ABSTRACT: An emergency brake control system for elevator cars is disclosed. The system is adapted to be carried in its entirety on the elevator car and requires no external source of energization. An electrical generator is operatively connected between the elevator car and frame for developing a voltage corresponding to the speed of the car. Control means is connected to the generator and is responsive to a predetermined voltage for applying brakes to the car. A permanent magnet direct current generator is used with a control means including a unidirectionally conductive voltage responsive device such as a silicon controlled rectifier so that the brakes are applied only when the polarity of the generator voltage corresponds to downward travel of the elevator car.
EMERGENCY BRAKE CONTROL SYSTEM FOR ELEVATORS

This invention relates to elevators and more particularly to emergency brake control systems to prevent overspeed in the descent of an elevator car.

It has been a common practice in certain types of elevators, such as hoistway and cargo lifts, to provide a safety brake in the event of mechanical failure such as cable breakage. In such systems the safety brakes are commonly spring actuated and self-energizing and the application thereof is initiated by an arrangement for detecting a slack cable at the elevator car.

In other types of elevator systems, such as passenger elevators, safety brake systems are also employed and commonly utilize an overspeed governor driven by a governor cable or the like to sense car speed. When an overspeed condition is reached the governor is effective to cause actuation of a brake in the drive train of the elevator motor. Such safety apparatus may also include additional brake means carried on the car which are adapted to grip the elevator guide rails in the event of a failure of the lift cable or a downward speed of the car such that the car is disengaged from the governor cable.

In accordance with this invention and in accordance with a magnet field and in the inventor's experience there is provided an emergency brake control system for elevators which is operable independently of the lift cable and drive train for the elevator car. It requires no external source of energization and it may be carried in its entirety on the elevator car. This is accomplished by an electrical generator operatively connected between the elevator car and frame for developing an electrical quantity corresponding to the speed of the car. Control means is connected to the generator and is responsive to a predetermined value of the electrical quantity for applying brake means to the car.

Furthermore, in accordance with the invention the brake control system may be carried entirely on the elevator car and be entirely self-energizing. This is accomplished by a permanent magnet direct current generator which develops a voltage magnitude corresponding to the speed of the car and the control means, responsive to a predetermined voltage magnitude, is effective to connect the generator to the brake applying means.

In accordance with a further feature of the invention, the brake control system is operable for only one direction of travel. This is accomplished by control means which includes a unidirectionally conductive and voltage-responsive device which is poled relative to the generator so that the brake-applying means is energized through the control means only when the generator voltage has a polarity corresponding to the downward travel of the elevator car.

Additionally, in accordance with the invention the brake-applying means may utilize the potential energy of a compressed spring or the like under the control of an electrically operated trigger device or release mechanism. This is provided by a keeper means retaining a brake shoe disengaged from the elevator guide track, retractor means connected therewith an electrical actuator connected with the retractor for operation thereof to initiate engagement of the brake shoe.

A more complete understanding of this invention may be obtained from the detailed description which follows taken with the accompanying drawings in which:

FIG. 1 is a perspective view of an elevator including the inventive emergency brake control system;
FIG. 2 is a diagram of the brake and the actuator therefor;
FIG. 3 shows a detail of construction of the brake and;
FIG. 4 is a schematic diagram of the control circuit for the emergency brake.

Referring now to the drawings, there is shown an illustrative embodiment of the invention in an emergency brake control system for an elevator of the type which is adapted primarily for cargo handling. In particular, the elevator is adapted for use in an automatic warehouse system of the type using a stacker vehicle operative in one or more aisles between arrays of storage bins. Such a stacker vehicle with a cargo elevator therein is adapted for high-speed operation under automatic control in a substantially unattended manner. It will be apparent, however, as the description proceeds that this invention may also be used with other types of elevators to provide a safety brake in the event of either control system or mechanical failure thereof.

Referring now to FIG. 1, there is illustrated an elevator including a car 10 movable vertically within an elevator frame including guide tracks 12 and 14 at opposite sides of the car. Lift means for the car include a drive chain 16 which is drivenly connected through a drive train to a hoist motor not shown.

The emergency brake control system for the elevator includes an electrical speed sensing means including an electrical generator 18 mounted by its stator on the car 10. The rotor of the generator 18 is provided with a pinion gear 20 on its shaft and meshing with a rack gear 22 on the flange of the guide track 14. It is apparent that the rotor of the generator 18 is driven at a speed and in a direction which corresponds to the vertical speed and direction of the car 10. The generator 18 is preferably a direct current generator with a permanent magnet direct current output voltage being variably in phase corresponding to the speed of rotation with a polarity corresponding to the direction of rotation. In particular it is desirable to use a DC generator which exhibits a substantially linear variation in output voltage as a function of rotational speed over the range of speeds of interest for the emergency braking system. The generator may advantageously employ a permanent magnet rotor and a stator winding having a rectifier connected therewith, thus avoiding the use of a commutator or brushes and slip rings.

The elevator is provided with brake means adapted upon actuation or energization thereof to bring the car 10 to a stop relative to the frame of the elevator. For this purpose the brake means includes a brake 24 on one side of the car and a brake 26 on the other side of the car. As shown in FIG. 2, the brakes 24 and 26 are identical to each other and are mounted at opposite ends of a support beam 28 which extends beneath the floor of the car 10 and is adapted to support the same during emergency braking. As best shown in FIG. 3, the brake 24 is supported from the support beam 28 by depending flange 30 secured to the end thereof with suitable clearance from the guide track 14. The brake 24 includes the pivot pins 32 and 34 which are pivotally mounted on the flange 30 by respective pivot pins 36 and 38. The brakeshones are provided at their lower outer edges with serrated side surfaces 40 and 42, respectively, which are adapted to engage the inner surfaces of the flanges of the guide track 14 when the seats are spread apart. A spreader spring 44 is disposed between the brake shoes 32 and 34 and has its opposite ends seated therein. The spreader spring 44 when compressed to the extend where the brakeshones are parallel to each other stores sufficient potential energy for actuation of the brakeshones into engagement with guide track with sufficient force that the serrated surfaces tend to bite into the metal of the track. Thereupon the brake tends to be self-energizing in that the downward thrust of the car 10 causes further separation of the brakeshones and further biting engagement with the track thereby bringing the car to a stop. The brake shoes 32 and 34 are retaining in parallel position as shown in FIG. 3 with the spring 44 compressed by means of a keeper 46. The keeper 46 comprises a bar 48 extending parallel to the support beam 28 and provided with a pair of laterally spaced pins 50 and 52 with the outer ends thereof extending into keeper holes 54 and 56, respectively, in the brake shoes 32 and 34. The bar 48 of the keeper is provided at its inner end with an offset rack gear 58. The rack gear 58 meshes with a pinion gear 60 which is rotatably mounted on a fixed shaft 62. The bar 48 and hence the rack gear 58 is urged laterally in a direction to retract pins 50 and 52 from the brakeshones 32 and 34 by a stretched spring 64 extending between the bar 48 and an anchor point on the
support beam 28. The bar 48 is restrained against movement by a latch 80 which will be described subsequently. Thus, when the keeper 46 is in the position shown in FIG. 2, brake shoes 32 and 34 are held in parallel relationship and the brake 24 is not energized.

The brake 26 is of the same construction as brake 24 and comprises a pair of brake shoes 66 and 68. The brake shoes 66 and 68 are held in the position shown in the guide track 12 by a keeper 70 which comprises a bar 72 provided at its outer end with a pair of pins 74 and 76 which extend into keeper holes in the brake shoes. The bar 72 is provided at its inner end an offset rack gear 78 which meshes with the pinion gear 60. When the keeper 70 is in the position shown in FIG. 2, the brake shoes 66 and 68 are retained in parallel position with clearance from the guide track 12 and thus are deenergized.

Keepers 46 and 70 for the brakes 24 and 26 are retained in the position shown in FIG. 2 against the force of spring 64 by a locking detent or latch 80 which includes a shaft 82 rotationally mounted in fixed position and provided at its free end with a diametral flat 84 forming a half shaft 86. The bar 48 at the portion opposite the rack gear 58 is provided with a notch 88 having a transverse straight side and arcuate side where the half shaft 86 is seated. Thus, the half shaft 86 is effective to restrain motion of the keeper 46 against the force of the spring 64 so long as the diametral flat portion thereof is retained in abutment with the side of the notch 88. In order to retain the half shaft in this position it is provided with a latch arm 90 fixedly secured thereto and extending in a radial direction. The latch arm 90 is long relative to the distance between the center of the shaft 82 and the point at which the back edge of the bar 48 engages the diametral flat 84. This relationship provides for desired mechanical advantage which permits a small force acting on the brake at the end of the latch arm 90 to overcome the large force of the spring 64.

The actuator further includes electrical operating means which takes the form of an electromagnet or solenoid 92 having a reciprocable armature 94 which terminates in a fork 96 adapted to straddle the latch lever 90 and retain it in position. Thus, when the solenoid 92 is deenergized and its armature 94 is in the extended position, the latch lever 90 is held against displacement and the keepers 46 and 70 retain the brakes 24 and 26 in a deenergized condition. When the solenoid 92 is energized and its armature 94 is pulled in or retracted the latch lever 90 is released by the fork 96. The spring 64 pulls the bar 48 and the rack gear 58 to the right causing the half shaft 86 to rotate counterclockwise without substantial resistance to an angular position affording ample clearance for the translation of the rack gear 58 in the direction to retract the pins 50 and 52 from the brake shoes 32 and 34. This motion of the rack gear 58 causes the pinion gear 60 to rotate and thereby drive the rack gear 78 in a direction to retract the pins 74 and 76 from the brake shoes 66 and 68, respectively. With the keepers 46 and 70 retracted, the brakes 24 and 26 are applied by the respective spreader springs into engagement with the guide tracks to bring the elevator car 10 to a stop.

In order to control the actuator just described in accordance with the speed of the car 10, a control circuit as illustrated in FIG. 4 is provided. The control circuit includes the generator 18 and the electromagnet or solenoid 92 for energization thereof under the control of voltage responsive means 100. The voltage-responsive means includes a silicon-controlled rectifier 102 having its anode connected to the positive terminal of the generator 18 and its cathode connected to one terminal of the electromagnet 92. The negative terminal of the generator is connected directly to the other terminal of the solenoid 92. The silicon-controlled rectifier has its gate connected to a bias circuit, including voltage divider resistors 104 and 106, connected in parallel with the anode-to-cathode circuit of the silicon-controlled rectifier. The values of resistors 104 and 106 are selected so that the ratio thereof produces a voltage at the gate of the silicon-controlled rectifier relative to the cathode which is sufficient to switch the controlled rectifier on at a value of generator voltage which corresponds to the value of overspeed of the elevator car at which the emergency brakes 24 and 26 are to be applied.

In operation of the inventive brake control system, the upward motion of the car 10 will cause rotation of the rotor of the generator 18 in a direction which will produce a direct voltage having a negative polarity at its output. Simultaneously, the silicon-controlled rectifier 102. Accordingly, the upward motion of the elevator at any speed within its operating range will not cause the control circuit 100 to respond and the emergency brake system will be immune to such generator voltage. With the elevator 10 moving in a downward direction the generator 18 will generate a direct voltage of positive polarity at the anode of the silicon-controlled rectifier 102 as indicated in FIG. 4. As long as the downward motion of the car 10 is within the established and desired speed range, the voltage applied to the anode of the controlled rectifier and that applied will be insufficient to turn on the rectifier and hence the solenoid 92 will remain deenergized. However, when speed on the elevator car exceeds the desired value in the downward direction of voltage developed at the gate of the controlled rectifier 102 relative to the cathode will be effective to turn on the silicon-controlled rectifier and the voltage of the generator 18 will be effectively applied directly across the solenoid 92 thereby energizing the same and retracting the armature 94. This permits the latch arm 90 to rotate in a counterclockwise direction whereby the half shaft 86 clears the bar 48 which is moved by the spring 64 in a direction to retract the pins 50 and 52 from the brake shoes 32 and 34. Simultaneously, the brake shoes 66 and 68 driven by the rack gear 58 drives the rack gear 78 in a direction to retract the pins 74 and 76 from the brake shoes 66 and 68. Accordingly, the brakes 24 and 26 are applied under the influence of their spreader springs and engage the respective guide tracks 14 and 12 and thereby bring the elevator to a stop.

Although the description of this invention has been given with respect to a particular embodiment thereof, it is not to be construed in a limiting sense. Many variations and modifications will now occur to those skilled in the art. For a definition of the invention reference is made to the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An emergency brake control system for an elevator car movable relative to a frame, an electric generator adapted to be operatively connected between the car and the frame for developing an electrical quantity corresponding to the speed of said car, brake means for said car including a brake actuator, and control means connected between said brake actuator and said control means for connection of said brake means to said actuator.

2. The invention as defined in claim 1 wherein said actuator is electrically operated and said control means is operative to connect said generator to said actuator.

3. The invention as defined in claim 1 wherein said electrical generator is a permanent magnet direct current generator and said control means is polarity responsive thereby preventing energization of said actuator in one direction of travel.

4. The invention as defined in claim 3 wherein said control means comprises a controlled rectifier with its anode and cathode connected serially between the generator and the actuator and having its gate connected through voltage divider means to said generator, said controlled rectifier being poled to conduct in a forward direction when said car reaches a predetermined overspeed in the downward direction.

5. The invention as defined in claim 1 wherein said electrical generator is adapted to generate a voltage magnitude corresponding to the speed of said car and wherein said control means is responsive to a voltage of a predetermined magnitude for actuation of said brake means.

6. The invention as defined in claim 5 wherein said control means includes unidirectionally conductive means and voltage-responsive means for connection of said generator to said actuator.
7. An emergency brake control system for an elevator comprising: an elevator frame, a car movable within the frame and lift means interconnecting said car and said frame, an electrical generator mounted on said car with its rotor connected through rotative drive means to said frame whereby said rotor is rotatably driven in a direction and at a speed corresponding to the motion of said car, brake means mounted on said car and including a brakeshoe adapted to coact with said frame, an electrical actuator for said brakeshoe on said car, and control means connected between said generator and said actuator and being responsive to a predetermined value of voltage for actuating said brake means.

8. The invention as defined in claim 7 wherein said electrical generator is a permanent magnet direct current generator and said control means is polarity responsive thereby preventing energization of said actuator in one direction of travel.

9. The invention as defined in claim 7 wherein said control means comprises a controlled rectifier with its anode and cathode connected serially between the generator and the actuator and having its gate connected through voltage dividing means to said generator, said controlled rectifier being poled to conduct in a forward direction when said car reaches a predetermined overspeed in the downward direction.

10. The invention as defined in claim 7 wherein said control means includes unidirectionally conductive means and voltage-responsive means for connection of said generator to said actuator.

11. The invention as defined in claim 7 wherein said actuator comprises keeper means engaging said brakeshoe and retaining it in disengaged position, retractor means connected with said keeper means and a solenoid connected with said retractor means for operation thereof to initiate engagement of said brakeshoe with said frame member.

12. The invention as defined in claim 7 wherein said actuator means comprises a spring-loaded operating means for causing engagement of said brake means and a solenoid actuated release means connected between said generator and said operating means.