

Aug. 12, 1958

D. SANTINI ET AL
LEVELING ELEVATOR SYSTEMS

2,847,091

Filed May 29, 1957

5 Sheets-Sheet 1

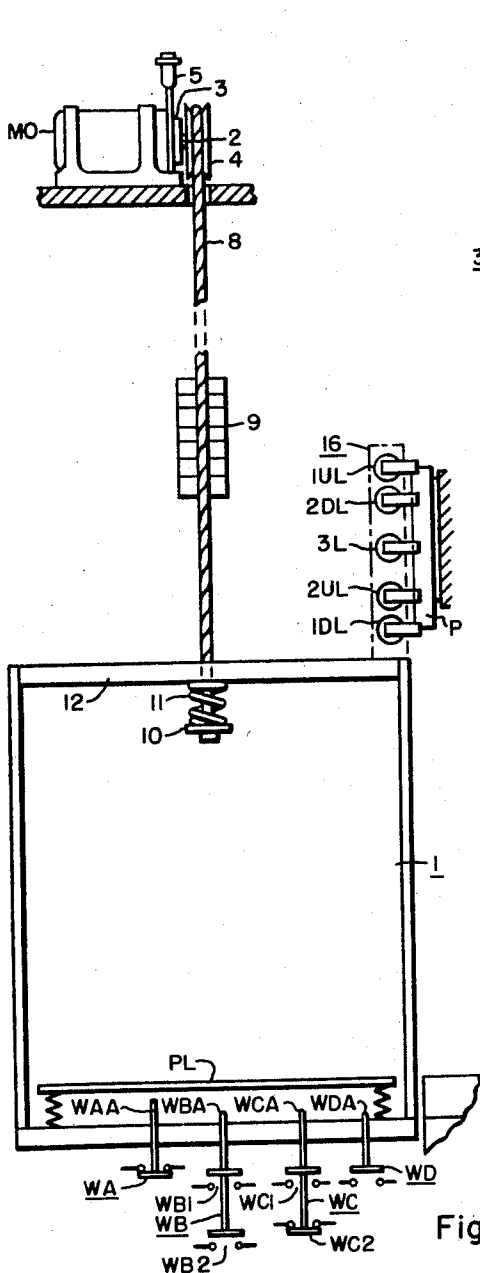


Fig. 1.

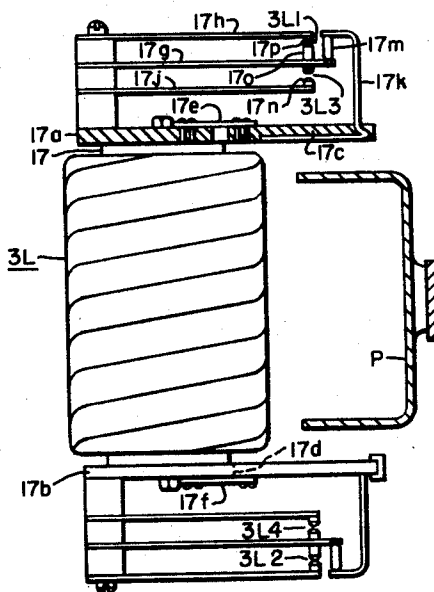


Fig. 2.

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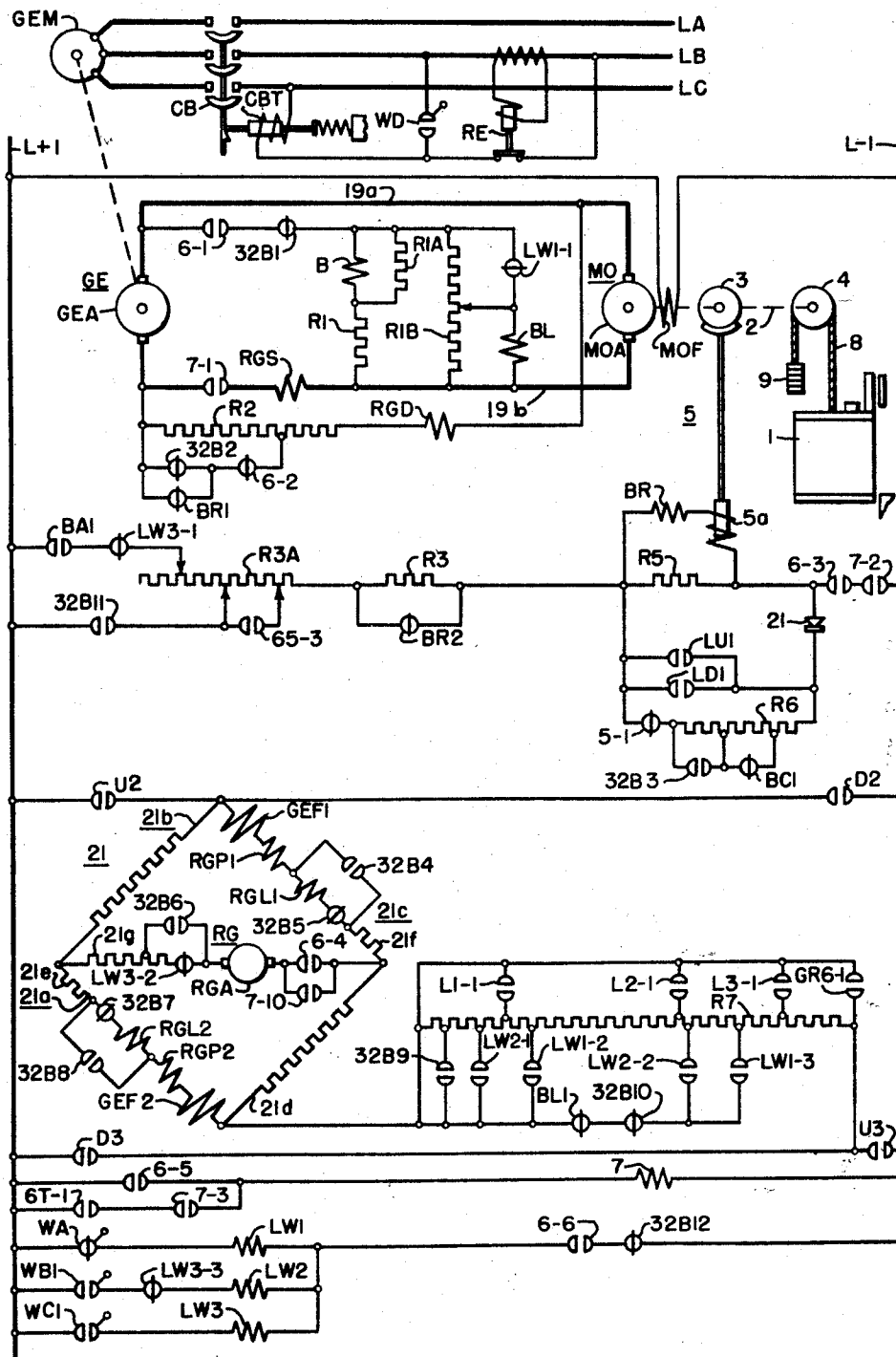


Fig. 3.

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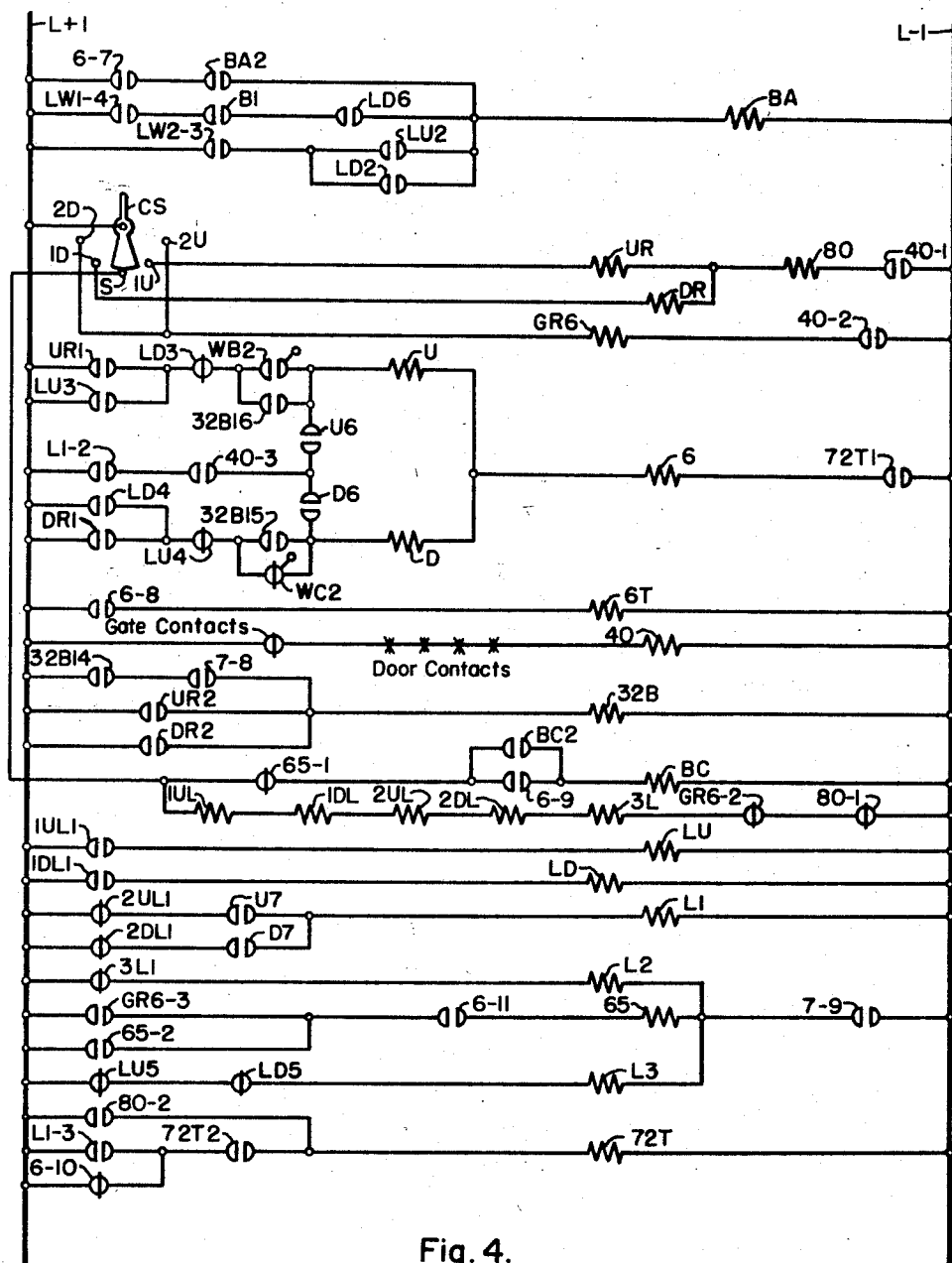


Fig. 4.

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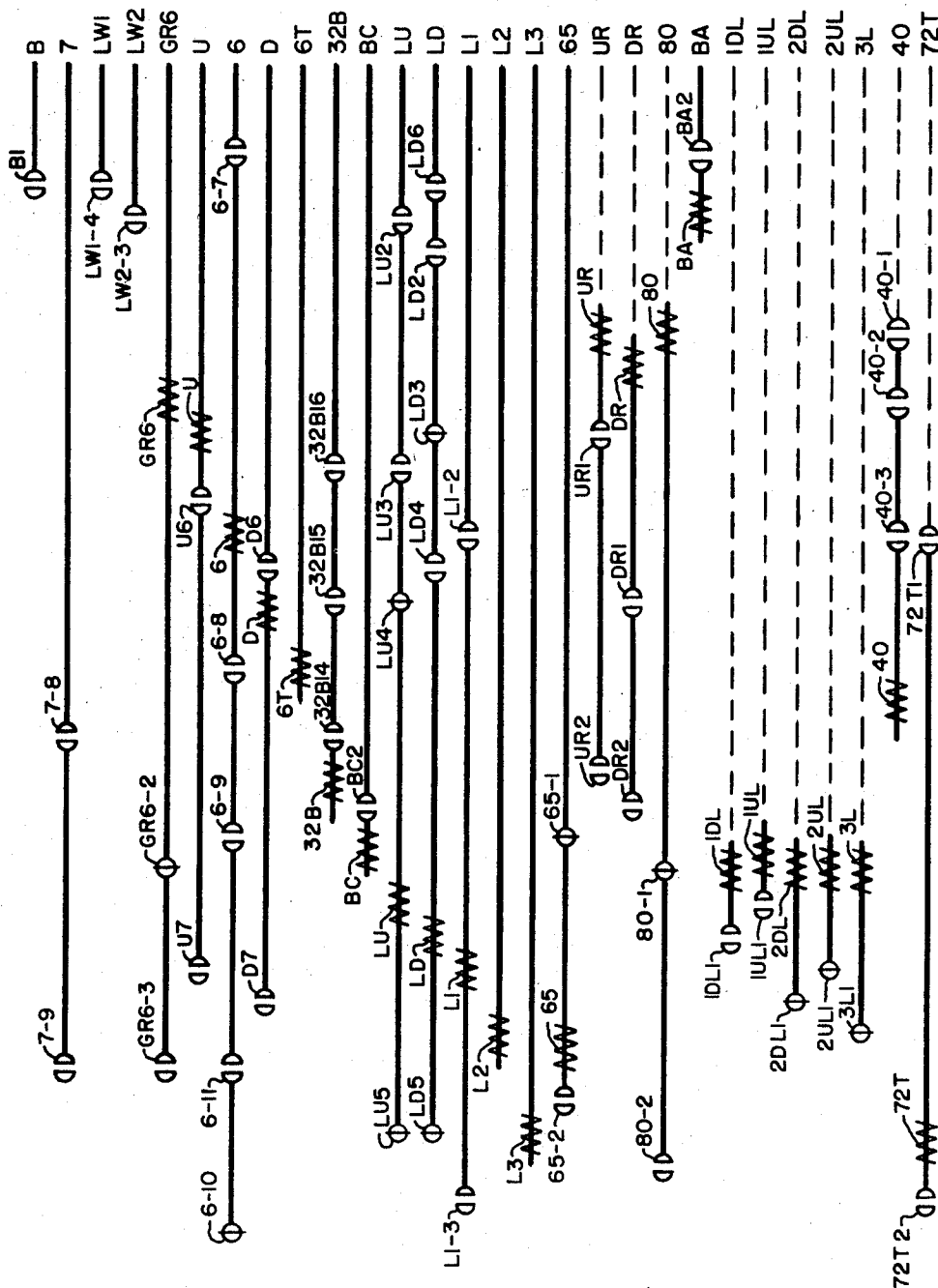
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2,847,091

LEVELING ELEVATOR SYSTEMS

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Application May 29, 1957, Serial No. 662,416

14 Claims. (Cl. 187—29)

This invention relates to elevator systems and it has particular relation to elevator systems which provide automatic leveling of an elevator car.

In elevator systems, it is desirable that an elevator car land accurately at any landing at which it is to stop and that the elevator car be maintained in registry with such landing. Failure of an elevator car to stop accurately at a landing may be due to overrun or under-run of a landing during a stopping operation or it may be due to cable stretch or contraction as the elevator car loads or unloads while stopped at a landing.

In a conventional traction-type elevator, an elevator car commonly is secured to a counterweight through one or more cables or ropes which pass over a traction sheave. Ordinarily, the counterweight is designed to balance the weight of the elevator car and in addition, to counterbalance approximately 40% of the rated load capacity of the elevator car. Suitable electromotive means may be coupled to the traction sheave. In a preferred embodiment of the invention, the electromotive means may be in the form of a direct-current motor having its armature coupled in a loop to the armature of a direct-current generator. The speed of the motor is controlled by varying the field excitation of the generator.

It will be understood that various loads may be presented to the electric motor. For example, if the elevator car is loaded to approximately 40% of its rated full load capacity, a balanced load is presented to the motor. If the loading of the elevator car is other than 40% of its rated full load capacity, a hauling or overhauling load may be presented to the motor. In a hauling load, the load presented to the motor acts in a direction opposed to the desired direction of movement of the elevator car. It follows that in an overhauling load, the load acts in the direction of the desired movement of the elevator car. During movement of the elevator car, a small friction load is presented to the motor. However, if the elevator car has remained at rest for a time sufficient to permit oil to be forced out of the bearings employed in the elevator system, substantial force may be required to overcome the increased friction load resulting from such loss of lubrication.

In prior art leveling systems, it has been conventional to provide a leveling operation which is continuously effective for maintaining the elevator car accurately in registry with a landing at which it is stopped. In such a system, the leveling equipment must be capable of handling heavy loads in both hauling and overhauling directions. An effective leveling system of this type is disclosed in the Santini et al. Patent 2,674,348, issued April 6, 1954.

In accordance with the invention, certain displacements of the platform or floor of the elevator car with respect to the floor of a corridor or landing at which the elevator car is stopped are permitted if the direction of displacement is such that in moving, loads step down from one floor to the other floor. Such displacement is quite safe. By properly coordinating this principle with the

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loading of the elevator car and the displacement of the elevator car, it is possible to provide an effective leveling system in which the leveling of heavy loads and of overhauling loads is eliminated. As a result, the leveling equipment is substantially simplified and provides excellent performance.

The invention establishes several zones of loading. Thus, a light loading zone may include loads below say 400 pounds. A balanced load zone may include elevator car loads of the order of 30% to 60% of the rated load capacity of the elevator car. For such loads, the brake, conventionally employed for an elevator car, may be released without appreciable movement of the driving motor for a time by the effect of unbalanced load. A heavy load zone may include elevator car loads in excess of say 60% of rated load capacity.

The invention may be understood more fully by considering the operations following the stopping of a fully-loaded elevator car at a landing. It will be assumed that the elevator car stops accurately at the desired landing.

As the elevator car unloads, the cables contract and the car platform or floor rises above the corridor or landing floor. This is a safe condition for the reason that load steps down in moving from the elevator car to the associated landing. For this reason, it is permissible to defer releveleving of the elevator car until the load in the elevator car decreases appreciably. This avoids the leveling of a heavy load in an overhauling direction.

When the load decreases to a balanced value such as 40% of rated full-load capacity, the elevator brake may be released to permit releveleving of the elevator car. Because of the balanced nature of the load, the elevator car does not move appreciably following the release of the brake. At the same time, voltage is applied to the driving motor in a direction suitable for leveling the elevator car. The voltage is increased to a value sufficient to move the elevator car at a slow speed and is held at such value.

Following the releveleving of the elevator car, load may continue to leave the elevator car and the elevator car again may rise due to cable contraction. When the load drops to a small value such as below 400 pounds, the brake again may be released to initiate a releveleving operation. However, the release of the brake is delayed until voltage applied to the motor has increased to a value sufficient to hold the hauling load presented to the motor. The voltage continues to increase until it is sufficient in value to move the elevator car at the desired slow speed and is then held at such value.

The invention further contemplates that load may move into the empty car from the associated landing. Under such circumstances, the car platform or floor may sink relative to the associated floor of the corridor or landing due to cable stretch. However, such displacement is safe for the reason that the load in moving into the elevator car is stepping down from one to the other of the floors. Consequently, it is permissible to defer releveleving of a load which, at this time, is an overhauling load.

When the car loading reaches a value such that it is in a balanced zone for example, 40% of rated load capacity, the elevator brake is released and voltage is applied to the motor for the purpose of releveleving the elevator car.

As the elevator car continues to load, the car platform or floor again sinks relative to the associated floor of the landing. As previously pointed out, such displacement of the floors is safe for the specified loading condition. If the loading reaches a heavy value such as a load in excess of 60% of rated full load capacity, releveleving of the elevator car is not permitted. This eliminates the

need for releveling a heavy load which is difficult to control smoothly without hunting.

Occasionally, the elevator brake may be unable to hold a heavily-loaded elevator car. Under such conditions, the elevator car moves slowly away from a landing at which it is stopped in the down direction. Under such circumstances, the invention contemplates the application of a voltage to the driving motor which produces a force acting to support the elevator car. This force is insufficient to produce movement of the elevator car with the brake applied, but the force together with the applied brake, are sufficient to hold the elevator car stationary. Thus, the elevator car is held in a perfectly safe condition.

It is conventional practice to provide an elevator system with an overload relay which interrupts the supply of power to the driving motor when the elevator car stalls for an appreciable length of time. In order to permit the driving motor to assist the elevator brake in holding stationary a heavily loaded car, it may be desirable to disable the over-current relay when the elevator car is loaded above a predetermined value such as 80% of its rated full load capacity. This will not damage the electrical equipment for the reason that the elevator system will not remain in such condition long enough to damage the equipment.

It is therefore an object of the invention to provide an elevator system having improved leveling equipment.

It is another object of the invention to provide an elevator system wherein leveling of an elevator car to correct cable stretch or contraction is permitted only for certain load zones.

It is also an object of the invention to provide an elevator system with leveling equipment which is not required to level a heavily loaded elevator car.

It is an additional object of the invention to provide an elevator system wherein a driving motor may be energized to assist an elevator brake in holding stationary an elevator car.

It is a further object of the invention to provide an elevator system having leveling equipment which is prevented from leveling an elevator car in an overhauling direction.

It is a still further object of the invention to provide an elevator system having leveling equipment which does not level a heavy overhauling load.

It is still another object of the invention to provide an elevator system with leveling equipment capable of leveling an elevator car carrying a load within a predetermined zone in only one direction.

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

Figure 1 is a view in elevation with parts broken away and parts shown schematically of an elevator system incorporating the invention;

Fig. 2 is a view in top plan with parts shown in section of an inductor relay assembly suitable for the system of Fig. 1;

Fig. 3 is a schematic view in straight line form, showing control circuits suitable for the elevator system of Fig. 1;

Fig. 3A is a schematic view showing various relays, switches and contactors employed in the circuits of Fig. 3. If Figs. 3 and 3A are placed in horizontal alignment, it will be found that corresponding coils and contacts of the two figures are substantially in horizontal alignment.

Fig. 4 is a schematic view in straight line form, showing further control circuits suitable for the system of Fig. 1; and

Fig. 4A is a schematic view of relays, switches and contactors employed in the circuits of Fig. 4. If Figs. 4 and 4A are placed in horizontal alignment, it will be found that corresponding contacts and coils of the two figures are substantially in horizontal alignment.

The invention may be incorporated in various types of elevator systems. For example, it may be employed in an automatic elevator system wherein the elevator car is started in response to operation of a car push button located in the elevator car or a corridor push button located at any of the landings served by the elevator car. As a further example, the invention may be incorporated in a system wherein the elevator car is started by means of a car switch and is stopped at landings served by the elevator car in response to operation of a car push button or a corridor push button for each desired landing. However, the invention may be described adequately for an automatic landing and leveling elevator system of the car switch type. Although the invention is described as incorporated in the car switch operated elevator system, it is to be understood that this system represents only one embodiment of the invention and that the invention may be incorporated in other types of elevator systems.

Inasmuch as a large number of relays, contactors, or switches are employed, a standard convention has been adopted for designating such system components. Each of the switches, relays or contactors is identified by a suitable reference character. Each set of contacts of each switch, relay or contactor is identified by the appropriate reference character therefor, followed by an identifying numeral specific to the set of contacts. For example, the expression U2 designates one set of contacts of the up switch U. As a further example, the expression U4 designates another set of contacts of the up switch U.

A switch, relay or contactor may have break (back) contacts or make (front) contacts. It will be understood that the break contacts of a relay or other device are closed when the relay or other device is deenergized and open when the relay or other device is energized sufficiently to pick up. On the other hand, make contacts of a relay or other device are open when the relay or other device is deenergized and are closed when the relay or other device is energized sufficiently to pick up. Unless otherwise stated, the various circuit components are illustrated in their deenergized conditions.

In order to facilitate reference to the specification and drawings, the following apparatus list is presented:

APPARATUS LIST

GR6—Full speed relay
B—Loop voltage relay
BL—Second loop voltage relay
BR—Brake-released relay
7—Running contactor
LW1-LW3—Load zone relays
BA—Brake relay
UR—Up relay
DR—Down relay
6—Running relay
80—Auxiliary running relay
U—Up switch
D—Down switch
6T—Timing relay
40—Door relay
32B—Cable-stretch relay
BC—Brake-modifier relay
LU—Up leveling relay
LD—Down leveling relay
L1—Third landing relay
L2—Second landing relay
L3—Field-control relay
65—Brake regulator relay
72T—Timing relay
IUL, 2DL, 3L, 2LU, 1DL—Inductor relays

Apparatus in Figure 1

In Fig. 1, an elevator car 1 is mounted in the hoistway of a building structure for the purpose of serving the floors or landings of the building structure. In Fig. 1, the elevator car is shown stopped at one of the landings of the structure.

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In order to move the elevator car through the hoistway, a motor MO is located in a penthouse provided in the structure. This motor has a shaft 2 on which a brake drum 3 and a sheave 4 are secured. A brake 5 is provided for applying a brake shoe to the drum 3 in order to prevent or resist rotation of the shaft 2.

A rope or cable 8 passes over the sheave 4. One end of the cable 5 is secured to a counterweight 9 which may be proportioned to counterbalance the weight of the elevator car plus say 40% of the rated full load capacity of the elevator car. The remaining end of the cable is secured to a plate 10. A compression spring 11 is located between the plate 10 and a crossbeam 12 which is secured to the elevator car.

Any suitable load weighing device may be employed for measuring the load carried by the elevator car. For illustration purposes, it will be assumed that the elevator car has a spring-mounted platform PL which deflects in proportion to load. Four switches WA, WB, WC and WD have movable contacts WAA, WBA, WCA and WDA, respectively, which are suitably biased towards the platform PL as by springs (not shown). The movable contact WAA bridges a pair of fixed contacts as long as the elevator load is small; for example, below 400 pounds. The fixed contacts are unbridge or open for heavier loads. The fixed contacts WB1 and WB2 of the switch WB are open for small platform loads and are bridged by the movable contact WB for heavier loads, say in excess of 30% of rated car capacity. The fixed contacts WC1 of the switch WC are bridged and the contacts WC2 are unbridge only for heavier loads, say in excess of 60% of rated car capacity. The switch WD closes its contacts when the load is above say 80% of rated full load capacity.

Suitable mechanism is provided for detecting accurately the distance of the elevator car from a landing at which it is to stop. Mechanism of this type is well known in the art and conventional mechanism may be employed for this purpose. However, Fig. 1 shows an improved and preferred embodiment in the form of an inductor assembly 16.

The inductor assembly 16 includes five inductor relays 1UL, 2DL, 3L, 2UL and 1DL. These relays cooperate with a single inductor plate P for each of the landings to provide slowdown and leveling controls for the elevator car. Thus, if the elevator car 1 is travelling up towards a landing at which it is to stop, the inductor relay 1UL is the first of the inductor relays to reach the plate P for the desired landing. This inductor relay 1UL consequently operates a predetermined distance from the floor, such as 20½ inches to initiate a slowdown of the elevator car.

As the elevator car continues its upward travel, the plate P completes a magnetic circuit for the inductor relay 2DL, but this relay is not effective for control purposes during such upward travel of the elevator car.

When the elevator car reaches a point approximately 10 inches from the desired landing, the plate P completes a magnetic circuit for the inductor relay 3L. This relay initiates a further slowdown of the elevator car. When the elevator car is approximately 2½ inches from the desired landing, the plate P completes a magnetic circuit for the inductor relay 2UL and this relay operates to slow the elevator car to a landing speed.

Approximately ½ inch from the desired landing, the inductor plate P begins to leave the inductor relay 1UL. This relay thereupon drops out to initiate application of the elevator brake and the elevator car stops accurately at the desired landing.

It will be noted that the inductor relays 1UL and 1DL are adjacent to the ends of the inductor plate P while the elevator car is stopped at a landing. If the elevator car overshoots the desired landing or if the car fails to register with the landing because of cable stretch, one

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of these relays 1UL or 1DL is effective for initiating a leveling operation of the elevator car.

Apparatus in Figure 2

The inductor relays all are of similar construction. Consequently a description of the inductor relay 3L will suffice. The inductor relay 3L has a coil which is wound on a magnetic core 17. At each end, the magnetic core 17 has a polar plate 17a or 17b. Each of the polar plates has a slot within which a magnetic armature 17c or 17d is positioned. These armatures are hinged in any suitable manner to their associated polar plates. In the specific embodiment of Fig. 2, the armature 17c is hinged on the polar plate 17a by means of a flexible spring 17e. In a similar manner, the armature 17d is hinged on the polar plate 17b by means of leaf spring 17f.

It will be noted that a long airgap is between the armatures 17c and 17d. When the inductor relay reaches the inductor plate P, the airgap is bridged substantially by the inductor plate. Consequently, if the coil of the inductor relay is energized, the forces applied to the armatures are sufficient to move the armatures against the biases of their associated springs towards each other. Such movements of the armatures are employed for operating suitable contacts.

Break contacts 3L1 and make contacts 3L3 are operated by the armature 17c. For this purpose, a leaf spring 17g is positioned between strips 17h and 17j. The spring 17g and the strip 17h are biased normally into engagement with each other. Such engagement provides the contacts 3L1. The spring 17g and the strip 17j are normally biased out of engagement with each other to provide the make contacts 3L3.

It will be understood that the spring and each strip when separated are insulated from each other. When the armature 17c is moved toward the inductor plate by magnetic forces, an arm 17k secured to the armature operates through a link 17m to move the spring 17g out of engagement with the strip 17h and into engagement with the strip 17j.

Although the spring and strips could engage each other directly, contact buttons 17n, 17o and 17p, may be secured to the ends of the spring and strips for the purpose of effecting the desired engagement.

In this way, each of the inductor relays may provide either a make contact or a break contact or the relay may provide both make and break contacts as desired.

The armature 17d may operate the contacts 3L2 and 3L4 in an analogous manner. However, it is believed that a discussion of the contacts operated by the armature 17c suffices for present purposes.

Apparatus in Figure 3

In Fig. 3, the direct-current motor MO is connected for energization in a variable-voltage circuit. Energization for the motor MO is supplied by a main direct-current generator GE. This generator has two separate and similar generator field windings GEF1 and GEF2.

The energization of the field windings of the main generator GE is controlled in part by a direct-current regulating generator RG which has a number of field windings. Thus, the regulating generator has pattern field windings RGP1 and RGP2 which are similar to each other. In addition, the regulating generator has two auxiliary pattern field windings RGL1 and RGL2 which are employed to boost the excitation of the regulating generator derived from the main pattern field windings during certain leveling operations. When the main pattern field windings RGP1 and RGP2 alone are effective, the regulating generator has a first volts-per-ampere characteristic. In other words, a first ratio is provided between the volts output from the regulating generator armature RGA and the current passing through the pattern field windings. When the main and auxiliary pattern field windings all are effective, a second volts-per-ampere

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characteristic is obtained. The ratio in the latter case is substantially greater than the ratio obtained when the main pattern field windings alone are effective.

The armature GEA is rotated at a substantially constant rate in any suitable manner as by a three-phase motor GEM which is energized from a three phase source having phase conductors LA, LB, LC through a circuit breaker CB. The circuit breaker has a tripping latch CBT which is spring biased towards its tripping position. The latch is held in latching position by a solenoid which is connected across the conductors LB and LC through contact of an overload relay RE or through the switch WD.

The regulating generator has a series field winding RGS which increases the field excitation of the regulating generator to compensate for the voltage drop due to the resistance of the armature MOA of the driving motor MO. Finally, the regulating generator has a differential field winding RGD which is energized to provide a field excitation which is in opposition to the field excitation of the pattern field windings.

Energization for various circuits employed in Fig. 3 is derived from a suitable source of direct current represented by two buses L+1 and L-1. The field winding MOF for the motor MO is connected directly across the buses L+1 and L-1.

The armature MOA of the driving motor and the armature GEA of the main generator GE are connected in a loop circuit by means of two conductors 19a and 19b. The loop circuit may be interrupted by the opening of the make contacts 7-1 of a running contactor. The series field winding RGS of the regulating generator is included in the loop circuit in series with the armatures MOA and GEA.

When the elevator car is to be leveled for the purpose of compensating for cable stretch or contraction, a loop-voltage relay B is connected between the conductors 19a and 19b through the resistor R1, make contacts 6-1 of a running relay 6 (shown in Fig. 4) and break contacts 32B1 of a cable-stretch relay 32B (shown in Fig. 4). A resistor R1A is connected across the relay B to control the pick up of the relay.

A second loop-voltage relay BL is connected across the conductors 19a and 19b through the make contacts 6-1 and the break contacts 32B1 and LW1-1. The contacts LW1-1 and the relay BL are shunted by separate parts of a resistor R1B in order to control the pick up of the relay BL. The relay BL is designed to pick up when the generator voltage has reached a value sufficient to move the elevator car.

The purpose of the relay B is to permit a release of the elevator brake when the driving motor is to level the elevator car in the hauling direction only after the generator GE has a voltage output sufficient to support the hauling load.

It will be understood that the armature of the direct-current regulating generator RG is rotated in any suitable manner at a constant rate of rotation. Thus, the generator may be driven at a constant rate by an electric motor (not shown).

When the generator GE initially is excited, the voltage across the terminals thereof starts to increase. The increasing voltage increases the energization of the differential field RGD in a direction which opposes further increase in the excitation supplied to the generator GE. The rate at which the differential field windings RGD opposes such increase in the excitation of the generator GE, may be controlled by controlling the effective resistance value of a resistor R2 which is connected in series with the differential field winding across the terminals of the armature GEA. During normal running of the elevator car between landings, the entire resistance of the resistor R2 may be employed. As the elevator car stops at a landing, a portion of the resistor may be shunted through the break contacts 6-2 of the running relay and

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break contacts 32B-2 or BR-1. Such shunting of a portion of the resistor R2 increases the rate on which the excitation of the generator GE is decreased.

The brake 5 is of the type which is biased into braking position by means of a spring (not shown). The brake is released by means of energization of a brake-releasing coil 5a. The brake release circuit is as follows:

L+1, (BA1, LW3-1, R3A)

or

(32B11, R3A), BR2, BR, 5a, 6-3, 7-2, L-1

The energization of the brake coil 5a also energizes the brake-released relay BR. This relay opens its break contacts BR2 to insert a resistor R3, in the brake-release circuit, thereby reducing the current through the circuit to a value merely sufficient to hold the brake 5 in its released position.

A brake discharge resistor R5 is connected across the brake coil 5a. This resistor has a high resistance value and would result in the fast and hard application of the brake if it were employed alone.

The rate of dissipation of energy stored in the brake coil 5a is controlled further by means of make contacts LU1 or LD1 of up and down leveling relays. When either of these sets of contacts is closed, a low resistance circuit is established across the brake coil 5a through a rectifier 21. Consequently, the energy stored in the brake coil discharges at a very slow rate and the brake remains picked up for a substantial time after the brake-release circuit is open.

The rectifier 21 is very desirable in the brake discharge circuit. It prevents flow of energy between the buses therethrough. At the same time, it establishes a low resistance path for discharge currents from the brake coil; it eliminates the requirement for contacts which may introduce a variable contact resistance and it eliminates the arcing problems introduced by such contacts.

Further control of the discharge rate of energy stored in the brake coil 5a is provided by means of a resistor R6 which is connected across the coil 5a through the rectifier 21 and through contacts 5-1. The contacts 5-1 are open in the fully released position of the brake 5. However, they close immediately after the brake 5 starts to set and introduce all or a portion of a resistor R6 in the discharge circuit of the brake coil. The amount of the resistor R6 which is effective in the brake discharge circuit, depends on the condition of the break contacts BC1 of a brake modifier relay and the make contacts 32B3 of the cable stretch relay. It will be understood that the greater the value of resistance in the discharge circuit for the brake coil, the faster will be the application or setting of the brake.

A portion of the resistor R3A may be shunted by make contacts 65-3 of the brake regulator relay 65 to provide a slow pick up of the brake in order to obtain a smooth start.

Four different brake applications are provided by the circuits of Fig. 3. If the elevator car is approaching a floor for a normal landing, the contacts BC1 and 32B3 are closed and only a small proportion of the resistor R6 is effective in the discharge circuit for the coil 5a. Consequently, the elevator brake is applied at a comparatively slow rate to provide a soft braking action.

Should the elevator car overrun the floor during the landing operation, one of the sets of contacts LU1 or LD1 closes to establish a shunt across the brake coil 5a. This delays the completion of the brake setting for a time sufficient to permit reestablishment of the brake-release circuit before the brake is completely set. The maintenance of the brake in a released condition facilitates the rapid and smooth reversal of the elevator car for the ensuing leveling operation.

Following the overrun of the floor, the elevator car is leveled or returned towards a position in registration with the desired floor. During this return to the floor,

the contacts BC1 open to introduce a greater proportion of the resistor R6 in the discharge circuit for the brake coil 5a. This means that the elevator brake sets more rapidly and prevents over-travel of the elevator car as it levels into the desired position.

If the elevator car is being leveled to compensate for cable stretch or contraction, both of the sets of contacts 32B3 and BC1 are open to introduce the entire resistor R6 into the discharge circuit for the coil 5a. This results in a fast and hard braking action to stop the elevator car accurately at the completion of the leveling operation.

In order to facilitate rapid and accurate changes in the speed of the elevator car, the regulating generator RG is arranged in a "split" Wheatstone bridge 21 which has four arms 21a, 21b, 21c and 21d connected successively in a ring. The arm 21a includes in series the generator field winding GEF2, the regulating generator main pattern field winding RGP2, the regulating generator auxiliary pattern field winding RGL2, break contacts 32B7 and a resistor 21e. Make contacts 32B8 are connected to shunt the auxiliary regulating generator field winding RGL2 and the break contacts 32B7.

In an analogous manner, the arm 21c of the bridge includes in series the generator field winding GEF1, the regulating generator main pattern field winding RGP1, the regulating generator auxiliary pattern field winding RGL1, the break contacts 32B5 and a resistor 21f. Make contacts 32B4 are arranged to shunt the auxiliary field winding RGL1 and the break contacts 32B5. As shown in Fig. 3, the remaining arms of the bridge may comprise resistors.

The armature RGA of the regulating generator is connected across one diagonal of the bridge through make contacts 6—4 of the running relay or make contacts 7—10 of the running contactor, the make contacts 32B6 or the break contacts LW3—2 and part of a resistor 21g.

The remaining diagonal of the bridge is connected across the buses L+1 and L—1 through a resistor R7 and a reversing switch. The reversing switch includes make contacts U2 and U3 of the up switch. These contacts are closed when the system is conditioned for up travel. The reversing switch also includes make contacts D2 and D3 which are closed when the elevator system is conditioned for down travel.

When the bridge is connected across the buses, current flows through the field windings connected in the arms of the bridge circuit. Certain of these windings excite the regulating generator and this develops a voltage across the armature RGA which produces currents increasing the excitation of the field windings. The auxiliary pattern field windings RGL1 and RGL2 are connected in the bridge circuit only when the elevator car is being leveled to compensate for cable stretch or contraction. When the auxiliary pattern field windings are connected for energization, the contacts 32B6 are open to introduce a larger part of the resistor 21g in series with the armature RGA. If the contacts 32B6 and LW3—2 are both open, the armature RGA is ineffective for increasing field excitation.

The effective value of the resistance introduced in series with the bridge by the resistor R7 controls to a substantial extent, the excitation of the generators. It will be noted by inspection of Fig. 3 that make contacts L1, L2, L3 and GR6—1 are connected to taps on the resistor R7 for the purpose of shunting portions of the resistor. These contacts are opened to control the retardation of the elevator car.

Furthermore, it will be noted that a plurality of make contacts LW1—2, LW2—1, LW2—2 and LW1—3 of the load zone relays are employed for shunting portions of the resistor R7. Further control of the effective resistance of the resistor R7 is provided by make contacts 32B9 and break contacts 32B10 of the cable stretch relay and by break contacts BL1 of the second loop-voltage relay BL.

A running contactor 7 is connected for energization while the elevator system is in running condition. This contactor has a self-holding circuit which is completed through its make contacts 7—3 and make contacts 6T1 a timing relay.

Energization of the load zone relays LW1, LW2 and LW3 requires closure of the contacts 6—6 and 32B12. In addition, for energizing the load zone relay LW1, the switch WA must be closed.

The load zone relay LW2 is associated in an analogous manner with the switch WB1. In addition, energization of the relay LW2 requires closure of the break contacts contacts LW3. The load zone relay LW3 is associated in analogous manners with the switch WC1.

It will be recalled that the switches WA to WC respond to elevator car loading. To review briefly the operation of these contacts, if the car is not loaded, or has a small load of not more than say 400 pounds, the switch WA is closed and the relay LW1 is picked up. For all other loadings, the switch WA is open and the relay LW1 is dropped out.

In conventional practice, the counterweight 9 (Fig. 1) is designed to balance the weight of the elevator car and 40% of the rated full load capacity of the elevator car. The relay LW2 is energized to pick up only for substantially balanced loads. For such loads, the release of the brake 5 is not accompanied by substantial movement of the elevator car for an appreciable time in the absence of power. Consequently, the power to move the car may be built up without fear that the car will move appreciably during such build up.

For loads below the balanced range, say below 30% of rated capacity, the switch WB is open. For loads above the balanced range, say above 60% of rated capacity, the contact LW3—3 is open and the relay LW2 cannot pick up.

The switch WC is designed to close its contacts WC1 and open contacts WC2 for loads above the balanced range, say above 60% of rated capacity.

Apparatus in Figure 4

The brake relay BA is energized for a leveling operation. Thus, if the elevator car is lightly loaded or not loaded (make contacts LW1—4 are closed) if the elevator car is to level in the down direction (make contacts LD6 are closed) and if the voltage supplied to the motor MO is sufficient to support the load (make contacts B1 are closed) the brake relay BA is energized. This relay also is energized if a balanced load is present in the elevator car (make contacts LW2—3 are closed) and the car is to level either up or down (make contacts LD2 or LU2 are closed). Make contacts 6—7 and BA2 establish a holding circuit for the relay BA.

Inasmuch as the elevator system is assumed to be designed for car switch operation, a car switch CS is illustrated in Fig. 4. When the car switch is rotated in a counterclockwise direction as viewed in Fig. 4, it engages the contact 1U to complete an energizing circuit for the up relay UR through the auxiliary running relay 80 and make contacts 40—1 of the door relay. If the rotation of the car switch is continued, it also engages the full speed contact 2U to energize the full speed relay GR6 through the make contacts 40—2 of the door relay.

When the car switch is rotated in a clockwise direction as viewed in Fig. 4, it engages the contact 1D to complete an energizing circuit for the down relay DR through the auxiliary running relay 80 and the make contacts 40—1 of the door relay. Continued motion of the car switch in the clockwise direction brings it into engagement with the contact 2D to establish an energizing circuit for the full speed relay GR6 through the make contact 40—2 of the door relay.

When the car switch CS is in its neutral position, as illustrated in Fig. 4, it completes an energization circuit for the coils of the inductor relays through break contacts

GR6—2 of the full-speed relay and break contacts 80—1 of the auxiliary running relay.

The up switch U, the down switch D, and the running relay 6 can be energized only if the make contacts 72T1 of a timing relay are closed. When the car switch CS is operated to energize the up relay UR, the resulting closure of the make contacts UR1 establishes the following circuit:

L+1, UR1, LD3, 32B16, U, 6, 72T1, L—1

Assuming that the make contacts L1—2 of the third landing relay and 40—3 of the door relay are closed, the energized up switch U closes its contacts U6 to establish a self-holding circuit around the contacts UR1 and LD3. Deenergization of the third landing relay would result in opening of the contacts L1—2 to deenergize the up switch.

For a leveling operation, the up switch may be energized by closure of the contacts LU3 of the up leveling relay. Closure of the make contacts LU3 would be accompanied by opening of break contacts LU4 to prevent energization of the down switch D.

Make contacts WB2 permit leveling of the elevator car for cable stretch provided the car is loaded above a predetermined value, such as 30% of rated full load capacity.

The down switch D may be energized in an analogous manner. For example, if the car switch CS is operated to energize the down relay DR, the resulting closure of the make contacts DR1 establishes the following circuit:

L+1, DR1, LU4, WC2 or 32B15, D, 6, 72T1, L—1

The resulting closure of the make contacts D6 establishes a self-holding circuit for the down switch D which is completed through the contacts L1—2 and 40—3.

For a down leveling operation, closure of the contacts LD4 of the down leveling relay would establish an energizing circuit for the down switch D and the running relay 6. The closure of the make contacts LD4 would be accompanied by opening of the break contacts LD3 to prevent energization of the up switch. The contacts WC2 and 32B15 are added to prevent energization of the down switch D to relevel if a heavily-loaded car moves above a landing due to cable contraction.

The timing relay 6T is energized in response to energization of the running relay 6 which closes its make contacts 6—8. The timing relay 6T may have a time delay in dropout of the order of two seconds. It is employed for preventing prompt dropout of the running contactor 7 (Fig. 3) when the running relay 6 is deenergized.

The door relay 40 (Fig. 4) is a safety device which is energized through car gate contacts and hoistway door contacts only if the car gate and the hoistway doors associated with the elevator car are all closed. The gate contacts and the door contacts are responsive to the positions of the gate and doors and are illustrated in Fig. 4. Such a safety circuit is well understood in the art.

The cable-stretch relay 32B is energized when either the up relay or the down relay UR or DR is energized. Upon energization, the cable-stretch relay 32B closes its make contact 32B14 to establish a self-holding circuit which is completed through the make contacts 7—8 of the running contactor. As long as the elevator car continues to run between floors, and for an additional time determined by the dropout of the running contactor 7, the cable-stretch relay 32B remains energized. As long as the relay 32B is energized, it prevents energization of the loop voltage relays B and BL (Fig. 3), it prevents the break contacts 32B2 from completing a shunt around the portion of the resistor R2 and it maintains the make contacts 32B3 closed to provide a comparatively soft brake operation. In addition, the energized cable-stretch relay 32B prevents energization of the auxiliary pattern field windings RGL1 and RGL2. A portion of the resistor 21g is shunted by the closed contacts 32B6; and similarly, a portion of the resistor R7 is shunted by the contacts 32B9. The break contacts 32B10 remain open to segre-

gate contacts of the load zone relays associated with the resistor R7. The break contacts 32B11 remain closed to hold the brake 5 released. The break contacts 32B12 remain open to prevent energization of the load zone relays LW1 to LW3.

When the relay 32B is deenergized, the system is conditioned for fast and efficient leveling of the elevator car to compensate for cable stretch or contraction.

The brake modifier relay BC can be energized only when the car switch CS is in its neutral or stopping position. The circuit for energizing the relay BC is completed through the break contacts 65—1 of a brake regulator relay and the make contacts 6—9 of the running relay. When the relay BC is energized, it opens its break contacts BC1 (Fig. 3) to modify the effective resistance value of the resistor R6. In addition, make contacts BC2 (Fig. 4) are closed to establish a holding circuit around the contacts 6—9.

The up and down leveling relays LU and LD are energized respectively by closure of the make contacts 1UL1 and 1DL1 of the inductor relays 1UL and 1DL.

The third landing relay L1 is energized when make contacts U7 of the up switch and break contacts 2UL1 of the inductor relay 2UL are closed. Alternatively, the relay L1 may be energized when the make contacts D7 of the down switch and the break contacts 2DL1 of the inductor relay 2DL are closed.

The second landing relay L2, the brake regulator relay 65 and the field-control relay L3 can be energized only if the make contacts 7—9 of the running contactor are closed. The energizing circuit of the second landing relay L2 is completed through break contacts 3L1 of the inductor relay 3L. The energizing circuit for the brake regulator relay 65 is completed through the make contacts of the full speed relay GR6 and make contacts 6—11 of the running relay. When energized, the brake regulator relay 65 closes its make contacts 65—2 to establish a holding circuit around the contacts GR6—3.

An energizing circuit for the field-control relay L3 is completed through the break contacts LD5 and LU5 of the up and down leveling relays.

The timing relay 72T is connected for energization when the auxiliary running relay is energized to close its make contacts 80—2. When energized, the timing relay closes its make contacts 72T2 to establish a self-holding circuit which is completed either through the make contacts L1—3 of the third landing relay or through the break contacts 6—10 of the running relay 6. The timing relay 72T may have a time delay in dropout of the order of 6 seconds.

OPERATION A

(Fully-loaded car runs from the third to the first landing)

The operation of various portions of the elevator system have been discussed to some extent in the discussions of the various figures. However, it is believed that an understanding of the invention will be facilitated by a review of certain typical operations of the elevator system. For the first operation, it is assumed that the elevator car is at the third landing and that the elevator car doors are open. In addition, it is assumed that the elevator car is fully loaded. The full load rating of the elevator car may be of the order of 10,000 pounds. Such a loading depresses the spring-supported platform PL (Fig. 1) sufficiently to open the switch WA and close the switches WB1, WB2 and WC1, while opening the switch WC2.

It is assumed further that the circuit breaker CB is closed to connect the motor GEM to the polyphase circuit LA, LB, LC to effect rotation of the generator armature GEA, that the armature RGA of the regulating generator is rotating and that the buses L+1 and L—1 are properly energized.

Inasmuch as the elevator car is standing at the third landing, the car switch CS (Fig. 4) is in its neutral or

stopping position. Since the break contacts GR6—2 of the full speed relay and the break contacts 80—1 of the auxiliary running relay are closed, it follows that the following circuit is established.

L+1, CS, S, 1UL, 1DL, 2UL, 2DL,

3L, GR6—2, 80—1, L—1

Consequently, as long as the elevator car remains at the third landing with its doors open, the coils of the inductor relays are energized, and are available for maintaining the elevator car in register with the third landing.

When the elevator attendant closes the car doors and gates, the door relay 40 is energized and closes its make contacts 40—1, 40—2, 40—3. Such contact closures prepare the system for subsequent operations.

The car attendant then rotates the car switch CS in a clockwise direction, as viewed in Fig. 4, to start the elevator car in a down direction. When the car switch engages the contact 1D, the following circuit is established:

L+1, CS, 1D, DR, 80, 40—1, L—1

The resultant energization of the auxiliary running relay 80 is effective for opening the break contacts 80—1 to deenergize the coils of the inductor relays. In addition, the make contacts 80—2 close to energize the timing relay 72T. This timing relay closes its make contacts 72T—1 to prepare the running relay 6 and the down switch D for subsequent energization. Also, the timing relay closes its make contacts 72T2 to complete a holding circuit through the contacts 72T2 and the break contacts 6—10 of the running relay.

Because of its energization, the down relay closes its make contacts DR2 to energize the cable-stretch relay 32B which operates a number of contacts. For example, make contacts 32B15 of cable-stretch relay are now closed. The energization of the down relay DR resulting from operation of the car switch also completes the following circuit:

L+1, DR1, LU4, 32B15, D, 6, 72T1, L—1

The make contacts D2 and D3 of the energized down switch close to connect the bridge 21 for energization through the resistor R7 with proper polarity for down travel of the elevator car.

The make contacts D6 close to establish a holding circuit for the relays D and 6 through the make contacts 40—3 as soon as the make contacts L1—2 are closed. Closure of the make contacts D7 completes the following energizing circuit for the third landing relay:

L+1, 2DL1, D7, L1, L—1

Referring now to the energized running relay 6, it will be noted that the running relay closes its make contacts 6—1 (Fig. 3) to prepare the loop voltage relays B and BL for energization. However, inasmuch as the contacts 32B1 are now open, the relays B and BL cannot be energized at this time.

The running relay also opens its break contacts 6—2 to make certain that the entire resistor R2 is effective for limiting current flowing through the differential field winding RGD.

The make contacts 6—3 are closed by energization of the running relay 6. As previously explained, closure of these contacts is necessary for energization of the brake coil.

The closure of the make contacts 6—4 of the running relay together with the now-closed contacts 32B6 connects the armature RGA of the regulating generator across a diagonal of the bridge 21 and the armature now is effective for supplying current to the field windings of the bridge.

Upon energization of the running relay, the make contacts 6—5 close to energize the running contactor 7.

The make contacts 6—6 close, but have no immediate

effect on the operation of the system, for contacts 32B12 are now open.

The closure of the make contacts 6—8 completes an energizing circuit for the timing relay 6T. The make contacts 6—9 also close, but have no immediate effect on the operation of the system.

The break contacts 6—10 open to prevent the establishment therethrough of a holding circuit for the timing relay 72T. Finally, the break contacts 6—11 close to prepare the relay 65 for subsequent energization.

As previously pointed out, the cable-stretch relay 32B was energized as a result of closure of the make contacts DR2. The relay 32B, upon energization, opens its break contacts 32B1 (Fig. 3) to prevent energization of the 15 loop voltage relays B and BL. In addition, the break contacts 32B2 open, but such opening has no immediate effect on the operation of the system.

Closure of the make contacts 32B3 shunts a portion of the resistor R6, but such shunting has no immediate effect on the operation of the system.

The energization of the relay 32B also results in closure of the make contacts 32B4 and 32B8, together with openings of the break contacts 32B5 and 32B7. Such contact operation removes the auxiliary pattern field windings RGL1 and RGL2 of the regulating generator from the bridge.

Closure of the make contacts 32B6 shunts a portion of the resistor 21g and increases the effectiveness of the output of the regulating generator.

The closure of the make contact 32B9 and the opening of the break contacts 32B10 of the cable-stretch relay, modifies the tap connections of the resistor R7. However, for reasons which will be pointed out below, such modification has substantially no effect on the operation of the system at this time.

Because of the closing of the break contacts 32B11, the brake circuit is prepared for subsequent energization. Furthermore, because of its opening of the break contact 32B12, the load zone relays LW1 to LW3 cannot be energized.

The make contacts 32B14 close as a result of energization of the relay 32B. These contacts 32B14 with the make contacts 7—8 of the running contactor (when they close) establish a holding circuit for the relay 32B. It will be recalled that contacts 32B15 also close to permit energization of the down switch D and the relay 6. Closure of make contacts 32B16 has no immediate effect on system operation.

Contact changes resulting from energization of the third landing relay L1 now will be considered. The make contacts L1—1 (Fig. 3) close to shunt a portion of the resistor R7. Consequently, closure of these contacts increases the energization of the field windings of the main generator GE. While the contacts L1—1 are closed, the contacts 32B9 have no effect on the operation of the system.

In addition, the make contacts L1—2 (Fig. 4) close to establish a holding circuit for the relays D and 6 which includes the make contacts L1—2, 40—3 and D6.

Finally, the make contacts L1—3 close to complete with the make contacts 72T2 of the timing relay, a holding circuit for the timing relay.

Referring again to Fig. 3, it will be noted that energization of the running contactor 7 results in closure of the make contacts 7—1 to complete the loop circuit for the armatures GEA and MOA.

Also, make contacts 7—2 close. It will be recalled that closure of these contacts is a prerequisite for energization of the brake coil 5a, which is now energized through the circuit:

L+1, 32B11, R3A, BR2, BR, 5a, 6—3, 7—2, L—1

Energization of the brake coil releases the brake 5. The concurrent energization of the brake-release relay BR results in opening of the brake contacts BR1 and BR2.

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Opening of the former contacts has no immediate effect on the system, but opening of the contacts BR2 inserts the resistor R3 in the brake circuit to reduce current flow therein.

The closure of the make contacts 7—3 complete with the make contacts 6T1, a holding circuit for the running contactor 7. Inasmuch as the timing relay 6T (Fig. 4) has a time delay on dropout, it follows that the running contactor 7 remains energized after the deenergization of the running relay 6 for a time corresponding to the dropout time of the timing relay 6T.

Closure of the make contacts 7—8 (Fig. 4) completes with the make contacts 32B14, a holding circuit for the cable-stretch relay 32B.

Inasmuch as the variable-voltage loop is complete, the elevator brake is released and the field windings of the main generator are excited with proper polarity for down travel of the elevator car, the elevator car starts down from the third landing. It may be pointed out that when the brake 5 (Fig. 3) was released, the contacts 5—1 opened, but such opening had no immediate effect on the operation of the system.

When the running contactor was energized, the make contacts 7—9 closed. Closure of the make contacts completes the following two circuits.

L+1, 3L1, L2, 7—9, L—1

and

L+1, LU5, LD5, L3, 7—9, L—1

The energization of the second landing relay L2 and of the field control relay L3 results in closure of the make contacts L2—1 and L3—1 (Fig. 3) to shunt portions of the resistor R7. Such shunting results in substantial energization of the main field windings of the main generator GE and produces a substantial car speed which may be of the order of 160 feet per minute.

If a higher car speed is desired, the car attendant may rotate the car switch CS (Fig. 4) until it also engages the high speed contact 2D. Such rotation of the car switch results in energization of the full speed relay GR6. The full speed relay GR6 closes its make contacts GR6—1 (Fig. 3) to shunt a major proportion of the resistor R7. This results in full-speed energization of the bridge 21 and maximum excitation for normal car operation is supplied by the bridge to the field windings GEF1 and GEF2 of the main generator. Consequently, the motor MO rapidly accelerates to the maximum running speed.

It will be understood that as the voltage output of the generator GE increases the energization of the differential field winding RGD also increases. This field winding acts in opposition to the pattern field windings, and permits the voltage output of the generator to increase until a predetermined value thereof is reached.

The full speed relay also opens its break contacts GR6—2 (Fig. 4) to prevent energization therethrough of the windings of the inductor relays.

Closure of the make contact GR6—3 of the full speed relay results in energization of the brake regulator relay 65 through the make contacts 6—11 of the running relay and the make contacts 7—9 of the running contactor. Upon energization, the brake regulator relay 65 closes its make contacts 65—2 to establish a holding circuit around the contacts GR6—3. The energized relay 65 also opens its break contacts 65—1 to prevent energization therethrough of the brake modifier relay BC. Make contacts 65—3 reduce the resistance of the brake circuit.

As the elevator car approaches the first landing, the car attendant centers the car switch CS to prepare for a stopping operation of the elevator car. Such centering of the car switch deenergizes the down relay DR, the auxiliary running relay 80 and the full speed relay GR6. The deenergized down relay DR opens its make contacts DR1, but such opening has no effect on the energization of the down switch D and the running relay 6 be-

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cause of the holding circuit which includes the contacts L1—2, 40—3 and D6.

The make contacts DR2 also open, but have no effect on the energization of the cable-stretch relay 32B because of the holding circuit established through the contacts 32B14 and 7—8.

The auxiliary running relay 80, upon deenergization, closes its break contacts 80—1 to prepare the coils of the inductor relays for energization. In addition, contacts 80—2 of the auxiliary running relay open, but such opening has no effect on the energization of the timing relay 72T because of the holding circuit established through the contacts L1—3 and 72T2.

The deenergization of the full speed relay GR6 results in the opening of the make contacts GR6—1 (Fig. 5). Such opening reintroduces the portion of the resistor R7 between the taps connected to the contacts L3—1 and GR6—1 in series with the bridge 21. The resulting decrease in the field excitation of the main generator GE results in deceleration of the elevator car to a speed which may be of the order of 160 feet per minute.

The deenergization of the full speed relay also closes the break contacts GR6—2 (Fig. 4) to complete the following circuit:

L+1, CS, S, 1UL, 1DL, 2UL, 2DL, 3L, GR6—2,
80—1, L—1

The coils of the inductor relays now are energized and the relays are conditioned to assist in a landing operation.

Contacts GR6—3 of the full speed relay open as a result of the deenergization of the relay but such opening has no immediate effect on the operation of the system because of the holding circuit established around these contacts by the contact 65—2.

As the elevator car approaches the first landing, the inductor relay 1DL reaches the inductor plate P for the second landing and at a distance, which may be of the order of 20½ inches from the second landing, the inductor relay 1DL closes its contacts 1DL1 (Fig. 4) to energize the down leveling relay LD. This relay also serves as a first landing relay.

Upon energization, the relay LD closes its make contact LD1 (Fig. 4) but such closure has no immediate effect on the operation of the system. Also the relay closes its make contacts LD2 and LD6 (Fig. 4) but such closing again has no immediate effect on the operation of the system.

The down leveling relay LD, upon energization, opens its break contacts LD3 (Fig. 4) but such opening has no immediate effect on the operation of the system. The closure of the make contacts LD4 at this time has no immediate effect on the operation of the system.

Finally, the energization of the down leveling relay LD results in opening of the break contacts LD5 to deenergize the field-control relay L3. The relay L3 thereupon opens its make contacts L3—1 (Fig. 4) to insert in series with the bridge, the portion of the resistor R7 which lies between the taps connected to the contacts L2—1 and L3—1. The resulting reduction in energization of the field windings of the main generator GE results in retardation of the elevator car to a lower speed which may be of the order of 80 feet per minute.

As the elevator car proceeds downwardly, the inductor relay 1UL reaches the inductor plate P (Fig. 1) for the second landing and this inductor relay opens its break contacts 2UL1 (Fig. 4). Such opening has no immediate effect on the operation of the system.

Further movement of the elevator car toward the first landing brings the inductor relay 3L to the inductor plate P for the first landing (Fig. 1) and this inductor relay operates to open its break contacts 3L1 (Fig. 4). Such opening deenergizes the second landing relay L2.

Upon deenergization, the second landing relay opens its make contacts L2—1 (Fig. 3). Such opening may

occur at a distance of the elevator car of the order of 10 inches from the first landing. The opening of the contact L2—1 inserts the portion of the resistor R7 between the taps connected to the contacts L1—1 and L2—1 in series with the bridge 21. This further reduces the energization of the field windings of the main generator GE and the elevator car is retarded to a speed which may be of the order of 25 feet per minute.

Upon further movement of the elevator car towards the first landing, the inductor relay 2DL finally reaches the inductor plate P for the second landing (Fig. 1) at a point which places the elevator car approximately 2½ inches from the second landing. At this point, the inductor relay 2DL operates to open its break contacts 2DL1 (Fig. 4). This interrupts the energization of the third landing relay L1.

Upon deenergization, the third landing relay opens its make contacts L1—1 (Fig. 3) and the major part of the resistor R7 now is in series with the bridge 21. This further reduces the excitation of the main generator GE and the elevator car slows to a landing speed which may be of the order of 5 to 10 feet per minute.

The third landing relay L1 also opens its make contacts L1—2 but this has no immediate effect on the system for the reason that the contacts LD4 and LU4 establish a holding circuit for the relays D and 6. The contacts L1—3 also open to deenergize the timing relay 72T and this relay starts to time out.

Referring again to Fig. 1, the continued motion of the elevator car at its landing speed towards the first landing finally moves the inductor relay 1DL past the end of the inductor plate P for the first landing sufficiently to cause this inductor relay to reopen its make contacts 1DL1 (Fig. 4). Such reopening deenergizes the down leveling relay LD.

The deenergization of the relay LD may occur at a point in the travel of an elevator car such that if the elevator car brake is applied, the elevator car will drift accurately to a stop of the first landing. As a specific example, the drift distance may be of the order of ½ inch. The relay LD, upon deenergization, opens its make contacts LD1, but such opening has no immediate effect on the operation of the system.

The relay LD also opens its make contacts LD2 and LD6 (Fig. 4) and closes its break contacts LD3, but these operations have no immediate effect on the operation of the system.

The deenergization of the down leveling relay also results in opening of the make contacts LD4 to deenergize the down switch D and the running relay 6. The down switch D, upon deenergization, opens its make contacts 2, 3, 6 and 7.

The down switch also opens its contacts D2 and D3 to disconnect the bridge from the buses.

The contacts D6 and D7 in opening, have no immediate effect on the operation of the system.

Upon deenergization, the running relay 6 opens its make contacts 6—1 (Fig. 3), but such opening has no immediate effect upon the operation of the system. The break contacts 6—2 close to prepare for the shunting of a portion of the resistor R2 therethrough. Opening of the make contacts 6—3 (Fig. 3) results in application of the brake 5. As the brake leaves its fully open position, the contacts 5—1 close to insert a portion of the resistor R6 in the discharge circuit for the brake coil. The value of resistance inserted by closure of the contacts 5—1 is selected to provide a soft braking action. That is, the brake shoe is forced against the brake drum comparatively slowly. It should be noted that the discharge current from the brake coil passes through the rectifier 21, but this rectifier prevents current from the buses from flowing therethrough.

It will be understood that when the brake circuit is deenergized, the brake-released relay closes its break contacts BR1 and BR2. The relay BR has a time delay in

dropout determined by the discharge circuit for energy stored in the relay coil. Preferably, the relay BR drops out just as the car comes to rest. The break contacts BR1 and 6—2 now shunt a portion of the resistor R2. The increased energization of the differential field winding rapidly changes the field excitation of the main generator to reduce the voltage output of the main generator to zero.

Continuing with the effect of the deenergization of the running relay 6, it should be noted that the make contacts 6—4 open in the circuit of the armature RGA of the regulating generator. However, contacts 7—10 remain closed and the armature remains connected in the bridge. Consequently, the differential field winding RGD remains effective to force the generator voltage to zero. The opening of the make contacts 6—5, 6—6 and 6—7 has no immediate effect on the operation of the system. The opening of the make contacts 6—8 disconnects the timing relay 6T from the buses and this relay starts to time out.

Make contacts 6—9 open, but such opening has no immediate effect on the operation of the system. The break contacts 6—10 close to reenergize the timing relay 72T. Thus, the relay 72T is energized during floor-to-floor runs and while stopped at a landing. If the elevator car were to stall while attempting to make a landing, the relay 72T would time out and interrupt the energizing circuit for the running relay 6 and one of the switches U or D.

Contacts 6—11 (Fig. 4) open to deenergize the brake regulator relay 65. The relay 65 closes its break contacts 65—1 and opens its make contacts 65—2 and 65—3, but these changes have no immediate effect on the system.

It will be recalled that the timing relay 6T has started to time out. Until this relay times out to open its make contact 6T1, the running contactor 7 remains energized. Consequently, the running contactor during this timing out period maintains the loop circuit for the main generator armature GEA and the motor armature MOA in closed condition. Moreover, the make contacts 7—2 and 7—3 remain closed. Also, the make contacts 7—8 (Fig. 4) remain closed to maintain the energization of the cable-stretch relay 32B. The make contacts 7—10 remain closed (Fig. 3) to maintain a closed armature circuit for the regulating generator.

During the timing out period of the relay 6T, the elevator car stops at the first landing and the doors and car gate are open. Such opening of the doors and gates deenergizes the door relay 40 (Fig. 4) to open the make contacts 40—1 and 40—2. The relay 6T then times out to reset the running contactor 7, and this in turn opens its contacts 7—8 to reset the cable-stretch relay 32B.

OPERATION B

(Elevator car overruns first landing)

The elevator car in Operation A normally would land accurately at the first landing. However, in a rare case it is conceivable that the elevator car may overrun the first landing. To illustrate the leveling operation of the elevator car for such an overrun, it will be assumed that the elevator car of Operation A overruns the first landing by more than ½ inch during the landing operation. This overrun occurs while the timing relay 6T is still timing out.

As a result of the overrun of the elevator car, the inductor relay 1UL (Fig. 1) has its magnetic circuit completed by the inductor plate P for the second landing sufficiently to operate the contacts of the inductor relay. These contacts 1UL1 (Fig. 4) consequently close to energize the up leveling relay LU.

The up leveling relay LU closes its make contacts LU1 (Fig. 3) to complete a low resistance discharge circuit for the brake coil 5a. Because of this low-resistance discharge circuit, the energy stored in the brake coil discharges slowly and the brake is unable to set fully before the elevator car is reversed.

The make contacts LU2 close, but such closure has no immediate effect on the operation of the system.

The make contacts LU3 of the up leveling relay (Fig. 4) close to establish the following energizing circuit:

L+1, LU3, LD3, 32B16, U, 6, 72T1, L-1

The break contacts LU4 open to prevent energization of the down switch D and the break contacts LU5 open to prevent energization of the leveling field control relay L3.

Inasmuch as the up switch U now is energized, it closes its make contacts U2 and U3 to connect the bridge 21 for energization with proper polarity for up travel of the elevator car. The make contacts U6 and U7 close but have no immediate effect on the operation of the system.

The running relay 6 closes its make contacts 6-1, but since the break contacts 32B1 are open, the closure of the make contacts 6-1 has no effect on the operation of the system at this time.

The break contacts 6-2 open to prevent shunting of a portion of the discharge resistor R2. The make contacts 6-3 close to complete with the still closed contacts 7-2 and 32B11 an energizing circuit for the brake coil 5a. The energization of the brake coil and the resulting opening of the brake occur before the brake has an opportunity to set completely. Consequently, the reversal of the elevator car takes place with no perceptible jar or bump. The make contacts 6-4 close but have no effect at this time because contacts 7-10 have remained closed. Closure of the make contacts 6-5, 6-6 and 6-7 has no immediate effect on the operation of the system. However, closure of the make contacts 6-8 reenergizes the timing relay 6T before the relay has had an opportunity to drop out. Closing of the make contacts 6-9 completes an energizing circuit for the brake-modifier relay BC. The relay BC opens its break contacts BC1 (Fig. 3) to increase the effective resistance of the resistor R6, but this does not immediately affect system operation. Also contacts BC-2 (Fig. 4) close to establish a holding circuit around the contacts 6-9. Opening of the break contact 6-10 deenergizes the timing relay 72T and this relay starts to time out. The time delay in dropout of the relay is ample for a normal leveling operation. Finally make contacts 6-11 close but this closure has no immediate effect on the system operation.

The elevator car now is conditioned for up travel and moves toward the first landing. During the course of such movement, the inductor relay 1UL (Fig. 1) begins to leave the associated inductor plate P and the relay contacts 1UL1 (Fig. 4) open to deenergize the up leveling relay LU.

The up leveling relay LU opens the make contacts LU1 (Fig. 3) to interrupt the low resistance discharge path for the brake coil 5a. The opening of the make contacts LU2 has no immediate effect on the operation of the system.

The opening of the make contacts LU3 (Fig. 4) interrupts the energizing circuit for the up switch U and the running relay 6.

The break contacts LU4 close but have no immediate effect on the system operation. Closure of the break contacts LU5 completes an energizing circuit for the leveling-field-control relay L3. This relay closes its make contacts L3-1 (Fig. 3) but since the elevator car is now in a condition to stop the closure of the contacts L3-1 has substantially no effect on the system operation.

Make contacts U2 and U3 open to interrupt the connection of the bridge to the buses. Opening of the make contacts U6 and U7 has no immediate effect on the operation of the system.

The running relay 6 opens its make contacts 6-1, and closes its make contacts 6-2 without further change in the operation of the system.

Upon deenergization, the relay 6 also opens to contact 6-3 to interrupt the energization of the brake coil 5a.

As the brake begins to set, the contacts 5-1 close to introduce a substantial portion of the resistor R6 in the brake discharge circuit for the coil 5a. (It will be recalled that the contacts BC1 are open). The brake thereupon is applied to provide a medium braking action. It should be noted that this braking action is faster and harder than that employed for a normal landing operation. Since the "brake" is applied faster, the full brake retarding force is developed more rapidly and the brake action may be said to be "harder." As previously explained, the term "harder" does not necessarily mean that the resultant braking force is larger but indicates that the car is brought to a stop more rapidly, as by an earlier full application of the brake. This reduces the likelihood of an overrun of the floor during the leveling operation.

Opening of the make contacts 6-4, 6-5, 6-6, 6-7 and 6-9 has no immediate effect on the operation of the system.

Opening of the contacts 6-8 disconnects the timing relay 6T and this relay again starts to time out. As previously pointed out, when the time relay 6T has completed its timing out, it interrupts the energization of the running contactor 7 (Fig. 3).

The closing of the break contacts 6-10 reenergizes the timing relay 72T. The opening of the make contacts 6-11 has no immediate effect on the system.

From the foregoing discussion it is believed that the operation of the system for floor-to-floor runs and for leveling following an overrun of a landing is clear. It will be understood that during down travel of the elevator car on a floor-to-floor run, the inductor relays 1DL, 3L and 1DL are successively effective for a normal landing operation. For a floor-to-floor run in the up direction, the inductor relays 1UL, 3L, 2UL and 1U1 are successively effective in a similar manner to produce a normal landing of the elevator car.

The up and down relays operate in a similar manner, one being effective to produce up travel and one being effective to produce down travel of the elevator car.

The full speed relay GR6 operates in the same manner for both up and down travel. It will be understood that for full speed up travel, the car switch CS engages both of the contacts 1U and 2U. For full speed down traveling, the car switch engages the two contacts 1D and 2D.

The up switch and the down switch operate in a similar manner respectively for up travel and down travel of the elevator car.

OPERATION C

(Cable contracts, car levels down)

It will be assumed next that after the fully loaded elevator car reaches the first landing, it is unloaded until the load remaining in the elevator car totals 8000 pounds. The cable supporting the elevator car has some resilience and as the elevator car load increases and decreases, the cable stretches and contracts to some extent. It will be assumed that the reduction in the loading of the car from 10,000 to 8000 pounds results in a cable contraction sufficient to move the elevator car 1/2 inch above the first landing.

Inasmuch as the elevator car is stopped at the first landing, the coils of the inductor relays 1UL, 1DL, 2UL, 2DL and 3L are energized by the following circuit:

L+1, CS, S, 1UL, 1DL, 2UL, 3L, GR6-2, 80-1, L-1

Furthermore, the timing relay 72T is energized through the contacts 72T2 and 6-10.

The elevator car has remained at the first landing for a time sufficient to permit the timing relay 6T (Fig. 4) to time out. This relay consequently has opened its contacts 6T1 (Fig. 3) to deenergize the running contactor 7 and the running contactor has opened its make contacts 7-1, 7-2, 7-3, 7-8, 7-9 and 7-10. The opening of the contacts 7-3 (Fig. 4) has deenergized the

cable-stretch relay 32B. Since neither set of contacts UR2 or DR2 is closed during Operation C, the relay 32B remains deenergized throughout the operation.

By reference to Fig. 1, it will be noted that as the elevator car loading decreases, the spring-supported platform rises. It will be assumed that the switch WA is closed only for car loadings under 400 pounds, that the switches WB1 and WB2 are closed only for loads in excess of 3000 pounds, and that the switch WC1 is closed while the switch WC2 is open only for loads in excess of 6000 pounds. The counterweight 9 is assumed to counter-balance the weight of the elevator car plus 4000 pounds of car load.

From the previous discussion of Fig. 1, it will be recalled that the movement of the elevator car for a distance of the order of $\frac{1}{2}$ inch above the first landing moves the inductor relay 1DL sufficiently with respect to the inductor plate for the first landing to operate the inductor relay. Consequently, the inductor relay closes its make contacts 1DL1 (Fig. 4) to energize the down leveling relay LD. The down leveling relay closes its make contacts LD1, LD2 and LD6, opens its break contacts LD3 and opens its break contacts LD5. These contact changes have no immediate effect on the operation of the system.

At the same time, the down leveling relay LD closes its make contacts LD4 but both the switch WC2 and the make contacts 32B15 are now open and the down switch D cannot be energized to correct for cable contraction until the car loading drops enough for the switch WC2 to close. Since the car platform is above the first landing and is discharging load, the car position is quite safe.

It will be assumed now that a sufficient number of passengers leave the elevator car for the load to drop to a value below 6000 pounds. The switch WC1 opens whereas the switch WC2 closes. The opening of the switch WC1 has no immediate effect on the system, but closure of the switch WC2 establishes the following circuit:

L+1, LD4, LU4, WC2, D, 6, 72T1, L-1

The down switch D closes its make contacts D2 and D3 to prepare the bridge 21 for energization with proper polarity for down travel of the elevator car. The closures of make contacts D6 and D7 have no immediate effect on the operation of the system. It will be understood that the inductor relay contacts 2UL1, 2DL1 and 3L1 (Fig. 4) are all open.

The energized running relay 6 closes its make contacts 6-1 (Fig. 3) to establish with the now-closed contacts 32B1, an energizing circuit for the loop voltage relays B and BL. Break contacts 6-2 open to prevent shunting therethrough of a portion of the resistor R2. Make contacts 6-3 close to prepare the brake coil 5a for energization. Make contacts 6-4 close to establish a circuit for the armature of the regulating generator RG. Make contacts 6-5 close to energize the running contactor 7.

For this operation C, the cable-stretch relay 32B is deenergized. Consequently, the auxiliary field windings RGL1 and RGL2 are effectively connected in the bridge 21 and assist the main pattern field windings in building up the output voltage of the main generator GE with great rapidity. The "split" bridge also is effective in increasing the ratio at which the main generator voltage builds up. The entire resistor 21g is effective (contacts 32B6 are open). Because of these factors, the voltage of the main generator rapidly builds up to start the elevator car against the substantial friction which is present if the elevator car remains at rest for a substantial time.

Closure of make contacts 6-6 completes with the switch WB1, the contacts LW3-3 and the contacts 32B12 an energizing circuit for the relay LW2 which picks up to indicate the presence of a balanced load.

The load zone relay LW2 closes its make contacts LW2-2 to complete with the contacts BL1 and 32B10 a shunt across a substantial part of the resistor 7. Consequently, the generator field excitation and voltage rapidly build up.

Closure of make contacts LW2-3 (Fig. 4) completes with the contacts LD2 an energizing circuit for the brake relay BA. In picking up, the relay BA closes its make contacts BA1 to complete in part a circuit for the brake coil 5a and its make contacts BA2 to complete with the now closed contacts 6-7 a self-holding circuit.

Closure of the make contacts 6-11 have no immediate effect on the operation of the system.

Make contacts 6-8 close to energize the timing relay 6T. Contacts 6-9 close to energize the brake-modifier relay BC and contacts 6-10 open to disconnect the timing relay 72T from the buses.

Turning now to the effect of pick up of the contactor 7 (Fig. 3), this contactor closes its make contacts 7-1 to complete the loop circuit for the armatures GEA and MOA. Contacts 7-2 close to establish the following energizing circuit for the brake coil.

L+1, BA1, LW3-1, R3A, BR2, BR,
5a, 6-3, 7-2, L-1

The brake is now released in the manner previously discussed. It will be recalled that such opening is accompanied by opening of the break contacts BR2 to decrease the current supplied to the coil 5a to a reduced value merely sufficient to maintain the brake released. Because the elevator car load is in the balanced zone, the release of the brake does not tend to produce immediate undue car movement.

Inasmuch as the timing relay 6T (Fig. 4) has picked up to close its contacts 6T1 (Fig. 3), closure of the make contacts 7-3 completes a holding circuit for the running contactor 7.

Closure of the make contacts 7-8 and 7-9 (Fig. 4) and 7-10 (Fig. 3) has no immediate effect on the operation of the system.

The brake-modifier relay BC opens its break contacts BC1 (Fig. 3) to make effective a substantial portion of the resistor R6. In addition, this relay closes its make contacts BC2 (Fig. 4) to establish a holding circuit around the contacts 6-9.

The timing relay 72T has started to time out but it will be recalled that this relay has a substantial delay in dropout.

Since the system now is conditioned for down travel, when the voltage supplied to the motor MO builds up to a sufficient value the elevator car starts to move down. The loop-voltage relay BL is set to pick up when the voltage applied to the motor MO is just sufficient to start movement of the car. The relay then opens its contacts BL1 to render the contacts LW2-2 ineffective to shunt the resistor R7. The only part of the resistor now shunted is that shunted by the contacts LW2-1 and the voltage supplied to the motor MO is thus held to a value merely sufficient to produce a slow speed return of the car into register with the first landing.

As the elevator car returns to the first landing, the inductor relay 1DL (Fig. 1) leaves the associated inductor plate sufficient to drop out. The resulting opening of the make contacts 1DL1 (Fig. 4) deenergizes the down leveling relay LD. This relay opens its make contacts LD1 (Fig. 3) and LD2 (Fig. 4), but such opening has no immediate effect on the operation of the system. Reclosure of the break contacts LD3 has no immediate effect on the operation of the system. However, opening of the make contacts LD4 deenergizes the down switch D and the running relay 6. Also, the break contacts LD5 reclose to energize the field-control relay L3. Since the elevator car now is conditioned to stop, the energization of the relay L3 has substantially no effect on the system.

The deenergization of the down switch D and the running relay 6 results in the stopping of the elevator car in a manner which will be apparent from the foregoing discussions. It should be noted that as the brake is applied, the entire resistor R6 is connected in the discharge circuit of the brake coil 5a. Consequently, an extremely fast and hard brake is applied to stop the elevator car accurately at the first landing.

Next, let it be assumed that as the elevator car continues to unload, the load drops below 3000 pounds. At this point, the switch WB1 opens without immediate effect on the operation of the system. When the load drops below 400 pounds, the switch WA closes without immediate effect on the system. At this stage, it is assumed that cable contraction has moved the elevator car up sufficiently for the inductor relay 1DL to pick up. The down leveling relay LD is energized through the contacts 1DL1 and closes its make contacts LD1, LD2 and LD6 and opens its break contacts LD3 and LD5 without immediate effect on the operation of the system. Closure of the make contacts LD4 establishes the following circuit.

L+1, LD4, LU4, WC2, D, 6, 72T1, L-1

The energized down switch D operates in the manner previously discussed to condition the elevator system for operation in the down direction. The running relay 6 also operates in the manner previously discussed with the exception that the closure of the make contacts 6-6 now completes an energizing circuit for the load zone relay LW1 instead of for the load zone relay LW2. Inasmuch as the releveling of the elevator car is similar to the previously discussed releveling of the elevator car for a balanced load except for the effects of the relays LW1 and LW2, the present discussion will be directed primarily to these relays.

Inasmuch as the load zone relay LW2 remains deenergized, the make contacts LW2-1, LW2-2, and LW2-3 all remain open. The energization of the load zone relay LW1 results in opening of the break contacts LW1-1 to place a portion of the resistor R1B in series with the second loop voltage relay BL. This increases the loop voltage required to pick up the second loop voltage relay BL.

In addition, the load zone relay LW1 closes its make contacts LW1-2 and LW1-3 to shunt a portion of the resistor R7. This permits a rapid buildup of the excitation and voltage output of the generator GE. Closure of the make contacts LW1-4 has no immediate effect on the operation of the system.

As the voltage output of the generator GE builds up, it becomes sufficient to support the elevator car and its load with the brake released. At this stage, the voltage is sufficient to pick up the loop voltage relay B and this relay closes its make contacts B1 to complete with the now closed contacts LW1-4 and LD6 an energizing circuit for the brake relay BA. Consequently, the brake relay closes its make contacts BA2 to establish with the contact 6-7 a self-holding circuit. In addition, the make contacts BA1 close to establish the following circuit.

L+1, BA1, LW3-1, R3A, BR2, BR, 5a, 6-3, 7-2, L-1

The brake 5a consequently is released and the energized brake-released relay BR opens its break contacts BR1 without effecting the immediate operation of the system and opens its break contacts BR2 to introduce the resistor R3 in series with the brake coil 5a.

The continued buildup of the voltage output of the generator GE finally reaches a value sufficient to move the elevator car at the desired leveling speed. This value is sufficient to pick up the second loop voltage relay BL and this relay opens its break contacts BL1 to render the make contacts LW1-3 ineffective for shunting the resistor. Inasmuch as part of the resistor R7 to the

right of the contacts LW1-2 is now effectively in series with the bridge 21, the voltage of the generator GE is held to the value producing the desired slow leveling speed of the elevator car.

As the elevator car approaches the first landing, the inductor relay 1DL leaves the plate P and opens its contacts 1DL1 to deenergize the down leveling relay LD. This results in the stopping of the elevator car accurately in registry with the first landing by a sequence which will be understood from the preceding discussion of the releveling of a balanced load.

OPERATION D

(Car loads and cable stretches)

It will be assumed that while the empty car is stopped accurately at the first landing, load starts to enter the car. As the elevator car loads, the cables supporting the elevator car stretch and the elevator car moves below the first landing. If the movement is sufficient to bring the inductor relay 1UL adjacent the plate P, the inductor relay picks up to close its make contacts 1UL1 for the purpose of energizing the up leveling relay LU. For present purposes, it will be assumed that the elevator car is lightly loaded. Under these circumstances, the pick-up of the up leveling relay LU results in closure of the make contacts LU1, LU2 and LU3, and the opening of the break contacts LU4 and LU5 without immediate effect on the operation of the system.

As the loading of the elevator car continues, it reaches a value in excess of 400 pounds and the platform PL of the elevator car 1 sinks sufficiently to open the switch WA. Such opening has no effect on the immediate operation of the system.

As a result of continued loading of the elevator car, the load reaches a value which is in the balanced zone, such as 3000 pounds. This results in closure of the switches WB1 and WB2 (Fig. 1). Closure of the switch WB1 has no immediate effect on the operation of the system. However, closure of the switch WB2 completes the following circuit.

L+1, LU3, LD3, WB2, U, 6, 72T1, L-1

The energized up switch U closes its make contacts U2 and U3 for the purpose of energizing the bridge 21 in proper direction for up travel of the elevator car. Closure of the make contacts U6 has no effect on the immediate operation of the system.

The energized running relay 6 operates in the manner similar to that previously discussed. Closure of the make contacts 6-1 and 6-3 has no immediate effect on the operation of the system. Opening of the brake contact 6-2 renders effective the entire resistor R2. Closure of the make contacts 6-4 completes an energizing circuit for the armature of the regulating generator RG and the generator GE consequently starts to build up its voltage in the proper direction to produce up travel of the elevator car. Closure of the make contacts 6-5 completes an energizing circuit for the running contactor 7. Closure of make contacts 6-6 completes with the now closed contacts 32B12, WB1 and LW3-3 an energizing circuit for the load zone relay LW2. Closure of the make contacts 6-7 has no immediate effect on the operation of the system. Closure of the make contact 6-8 completes an energizing circuit for the timing relay 6T. Closure of the make contact 6-9 completes with the contacts 65-1 and the car switch CS an energizing circuit for the brake modifier relay BC. Opening of the break contacts 6-10 starts a timing out operation of the timing relay 72T. Closure of the make contacts 6-11 has no immediate effect.

In response to its energization, the running contactor 7 closes its make contacts 7-1 to complete the loop circuit between the armature of the generator and the motor, and voltage now is applied to the motor, to the loop voltage relay B and to the second loop voltage

relay BL. Closure of the make contacts 7—2 further prepares the circuit of the brake coil 5a for subsequent energization. Closure of the make contacts 7—10 has no immediate effect on the operation of the system. Closure of the make contacts 7—3 completes with the now closed contacts 6T1 a holding circuit for the running contactor. Closure of make contacts 7—8 and 7—9 has no immediate effect on the operation of the system. The energized brake modifier relay BC opens its break contacts BC1 without affecting at this time the operation of the system.

Turning now to the effect of energization of the load zone relay LW2, it will be recalled that this relay picks up to indicate the presence of a substantially balanced load in the elevator car. As a result of its pick up, this relay closes its make contacts LW2—1 and LW2—2 to shunt a substantial portion of the resistor R7. Consequently, the field excitation and voltage output of the generator GE rapidly build up. In addition, the load zone relay LW2 closes its make contacts LW2—3 to complete with the make contacts LU2 an energizing circuit for the brake relay BA. This relay closes its make contacts BA2 to establish with the make contacts 6—7 a self-holding circuit. In addition, the make contacts BA1 close to complete with the make contacts 6—3 and 7—2 and the break contacts LW3—1 an energizing circuit for the brake coil 5a and the brake-released relay BR. Inasmuch as the brake is now released, the elevator car is free to move in an upward direction. The opening of the break contacts BR1 has no immediate effect on the operation of the system. Opening of the break contacts BR2 introduces the resistor R3 in circuit with the brake coil 5a for the purpose of reducing current flowing thereto to a value sufficient merely to hold the brake in released condition.

As the voltage output of the generator GE builds up, the loop voltage relay B picks up to close its make contacts B1 without affecting the immediate operation of the system. However, when the voltage becomes sufficient to produce motion of the elevator car, the second loop voltage relay BL picks up through contacts 6—1, 32B1 and LW1—1. Consequently, break contacts BL1 now open to introduce a substantial part of the resistor R7 in series with the bridge 21. This limits the excitation and voltage output of the generator GE to a value sufficient to produce a slow leveling speed for the elevator car.

As the elevator car approaches the first landing in the up direction, the inductor relay 1UL finally leaves the plate P and opens its make contacts 1UL1 to deenergize the up leveling relay 1LU. This relay opens its make contacts LU1 and LU2 without immediate effect on the operation of the system. Closure of the break contacts LU4 also has no immediate effect on the operation of the system. However, opening of the make contact LU3 interrupts the energizing circuit for the up switch U and the running relay 6. The up switch U opens its break contacts U2 and U3 to interrupt the energization of the bridge 21 from the buses L+ and L—. Opening of make contact U6 has no effect on the operation of the system at this time.

The running relay 6 opens its make contacts 6—1 to deenergize the loop voltage relays B and BL and these relays drop out without immediate effect on the operation of the system. Closure of the break contacts 6—2 establishes with the contacts 32B2 a shunt around a portion of the resistor R2. Opening of the make contact 6—3 interrupts the energizing circuit for the brake coil 5a and the brake-released relay BR. Consequently, the brake is applied to stop the elevator car accurately at the first landing. The deenergized brake-released relay BR closes its break contacts BR1 and BR2 without immediate effect on the operation of the system.

Opening of the make contacts 6—4 and 6—5 has no immediate effect on the operation of the system. How-

ever, opening of the make contact 6—6 deenergizes the load zone relay LW2. Opening of the make contact 6—7 deenergizes the brake relay BA which opens its make contacts BA1 and BA2 without immediate effect on the operation of the system. Opening of the relay contact 6—8 deenergizes the timing relay 6T which starts to time out. Opening of the make contacts 6—9 deenergizes the brake modifier relay BC which closes its break contacts BC1 to shunt a portion of the resistor R6. Closure of the break contact 6—10 reenergizes the timing relay 72T before this relay has time to drop out. Opening of the make contacts 6—11 is without immediate effect.

The deenergized load zone relay LW2 opens its make contacts LW2—1, LW2—2 and LW2—3 without immediate effect on operation of the system.

Upon the expiration of its time delay in dropout, the relay 6T drops out and in turn, drops out the running contactor 7. This running contactor 7 resets in the manner previously described without affecting at this time the operation of the system.

It will be assumed next that the elevator car continues to receive load until it is overloaded and that the brake fails to hold the elevator car load. As a result of such loading, the switch WA and the switch WC2 are open and switches WB1, WB2 and WC1 and WD are all closed.

The elevator car drops slowly until the inductor relay 1UL reaches the inductor plate P, at which time the relay picks up to close its make contact 1UL1 and energize the up leveling relay LU. This relay closes its make contacts LU1 and LU2 without affecting at this time the operation of the system. Closure of the make contact LU3 completes the following circuit.

L+1, LU3, LD3, WB2, U, 6, 72T1, L—1

Opening of the break contacts LU4 has no effect on the operation of the system at this time.

The energized up switch operates in the manner previously described to energize the bridge 21 in the proper direction for up travel of the elevator car. The energization of the running relay 6 also operates in the manner previously described. However, the closure of the contacts 6—6 now completes with the closed switch WC1 an energizing circuit for the load zone relay LW3. This relay opens its break contacts LW3—1 to prevent energization of the brake coil 5a therethrough. Since the make contacts 32B11 are also open, it is clear that the brake cannot be released for the present operation.

In addition, the load zone relay LW3 opens its break contacts LW3—2. Since the make contacts 32B6 also are open, it is clear that the armature RGA of the regulating armature is disconnected from the bridge circuit. Consequently, the regulating generator does not amplify the energization of the generator field windings GEF1 and GEF2. It should be noted further that the entire resistor R7 is effective at this time and the energization of the generator field winding consequently is maintained at a desired low value. Finally, the load zone relay LW3 opens its break contacts LW3—3 to prevent energization therethrough of the load zone relay LW2.

It will be recalled that the pickup of the running relay 6 is accompanied by pickup of the timing relay 6T and the running contactor 7. Since these relays condition the motor MO to develop torque urging the elevator car in the up direction, it follows that the motor assists the brake in supporting the elevator car and its load. However, because of the small excitation of the generator GE resulting from disconnection of the armature RGA of the regulating generator and from the introduction of the entire resistor R7 in the energizing circuit for the bridge 21, the torque developed by the motor MO is held to a value insufficient to produce motion of the elevator car in the up direction with the brake applied. This condition is maintained until load leaves the elevator car or until the car switch CS is actuated in the manner previously described to initiate movement of the elevator car.

The overcurrent relay RE is of a time delay type. In order to prevent operation of this relay while the motor MO is assisting the brake 5 in holding the elevator car and its load, the switch WD is arranged to shunt the contacts of the relay. Inasmuch as the elevator car would not be allowed to remain long in this condition, the shunting of the relay RE does not result in damage to the electrical equipment.

Although the invention has been described with reference to certain specific embodiments thereof, numerous modifications falling within the spirit and scope of the invention are possible.

We claim as our invention:

1. In an elevator system for a structure having a plurality of landings, an elevator car, motive means for moving the elevator car relative to the structure, load-responsive mechanism operable selectively into each of a plurality of conditions dependent on the weight of the load in the elevator car, and control means cooperating with the motive means for moving the elevator car and stopping the elevator car at desired landings, said control means including leveling means responsive to displacement of the elevator car from registry with a landing at which the elevator car has been stopped in register for operating the motive means to level the elevator with the last-named landing and supervising means responsive to a predetermined one of said conditions of the load-responsive mechanism for rendering the leveling means ineffective.

2. In an elevator system for a structure having a plurality of landings, an elevator car, motive means for moving the elevator car relative to the structure, load-responsive mechanism operable selectively into each of a plurality of conditions dependent on the weight of the load in the elevator car, and control means cooperating with the motive means for moving the elevator car and stopping the elevator car at desired landings, said control means including leveling means responsive to displacement of the elevator car from registry with a landing at which the elevator car has been stopped in register for operating the motive means to level the elevator with the last-named landing, and supervising means responsive to the condition of the load-responsive mechanism and to the direction of displacement of the elevator car from the last-named landing for rendering the leveling mechanism ineffective to level the elevator car when the elevator car is displaced from the last-named landing in a first direction with a predetermined load, said supervising means permitting the leveling mechanism to operate when the elevator car is displaced from the last-named landing in a second direction with a predetermined load.

3. In an elevator system for a structure having a plurality of landings, an elevator car, motive means for moving the elevator car relative to the structure, load-responsive mechanism operable selectively into each of a plurality of conditions dependent on the weight of the load in the elevator car, and control means cooperating with the motive means for moving the elevator car and stopping the elevator car at desired landings, said control means including leveling means responsive to displacement of the elevator car from registry with a landing at which the elevator car has been stopped in register for operating the motive means to level the elevator with the last-named landing, and supervising means responsive to a predetermined one of said conditions of the load-responsive mechanism indicating a car load in excess of a predetermined heavy weight for rendering the leveling means ineffective to level the elevator car with the last-named landing.

4. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of the landings in a substantially vertical direction, counter-balance mechanism for balancing the weight of the elevator car plus a portion of the load carried by the elevator car, motive

means for moving the elevator car relative to the structure, said elevator car, the load in the elevator car and the counter-balance mechanism presenting a substantially balanced resultant load to the motive means for a first range of load weight and presenting an overhauling or hauling resultant load to the motive means dependent on a load in the elevator car outside said first range of load weight and the direction in which the load is to be moved, load-responsive mechanism operable selectively into each of a plurality of conditions dependent on the weight of the load in the elevator car, and control means cooperating with the motive means for moving the elevator car and stopping the elevator car at desired landings, said control means including leveling means responsive to displacement of the elevator car from registry with a landing at which the elevator car has been stopped in register for operating the motive means to level the elevator with the last-named landing, and supervising means responsive to the direction of displacement of the elevator car from the last-named landing and to the condition of the load-responsive mechanism for rendering the leveling means ineffective to level an overhauling load.

5. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of the landings in a substantially vertical direction, counter-balance mechanism for balancing the weight of the elevator car plus a portion of the load carried by the elevator car, motive means for moving the elevator car relative to the structure, said elevator car, the load in the elevator car and the counter-balance mechanism presenting a substantially balanced resultant load to the motive means for a first range of load weight and presenting an overhauling or hauling resultant load to the motive means dependent of a load in the elevator car outside said first range of load weight and the direction in which the load is to be moved, load-responsive mechanism operable selectively into each of a plurality of conditions dependent on the weight of the load in the elevator car, and control means cooperating with the motive means for moving the elevator car and stopping the elevator car at desired landings, said control means including leveling means responsive to displacement of the elevator car from registry with a landing at which the elevator car has been stopped in register for operating the motive means to level the elevator with the last-named landing, and supervising means responsive to the direction of displacement of the elevator car from the last-named landing and to the condition of the load-responsive mechanism for rendering the leveling means ineffective to level the elevator car when carrying a load substantially in excess of said first range of load weight and ineffective to level the elevator car in an overhauling direction when carrying a load less than said first range of load weight.

6. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of the landings in a substantially vertical direction, counter-balance mechanism for balancing the weight of the elevator car plus a portion of the load carried by the elevator car, motive means for moving the elevator car relative to the structure, said elevator car, the load in the elevator car and the counter-balance mechanism presenting a substantially balanced resultant load to the motive means for a first range of load weight and presenting an overhauling or hauling resultant load to the motive means dependent on a load in the elevator car outside said first range of load weight and the direction in which the load is to be moved, load-responsive mechanism operable selectively into each of a plurality of conditions dependent on the weight of the load in the elevator car, and control means cooperating with the motive means for moving the elevator car and stopping the elevator car at desired landings, said control means including leveling means responsive to dis-

placement of the elevator car from registry with a landing at which the elevator car has been stopped in register for operating the motive means to level the elevator with the last-named landing only if the elevator car carries a load weight less than said first range of load weight and presents a resultant hauling load to said motive means or if the loading of the elevator car provides a substantially balanced resultant load to the motive means.

7. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, electromotive means for applying a force to said elevator car dependent on the energization of the electromotive means, releasable brake mechanism for preventing movement of the elevator car relative to the structure, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator cars at desired landings, said control means comprising means for supplying a gradually-increasing energization to the electromotive means to make available gradually-increasing force for moving the elevator car, electroresponsive brake control means responsive to said energization when the electromotive means is to move a substantial hauling load for releasing the brake mechanism when said energization reaches a value sufficient for said electromotive means to support substantially the resultant load as said electromotive means, and energization-controlling means responsive to said energization for retarding the increase in said energization when the energization reaches a predetermined value sufficient to move the resultant load on the electromotive means.

8. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, electromotive means for applying a force to said elevator car dependent on the energization of the electromotive means, releasable brake mechanism for preventing movement of the elevator car relative to the structure, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator cars at desired landings, said control means comprising means for supplying a gradually-increasing voltage to the electromotive means to make available a gradually-increasing force for moving the elevator car, first relay means responsive to a first value of said voltage for releasing said brake mechanism, said first value being sufficient for the electromotive means to develop a force capable of substantially supporting a substantial hauling load, and second relay means responsive to a second value of said voltage for retarding the increase in said voltage, the second value being sufficient to produce movement of a substantial hauling load.

9. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, electromotive means for applying a force to said elevator car dependent on the energization of the electromotive means, releasable brake mechanism for preventing movement of the elevator car relative to the structure, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator cars at desired landings, said control means comprising means for assisting the brake mechanism in holding the elevator car stationary, said last-named means comprising aiding means for energizing the electromotive means to aid the brake mechanism in holding the elevator car stationary, said aiding means supplying insufficient energization to the electromotive means to produce movement of the elevator car with the brake mechanism applied.

10. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, electromotive means for applying a force to said elevator

car dependent on the energization of the electromotive means, releasable brake mechanism for preventing movement of the elevator car relative to the structure, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator cars at desired landings, said control means comprising means for assisting the brake mechanism in holding the elevator car stationary, said last-named means comprising aiding means responsive to the loading of the elevator car for energizing the electromotive means to aid the brake mechanism in holding the elevator car stationary, said aiding means supplying insufficient energization to the electromotive means to produce movement of the elevator car with the brake mechanism applied.

11. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, a counter-balance mechanism, a sheave, a flexible cable extending between the elevator car and the counter-balance mechanism over said sheave, electromotive means effective when energized for applying a vertical force to the elevator car relative to the structure, releasable brake mechanism for preventing movement of the elevator car relative to the structure, load-responsive mechanism operable from a first condition to a second condition in response to a predetermined loading of the elevator car, elevator car displacement means operable from a first condition to a second condition in response to a predetermined displacement of the elevator car from a landing, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator car at desired landings, said control means including aiding means responsive to operation of the load-responsive mechanism and the displacement means to their second conditions while the elevator car is intended to be stopped at a landing for energizing the electromotive means to aid the brake mechanism in holding the elevator car stationary, said aiding means supplying insufficient energization to the electromotive means to produce movement of the elevator car with the brake mechanism applied.

12. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, electromotive means for applying a force to said elevator car dependent on the energization of the electromotive means, releasable brake mechanism for preventing movement of the elevator car relative to the structure, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator cars at desired landings, said control means comprising protective means responsive to a predetermined energization of the electromotive means for interrupting the energization of the electromotive means, load-responsive mechanism operable from a first to a second condition in response to a predetermined loading of the elevator car, and supervising means responsive to the operating of said load-responsive mechanism to its second condition for rendering the protective means ineffective to interrupt the energization of the electromotive means.

13. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, a counter-balance mechanism, a sheave, a flexible cable extending between the elevator car and the counter-balance mechanism over said sheave, electromotive means effective when energized for applying a vertical force to the elevator car relative to the structure, releasable brake mechanism for preventing movement of the elevator car relative to the structure, load-responsive mechanism operable from a first condition to a second condition in response to a predetermined loading of the elevator car, elevator car displacement means operable from a first

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condition to a second condition in response to a predetermined displacement of the elevator car from a landing, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator car at desired landings, said control means including aiding means responsive to operation of the load-responsive mechanism and the displacement means to their second conditions while the elevator car is intended to be stopped at a landing for energizing the electromotive means to aid the brake mechanism in holding the elevator car stationary, said aiding means supplying insufficient energization to the electromotive means to produce movement of the elevator car with the brake mechanism applied, protective means responsive to a predetermined energization of the electromotive means for interrupting the energization of the electromotive means, and supervising means responsive to the operation of the load-responsive mechanism to its second condition for rendering the protective means ineffective to interrupt the energization of the electromotive means.

14. In an elevator system for a structure having a plurality of vertically-spaced landings, an elevator car for carrying load from one to another of said landings, a counter-balance mechanism, a sheave, a flexible cable extending between the elevator car and the counter-balance mechanism over said sheave, electromotive means effective when energized for applying a vertical force to the elevator car relative to the structure, releasable brake

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mechanism for preventing movement of the elevator car relative to the structure, load-responsive mechanism operable from a first condition to a second condition in response to a predetermined loading of the elevator car, elevator car displacement means operable from a first condition to a second condition in response to a predetermined displacement of the elevator car from a landing, and control means cooperating with the electromotive means and the brake mechanism for moving the elevator car and stopping the elevator car at desired landings, said control means including aiding means responsive to operation of the load-responsive mechanism and the displacement means to their second conditions while the elevator car is intended to be stopped at a landing for energizing the electromotive means to aid the brake mechanism in holding the elevator car stationary, said aiding means supplying insufficient energization to the electromotive means to produce movement of the elevator car with the brake mechanism applied, and said control means including leveling means responsive to a loading less than said predetermined loading and to displacement of the elevator car from registry with a landing at which the car is stopped for releasing the brake mechanism and energizing the electromotive means to level the elevator car with the last-named landing.

No references cited.