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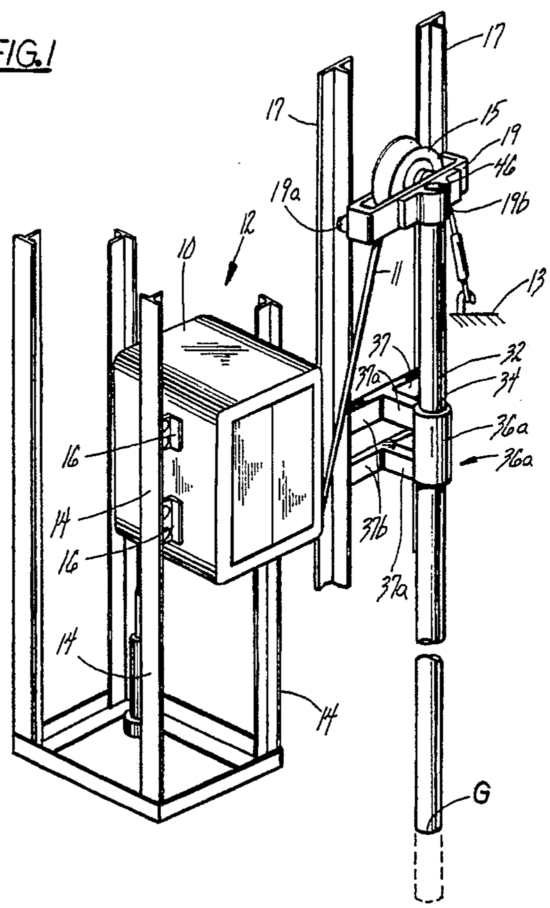
(54) **Linear motor driven elevator.**

(57) An elevator is comprised of: a cage 10, a rotable sheave 15, a rope 11 having a first portion supporting the cage and a second portion passing about the sheave, and a linear motor 30, the linear motor comprising a first element attaching to the sheave and a second fixed element. One of the first element or the second element forms a primary conductor connected to a power source. The other of the first or second element forms a secondary conductor which generates an induced magnetic field due to excitation of the primary conductor, the first element thereby driving the sheave, the rope and hence the cage upwardly and downwardly as desired.

FIG.1



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Linear Motor Driven Elevator

This invention relates to elevators and more particularly to an elevator driven by a linear motor.

Conventionally, hydraulic elevators are used in buildings with relatively few stories. The hydraulic unit is usually arranged in a pit formed in a lower portion of an elevator shaft. The hydraulic unit moves the elevator cage upwardly and downwardly. Compared to roped elevators, an hydraulic elevator has a simplified structure at the upper portion of the elevator shaft. Roped elevators typically have very complicated structures at the top of the elevator shaft including traction motors, drive sheaves and the like. Such complicated structures typically occupy a great deal of space which is undesirable where building space is at a premium.

In recent years, elevators having a linear motor as a driving source have been developed. For example, elevators using a linear motor as a driving source are disclosed in Japanese Kokai Patents No. Sho 48 [1973]-54644 and No. Sho 57 [1982]-121568.

Even though the structure of the upper portion of the elevator shaft is significantly reduced in hydraulic elevators, the hydraulic unit set in the lower portion of the elevator shaft is large and is relatively noisy. Conversely, for a linear motor driven elevator, even though there is no need for a large hydraulic unit and the noise level is much lower than a hydraulic elevator, the linear motor driven elevators typically require much more space in the upper portion of the elevator shaft as compared to the hydraulic elevator.

It is an object of the invention to provide a new type of driven elevator which has a low noise level and requires a minimum of space at the bottom of the elevator shaft and at the top of the elevator shaft.

According to the invention there is provided an elevator characterized by:

a cage,

a rotatable sheave,

a rope having one portion supporting said said cage and another portion engaged about said sheave,

a first driving element attached to said sheave, and a fixed second driving element separated from said first element by a prescribed gap wherein one of said first driving element and said second driving element forms a primary conductor of a linear motor connected to a power source and the other of said first driving element and said second driving element forms a secondary conductor of said linear motor which generates an induced magnetic field due to excitation of the said primary conductor, said linear motor thereby translating said sheave, said rope and said cage up and down.

In an embodiment of the invention, the first element is an axially translatable column protruding downwardly from a frame attaching to the sheave. The second element is a cylinder fixed below the lowest stroke of the sheave within the shaft, the column penetrating the cylinder to form the linear motor.

In a further embodiment, the first element is a cylinder attaching to a movable frame. The second element is a relatively fixed column arranged in parallel to the elevator shaft, the column penetrating the cylinder to form the linear motor.

Two embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Figure 1 is an oblique view of an elevator employing an embodiment of this invention;

Figure 2 is a front view of the elevator of Figure 1;

Figure 3 is a front view of a brake unit used in the elevator shown in Figures 1 and 2;

Figure 4 is an oblique view illustrating brake units of Figure 3 attached to an elevator cage;

Figure 5 is a schematic view of a control circuit for the elevator of Figure 1;

Figure 6A illustrates a side view of a portion of the linear motor of Figure 1;

Figure 6B illustrates a front view of the linear motor of Figure 6A;

Figure 7A illustrates a gap sensor for detecting relative displacement between portions of the linear motor of Figure 1;

Figure 7B illustrates an enlarged portion of Figure 7A;

Figure 8 is a plan view of a second embodiment of the elevator of the invention;

Figure 9 is a front view of a support structure of a portion of the linear motor of Figure 8; and

Figure 10 is a front view of an upper support structure of the linear motor of Figure 8.

Referring to Figures 1 and 2, an elevator employing an embodiment of the invention is disclosed. Cage 10 is guided by guide rollers 16 along a pair of guide rails 14 mounted in an elevator shaft 12. A brake unit (as shown in Figure 4) may be formed within a structural part of lower portion of cage 10. The brake unit is engaged to engage the guide rails to stop the car at a certain floor, upon interruption of the power source, or upon the occurrence of an earthquake or other emergency as will be discussed below.

A rope 11 has one end thereof engaged to the cage 10 and a second end thereof engaged to a structural part 13 of the elevator shaft. A portion of the rope is engaged by a sheave 15 thereby forming a well-bucket type elevator driving mechanism. The sheave is rotatably supported on a movable frame 19 which has guide rollers 19a engaging a pair of guide rails 17. The movable frame 19 moves upwardly and downwardly in the elevator shaft.

As shown, movable frame 19 has a mounting bracket 19b. Cylindrical part 32 is mounted on the mounting bracket 19b and protrudes downwardly. Cylindrical part 32 is made of aluminum or other lightweight electroconductive material. Cylindrical part 32 may also be made of a hollow body of steel or other material with high rigidity and high wear resistance and coated with a layer of aluminum or other electroconductive material as required. The cylindrical part 32 may also be formed of a hard synthetic resin which is treated to be electroconductive or coated with an electroconductive layer. The cylindrical part 32 is longer than the stroke of the movable frame. The lower portion of the cylindrical part 32 is disposed within hole G formed in the floor of the shaft.

Fixedly disposed below the lowest position of the stroke of the frame 19, a cylindrical electromagnetic coil 36 having a central hole 34 with an inner diameter greater than the outer diameter of the cylindrical part 32. The cylindrical part is supported by a frame 37. The frame 37 is made of a support strut 37a which is connected to an outer casing 36a of the cylindrical electromagnetic coil and a horizontal frame 37b connected to or integrated with the support strut. Horizontal frame 37b is rigidly connected to rail 17.

The central hole 34 of the electromagnetic coil 36 is arranged coaxially with the cylindrical part 32 and the hole G. Cylindrical part 32 penetrates the central hole 34 of electromagnetic coil 36. An air gap exists between the cylindrical part 32 and an electromagnetic coil 38 mounted within the electromagnetic coil 36. The electromagnetic coil 38 defines the central hole.

As shown, the cylindrical part 32 acts as a first driving element for driving the cage 10 up and down via rope 11, sheave 15 and movable frame 19 attaching to the cylindrical part. The electromagnetic coil acts as a secondary driving element thereby forming a linear motor 30 with the cylindrical part.

Electromagnetic coil 36 is connected conventionally to a control circuit containing an inverter circuit as shown in Figure 5 as will be discussed below. Driving current fed from the control circuit induces a magnetic field in the cylindrical part 32.

Referring to Figures 3 and 4, an example of the brake device 20 mounted on the cage 10 is shown. The brake device 20 has a brake shoe 202 attached to each tip portion of a pair of brake arms 201. The pair of brake arms rotate freely about an arm support shaft 203. A brake unit 200 is supported in the middle of the rear portion of the brake device 20. The brake unit 200 is comprised of a magnetic core 204, a translatable shaft 205, a bracket 206, and a compression spring 207. The brake unit is attached to the brake arms by pins 208 inserted into a hole formed at an end portion of the shaft 205 and the bracket 206. The brake unit 200 is connected to a power source (not shown). When power is activated, the magnetic core 204 is energized contracting the shaft against the compressive spring 207 so that brake shoes are moved away from rail 14. Conversely, if power is turned off, the magnetic core 204 is deenergized and the compression spring pushes the shaft out of the core thereby urging the brake shoes into frictional contact with guide rail 14.

Referring to Figure 5, a schematic diagram of the control system which controls the driving of the linear motor and operation of the brake device 20 is shown. Cage position sensor 300 contains a conventional proximity switch, a cage position detecting encoder, or the like, and generates a cage position detecting signal which indicates the positional relationship of the cage to the floors of the various stories. Hall call unit 302 is a command device which receives hall call commands from the various stories. Cage call unit 304 generates a call command as passengers in the cage push buttons within the cage to reach a desired floor.

Control circuit 306 receives a cage position detecting signal from the cage position detector, a hall call command input from the hall call unit, and a cage call command input from the cage call unit. Control circuit 306 then generates a control signal for moving the cage upwardly or downwardly as is known in the art. The signal is then output as a control signal to a motor control unit 308 containing an inverter circuit or the like. Motor control unit 308 supplies power to the primary movable element 19 to move the cage 10 to the target story. As cage 10 is lowered or raised the control circuit 306 compares a cage position detection signal input from the cage position detecting unit with the story assigned by the hall call command or cage call command. When it is found that the cage reaches the desired story, a stop command is output to the motor control unit and the power to electromagnetic coil 36 is cut off.

During the period when power is supplied to the electromagnetic coil, the control circuit continuously supplies a brake off command to brake unit 310. During this brake off command, the brake control unit 310 supplies power to the electromagnetic core and brake device 20 is held in the release position thereby. When control circuit 306 outputs a stop command to the motor control unit, it supplies a brake on command to the brake control unit at the same time thereby cutting off power to the magnetic core and activating the braking device.

For the given configuration, if the power supply to the linear motor is cut off, the brake device directly holds the cage at rest. As a result, it is easy to control the cage position. The control unit may be mounted within the cage thereby facilitating maintenance of the brake unit.

As shown in Figure 2, electromagnetic coil 36 is mounted on support frame 37 via an elastic collar 42. Due to the elasticity of the collar 42, displacement of the electromagnetic coil 36 is tolerated. In the upper portion of electromagnetic coil 36, rollers 44 are arranged circumferentially about the cylindrical part (see Figs. 6A and 6B). Rollers 44 are in elastic contact with the outer surface of cylindrical part 32. By utilizing the rollers, a prescribed minimum air gap is ensured between the outer surface of the cylindrical part 32 and the inner surface of the electromagnetic coil 36. Given this configuration, it is possible to prevent contact between the electromagnetic coil 36 and the cylindrical part 32 even in the case of transverse rolling vibration with relative displacement between the cylindrical part and the electromagnetic coil caused by an earthquake or the like. An elastic collar 46 may be used for mounting the cylindrical part with respect to frame 19 to prevent transfer of vibration energy between the cylindrical part and the frame thereby preventing transfer of vibration to the rope via the sheave to improve the comfort of passengers in the cage.

Referring to Figures 6A and 6B, rollers 44 are mounted on brackets 45 about roller shafts 44a. Each bracket 45 has a transverse through a hole 44b formed therethrough. Hole 44b supports a roller shaft 44a for displacement side to side. Spring 43 connects at one end to roller shaft 44a and at a second end to an outer wall of bracket 45. The spring urges roller shaft 44a and the roller 44 towards the cylindrical part. The roller, or at least an outward portion thereof is made of a soft rubber or other such material to absorb vibrations caused by unevenness of the cylindrical part. The level of frictional noise generated by contact between the cylindrical part and the rollers is thereby minimized. The elastic force of the spring 43 is as small as possible to urge contact while minimizing the pressing force of the roller upon the surface of the cylindrical part. If the coefficient of friction is small, noise caused by the friction can be further reduced effectively.

The through hole 44b is designed to maintain a minimum air gap between the cylindrical part and the inner surface of the electromagnetic coil. The roller shaft will abut the edges of the hole before the cylindrical part gets too close to the electromagnetic coil.

As shown in Figures 7A and 7B, an air gap sensor 35 may be arranged in the upper portion of electromagnetic coil 36. The sensor emits a signal when the gap between the cylindrical part and the electromagnetic coil becomes smaller than a preset minimum. A signal is input to the control circuit to bring the cage to an emergency stop.

The air gap sensor 35 has an annular casing 351 and a switch piece 352 mounted to the casing by bolt 353. The switch piece is separated from the surface of cylindrical part by a gap L. Screw 354 can be used to adjust the distance L. The switch piece 352 is conventionally connected to the control circuit shown in Figure 5 conventionally by a lead 355.

Referring to Figure 8, a further embodiment of the invention is shown. Electromagnetic coil 50 is attached to a movable frame 19. This electromagnetic coil is penetrated by cylindrical part 52. Electromagnetic coil 50 forms the first driving element and cylindrical part 52 forms the second element. Cylindrical part 52 is fixed relative to the electromagnetic coil thereby eliminating the hole and minimizing the weight of the movable frame.

Referring to Figures 9 and 10, the support of the cylindrical part in the elevator shaft is shown. As stated above, the cylindrical part is usually made of an aluminum alloy having an extended portion 400 arranged on one end so that the overall length of the cylindrical part can be adjusted. One end of the extended portion is connected to a ball joint 405 which has an eyebolt 401. Eyebolt 402 is fixed to the bottom of the elevator shaft. Eyebolts 401 and 402 are connected to each other by a coil spring 403 and a conventional turnbuckle 404. By adjusting the turnbuckle, prescribed tension in the cylindrical part may be maintained.

Ball joint 405 is comprised of a pair of yokes 406 connected to the eyebolt 401. A ball 409 is held between the yokes by pin 410. Eyebar 407 attaches the ball joint to the extended portion 400 rotatably. It is possible thereby to rotate the yoke about 360°. Because of this configuration the cylindrical part may vibrate in different directions with appropriate degrees of freedom.

Referring to Figure 10, the upper support 58 of the apparatus is shown. The structure of the upper support may be the same as that of the lower support. However, as the vibration and motion of the cylindrical part can be reduced through a spring at one end portion, the upper support is comprised essentially of a ball joint 410. This ball joint, as in the lower ball joint 405 can rotate freely in a certain range. Together with the lower support, the linear motor can tolerate a certain movement due to vibration or other motion of the cylindrical part. The upper and lower joint portions can tolerate the deflection of the cylinder part to a certain degree while the spring can attenuate and absorb vibration thereby effectively protecting the cylindrical part 52.

As a result according to the invention, drive of the cage is provided by a linear motor. Further, all the structure above the cage can be eliminated. Hence just as in the case of a hydraulic elevator, the clearance needed for the upper portion of the elevator shaft is minimized.

Although the invention has been shown and described with respect to certain embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions and the form and detail thereof may be made therein without departing from the scope of the invention. Specifically, this invention is not limited to the well-bucket type elevator. As a matter of fact, it can be applied for any type of elevator which has a movable sheave.

Claims

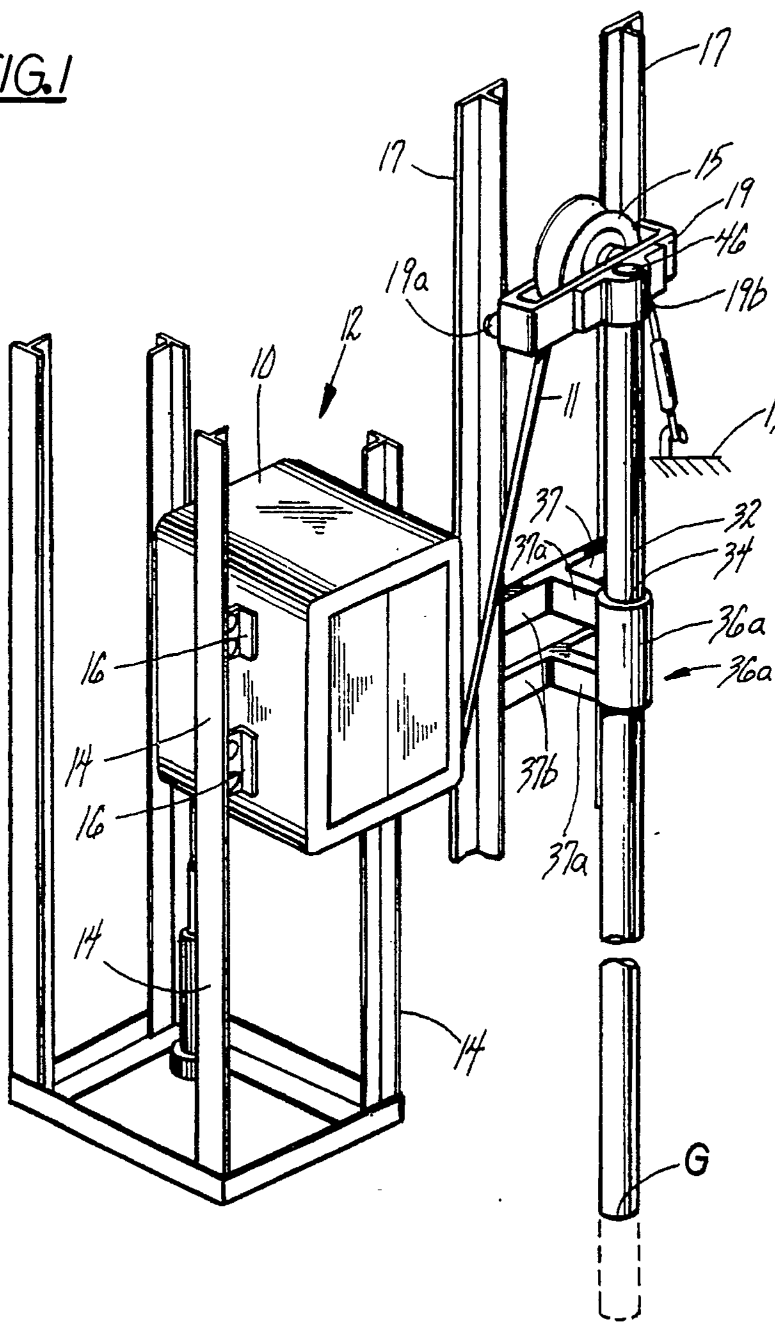
1. An elevator characterized by:
a cage,
a rotatable sheave,
a rope having one portion supporting said cage and another portion engaged about said sheave,
a first driving element attached to said sheave, and
a fixed second driving element separated from said first element by a prescribed gap wherein one of said first driving element and said second driving element forms a primary conductor of a linear motor connected to a power source and the other of said first driving element and said second driving element forms a secondary conductor of said linear motor which generates an induced magnetic field due to excitation of the said primary conductor, said linear motor thereby translating said sheave, said rope and said cage up and down.

2. An elevator as claimed in claim 1 further characterized in that:
said first driving element is made of a rod like part protruding downwardly from said sheave; and
said second driving element is a cylinder, said rod-like part penetrating said cylinder to form said linear motor.

3. An elevator as claimed in claim 1 further characterized in that:
said first driving element is a cylinder attaching to said sheave; and
said second driving element is a rod-like part, said rod-like part penetrating said cylinder to form said linear motor.

4. An elevator as claimed in Claim 3 further characterized by:
a flexible collar for attaching said first element to said sheave.

FIG.1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G

FIG. 2

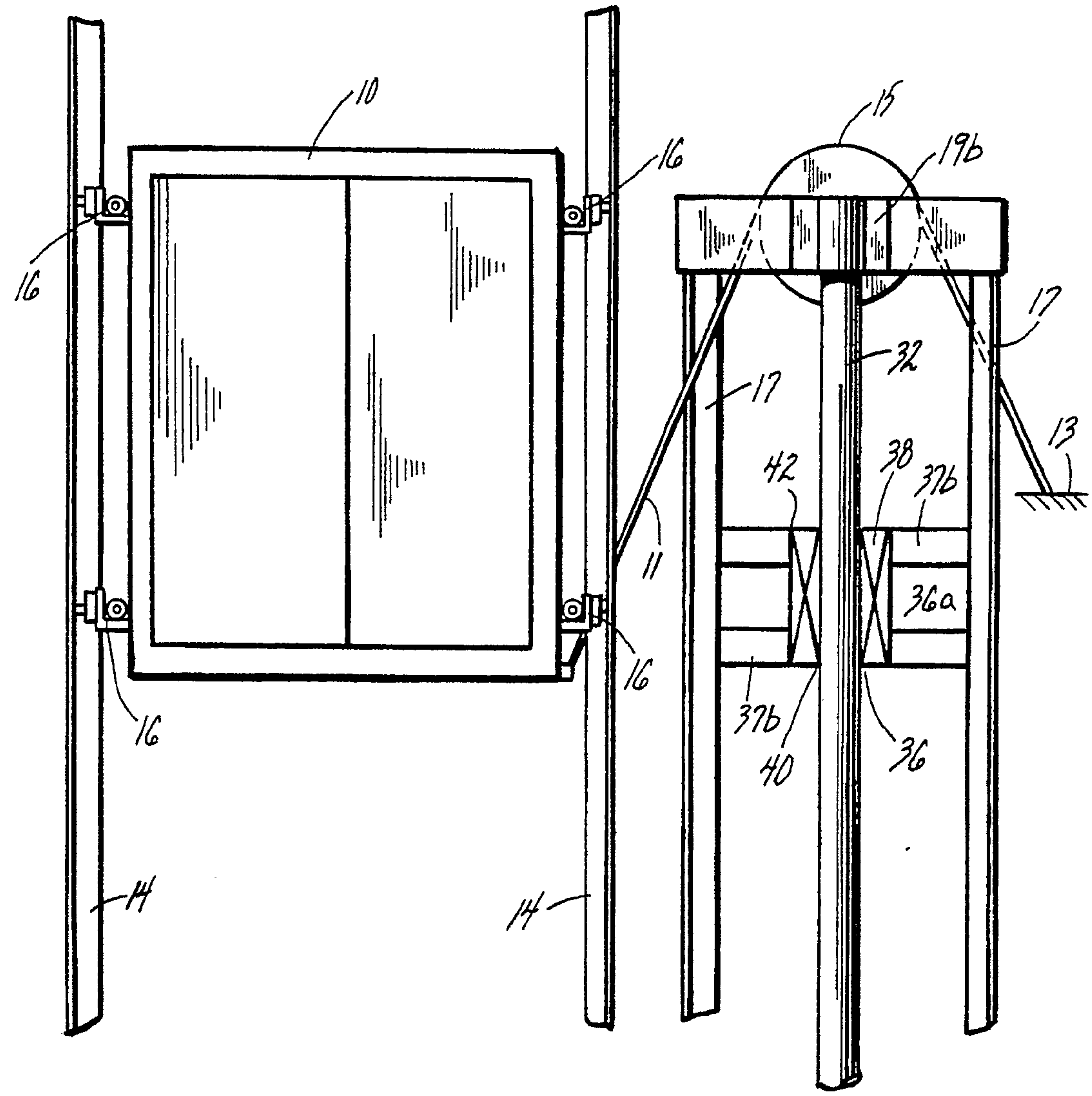


FIG.3

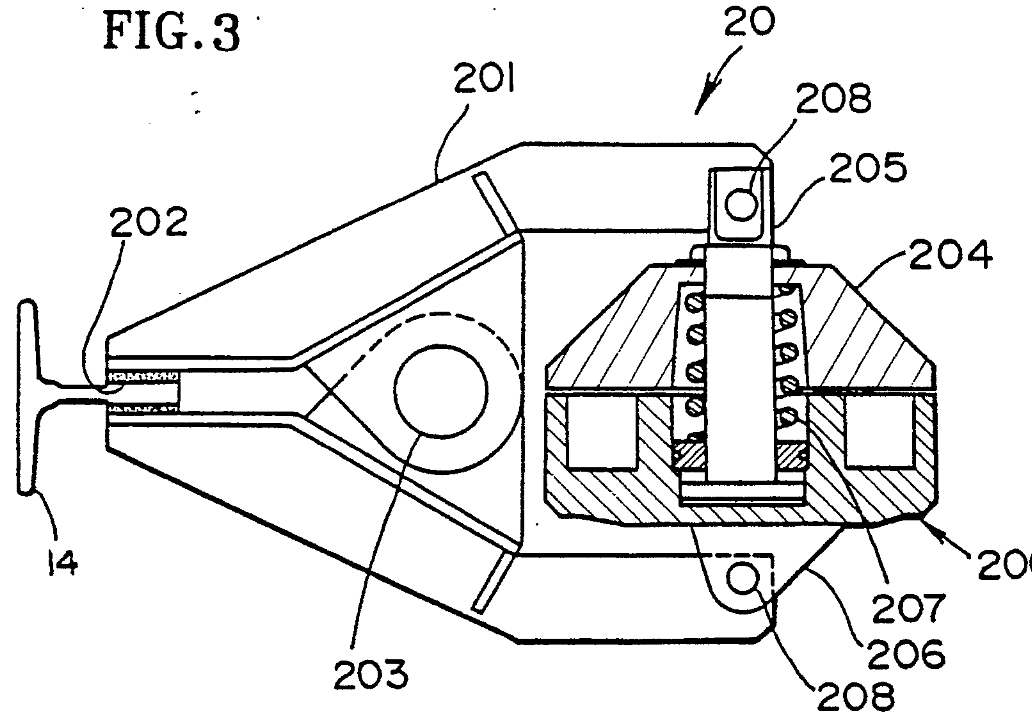


FIG.4

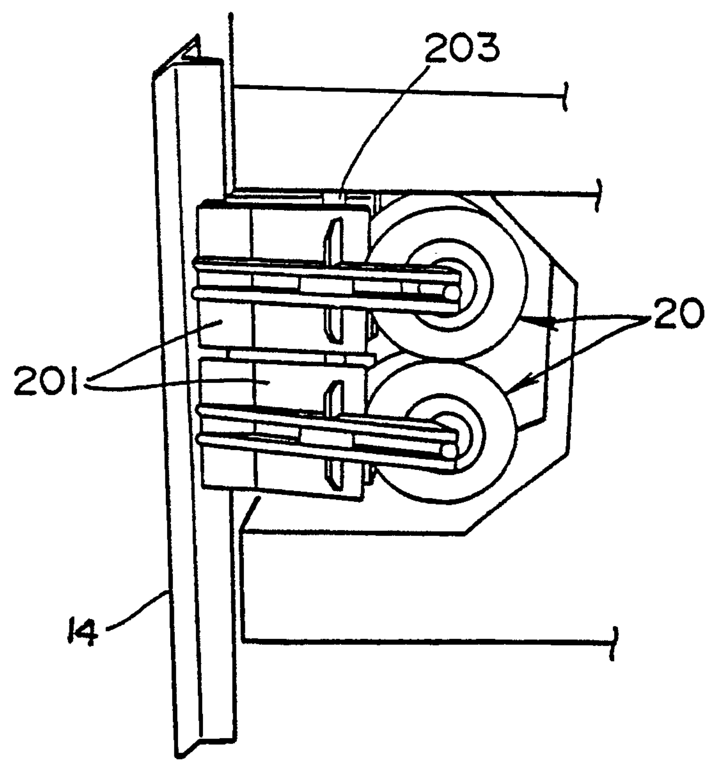


FIG.5

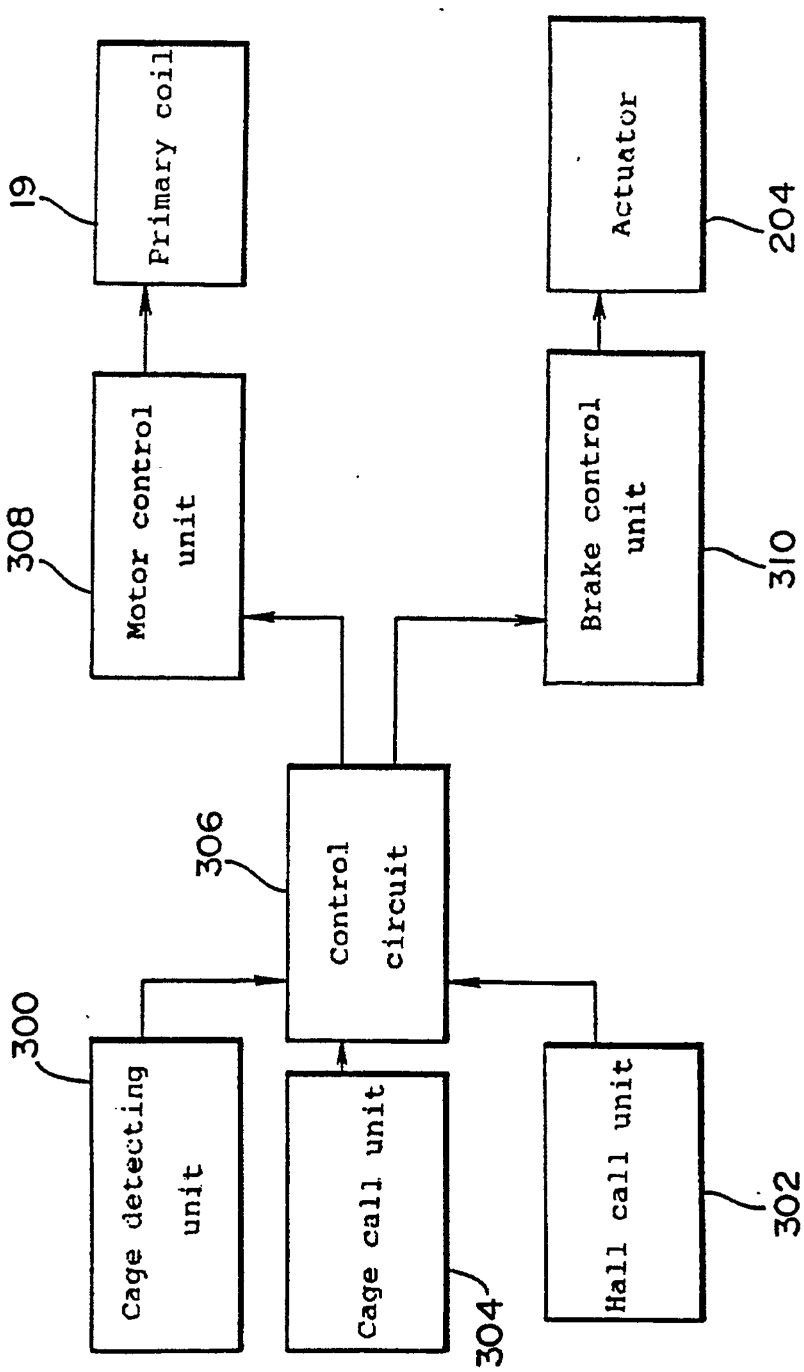
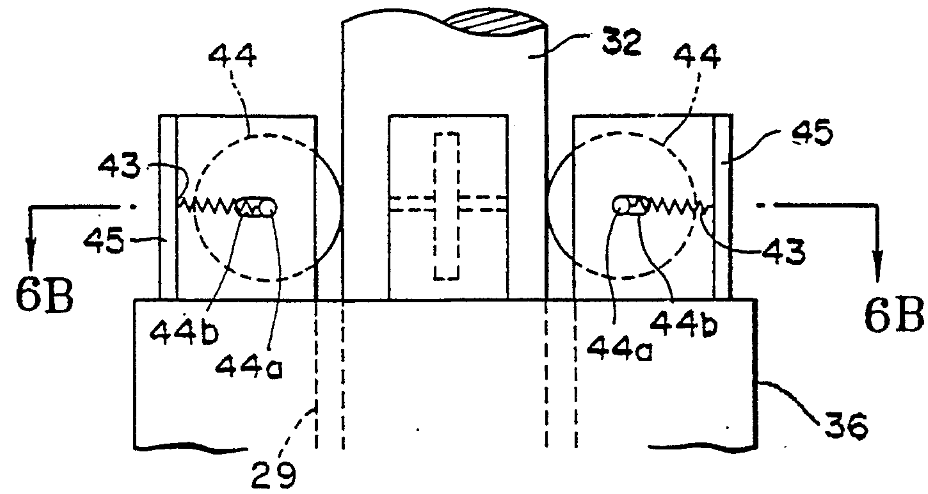

Cage detecting unit
300
Cage call unit
304
Hall call unit
302
Control circuit
306
Motor control unit
308
Brake control unit
310
Primary coil
19
Actuator
204

FIG.6 A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6B
44b
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44a
44b
36
29

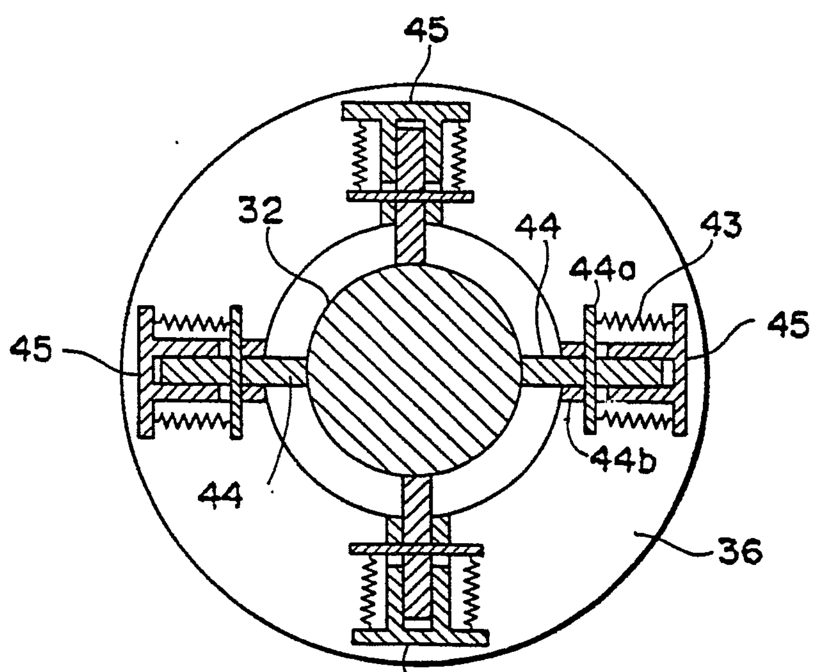
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FIG.6B

FIG.7A

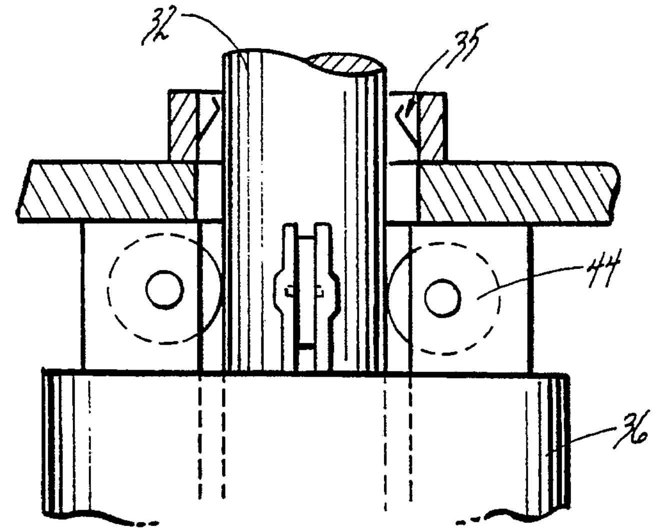


FIG. 7B

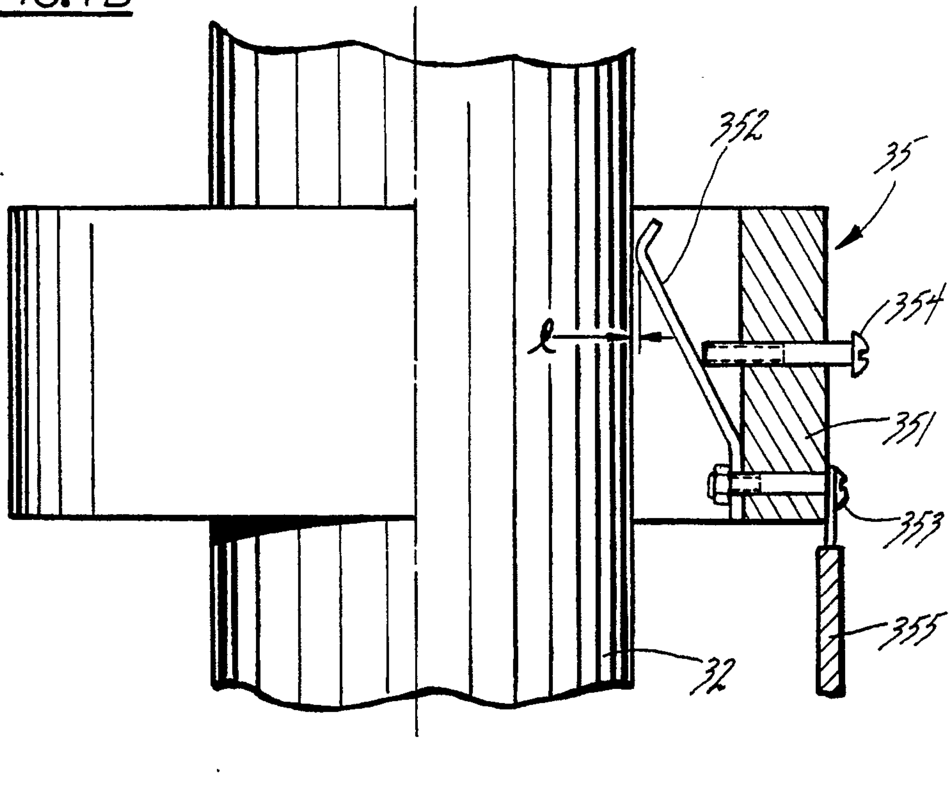
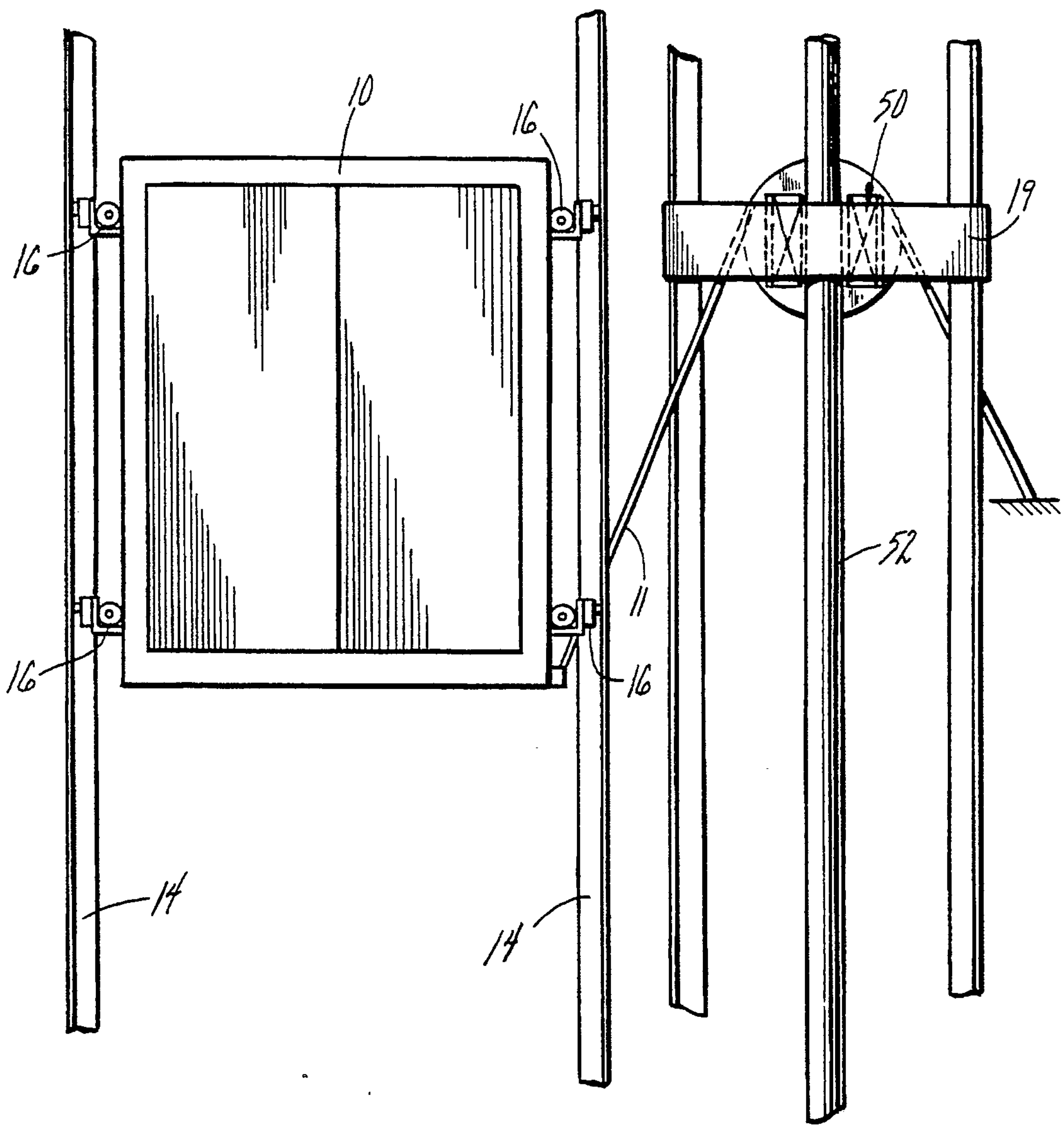


FIG. 8



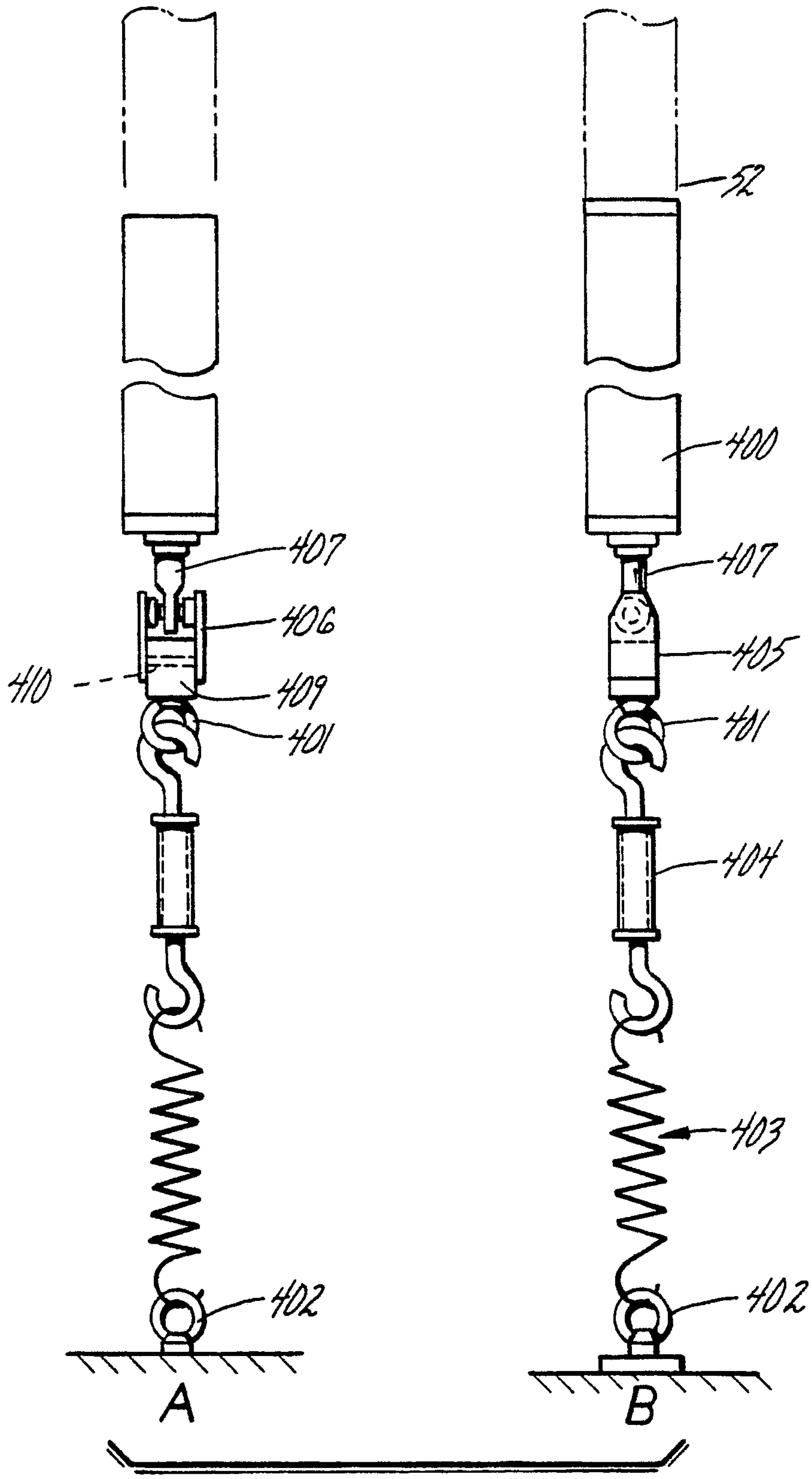


FIG. 9

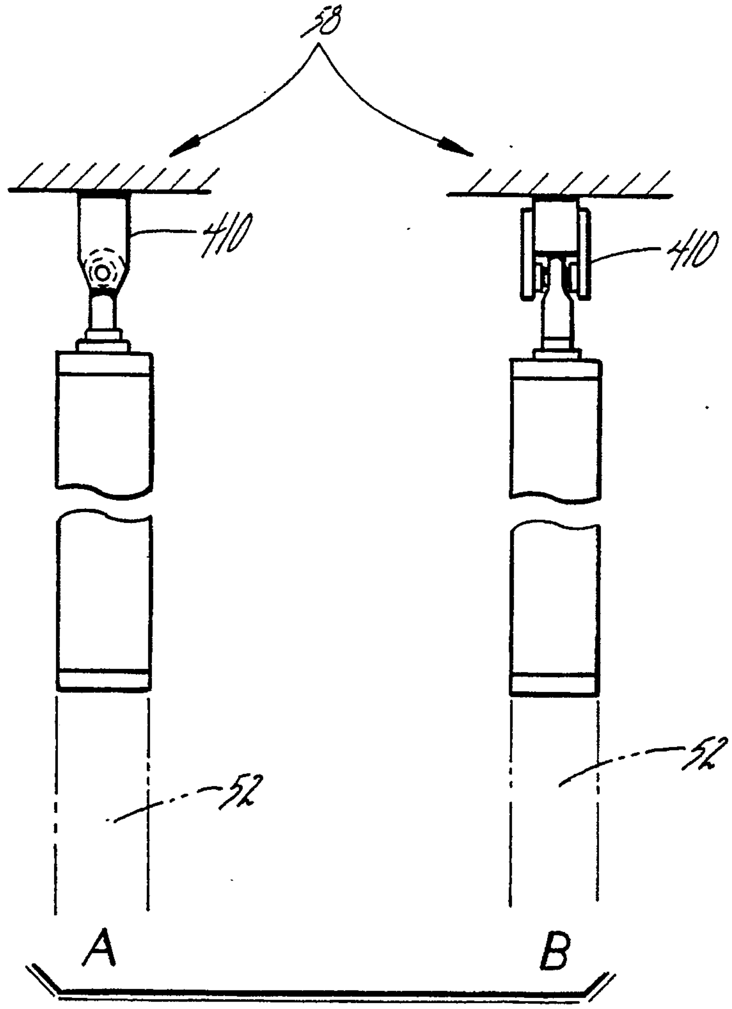


FIG.10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 5886

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.5)
D,A	EP-A-0048847 (OTIS ELEVATOR COMPANY) * page 5, lines 15 - 35; figures 1, 2 * ---	1	B66B11/04
A	DE-A-2002081 (KLEEMANN'S VEREINIGTE FABRIEKEN) * page 5, lines 2 - 10; figures 4, 5 * ---	1	
A	DE-A-2343461 (KIRSCH) * page 2, lines 14 - 28; figures 1-3 * ---	1	
A	FR-A-1359951 (HERBERT MORRIS LTD) * page 2, right-hand column, line 47 - page 3, left-hand column, line 3; figures 12-16 * ---	1	
A	DE-A-3422374 (HEIDENREICH) * page 7, line 9 - page 8, line 9; figures 1, 2 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B66B H02K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06 SEPTEMBER 1990	CLEARY F.M.

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CATEGORY OF CITED DOCUMENTS

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D : document cited in the application
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& : member of the same patent family, corresponding document