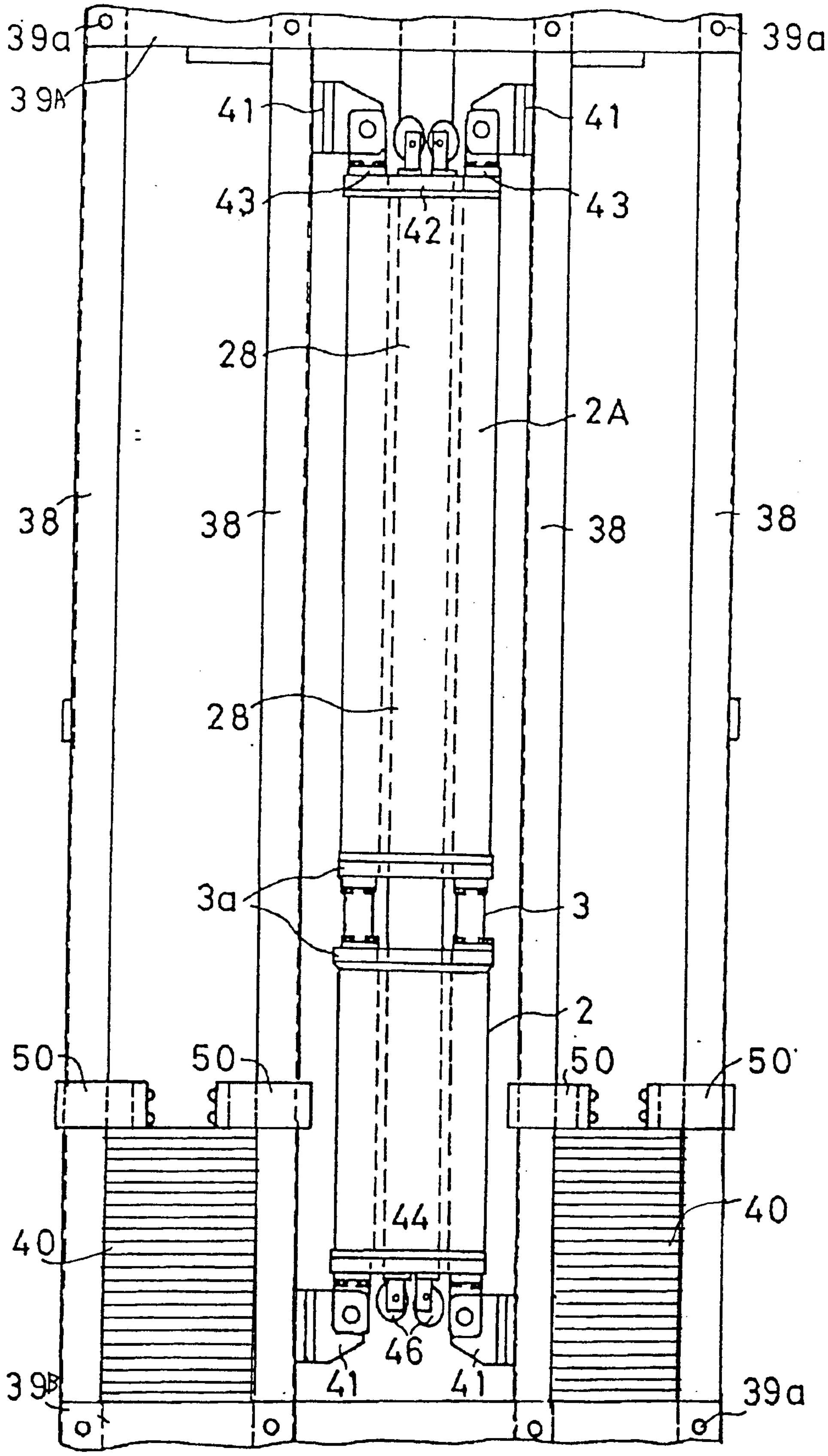
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FIG.3

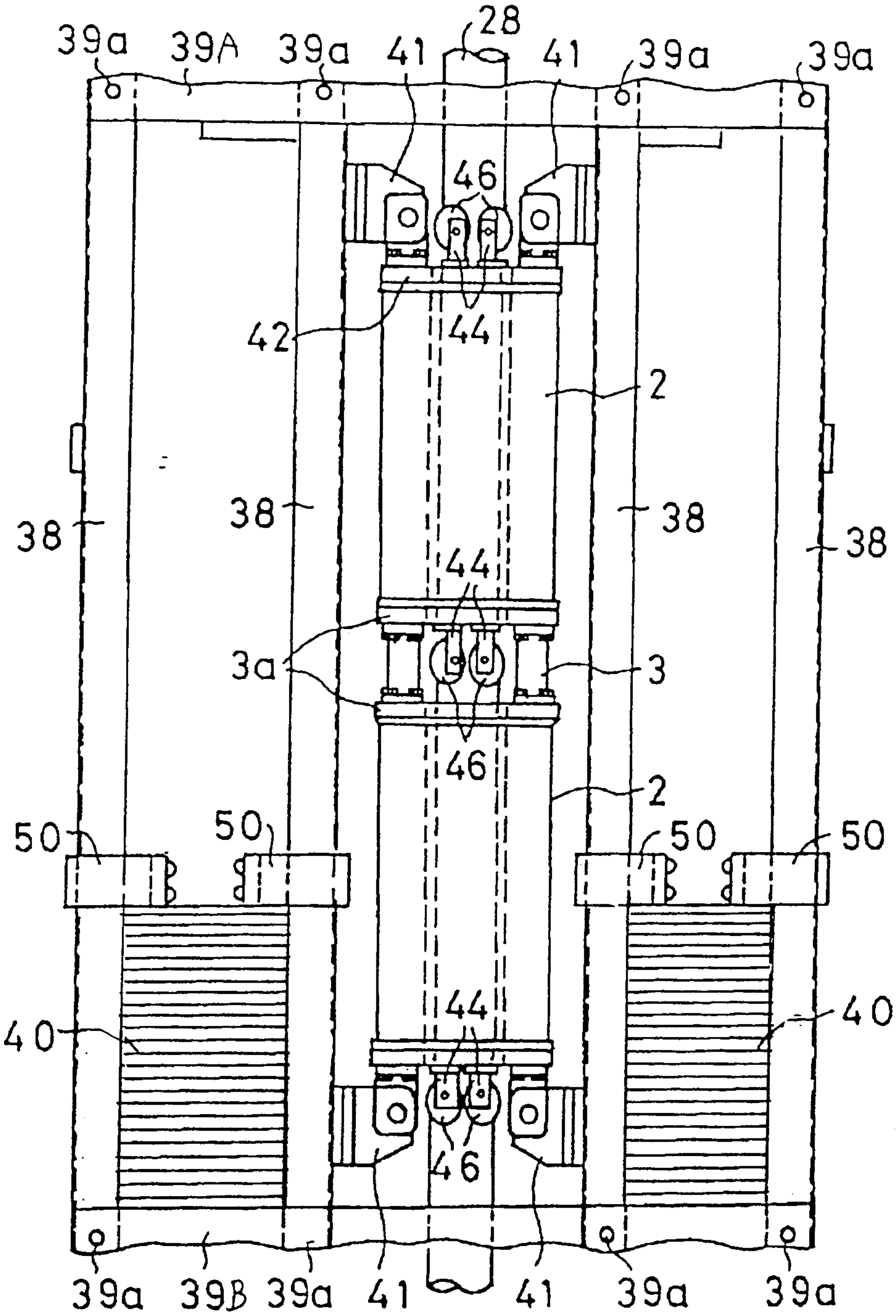
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FIG. 4

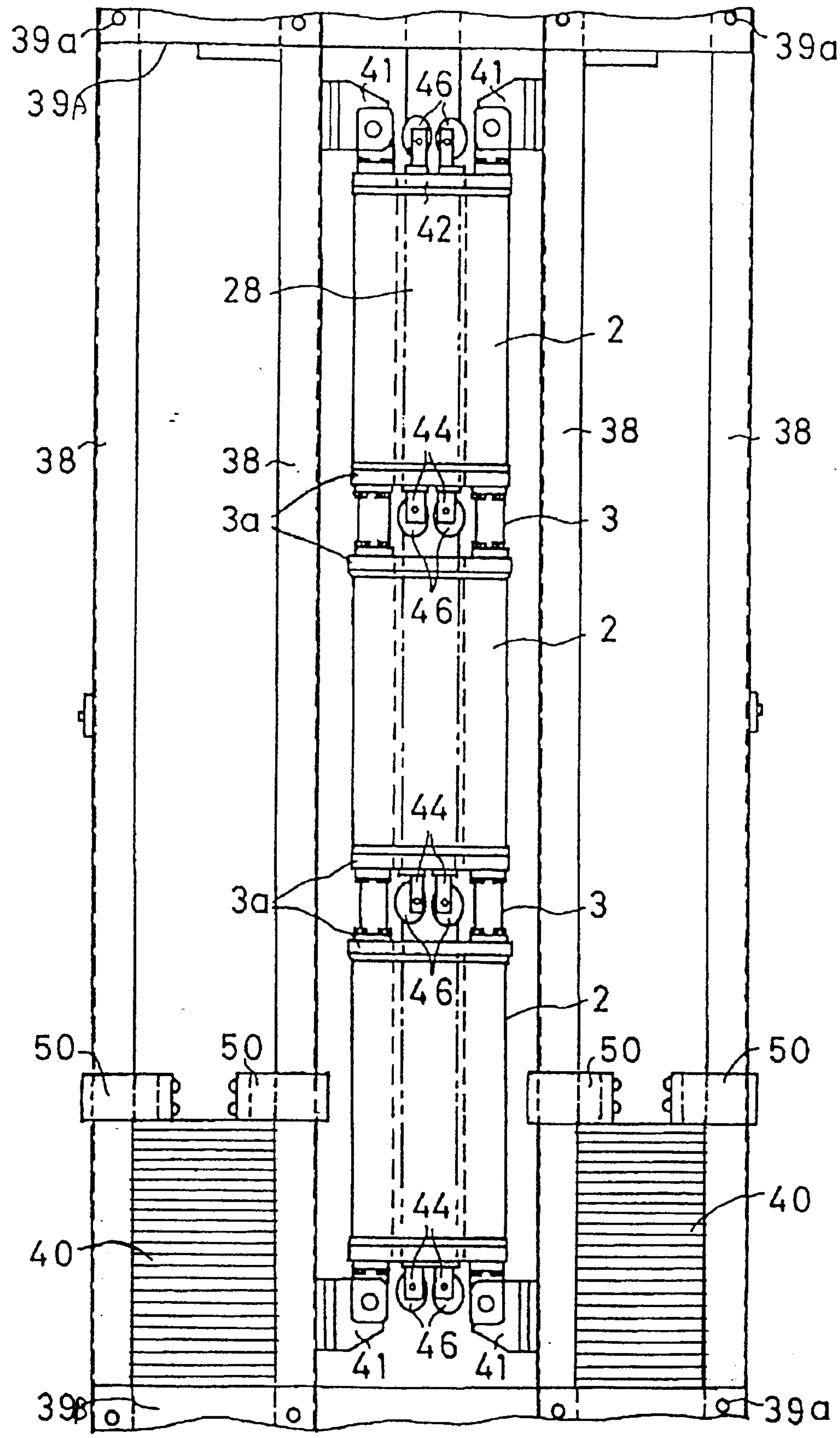
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FIG. 5

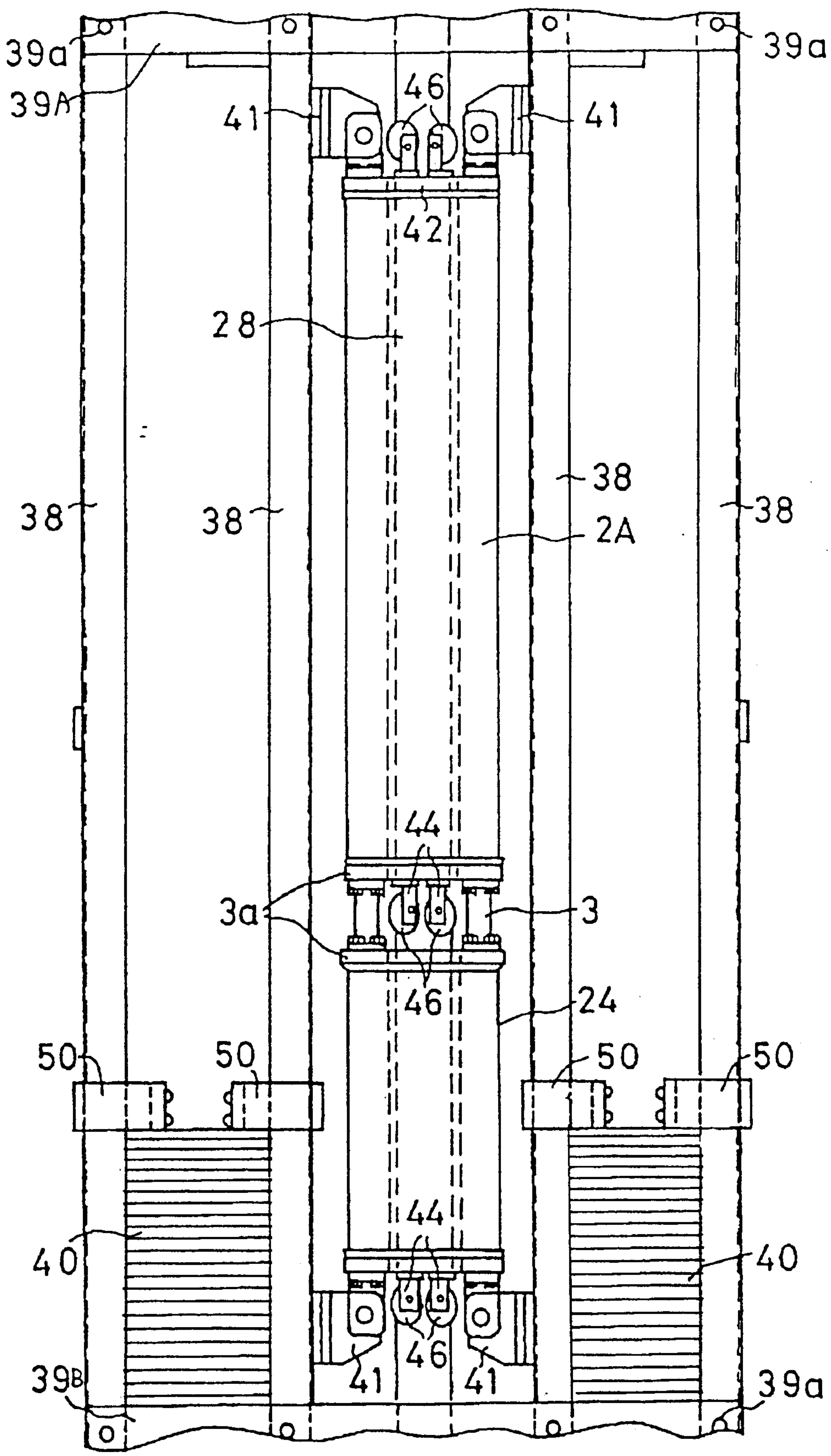
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FIG. 6

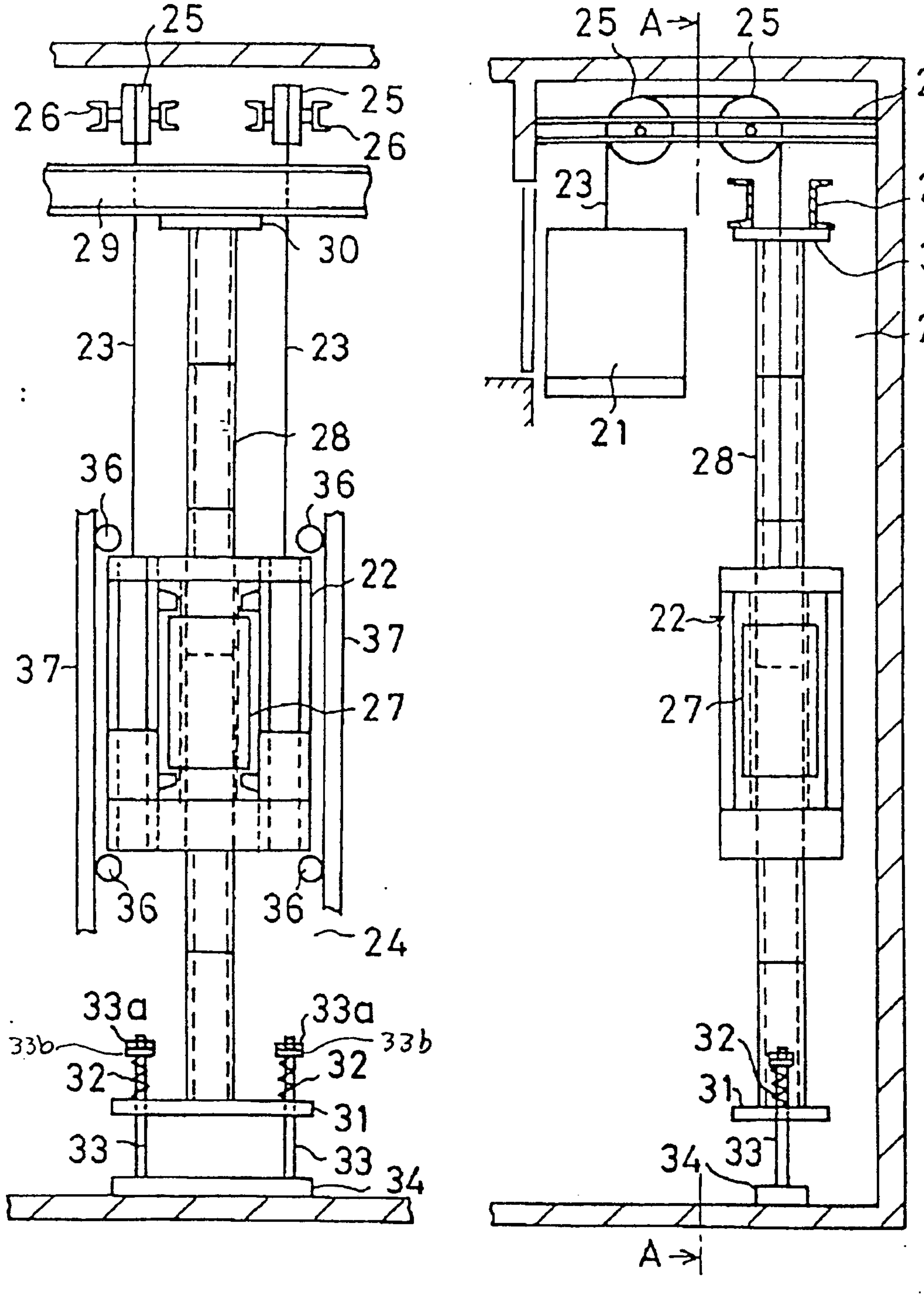

FIG. 7 (PRIOR ART)

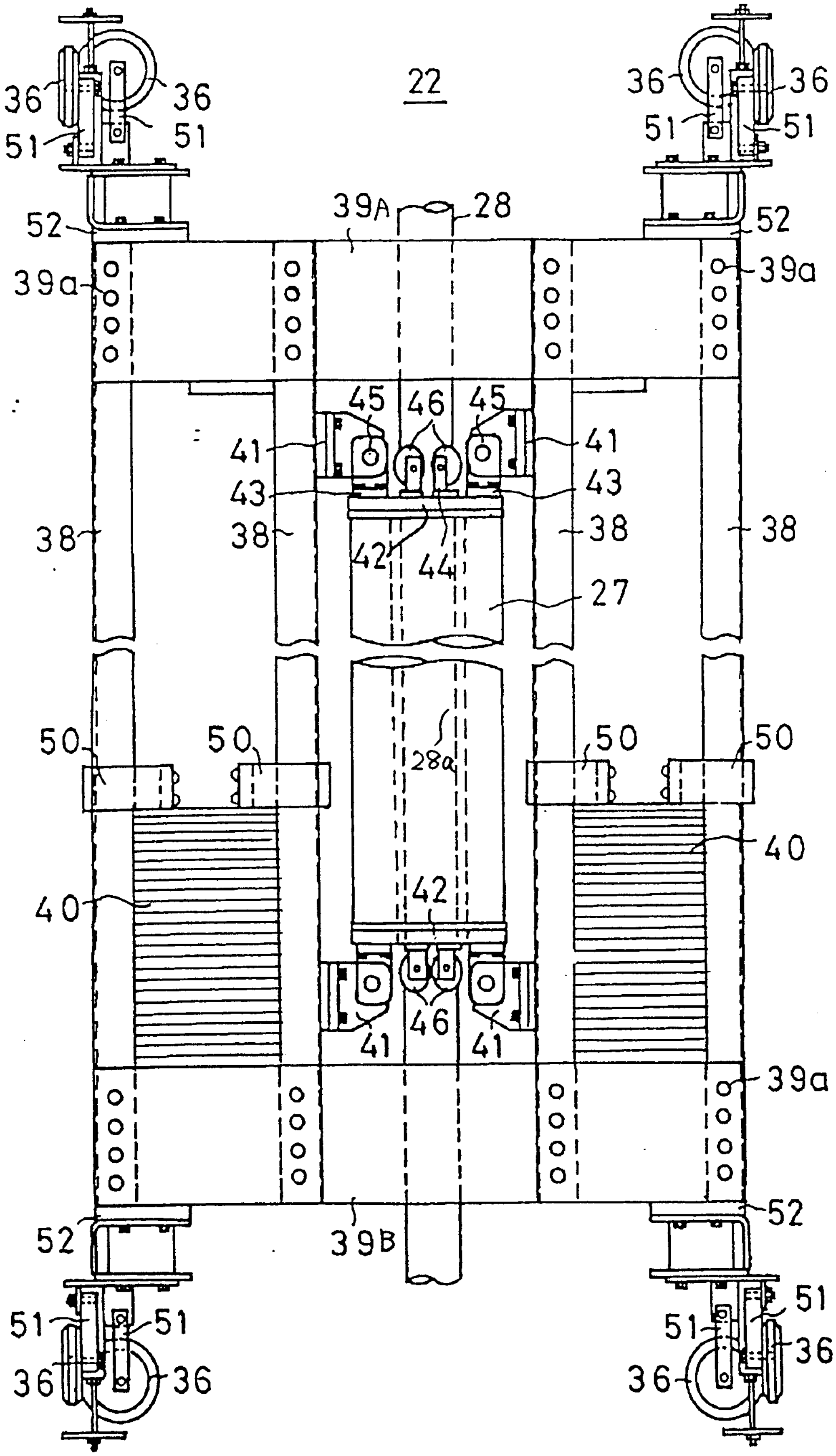

FIG. 8 (PRIOR ART)