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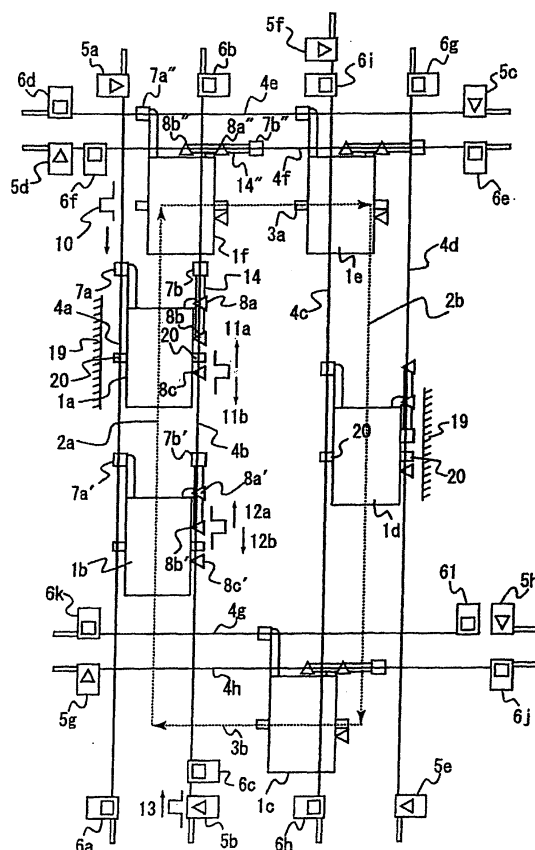
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(54) **Multi-car elevator**

(57) At the present invention a multi-car elevator includes: an in-tower transmitter (5b) which generates a sound signal, the in-tower transmitter (5b) being provided on a measuring side of a first sound signal conductor (4a); an in-tower detector (6b) which detects the sound signal, the in-tower detector (6b) being provided on the measuring side of a second sound signal conductor (4b); on-car detectors (7a) provided on respective cars (1); and on-car transmitters (8a) provided on respective cars (1). The in-tower transmitter (5a) generates a call signal, the on-car transmitters (8a) generate the response signals to the second sound signal conductor (4b) after the call signal is detected by the on-car detectors to obtain positions of the respective cars (1).

FIG.1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a multi-car elevator in which a plurality of cars move along an elevator shaft in a circulating manner, and the present invention is particularly suitable to a multi-car elevator having a double-spaced elevator shaft.

2. Description of the Related Art

[0002] Conventionally, in the case of an ordinary elevator having a car moved in a shaft, the position of the car only needs to be precisely detected near the door to obtain an exact landing position. However, in the case of a multi-car elevator having a plurality of cars moved in a shaft, the positions of the respective cars need to be precisely detected and constantly controlled to ensure that the cars do not collide with each other.

[0003] To detect the positions of the cars and safely control the cars, it is suggested that a roller attached on each car is pressed on a rail attached along the shaft to detect a rotational amount of the roller, that a light or radio wave is radiated from the top of a car to above car to obtain the distance between the two cars to obtain the distance between the two cars based on the reflected signal, and that the position information is transmitted to a main controller on the shaft side by radio communication (according to Japanese Patent Laid-Open Publication No. Hei05-286655).

[0004] Further, it is suggested that, in order to enable the cars to move with shorter distance to improve the transportation efficiency, the positions of the cars are directly detected from the machine room based on the propagating times, taking advantage of the fact that the ultrasonic sound signal propagates in a magnetostrictive wire at a uniform speed (according to Japanese Patent Laid-Open Publication No. 2000-221258).

[0005] Further, it is suggested that, in order to reduce electricity consumption, a looped main cable such as a rope is used to link and drive two cars opposite each other (according to Japanese Patent Laid-Open Publication No. Hei08-26629).

[0006] However, in the art disclosed in Japanese Patent Laid-Open Publication No. Hei05-286655 in which radio communication is used, it is difficult to secure reliability due to external disturbance. Further, in the art disclosed in Japanese Patent Laid-Open Publication No. 2000-221258 in which a sound signal conductor is provided and only the propagating times are used, it is difficult to detect positions of the plurality of cars in the same shaft, and therefore the art can not be used in the multi-car elevators described in, for example, Japanese Patent Laid-Open Publication No. Hei05-286655 and Japanese Patent Laid-Open Publication No. Hei08-26629. Further,

in the art disclosed in Japanese Patent Laid-Open Publication No. Hei08-26629, the document did not include a description on how to correctly and precisely detect the positions of the cars, and the document did not discuss how to improve transportation efficiency without interfering with the main cable and the cars.

SUMMARY OF THE INVENTION

[0007] An object of the present invention is to provide a multi-car elevator capable of detecting positions and speeds of a plurality of cars with high accuracy, even when moving in the same elevator shaft, to safely improve the transportation efficiency. Another object of the present invention is to provide a multi-car elevator capable of detecting the positions of the cars, even when the cars move in two directions of the vertical direction and the horizontal direction, and preventing interference with components to improve reliability.

[0008] A multi-car elevator according to an aspect of the present invention is a multi-car elevator having a plurality of cars in a running path, the multi-car elevator including: a first sound signal conductor and a second sound signal conductor for propagating a sound signal along the running path; an in-tower transmitter which converts an electrical signal into the sound signal and outputs the sound signal, the in-tower transmitter being provided on one end, which serves as a measuring side, of the first sound signal conductor; an in-tower detector which detects the sound signal and converts the sound signal into the electrical signal, the in-tower detector being provided on one end, which serves as the measuring side, of the second sound signal conductor; an on-car detector which detects the signal propagating from the first sound signal conductor, the on-car detector being provided on each of the cars; and an on-car transmitter which generates a response signal to the second sound signal conductor, in which the in-tower transmitter generates a call signal, the on-car transmitter generates the response signal to the second sound signal conductor after the call signal is detected by the on-car detector, and positions of the respective cars are obtained by calculating time interval from the time when the call signal is generated to the time when the response signal is detected by the in-tower detector.

[0009] A multi-car elevator according to another aspect of the present invention is a multi-car elevator having a plurality of cars in a running path, the multi-car elevator including: a first sound signal conductor and a second sound signal conductor for propagating a sound signal along the running path; an in-tower transmitter which converts an electrical signal into the sound signal and outputs the sound signal, the in-tower transmitter being provided on one end, which serves as a measuring side, of the first sound signal conductor; an in-tower detector which detects the sound signal and converts the sound signal into the electrical signal, the in-tower detector being provided on one end, which serves as the measuring side,

of the second sound signal conductor; an on-car detector which detects the signal propagating from the first sound signal conductor, the on-car detector being provided on each of the cars; and an on-car transmitter which generates a response signal to the second sound signal conductor, the on-car transmitter being provided on each of the cars, in which the in-tower transmitter generates a call signal, the on-car transmitter generates the response signal to the second sound signal conductor at different delays for each car after the call signal is detected by the on-car detector, and positions of the respective cars are obtained based on the time when the call signal is generated, time when the response signal is detected, and speeds of the respective cars.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a block diagram showing an entire construction of an embodiment of the present invention; Figs. 2A, 2B and 2C are block diagrams explaining how response signals interfere with each other; Figs. 3A, 3B and 3C are block diagrams showing an example in which response signals do not interfere with each other according the aforesaid embodiment; Fig. 4 is a perspective view showing a driving method using a circulating rope according to the aforesaid embodiment; Fig. 5 is a block diagram showing an entire construction of another embodiment of the present invention; Figs. 6A and 6B explain methods for holding sound signal conductors according to the aforesaid embodiment; Fig. 7 explains method for attaching reception and transmission coils according to the aforesaid embodiment; and Fig. 8 is a top view showing attachment positions of respective components according to the aforesaid embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT(S)

[0011] Fig. 1 shows an entire construction of a multi-car elevator in which six cars 1 move along a circular running path in a circulating manner. The circular running path is divided into two linear running paths 2a, 2b vertically extending on the left and right sides, and two running paths 3a, 3b horizontally extending to respectively connect the upper and lower portions of the running paths 2a, 2b. The divided running paths are respectively called "left running path 2a", "right running path 2b", "upper running path 3a" and "lower running path 3b".

[0012] The cars 1 move upward along the left running path 2a until reaching the upper running path 3a, then move along the upper running path 3a to the right until

reaching the right running path 2b, then move downward along the right running path 2b until reaching the lower running path 3b, and then move along the lower running path 3b to the left until returning to the left running path 2a. In this manner the cars 1 circulate along the circular running path. The cars never overtake each other in the running paths 2, 3. The following paragraphs describe the construction of a device for detecting positions of a plurality of cars 1 in the left running path 2a.

[0013] A first sound signal conductor 4a and a second sound signal conductor 4b are provided respectively on the left side and right side of the left running path 2a. A signal is received by the upper end portions of the two sound signal conductors 4a, 4b to measure the positions of the cars 1, therefore the upper end portions of the sound signal conductors 4a, 4b serve as a measuring side. On the other hand, the lower end portions are used to generate an auxiliary signal (which will be described later), therefore the lower end portions serve as an auxiliary signal generating side.

[0014] Note that in the following description, the word "in-tower" is added before the names of components and the like attached on the building side, and the word "on-car" is added before the names of components and the like attached on the car side.

[0015] Provided at the end of the of the measuring side of the first sound signal conductor 4a is an in-tower transmitter 5a which converts an electrical signal into a sound signal to generate the sound signal inside the first sound signal conductor 4a, and provided at the end of the of the auxiliary signal generating side of the first sound signal conductor 4a is a first in-tower detector 6a which detects the sound signal propagating through the first sound signal conductor 4a and converts the sound signal into the electrical signal. An in-tower detector 6b is provided at the end of the measuring side of the second sound signal conductor 4b, a second in-tower transmitter 5b is provided at the end of the auxiliary signal generating side of the second sound signal conductor 4b, and a third in-tower detector 6c is provided near the second in-tower transmitter 5b on the measuring side.

[0016] On-car detectors 7a, 7a' are attached on the respective cars 1a, 1b with respect to the first sound signal conductor 4a, and second on-car detectors 7b, 7b' are attached on the respective cars 1a, 1b with respect to the second sound signal conductor 4b. It is preferred that the distances between the measuring side and the second on-car detectors 7b, 7b' are equal to or less than the distances between the measuring side and the on-car detectors 7a, 7a'. However, if the distances between the measuring side and on-car transmitters 8 are large enough, the distances between the measuring side and the second on-car detectors 7b, 7b' can be greater than the distances between the measuring side and the on-car detectors 7a, 7a'.

[0017] On the respective cars 1a, 1b, first on-car transmitters 8a, 8a' are attached at the positions where the distances between the measuring side and the first on-

car transmitters 8a, 8a' are equal to or greater than the distances between the measuring side and the on-car detectors 7a, 7a', second on-car transmitters 8b, 8b' are attached at the positions further away from the measuring side than the first on-car transmitters 8a, 8a', and third on-car transmitters 8c, 8c' are attached at the positions further away from the measuring side than the second on-car transmitters 8b, 8b'.

[0018] The drawings show a case where the left running path 2a can contain up to three cars 1, therefore three on-car transmitters 8 are attached on the cars. However, if the left running path 2a extends high enough, it is possible for the left running path 2 to contain four or more cars 1. In such a case, the number of the on-car transmitter is increased until reaching the maximum number of the cars 1 possible to be contained in the left running path 2a, the increased on-car transmitters 8 being attached at positions sequentially further away from the measuring side one by one.

[0019] Based on the aforesaid basic construction, the method for measuring the positions of the cars 1a, 1b will be described below.

[0020] A controller (not shown) causes the in-tower transmitter 5a to generate a call signal 10 repeatedly at a predetermined time interval. The time interval is set long enough to perform one measurement operation. Thus, the next call signal 10 will not be generated until one measurement operation is completed. The call signal 10 generated by the in-tower transmitter 5a propagates the first sound signal conductor 4a downward at an acoustic velocity. The call signal 10 is firstly detected by the on-car detector 7a of the uppermost car 1a. Then the car 1a selects either one of the on-car transmitters 8 to generate a first wave of response signal 11 with respect to the second sound signal conductor 4b.

[0021] The on-car transmitter 8 attached farthest away from the measuring side is selected in the initial state. The selected on-car transmitter 8 is shifted to the one above on-car transmitter 8 every time the second on-car detector 7b detects the signal. Since the second on-car detector 7b of the car 1a has not detected any signal yet at this point, the first wave of response signal 11 is generated from the third on-car transmitter 8c with respect to the second sound signal conductor 4b.

[0022] The first wave of response signal 11 propagates upward and downward in the second sound signal conductor 4b at the acoustic velocity. Particularly, since the third on-car transmitter 8c is attached closer to the auxiliary signal generating side than to the on-car detector 7a, the first wave of response signal 11 propagates downward faster than the call signal 10.

[0023] The first wave of response signal 11a propagating upward is detected by the second on-car detector 7b. Thereby the car 1a shifts the on-car transmitter 8 to the second on-car transmitter 8b, which is the one above on-car transmitter 8.

[0024] Then the first wave of response signal 11a propagating upward is detected by the in-tower detector

6b. Further, the controller calculates the difference between the time when the call signal 10 is generated by the in-tower transmitter 5a and the time when the first wave of response signal 11a is detected by the in-tower detector 6b to obtain a propagation time of the sound signal, and the position of the uppermost car 1a is obtained by dividing the obtained propagation time by a known propagation speed.

[0025] On the other hand, the first wave of response signal 11b propagating downward propagates through the second on-car detector 7b' of the car 1b under the car 1a. Based on the detection by the second on-car detector 7b', the car 1b shifts the third on-car transmitter 8c', which was selected in the initial state, to the second on-car transmitter 8b', which is the one above third on-car transmitter 8c'.

[0026] Further, the first wave of response signal 11b propagating downward propagates through the third in-tower detector 6c. Thereby the controller confirms that there is one car 1 in the left running path 2a.

[0027] Meanwhile, the call signal 10 propagates through the on-car detector 7a' of the second car 1b later than the first wave of response signal 11a. Since the second on-car transmitter 8b' (the second one from the bottom) has already been elected by the car 1b at this point, a second wave of response signal 12 is generated therefrom.

[0028] The second wave of response signal 12a propagating upward is first detected by the second on-car detector 7b'. Thereby the car 1b shifts the on-car transmitter 8 to the first on-car transmitter 8a', which is the one above the second on-car transmitter 8b'.

[0029] Further, the second wave of response signal 12a propagating upward is detected by the second on-car detector 7b of the car 1a above the car 1b. Thereby the car 1a shifts the on-car transmitter 8 to the first on-car transmitter 8a, which is the one above the second on-car transmitter 8b.

[0030] Then the second wave of response signal 12a propagating upward is detected by the in-tower detector 6b. Further, the controller calculates the difference between the time when the call signal 10 is generated by the in-tower transmitter 5a and the time when the second wave of response signal 12a is detected by the in-tower detector 6b to obtain the propagation time of the sound signal, and the position of the second car 1b is obtained by dividing the obtained propagation time by the known propagation speed.

[0031] On the other hand, the second wave of response signal 12b propagating downward propagates through the third in-tower detector 6c. Thereby the controller confirms that there are two cars 1 in the left running path 2a.

[0032] Then the call signal 10 is detected by the first in-tower detector 6a provided on the auxiliary signal generating side. At this point, only two response signals 11b, 12b are detected by the third in-tower detector, so that the controller determines that two and only two cars exist

in the left running path 2a.

[0033] The controller causes the second in-tower transmitter 5b to generate the auxiliary signal 13 for the number less than the maximum number of the cars possible to be contained in the running path. Thus, the number of the auxiliary signal 13 generated by the second in-tower transmitter 5b is one in this case.

[0034] The auxiliary signal 13 propagating upward propagates through the second on-car detectors 7b, 7b' of the car 1a, 1b, and the car 1a, 1b then respectively shift the on-car transmitters 8, 8'. At this time, since the on-car transmitters 8, 8' have already been shifted to the uppermost first on-car transmitters 8a, 8a' and since there is no on-car transmitters 8, 8' above them, the on-car transmitters 8, 8' is shifted back to the lowermost third on-car transmitters 8c, 8c', which bring the on-car transmitters 8, 8' to the initial state.

[0035] The next call signal 10 will be generated to repeat the above measurement when enough time has elapsed after the above process is finished.

[0036] The method for allowing the multi-car elevator to carry out the aforesaid process will be described below.

[0037] Basically, the other three running paths 2b, 3a, 3b can be configured in the same manner as the above. Specifically, the upper running path 3a can be deemed as a path formed by rotating the left running path 2a clockwise by 90 degrees. Thus, among two sound signal conductors 4e, 4f, the first sound signal conductor 4e is located on the upper side, and the second sound signal conductor 4f is located on the lower side. Further, the right side is the measuring side.

[0038] The right running path 2b can be deemed as a path formed by rotating the upper running path 3a by 90 degrees, and the lower running path 3b can be deemed as a path formed by rotating the right running path 2b by 90 degrees.

[0039] In the construction shown in Fig. 1 is so configured that the on-car detectors 7 and the on-car transmitters 8 can be commonly used in all four running paths 2, 3. Specifically, the second on-car detector 7b, the first on-car transmitter 8a and the second on-car transmitter 8b are attached to a rotatable arm 14.

[0040] The car 1f moving along the upper running path 3a has its rotatable arm 14 rotated clockwise by 90 degrees with the first on-car transmitter 8a as a rotation center. The car 1d moving along the right running path 2b further has its rotatable arm 14 rotated clockwise by 90 degrees. The car 1c moving along the lower running path 3b further has its rotatable arm 14 rotated clockwise by 90 degrees.

[0041] In this manner, when the car 1 moves along any one of the running paths 2a, 2b, 3a, 3b, the second on-car detector 7b, the first on-car transmitter 8a and the second on-car transmitter 8b can constantly move along the second sound signal conductors 4b, 4f, 4c, 4g.

[0042] Since the upper and lower running paths 3 is short, the maximum number of the car 1 possible to be contained in the upper and lower running paths 3 is two.

Thus, since only two on-car transmitters 8 are used in the upper running path, only two on-car transmitters 8 are attached on the rotatable arm 14. Incidentally, although the two sound signal conductors 4e, 4f of the upper running path 3a are displaced from each other in the vertical direction as shown in Fig. 1, the two sound signal conductors 4e, 4f also can have the same height positions but be displaced from each other in the front-and-back direction. The same goes for the lower running path 3b, and in this case the two sound signal conductors 4a, 4b and 4c, 4d respectively provided in the left and right running paths 2a, 2b also need to be displaced from each other in the front-and-back direction.

[0043] Alternatively, the configuration also can be the one in which there is no rotatable arm, but other on-car transmitters 8 are added for the upper and lower running paths 3 instead. In such a case, a second on-car detector 7b is attached at the position where the first on-car transmitter 8a of the Fig. 1 is attached, and a first on-car transmitter 8a is attached below the second on-car detector 7b. Further, the right running path 2b has the same direction as the left running path 2a instead of having opposite direction to the left running path 2a, and the lower running path 3b also has the same direction as the upper running path 3a.

[0044] A high-order main controller controls the four controllers. The main controller grasps the positions of all cars 1. Thus, when the car 1 transfers to the other running paths 2, 3, the positions of the cars in the running paths 2, 3 change. Further, the car 1 shifts the on-car transmitter 8 to the first on-car transmitter 8a, which is in the position closest to the measuring side. Thus, it is necessary to provide a means for detecting the fact that the car 1 has transferred to the running paths 2, 3, and to serve this purpose, proximity sensors 20 are provided respectively on the left face and right face of the car 1 to detect the walls of the left running paths 2a, 2b or detect devices 19 attached along the walls of the left running paths 2a, 2b.

[0045] When the detection state of the proximity sensors 20 has changed, the car 1 determines that it has transferred to either of the running paths 2, 3 and therefore shifts the on-car transmitter 8 to the first on-car transmitter 8a.

[0046] The following paragraphs explain how the plurality of on-car transmitters 8 are discriminatingly used with reference to Figs. 2A, 2B, 2C, 3A, 3B, and 3C, which show an example in which two cars 1a, 1b are contained in the left running path 2a.

[0047] As shown in Figs. 2A, 2B and 2C, the cars 1a, 1b are each provided with one on-car detector 7 and one on-car transmitter 8. In other words, Figs. 2A, 2B and 2C show a case where the cars 1a, 1b each have a single on-car transmitter 8, instead of a plurality of on-car transmitters 8, to generate the response signals 11, 12.

[0048] Fig. 2A shows a state at the time when the call signal 10 is detected by the on-car detector 7, and the first wave of response signal 11 is generated by the on-

car transmitter 8.

[0049] Then, as shown in Fig. 2B, the response signals 11a, 11b respectively propagate upward and downward.

[0050] Fig. 2C shows a state at the time when the call signal 10 propagates through the on-car detector 7' of the second car 1b. At this time, the second wave of response signal 12 is generated by the on-car transmitter 8', and meanwhile the first wave of response signal 11b of first car 1a propagating downward propagates through exactly the same position. Thus, the second wave of response signal 12 is interfered. As a result, the second wave of response signal 12 attenuates, and therefore it will be difficult to carry out the measurement. In order to avoid this situation, a plurality of on-car transmitters 8 are attached as shown in Figs. 3A, 3B and 3C.

[0051] As shown in Fig. 3A, at the time when the call signal 10 is detected by the on-car detector 7a of the upper car 1a, the first wave of response signal 11 is generated by the second on-car transmitter 8b, which is in the position further away from the measuring side.

[0052] Then, as shown in Fig. 3B, the first wave of response signal 11b propagating downward propagates through the second on-car detector 7b' of the lower car 1b. At this time, the first wave of response signal 11b is detected by the second on-car detector 7b' of the lower car 1b. Further, the car 1b shifts the on-car transmitter 8 to the first on-car transmitter 8a', which is the one above the second on-car transmitter 8b'.

[0053] Fig. 3C shows a state at the time when the call signal 10 propagates through the on-car detector 7a' of the lower car 1b. Since the first wave of response signal 11b has already propagated through the second on-car transmitter 8b', the second wave of response signal 12 can be generated by the first on-car transmitter 8a' without interference.

[0054] Apart from physically changing the distance, another method is generating the response signals at different delays for each car 1. In other words, at the time represented by Fig. 2A, the upper car 1a instantly generates the first wave of response signal 11 upon receiving the call signal 10, yet at the time represented by Fig. 2C, the upper car 1a generates the second wave of response signal 12 with a predetermined delay. Namely, since the car knows the order of itself from the top through the second on-car detector 7b, the delays are set in accordance with the order. Thus, the interference between the response signals 11, 12 can be avoided even when only one on-car transmitter 8 is provided. However, the controller needs to calculate the position taking into account the speed of the car.

[0055] This purpose can be achieved by analyzing the response signal 11 reached the second in-tower detector 6b to calculate the speed of the car 1.

[0056] Specifically, when generating the response signal 11 by the car 1, two pulses are generated at a predetermined time interval. When the car 1 is not moving, the two pulses will reach the second in-tower detector 6b at the same time interval. When the car 1 is moving up-

ward, the two pulses will reach the second in-tower detector 6b at a shorter time interval. When the car 1 is moving downward, the two pulses will reach the second in-tower detector 6b at a longer time interval. Thus, the speed of the car 1 can be obtained using the fact that the time interval between the two pulses changes depending on the moving speed and moving direction of the car 1. Similarly, the speed also can be obtained by detecting the changing of the width and wavelength of the response signal 11 by the second in-tower detector 6b.

[0057] The configuration also can be the one in which the response signals can be distinguished from each other according to the number of the pulse, the width of the pulse, or the like so that the car 1 can be specified. For example, a pulse having one peak is assigned for calling the car 1a, and a pulse having two peaks is assigned for calling the car 1b. In the first measurement, the call signal of the pulse having one peak is generated to the first sound signal conductor 4a. The first on-car detectors 7a of the upper car 1a detects the pulse having one peak and therefore determines that the car 1a itself is being called, so that the response signal 11 is generated by the on-car transmitter 8. The first on-car detectors 7a of the lower car 1b ignores the call signal generated in the first measurement and detects the call signal of the pulse having two peaks generated in the second measurement and, at this point, generates the response signal 12. Herein, to avoid the interference between the response signal 11 and the response signal 12, the second call signal shall be generated after enough time has elapsed. Thus, in the case where the measuring interval is long due to a high building, since the time interval becomes long, there is a possibility that the position of the first measured car 1 will widely deviate at the time when the last car 1 is measured. Thus, this method is effective when the measuring interval is short enough and moving speed of the car is slow enough.

[0058] Further, since interference between the response signals will be small when the measuring interval is short enough, as shown in Figs. 3A, 3B and 3C, even when the second wave of response signal 12 is generated before the first wave of response signal 11b propagating downward has propagated through, the second wave of response signal 12 propagating upward will not be affected by the first wave of response signal 11b propagating downward. Thus, in such a case, the response signals 11 can be generated in the order from the uppermost on-car transmitter 8a.

[0059] Further, as shown in Figs. 3A, 3B and 3C, when the cars 1a, 1b generate response signals having waveform specified for respective cars 1a, 1b, the controller on the receiving side will know the positions of respective cars. Although Figs. 3A, 3B and 3C show a method in which the call signals are distinguished from each other by the number of the pulse, other methods can be used, for example, the call signals can be distinguished from each other by changing the width of the pulse, or by changing the height of the pulse.

[0060] In the case where all cars 1 generate the same waveform, the cars 1 are identified by radio when performing initialization (for example, when turning on the power). Specifically, when performing first measurement, at the times respectively represented by Figs. 3A and 3C, when the response signals 11, 12 are generated, identification numbers of the cars 1a, 1b and the order of the selected on-car transmitter 8 (or the number of the signals detected by the second on-car detector 7b) are output to the controller by radio. The controller assigns the identification numbers to positions of the cars 1 based on the detected result and radio information. Alternatively, the controller can determine the identification numbers of respective cars, and only pertinent car 1 generates the response signal. With such arrangement, the cars can be distinguished from each other without depending on the waveform.

[0061] After having performed initialization, the controller or the main controller assign the identification numbers of the cars 1 to the positions of the cars 1 by determining which car 1 is close to the previous information, taking advantage of the fact that the positions and speeds of the respective change continuously.

[0062] In such a manner, the order and speed of each car 1 are stored at the time when performing initialization, and then the cars 1 are driven while being identified. This is an effective method to achieve a multi-car elevator in which cars never overtake each other.

[0063] In the case of an one-shaft multi-car elevator, in which a plurality of cars 1 are moved in a single running path 2a, since the relationship between the cars 1 does not change, it is not necessary to distinguish the cars 1 from each other at the time when performing initialization. Further, since the total number of the cars 1 in the running path 2a does not change, the first in-tower detector 6a, the second in-tower transmitter 5b and the third in-tower detector 6c are unnecessary. Further, only one on-car transmitter 8 needs to be attached on each car 1 at different position. In other words, when in the case shown in Figs. 3A, 3B and 3C, only the on-car transmitter 8b needs to be attached on the upper car 1a, and only the on-car transmitter 8a needs to be attached on the lower car 1b. Thus, it is not necessary to shift the on-car transmitter 8, and it is not necessary to provide the second on-car detector 7b.

[0064] The following paragraphs describe how to detect a problem when the response signal 11 can not be generated due to failure of the on-car transmitter 8.

[0065] Since the cars 1 never overtake each other, the order of the cars 1 will not change. However, when the on-car transmitter 8 of the car 1a in the left running path 2a goes into failure and when there is a car 1b under the car 1a, the response signal 12a of the car 1b will reach the in-tower detector 6b. By confirming the order of the signal of the car 1b and the instantaneous movement of the car 1a by the controller or the main controller, the failure of the on-car transmitter 8 can be detected.

[0066] Further, the failure also can be detected by pro-

viding a watchdog timer to the controller. For example, in the case where the number of the cars in the left running path 2a is known in advance, when the on-car transmitter 8a of a certain car 1 goes into failure, the response signal 12a of the last car will never reach the in-tower detector 6b. Thus, the abnormality can be detected by letting the watchdog timer go off when a predetermined time has elapsed.

[0067] The watchdog timer can be set to a time which is longer than the time taken for the first on-car transmitter 8a of the car 1 farthest away from the measuring side to propagate the response signal 12 generated thereby to the controller, but shorter than the time taken to perform one measurement operation.

[0068] The following paragraphs describe how six cars 1 are each driven by looped circulating ropes 16 and motors 17 with reference to the Fig. 4.

[0069] Two places opposite each other along a diagonal line of the upper portion of the car 1b are respectively fixed to two circulating ropes 16b, 16b' respectively provided before and behind the car 1b. Further, another car 1b' is fixed to the circulating ropes 16b, 16b' at another two places opposite the aforesaid two places at which the car 1b is fixed. In this manner, the cars are grouped into three pairs, each pair being fixed to two circulating ropes. A plurality of driving pulleys 18a, a plurality of driving pulleys 18b, and a plurality of driving pulleys 18c are respectively arranged in circular arc shape and are respectively driven by a motor 17a, a motor 17b and a motor 17c shown in the upper of Fig. 4 to independently drive each pair of ropes 16a, 16b, 16c.

[0070] The plurality of driving pulleys 18 are arranged in circular arc shape so that they contact with the rope with uniform friction force. Due to this reason, the upper running path 3a is in circular arc shape. In order to have a longitudinally symmetric shape, the lower running path 3b is also in circular arc shape.

[0071] Further, since the upper running path 3a and the lower running path 3b are provided for the purpose of reversing the moving direction of each car 1 along the left running path 2a and the right running path 2b, the lengths of the upper running path 3a and the lower running path 3b are made as short as possible. Thus, the number possible to be contained in the upper running path 3a and the lower running path 3b is limited to one.

[0072] Fig. 5 shows an entire construction. Since two cars 1 are fixed to the circulating rope 16 in positions opposite each other, when the left running path 2a has one car 1, then the right running path 2b must have one car 1'. In other words, each of the left running path 2a and the right running path 2b can have three cars 1 at most. Thus, the number of the on-car transmitter 8 on each car 1 is three regardless of the length of the running paths 2.

[0073] Since the number possible to be contained in the upper running path 3a and the lower running path 3b is one at most, the response signals 11 will never interfere with each other no matter what on-car transmitter 8 is

used. This corresponds to the case where there is only one car in the running path shown in Figs. 2A, 2B and 2C. Thus, only the first on-car transmitter 8a needs to be attached on the rotatable arm 14.

[0074] Further, since the auxiliary signal 13 is not necessary, the first in-tower detector 6a, the second in-tower transmitter 5b and the third in-tower detector 6c can be skipped. In such a case, however, the car 1 needs to detect that it is in the running path, and select the first on-car transmitter 8a. To serve this purpose, the proximity sensors 20 are attached respectively on the left side and right side of the car 1 to detect the walls of the left running paths 2a, 2b or detect devices 19 attached along the walls of the left running paths 2a, 2b. When no signal is detected by the proximity sensors 20, the car 1 determines that it is in either the upper running path 3a or the lower running path 3b, and select the first on-car transmitter 8a.

[0075] If the fact that there is a car 1 in either upper running path 3a or lower running path 3b is known, then it is obvious that there are two cars 1 in each of the running paths 2a, 2b. Thus, by letting the controller of the left and right running paths 2 know whether or not there is a car 1 in either upper and lower running paths 3a, 3b in advance through the main controller, it is possible to judge whether the auxiliary signal should be generated for one time. Thus, the third in-tower detector 6c is unnecessary.

[0076] The following paragraphs describe details of the method to hold the sound signal conductor 4.

[0077] The sound signal conductor 4 is formed of long and thin wire made of a magnetostrictive material, and therefore tends to sway because of wind or earthquake. As shown in Figs. 6A and 6B, the swing of the sound signal conductor 4 is restrained by passing the wire through guide rings 21.

[0078] The on-car detector 7 detects the signal from the sound signal conductor 4 through a reception coil 22, and the on-car transmitter 8 generates a signal to the sound signal conductor 4 through a transmission coil 23.

[0079] For the following three purposes, each of the reception coil 22 and the transmission coil 23 is U-shaped.

[0080] The first purpose is to prevent the sound signal conductor 4 from coming off from the reception coil 22 and the transmission coil 23; the second purpose is to prevent the reception coil 22 and the transmission coil 23 from colliding with the fixing portions of the guide rings 21; and the third purpose is to allow the reception coil 22 and the transmission coil 23 to transfer from the present sound signal conductor to the next sound signal conductor when the reception coil 22 and the transmission coil 23 transfer from one running path 2, 3 to another.

[0081] The fixing portions of the guide rings 21 are made of soft material, and therefore the reception coil 22 and the transmission coil 23 will not be damaged even when colliding with the guide rings 21 due to the earthquake.

[0082] In the upper and lower running paths 3, the

sound signal conductor 4 is attached through the guide rings 21 in a manner in which the sound signal conductor 4 curves along the circular arc shaped moving trajectory of the car 1. Since the sound signal transmitted by the sound signal conductor 4 is a longitudinal wave, even when the sound signal conductor 4 is in constant contact with the guide rings 21, the signal almost does not attenuate

[0083] As shown in Figs. 6A and 6B, there are two methods to arrange the sound signal conductor 4 at places where the sound signal conductor 4 transfers from the left and right running paths 2 to the upper and lower running paths 3.

[0084] Fig. 6A shows a method in which two sound signal conductors 4 are arranged along the same reception coil 22. The two sound signal conductors 4a, 4e are partly overlapped with each other so that they can pass through the U-shaped reception coil 22. However, to prevent the two sound signal conductors 4a, 4e from directly contacting each other, a two-holes guide ring 24 is provided so that, as shown in the enlarged view, the two sound signal conductors 4a, 4e respectively pass through the two-holes guide ring 24 separated from each other with a space. Incidentally, as to be described later, the reception coil 22 is attached so that it rotates along the curve.

[0085] The above method applicable to the time when the reception coil 22 of the on-car detector 7a transfers from the first sound signal conductor 4a of the left running path 2a to the fifth sound signal conductor 4e, and from the third sound signal conductor 4c to the seventh sound signal conductor 4g of the lower running path 3b.

[0086] The first on-car transmitter 8a also can be used at time when the car 1 transfers from the left running path 2a to the upper running path 3a. At this time, the second on-car detector 7b is attached closer to the lower side than the first on-car transmitter 8a.

[0087] This method also can be used in the case where the running path is divided by the sound signal conductor 4, and in such case, the running path becomes longer due to being divided.

[0088] Fig. 6B shows a method in which different transmission coils 23a, 23b are used respectively in the left and right running paths 2 and in the lower running path 3b.

[0089] Since the second and third on-car transmitters 8b, 8c are provided below the first on-car transmitter 8a, they have to be passed through to positions closer to the lower side than the eighth sound signal conductor 4h when coming into the lower running path 3b. Thus, to avoid the interference with the eighth sound signal conductor 4h, the transmission coil 23 is arranged to a position displaced from the fourth sound signal conductor 4d and the eighth sound signal conductor 4h in the front-and-back direction so that a space for passing through the on-car transmitter 8 is formed. Further, a transmission coil 23b is provided conforming to the position of the eighth sound signal conductor 4h.

[0090] Fig. 7 shows a method for attaching the recep-

tion and transmission coils 22, 23 so that the reception and transmission coils 22, 23 move along the sound signal conductor 4.

[0091] The reception coil 22a of the on-car detector 7a and the transmission coils 23a, 23b of the first on-car transmitter 8a need to constantly move along the inner side of the sound signal conductor 4 while rotating. Since rope fasteners 14 are integrally fixed to the circulating ropes 16, they move while rotating 360 degrees. In other words, the rope fasteners 14 serve as the rotatable arms that attach the on-car detectors 7, the on-car transmitters 8 and the like. Thus, the reception coil 22a is attached on the rope fastener 14a of the left circulating rope 16a, and the transmission coils 23a, 23b are attached on the rope fastener 14b of the right circulating rope 16a.

[0092] The reception and the transmission coils 22, 23 of the second on-car detector 7b and the second and third on-car transmitters 8b, 8c need to move along the inside of the sound signal conductors 4b, 4d so that they do not abut the sound signal conductors 4b, 4d when the car 1 moves horizontally in the upper and lower running paths 3. However, a complicated mechanism will be needed to make both the reception and the transmission coils 22, 23 rotate to change the direction thereof by 180 degrees. Thus, the reception and the transmission coils 22, 23 of the on-car detector 7 and the second and third on-car transmitter 8 are divided into two parts left and right with a difference of 180 degrees

[0093] Thus, when the car 1 is in the left running path 2a, the reception coil 22b and the transmission coils 23c, 23e on the left side move along the second sound signal conductor 4b from the inner side. When the car 1 is in the right running path 2b, the reception coil 22c and the transmission coils 23d, 23f on the right side move along the fourth sound signal conductor 4d from the inner side. The signal may be output to the transmission coils 23 on the left and right sides alternately in accordance with the position of the car 1, or the signal can be simultaneously output on the left and right sides regardless of the position of the car 1.

[0094] The relative position of the circulating rope 16, the car 1, the sound signal conductor 4, and the reception and transmission coils 22, 23 will be described below with reference to Fig. 8.

[0095] Fig. 8 is a top view showing two cars 1a, 1a' in the left and right running paths 2a, 2b, the circulating ropes 16, 16' arranged before and behind the cars 1, the cross section of the sound signal conductors 4a, and the reception and transmission coils 22, 23. The reference numeral 25 on the lower side of Fig. 8 is assigned to the front side of the elevator, and the reference numeral 26 on the upper side of Fig. 8 is assigned to the rear side of the elevator. Incidentally, the door of the cars 1 also can be arranged on the opposite side so that the said front side becomes the rear side, and the said rear side becomes the front side.

[0096] The following describes how to install the cars 1 to the circulating ropes 16.

[0097] In the left circulating ropes 16' on the rear side 26 of the cars 1, the rope fastener 14a catches the circulating rope 16a'. The part of the rope fastener 14 where the rope is caught is referred to as "belly", and the part opposite the belly is referred to as "back" hereinafter. The belly side of the rope fastener 14 faces the circulating rope, and the back side of the rope fastener 14 faces the outside.

[0098] In the right circulating ropes 16' on the front side 25 of the cars 1, the rope fastener 14b catches the circulating rope 16a. The rope fasteners 14a, 14b are fixed to the car 1a by rotating shafts 27a, 27b respectively attached on the left rear side and the right front side of the car 1a.

[0099] As described above, since the cars 1 are attached to the circulating ropes 16, 16', in order not to have the sound signal conductors 4 to interfere with the circulating ropes 16, 16' and the car 1, the following two conditions must be met:

[0100] First, the sound signal conductors 4 shall be arranged sufficiently away from the circulating rope 16a on its outer side so that the sound signal conductors 4 do not abut the rope fasteners 14a; Second, the sound signal conductors 4 shall be arranged in front of or behind the cars 1 so that the sound signal conductors 4 do not abut the cars 1.

[0101] Based on the above two conditions, the following describes how to dispose the left circulating rope 16' and the surrounding components.

[0102] The first sound signal conductor 4a and the third sound signal conductor 4c are disposed in the vicinity of back side of the rope fasteners 14a, 14b at positions behind the cars 1. Further, the fifth and seventh sound signal conductors 4e, 4g used in the upper and lower running paths 3 are disposed on the extended lines of the first sound signal conductor 4a and the third sound signal conductor 4c.

[0103] In the left car 1a, only the reception coil 22a of the on-car detector 7a is needed on the rear side of the car 1a. The reception coil 22a is attached on the back of the rope fasteners 14a so that the U-shaped opening of the reception coil 22a opens to the left. When transferring to the right running path 2b, since the rope fasteners 14a rotates by 180 degrees, opening of the reception coil 22a' of the car 1a' in the right running path opens to the right. Thus, it is possible for the reception coil 22a to constantly move along the sound signal conductors 4 from the inner side.

[0104] The reception coil 22a also can be fixed to a bearing 28 of the rope fasteners 14 after being rotated by 360 degrees when shape of the reception coil 22a becomes the shape of the reception coil 22A, so that the reception coil 22A does not rotate, which facilitates the wiring work.

[0105] The following describes how to dispose the right circulating rope 16 and the surrounding components.

[0106] The right circulating rope 16 is on the front side 25 of the cars 1, where the reception and transmission

coils 22, 23 are needed.

[0107] Since the reception and transmission coils 22, 23 of the on-car detector 7b and the second and third on-car transmitter 8b, 8c of the car 1a are divided into two parts opposite each other, they need to be arranged on the positions closer to the rear side than the circulating ropes so that they do not interfere with the circulating ropes 16. Thus, the second and fourth sound signal conductor 4b, 4d are disposed in the vicinity of the back of the rope fasteners 14b, 14b' at positions between the cars 1 and the circulating ropes 16.

[0108] Further, the sixth and eighth sound signal conductors 4f, 4h used in the upper and lower running paths 3 are disposed at positions closer to the front side than the second and fourth sound signal conductors 4a, 4d. The second transmission coil 23b of the first on-car transmitter 8a is attached on the back of the rope fasteners 14b conforming to the position of the sixth and eighth sound signal conductors 4f, 4h for being used in the upper and lower running paths 3. The sixth and eighth sound signal conductors 4f, 4h of the upper and lower running paths 3 also can be displaced toward the rear side, however, the area of the cross section of the elevator shaft can be reduced when the sixth and eighth sound signal conductors 4f, 4h are displaced toward the front side.

[0109] The coil 23b of the rope fasteners 14 also can be fixed to the bearing 28 of the rope fasteners 14 after being rotated by 360 degrees when shape of the coil 23b becomes the shape of the coil 23B. However, to avoid the interference with the circulating ropes 16, the sixth and eighth sound signal conductors 4f, 4h of the upper and lower running paths 3 are disposed between the cars 1 and the circulating ropes 16, so that the coil 23B does not rotate, which facilitates the wiring work.

[0110] The method for calibrating the attachment positions of the on-car transmitters 8 will be described below.

[0111] During the time while the calibration is being performed, only a specified car 1 generates a signal in response to the call signal 10, and the other cars 1 ignore the call signal 10.

[0112] In a state where all cars 1 stop, the controller generates the call signal a plurality of times. Every time when the on-car detector 7a of the specified car 1 detects the signal, the on-car transmitters 8 transmit response signals sequentially from up to down.

[0113] Based on the response signals transmitted from the on-car transmitters 8 disposed on different positions of the specified car 1, the controller calculate to obtain the actual attachment positions of the on-car transmitters 8, and uses the values as calibration values for performing calibration.

[0114] By subtly displacing the positions of the on-car transmitters 8, the on-car transmitters 8 can be attached on each car 1 separated from each other with specified spaces. Thus, it is possible to recognize the respective cars.

Features, components and specific details of the struc-

tures of the above-described embodiments may be exchanged or combined to form further embodiments optimized for the respective application. As far as those modifications are readily apparent for an expert skilled in the art they shall be disclosed implicitly by the above description without specifying explicitly every possible combination, for the sake of conciseness of the present description.

Claims

1. A multi-car elevator having a plurality of cars in a running path, comprising:

a first sound signal conductor (4a) and a second sound signal conductor (4b) for propagating a sound signal along the running path;

an in-tower transmitter (5b) which converts an electrical signal into the sound signal and outputs the sound signal, the in-tower transmitter (5b) being provided on one end, which serves as a measuring side, of the first sound signal conductor (4a);

an in-tower detector (6b) which detects the sound signal and converts the sound signal into the electrical signal, the in-tower detector (6b) being provided on one end, which serves as the measuring side, of the second sound signal conductor (4b);

an on-car detector (7a) which detects the signal propagating from the first sound signal conductor (4a), the on-car detector being provided on each of the cars (1); and

an on-car transmitter (8a) which generates a response signal to the second sound signal conductor (4b),

wherein the in-tower transmitter (5a) generates a call signal, the on-car transmitter (8a) generates the response signal to the second sound signal conductor (4b) after the call signal is detected by the on-car detector (7a), and positions of the respective cars (1) are obtained by calculating time interval from the time when the call signal is generated to the time when the response signal is detected by the in-tower detector (6b).

2. The multi-car elevator according to claim 1, wherein the on-car transmitter (8) includes a plurality of on-car transmitters (8a, 8b) for each of the cars (1), each on-car transmitter (8) having different distance from the measuring side, and either one of the on-car transmitters (8) is selected to generate the response signal to the second sound signal conductor (4b) after the on-car detector (7a) has detected the call signal generated by the in-tower transmitter (5b).

3. The multi-car elevator according to claims 1 or 2, further comprising:

a plurality of the on-car transmitters (8) for each car (1), each on-car transmitter (8) having different distance from the measuring side; and second on-car detectors (7b) which detect the signal propagated from the second sound signal conductor (4b), the second on-car detectors (7b, 7b') being provided on the respective cars (1),

wherein when the second on-car detector (7b) detects a signal, the selected on-car transmitter (8) will be shifted to another.

4. The multi-car elevator according to at least one of the preceding claims 1 to 3, further comprising:

a plurality of the on-car transmitters (8) attached on each car (1), each on-car transmitter (8) having different distance from the measuring side; and second on-car detectors (8b) which detect the signal propagated from the second sound signal conductor (4b), the second on-car detectors (7b) being provided on the respective cars (1),

wherein when the second on-car detector (7b) detects a signal, the on-car transmitters (8) will be sequentially selected in accordance with the distances to the measuring side.

5. The multi-car elevator according to at least one of the preceding claims 1 to 4, wherein a number of the on-car transmitters (8) for each car (1) is determined in accordance with a number of the cars (1).
6. The multi-car elevator according to at least one of the preceding claims 1 to 5, wherein the running path is divided into a plurality of sectional running paths each provided with the first sound signal conductor (4a) and the second sound signal conductor (4b).
7. The multi-car elevator according to at least one of the preceding claims 1 to 6, wherein the running path is divided into a plurality of sectional running paths, and a proximity sensor for detecting devices attached on the respective sectional running paths is provided on each car (1) to detect whether or not the cars (1) are in either one of the sectional running paths.
8. The multi-car elevator according to at least one of the preceding claims 1 to 7, wherein the running path is divided into a plurality of sectional running paths, and the cars (1) are fixed to a circu-

lating rope (16) so that the cars (1) move in a circulating manner.

9. A multi-car elevator having a plurality of cars in a running path, comprising:

a first sound signal conductor (4a) and a second sound signal conductor (4b) for propagating a sound signal along the running path; an in-tower transmitter (5b) which converts an electrical signal into the sound signal and outputs the sound signal, the in-tower transmitter (5b) being provided on one end, which serves as a measuring side, of the first sound signal conductor (4a); an in-tower detector (6b) which detects the sound signal and converts the sound signal into the electrical signal, the in-tower detector (6b) being provided on one end, which serves as the measuring side, of the second sound signal conductor (4b); an on-car detector (7a) which detects the signal propagating from the first sound signal conductor (4a), the on-car detector (7a) being provided on each of the cars (1); and an on-car transmitter (8a) which generates a response signal to the second sound signal conductor (4b), the on-car transmitter (8a) being provided on each of the cars (1),

wherein the in-tower transmitter (5a) generates a call signal, the on-car transmitter (8a) generates the response signal to the second sound signal conductor (4b) at different delays for each car (1) after the call signal is detected by the on-car detector (7a), and positions of the respective cars are obtained based on the time when the call signal is generated, time when the response signal is detected, and speeds of the respective cars (1).

FIG.1

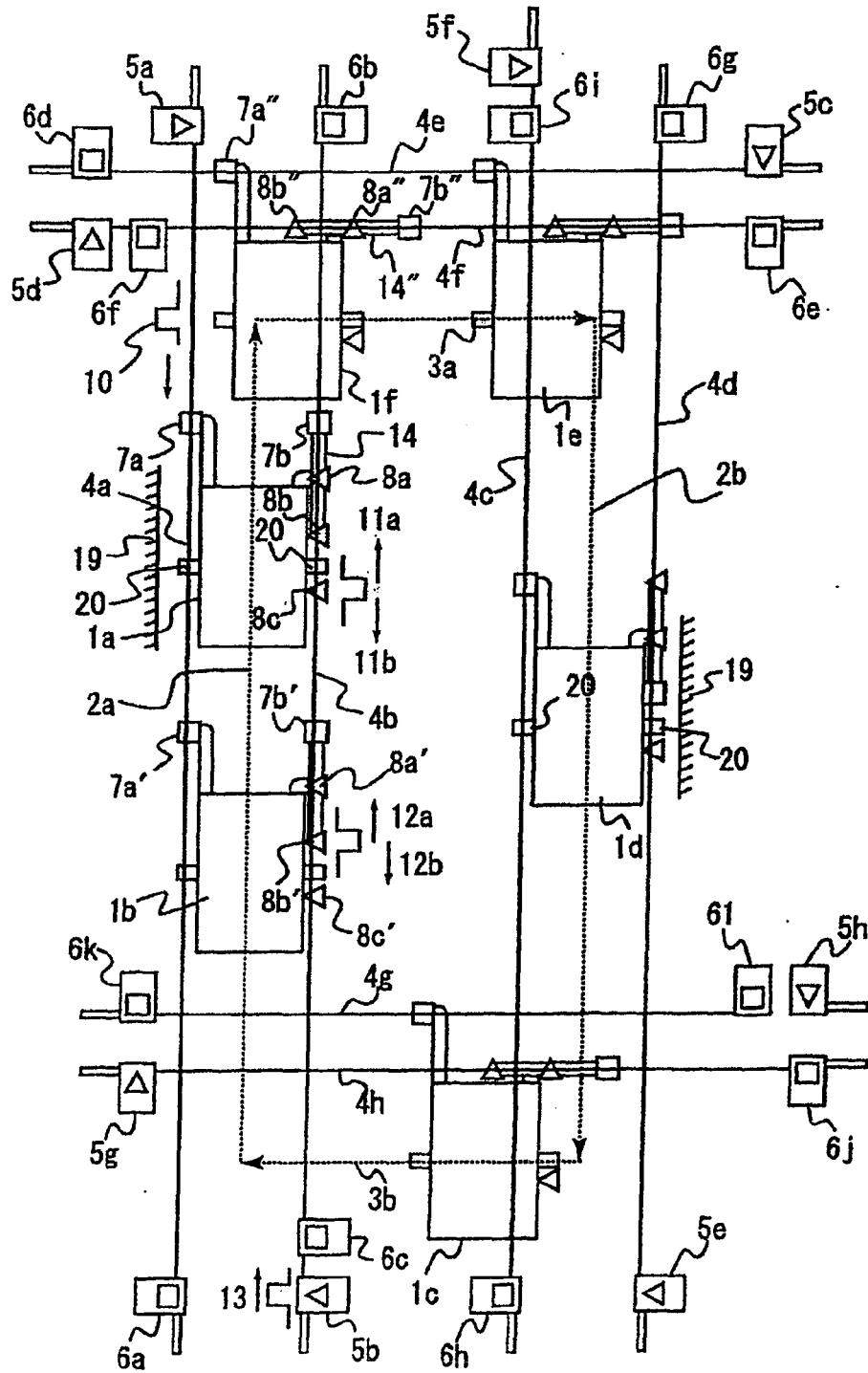


FIG.2A

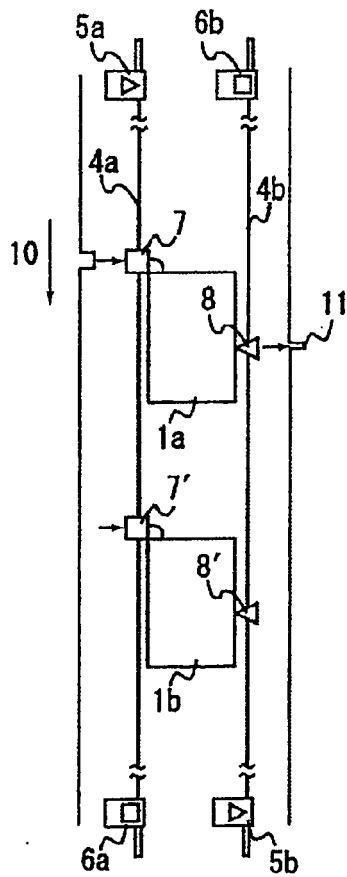


FIG.2B

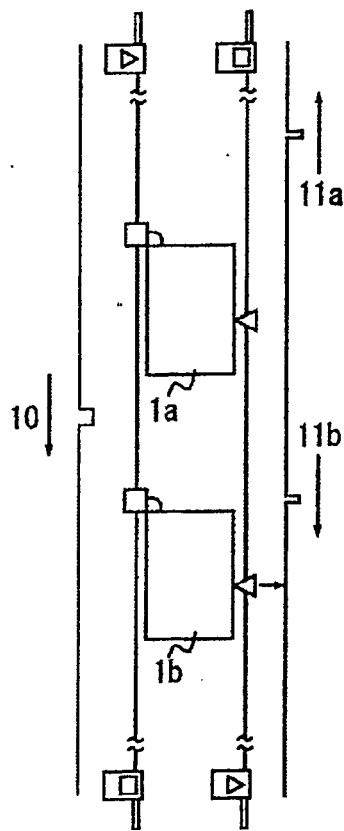


FIG.2C

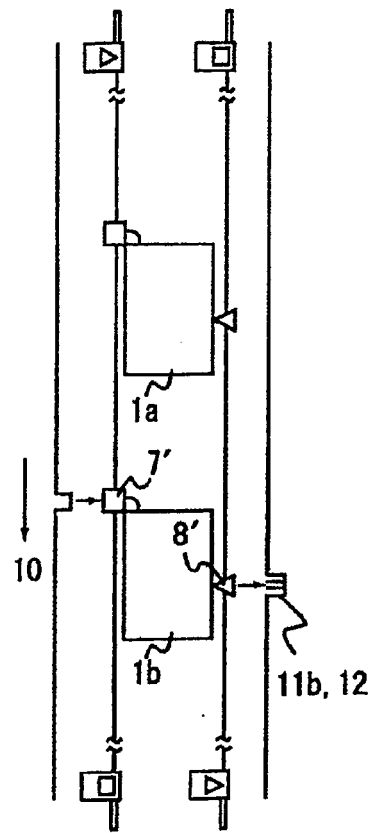


FIG.3A

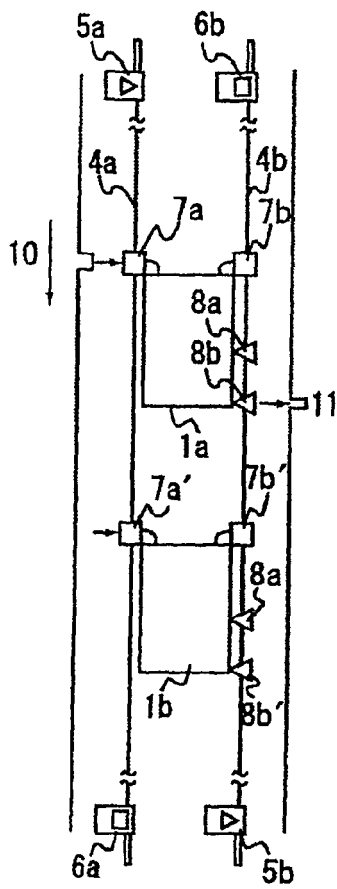


FIG.3B

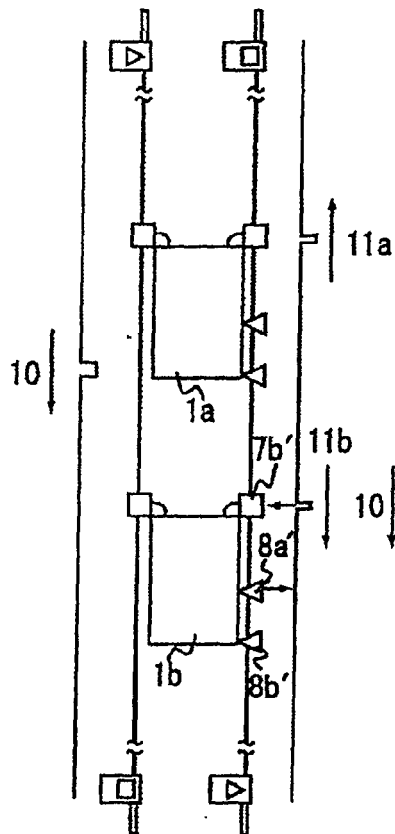


FIG.3C

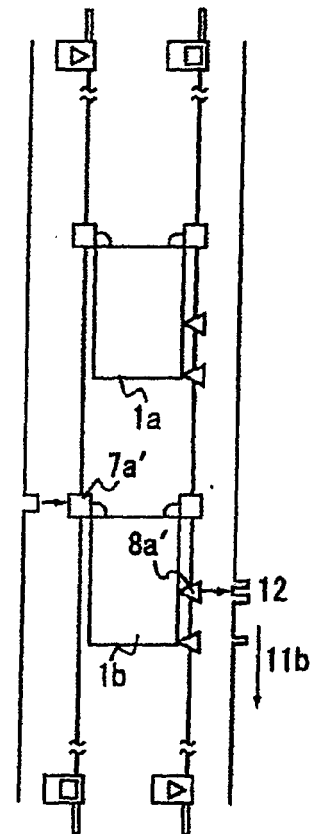


FIG.4

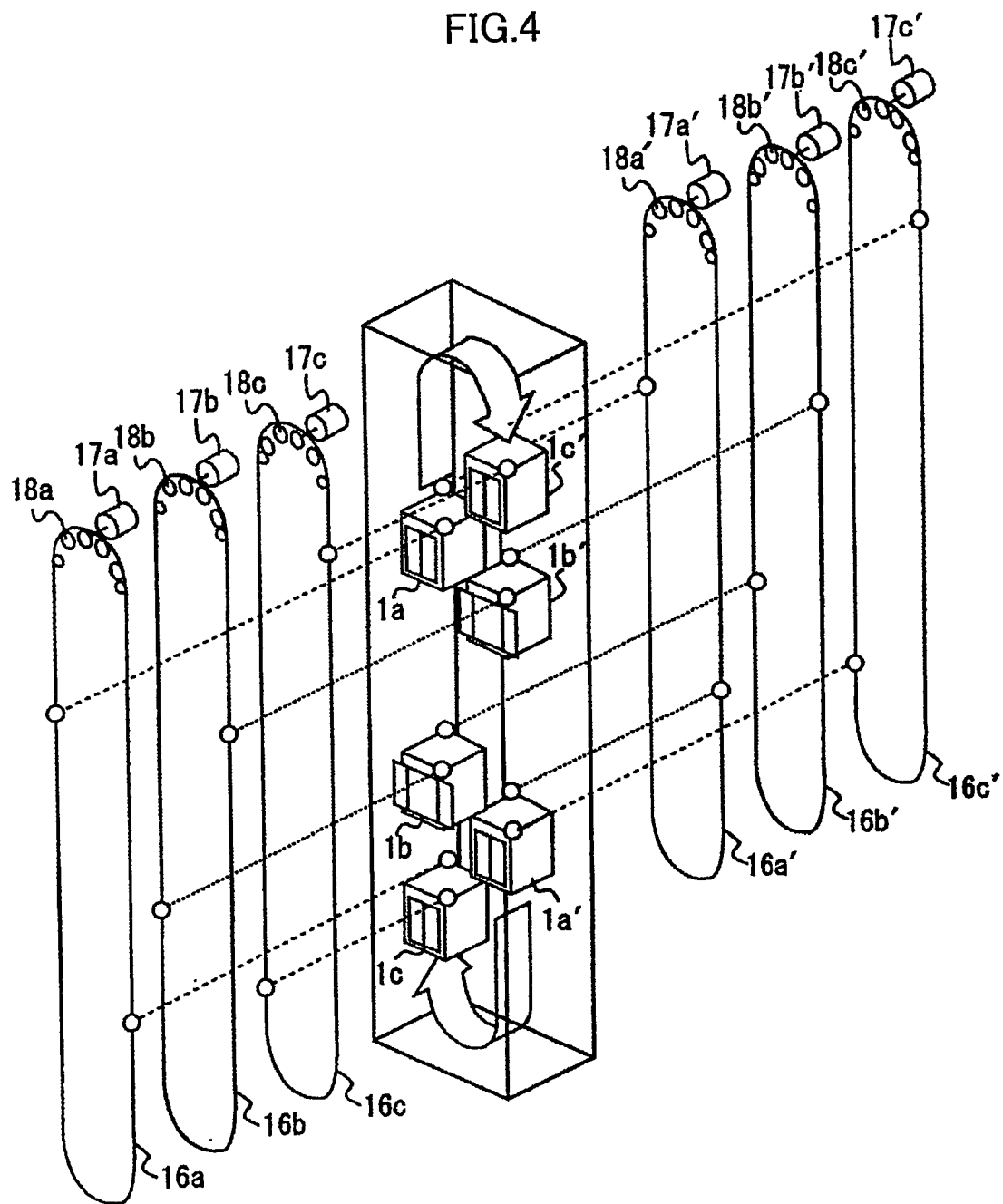


FIG.5

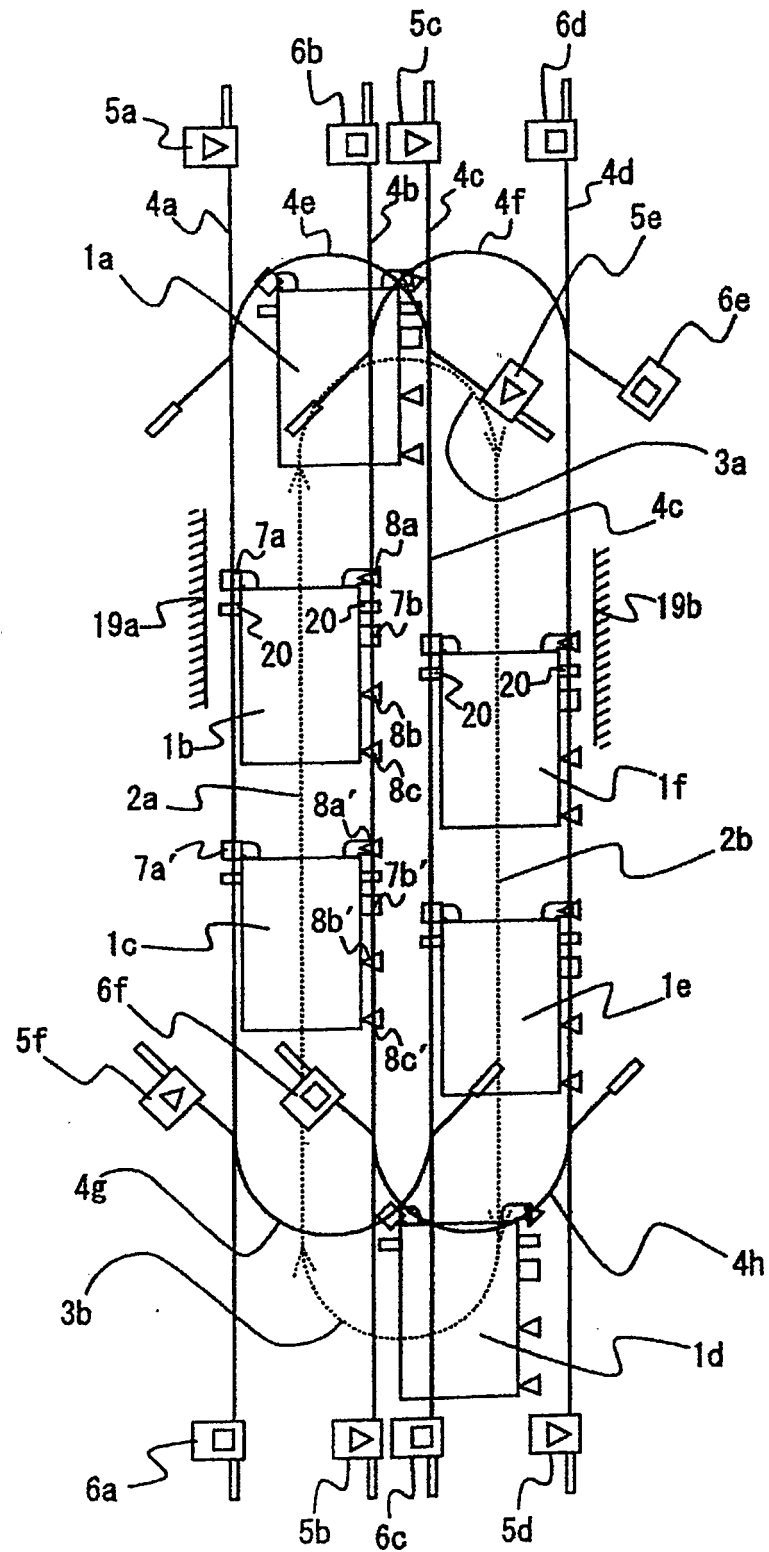


FIG.6A

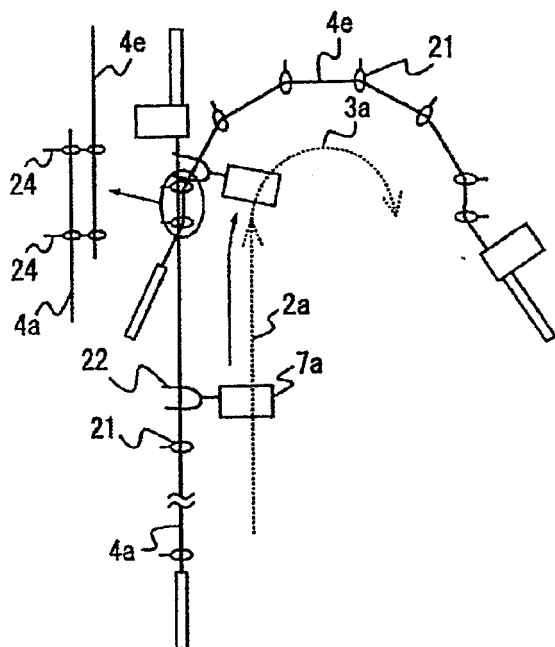


FIG.6B

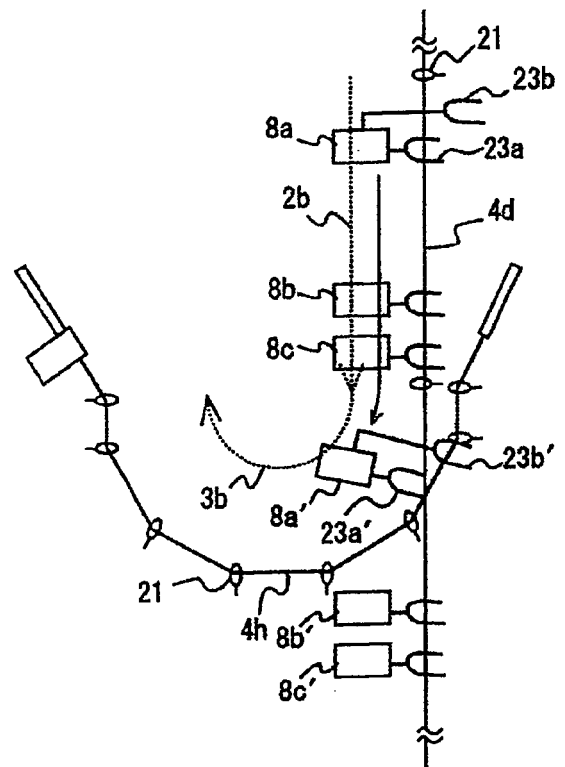


FIG.7

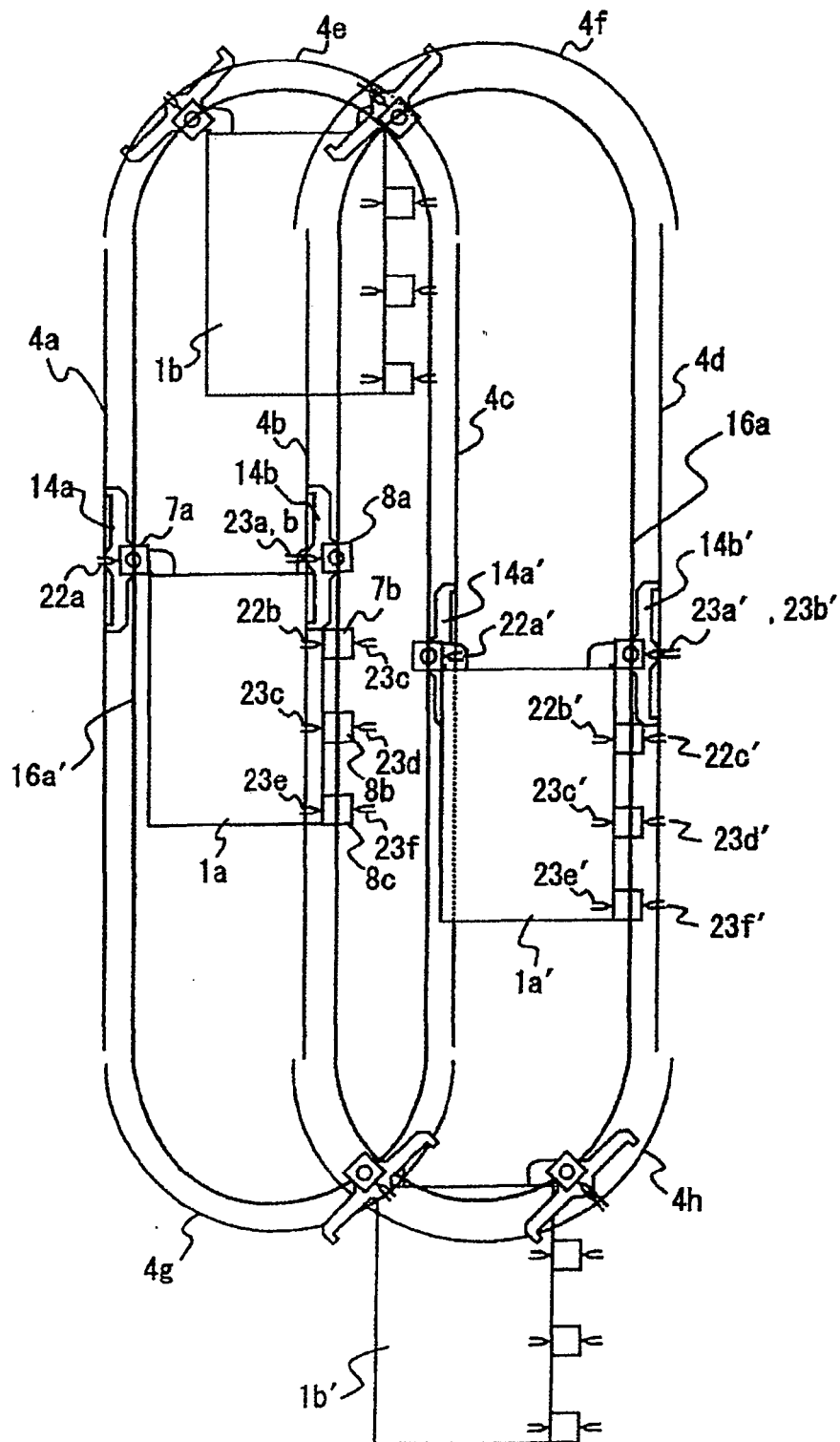
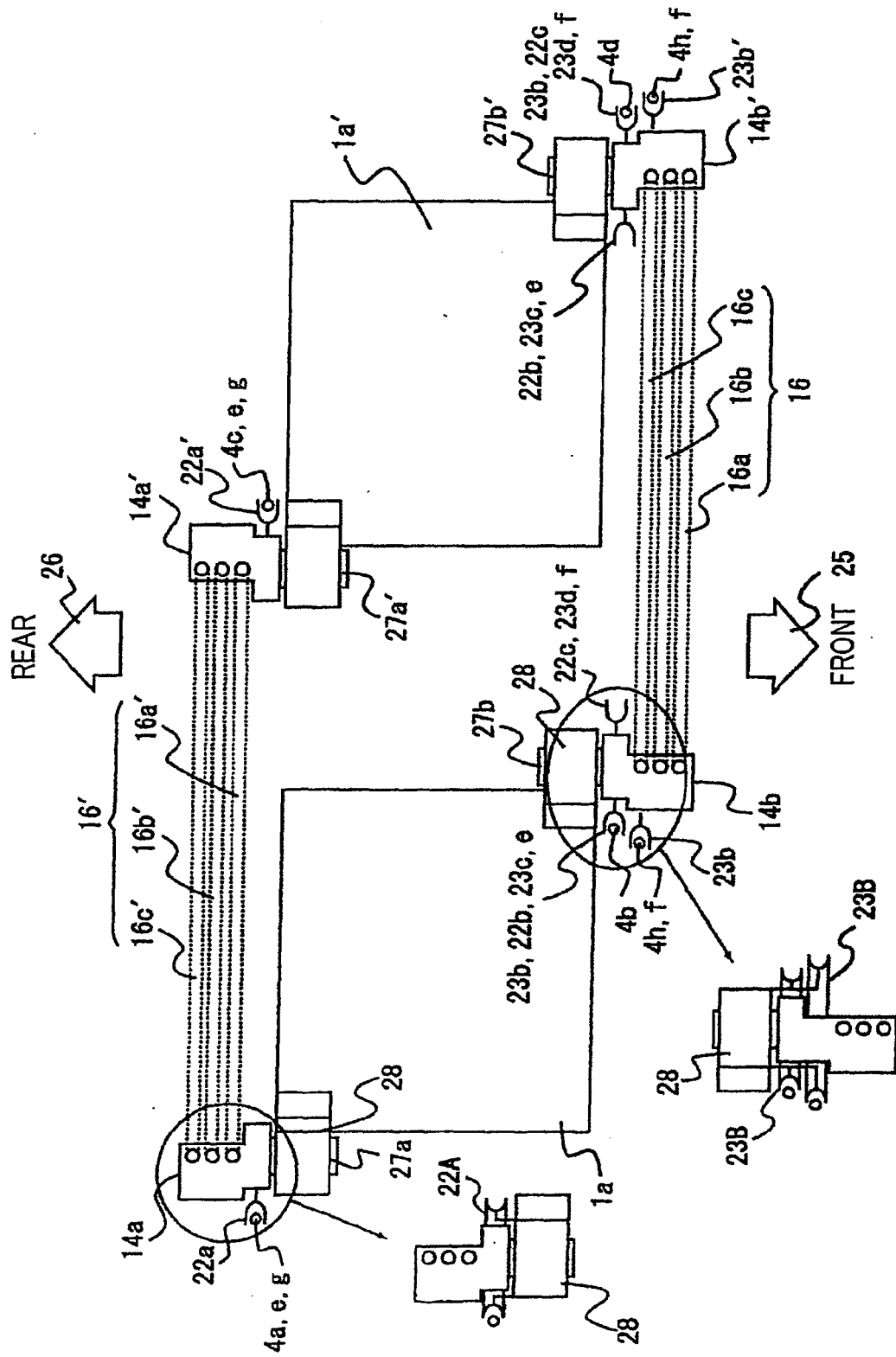


FIG.8



REFERENCES CITED IN THE DESCRIPTION

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