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(54) **Safety system for a powered door**

(57) A roller shutter door (10) is mounted on a barrel (12) above a doorway opening (14). A motor (not shown) is used to turn the barrel (12) to allow the roller shutter door (10) to be rolled up and down to either open or close the doorway (14). A leading edge (16) of the roller shutter door (10) comprises a compressible rubber strip. The

leading edge (16) is secured to a lower lath (18) of the roller shutter door (10). There is a channel (20) that extends inside the length of the leading edge (16). The channel is enclosed to prevent the ingress of external light that could give undesired light detection. The passage/non-passage of light along the channel (20) is used to determine the presence of obstructions.

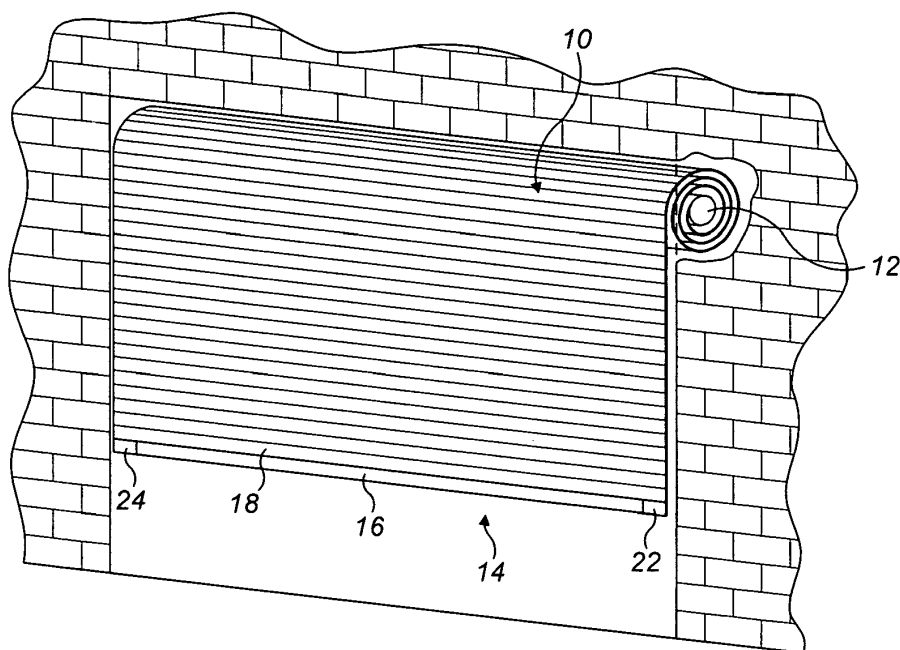


FIG. 1

Description

[0001] This invention relates to a safety system for a powered door, particularly, but not limited to, a safety system for a roller shutter door. The invention also relates to a method of controlling a powered door, such as a roller shutter door.

[0002] Roller shutter doors typically comprise an assembly of laths that be can be stored on a rotatable barrel above a doorway. The rotatable barrel is turned to lower the assembly of laths to cover the doorway. The laths are hinged together to allow for movement between the rolled configuration referred to above and the deployed configuration.

[0003] An important safety aspect of a roller shutter door is a system to detect when a blockage is present in the doorway, which may foul on a leading edge of the roller shutter door. An obstruction in the doorway may cause a motor driving the roller shutter door to stall and may cause injury if a person is in the doorway when the roller shutter door is being operated.

[0004] Various systems have been developed to detect the presence of an obstruction. One system is used to detect when a leading edge of the roller shutter door contacts an obstruction. The system is based on using an infrared beam which is directed through a compressible tube that extends along the length of the leading edge of the roller shutter door. When the compressible tube touches an obstruction the tube is compressed which impedes the infrared light from passing along the tube. A loss of signal between an infrared transmitter at one end of the tube and a receiver at an opposite end of the tube is taken to be an obstruction event by a control system of the roller shutter door.

[0005] The type of system described above typically requires a transmitter and receiver pair which must be hardwired to an extendable spiral-wound cable secured to the leading edge of the door. Given that the leading edge moves across all of the doorway a flexible coil arrangement is typically used for the cables. These cables can be hazardous to users near the moving roller shutter door, because the user could become entangled in the cable as it moves between open and closed positions of the roller shutter door.

[0006] Wireless technology is available, but at present it has very high power demands, which requires regular replacement of batteries for the infrared transmitters and sensors.

[0007] It is an object of the present invention to address the above mentioned disadvantages.

[0008] According to a first aspect of the present invention there is provided a safety system for a powered door, the system comprising a compressible door edge having a channel therein, with an optical transmitter and an optical receiver located at spaced positions in the channel, wherein the system comprises control circuitry operable to detect a variable response time of the optical receiver in response to light transmitted by the optical transmitter,

and wherein the control circuitry is operable to control a motor of the powered door to control movement thereof.

[0009] The control circuitry may be operable to stop and/or reverse the motor.

5 **[0010]** The control circuitry is preferably operable to log multiple response times and trigger a blockage event, or to send control signals to the motor, when the number of response times above a threshold time reaches a threshold value.

10 **[0011]** A power supply of the system preferably includes a dc bus reservoir, or charge store. Advantageously the reservoir reduces sudden drains on an attached battery.

[0012] The power supply may include a charge pump.

15 **[0013]** The powered door may be a roller shutter door.

[0014] The control circuitry may include a microcontroller and preferably a separate current control unit. The current control unit is preferably implemented separately in hardware, which advantageously reduces a required microcontroller clock speed and thereby reduces power consumption.

[0015] The control circuitry, preferably the current control unit, may be operable to pulse the output of the optical transmitter. The pulsing may be to a duty cycle of 0.1%
25 The pulse duration is preferably controlled by the hardware instead of software or the microcontroller.

[0016] The control circuitry is preferably operable to detect fluctuations in response times of the optical receiver. The control circuitry is preferably operable to discern between a (generally horizontal) flexure type fluctuation of the compressible door edge and a (generally vertical) compression of the compressible door edge.

[0017] The compressible door edge is preferably sufficiently compressible to close the channel under the weight of the door to which it is attached.

[0018] The system is preferably operable to communicate wirelessly with the motor of the powered door.

[0019] The channel is preferably substantially sealed to external light.

40 **[0020]** According to a second aspect of the present invention there is provided a method of controlling a powered door comprising transmitting optical signals along a channel located along a compressible door edge from an optical transmitter to an optical receiver, wherein a response time of the optical receiver is used to determine whether a motor of the powered door should be stopped to stop movement of the powered door.

[0021] The invention extends to a powered door assembly fitted with the system of the first aspect.

50 **[0022]** The invention extends to a retrofit system according to the first aspect.

[0023] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is a schematic perspective view of a roller

shutter door shown between open and closed configurations;

Figure 2 is a schematic cross-sectional view of a tubular leading edge structure of the roller shutter door shown in Figure 1;

Figure 3 is a schematic system diagram of an optical control system implemented in hardware; and

Figure 4 is a schematic hardware diagram of the safety system for the roller shutter door.

[0024] As shown in Figure 1 a roller shutter door 10 is mounted on a barrel 12 above a doorway opening 14. A motor (not shown) is used to turn the barrel 12 to allow the roller shutter door 10 to be rolled up and down to either open or close the doorway 14.

[0025] A leading edge 16 of the roller shutter door 10 comprises a compressible rubber strip shown in cross-section of Figure 2. The leading edge 16 is secured to a lower lath 18 of the roller shutter door 10. There is a channel 20 that extends inside the length of the leading edge 16. The channel is enclosed to prevent the ingress of external light that could give undesired light detection.

[0026] In Figure 1 a transmitter assembly 22 is shown at one end of the leading edge 16 and a receiver assembly 24 is shown at an opposite end of the leading edge 16.

[0027] The transmitter assembly 22 is used to transmit an infrared light along the channel 20 to be received by the receiver assembly 24.

[0028] The transmitter assembly 22 and the receiver assembly 24 are hardwired together, but are able to communicate wirelessly with a control mechanism (not shown) of the roller shutter door motor.

[0029] The details of the safety system as shown in Figures 3 and 4 will now be discussed in more detail. At the base of those figures the infrared transmitter assembly 22 and in the infrared receiver assembly 24 are shown. In addition, the safety system includes a microcontroller 26, a dual frequency radio transmitter 28 that communicates with the control circuitry of the roller shutter door motor, a 3.6V lithium thionyl chloride (LTC) battery 30 connected to power control elements 32a to 32d.

[0030] The power control elements comprise a charge pump 32a which is used to boost the battery voltage to accommodate the full range of shutter widths encountered regarding resistance in cable length and optical transmission characteristics, although the charge pump is not essential, because an optical receiver 24 can be used that incorporates electronics to provide sufficient charge to remove the need to have a charge pump. The voltage is typically 4.8V to accommodate all widths of shutter but can be reduced with smaller shutters for increased efficiency. Smaller widths of shutter may operate without a boost voltage. The charge pump 32a supplies charge to a DC bus reservoir 32b. This is constituted as a number of capacitors used to avoid a sudden draw on

the battery 30, because a sudden drain on the battery 30 may reduce its useful life. The size of the bank of capacitors used in the DC bus reservoir 32b is chosen to accommodate a widest door likely to be used in the safety system to ensure that a sufficient amount of current can be provided. The DC bus reservoir 32b supplies current to a current control element 32c which receives a current reference from a digital to analogue converter 34 and also receives an enable instruction from the microcontroller 26. The current control element 32 also includes an input from the current measurement element 32d to provide feedback before outputting a signal to the infrared transmitter assembly 22.

[0031] The microcontroller 26 is also connected to the digital to analogue converter 34 which provides a control signal to the power control circuitry 32c.

[0032] The elements 32a-d allow pulsing of the infrared transmitter to be achieved in a hardware implementation, as opposed to in software. The pulsing reduces energy consumption.

[0033] The current control scheme for pulsing the output of the transmitter 22 has the following steps

- 1) An ENABLE input of the current control unit 32c is deasserted.
- 2) A zero is written to the DAC 34.
- 3) An SR (set/reset) latch 27 of the microcontroller 26 is set.
- 4) The microcontroller 26 writes a current demand to the DAC 34 via a databus 29.
- 5) Software of the microcontroller 26 clears a timer 31 of the microcontroller 26.
- 6) Software of the microcontroller 26 waits for a comparator 33 of the microcontroller 26 to switch.
- 7) The timer value is read.
- 8) Following that step 2) above is repeated.

[0034] It is possible to return to step 2 (with good control over the current falling edge rate and EMC emissions) or step 1 (with quicker current turn-off and no control over fall rate, but more efficient). Recycle to step 1 is preferred for energy efficiency.

[0035] As shown in Figure 4 the microcontroller 26 receives inputs from reed switches and a motion sensor, a rotary switch, dip switches, external push button and an internal push button. These inputs are used for the following functions.

[0036] Reed switches plus external magnets located on the door and on or in rails in which edges of the door run provide a wakeup source indicating movement of the door to the control system to allow a low current sleep-

mode during non-operation. The reed switches also provide positional information regarding top/mid position/ bottom of the roller shutter door with respect to the maximum and minimum (open/closed) positions.

[0037] The motion sensor is an alternative wakeup source to reed switches, in which case the external magnets are not required. For a system fitted with a motion sensor, the magnets are not required for the safety system to operate but may be optionally fitted in addition to a motion sensor to provide absolute positional information for enhanced functionality, for example to prevent false triggering of the safety system when fully closed due to a stone on the ground or to detect an unauthorised entry through a forced shutter.

[0038] The rotary switch is an option to set the system sensitivity manually. Not fitting the switch or setting to position zero would be automatic self-calibration mode.

[0039] The DIP switches are to configure installation-related parameters such as radio (e.g. protocol, frequency, power) and optional magnets for positional information (e.g. bottom magnet for intruder detection.)

[0040] The external push button is for system commissioning and end-user diagnostics.

[0041] The internal pushbutton is for factory commissioning/test and engineer-mode configuration.

[0042] The microcontroller 26 has outputs to external and internal LEDs 36a and 36b.

[0043] The external LED is to convey end-user information e.g. safety system status and simple fault data.

[0044] The internal LED is to convey trained engineer information e.g. detailed fault diagnostics and reset parameters.

[0045] The main point regarding the LEDs and push-buttons is that only the external LED and pushbutton are accessible with the lid fitted i.e. when the product has been installed. However access to the internal LED and pushbutton requires the lid to be removed so the product is either in manufacture, in the process of being installed, or has been installed and an engineer is onsite.

[0046] A significant feature of the system described herein is that the infrared receiver assembly 24 can detect varying degrees of light reception, for example intermediate levels of light can be discerned to detect a partial blockage. In the prior art system described above an optical system requires the optical beam to be wholly interrupted to detect an obstacle, i.e. the system works in a binary mode of receiving light or not receiving light. In the infrared receiver assembly 24 many steps have been taken in the design of the infrared receiver to maximise energy efficiency so that the safety system can function with a 3.6V battery over a period of many years of use. Compared to a typical off the shelf infrared receiver many of the components have been removed to reduce power requirements. For example, the control circuitry of the infrared receiver assembly 24 has been much reduced. The infrared receiver cells have no daylight filter in our circuitry, which reduces complexity. The standard cells would usually have a voltage regulator to stabilise the

supply voltage across a range of input values. Removing this and implementing separate current control in hardware outside the infrared receiver cells improves system efficiency, gives a higher degree of control and sensitivity and allows physically smaller cells. Removing the daylight filter improves optical response.

[0047] In the infrared receiver assembly 24, the response time of the infrared light detection is related to the intensity of the light received. The receiver indicates that it has received infrared light when the receiver has effectively been "charged" by the incoming infrared light. This means that the more intense the light, the more quickly the receiver is charged and so indicates that infrared light has been received. For example, if infrared light passes directly along the channel 20 without obstruction the receiver will show that light has been received more quickly than if the channel is partially obscured.

[0048] The receiver is typically saturated with infrared light after 10 micro seconds, which leads to a signal at the microcontroller 26 confirming that light from the infrared transmitter assembly 22 has been received at the infrared receiver assembly 24. By collecting data at the microcontroller 26 as to the time taken to achieve saturation of the infrared receiver assembly 24 further information as to the status of the leading edge 16 can be obtained. For example a partial obstruction of the leading edge may result in a longer saturation time of the receiver assembly 24, to a response time of for example 15 micro seconds. After that, a further effect of an obstruction may result in more deformation of the leading edge 16, which would cause a further rise in the response time, to perhaps 20 micro seconds.

[0049] The infrared receiver 24 is operated at a sampling frequency of approximately 60 Hz with a duty cycle of perhaps 1 in 1,000. Thus, the differences in saturation time referred to above can show the arrival of an obstruction to the leading edge 16 over a very short period of time.

[0050] The microcontroller 26 is programmed to signal a blockage event at the leading edge 16 when the response time for transmitted infrared light from the transmitter assembly 22 reaches a predefined threshold. That threshold may for example be 30 microseconds. The microcontroller may also be programmed to require a number of repetitions of the threshold triggering before it triggers a blockage event. For example, at a frequency of 60 Hz, the microcontroller may be programmed to require 5 to 10 response times to be greater than 30 microseconds before a blockage event is triggered. Thus, a blockage can be detected in, for example 10 cycles, which at 60 Hz is approximately 1/6 of second. It is also possible for the microcontroller 26 to stop the detection cycle of the receiver 24 if the threshold is achieved before the 30 microsecond window ends, for example at 10 microseconds. This feature reduces power consumption.

[0051] The time period of 30 microseconds for saturation to signal a blockage is just one example, which can

be adjusted to suit the particular circumstances. Similarly, the number of cycles that are detected with the threshold of 30 microseconds saturation time can also be adjusted to the particular circumstances to ensure that false blockages are not shown, perhaps based on vibrations of the door which could cause temporary compression of the leading edge 16, but are not in fact blockage events that require action.

[0052] The leading edge 16 is in effect a long thin member that is open to flexure, potentially from being blown by the wind. This sort of flexure is not a blockage event, but could be detected by the infrared receiver assembly, because flexure of over the full length of the leading edge 16 will likely lead to increased response times of the receiver assembly 24, which could be response times over the threshold referred to above. In order to combat such false blockage signals, the typical oscillation frequency of a vibration caused by wind movement can be determined and is likely to oscillate between certain periods in which the threshold of 30 microseconds is achieved and periods when it is not as it flexes in the wind. The period of such oscillations can be detected in the variation of response times and the false blockage signals can be filtered out based on prior knowledge of the frequency of oscillation of the leading edge due to wind movement. The prior knowledge can be obtained by testing.

[0053] In the channel 20 in the leading edge 16 light propagates down along the channel 20 both by direct transmission between the infrared transmitter assembly 22 and the infrared receiver assembly 24, and also by reflection from side walls of the channel 20. The light output of the infrared transmitter 22 is proportional to its current supply. This means that a wider roller shutter door 10 will require a greater current supply, because the infrared light must travel further along the channel 20 in the leading edge 16 and so is more likely to be dissipated and not received at the infrared receiver assembly 24 over longer lengths. Furthermore, inductance in the system varies according to the cable lengths. As mentioned above, the infrared transmitter and receiver assemblies 22 and 24 are hardwired together, with requires a greater cable length for a wider door. A longer cable limits the pulse duration of light that is achievable. The range of cable lengths typically used present a variable parameter to the current control circuitry. The reason for this is that the inductance and resistance of the transmitter cable increases with shutter width, due to the longer cable used to connect to the control circuit. The presence of inductance introduces a non-linear element and makes it difficult to control a narrow current pulse. This could normally be compensated for in a fixed system. However the inductance property varies from one installation to another according to shutter width (cable length). Hence for the control circuitry to work in all installations (ranges of shutter widths 0.5m-7m), it needs to accommodate a large range of cable lengths (i.e. inductance and resistance)

[0054] In order to combat the problems with inductance and higher light output requirements the system is ar-

ranged to have a fixed rate of rise of current supply, which reduces the inductance effect. Therefore, the safety system is auto-tuned to cable length and so the inductance is invariant in relation to length of the leading edge 16 and channel 20. This feature is achieved, by the microcontroller 26 outputting to the digital to analogue converter 34 and then to the current control element 32c to give a fixed rate of rise of current.

[0055] When considering the principals referred to above, it can be seen that any deflection of the leading edge 16 will lead to a change in the light transmission characteristics and so the response time of the infrared receiver assembly 24. Each of those deflections will have a frequency characteristic. For example, wind vibration will be an oscillation, which will be manifested in AC signal of response times. On the other hand a blockage, would cause a steady increase in response times until the channel 20 was completely closed and no light was transmitted to the receiver 24. Thus, at the onset of a blockage the response time would continually increment. This can lead to the prediction of a blockage, which can be used to cut a power supply to the motor to prevent damage to an item causing a blockage or to the roller shutter door 10 or the various control mechanisms thereof.

[0056] In the situation that a wind oscillation is detected which is causing potential problems for false triggers of a blockage event, then the current supply to the infrared transmitter assembly 22 can be increased to provide more light transmission along the channel 20.

[0057] When the infrared sensor in the receiver assembly 24 has been saturated (or charged as discussed above) there is a fall time required for the sensor to become unsaturated (or discharged) to allow it to again detect infrared light. During set up of the safety system described herein an auto-calibration is possible, which could also be used during use of the safety system. In order to minimise the amount of light transmitted to the infrared sensor assembly 24 (and thereby reduced power requirements) the fall time of the detector is measured. When the sensor is saturated the fall time will be constant for increased light intensity. During the auto-calibration set up procedure the intensity of the infrared transmitter 22 can be reduced until the fall time starts to reduce. At this stage it can be appreciated that the amount of current supplied to the infrared transmitter is not too great, because the fall time is reducing and the sensor is not over saturated at each triggering event. Thus, at the stage where the fall time starts to reduce it can be determined that the amount of current supply to the transmitter is approximately correct. The auto-calibration feature is engaged for a new installation by pressing and holding one of the buttons on the microcontroller 26, which causes a scan through different intensities of light, as mentioned above. As part of the auto-calibration a rotary switch of the microcontroller 26 is can be set to 0 to set the auto-calibration mode. Otherwise a manual override function is obtained by setting the rotary dial to any one of 1 to 9 on the rotary dial to achieve a different level of respon-

siveness to that set in auto-calibration.

[0058] The microcontroller 26 also has a de-passivation routine for de-passivation of the battery 30. This is used for a new battery 30, which will require de-passivation as is normal for an LTC battery. Also, a routine is run by the microcontroller to provide passivation prevention to an existing battery, by providing an intermittent load to prevent passivation.

[0059] The system also has a variety of self test features as follows. Firstly, the receipt of light at the infrared receiver 24 is checked, if no light is received then there may be no signal transmitted by the infrared transmitter assembly 22.

[0060] Also, part of the test feature is to provide a series increasing intensity light pulses from the infrared transmitter assembly 22, which should result in a series of decreasing trigger times at the infrared receiver assembly 24 and by microcontroller 26.

[0061] Part of the self test features referred to above also involves emitting a pulse of infrared light from the transmitter assembly 22, which draws energy from the DC bus reservoir 32b. The DC bus reservoir 32b is monitored by the microcontroller 26 and so it can be measured that the correct draw on the DC bus reservoir 32b was detected. For example it might be expected that a 0.5V drop in the DC bus reservoir 32b would be seen for a given infrared pulse of the transmitter assembly 22. If in this situation a higher voltage drop is detected then a fault can be diagnosed.

[0062] The advantages of the system described herein are that the variation in response time of an infrared receiver assembly is used to determine specific features about potential blockages or flexure of a leading edge of a roller shutter door. Furthermore, the use of a number of strategies to reduce power requirements have enabled a wireless optical system to be built that has a good battery life using standard low voltage batteries. For example pulsing the infrared sensor on a duty cycle of 1 in 1000 increases battery life, as does using a charge pump, and stopping a detection cycle early on detection of a threshold light level. Pulsing the infrared transmitter also reduces power consumption. The use of hardware components such as the control circuits for pulse power control allows a shorter pulse duration to be achieved and a lower microcontroller clock speed to be used, both of which reduce power consumption.

[0063] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0064] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0065] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0066] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A safety system for a powered door, the system comprising a compressible door edge having a channel therein, with an optical transmitter and an optical receiver located at spaced positions in the channel, wherein the system comprises control circuitry operable to detect a variable response time of the optical receiver in response to light transmitted by the optical transmitter, and wherein the control circuitry is operable to control a motor of the powered door to control movement thereof.
2. A safety system for a powered door as claimed in claim 1, in which the control circuitry is operable to log multiple response times and trigger a blockage event, or to send control signals to the motor, when the number of response times above a threshold time reaches a threshold value.
3. A safety system for a powered door as claimed in claim 1 or claim 2, wherein a power supply of the system includes a DC bus reservoir, or charge store.
4. A safety system for a powered door as claimed in any preceding claim, wherein the control circuitry includes a microcontroller and a separate current control unit.
5. A safety system for a powered door as claimed in claim 4, in which the current control unit is implemented separately in hardware.
6. A safety system for a powered door as claimed in any preceding claim, wherein the control circuitry is operable to pulse the output of the optical transmitter.
7. A safety system for a powered door as claimed in any preceding claim, wherein the control circuitry is operable to detect fluctuations in response times of the optical receiver.

8. A safety system for a powered door as claimed in any preceding claim, wherein a the channel is preferably substantially sealed to external light.
9. A method of controlling a powered door comprising transmitting optical signals along a channel located along a compressible door edge from an optical transmitter to an optical receiver, wherein a response time of the optical receiver is used to determine whether a motor of the powered door should be stopped to stop movement of the powered door.
10. A powered door assembly fitted with the system any one of claims 1 to 8.
11. A retrofit system according to any one of claims 1 to 8.

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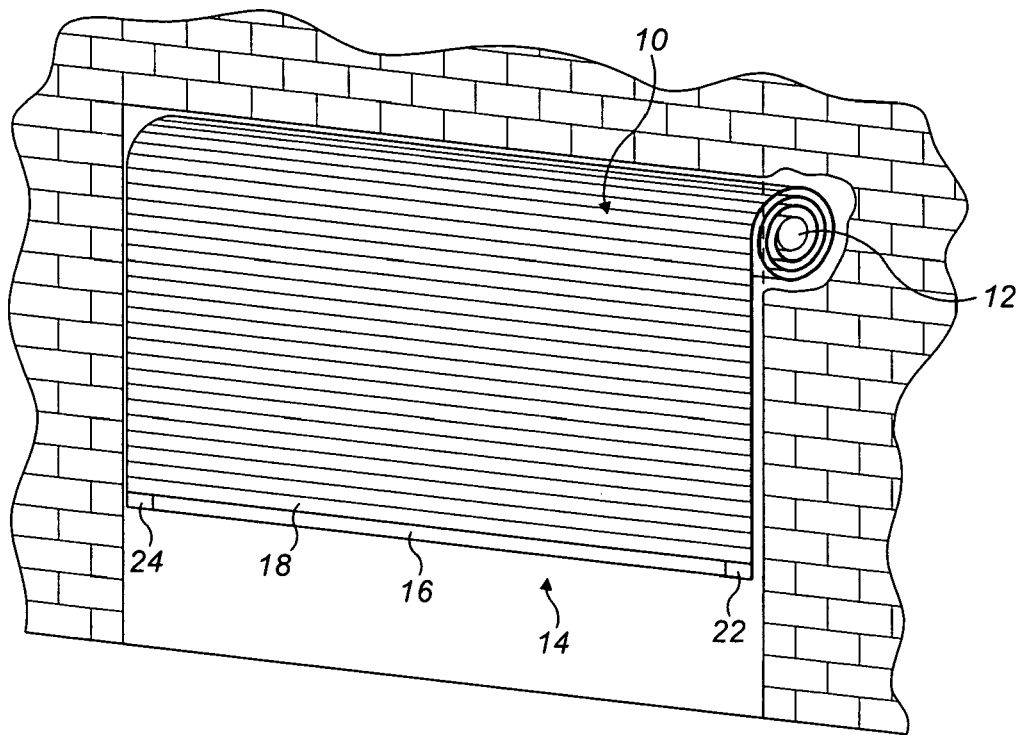


FIG. 1

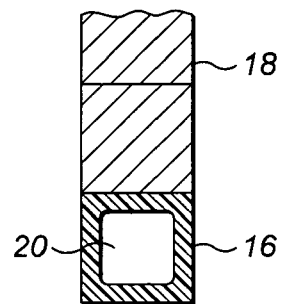
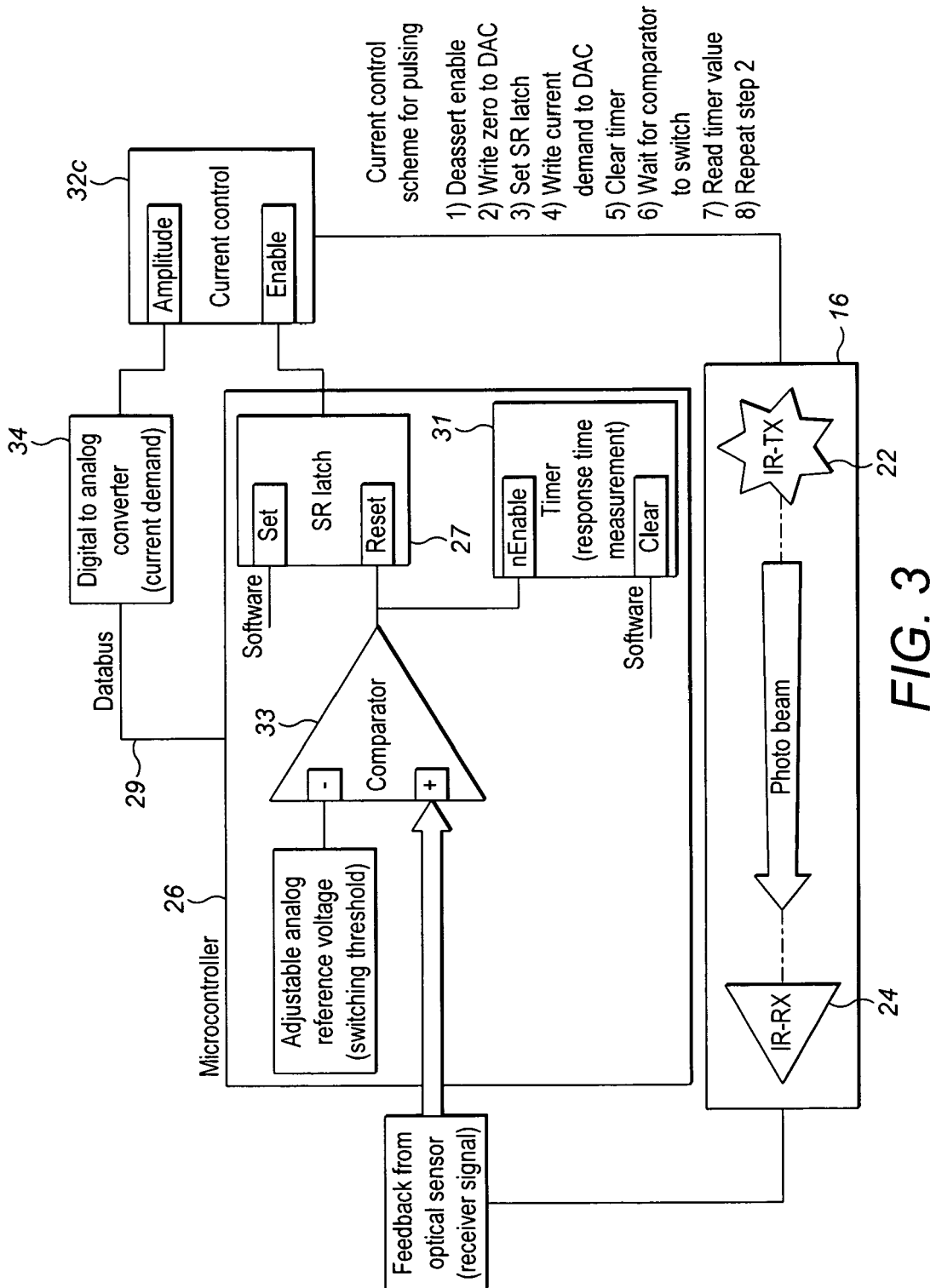


FIG. 2



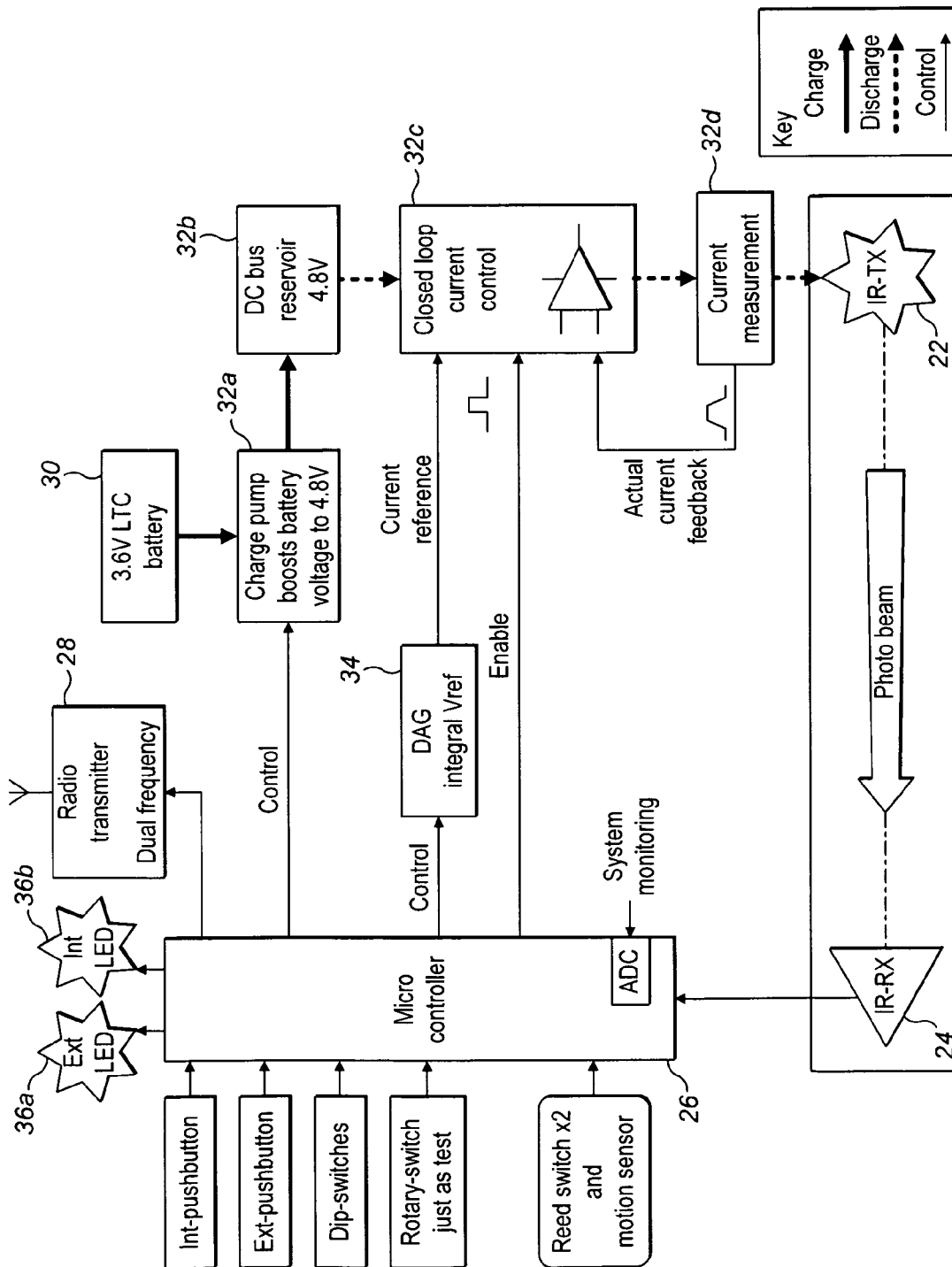


FIG. 4