United States Patent [19]

Graziano

[11] **3,918,201**

[45] **Nov. 11, 1975**

[54] **AUTOMATIC CONTROL SYSTEM FOR A SLIDING DOOR**

[75] Inventor: **Charles Graziano,** Seine-Saint-Denis, France

[73] Assignee: **Faiveley S.A.,** Saint Ouen, France

[22] Filed: **July 12, 1974**

[21] Appl. No.: **488,490**

[30] **Foreign Application Priority Data**

July 27, 1973 France 73.27558

[52] **U.S. Cl.** **49/28;** 49/139; 49/362

[51] **Int. Cl.²** **E05F 15/14**

[58] **Field of Search** 49/26–28, 138–140, 49/360, 362, 117, 118

[56] **References Cited**

UNITED STATES PATENTS

1,282,128	10/1918	Rosentreter	49/28 X
3,104,098	9/1963	Daugirdas	49/14

FOREIGN PATENTS OR APPLICATIONS

221,455	5/1959	Australia	49/26
507,803	6/1939	United Kingdom	49/28

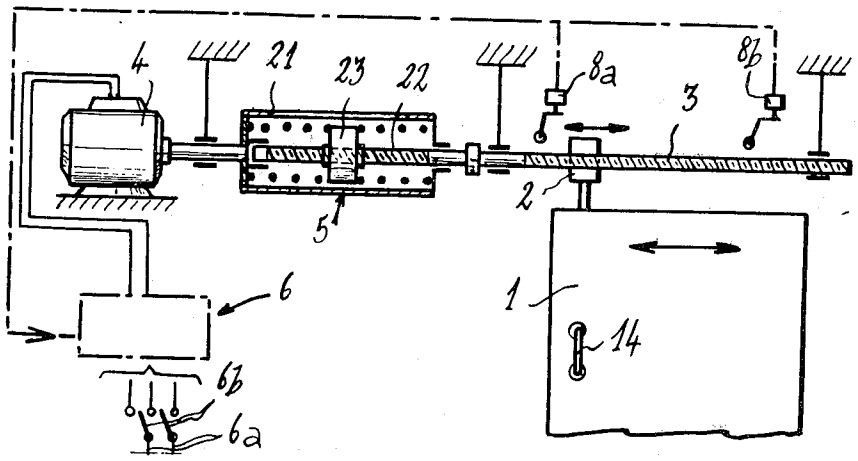
Primary Examiner—Kenneth Downey

Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

A sliding door is operated automatically by means of a nut and threaded rod which are driven by a reversible motor and constitute a reversible-action motion converter. The motor supply circuit comprises a switchable speed-reduction resistor, a protective resistor in series with the motor and a switchable voltage-limiter which can be connected in shunt across the motor terminals at the end of travel of the door-leaf.

5 Claims, 2 Drawing Figures



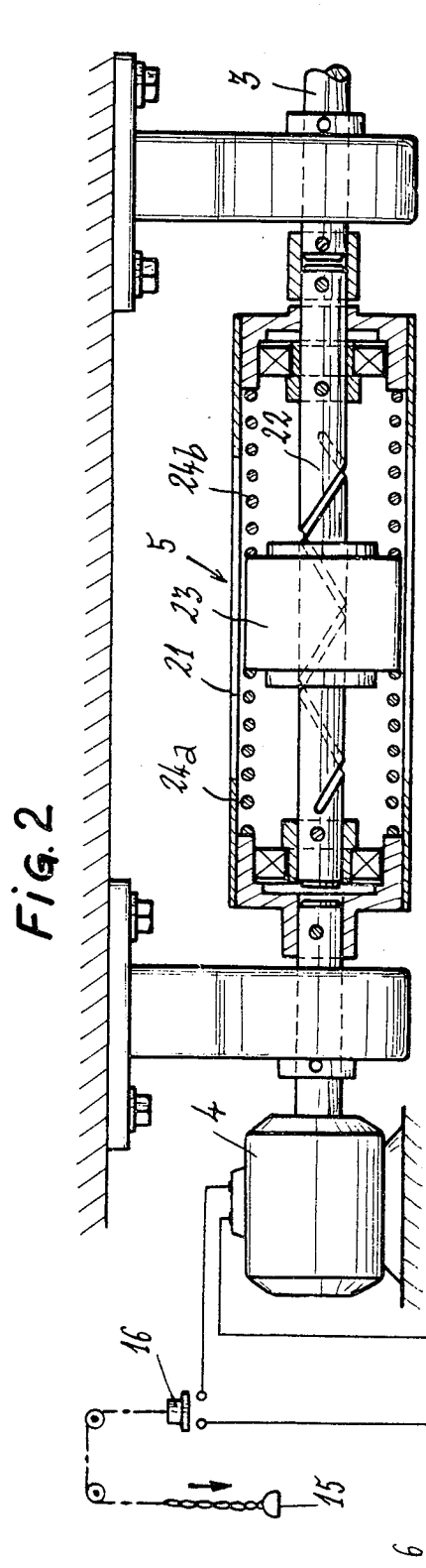
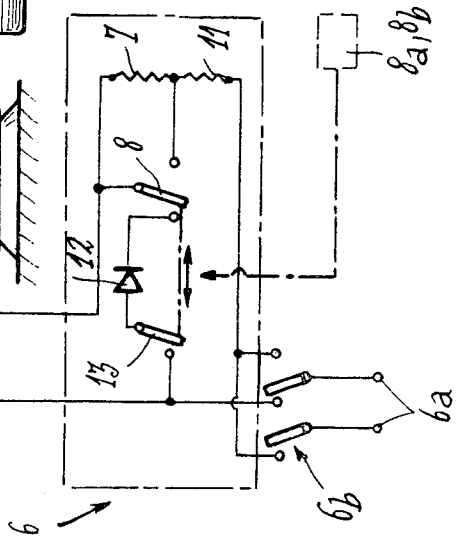

3
24b
22
5
23
21
24a
4
16
15
6

Fig. 2


7
11
8a,8b
8
12
13
6a
6b
6

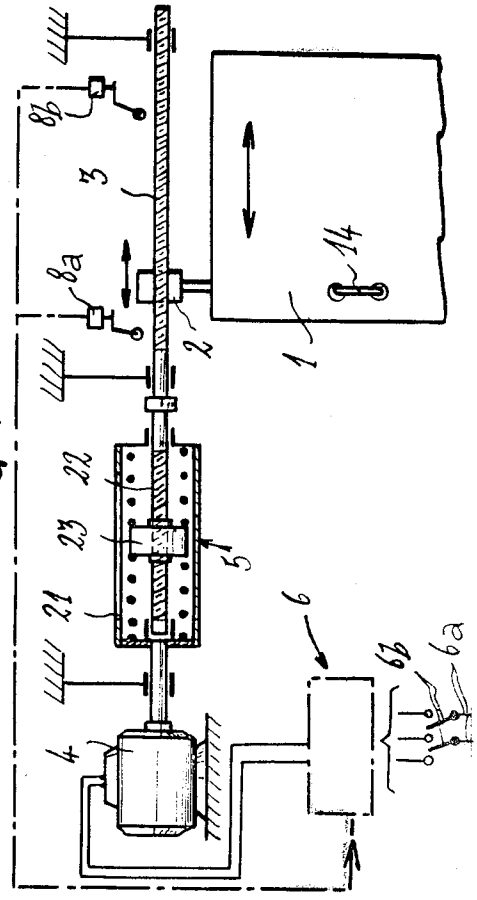

8b
3
8a
2
1
14
22
23
5
21
6
6b
6a
4

Fig. 1

AUTOMATIC CONTROL SYSTEM FOR A SLIDING DOOR

This invention relates to an automatic control system for a door of the sliding motion type.

For reasons of simplicity, the following description will be essentially concerned with doors of the type comprising a leaf which operates only in sliding motion or in other words remains substantially in the same plane during the entire operation of the door. It should be understood, however, that the invention also applies to doors in which a sliding movement is combined with various other movements. For example, the invention also applies to doors having multiple leaves articulated in a bellows arrangement or to doors of the type which may or may not comprise a single leaf and operate in a movement of translation and disengagement.

There are various known types of doors of the sliding motion type and various systems for controlling these doors. The invention applies to doors in which the movement is controlled in rotation by a motor and in particular to doors of the type having at least one leaf, the sliding motion of said leaf controlled by a nut associated with a threaded operating rod driven in rotation by a motor which is capable of operating in both directions. Doors of this type are employed especially in public transport vehicles and in public buildings. These doors are often required to operate automatically at a very high rate with the minimum of incidents and maintenance contingencies while satisfying strict conditions of safety.

In particular, at the moment of automatic closure of these doors, steps must be taken to ensure that users or their clothes are not liable to be trapped accidentally by the door-leaf. It is therefore necessary, without disturbing the remainder of the automatic operation, to provide the possibility of stopping the leaf upon moderate resistance, at least over the last portion of the door-closing travel. This enables the user to free himself without difficulty and the door-leaf can be provided for this purpose with an elastic edge strip which may be made of rubber, for example. It must then be ensured that the automatic movement of the leaf can be completed as initially intended.

Finally, the door-control system must be simple and economical to construct and to install. However, the control systems provided up to the present time are attended by major disadvantages from the various points of view which have just been mentioned.

The aim of the invention is to overcome these disadvantages by making it possible to provide for a door of the sliding-motion type a control system which offers complete safety and is both economical and rugged as well as being easy to mount and to maintain.

The invention is directed to an automatic control system for a sliding-motion door having at least one leaf rigidly fixed to a nut associated with a threaded operating rod driven in rotation by a reversible motor associated with an elastic coupling system which is deformable in rotation; the supply circuit of the motor comprises a speed-reduction resistor which can be changed-over by means of a switch controlled by the displacement of the door-leaf.

In accordance with the invention, the system aforesaid is characterized by the combination of the following particular features: the supply circuit of the motor comprises a protective resistor permanently mounted in series with the motor, and a voltage limiter which can be changed-over by means of a second switch controlled by the displacement of the door-leaf so as to connect the voltage limiter in shunt across the motor terminals at the end of the travel of the door-leaf, the nut and the threaded operating rod being such as to constitute a reversible-action motion converter.

As is explained below, the combination of the above-mentioned features makes it possible to avoid the costly and complicated installation of end-of-travel switches which have to operate repeatedly at the full current intensity of the motor. The motor is permitted to remain at low voltage when stationary.

The longitudinal force applied to the door-leaf can thus be also limited by making a consequent selection of values of the elements of the electric supply circuit. This makes it possible to prevent any bodily injury during closure since the driving torque on the operating rod has then decreased to a considerable extent. If the motor has been stopped prior to the normal end of travel of the door-leaf, said leaf can then continue its automatic closing movement if so required, this being achieved by virtue of the elastic coupling system and the permanent motor torque.

Further properties and advantages of the invention will become apparent from the following description of a preferred embodiment which is given hereinafter by way of example without any limitation being implied, reference being made to the accompanying drawing, wherein:

FIG. **1** is a general diagram of a door equipped with an automatic control system in accordance with the invention;

FIG. **2** is a detailed illustration of the deformable elastic coupling system and the supply circuit of the motor shown in FIG. **1**.

In the embodiment of FIGS. **1** and **2**, the door which is equipped with the automatic control system comprises a sliding leaf **1** rigidly fixed to a nut **2** which is associated with a threaded operating rod **3**. Said rod can be driven in rotation by a reversible electric motor **4** associated with an elastic coupling system **5** which is deformable in rotation.

The motor **4** comprises a supply circuit **6** connected to the terminals **6***a* of a supply line by a change-over switch **6***b*. In the supply circuit **6**, a speed-reduction resistor **7** can be changed-over by means of a switch **8** controlled by contactors **8***a*, **8***b* which are actuated as a result of the displacement of the door-leaf **1**. This device makes it possible to moderate the speed of the door-leaf at preselected points of its opening and closing travel.

In accordance with the invention, the device aforesaid is characterized by the combination of the subsequently described features of the supply circuit **6** of the motor **4** and of the motion converter constituted by the nut **2** and the threaded operating rod **3**. The supply circuit **6** of the motor **4** comprises a protective resistor **11** permanently connected in series with the motor **4** and a voltage limiter **12** which can be changed-over by means of a second switch **13** associated with the switch **8** and controlled in the same manner as this latter by the displacement of the door-leaf **1** so as to connect the voltage limiter **12** in shunt across the terminals of the motor **4** at the end of travel of the door-leaf **1**.

The aforesaid combination is completed by the fact that the nut **2** and the operating rod **3** constitute a reversible-action motion converter for actuating the door-

leaf **1** in translational motion under the action of rotational motion of the rod **3** or conversely to drive the rod **3** in rotational motion when action is produced on the door-leaf **1** so as to displace this latter in translational motion, especially under conditions of emergency hand operation by means of a handle **14** as is explained hereinafter.

The operating rod **3** of ground steel, for example, has a hollow screw-thread of trapezoid profile. In the case of a rod having a diameter of 15 to 30 mm corresponding to doors of usual dimensions, there is chosen by way of example a thread pitch of 60 to 120 mm which permits both rapid operation by the motor and easy emergency operation by hand when making use of the handle **14**. The nut **2** is a ball circuit nut and has bearings so adjusted as to slide with the minimum friction over the cylindrical surface of the threaded rod **3**.

For the emergency hand operation of the door-leaf **1**, a separate control device **15** placed within the reach of users serves to cut-off the current supply to the motor **4** by means of an emergency switch **16** (as shown in FIG. **2**).

In the embodiment herein described by way of example, the elastic coupling system **5** comprises a cage **21** substantially of revolution and keyed along its axis on one end of the shaft of the motor **4**. An axial rod **22** mounted on two bearings contained within the cage **21** is capable of rotating with respect to said cage and is coupled to the threaded rod **3** which serves to operate the door-leaf **1**. The axial rod **22** which is similar to the threaded rod **3** is provided in the same manner as this latter with a hollow screw-thread having a trapezoidal profile and associated with a nut **23** which is similar to the nut **2** and capable of sliding within the cage **21** without rotating.

Oppositely-acting helical springs **24***a*, **24***b* which are mounted around the axial rod **22** between each end of the cage **21** and the nut **24** serve to maintain this latter substantially at the mid-length of the cage when the system is at rest and when the torque exerted between the motor **4** and the threaded rod **3** is zero. In fact, the motion converter constituted by the axial rod **22** and the nut **23** is a reversible-action converter of the same type as the unit constituted by the threaded operating rod **3** and the nut **2**.

The strength of the springs **24***a*, **24***b* which determines the elasticity of the elastic coupling system **5** is chosen so as to take various operating conditions into account as explained hereinafter.

In the supply circuit **6** of the motor **4**, the values of the two resistors **7**, **11** as well as the value of the voltage defined by the voltage limiter **12** are preferably chosen so as to ensure complete slowing-down and stopping of the motor **4** without any danger, this being achieved under the action of the resisting torque exerted on the operating rod **3** by the nut **2** when said torque attains a value corresponding to a predetermined longitudinal effort on the door-leaf **1**.

As will be explained hereinafter, the values and characteristics mentioned in the foregoing are advantageously selected so as to limit the current intensity within the stationary motor **4** to a value which is sufficiently low to allow the normal operating voltage at the terminals of the motor supply circuit to be maintained without any difficulty.

A few numerical values and characteristics thus chosen for the elements mentioned above are given hereinafter by way of example in a preferred industrial embodiment of the invention.

The operation of the system which has just been described will now be explained.

When the changeover switch **6***b* is placed in a predetermined position, the motor **4** tends to drive the elastic coupling system **5** and the rod **3** so as to displace the nut **2** and the door-leaf **1** in the direction of opening or closing of this latter. As the door-leaf **1** approaches the end of travel in the movement just mentioned, one of the contactors **8a, 8b** is accordingly actuated by the door-leaf and initiates the remote operation of the switch **8** (as shown in FIG. **2**) of the supply circuit **6** of the motor **4**. The switch **8** thus connects the motor **4** in series with the speed-reduction resistor **7**. At the same time, the second switch **13** associated with the switch **8** connects the voltage-limiter **12** in shunt across the terminals of the motor **4**.

The device is arranged by means of a follow-up control relay (not shown) so that the above-mentioned action of the switches **8, 13** continues as long as the control changeover switch **6***b* is maintained in the same position. The torque of the motor **4** is accordingly limited so as to permit complete slowing-down and stopping of the motor and of the threaded rod **3** without excessive shock under the action of the resisting torque exerted on the rod **3** by the nut **2** (shown in FIG. **1**) when said resisting torque attains a predetermined value corresponding to a predetermined longitudinal force applied to the door-leaf **1**.

At the same time, the elasticity of the coupling system **5** ensures damping of the rotational motion of the motor **4** and of the rod **3** at the end of travel of the door-leaf **1**. The resultant deformation of the springs **24***a*, **24***b* provides favorable conditions for starting of the system in the reverse direction by virtue of the storage of energy which is thus acheived.

In a preferred industrial embodiment of the invention in the case of urban transport railway vehicles, use is made of a motor **4** of commercial type which is designed to operate normally at a direct-current voltage of 220 volts, and a running speed of 1000 revolutions per minute on low load corresponding to a power level of the order of 250 watts.

The supply voltage at the terminals **6***a* is only 90 volts. The ohmic resistance of the motor **4** is 13 ohms. The resistors **11** and **7** have values of 15 and 62 ohms respectively. The voltage-limiter **12** which is constituted by a Zener diode limits the voltage developed across the terminals of the motor **4** to 24 volts. This value is substantially eight times lower than the rated operating voltage.

In the device aforesaid and under conditions of rapid operation, the motor **4** operates at an effective voltage of the order of 80 volts, at an intensity of approximately 0.7 amp, and at a running speed in the vicinity of 400 revolutions per minute. In the case of a thread pitch of 80 mm per revolution on the operating rod **3**, said running speed corresponds to a linear velocity of the order of 0.5 m per second in the case of the door-leaf **1**.

As a result of shunt-connection of the voltage-limiter **12** across the terminals of the motor **4** and the simultaneous connection of the 62-ohm speed-reduction resistor **7** in series, the running speed of the motor **4** is only 85 revolutions per minute corresponding to a velocity of 11 cm per second in the case of the door-leaf **1**. The current intensity is then 0.7 amp in the motor **4** and 0.16 amp in the voltage-limiter **12**.

When the edge of the door-leaf is applied against a door-post or against the opposite edge of a symmetrical door-leaf, the torque on the shaft of the motor **4** increases as well as the current intensity in the supply circuit **6.** However, the series resistors **7, 11** and the internal resistor of the motor **4** limit this current intensity to 1.0 amp, this value being only slightly higher than the rated current intensity. The motor **4** can therefore withstand this stopping intensity over a long period of time without any difficulty.

The longitudinal force applied to the door-leaf **1** is accordingly of the order of 15 Kg, for example. The deformation of the springs **24***a*, **24***b* then corresponds substantially to one-quarter of a revolution of the axial rod **22,** namely 20 mm of deflection for a screw-thread having a pitch of 80 mm per revolution.

The longitudinal force applied to the door-leaf **1** by the motor **4** in the stationary position can be adjusted to a predetermined value by selecting in consequence the torque of the motor **4** and the thread pitch of the operating rod **3.**

The system which has just been described offers a number of important advantages over the systems of known types.

The mechanisms and the circuit **6** of the motor **4** are particularly simple, rugged and economical. In fact, the elasticity of the elastic coupling system **5** facilitates start-up of the system in each direction and makes it possible to employ a motor **4** of relatively limited power which is less cumbersome and easier to maintain at a suitable temperature. Similarly, all the elements of the circuit **6** can take up relatively little space, taking into account the low power of the motor **4.**

Moreover, since it is possible to maintain the supply circuit **6** of the motor **4** energized without any difficulty over a long period of time, it is unnecessary to provide the stopping switches and the brake system which are normally employed in known systems for the purpose of cutting-off the supply and maintaining the motor in a stationary position at the end of travel of the door-leaf. This advantage is important from the point of view of economy, overall size and endurance of the installation.

It has been noted that the series resistors **7, 11** and the voltage-limiter **12** which are associated with the switches **8, 13** also make it possible to reduce the torque of the motor **4** at a standstill. This results in a moderate value of the longitudinal force applied to the door-leaf **1.** As a precautionary measure in order to limit the dangers of even minor accidents which might conceivably arise upon closure of the door-leaf **1,** the speed-reduction contactor **8***a* which is actuated closure can be placed at a fairly substantial distance short of the stopping position of the door-leaf.

It is readily apparent that the invention is not limited to the embodiment which has just been described and many alternative forms may accordingly be comtemplated without thereby departing either from the scope or the spirit of the invention.

From this it follows, for example, that the elastic coupling system may be designed in a number of different alternative forms such as in particular a spring which works in torsion. Similarly, the voltage-limiter **12** need not be a Zener diode but can comprise a number of different equivalent complementary resistors connected in series with the motor **4.**

The operation of the switch **13** of the voltage-limiter **12** can be retarded or advanced with respect to the operation of the switch **8** of the speed-reduction resistor. This makes it possible to obtain a more progressive variation of the speed of the door-leaf **1,** especially if this latter has high inertia.

What is claimed is:

1. An automatic control system for a sliding-motion door having at least one leaf rigidly fixed to a nut associated with a threaded operating rod driven in rotation by a reversible electric motor associated with an elastic coupling system which is deformable in rotation, the supply circuit of the motor being provided with a first switch and a second switch, a speed-reduction resistor which can be changed-over by means of the first switch controlled by the displacement of the door leaf, wherein the supply circuit of the motor includes a protective resistor permanently mounted in series with the motor, and a voltage limiter which can be changed-over by means of the second switch controlled by the displacement of the door leaf so as to connect the voltage limiter in shunt across the motor terminals at the end of travel of said door leaf, the values of the two resistors and the threshold values of the voltage limiter as well as the characteristics of the motor being so selected as to limit the current intensity in the motor, when said motor is at a standstill, at a sufficiently low value to maintain the normal operating voltage at the terminals of the motor supply circuit, said nut and said threaded operating rod moreover constituting a reversible-action motion converter.

2. A system according to claim **1,** including an emergency control for the hand operation of the door, wherein said emergency control is associated with a cut-off switch on the supply line of the motor.

3. A system control according to claim **1,** wherein said values of the resistors and of the voltage limiter, as well as the characteristics of said reversible-action motion convertor and of said motor are selected so as to ensure complete slowing-down and stopping of the motor under the action of the torque exerted on the operating rod, when said torque attains a predetermined value corresponding to a predetermined longitudinal force applied to the door leaf, said longitudinal force being consistent with the safety of users.

4. A system according to claim **3,** wherein the operating rod has a diameter of 15 to 30 mm and a thread pitch of 60 to 120 mm, the deformation of the elastic coupling system corresponding substantially to one-quarter of a revolution of the operating rod for said predetermined longitudinal force applied to the door leaf.

5. A system according to claim **4,** wherein said elastic coupling system comprises a cage containing a nut capable of sliding within the cage without rotating and an axial rod similar to said operating rod of the door, oppositely acting springs mounted between said cage and said sliding nut, said cage and said axial rod being respectively coupled to the shaft of said motor and to the operating rod of the door.

* * * * *