

(12) CERTIFIED INNOVATION PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2020100168 B4**

(54) Title
**SOLID AND SECTIONAL PANEL, ROLLER DOOR AND CURTAIN OPENER UTILISING
EMBEDDED LINEAR MOTOR TECHNOLOGY**

(51) International Patent Classification(s)
E06B 9/08 (2006.01) **E06B 9/68** (2006.01)
E06B 9/17 (2006.01) **H02K 41/02** (2006.01)
E06B 9/58 (2006.01)

(21) Application No: **2020100168** (22) Date of Filing: **2020.02.01**

(45) Publication Date: **2020.03.12**
(45) Publication Journal Date: **2020.03.12**
(45) Granted Journal Date: **2020.03.12**
(45) Certified Journal Date: **2020.10.15**

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ABSTRACT

The invention is a sectional and roller door opening mechanism which incorporates the opening and closing automation within the guide rails. The method is completely unique and is applicable to sectional panel, full panel and roller doors and curtains across domestic, commercial and industrial spheres.

The invention replaces traditional spring assisted geared rotary motor winching or winding systems. Based on a linear motor methodology, it is a completely bespoke adaptation of this technology representing a much higher level of control and monitoring, coupled with equally bespoke software and firmware in the art.

The invention incorporates unique components replacing traditional running gear on current manual and automated sectional and roller doors.

The invention is not merely the application of a linear motor, it is a completely unique method of applying this technology as a basis for a powerful yet extremely precise method of automating sectional and roller doors in residential, commercial and industrial situations.

The invention offers aesthetic, noise and installation advantages over currently used vertical door/curtain operator mechanisms.

SOLID AND SECTIONAL PANEL, ROLLER DOOR AND CURTAIN OPENER UTILISING EMBEDDED LINEAR MOTOR TECHNOLOGY

Field of the Invention

The invention relates to a rail system which guides movement of a panel, for example, pedestrian and vehicular access doors, fixed and sectional panels, roller doors, curtains and the like.

Background of Invention

Modern use of sectional and roller doors now more than likely incorporate an automated method of opening and closing for safety, convenience and efficiency. Universally these automation methods rely on a wound spring or counterweight assisted winching systems using a geared rotating motor with cables and/or chains. This design methodology has seen only incremental improvements over many decades.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each of the appended claims.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Summary

According to the present disclosure, there is provided a rail system which guides movement of a panel, the rail system comprising:

- a guide rail;

- a plurality of stationary electromagnets mounted in the guide rail; and

- a carriage having a plurality of wheels configured to travel along the guide rail, the carriage configured for attachment to the panel;

- wherein the wheels are magnets, and

- wherein movement of the carriage along the guide rail is brought about by a fluctuating magnetic field generated by the stationary electromagnets acting on the wheels.

The rail system may comprise a plurality of the guide rails and a plurality of the carriages. The plurality of guide rails may include a first guide rail and a second guide rail, the first guide rail and the second guide rail being space apart. The plurality of carriages may include one carriage mounted on the first guide rail and one carriage mounted on the second guide rail. The panel may be attached to the one carriage on the first guide rail and to the one carriage on the second guide rail. The panel may be moved by coordinated movement of the carriage on the first guide rail and the carriage on the second guide rail.

More than one carriage may be mounted on the first guide rail. The panel may be attached to each carriage on the first guide rail. More than one carriage may be mounted on the second guide rail. The panel may be attached to each carriage on the second guide rail.

Each guide rail may comprise a brake engaging surface. At least one carriage mounted on each guide rail may include a brake having a shape configured to engage the brake engaging surface. When there is more than one carriage mounted on each guide rail, each carriage may include a brake having a shape configured to engage the brake engaging surface of its associated guide rail. The brake of the carriage may engage the brake engaging surface of the guide rail to limit movement of the carriage when power supply to the electromagnets is interrupted.

The brake engaging surface may have a serrated profile. The brake of the carriage may have a matching serrated profile configured to engage positively with the brake engaging surface of the guide rail. The brake of the carriage may be in the form of a cam and the cam may have a serrated braking surface or foot.

Once the brake of the carriage and the brake engaging surface of the guide rail are engaged to limit the movement of the carriage, release of the engagement may be brought about by movement of the brake in a direction opposite to the movement which brought about the engagement. For example, if downward movement of the carriage brings about engagement of the brake and the brake engaging surface, the upward movement of the carriage releases the engagement of the brake and the brake engaging surface.

The term “panel” is used to refer to a range of architectural structures suitable for closing or covering an opening in a building such as those for pedestrian and/or vehicular access.

The rail system may further comprise the panel. In the present disclosure, various terms including “panel” have been used to refer to a range of architectural structures suitable for closing or covering an opening in a building such as those for pedestrian and/or vehicular access and suitable for movement by the guide rail system. For example, terms such as curtain, door, roller door, sectional panel door, full panel door, solid panel door, garage door, and the like have been used. For simplicity, in the present disclosure, the term “panel” has also been used generally and inclusively to refer to these and similar architectural structures collectively.

The system may include a control system in order to control the provision of energy to the electromagnets. The control system may be powered by an external power source. A backup battery may also be provided to supply backup power in an emergency or to provide bulk power during operations to move the panel.

According to the present disclosure, there is provided a method of operating (e.g., opening and closing) such doors by incorporating a lifting mechanism into guide rails which are a common component of automatic solid or sectional panel, roller door or curtain. The lifting mechanism includes the plurality of stationary electromagnets mounted in the guide rail and the plurality of wheels (being magnets) of the carriages.

According to the present disclosure, such an arrangement may allow for a reduction in installation components, and therefore installation time. It may lower maintenance costs and it may allow for quiet operation, as well as improved aesthetics.

According to an embodiment, the invention includes a fail-safe mechanism in the form of a braking system which operates in the event of a component failure or a disruption to electricity supplies. Such a system may enhance safety.

The rail system may be configured to lift a panel vertically. For example, a pair of guide rails may be arranged vertically and the panel may extend vertically between them. Movement of the carriages along the pair of guide rails may raise the panel vertically or lower the panel vertically. The system may be configured to move a panel in a horizontal direction. For example, a pair of guide rails may be arranged horizontally and the panel may extend between them. Movement of the carriages along the pair of guide rails may move the panel horizontally. The system may be configured to combine guide rails with vertical and horizontal portions and movement of the carriages along these respective portions will move the panel accordingly. It will be appreciated that the guide rail system is not limited only to vertical and horizontal configurations and that guide rails could be arranged at angles with respect to the vertical or horizontal planes in order to arrange a system that could move the panel in any direction.

Embodiments disclosed herein may be applicable to domestic, commercial and industrial applications with scale-able design to match weights, travel speeds and environments which vary dependent on application.

Brief description of the drawings

Fig. 1 – A schematic cross sectional view of an embodiment of a guide rail showing an arrangement of the stationary electromagnets, electrical components, the serrated braking strip and fixing arrangements.

Figs. 2A to 2D – Schematic views of embodiments of the guide rails showing straight and bent, and open and closed configurations and showing examples of locations and frequency of stationary electromagnets, and fixing options.

Fig. 3 – A schematic side view of an embodiment of a carriage showing various inclusions and options for applications.

Figs. 4A and 4B. – Schematic cross-sectional views of an embodiment of the carriage showing various internal components and their functions.

Fig. 5 – Schematic diagram of an embodiment of the control logic of the electronic drivers and controls.

Detailed description of the embodiments

According to an embodiment, there is provided a guide rail system for the positioning and movement of panels (for example, single and sectional panel doors, roller doors or curtains) in the vertical plane incorporating a magnetic drive and positioning system. The guide rails incorporate a series of electromagnet arrays (the stationary electromagnets) which and are positioned in the guide rail to provide magnetic attraction and repulsion in a sequential manner which will cause a carriage incorporating permanent magnets to move along the rail assembly with variable force and speed dependent on instructions from a control system.

According to an embodiment, there is provided a carriage system incorporating permanent magnets which form wheels. The carriage is designed to connect to a panel, a roller door or the like. The carriage is mounted on a guide rail and driven via electromagnets incorporated into the guide rail. The panel may be positioned or move via interaction of the wheels of the carriage and the electromagnets in the guide rail.

According to an embodiment, the system includes an integrated automatic mechanically operated braking system capable of maintaining a panel or roller door in a fixed position in the absence of deliberate and specific operations of the rail and carriage system or a disruption to electricity supplies. This system ensures that the panel or roller door remains in any position intended without the requirement for constant drive signals and prevents movement in any direction if power should fail to the door control or drive system. In the event of an emergency, the system can be manually over-ridden, and the carriages will allow the opening of the door.

According to an embodiment, the system is component based with selection and quantity of components based on the application. Components can be manufactured at scale, that being physical characteristics other than size can remain consistent through light, medium and heavy-duty versions of the system. Force capacity may range from 500 to 4000 newtons whilst operational speed may range from 0.1 to 4 metres per second.

The system is suitable to many panel materials and is adaptable to varying widths and heights of panels, roller doors, curtains, and the like.

According to an embodiment, the system includes a pair of guide rails which are either straight or include a bend of up to ninety degrees dependent on the application and location. Carriages which are fixed to the moveable panel or curtain are attached in numbers required for the application and inserted onto the guide rails. According to an embodiment, a control system which incorporates a small battery back-up is installed adjacent to the rails to provide controlled energy to the rail electromagnets which are electrified at varying currents and sequences to initiate movement of the carriages.

According to an embodiment, each carriage has a linkage which is designed to connect to the door, this linkage incorporates a brake in the form of a serrated cam feature that allows the linkage to engage positively with a matching brake engaging surface in the form of a serrated profile incorporated into the guide rail (see Figs. 3 and 4). When the panel attempts to move in a downward direction without a direct force from the carriage, the serrated cam feature engages with the brake engaging surface of the guide rail to cease any downward movement. According to this embodiment, only when an upward force is applied to the linkage by the carriage will the cam disengage. This ensures that there is no uninstructed downward movement of the panel or curtain. In the event of an obstruction occurring to the downward movement of the panel or curtain, the serrated cam feature will immediately engage serrated profile on the guide rail preventing further travel.

According to an embodiment, in order to enable travel in the downward direction, the carriages will be initially moved in the upward direction to disengage the cam braking mechanism and the speed of travel is regulated in such a way that whilst under instruction the cam locks remain disengaged.

According to an embodiment, a complex system of electronics housed in the control unit uses current sensing and power loops to provide precise energization of the stator electromagnets (stationary magnets) which induce infinitely variable movements in the carriage fixed magnets. Using a loop feedback system, each rail and the carriages travelling upon it can be precisely located to avoid any misalignment of the panel or curtain and can maintain exact relative positioning at any point of travel.

According to an embodiment, the electronic control system has a self-calibration system which takes into account anomalies such as external factors such and wind, ice and other factors as well as friction variables due to age and maintenance. In this embodiment, a non-volatile memory of events and parameters forms part of the control system in order to provide service history and produce alarms and service requests via a basic display.

According to an embodiment, integrated dry contact triggering as well as on-board RF and Bluetooth communication provide several external control and monitoring solutions to the user of the system.

According to an embodiment, the control and operating system is designed for operation on a 24VDC external supply, where the size of the supply is dependent on the operating frequency of the system and the size of the unit, small, medium or large model.

In the following, embodiments are described with reference to the drawings. The numbering used in the drawings is unique to each drawing and is not consistent across the drawings.

Fig. 1 shows a cross-section through an embodiment of a guide rail (2). In this embodiment, the guide rail (2) is fixed to the accommodating structure via "L" brackets (1) which permit attachment on the same or a perpendicular plane. The guide rail (2) is made up of two guide rail sections which are made of non-ferrous metal or polymer and are joined via screws (3) fixing at prescribed intervals. Electromagnets (stator magnets) are formed from ferrous bobbins (6) which are attached to the guide rail sections and host copper induction coils (4) wound around them. Each coil is connected through an embedded PCB backplane which interconnects to other rail sections or final controls via a multi pin connector (5). A serrated braking profile 7A as well as nylon guide inserts 7B form one half of the braking system. The guide rails (2) are produced in modular sections and dependent on their location within the travel range of the panel or curtain may contain many, some or no stator electromagnets as required by each application.

Figs. 2A to 2D shows configurations of the guide rail (3). Figs. 2A and 2B show a bent configuration with a portion of the guide rail (3) being vertical and a portion of the guide rail being horizontal. Fig. 2A shows the arrangement of carriages (1) in the vertical portion as they would be for a panel in a fully closed position and Fig. 2B shows the arrangement of carriages (1) in the horizontal portion as they would be for a panel in a

fully open arrangement. The guide rail (3) which incorporates the electromagnetic stator coils (4) can be configured in a bent configuration (Figs 2A and 2B) or straight configuration (Figs. 2C and 2D). The figures indicate indicative positions and size of electromagnetic stator coils (4) embedded in the guide rail (3) and representations of rotor carriages (1), showing fully closed (Fig 2A and 2D) and fully open positions (Fig 2B and 2C). Note: these are cut away views showing an example and they are non-specific as to location and quantity of coils (electromagnets) and or carriages. Where the guide rail (3) is required to be bent, a proprietary bend (2) is fitted in between standard rail sections which guide the carriages and maintain the electrical circuits.

Fig 3 shows a schematic side view of a carriage. According to this embodiment, the rotor function of the system includes circular rare earth high strength magnets which are also the wheels (1) of the carriage 10, dependent on application, additional magnets/wheels (2) may be added to the carriage 10. The wheels (2) and the connecting dolly 8 are joined by non-ferrous connecting plates (6) (7), using pin and clip arrangements. The main connector incorporates a cam (3) for the braking system, a keyed central pin (5) which rotates the cam (3) through several degrees dependent on transferred load to the panel/curtain which is connected via a rod (4) incorporated into the main connector.

Fig. 4 shows schematic cross-sections of the guide rail 8 according to an embodiment. Fig. 4A shows a cross section through a guide rail 8 and the main connector of a carriage. Figure 4B shows a cross section through a guide rail and a wheel of a carriage. The rare earth magnets which are also the guide wheels (1) of the carriage are arranged such that the poles of the magnet interact with the electromagnetic stators on the guide rail. The magnets are bespoke and sized in accordance with small, medium and large versions of the invention. The wheels (1) are guided by a groove (2) which is formed in the guide rail. Wheels may have a nylon outer ring dependent on application. The wheels are held by a non-ferrous pin and clip arrangement (3). The main connector (4) incorporates a rigid pin for attachment of the door/curtain, a cam shaped casting as the body incorporating a cam mechanism and serrated braking foot which keys to the matching serrations on the guide rail. The main connector is connected by a large pin and clip

arrangement ⑤. Connection to the door/curtain ⑦ is via a specific bracket suited to the particular application ⑥.

Fig. 5 shows a schematic diagram of an embodiment of the control logic of the electronic drivers and controls. The operation of the guide rail system is controlled by an electronic control system in order to deliver precise power to the stators in order to ensure smooth travel of the panel, door, curtain, or the like. This can be affected by environmental factors, physical interference and power fluctuations. In this embodiment, the control system is powered by an external 24v source ① which is sized based on the size and duty of the installation. A small battery ② is installed to provide back-up power in and emergency and provide bulk power during operation of the door/curtain mechanisms ⑦. A control circuit ③ will receive external operation signals ⑥ which include dry contact inputs, RF signals (remote control). On-board Bluetooth® connectivity for control and monitoring functions ⑨ is also possible.

In this embodiment, controls will provide electrical energy to groups of electromagnetic coils in specific sequences and variable energy levels to provide travel via the carriages ⑤. A constant feedback loop will compare energy consumption on right- and left-hand side units to ensure that both sides are performing in unison ⑧, an additional pulse counter will provide positional data from each side to provide positional, speed and alert signals. A calibration sequence will be programmed, this will be used for initial set-up but will also run routinely once parameters are sensed which fall outside of operational set points or in the event of interrupted or impeded operation. There is a solenoid activated lock mechanism to prevent manual uplift of the door curtain which is available an option ⑩.

The Claims defining the invention are as follows:

1. A rail system which guides movement of a panel, the rail system comprising:
 - a guide rail;
 - a plurality of stationary electromagnets mounted in the guide rail; and
 - a carriage having a plurality of wheels configured to travel along the guide rail, the carriage configured for attachment to the panel;wherein the wheels are magnets, and
wherein movement of the carriage along the guide rail is brought about by a fluctuating magnetic field generated by the stationary electromagnets acting on the wheels.

2. A rail system according to claim 1 comprising:
 - a plurality of the guide rails and a plurality of the carriages;
 - wherein the plurality of guide rails includes a first guide rail and a second guide rail, the first guide rail and the second guide rail being space apart;
 - the plurality of carriages includes one carriage mounted on the first guide rail and one carriage mounted on the second guide rail; and
 - the panel is attached to the one carriage on the first guide rail and to the one carriage on the second guide rail; and
 - the panel is moved by coordinated movement of the carriage on the first guide rail and the carriage on the second guide rail.

3. A rail system according to claim 1 or claim 2, wherein
 - each guide rail comprises a brake engaging surface, and
 - at least one carriage mounted on each guide rail includes a brake having a shape configured to engage the brake engaging surface,
 - wherein the brake engages the brake engaging surface of the guide rail to limit movement of the carriage when power supply to the electromagnets is interrupted.

4. A rail system according to any one of the preceding claims, further comprising the panel.

5. A rail system according to any one of claims 2 to 4 wherein the first guide rail and the second guide rail are aligned at an angle with respect to a horizontal plane such that movement of the carriages along the first guide rail and the second guide rail raises or lowers the panel with respect to the horizontal plane.

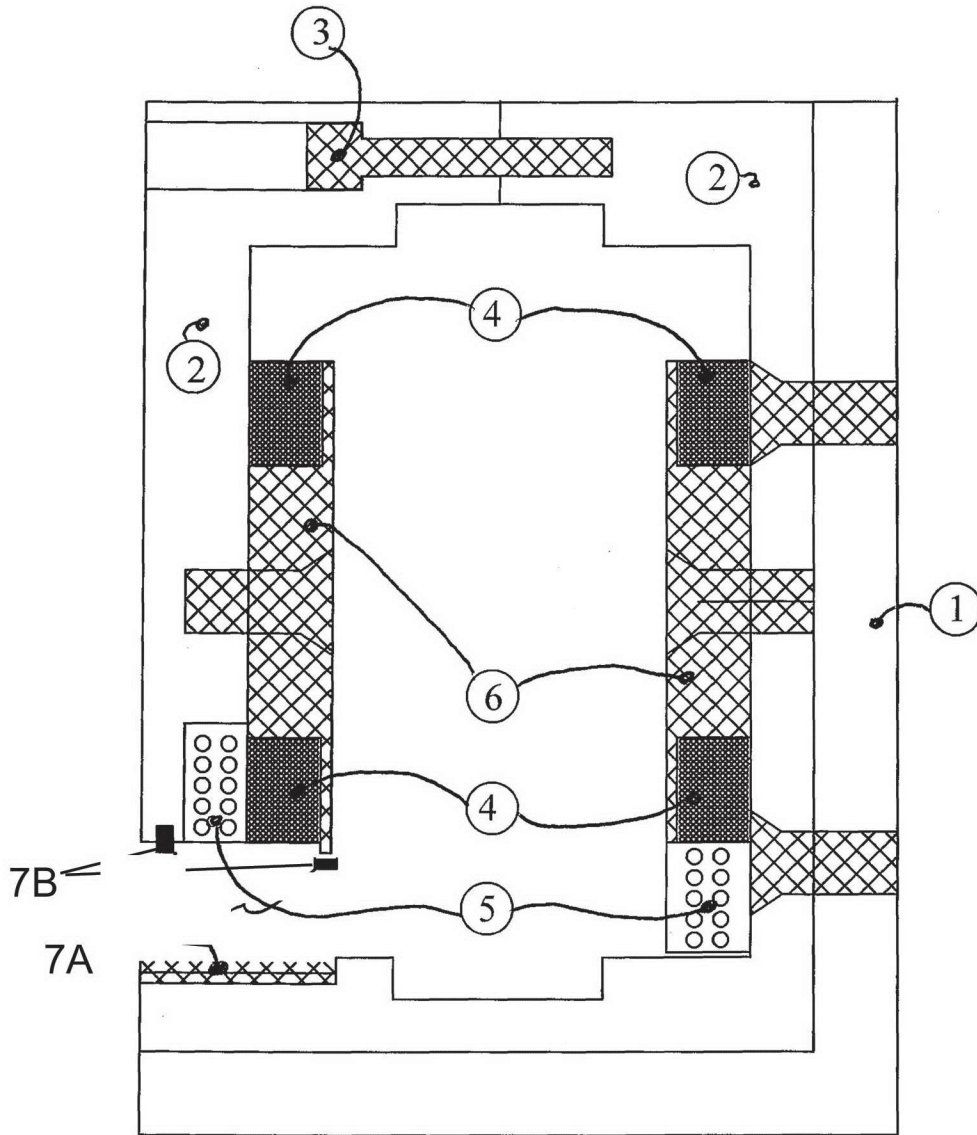


Fig. 1

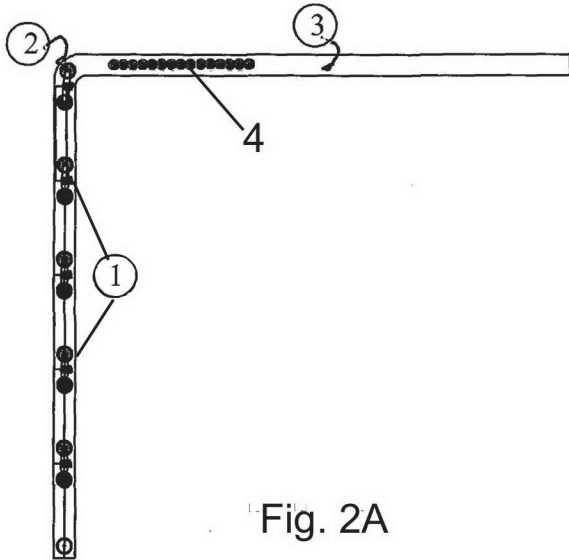


Fig. 2A

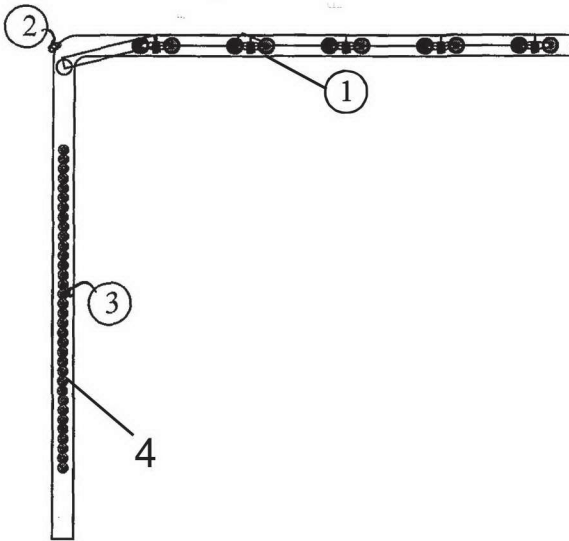


Fig. 2B

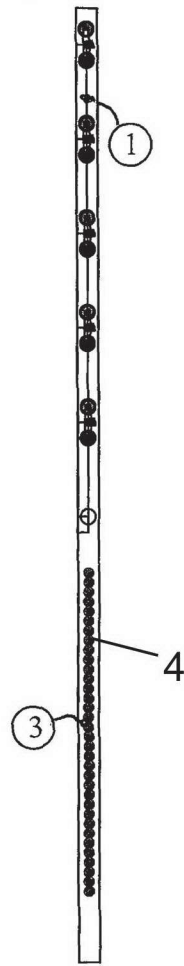


Fig. 2C

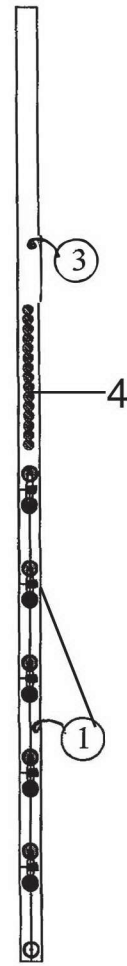


Fig. 2D

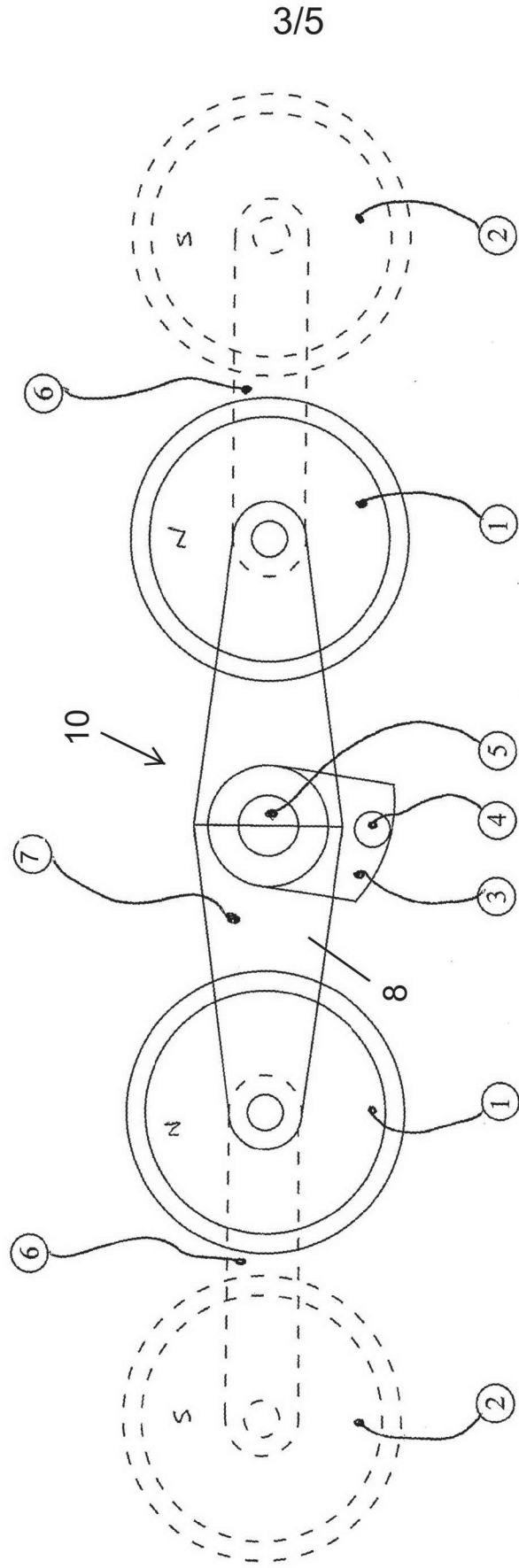


Fig. 3. Carriage module overview

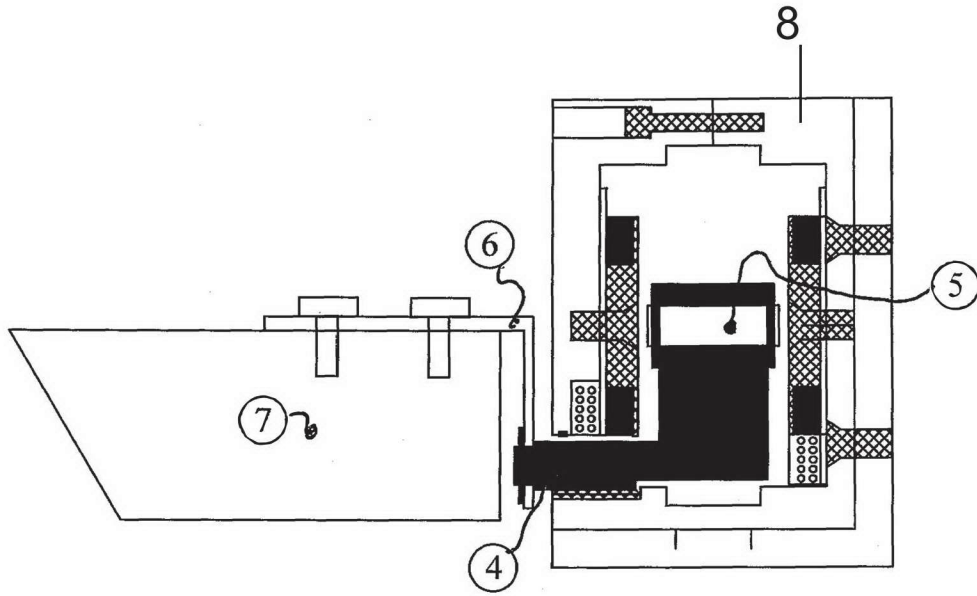


Fig. 4A

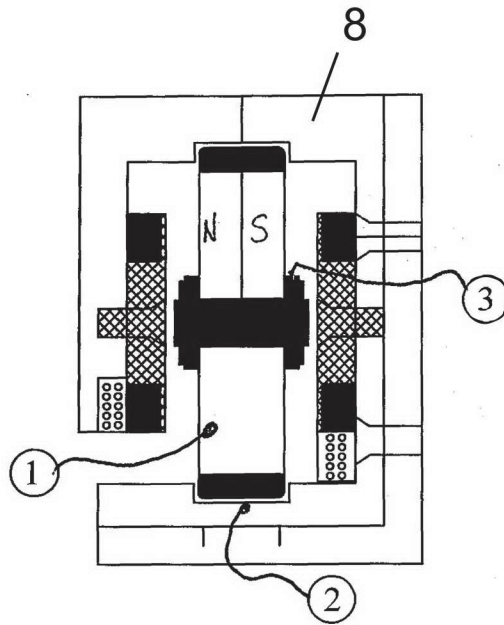


Fig. 4B

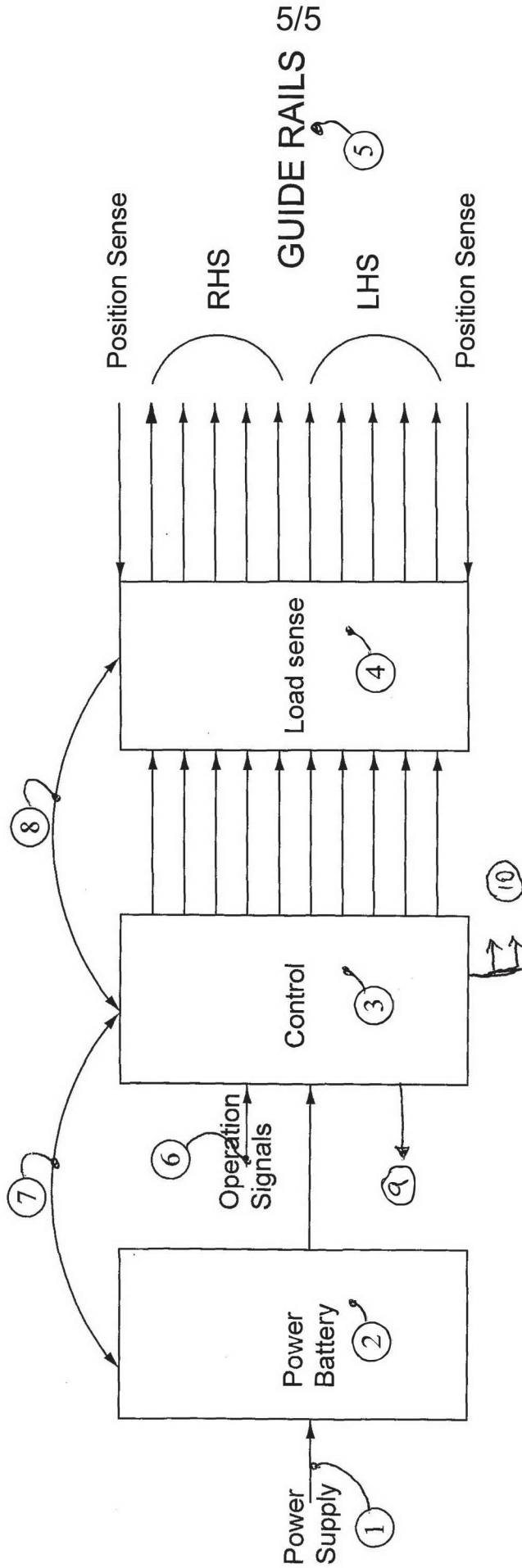


Fig. 5 - Control Logic Diagram