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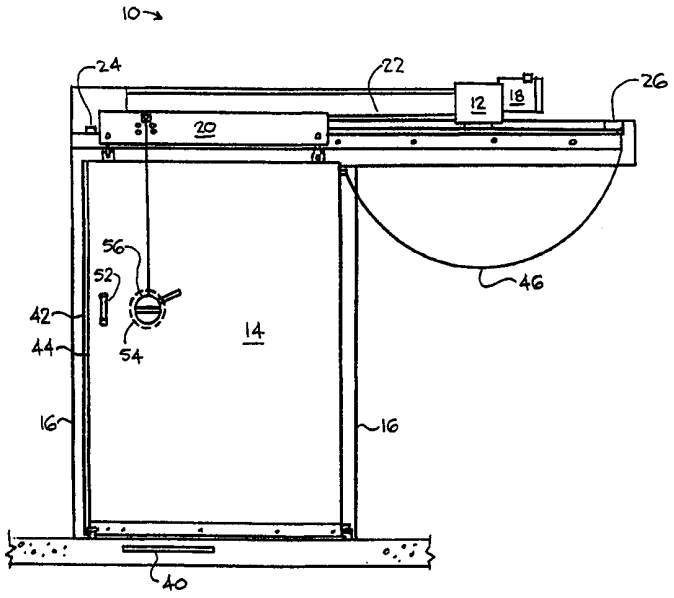
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(57) Abstract

It has been discovered that operation of movable partitions, such as doors, to permit or deny access to spaces, such as climate–controlled rooms, may be improved by use of a programmable logic controller and a directly linked mechanical mechanism that opens and closes the movable partition. Such a system permits the partition to be carefully accelerated and decelerated over an opening or closing cycle to reduce potential damage to the partition, the aperture, the mechanical mechanism, and other components. The system can also be programmed to limit and permit access to the room in various beneficial ways, and can increase safe use of the partition or door by not permitting it to coast uncontrollably at any time.

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PROGRAMMABLE ENVIRONMENT DOORS

Field of the Invention

The invention relates to programmable automatic movable partitions, and more particularly relates, in one embodiment, to programmable automatic movable partitions, such as doors, for environmentally controlled spaces, such as coolers, freezers.

Background of the Invention

Doors that are motor-driven and/or which automatically open and close are well known in the art. Sliding doors generally run along wheels and travel over a track. Mechanical mechanisms open and close the doors, which mechanisms include, but are not limited to, motors driving the doors along the tracks either directly or using cables, pulleys, chains, hydraulics or the like. Swinging doors may be actuated by arms in turn driven by electric motors.

A difficulty with some doors is that the motors operate at one speed. The door begins moving suddenly and often slams into the door frame or a stop with an impact or jolt that can damage the door and the frame or stop, and also possibly the drive mechanism. Some prior motorized doors have brakes to facilitate stopping the door.

Further problems develop with large doors. Having a safety edge along the leading edge of the door similar to that on a conventional elevator door is well known. However, with a large, heavy door, considerable momentum can be present in the door and the door may not stop until it travels additional distance — a dangerous situation if a person or piece of equipment is present between the door and the frame.

Additionally, if a door is present on a climate controlled room which is large enough to admit a forklift or other vehicle, it is not economic to fully open the door for the passage of a relatively small person. It is further not economic if there are a number of doors to the room and all the doors open in response to a safety edge or a floor switch near one door responding to one forklift approaching only one of the doors, as is conventional with some systems. In both situations, the climate controlled atmosphere spills outside the room and must be restored at considerable cost.

Summary of the Invention

Accordingly, it is an object of the present invention to provide a programmable movable partition system which opens and closes the partitions according to an acceleration profile to begin movement of the door and a deceleration profile to stop movement of the movable partitions.

It is another object of the present invention to provide a system for programming movement of movable partitions in which the partition is positively controlled at all times and not allowed to coast.

Another object of the invention is to provide a programmable movable partition system where activation of a safety edge brings the partition to an immediate stop, and optionally reverse its direction to an open and even full open position.

A further object of the invention is to provide a programmable movable partition system which can be set to open the partition to a position and at a speed less than that necessary to fully open the partition.

Still another object of the invention is to offer greatly improved ease in setting limits on partition position and acceleration and deceleration.

Another object of the invention is to provide a programmable movable partition system where the program may be easily updated.

A further object of the invention would be to provide a programmable movable partition system which can open partitions in response to a variety of signals and also has the ability to close the partitions after a timed interval.

Another object of the present invention would be to provide a system for programming movement of multiple movable partitions to a room, where the partitions may be programmed to move independently.

Still another object of the invention would be to provide a programmable movable partition system in which activity of all of the partitions may be monitored from a central monitoring location.

In carrying out these and other objects of the invention, there is provided, in one form, a programmable movable partition system having a programmable logic controller (PLC); a movable partition adapted to open and close over an aperture; and a mechanical mechanism for opening and closing the movable partition over the aperture. A first limit switch mechanism is present for determining that the movable partition is closed and sending a signal to the PLC that the movable partition is closed. A second limit switch mechanism is present for determining that the movable

partition is open and sending a signal to the PLC that the movable partition is open. Also present is at least one first signal line from the PLC to the mechanical mechanism, at least one second signal line from the PLC to the first limit switch mechanism, and at least one third signal line from the PLC to the second limit switch mechanism. Control programming is present in the PLC to control the mechanical mechanism over the first signal line to open and close the movable partition over the aperture.

Brief Description of the Drawings

FIG. 1 is a schematic view of the overall programmable multiple partition system; and

FIG. 2 is an expanded view of the various components of the electronics panel for the programmable multiple partition system.

It will also be appreciated that the drawings are not necessarily to scale, and that the position and proportions of the various parts can vary without departing from the scope of the present invention.

Detailed Description of the Invention

Shown in FIG. 1 is a schematic view of the overall programmable multiple partition system 10 of this invention having an electronics panel 12, a multiple partition or door 14 for opening and closing over an aperture or doorway 16, and a mechanical mechanism 18, in the case illustrated only, a variable speed motor, for opening and closing the door 14. In the particular non-limiting embodiment of the invention illustrated in FIG. 1, the door 14 is a sliding door and is carried into place by carrier bar 20 which in turn runs along rail system 22. A first limit switch mechanism 24 is present in the illustrated embodiment on the left side of the rail system 22. First limit switch mechanism 24 indicates the door 14 is closed, and may be a proximity switch, sensor or other suitable device for this purpose. It communicates with a programmable logic controller (PLC) 30 (seen in FIG. 2) over second signal line 31. Second limit switch mechanism 26 is present in the illustrated embodiment on the opposite or right side of the rail system 22, and indicates the door 14 is in full open, and may also be a proximity switch, sensor or other suitable device. It communicates with PLC 30 over third signal line 31.

Electronics panel 12 is shown in more detail in FIG. 2. It contains a variable frequency drive 28, in this case a Mitsubishi FR-A024/A044 0.4K-UL

1/2 to 3/4 HP drive; PLC 30, in this case a Mitsubishi FXON-24MR-ES-UL PLC with 14 in/10 out VDC input, relay output and sink source 120/240 VAC power supply; fuses 32 and a 24 VDC control transformer 34. The particular part numbers given are merely examples and do not limit the invention. Equivalent components capable of accomplishing the stated purposes may be used. Not shown but contained within the PLC 30 is an EEPROM memory cassette with a real time clock. This cassette permits the overall programmable door system 10 to be loaded with an upgraded software control program without erasing the settings and limits used for a particular door or set of doors with a previous program. It will be appreciated that the invention is not limited to the particular electronic components employed in the embodiment illustrated herein, but that other components which may accomplish the same functions may be used.

Shown in electronics panel 12 of FIG. 2 are a plurality of signal lines 31 to various components such as mechanical mechanism 28, the first and second limit switch mechanisms 24 and 26, respectively, etc. Also shown in the electronics panel 12 of FIG. 2 is a floor loop control 38 which would be in electronic communication via a signal line (not shown) with floor loop 40 of FIG. 1. Floor loop 40 would be proximal to door 14, that is, either before or after door 14 as one would leave or enter the doorway 16, or both. It would detect the presence of an object such as a forklift or a of a person through conventional means such as pressure, weight, magnetic field, electromagnetic field, etc.

The programmable door system 10 is designed to control the door 14 at all times, that is, to never let it coast at any point, neither coast to a close or coast to an open position. This is very important for safety reasons, as well as to prolong the life of the door 14 and the system 10. In some conventional systems, the door is driven by a motor that operates at one speed. Thus, if a motor is activated to open the door, the motor causes the door to move with rapid acceleration. For closure, the motor shuts off and the door either rapidly decelerates against the door frame or is permitted to coast to a stop, or if the door is being opened, coast or rapidly decelerate against a stop of some sort. Some prior systems to have brakes to stop the door, which may be a brake on the motor. Repeated opening and closing of a door of this type often causes accumulating damage to the door, the door frame or doorway, and the stop against which the door opens. The impact of such jolting and jarring can cause the mechanical mechanism, inclusive of a

motor, pulleys, arms, chains, cables, and the like, the mechanical parts that move the door, to be damaged as well.

In a particular embodiment of the invention, the door 14 is a door to a cooler or a freezer, that is, a room at reduced temperature or at a temperature below freezing, respectively. Of course, the programmable movable partition system 10 of the subject invention could be readily adapted to carefully control partitions over windows, skylights, floor openings and the like. Further, rooms and other spaces with controlled environments or access, such as heated spaces, spaces with controlled humidity, pressure and light, spaces of high security or safety risk, and the like, could all benefit from the system 10 of this invention.

Doors on coolers and freezers, *e.g.*, typically range from 8' wide x 10' tall to 20' wide x 24' tall, in non-limiting examples. Because of their size, and because such doors are heavily insulated, they may have considerable weight, and may have considerable momentum if they are moving very quickly.

A further problem with coasting a door 14 to a stop, is that the coasting rate will vary according to a number of factors including, but not limited to, the temperature of the environment, the length the door 14 travels to close, the wear and tear of the mechanism 18 and carrier bar 20 and rail system 22, and the like. A little difference in starting position can multiply into a big difference on the stopping position. Limit switch mechanisms (sensors) 24 and 26 and other sensors (not shown) along the length of the rail system 22 determine the position of the door 14 and send signals to the PLC 30 over second and third signal lines 31 about the exact position of the door 14 so that the programming in the PLC 30 can adjust the acceleration, speed, and deceleration position of the door 14 accordingly and take the various factors such as temperature, starting position, etc. into account. This constant feedback from the sensors 24, 26 and others, and constant control over mechanism 18 ensures that the door 14 opens to and closes at the same position every time. In one non-limiting embodiment of the system 10, first and second limit switch mechanisms 24 and 26 are integrated into one positioner mechanism, such as a rotary optical encoder 27 with flexible coupling that can sense or determine the position of the partition or door 14 at any point along its path or line of travel, in the case illustrated rail system 22.

In the present invention, PLC 30 is programmed to open and close the door 14 by directing the mechanical mechanism 18 over a first signal

line 31 to gradually ramp up the speed of the door, that is, in a planned acceleration, and then to gradually ramp down the speed of the door 14 in a planned deceleration as the stopping point is approached. This constant control prevents or greatly reduces the problem of the door 14 slamming into the doorway 16, or a stop, or anything else in the path of the door 14 — as will be explained.

Further shown in FIG. 1 is a safety edge 42 for detecting an object or a person in the path of the leading edge 44 of the door 14 when it is closing. Safety edge 42 may be a conventional hollow rubber or polymer barrier supplied by air or other gas under pressure through safety edge air hose 46. Safety edge 42 communicates directly with safety edge diaphragm switch 48 (shown in FIG. 2) via air pressure, which in turn communicates with PLC 30 over a fourth signal line 31 which immediately lets PLC 30 know if an object is encountered. Because door 14 is never allowed to coast and is in constant, direct control of the mechanism 18, PLC 30 can immediately send a signal to mechanism 18 over first signal line 31 to immediately stop the door 14 and begin reversing its direction (typically to open the door, although this portion of the invention could be implemented on the opposite, trailing edge of door 14 as well). This immediate feedback loop to PLC 30 will help prevent injury to people and damage to equipment that might otherwise occur from a heavy door that was coasting and that might take a few critical inches to stop.

PLC 30 programming may also contain software to permit door 14 to be partially open. For example, if door 14 is designed to let a relatively large object therethrough, such as a forklift (not shown) or other vehicle, it may be desirable to open door 14 to less than its fully open position, such as to permit a single person through. This may be economically important if the doorway 16 is to a climate-controlled room or the like and it is desirable to retain the climate-controlled atmosphere within the room as much as possible. With multiple sensors 24, 26, and others (or one rotary optical encoder 27 or the like), the PLC 30 can direct the mechanism 18 to open the door 14 to the desired distance at the desired speed and/or acceleration and deceleration profiles. The system 10 may be designed so that controls 50 for setting speed and open width distance of the door 14 may be present on the variable frequency drive 28 or elsewhere.

It may be desirable to have a locked key switch 62 of FIG. 2 to limit access to personnel's ability set the door limits and parameters with either

the variable frequency drive 28 and/or the PLC 30. Such limits, for example a partial opening, could be programmed to be easy established by an authorized user. For example, pressing a particular control 50 once could send the door 14 to a predetermined "home" or preset default position; pressing the same control 50 could direct the door 14 to open or close (depending on its starting position); pressing the control 50 a third time could set the limit until it is changed by a similar procedure.

In the programmable door system 10 of the invention where a user has the ability to access and change preset limits and parameters of door 14 control it is useful for the programming of the PLC 30 to control the mechanical mechanism 18 to return the door 14 to a preset "home" or default position in the event of an error or confusion in the PLC 30. For example, if the PLC 30 receives too many conflicting signals over a short period of time, an error may occur. It may be useful to have the PLC 30 programmed to automatically open the door 14 to its full open position instead of permitting it to coast or otherwise go to its full closed position to avoid accidental trapping of a person or object between the door 14 and the doorway 16. This feature may be understood as an automatic correction feature or "autocorrect".

Another optional part of this invention would be the inclusion of mechanisms for manually opening the door 14. The PLC 30 could be programmed to close the door 14 after a preset time delay when the door 14 would be opened by any of such means or other means. This latter feature would prohibit the door 14 from standing open too long, for instance if it were a door to a climate-controlled room. Such manually controlled mechanisms would include, but are not necessarily limited to front door pull 52; rear recessed pull 54, inside/outside release mechanism 56 (all seen in FIG. 1); floor loop 40 (previously discussed); switches (not shown) proximal to but not on the door 14 itself as well as switches on the door; remote controls (not shown), similar to garage door openers and the like, which direct remote control receiver 58 on electronics panel 12 shown in FIG. 2, which would work via radio, infrared, UV or other remote signal; photosensitive receiver (not shown) proximal to the door 14; and the like. These are all devices that would be utilized to permit automatic opening of the door 14 by the PLC 30 via a convenient mechanism that would permit, for example, a user to approach the door 14 and have it open with minimum involvement by the user.

The modes of access discussed above may be designed to be specified or dedicated to a particular door 14 when a plurality of doors 14 permit access to a single room, or each of the plurality of doors 14 permits access to its own room. In some prior systems, all doors 14 to a room were opened automatically when substantially the entire length of a safety edge on one door, rather than a single point, was contacted — for example by a forklift. For climate-controlled rooms, this can result in the waste of a temperature controlled atmosphere. Such situations could also undesirably permit access to room or rooms by unauthorized personnel. By dedicating a particular type of control to a particular door 14, limited access, energy savings and added security, among other benefits, may be had. In one specific, non-limiting example, a particular remote control could be tuned or otherwise set to open only a particular door 14.

In some embodiments of the invention, it would be desirable and possible to program PLC 30 to limit any access or perhaps certain kinds of access to the room in question during particular times of the day. For instance, the PLC may be provided with a real time clock enabling time control functions (incorporated into controls 50) for a key operator to keep the door closed during non-working hours, in a non-limiting example.

Another optional feature of the inventive system 10 would be to provide the interior of the door 14 with a room temperature monitor (not shown) which would activate an alarm (not shown) of some sort via a signal to the PLC 30 over a fifth signal line 31 to alert an operator that the temperature in the climate-controlled room was different from a preset temperature limit. Such a subsystem would be employed whether the room was to be kept at a temperature above or below ambient. Of course, it is anticipated that corresponding monitors or sensors for other conditions, *e.g.* humidity, light, pressure, etc. could be employed instead of or in addition to one for temperature. If PLC 30 were connected to a modem (not shown), PLC 30 would call an operator at a remote location to alert them of a temperature control failure, or an unauthorized opening of a door 14 or other urgent event.

The programmable door system 10 of this invention may be provided with an output mechanism to display information about present and past limits and parameters of the door 14. If a history of the door 14 operations was stored in memory (not shown), an operator would review this history via output to determine if the door 14 were being used properly. Such data

as discussed above would be provided by any convenient means, such as visual display, such as a screen 60 on variable frequency drive 28 shown in FIG. 2, by printing, etc. This data could be used for recalibration of the door 14, trouble-shooting of the system 10, tabulation of faults, etc. Such data would also alert an operator that a particular component of the system, including but not limited to, the sensors 24 and 26, mechanism 18, safety edge 42, is about to fail.

Further, each PLC 30 from more than one programmable door system 10 of this invention may be linked to a central monitoring unit (not shown) via at least a pair of signal lines per system 10. Programming in the central monitoring unit would permit receiving and displaying information from each PLC 30, and/or for controlling each PLC 30 from the central monitoring unit. The central monitoring unit may be a personal computer, work station, server or other suitable device.

Many modifications may be made in the structures and processes of this invention without departing from the spirit and scope thereof which are defined only in the appended claims. For example, it is anticipated that the invention herein may be implemented on both single slide doors and bi-part doors, *i.e.* two doors which slide closed together. It can be appreciated that the system 10 of this invention would be particularly useful in helping prevent the two sides of a bi-part door to crash together. Further, it is anticipated that the system 10 of this invention could be implemented on other door types, for example swinging doors, accordion doors, articulated rolling doors, etc. as well as on windows, louvers, blinds, and other physical partitions which mechanically close over apertures or openings in a wall or barrier.

Claims

I Claim:

1. A programmable movable partition system comprising:
a programmable logic controller (PLC);
a movable partition adapted to open and close over an aperture;
a mechanical mechanism for opening and closing the movable partition over the aperture;
a first limit switch mechanism for determining that the movable partition is closed and sending a signal to the PLC that the movable partition is closed;
a second limit switch mechanism for determining that the movable partition is open and sending a signal to the PLC that the movable partition is open;
at least one first signal line from the PLC to the mechanical mechanism, at least one second signal line from the PLC to the first limit switch mechanism, and at least one third signal line from the PLC to the second limit switch mechanism; and
control programming in the PLC to control the mechanical mechanism over the first signal line to open and close the movable partition over the aperture.

2. The programmable movable partition system of claim 1 where the control programming in the PLC opens and closes the movable partition according to a programmed acceleration and deceleration.

3. The programmable movable partition system of claim 1
where the movable partition comprises a leading edge having a safety edge for detecting an object in the path of the leading edge when the movable partition is closing; and
where the programmable movable partition system further comprises
a fourth signal line from the PLC to the safety edge;
control programming in the PLC to detect a signal from the fourth signal line that an object has been detected by the safety edge and to send a signal over the first signal line to immediately stop the movable partition and to open the movable partition.

4. The programmable movable partition system of claim 3 further comprising control programming in the PLC to detect a signal from the fourth signal line that an object has been detected by the safety edge and to send a signal over the first signal line to immediately stop the movable partition and to open the movable partition until a signal is received by the second limit switch mechanism that the movable partition is open.

5. The programmable movable partition system of claim 1 further comprising:

controls for setting speed and open distance of the movable partition to less than fully open; and

control programming in the PLC to detect signals from the controls and to control the mechanical mechanism to open and close the movable partition over the first signal line which opens and closes the movable partition according to desired speed and open distance.

6. The programmable movable partition system of claim 1 further comprising:

a positioner mechanism for determining the position of the movable partition between a fully open and fully closed position;

control programming in the PLC to control the mechanical mechanism over the signal line to return the movable partition to a preset default position in the event of an error.

7. The programmable movable partition system of claim 6 where the positioner mechanism incorporates the first limit switch mechanism and the second limit switch mechanism.

8. The programmable movable partition system of claim 1 further comprising:

manually operated mechanisms for sending a signal to the PLC to open the movable partition and to close the movable partition after a preset time delay, said manually operated mechanisms being selected from the group consisting of:

weight sensitive floor loops proximal to the movable partition;
photosensitive light beam proximal to the movable partition;
remote control; and
switch on the movable partition.

9. The programmable movable partition system of claim 1 further comprising control programming in the PLC to display information about movable partition operation via an output mechanism.

10. The programmable movable partition system of claim 1 further comprising:
controls for selecting real time settings during which the movable partition may be opened and closed, and at least one additional signal line to the PLC to transmit the settings to the PLC; and
control programming in the PLC to control the mechanical mechanism to open and close the movable partition over the signal line which opens and closes the movable partition according to the selected real time settings.

11. A programmable movable partition system for a temperature controlled room comprising:
a programmable logic controller (PLC);
a movable partition adapted to open and close over an aperture;
a mechanical mechanism for opening and closing the movable partition over the aperture;
a first limit switch mechanism for determining that the movable partition is closed and sending a signal to the PLC that the movable partition is closed;
a second limit switch mechanism for determining that the movable partition is open and sending a signal to the PLC that the movable partition is open;
at least one first signal line from the PLC to the mechanical mechanism;

a temperature sensor on an inside surface of the movable partition, where the temperature sensor is connected to the PLC by a fifth signal line; and

control programming in the PLC to activate an alarm if the temperature sensor sends a signal to the PLC different from a preset threshold limit.

12. The programmable movable partition system of claim 11 where the control programming in the PLC opens and closes the movable partition according to a programmed acceleration and deceleration.

13. The programmable movable partition system of claim 11 further comprising a positioner mechanism for determining the position of the movable partition between a fully open and fully closed position, where the positioner mechanism incorporates the first limit switch mechanism and the second limit switch mechanism.

14. A programmable movable partition system comprising:

a plurality of movable partitions, each movable partition comprising in turn:

a programmable logic controller (PLC);

a movable partition adapted to open and close over an aperture;

a mechanical mechanism for opening and closing the movable partition over the aperture;

a first limit switch mechanism for determining that the movable partition is closed and sending a signal to the PLC that the movable partition is closed;

a second limit switch mechanism for determining that the movable partition is open and sending a signal to the PLC that the movable partition is open;

at least one first signal line from the PLC to each mechanical mechanism; and

control programming in the PLC to control the mechanical mechanism over the first signal lines to open and close the movable partitions over the respective apertures;

a central monitoring unit;
at least one pair of signal lines from each PLC to the central monitoring unit; and
programming in the central monitoring unit for receiving and displaying information from each PLC, and for controlling each PLC from the central monitoring unit.

15. The programmable movable partition system of claim 14 where the control programming in the PLC opens and closes the movable partition according to a programmed acceleration and deceleration.

16. The programmable movable partition system of claim 14 further comprising a positioner mechanism for determining the position of the movable partition between a fully open and fully closed position, where the positioner mechanism incorporates the first limit switch mechanism and the second limit switch mechanism.

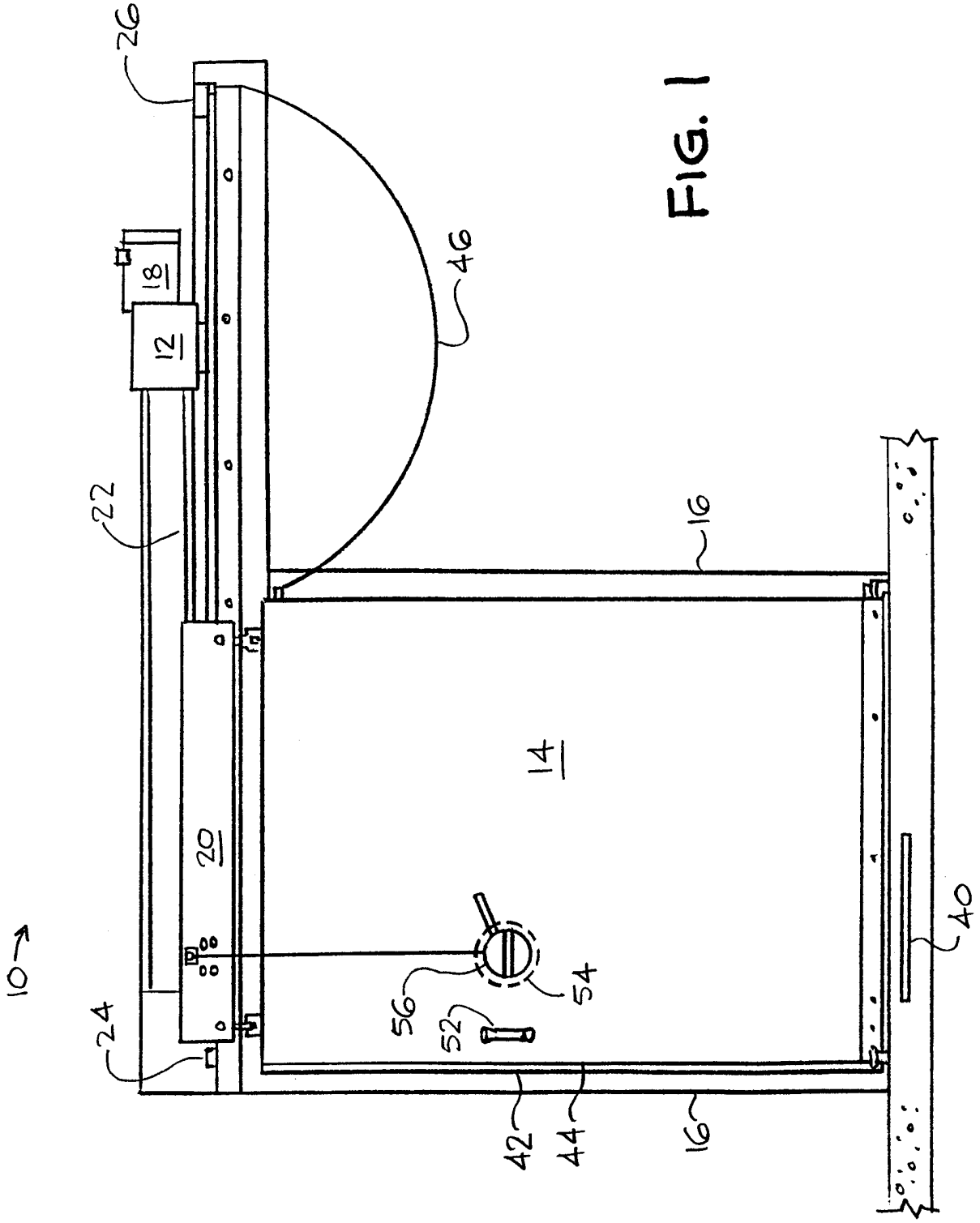


FIG. 1

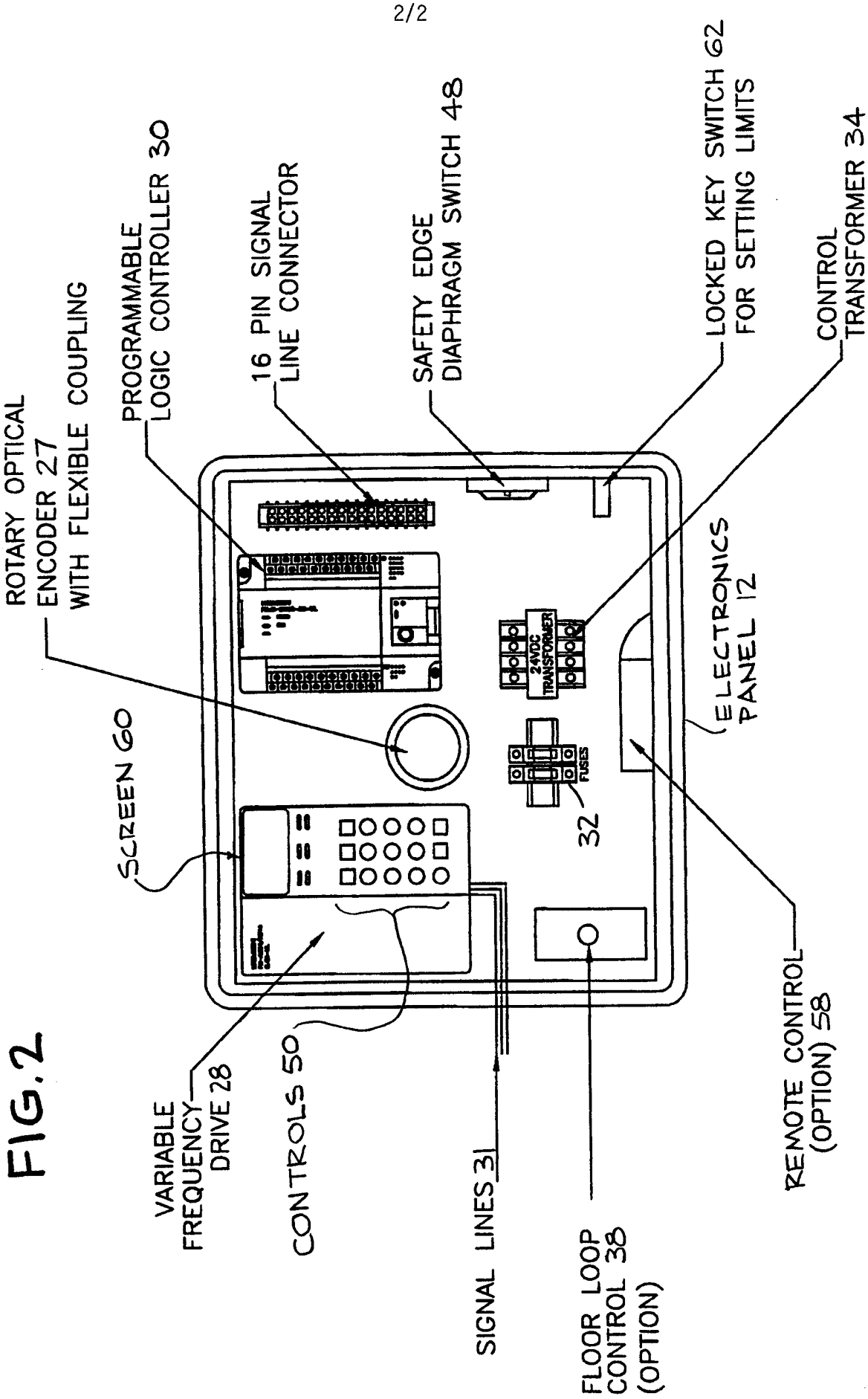

ROTARY OPTICAL ENCODER 27 WITH FLEXIBLE COUPLING
PROGRAMMABLE LOGIC CONTROLLER 30
16 PIN SIGNAL LINE CONNECTOR
SAFETY EDGE DIAPHRAGM SWITCH 48
LOCKED KEY SWITCH 62 FOR SETTING LIMITS
CONTROL TRANSFORMER 34
ELECTRONICS PANEL 12
24VDC TRANSFORMER
FUSES
32
SCREEN 60
VARIABLE FREQUENCY DRIVE 28
CONTROLS 50
SIGNAL LINES 31
FLOOR LOOP CONTROL 38 (OPTION)
REMOTE CONTROL (OPTION) 58

FIG. 2