

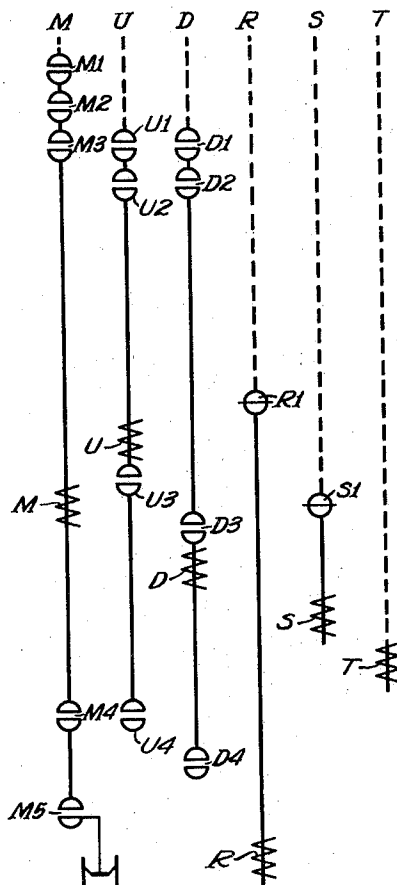
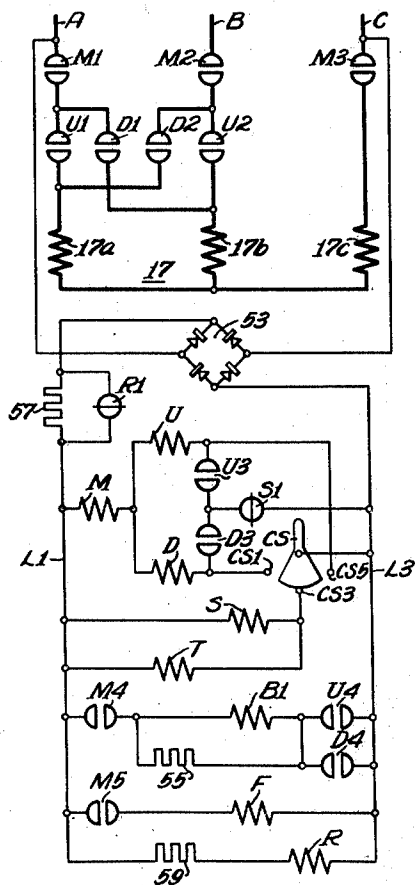
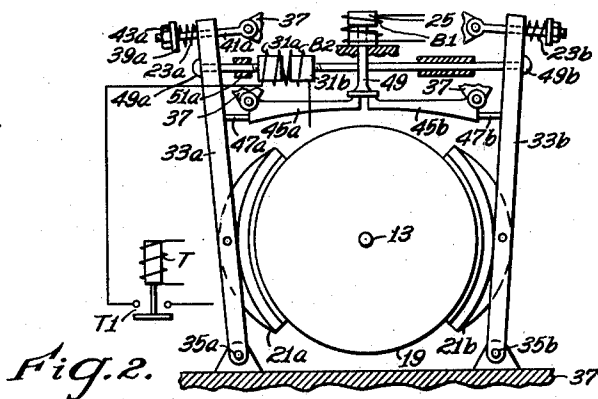
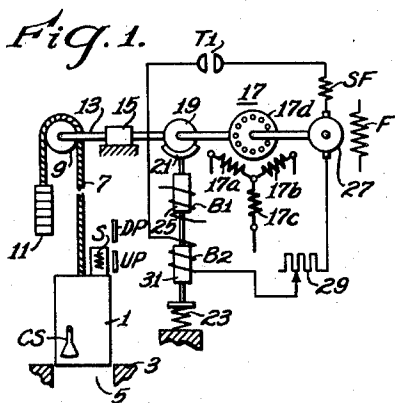
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H. BERKOVITZ

2,491,948

ELEVATOR SYSTEM

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WITNESSES:

WITNESSES:
Robert G Baird

INVENTOR

Harry Berkovitz.

BY C. L. Freedman

ATTORNEY

UNITED STATES PATENT OFFICE

2,491,948

ELEVATOR SYSTEM

Harry Berkovitz, Weehawken, N. J., assignor to
Westinghouse Electric Corporation, East Pitts-
burgh, Pa., a corporation of Pennsylvania

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1

This invention relates to systems for controlling moving bodies, and it has particular relation to systems for bringing moving bodies, such as elevator cars, to accurate landings at a desired station or floor.

In systems for controlling moving bodies, such as hoists and elevator cars, it is desirable that the moving body be brought accurately to a stop adjacent any desired station or floor. For example, if an elevator car serves several floors of a building, it is desirable that control equipment be provided for bringing the car to a stop at any desired floor with the floor of the car and the associated floor of the building substantially in the same plane.

In many elevator systems, it is desirable to provide a simple motive means which may include a polyphase induction motor. Such a motor has a rate of rotation which varies as a function of the load connected to the motor. This means that the speed of an elevator car driven by such an induction motor varies as a function of the loading of the elevator car.

In order to stop an elevator car accurately at a desired floor or station, it is conventional to employ inductor plates at each floor for the purpose of controlling an inductor relay located on the elevator car. In such a system, when the elevator car is at a predetermined distance from a desired floor, the inductor relay operates to apply a brake to the elevator car and to deenergize the motive means for the elevator car. The elevator car then is intended to drift until it stops with its floor in alignment with the desired floor of the building.

The drift of an elevator car following application of a predetermined braking effort thereto, depends on a number of factors which include the total mass of the moving system, the unbalanced force applied to the moving system, and the square of the final speed of the moving system. Since these factors all vary as a function of load in the elevator system herein discussed, it follows that the drift of the elevator car also is a function of the load and the elevator car cannot stop accurately in the desired position for all loads within the rated capacity of the elevator car.

In accordance with the invention, the braking effort applied for the purpose of stopping the elevator car is varied as a function of the load carried by the elevator car to bring the elevator car to an accurate stop at any desired floor or station for any load within the rated capacity of the elevator car. To this end, an output voltage is

2

provided which varies as a function of the load. Since the elevator car moves at a speed dependent upon the load thereof, the desired output voltage may be obtained from a generator coupled to the induction motor which drives the elevator car. The output voltage is applied to an electromagnetic device for the purpose of increasing the braking effort applied to the elevator car. By properly relating the output voltage to the speed of the elevator car, the elevator car may be stopped accurately at any desired floor of a building when carrying any load within its rated capacity.

It is therefore, an object of the invention to provide an improved system for stopping a moving body at any desired station.

It is a further object of the invention to provide an elevator system with braking means which develops a braking effort varying as a function of the load on the elevator system.

It is a still further object of the invention to provide an elevator system with a generator for producing an output voltage which varies as a function of the load on the associated elevator car and a brake for the elevator car which produces a braking effort having a value dependent on said output voltage.

Other objects of the invention will be apparent from the following description, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a schematic view of an elevator system embodying the invention;

Fig. 2 is a view, in elevation, of brake apparatus suitable for the elevator system of Fig. 1 with circuit elements schematically shown;

Fig. 3 is a schematic view of a control circuit suitable for the elevator system of Fig. 1; and

Fig. 3A is a straight-line diagram showing the relationship between relay coils and relay contacts employed in the control circuit of Fig. 3.

In describing a specific embodiment of the invention, reference will be made to the following apparatus:

D—down relay
M—car-running relay
P—inductor plates
R—regulating relay
S—floor-stopping relay
T—auxiliary stopping relay
U—up relay

Referring to the drawing, Fig. 1 shows an elevator car 1 which is mounted for reciprocation in a vertical direction in a structure, such as a building. Although the building may have a

large number of floors, for the purpose of simplicity in illustration only one floor 3 is illustrated in Fig. 1. It will be understood that a hatchway 5 extends through all floors of the building to permit passage of the elevator car therethrough.

The elevator car 1 is secured to one end of a flexible cable 7 which passes over a sheave 9. The remaining end of the cable is secured to a suitable counterweight 11. The sheave 9 is secured to a shaft 13 for rotation therewith in a suitable bearing structure 15.

For the purpose of reciprocating the elevator car, motive means are provided which include a three-phase induction motor 17 having three phase windings 17a, 17b and 17c. The rotor 17d of the induction motor is secured to the shaft 13.

In order to stop the elevator car, a brake drum 19 is secured to the shaft 13. This brake drum has associated therewith a brake shoe 21 which is biased against the drum 19 by means of a coil spring 23. Since the brake shoe 21 should be retracted from the drum 19 during normal running operation of the elevator car, a solenoid B1 is provided which has a magnetic core 25 secured to the brake shoe 21. When the solenoid B1 is energized, the brake shoe 21 is retracted from the drum 19 against the force exerted by the spring 23.

Movement of the elevator car 1 is controlled in part by a car switch CS mounted in the elevator car. In addition, the elevator car carries an inductor or floor-stopping relay S which is positioned to pass inductor plates UP and DP carrying reciprocation of the elevator car in its hatchway. The inductor plate DP is for the purpose of controlling the stopping of the elevator car 1 as the car descends toward the floor 3. The inductor plate UP is for the purpose of controlling the stopping of the elevator car as it ascends toward the floor 3. It will be understood that a similar pair of inductor plates are provided for each of the floors served by the elevator car. The portions of Fig. 1 thus far specifically described are well-known in the art, and a detailed discussion thereof is believed to be unnecessary.

As previously pointed out, the drift of the car 1, after the spring 23 has applied the brake shoe 21 to the drum 19, depends on the loading of the car. To compensate for variations in such loading, a generator 27 has its rotor secured to the shaft 13. Although an alternating-current generator may be employed, it will be assumed for the purpose of discussion that the generator 27 is a direct-current generator having a separately-excited field winding F. It will be understood that the output voltage of the generator 27 varies as a function of the load on the elevator car 1. The output voltage is connected through contacts T1 of a suitable relay and a variable resistor 29 to a solenoid B2. This solenoid has a magnetic core 31 connected to the brake shoe 21. Energization of the solenoid B2 increases the braking effort developed by the brake shoe 21 and the drum 19 in accordance with a function of the load carried by the elevator car 1.

If the output voltage of the generator 27 varies linearly with the load on the elevator car 1, and if the force developed by the solenoid B2 and the magnetic core 31 varies as the square of the energization thereof, the braking effort will be increased by a component which varies as the square of the load. Such a relationship is suitable for many elevator installations. However, the characteristics of the generator 27 may be

varied as desired, by providing a series field SF therefor and by varying the compounding of the generator to obtain the desired characteristics. The increase in braking effort also may be adjusted to a substantial extent by adjustment of the variable resistor 29.

A brake assembly suitable for the system of Fig. 1 is illustrated in Fig. 2. It will be observed that the drum 19 has associated therewith two brake shoes 21a and 21b. These brake shoes are pivoted respectively to brake arms 33a and 33b. The arms, in turn, are pivotally secured by means of pivots 35a and 35b to a support 37 which is secured to the associated building.

For biasing the brake shoes 21a and 21b toward the drum 19, two coil springs 23a and 23b are provided. The coil spring 23a is located between the arm 33a and the washer 39a which is retained on a pin 41a by means of a nut 43a. The pin 41a is pivotally secured to part of the supporting structure 37. The coil spring 23b similarly is associated with the arm 33b.

In order to urge the brake shoes 21a and 21b away from the associated drum 19, bell cranks 45a and 45b are pivotally secured to the supporting structure 37. The bell crank 45a has an arm engaging a pin 47a which is secured to the arm 33a. Similarly, the bell crank 45b is associated with a pin 47b secured to the arm 33b. The bell cranks 45a and 45b have additional arms positioned to engage a plunger 49 which is secured to the magnetic core 25 of the solenoid B1. Upon energization of the solenoid B1, the plunger 49 moves downwardly, as viewed in Fig. 2, to force the brake shoes 21a and 21b away from the drum 19. The structure of Fig. 2 thus far specifically described is similar to brake assemblies commonly employed in the art.

In order to adjust the braking effort developed by the brake assembly, a machine screw 49a passes through the arm 33a and is slidably received in a bearing 51a which is secured to the supporting structure 37. At its free end, the machine screw 49a is attached to a magnetic core 31a which is disposed within the solenoid B2. In a similar manner, the machine screw 49b is associated with the arm 33b and a magnetic armature 31b disposed within the solenoid B2. By inspection of Fig. 2, it will be observed that when the solenoid B2 is energized, the magnetic cores 31a and 31b are urged toward each other to force the brake shoes 21a and 21b against the drum 19 with increased pressure.

The ratio of the braking efforts developed by the springs 23a and 23b to the maximum braking effort developed by the solenoid depends on the characteristics desired. The proportion of the retarding force supplied by the solenoid B2 may be larger for higher speed elevators than for slow speed elevators. Preferably the springs should be capable of holding the elevator when full torque is applied thereto. For the slow speed elevators hereinafter discussed (such as those traveling 100 feet per minute or less), it is assumed that the solenoid B2 supplies a small proportion of the braking effort developed by the springs. The same principles may be employed for elevators traveling at higher speeds.

Referring now to the control circuit illustrated in Fig. 3, it will be observed that a source of three-phase electrical energy is represented by three phase conductors A, B and C. Two of the phase conductors A and C are connected through a full-wave rectifier 53 which may include a filter, if desired, to provide a direct voltage between

5

the output conductors L1 and L3. The various relays are energized by direct current supplied from these conductors L1 and L3.

With the car switch CS in the neutral position indicated in Fig. 3, a circuit is established for energizing the floor-stopping relay S and an auxiliary stopping relay T which controls the previously mentioned contacts T1. When the car switch CS is rotated in a clockwise direction, as viewed in Fig. 3, to engage a contact CS1, an energizing circuit is established for the down relay D and the car-running relay M. Energization of the down relay D results in closure of the front contacts D3 of the relay D to establish a holding circuit for the relays D and M. This holding circuit may be traced from the conductor L1 through the relays M and D, the front contacts D3 and back contacts S1 of the floor-stopping relay S. Energization of the relay M also results in the closure of the front contacts M1, M2 and M3, which respectively connect the phase conductors A, B and C to the induction motor 17. Front contacts D1 and D2 of the down relay D also are closed by energization of the relay D. These contacts D1 and D2 complete an energizing circuit for the three-phase motor 17 which conditions the motor to move the elevator car 1 of Fig. 1 in a downward direction.

At the same time, closure of the front contacts M4 by energization of the car-running relay M and closure of the front contacts D4 of the relay D, completes an energizing circuit for the solenoid B1. Energization of the solenoid B1 releases the brake shoe 21 from the drum 19 to permit the desired movement of the elevator car. Consequently, the car 1 moves in a downward direction. It will be noted that the required movement of the car switch CS into engagement with the contact CS1, for the purpose of initiating downward movement of the elevator car, results in deenergization of the relays S and T.

Energization of the car-running relay M also closes the front contacts M5 thereof to energize the field winding F of the generator 27. However, since the contacts T1 are open, the voltage output of the generator is not applied to the solenoid B2.

Let it be assumed that with the elevator car conditioned for movement in a downward direction, it is desired to stop the elevator car at the floor 3. Such stopping is initiated by centering the car switch CS to engage the contact CS3. The movement of the car switch energizes the relays S and T. Energization of the auxiliary stopping relay T closes its front contacts T1, but the resulting energization of the solenoid B2 is ineffective for the reason that the solenoid B1, which develops an appreciably stronger force, is still energized. Since the floor-stopping relay S is of the inductor type, energization of its winding does not affect the relay contacts until the floor-stopping relay reaches the down inductor plate DP. At such time, the back contacts S1 open to deenergize the down relay D and the car-running relay M. The resulting opening of the contacts M1, M2, M3, D1 and D2 deenergizes the induction motor 17.

The deenergization of the down relay D and the car-running relay M also opens the front contacts D4 and M4 to deenergize the solenoid B1. The rate of the deenergization of the solenoid is determined by a discharge resistor 55 connected across the terminals of the solenoid. Deenergization of the solenoid B1 permits the spring 23 to urge the brake shoe 21 against the drum

6

19. Furthermore, since the solenoid B1 is deenergized, the solenoid B2 now is effective for increasing the braking effort developed by the brake shoe 21 and the brake drum 19 in accordance with the voltage output of the generator 27. The elevator car now drifts until the floor of the elevator car 1 and the floor 3 are substantially in the same plane. Since the output of the generator 27 compensates for variations in loading of the elevator car 1, the elevator car is landed accurately at the floor 3 despite substantial variations in the loading thereof. The front contacts M5 of the car-running relay are provided with a time delay in opening, sufficient to assure energization of the field winding F until the elevator car is completely stopped.

If it is desired to operate the elevator car in an upward direction, the car switch CS is actuated to engage the contact CS5. Such operation deenergizes the floor-stopping relay S and the auxiliary stopping relay T. Consequently, the contacts T1 are open and the back contacts S1 are closed. At the same time, the car switch establishes an energizing circuit for the up relay U and the car-running relay M. A holding circuit for the relays U and M is established through the contacts U3 and S1. The car-running relay M functions in the same manner discussed with respect to down operation of the relay. However, the up relay U when energized closes its front contacts U1 and U2 to complete an energizing circuit for the induction motor 17 with phase relationships such that the elevator car 1 moves in an upward direction. Consequently, the contacts U1, D1, D2 and U2 operate as a reversing switch for the induction motor 17.

Closure of the front contacts M4 and U4 of the car-running and up relays energizes the solenoid B1 to retract the brake shoe 21 from the drum 19, and the car now moves in an upward direction. Closure of the contacts M5 again energizes the field winding F.

If the elevator car 1 is moving in an upward direction and it is desired to stop at the floor 3, the car switch CS again is centered to engage the contact CS3 as illustrated in Fig. 3. The resulting energization of the auxiliary stopping relay T closes the front contacts T1. Since the solenoid B1 is still energized, closure of the contacts T1 has no effect on the brake shoe 21. The winding of the floor-stopping relay S also is energized, and, when this relay reaches the up conductor plate UP, it opens its back contacts S1 to interrupt the holding circuit of the car-running relay M and the up relay U. Consequently, these relays open their front contacts to deenergize the induction motor 17. In addition, the contacts M4 and U4 are opened by the car-running relay and the up relay to deenergize the solenoid B1. It will be recalled that the discharge of energy stored in the solenoid B1 takes place at a rate determined by the value of the resistor 55. As a result of deenergization of the solenoid B1, the spring 23 applies the brake shoe 21 to the drum 19. Additional braking effort is obtained from the solenoid B2 for the purpose of compensating for variations in the loading of the elevator car 1. Consequently, the elevator car 1 is brought accurately to a stop at the floor 3 for any loading within the capacity of the elevator car. The time delay in opening of the contacts M5 again suffices to assure energization of the field winding F until the elevator car has come to a complete stop.

Since the voltage output of the generator 27

7

is determined in part by its field energization, a constant field is desirable. Such a field may be obtained from permanent magnets in a manner well understood in the art. As an alternative, the field winding F may be energized from a constant voltage source. To this end, any suitable voltage regulator may be employed for energizing the conductors L1 and L3 from the phase conductors A and C. For example, the voltage regulator may take the form of a voltage regulating relay R having back contacts R1 connected across a resistor 57. The conductor L1 is connected to an output terminal of the rectifier 53 through the parallel combination consisting of the resistor 57 and the back contacts R1. The relay R is a voltage relay and may be energized from the conductor L1 and L3 through a resistor 59. If the voltage between the conductors L1 and L3 increases above a predetermined value, the regulating relay R opens its back contacts R1 to introduce the resistor 57 into the circuit for the purpose of dropping the voltage between the conductors L1 and L3. If the voltage between these conductors drops below a predetermined value, the regulating relay R drops out to close its back contacts R1. This shunts the resistor 57 and increases the voltage between the conductors L1 and L3. Voltage regulators of this type are well-known in the art and the specific voltage regulator illustrated and described is representative of any of the conventional voltage regulators which may be employed for maintaining a substantially constant voltage between the conductors L1 and L3.

It should be noted that the safety of the system is not impaired by incorrect operation of the relay T. If the relay contacts remain permanently closed, the elevator car still stops accurately at the desired floors. If the relay contacts remain permanently open, the system operates in a manner similar to that of prior art systems, and the elevator car stops with less accuracy adjacent desired floors. The relay T essentially decreases the time during which the generator 27 and the solenoid B2 are energized.

The compensation introduced by the invention is continuous over the entire stopping operation. Since the compensating braking effort decreases as the elevator car slows to a complete stop, no discomfort is experienced by elevator passengers. The comfort of the stop can be controlled further by employing a high time constant for the combination of the solenoid B1 and the discharge resistor 55. Any error introduced in the stopping distance by the high time constant can be compensated by suitable compounding of the generator 27 and by adjustment of the resistor 29.

Although the invention has been described with reference to certain specific embodiments thereof, numerous modifications are possible. Therefore, the appended claims are intended to cover not only the specific embodiments illustrated, but also all other embodiments falling within the spirit and scope of the invention.

I claim as my invention:

1. In an elevator system, a structure for receiving an elevator car, said structure having stations to be served by an elevator car, an elevator car,

8

motive means for reciprocating the elevator car in a vertical direction relative to the structure at a rate of movement which varies as a function of the load on the elevator car, a brake for stopping said elevator car at a station of said structure, brake-operating means responsive to arrival of the elevator car at a predetermined distance from a station for initiating an operation of the brake to stop the elevator adjacent the desired station, means for generating an electrical voltage having a magnitude which varies as a function of the rate of movement of the elevator car, and adjusting means responsive to the electrical voltage for adjusting the braking effort to bring the elevator car to rest substantially at the desired station for any load on the elevator car within the rated capacity thereof.

2. An elevator system as defined in claim 1, wherein said brake-operating means comprises spring means for applying the brake, to develop a braking effort, and said adjusting means comprises an electromagnetic device energized by the electrical voltage to increase the braking effort.

3. In an elevator system as defined in claim 1, means responsive to the conditioning of said elevator car for movement for deenergizing the adjusting means.

4. In an elevator system, an elevator car, a structure having stations to be served by the elevator car, motive means for reciprocating the elevator car vertically relative to the structure at a rate which varies as a function of the load on the elevator car, a spring-actuated brake for stopping the elevator car at a station of the structure, electromagnetic means effective when energized for holding the brake in retracted condition, said electromagnetic means being energized while the elevator car is conditioned to run between stations, control means responsive to arrival of the elevator car at a predetermined distance from a desired station at which the car is to stop for deenergizing the electromagnetic means, a generator driven by said motive means to produce an output voltage which varies as a function of the rate of travel of the elevator car, and electromagnetic means responsive to the output voltage for varying the braking effort applied to the elevator car to bring the elevator car to rest at said desired station despite a substantial range of variation of the speed of the elevator car at the predetermined distance from said desired station.

5. An elevator system as defined in claim 4, wherein the motive means includes an electric motor effective when energized for reciprocating the elevator car, said control means including means responsive to arrival of said elevator car at the predetermined distance from said desired station for deenergizing said electric motor.

HARRY BERKOVITZ.

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