

## **AUTOMATIC RESCUE DEVICE FOR ELEVATOR**

The present invention relates to an automatic rescue device for an elevator such as a traction elevator.

Conventionally, elevators have been provided with an automatic brake which, when there is a failure in the primary power source of the elevator, prevents movement of the elevator car until the power supply is re-established. Whilst the brake prevents the elevator car from moving out of control, which is likely to result in injuring any occupants of the elevator car, the application of the automatic brake when the elevator car is between door zones inconveniences any occupants of the elevator car because they will be trapped until power is resumed.

Automatic rescue devices (ARDs) are devices which have an auxiliary power supply, such as a battery, and which come into operation when the primary power source fails. ARDs release the automatic brake and move the elevator car to a door zone and open the doors to allow the occupants to leave the elevator car.

An object of the present invention is to provide an improved ARD.

According to a first aspect of the present invention there is provided a device for controlling operation of an elevator in the event of failure of the primary power source, the device comprising means for applying power from an auxiliary power source to drive the elevator motor, and being characterised by means for detecting the speed of operation of the motor, means for comparing the detected speed with a maximum speed value, and means for stopping motion of the elevator car when said comparing means determines that the detected speed exceeds the maximum speed.

It is advantageous to measure the speed of operation of the elevator motor because there may be a fault in the motor itself or in the electrical supply to the motor which would not be noticed if the speed of the motor was not detected.

According to a second aspect of the present invention there is provided a device for controlling operation of an elevator in the event of failure of the primary power source, the device comprising means for applying power from an auxiliary power source to drive the elevator motor, and characterised by means for detecting the position of the elevator car relative to a door zone, and means for controlling the motor to reduce the speed of the elevator car when the car is proximate a door zone.

Thus, when the elevator car is not near a door zone it travels at a relatively high speed, and as the elevator car approaches a door zone the elevator car is moved at a second, relatively slow speed until the elevator car arrives precisely at the door zone, whereupon it will stop. This feature provides passenger comfort when the elevator is under ARD control.

According to a third aspect of the present invention there is provided a device for controlling operation of an elevator in the event of failure of the primary power source, the device comprising means for applying power from an auxiliary power source to drive the elevator motor, and characterised by means for detecting the current drawn by the motor, means for comparing the drawn current to a maximum value, and means to change the direction of the motion of the elevator car if the current drawn exceeds the maximum value.

This may enable the direction of travel of the elevator car to depend on the load in the elevator car.

According to a fourth aspect of the present invention there is provided a device for controlling operation of an elevator in the event of failure of the primary power source, the device comprising means for supplying power from an auxiliary power source to drive the elevator motor, means for controlling movement of the elevator car to a door zone, and characterised by means for detecting re-establishment of the primary power source, and means for inhibiting application of primary power source until the elevator car is at a door zone and the auxiliary power source is no longer applied.

This feature prevents the ARD being damaged by the sudden re-application of the primary power source.

For a better understanding of the invention an embodiment will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a traction elevator;

Figs. 2A and 2B show an operation flow chart for the ARD;

Figs 3A and 3B show an example of a suitable control circuit for the ARD;

Fig. 4 shows circuitry for driving the elevator motor in response to output signals from the control circuit; and

Fig. 5 is a functional block diagram indicating the functions performed by the control circuitry of Figs. 3A and 3B.

Referring initially to Fig. 1, a traction elevator can be seen to comprise an

elevator car 1 which is counterbalanced by a weight 3 by means of a cable 5 attaching the elevator car 1 to the weight 3. A motor 7 is provided to control movement of the elevator car between door zones A, B, C and D. When the elevator car 1 is at one of the door zones A - D, this corresponds to the elevator car arriving at an appropriate floor of a building where the doors would automatically open to allow exit and entry of persons to the elevator car. A primary power source 9, under normal conditions, provides power to the motor 7. An automatic braking system 11 is provided which automatically clamps the cable 5 in the event of a power failure in the primary power source 9.

If the automatic brake 11 was not provided, and a failure in the primary power source 9 occurred, any imbalance in weight between the elevator car 1 and the counterweight 3 would result in free falling of the elevator car 1, which would be likely to injure any persons in the elevator car.

ARD processor 13 is provided which monitors the primary power source. In the event of failure of the primary power source, as discussed above, the automatic brake 11 is applied to the cable 5 to prevent movement of the elevator car 1. In addition to the automatic application of the brake 11, the failure of the primary power source 9 will be detected by the ARD processor 13. The ARD processor will perform a self-test to confirm the status of the primary power source 9, whereafter the ARD processor will take over operation of the elevator to move the elevator car to an appropriate door zone and to open the elevator car doors to allow any persons in the elevator car to exit in safety.

The ARD processor 13 includes relay interface logic which provides an interface between the ARD control circuitry and external components such as current and motor speed sensors (described later).

The ARD processor 13 is powered by an auxiliary power source 15, such as a battery. The auxiliary power source 15 could be a bank of lead acid or planté batteries. The capacity is such that when fully charged the power supply is capable of operating the elevator from one door zone to another for a minimum of 20 trips without further charging, and may be specified as 48V, 30Ah for an 11kW motor.

The auxiliary power source 15 is preferably charged by a microprocessor controlled charger 17. The charger 17 only operates when the primary power source is functioning. The charger automatically switches from boost charge to normal charge and finally to trickle charge. It can control different types of batteries by storing their charge/discharge profile curves. All parameters, both input and output are software controlled. Parameters can be changed via a RS232 serial port by using a personal computer. The parameters changed are stored inside an E<sup>2</sup>PROM of the microprocessor of the charger.

Normally, chargers do not monitor the AC input power. However the charger 17 monitors the AC input. If the AC input falls out of the range of plus or minus 20% of the desired value, the ARD charger will not function until the input is within the required range.

The charger also monitors the status of the batteries and can provide to the ARD processor signals indicating that the battery is disconnected, the battery is low, the battery is over discharged, etc., which can be taken into account by the ARD processor 13 when operating the elevator car 1 so that, for example, the ARD will apply the brake 11 if the battery is overdischarged.

Using the power source 15 the ARD processor generates a three phase supply for the motor 7. This supply may be at 5Hz or 20Hz, depending on the speed

at which the motor is to be driven.

The operation of the ARD processor will now be described with reference to the flow chart in Figs. 2A and 2B. At step 20 a power failure occurs, and the elevator stops due to application of the automatic brake 11, at stage 22. The ARD processor 13 then, at stage 24, performs a self-test operation. If the self-test operation produces a satisfactory result the three phase auxiliary power supply is initialised, at stage 26. At stage 28 door zone detectors 30 (see Fig. 1) are monitored by the ARD processor to determine whether the elevator is at a door zone. If the elevator car is not at a door zone then, at stage 32, the load of the elevator car is determined, for example, by determining whether the load weight is 45% more than a set value. If the load does exceed the maximum value, then the direction of motion of the elevator car is reversed, stage 34, and the elevator is moved in the reverse direction at the appropriate speed, stage 36.

Alternatively, if the prescribed load is not exceeded at stage 32, the elevator moves in a forward direction at the appropriate speed, stage 38. At stage 40 the current drawn by the motor is sensed so as to determine if the current is 45% more than a set value (e.g. the amount of current drawn under normal operating conditions of the ARD) at stage 42. If the load is exceeded, the direction of motion is reversed and the elevator proceeds in the reverse direction until it reaches a door zone (stages 44, 46, 48). If the load is not exceeded at stage 42, then the elevator car continues to move in the forward direction at the appropriate speed, at stage 50. When the elevator reaches a floor zone, at stage 52 (or if the elevator car was at a door zone when the ARD came into operation (stage 28)), the doors are opened, at stage 54. At stage 56 the primary power source is monitored, and while the primary power source is not operational the elevator car is in the door zone at which it has stopped (stage 54). When the power from the primary power source is resumed, normal operations of the

elevator resume, at stage 58.

Whilst the flow chart illustrated in Figs. 2A and 2B gives an indication of the way in which the ARD processor works, it will be understood by those skilled in the art that many of the operations shown in the flow chart will be performed iteratively, even though this is not illustrated in the flow chart for the sake of clarity.

Figs. 3A and 3B show a suitable form of control circuitry for implementing the ARD. The signals at the terminal blocks TB1 - TB5 are as follows:-

|     |      |     |                                                                                                                                                                                                                                                                                                     |
|-----|------|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TB1 | pin1 | E21 | This is an input +24V signal coming from the ARD relay interface logic for CS signal.                                                                                                                                                                                                               |
|     | pin2 | CS  | This is an output signal going to the ARD relay interface logic. If the signal from TB2-2 SH is more than 45% of the overcurrent preset value, relay RLY4 will be activated. This CS signal will, via the ARD relay interface logic, provide a signal to FRX on TB1-5 to activate direction change. |
|     | pin3 | P1  | Provides power supply source to the ARD controller from ARD relay interface logic, only upon ARD activation.                                                                                                                                                                                        |
|     | pin4 | TR  | Input signal from ARD relay interface logic to activate the window detector.                                                                                                                                                                                                                        |
|     | pin5 | FRX | Input signal from ARD relay interface logic (due to CS signal) requesting for direction change. This is the signal required to activate the phase sequence reversal.                                                                                                                                |
|     | pin6 | FF  | This is an input signal from the ARD relay interface logic requesting for fast speed mode when no door zones are                                                                                                                                                                                    |

detected. It is a primary input signal for the dual speed mode. Once this signal is not detected by the ARD controller (RLY3 not activated), the dual speed mode will switch to the slow speed mode.

|     |      |     |                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----|------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TB2 | pin1 | Gnd |                                                                                                                                                                                                                                                                                                                                                                                                                           |
|     | pin2 | SH  | Signal input from current sensing resistor (67 in Fig. 4) 0.05ohm 100W mounted on ARD cabinet. It is a required input signal for current sensing detector, OCT detector and OCT delay counter.                                                                                                                                                                                                                            |
|     | pin3 | P   | Vcc = +24V.                                                                                                                                                                                                                                                                                                                                                                                                               |
|     | pin4 | SP  | Signal coming from an optical speed sensor into the ARD controller. This signal can either be a High/Low type or Open/Close type.                                                                                                                                                                                                                                                                                         |
|     | pin5 | E2+ | This is an input +24V supply from the ARD relay interface logic. When one or more of the following alarms is/are activated: <ul style="list-style-type: none"> <li>i      ALM -      alarm from 3 phase detector and overspeed detector;</li> <li>ii     OCT -      alarm from overcurrent detector;</li> <li>iii    ST    -      direction change "pause" window;</li> </ul> this +24V will be supplied to the next pin. |
|     | pin6 | TI  | This signal goes out to the ARD relay interface logic. If +24V is present, the brake is caused to grip, thus stopping the elevator.                                                                                                                                                                                                                                                                                       |

TB3,4,5

All signals going to 3 power transistors. These comprise

the 3 stage output drivers of the 3 phase generator. This 3 phase generator will drive the elevator motor.

Fig. 5 is a functional block diagram indicating the functions performed by the control circuitry.

In addition to the operations shown in the flow chart illustrated in Figs. 2A and 2B, the ARD processor 13 may also monitor the elevator car 1 speed by monitoring the pulse input from an optical sensor 60 (Fig. 1) to provide overspeed detection. The monitored speed (signal SP at TB2, pin4 in Figs. 3A and 5) is compared to a stored maximum speed in the ARD processor 13 (process 100 in Fig. 5). If the monitored speed exceeds the maximum speed stored in the ARD processor 13, the ARD processor 13 operates the brake 11 to prevent the elevator car from moving (process 102 in Fig. 5), as a safety measure. The circuitry bounded by solid line 62 in Figs. 3A and 3B is the circuitry generally concerned with detecting the speed of the elevator car. Depending on what kind of pulse input is provided, selection is catered for High/Low and Open/Closed types at J8 and J9. With the sampling reset (RST of U22) at 1 sec, the customer provides the speed of travel of the elevator car to determine the overspeed limit. The lowest selectable overspeed limit is 16Hz. If an overspeed is detected, relay RLY8 alarm will be energised. A signal, T1 at TB2, pin6, is sent to clamp the brake 11 and stop the elevator car 1 from moving.

Also, in addition to the steps performed in the flow chart illustrated in Figs. 2A and 2B the ARD processor, as discussed above, may provide a three phase supply to the motor 7 at 5Hz or 20Hz. These two different supply frequencies are provided to enable the elevator car 1 to travel at two speeds. When the elevator car is not proximate any of the door zones A - D, the elevator motor

will operate at 20Hz. Once it is detected that the elevator car 1 is proximate one of the door zones (A - D), the motor 7 will operate at 5Hz. When the elevator car 1 finally reaches a door zone A - D, the elevator car stops. This is controlled at processes 104, 106 and 108 in Fig. 5.

The circuitry for performing these operations is generally contained within box 64 in Figs. 3A and 3B.

The ratio of values of C10 and C11 near U4 plays a part in determining the frequency of the dual mode of the three phase supply. During ARD operation when no door zones are detected a FF signal is sent via pin6 of TB1 to energise RLY3. Only C10 is involved. If the FF signal is cut off, RLY3 is de-energised, and C11 and C10 both become involved. For a 5Hz and 20Hz three phase speed, the value of C10 has to be four times the value of C11. VR2 is for fine-tuning the speed of three phase supply.

The circuitry for detecting the current drawn by the motor, to provide overcurrent detection, described with reference to the flow chart in Figs. 2A and 2B is indicated in Figs. 3A and 3B generally in box 66. Signal SH at pin2 of TB2 represents the current drawn by the motor 7. This input is provided by current sensing resistor 67 (Fig. 4). The detector circuit consists of a sensing amplifier, peak detecting circuit and an inverting amplifier. Window detector (WD) contact will provide the sampling path for the peak detecting circuit to detect the amplified signal (process 110 in Fig. 5). The output from the peak detecting circuit is then compared with the pre-set value set by VR1. If the peak detecting circuit's output is greater than the pre-set value (in this embodiment 45% more than the pre-set value), relay RLY4 will energise and the CS signal (current sensing signal) will be sent via pin2 of TB1 to activate a change of direction of travel of the elevator car (processes 112 and 114 in Fig. 5).

As discussed with reference to the flow chart shown in Figs. 2A and 2B, when it is desired to reverse the direction of travel of the elevator car, the phase sequence of the signal applied to the motor 7 is reversed. The circuitry for performing this operation is shown in Figs. 3A and 3B generally in box 68.

In this embodiment elevator car reversal is provided when the CS signal is output to the relay interface logic via pin2 of TB1. The relay interface logic, in response to the CS signal, applies signal FRX to pin 5 of TB1 (which signal is required to activate phase sequence reversal).

When elevator car direction reversal is required relay RLY2 FRX is energised. This contact will initiate the phase sequence reversal. The phase sequence reversal is made possible using two quad bi-lateral switches U8 and U9 (4066). Pin 3 of U13A will enable the phase sequence reversal. This signal will activate a set of control pins of U8 and U9. When phase sequence reversal is activated, the former set of pins will hold while the other set of control pins of U8 and U9 will hold to switch the phase sequence (process 114 in Fig. 5). Process 116 in Fig. 5 provides a direction change pause window by applying the brake 11 when the direction is being changed.

The control circuit may also be provided with means for detecting whether the elevator car exceeds a certain weight. If the pre-set weight is exceeded, then the car moves down to reduce energy consumption.

The signals generated by the control circuitry illustrated in Figs. 3A and 3B, and Fig. 5, are applied to terminal blocks TB3, TB4 and TB5. These three sets of output signals TZE, TZB, TZC, TWE, TWB; TXE, TXB, TXC, TUE, TUB; TYE, TYB, TYC, TVE, TVB are applied to respective power transistors to provide the three phase supply to the elevator motor 7. The power transistor 80

to which the output signals TZE, TZB, TZC, TWE, TWB of TB5 input is shown in Fig. 4. The power transistor 80 provides power to motor 7 at terminal XX. The outputs from TB3 and 4 are applied to similar power transistors (not shown) to drive motor 7 at terminals YY and ZZ in Fig. 4.

CLAIMS

1. A device for controlling operation of an elevator in the event of failure of the primary power source (9), the device comprising means for applying power from an auxiliary power source (15) to drive the elevator motor (7) and being characterised by means (60) for detecting the speed of operation of the motor (7), means (13) for comparing the detected speed with a maximum speed value, and means (11) for stopping motion of the elevator car when said comparing means (13) determines that the detected speed exceeds the maximum speed.
2. A device according to Claim 1, wherein means (13) are provided for altering the stored maximum speed value.
3. A device for controlling operation of an elevator in the event of failure of primary power source, the device comprising means for applying power from an auxiliary power source (15) to drive the elevator motor (7), and characterised by means for detecting the position of the elevator car relative to a door zone (A - D), and means (13) for controlling the motor (7) to reduce the speed of the elevator car when the car is proximate a door zone (A - D).
4. A device for controlling operation of an elevator in the event of failure of the primary power source, the device comprising means for applying power from an auxiliary power source (15) to drive the elevator motor (7), and characterised by means (13) for detecting the current drawn by the motor (7), means (13) for comparing the drawn current to a maximum value, and means (13) to change the direction of motion of the elevator car (1) if the current drawn exceeds the maximum value.



5. A device for controlling operation of an elevator in the event of failure of the primary power source, the device comprising means for applying power from an auxiliary power source (15) to drive the elevator motor (7), means for controlling movement of the elevator car (1) to a door zone (A - D), and characterised by means (13) for detecting re-establishment of the primary power source (9), and means (13) for inhibiting application of the primary power source (9) until the elevator car (1) is at a door zone (A - D) and the auxiliary power source (15) is no longer applied.