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

(11) Publication number: **0 567 897 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93106360.6**

(51) Int. Cl.5: **E05F 15/18**

(22) Date of filing: **20.04.93**

(30) Priority: **27.04.92 IT TO920116 U**

(43) Date of publication of application:
03.11.93 Bulletin 93/44

(84) Designated Contracting States:
CH DE ES FR GB LI SE

(71) Applicant: **APRIMATIC S.p.A.**
Zona Industriale
I-40060 Villa Fontana-Medicina (Bologna)(IT)

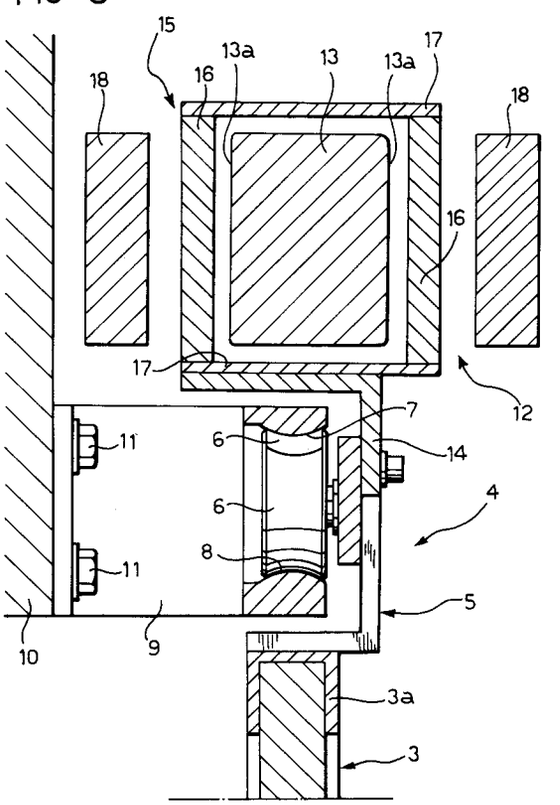
(72) Inventor: **Negroni, Andrea**
Via Berengario da Carpi, 23
I-40141 Bologna(IT)

(74) Representative: **Marchitelli, Mauro**
Jacobacci-Casetta & Perani S.p.A.
Via Alfieri, 17
I-10121 Torino (IT)

(54) A device for operating a sliding door.

(57) A device for operating a sliding door, particularly an automatic sliding door, comprises a brushless, direct-current linear electric motor including a main stator (13) constituted by a bar of ferromagnetic material mounted on a fixed structure parallel to the directions (A) of sliding of the leaf (3) of the door, at least one electrical winding which is disposed around a portion of the bar (13) and is intended to be supplied with direct current, a unit (15) which is movable linearly relative to the bar and is connected rigidly to the leaf (3), the movable unit (15) carrying permanent magnets facing two opposite sides (13a) of the bar (13), and two auxiliary stator bars (18) parallel to the main bar (13) and spaced from opposite sides thereof.

FIG. 3



EP 0 567 897 A2

The present invention relates to devices for operating sliding doors, particularly automatic sliding doors of the type which are operated, for example, as a result of the activation of a presence detector situated in the region of the floor in front of the door.

The operating devices used up to now for this type of doors comprise a rotary, direct-current, alternating current, or brushless electric motor which drives an endless belt, usually a toothed belt, by means of a reduction unit, the belt having two parallel passes connected rigidly to the two leaves of the sliding door so that the rotation of the belt in one sense or the other causes the leaves to open or close, respectively.

The main disadvantage of the solution indicated above lies in the fact that the transmission which brings about the movement of the leaves is quite complex, being constituted by a moderate number of parts, and is consequently the source of a series of possible problems such as, for example, wear of the belts or of the brushes of the motor, the need to tension the belt periodically, the generation of dust resulting from the wear of the belt and, finally, noise due to the reduction unit and to the belt.

The object of the invention is to prevent the problems indicated above by means of an operating system which is particularly simple and reliable.

In order to achieve this object, the subject of the invention is a device for operating a sliding door comprising at least one leaf mounted for sliding on guide means, characterised in that the device comprises a brushless, direct-current, linear electric motor including:

a main stator constituted by a bar of ferromagnetic material mounted on a fixed structure parallel to the direction of sliding of the leaf,

at least one electrical winding which is disposed around a portion of the bar and is intended to be supplied with direct current,

a unit which is movable linearly relative to the bar and is connected rigidly to the leaf, the movable unit carrying permanent magnets facing two opposite sides of the bar, and

two auxiliary stator bars parallel to the main bar and spaced from opposite sides thereof.

A brushless, direct-current, linear motor of the type indicated above formed the subject of the technical article "Analysis of a slotless permanent-magnet brushless DC linear motor" by B. Brunelli, D. Casadei, G. Serra, published in the Proceedings of "ICEM 90" - International Conference on Electrical Machines, Cambridge, Massachussetts, USA - 1990.

Various advantages result from the use of this electric motor in the operating device according to the invention. First of all, the transmissions of known systems (the reduction units, belts and pulleys) are eliminated with the consequent elimination of the corresponding problems. The number of components is thus minimised. The system does not require mutually sliding parts and is not therefore subject to wear as in known systems. Noise is reduced to a minimum and is due simply to the rolling of the carriage of each leaf on the respective guide. There is no need to make adjustments after mounting, such as the tensioning of the belt which is necessary in the known devices. Naturally, the elimination of the belt also eliminates the problem of dust generated by its wear. The elimination of the transmission, of course, maximises the performance of the device. Friction is reduced to a minimum.

The use of the linear electric motor indicated above also enables the leaf of the door to be braked electrically by the reversal of the polarity of the supply, which would be difficult to achieve with an asynchronous, linear electric motor.

Naturally, the reversal of the movement of the leaf is also brought about simply by the reversal of the polarities of the terminals of the stator winding.

A door with two leaves, of course, may have a single main stator with its two auxiliary stator bars, and two movable units associated with the two leaves, respectively.

The linear electric motor indicated above is also free of the problems which would affect other types of linear electric motors such as a linear stepper motor (which would have poor starting acceleration, an unsuitable working voltage and extreme sensitivity to dirt) or an asynchronous linear motor which would require a very complicated piloting system in order to achieve electrical braking.

The invention will now be described with reference to the appended drawings, provided purely by way of non-limiting example, in which:

Figure 1 is a front view of a sliding door with two leaves,

Figure 2 is a view of the detail indicated by the arrow II in Figure 1, on an enlarged scale, and

Figure 3 is a section taken on the line III-III of Figure 2, on an enlarged scale.

In Figure 1, the reference numeral 1 generally indicates an automatic sliding door, that is, a door of the type which is operated automatically as a result of the activation of presence sensors disposed on each side of the door in the region of the floor 2 which is in front of the door.

The door 1 comprises two leaves 3 (in the embodiment illustrated, two glass leaves, the frame 3a of each of which bears a pair of carriages 4). Each carriage 4 comprises a substantially T-shaped support bracket 5 (see also Figures 2, 3) which is fixed to the upper part of the respective frame 3a and on which three wheels 6 are mounted

idly. The central wheel 6 of the three and the other two end wheels 6 engage, respectively, two facing guide tracks 7, 8 (Figure 3) of a guide rail 9 fixed horizontally on a fixed structure 10, for example, by means of screws 11, so that each leaf 3 is supported for sliding, preferably along a straight path, in the directions indicated by the arrows A in Figure 1.

One of the two carriages 4 of each leaf 3 is associated with the movable unit of a brushless, direct-current, linear electric motor, generally indicated 12.

The electric motor 12 comprises a stator constituted by a bar 13 of ferromagnetic material, for example, of steel, the ends of which are anchored to the fixed structure 10 and which is disposed parallel to the guide rail 9. A substantial portion of the length of the bar 13 is covered by one or more electrical windings which are intended to be supplied with direct current. One of the two carriages 4 of each leaf 3 rigidly supports a movable unit 15 by means of a bracket 14, the unit 15 being mounted for linear movement on the stator bar 13 without having parts in contact therewith. The movable unit 15 comprises two permanent magnets 16 facing the two opposite sides 13a of the stator bar 13 and joined together by two plates 17. Finally, the electric motor is completed by two auxiliary stator bars 18 (Figure 3) disposed parallel to the main bar 13 and spaced from its two opposite sides so as not to interfere with the passage of each movable unit 15. The auxiliary bars are preferably connected at their ends to facilitate the closure of the lines of the magnetic field generated by the main bar 13 at the moment when the winding associated therewith is supplied with direct current.

The supply of current to the winding causes each movable unit to move in one direction or the other according to the polarity of the supply to the motor. It therefore suffices to reverse the polarity in order to reverse the movement of each leaf.

As can be seen from the foregoing description, the operating device according to the invention has no transmission between the motor and the leaf and is therefore free of all the problems of the prior art indicated above.

Naturally, the details of construction relating to the structural parts of the motor and to the manner in which the leaves of the door are guided for sliding may also differ from those illustrated purely by way of example. The two auxiliary bars 18 may also be used as guides for the movement of each unit 15. In this case, for example, each unit 15 has two appendages constituting two bushes which are mounted for sliding on the bars 18.

Claims

1. A device for operating a sliding door, comprising at least one leaf (3) mounted for sliding on guide means (9), characterized in that the device comprises a brushless, direct-current, linear electric motor (12), including:
   a main stator (13) constituted by a bar of ferromagnetic material mounted on a fixed structure parallel to the direction (A) of sliding of the leaf (3),
   at least one electrical winding which is disposed around a portion of the bar and is intended to be supplied with direct current,
   at least one auxiliary stator bar (18) parallel to the main bar (13) and spaced therefrom, and
   at least one unit which is movable linearly relative to the main bar (13) and is connected rigidly to the leaf (3), the movable unit carrying at least one permanent magnet (16) disposed between the main bar (13) and the at least one auxiliary stator bar (18).

2. An operating device according to Claim 1, characterized in that the linear electric motor (12) includes at least two auxiliary stator bars (18) parallel to the main bar (13) and spaced from the two opposite sides thereof, permanent magnets (16) facing opposite sides of the main bar (13).

3. An operating device according to Claim 1, characterized in that the leaf (3) slides in the direction (A) along a substantially straight path.

4. An operating device according to Claim 1, for a sliding door with two leaves (3), characterized in that it comprises a single main stator bar (13) associated with two movable units (12) connected rigidly to the two leaves (3) of the door, respectively.

5. A device according to Claim 1, characterized in that the two auxiliary bars (18) support each movable unit (15) slidably.

6. An automatic sliding door, characterised in that it comprises an operating device according to one or more of the preceding claims.

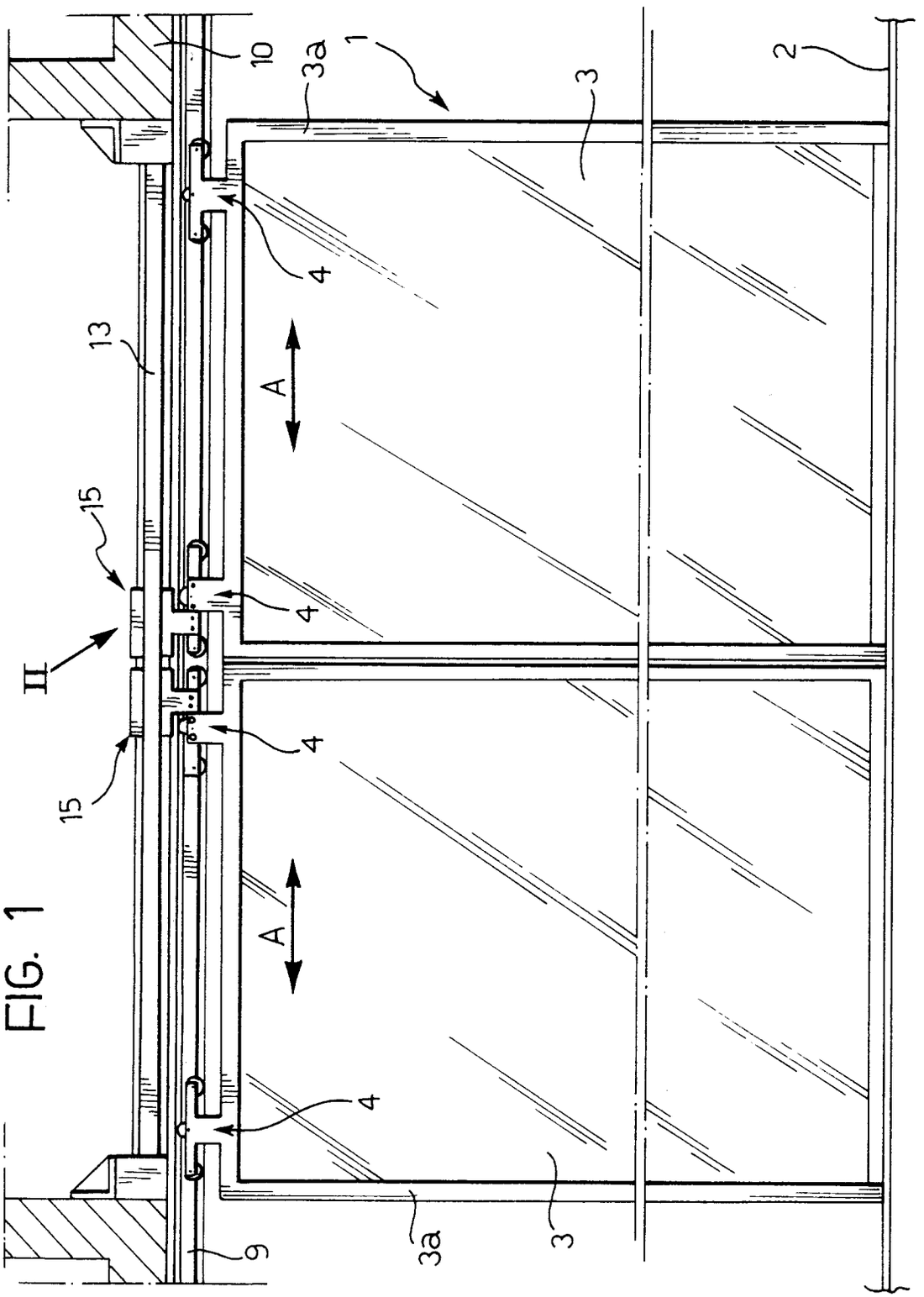


FIG. 1

FIG. 2

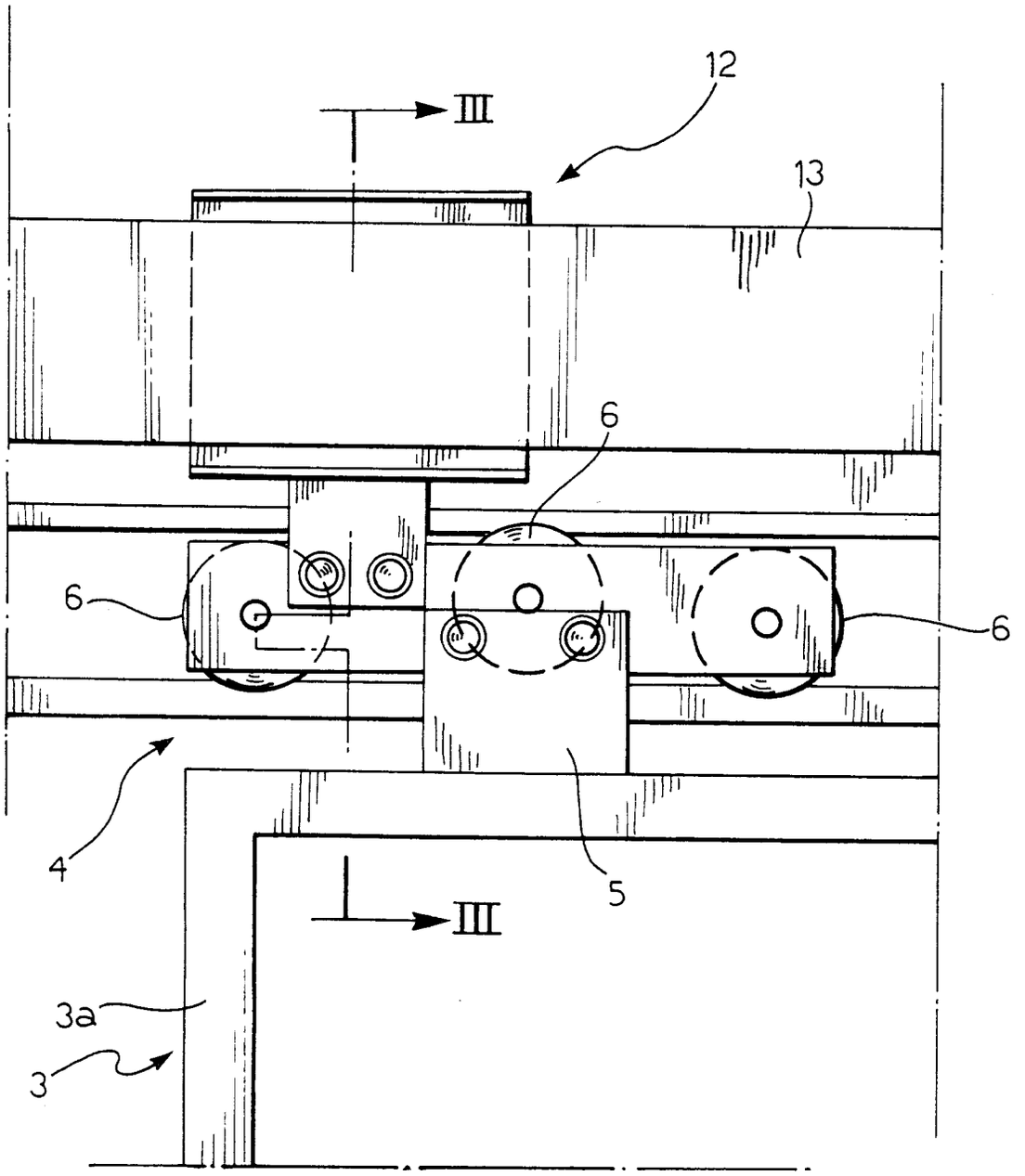


FIG. 3