May 7, 1935. P. C. KEIPER 2,000,703

ELEVATOR CONTROL SYSTEM

Filed April 27, 1932 2 Sheets-Sheet 1

Fig. 1.

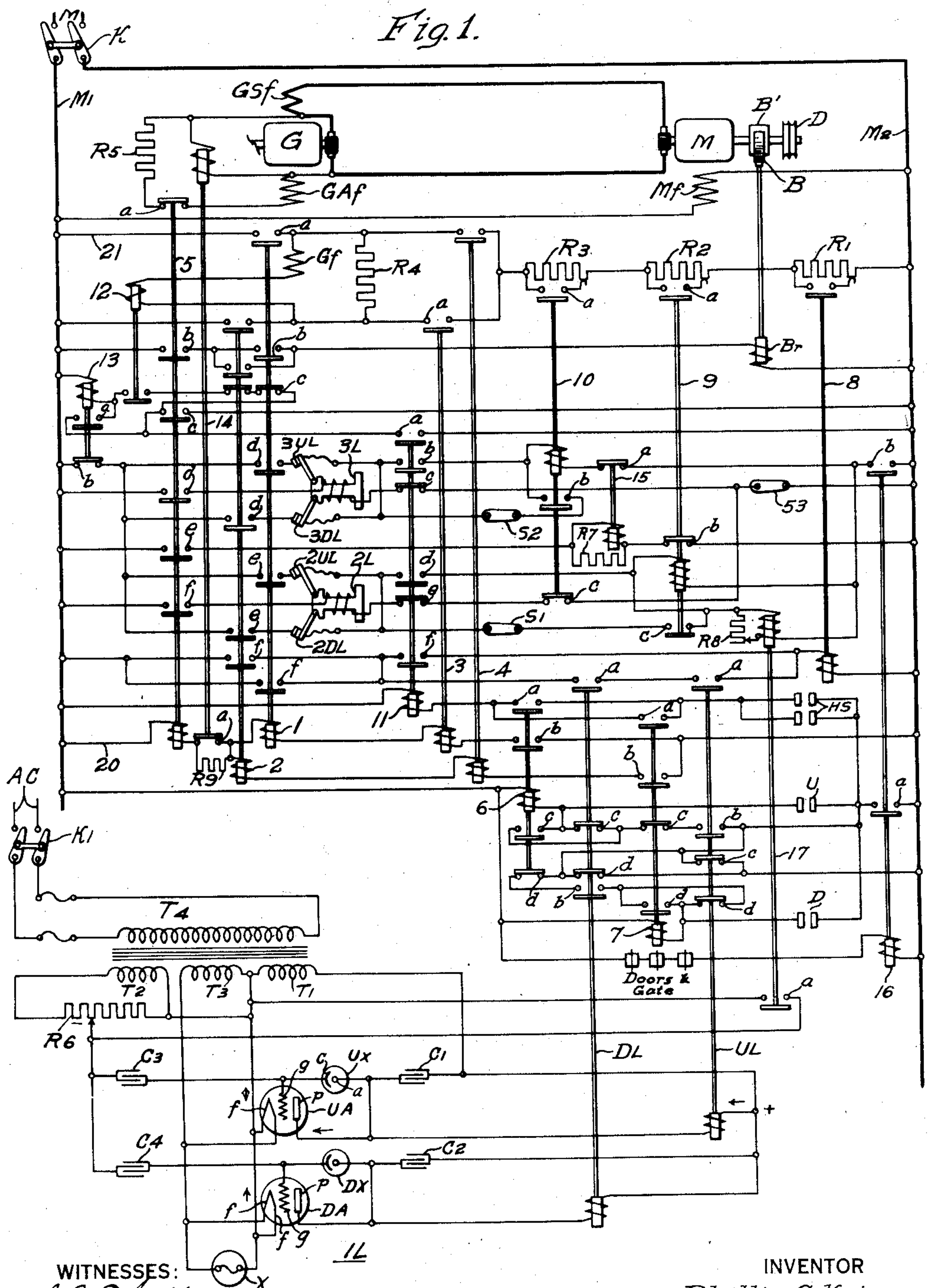

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Fig. 3.

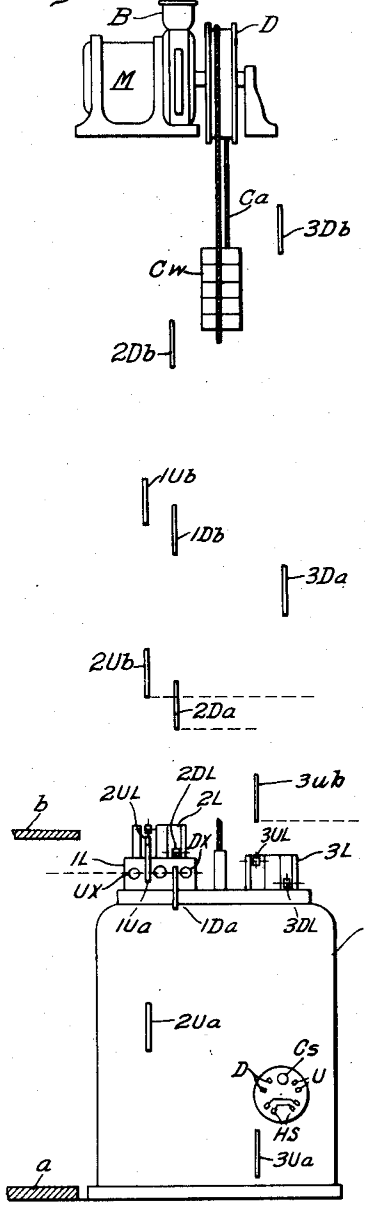
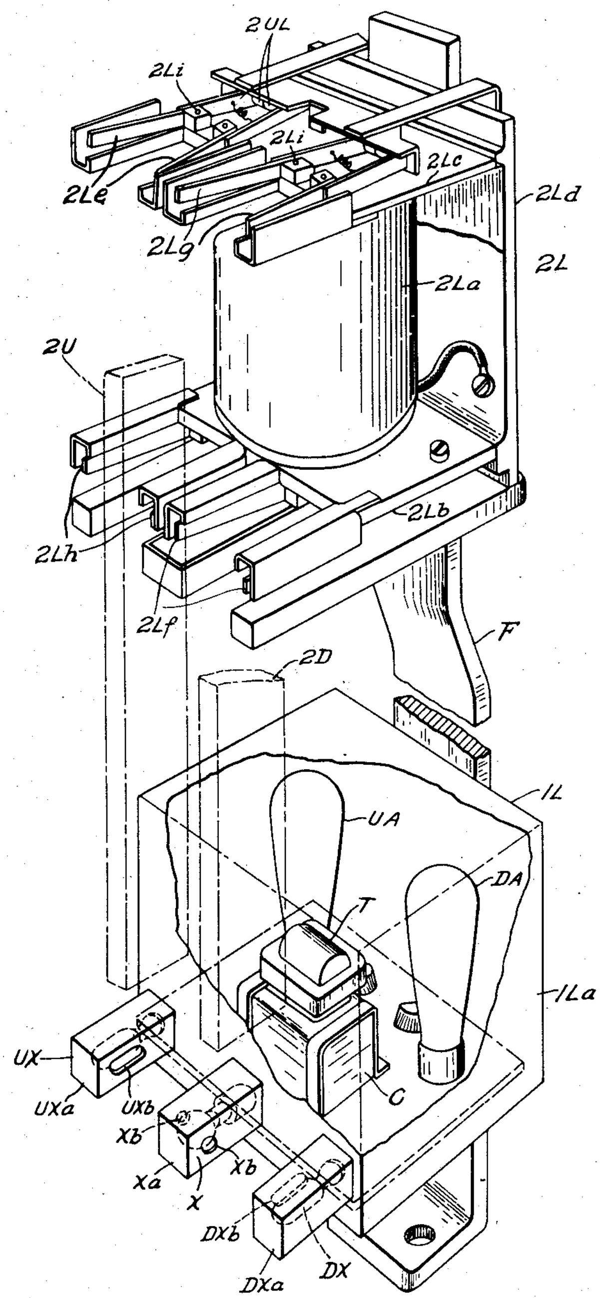


Fig. 2.



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UNITED STATES PATENT OFFICE

2,000,703

ELEVATOR CONTROL SYSTEM

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Application April 27, 1932, Serial No. 607,705

46 Claims. (Cl. 187—29)

My invention relates to electric elevator systems, and more particularly to systems in which switching devices mounted partly on the elevator car and partly in the elevator hatchway are employed to commutate various circuits in accordance with the position of the car in the hatchway.

In systems of this general character, which are well known in the prior art, the usual arrangement comprises a plurality of switching devices carried upon the elevator car, one for each circuit or group of circuits to be commutated, and disposed to cooperate with devices spaced at predetermined intervals in the hatchway. The arrangement has been such, however, that each of the switches must be mounted in a separate vertical plane, in order to prevent interference, and to obtain the proper sequence of operation of the switches.

In the more complicated elevator systems, which require commutation of a substantial number of such circuits, the switches require a considerable amount of space on top of the elevator car, and the mounting thereof in separate vertical planes becomes a serious problem.

In the majority of elevator systems, the rails which guide the movements of the elevator car are mounted on two sides of the elevator hatchway for cooperation with guide shoes resiliently mounted on the elevator car. Due to the fact that the spacing between the rails cannot be maintained constant throughout the hatchway, it is necessary to construct the guide shoes to permit a certain amount of relative movement between them and the car. This limited movement is ordinarily of the order of from three-fourths of an inch to one inch. It is also impossible to keep the load in the elevator car evenly distributed, and it frequently happens, therefore, depending upon the distribution of load in the car, that the car will be moved to one side of the hatchway or the other. It therefore becomes impractical to mount control apparatus on the sides of the elevator car which are parallel to the plane of such lateral movement.

A portion of the remaining two sides of the elevator car, which are available for the mounting of hatchway switching devices is taken up by other apparatus which must be mounted upon the elevator car. This additional apparatus comprises, in general, the mechanism for driving the governor cable, a junction box to receive the hanging cables which carry conductors which connect the electrical apparatus on the car with the main controller for the elevator, the limit switch mechanisms, the cross head beam on which the guide shoes are mounted, etc. It is usually found that the only space available for the mounting of the hatchway switching devices is limited to that on one side of the car, between the cross head beam and the side of the car, and with relatively small cars, it becomes very difficult to locate the required number of switches in this limited space.

The present invention comprises an arrangement of apparatus whereby more than one hatchway switch may be mounted in a single vertical plane, without permitting interference between the several switches in the same plane, and without disturbing the proper sequence of operation of the several switches. In a preferred embodiment of the present invention, to be hereinafter more fully described, this objective is effected partly by using hatchway switching devices having different operating characteristics, whereby a particular switch, although brought adjacent the hatchway members associated with other switches, is not caused to operate until brought adjacent the hatchway member associated with the particular switch; and partly by so arranging the circuits that operation of certain of the devices is dependent upon previous operation of others of the devices.

In the prior elevator art, a number of types of switching devices comprising a part carried on the car and a part mounted on the hatchway, have been used to commutate various control circuits in accordance with the position of the car in the hatchway. These include devices which are mechanically operated, devices which are inductively operated, devices which are magnetically operated, and devices which are operated through the cooperation between a source of light and a light sensitive device. Arrangements of the latter three types, which are preferable in high speed systems, due to quietness of operation and minimized danger of breakage, are illustrated and described respectively in patents to Claytor, granted May 16, 1933; Williams et al. 1,902,602, granted March 21, 1933; and Mattingly, 1,865,937, granted July 5, 1932, all of which are assigned to the Westinghouse Electric and Manufacturing Company.

In the practice of the present invention, I prefer to use switching devices of the magnetically operated type and of the light sensitive type. As described in the Williams et al. Mattingly patents, above identified, the magnetically operated devices comprise a switch having a portion of the magnetic circuit thereof carried upon the elevator car and the remaining portion thereof mounted in the hatchway, while the light sensitive arrangement comprises a source of light and a light sensitive device normally disposed to be illuminated by the light, both carried by the elevator car, and an opaque shield mounted in the hatchway to intercept the light.

The opaque shield may, of course, be made of a non-magnetic material. It is seen, therefore, that although the light sensitive unit and the magnetic unit are mounted in the same vertical plane, the opaque shield is effective to cause operation of only the light sensitive unit. The magnetizable member may, of course, be in the form of a preforated plate, which, while effective to operate the magnetic device would be ineffective to interrupt sufficient of the light from the light source to operate the light sensitive device. In the illustrated embodiment of the present invention, however, the usual solid magnetizable plate is employed, and independent means are provided to render the interruption of the light ineffective to actuate the apparatus controlled by the light sensitive device.

A representative use to which switches of the character in question may be put is that of controlling the deceleration, stopping, and, in certain cases, the leveling, of the elevator car, and in the illustrated embodiment of the present invention, the hatchway switching devices are used for these purposes.

The present invention, in addition to providing an arrangement to reduce the space requirements of the hatchway switching devices also comprises a novel leveling arrangement. In the usual prior art leveling arrangement an up-leveling switch and a down-leveling switch are mounted upon the elevator car for cooperation, respectively, with an up-leveling cam and a down-leveling cam, mounted in the hatchway in such positions that when the elevator car is level with the floor landing, both switches are out of engagement with the respective cams. In these systems, if the elevator car stops at, or drifts to, a point other than level with the landing, one of the switches is brought into engagement with the associated cam and is, therefore, actuated to complete circuits to cause the car to move to the landing. In these systems, since the leveling circuits are only completed when one of the switches is in engagement with the associated cam, the leveling zone is determined by the length of the cams. Accordingly, if the car stops or drifts to a point beyond the limits of the cams, no leveling movement takes place.

According to the present invention, however, the arrangement is such that the leveling zone is independent of the dimensions of the hatchway device. Accordingly, in the present arrangement, although relatively short devices may be mounted in the hatchway, the leveling zone is unlimited.

In addition to requiring a relatively simple circuit arrangement whereby the above leveling feature may be attained, a light sensitive arrangement having many of the features of the arrangement disclosed in the above identified Mattingly patent is particularly advantageous in controlling the leveling operations, in view of the extreme accuracy of operation of these devices. Accordingly, in the illustrated embodiment of my invention, light sensitive devices are used to control the leveling circuits.

As noted above, the leveling arrangement is such that the length of the leveling zone is in no way determined by the length of the shields, mounted adjacent the floor level. In the illustrated embodiment of the present invention, however, shields of from six to eight inches in length are used, since the present invention also comprises a circuit arrangement whereby under certain conditions of operation, one of the light sensitive devices controls a step of deceleration, from high leveling speed to landing speed, when one limit of the shield is reached, and, under other conditions controls the stopping of the car, when the other limit of the shield is reached. In accordance with this arrangement, although two leveling speeds are provided, for each direction of travel, a total of two light sensitive units is effective to control all four operations. By arranging each device to control more than one separate control function, it will be observed that less apparatus is required, thereby further reducing the space requirements of the hatchway switching devices without reducing the number of steps of deceleration.

It is accordingly an object of the present invention to provide an elevator system in which a plurality of independent hatchway switching devices may be mounted in the same vertical plane without producing interference or disturbing the proper sequence of operation of the switches.

It is a further object of the present invention to provide such an arrangement in which hatchway switches having different operating characteristics are employed whereby the cooperating hatchway members associated with other switches, although brought adjacent a particular switch, are ineffective to actuate that switch.

It is a further object of the present invention to provide such a system in which magnetically operated devices and light sensitive devices are arranged to selectively effect various control operations.

It is a further object of the present invention to provide an elevator system in which the leveling zone of the elevator is independent of the dimensions of the devices, mounted in the hatchway, which initiate the leveling operations.

A further object of the present invention is to provide a leveling system of the above type in which light sensitive devices are used to control the leveling operations.

It is a further object of the present invention to provide an elevator system in which a single hatchway switching device is effective to control a plurality of separate switching operations.

More particularly stated, it is a further object of the present invention to provide a system of the above character in which a single hatchway switching device is effective under certain conditions, to control a stopping operation, and is effective under other conditions, to control a step of deceleration.

Other objects and advantages of the present invention will be apparent in the course of the following detailed description thereof.

Referring to the drawings,

Figure 1 is a schematic diagram of a control system embodying the present invention,

Fig. 2 is a view in perspective, showing the relative positions and certain details of the magnetically operated, and light sensitive operated, switching devices used in the practice of the present invention, and

Fig. 3 is a view showing the relative positions, on the car, of the hatchway switching devices, and the members mounted in the hatchway for cooperation therewith, respectively.

In Fig. 1, a motor M, having a field winding M*f*, is connected to receive power from a generator G in accordance with the Ward Leonard or variable-voltage principle. Motor M is directly connected to a shaft which carries a brake-drum B, and a cable-drum D, over which the hoisting cables *Ca* pass. The elevator car C and counterweights *Cw* are attached to the opposite ends of cables *Ca*, in the usual manner.

Generator G, which is continuously driven at substantially constant speed by any suitable means (not shown), is provided with a separately excited field winding G*f*, a demagnetizing field winding GA*f* and a series field winding GS*f*.

Winding GS*f* is directly connected in the armature circuit of motor M and generator G and is designed to raise or lower the voltage of generator G, depending upon the magnitude and character of the load exchanged between the motor M and generator G, to render the speed of motor M substantially independent of load.

Winding GA*f* is arranged for connection, through a main switch **5**, across the armature terminals of generator G, at the expiration of the slow down operation, and is wound to produce a magnetomotive force in opposition to the residual magnetism of that machine, and therefore, to reduce the voltage thereof quickly to substantially zero.

Winding G*f*, which controls the direction and speed of operation of motor M, is arranged for connection across line conductors M**1** and M**2** through either of two sets of reversing switches **1** and **3** or **2** and **4**.

The reversing switches **1** and **3** and **2** and **4** are controlled, respectively, by up-direction relay **6** and down-direction relay **7**. The latter relays are also jointly control the main switch **5**.

Direction relays **6** and **7** are arranged for control, respectively, by car-switch contact members U and D. These relays are also subject to the joint control of leveling relays UL and DL. High-speed relay **10**, intermediate-speed relay **9**, and high-leveling-speed relay **8** are controlled by accelerating relay **11**. Relay **11**, in turn, is subject to joint control by car-switch contact members HS, and leveling relays UL and DL.

Speed-limiting relay **13**, current-relay **12**, and anti-plugging relay **14** are employed in connection with the late-stop feature of the present invention.

Auxiliary relay **15** is controlled by intermediate-speed relay **9** and main switch **5**, and is arranged to delay the operation of high-speed relay **10**, during acceleration.

Relay **16** is included in the door safety circuit, and controls a plurality of circuits including the high speed circuits and certain of the leveling circuits.

In accordance with the illustrated arrangement, the starting and acceleration to full speed of motor M is under the control of car-switch contact members U, D and HS. Referring to Fig. 3, these contact members are shown as carried upon the elevator car C for control by the usual rotatable car switch C*s*. In the conventional manner, clockwise rotation of switch C*s* is effective to sequentially close contact members U and contact members HS, while counter-clockwise rotation of switch C*s* is effective to sequentially close contact members D and contact members HS.

As discussed hereinbefore, the deceleration and leveling of the elevator car is controlled by means of switching devices carried partly upon the elevator car. In Fig. 1, these devices are illustrated schematically as switches **3**L, **2**L and a combination of apparatus shown at the bottom of the figure and identified generally as **1**L. As indicated hereinbefore, switches **3**L and **2**L are both of the magnetically operated type, while the apparatus identified as **1**L is of the light sensitive type.

Referring to Fig. 2, and as described in the Williams et al. application, identified hereinbefore switch **2**L, of which switch **3**L is a duplicate, comprises an electro-responsive or energizable coil **2**L*a*, the magnetic circuit of which includes the end plates **2**L*b* and **2**L*c*, a back plate **2**L*d* and a plurality of sets of fingers **2**L*e*, **2**L*f* **2**L*g* and **2**L*h*. The respective contact fingers **2**L*e*, **2**L*f*, **2**L*g* and **2**L*h* are mounted for a limited amount of rotation about pins **2**L*i*. As illustrated, contact fingers **2**L*e* normally occupy positions in which a set of contact members **2**UL controlled thereby is maintained in the closed position. Contact fingers **2**L*f* are similarly arranged to normally maintain a pair of contact members **2**DL in the closed position, although the latter contact members are not visible in Fig. 2. Contact fingers **2**L*g* and **2**L*h* are similarly provided, although the contact members associated with these fingers are not utilized in the system shown in Fig. 1.

The arrangement is such that, although coil **2**L*a* is energized, the several pairs of contact members are subjected to no magnetic force tending to cause rotation thereof about the respective pins **2**L*i* to thereby open the contact members associated therewith. If, however, a magnetizable plate, as **2**U, is moved into the slot between the extreme ends of fingers **2**L*e*, the flux density is substantially increased, and direction of the magnetic field between these fingers and the plate assumes such a direction as to rotate them about the pins **2**L*i* and thereby open the contact members **2**UL. Similarly, if a magnetizable plate **2**D is moved into the slot between the fingers **2**L*f*, these fingers are actuated to open the contact members **2**DL. As will be obvious, the magnetic force on the contact fingers is a maximum when a plate occupies a position opposite the slots of both ends of the switch, and the actuation of the contact members normally occurs when plate and switch occupy such relative positions.

Referring to Fig. 3, switches **2**L and **3**L are shown as mounted on the top of elevator car C, which is movable past floor levels *a* and *b*. Magnetizable iron plates **3**U*a* and **3**U*b* are mounted in the hatchway in positions to cooperate with switch **3**L and actuate contact members **3**UL thereof, and thereby interrupt the high speed circuits of the elevator car as the car approaches floors *a* and *b*, respectively, in the up direction.

A similar set of plates **3**D*a* and **3**D*b* is mounted in the hatchway in positions to pass between the fingers of switch **3**L which control contact members **3**DL and thereby interrupt the high speed circuits as the car approaches floors *a* and *b*, respectively, in the downward directions.

Similarly, a set of plates **2**U*a*, **2**U*b*, and **2**D*a* and **2**D*b* are provided to cooperate with switch **2**L, to actuate contact members **2**UL and **2**DL thereof, respectively, to interrupt the intermediate speed circuits of the elevator car during upward and downward travel thereof respectively.

In practice, the plates are normally from ten to twelve inches in length, or slightly longer than the vertical dimension of the switches.

As will be obvious from Fig. 3, the positioning of plates **3**U*a*, **3**D*a*, **2**U*a* and **2**D*a*, etc. with respect to the floor levels *a* and *b* depends upon the maximum speed of the elevator car. In a representative system arranged for operation at approximately 600 feet per minute, the series of plates arranged for cooperation with switch **3L** are so mounted as to actuate the associated contact members when the elevator car is at a distance of from ten to eleven feet from a selected floor; the series of plates associated with switch **2L** are disposed to actuate the associated contact members when the elevator car is at a distance of from five to six feet from the associated floor.

The light sensitive apparatus **1L** comprises, in general, two electro-responsive or light sensitive cells, associated, respectively, with the up and down directions of travel, and cooperating optical elements whereby the condition of illumination of the cells may be controlled in accordance with the relative positions of the several elements. In the illustrated embodiment, the arrangement of circuits and apparatus is such that the cells are preferably in a current conducting condition except when the car is substantially level with a floor landing. Accordingly, the associated optical elements comprise a source of light normally disposed to illuminate the cells, and cooperating members disposed to effect the darkening of the associated cells when the car reaches a point substantially level with the landing.

Returning to Fig. 2, the device **1L** is shown as comprising a source of light X, a light sensitive cell UX and a light sensitive cell DX, all of which are mounted, in spaced relation, in the same horizontal plane. The source of light X is provided with a casing X*a* having small apertures X*b* on opposite sides thereof through which a restricted beam of light is passed. Similarly, light sensitive cells UX and DX are provided with casings UX*a* and DX*a* which are provided respectively with longitudinal apertures UX*b* and DX*b*, which permit the restricted beam of light from the source X to fall upon the associated light sensitive cells. The respective casings are attached to the main casing **1L***a* in any suitable manner.

The remaining apparatus associated with the light sensitive cells UX and DX is mounted within the main casing **1L***a*, and comprises two amplifying tubes UA and DA, a transformer T, and a condenser C. The electrical characteristics and relationship of the several elements of the device **1L** will be described in connection with Fig. 1, in a later paragraph.

The switching devices **1L** and **2L** are both connected directly to the angle bracket F, and as shown in Fig. 3, the entire assembly is mounted directly on the top of the elevator car C.

As shown in both Figs. 2 and 3, the relative positioning of switch devices **1L** and **2L** is such that the slot between contact fingers **2L***e* is in vertical alignment with the space between casings UX*a* and X*a*, and that the slot between contact fingers **2L***f* is in vertical alignment with the space between the casing X*a* and casing DX*a*.

The actuating means associated with switching device **1L** comprises a pair of opaque shields of non-magnetic material, associated with each floor. Referring again to Fig. 3 a series of plates **1U***a* and **1D***a* are mounted in the hatchway to control switching device **1L** when the car is adjacent floor *a*, and a similar set, **1U***b* and **1D***b*, is mounted in the hatchway to control switching device **1L** when the car is adjacent floor *b*. The relative positioning of the plates is such that, if car C is exactly level with a floor landing, light-sensitive device **1L** occupies a position in which the beams of light between the source X and cells UX and DX are interrupted, respectively, by shields **1U***a* and **1D***a*.

When the car is moving upwardly, in the region just below floor a, shield **1D***a* interrupts the light falling on light sensitive cell DX, thereby reducing the speed from the high-leveling value to the landing value; as the car approaches the floor more closely, shield **1U***a* interrupts the light falling on cell UX, thereby stopping the car. During downward travel, shield **1U***a* controls the deceleration from high-leveling speed to landing speed and shield **1D***a* controls the stopping of the car.

In a typical system, the high-leveling speed may be of the order of from 50 to 60 feet per minute, in which case the high leveling speed circuits are interrupted when the car is from six to seven inches away from the floor; the landing speed may be of the order of from 15 to 25 feet per minute, depending upon the landing-accuracy required, in which case the stopping circuits are interrupted when the car is from one-quarter to one-half an inch away from the floor.

Accordingly, shield **1U***a* extends from one-quarter to one-half an inch below, and from six to seven inches above the point occupied by the center line of switch **1L** when the car is level with the floor; shield **1D***a* extends from one-quarter to one-half an inch above and from six to seven inches below the corresponding point. The shields associated with the other floors are similarly arranged.

Returning to Fig. 1, the light-sensitive cells UX and DX, are arranged to control leveling relays UL and DL respectively, through the intermediary of amplifiers UA and DA, the respective light-sensitive cells being connected in the grid circuits of the associated amplifiers. The light-sensitive cells are preferably, though not necessarily, of the two-element evacuated type comprising a photo-sensitive cathode *c* and an anode *a*. As is well known in the art, the resistance of these cells is substantially inversely proportional, throughout a predetermined range, to the amount of light falling upon the photo-sensitive cathode. The amplifiers UA and DA are preferably, although not necessarily, of the three-element vacuum type comprising filaments *f*, plates *p* and grids *g*.

The coils of leveling relays UL and DL are connected, respectively, in the plate circuits of amplifiers UA and DA across a source of alternating current, represented as the secondary winding **T1** of a transformer T. The light-sensitive cells UX and DX are connected respectively in the grid circuits of amplifiers UA and DA, the grids being connected, respectively, in series with condensers *c***3** and *c***4**, to a point of lower potential than the cathodes of the associated amplifiers.

The filaments of amplifiers UA and DA, and the source of light X are supplied with current from secondary winding **T3** of transformer T. Condensers *c***1** and *c***2** are connected in parallel, respectively, with the coils of leveling relays UL and DL, and serve to smooth out current changes, in the usual manner.

In the illustrated embodiment, the circuit arrangement is such that when the light-sensitive cells UX and DX are darkened, the negative bias of grids *g* is sufficient to reduce the plate current of the associated amplifiers to substantially zero. Accordingly, under these conditions, the coils of leveling relays UL and DL are deenergized and these relays occupy the illustrated positions. If, however, a beam of light is permitted to fall upon the cathode of either of the cells UX and DX, the resistance of that cell is decreased and the potential of the associated grid *g* is raised sufficiently to increase the plate current of the associated amplifier UA or DA to the value required to actuate the associated relay UL or DL. Since the light beams may be controlled with considerable accuracy, by limiting apertures UX*b* or DX*b*, or through use of lenses, and since cells UX and DX and amplifiers UA and DA respond almost instantaneously, it is obvious that light sensitive device 1L is effective to commutate the leveling circuits with corresponding accuracy.

As previously described, it is desirable, under certain conditions, to render relays UL and DL independent of the condition of light-sensitive cells UX and DX, respectively. To accomplish this, independent means to maintain sufficient voltage across these relays to either actuate them or to maintain them actuated may be provided. In the illustrated embodiment, the independent means comprises sequence relay 17, contact members *a* of which are maintained closed throughout the upper portion of the speed range of the elevator system and occupy the open position throughout the lower portion of the speed range. Contact members *a* of sequence relay 17 control the point at which the grid circuits of amplifiers UA and DA are connected to potentiometer resistor R6, associated with secondary winding T2 of transformer T. Closure of contact members *a* shunts an adjustable portion of resistor R6 and is effective to raise the potentials of grids *g* by an amount sufficient to increase the plate currents of the associated amplifiers to the value required to actuate the associated leveling relays UL and DL.

The circuits controlled by the contact members of the leveling relays UL and DL for effecting the starting, operating and stopping of the hoisting motor as a means to move the car are called the leveling circuits or leveling connections. The circuits controlled by the up leveling relay UL are the up leveling connections. The circuits controlled by the down leveling relay DL are the down leveling connections.

The light sensitive cells UX and DX and the cooperating opaque plates 1U*a*, 1D*a*, 1U*b* and 1D*b* comprise the leveling mechanism which, through the relays UL and DL control the leveling circuits or leveling connections, the cell UX and the plates 1U*a* and 1U*b* comprising the elements of the up leveling mechanism, and the cell DX and the plates 1D*a* and 1D*b* comprising the elements of the down leveling mechanism.

The several features of the present invention may best be understood from a detailed analysis of several operating cycles of the system.

Returning to Fig. 1, the system may be placed in condition for operation by energizing the driving motor (not shown) to thereby bring generator G up to running speed, by closing manual switch K to connect line conductor M1 and M2 to a source of direct current M, and by closing switch K1 to thereby connect the primary winding T4 of transformer T to a source of alternating current AC.

Bringing generator G up to full speed is without effect, since winding G*f* is deenergized and the voltage of generator G*l* is accordingly zero. Closure of switch K completes the circuit for the field winding M*f* of motor M, thereby preparing this machine for operation upon the application of voltage to the armature thereof. Closure of switch K1 applies voltage to the amplifiers UA and DA, and to the cells UX and DX. Relays UL and DL are not actuated, however, since contact members *a* of relay 17 are open, and, as illustrated in Fig. 3, the beam of light from source X are interrupted by plates 1U*a* and 1D*a*, respectively.

If all of the hatchway doors and the car gate are closed, door relay 16 is actuated to close contact members *a* and *b*.

Assuming that it is desired to move elevator car C upwardly, car switch C*s* (Fig. 3) may be moved in a clockwise direction to close contact members U and HS. In practice, switch C*s* is moved directly to the extreme position. For the purposes of this description, however, the operations caused by closure of contact members U and HS will be considered separately.

Upon closure of contact members U, a circuit is completed for the coil of up-direction relay 6, which extends from line conductor M1, the coil of relay 6, contact members U and contact members *a* of door-relay 16 to line conductor M2. Upon completion of this circuit, relay 6 is actuated to close contact members *a*, *b* and *c* and to open contact members *d*.

Closure of contact members *a* of relay 6 prepares a circuit for the coil of accelerating relay 11, which circuit is controlled by the car switch contact members HS. Closure at contact members *c* prepares a holding circuit for the coil of relay 6. Opening of contact members *d* is without immediate effect.

Closure of contact members *b* of relay 6 completes a circuit for the coils of main switch 5 and reversing switches 1 and 3. This circuit extends from line conductor M1 through the coil of switch 5, normally closed contact members *a* of anti-plugging relay 14, the coils of reversing switches 1 and 3, and contact members *b* of relay 6 to line conductor M2. Upon completion of this circuit, switch 5 is actuated to open contact members *a* and to close contact members *b*, *c*, *d*, *e* and *f*, reversing switch 1 is actuated to close contact members *a*, *b*, *d*, *e* and *f*; and to open contact members *c*; reversing switch 3 is actuated to close contact members *a*.

The opening of contact members *a* of switch 5 interrupts the circuit of the demagnetizing winding GA*f* which operation is without effect during acceleration. Closure of contact members *b* of switch 5 prepares a circuit for the release coil B*r* of the electromagnetic brake. Closure of contact members *c* of switch 5 is without effect, during acceleration. Closure of contact members *d* and *f* of switch 5 completes, respectively, the circuit for the windings of slow-down switches 3L and 2L, which operations are without effect, since these switches are not opposite any of the magnetizable plates associated therewith. Closure of contact members *e* of switch 5 completes a circuit for the coil of auxiliary accelerating relay 15, which is thereby actuated to open contact members *a* thereof.

Closure of contact members *a* of switches 1 and 3 completes a circuit for the separately excited field winding G*f* of generator G, which circuit extends from line conductor M1 through contact members *a* of switch 1, through field winding G*f* and resistor R4 in parallel, contact members *a* of switch 3 and thence to line conductor M2 through accelerating resistors R1, R2 and R3. Completion of the above circuit also energizes the winding of an auxiliary relay 12, the function of which will be described in connection with an emergency stopping operation.

Upon completion of the above circuit for winding Gf, sufficient magnetomotive force is impressed on the field structure of generator G to cause this machine to generate a voltage corresponding to the lowest or landing speed of elevator car C. Accordingly, upon release of the electromagnetic brake B, the coil Br of which is energized in response to closure of contact members b of switch 1, the elevator car is caused to start upwardly and accelerate to the landing-speed.

The opening of contact members c of switch 1 is without effect during acceleration. Closure of contact members d, e and f of switch 1 prepares circuits for the coils of high-speed relay 10, intermediate-speed relay 9, and high-leveling-speed relay 8, respectively.

Assuming that it is desired to operate the car at high speed and that car switch contact members HS are closed, a circuit is completed for the coil of accelerating relay 11, which circuit extends from line conductor M1 through the coil of relay 11, contact members a of up-direction relay 6, car switch contact members HS and through contact members a of door-relay 16 to line conductor M2.

Upon completion of this circuit, relay 11 is actuated to close contact members a, b, d and f and to open contact members c and e. Closure of contact members a is without effect, since the circuit for speed limiting relay 13 is interrupted elsewhere. The opening of contact members c and e has no effect other than to interrupt the previously traced circuits for the coils of slow-down switches 3L and 2L.

Closure of contact member f completes a circuit for the coil of high-leveling-speed relay 8, which is thereby actuated to short circuit resistor R1, increasing the current in the field winding Gf, which results in a corresponding increase in the voltage of generator G and the acceleration of motor M to the high leveling speed.

Closure of contact members d of relay 11 causes completion of circuits for the coils of intermediate-speed relay 9 and sequence relay 17, which circuit extends from line conductor M1, through normally closed contact members of relay 13, contact members e of reversing switch 1, contact members 2UL of slow-down switch 2L, contact members d of accelerating relay 11, in parallel through the coils of relays 9 and 17, and through contact members b of door relay 16 to line conductor M2. Closure of contact members b of accelerating relay 11 prepares a circuit for the coil of high-speed relay 10, which circuit is subject, however, to the now open contact members of auxiliary relay 15.

Upon being energized, sequence relay 17 is actuated to close contact members a, thereby short circuiting an adjustable portion of resistor R6. As previously described, this operation results in reducing the negative bias of the grid g of amplifiers UA and DA by an amount sufficient to increase the plate currents of these amplifiers to the values required to actuate leveling relays UL and DL, respectively. Accordingly, these relays are actuated to close, respectively, contact members a and b and to open contact members c and d. Closure of contact members a of relays DL and UL completes a maintaining circuit for the coil of high-leveling-speed relay 8, which is independent of accelerating relay 11. The operation of the remaining contact members of relay DL, and the opening of contact members c and d of relay UL is without effect, but closure of contact members b of relay UL completes a maintaining circuit for the coil of up-direction relay 6, which is independent of car switch contact members U. This circuit extends from the coil of relay 6, through contact members c thereof, the now closed contact members c of down direction relay 7 contact members b of leveling relay UL and through contact members a of door relay 16 to line conductor M2.

Upon being energized, intermediate-speed relay 9 is actuated to close contact members a and c, and to open contact members b. Closure of contact members a excludes resistor R2 from the circuit of field winding Gf, thereby increasing the voltage of generator G, and causing motor M to accelerate to intermediate speed.

Closure of contact members c of intermediate speed relay 9 completes a maintaining circuit for the coils of relays 9 and 17, which is independent of accelerating relay 11. This circuit extends, as previously traced, through contact members 2UL of slow-down switch 2L, thence through manual-and-automatic switch S1, contact members c of intermediate-speed relay 9 and thence through the coils of relays 9 and 17, as previously traced.

The opening of contact members b of intermediate-speed relay 9 interrupts the previously completed circuit for the coil of auxiliary relay 15. Upon interruption of this circuit, the energy stored in the coil of relay 15 discharges through a local circuit including resistor R7. At the expiration of a time interval determined by the ratio of resistance to inductance in this discharge circuit, relay 15 resumes the illustrated position, thereby closing contact members a, and completing the circuit for the coil of high-speed relay 10. The circuit for high-speed relay 10 extends from line conductor M1 through normally closed contact members of relay 13, contact members d of reversing switch 1, contact members 3UL of slow-down switch 3L, contact members b of accelerating relay 11, the coil of high-speed relay 10, contact members a of relay 15 and contact members b of door relay 16 to line conductor M2.

Upon being energized, high-speed relay 10 is actuated to close contact members a and b and to open contact members c. Opening of contact members c is without immediate effect. Closure of contact members b completes a maintaining circuit for the coil of high speed relay 10 which is independent of accelerating relay 11 and extends, as previously traced, through contact members 3UL of slow-down switch 3L, thence through manual-and-automatic switch S2, contact members b of high-speed relay 10 and thence through the coil thereof to line conductor M2, as previously traced. Closure of contact members a excludes resistor R3 from the circuit of field winding Gf, thereby increasing the voltage of generator G and causing motor M to accelerate to the maximum speed.

Referring briefly to Fig. 3, it will be observed that as car C moved upwardly from the floor landing, light sensitive device 1L was first moved out of range of shield 1Da and then out of range of shield 1Ua. As previously described, the resulting illumination of light sensitive cells DX and UX results in a further increase in the potentials of grids g of amplifiers DA and UA, thereby increasing the plate currents thereof.

In the present description, it was assumed that the energization of sequence relay 17 occurred prior to the illumination of cells UX and DX, which condition normally occurs, since, as previously described, it is usual practice for the operator to move the car switch *Cs* directly to the extreme position. Under these conditions, the subsequent illumination of cells UX and DX has no effect other than to further increase the excitation of the coils of leveling relays UL and DL, respectively.

If, however, it had been desired to limit the speed of the car to the high leveling speed, car switch contact members HS would not have been closed. Under these circumstances, the energization of leveling relays DL and UL would not have occurred, respectively, until light sensitive device 1L was moved out of range of shields 1*Da* and 1*Ua* to sequentially illuminate cells DX and UX. Under these conditions further, closure of contact members *a* of leveling relays UL and DL would have resulted in the initial energization of the coil of high leveling speed relay 8, to accelerate the car to high-leveling-speed, since contact members *f* of relay 11 would not have been closed. The effect of the remaining contact members of leveling relays UL and DL would have been as previously described. It will be observed that during acceleration, in response to closure of car switch contact members U, the sequence of energization of leveling relays UL and DL is immaterial, and also that it is immaterial whether the energization of these relays occurs as a result of the actuation of sequence relay 17 or as a result of the illumination of the light sensitive cells associated therewith.

Accordingly, it will be observed that as long as car switch contact members U and HS are maintained closed, the circuits for up-direction relay 6, main switch 5, reversing switches 1 and 3, brake coil *Br*, accelerating relay 11, sequence relay 17, high-leveling-speed relay 8, intermediate-speed relay 9, high-speed relay 10, and leveling relays UL and DL remain complete and motor M is caused to move car C at high speed. As previously described, series field winding GS*f* functions in the usual manner to maintain the speed of motor M at a desired value, independent of load.

It will further be observed that, although car C may be moved past several floors, the magnetizable plates and opaque shields mounted in the hatchway are without effect on any of the slow-down switches, since the coils of slow down switches 3L and 2L are deenergized, and since sequence relay 17 maintains the grid potentials of amplifiers UA and DA at sufficiently high values that the cooperation between the cells UX and DX, and any of the shields which may be passed is not operative to affect leveling relays UL and DL.

Assuming that the elevator car is moving upwardly, at some point in the region below floor *a*, and that it is desired to stop at floor *b*, car switch *Cs* may be returned to the neutral position, thereby opening contact members HS and U. The opening of contact members U is without effect, because of the previously traced holding circuit for the coil of up-direction relay 6. The opening of contact members HS interrupts the circuit for the coil of accelerating relay 11, contact members *a*, *b*, *d* and *f* of which are opened, and contact members *c* and *e* of which are closed. The opening of the several contact members is without effect because of the previously traced holding circuits for any relays which were initially energized by closure thereof. Closure of contact members *e* is without effect, since the circuit for the coil of slow-down switch 2L is now interrupted by contact members *c* of high speed relay 10. Closure of contact members *c*, however, completes a circuit for the coil of slow-down switch 3L, which extends from line conductor M1, through contact members *d* of main switch 5, the coil of slow-down switch 3L, contact members *c* of accelerating relay 11 and through manual-and-automatic switch S3 to line conductor M2.

Since the only immediate effect of centering car switch *Cs* is to energize the coil of slow-down switch 3L, it will be observed that the centering of the car switch, preparatory to making a stop at floor *b*, may occur any time after the car C passes magnetizable plate 3*Ua* and before it passes magnetizable plate 3*Ub*. When elevator car C, moving upwardly, reaches magnetizable plate 3*Ub* the magnetic circuit of slow-down switch 3L is modified in the manner previously described and contact members 3UL are actuated to the open position.

The opening of contact members 3UL interrupts the circuit for high-speed relay 10, thereby causing contact members *a* and *b* thereof to open and contact members *c* thereof to close. The opening of contact members *b* is without effect. The opening of contact members *a* reincludes resistor R3 in the circuit of field winding of G*f* thereby causing the voltage of generator G to fall at a rate determined by the value of resistor R4, and causing the speed of motor M to reduce at a corresponding rate.

Closure of contact members *c* of high speed relay 10 completes a circuit for the coil of slow-down switch 2L thereby preparing this switch for operation. This circuit extends from line conductor M1 through contact members *f* of main switch 5, the coil of slow-down switch 2L, contact members *e* of accelerating relay 11, contact members *c* of relay 10 and through manual-and-automatic switch S3 to line conductor M2.

When elevator car C brings slow-down switch 2L adjacent magnetizable plate 2*Ub*, contact members 2UL are actuated to the open position, in the manner described. The opening of contact members 2UL interrupts the circuit for intermediate-speed relay 9 and sequence relay 17. Deenergization of relay 9 causes contact members *a* and *c* thereof to open and contact members *b* thereof to close. The opening of contact members *c* is without effect. Closure of contact members *b* recompletes the circuit for auxiliary relay 15, actuation of which is without effect, however, since the circuit for high-speed relay 10 has been previously interrupted. Opening of contact members *a* of intermediate-speed relay 9 reinserts resistor R2 in the circuit of field winding G*f*, thereby initiating the reduction of the voltage of generator G and the speed of motor M to the high-leveling value.

Upon interruption of the circuit for the coil of sequence relay 17, the energy stored therein starts to discharge through a local circuit including a resistor R8. At the expiration of an interval, determined by the ratio of resistance to inductance in this circuit, relay 17 returns to the illustrated position, opening contact members *a*. The opening contact members *a* of sequence relay 17 has no immediate effect, however, other than to render leveling relays UL and DL subject to shields 1*Ub* and 1*Db*, respectively.

Referring to Fig. 3, it will be observed that the time delay in the opening operation of sequence relay 17 need only be sufficient to maintain this relay closed from the time slow-down switch 2L is brought adjacent magnetizable plate 2Ub until light sensitive device 1L is moved out of range of this magnetizable plate. It will also be observed that the time delay is only necessary, with the illustrated arrangement, during upward travel of the car, since, during downward travel of the car, light sensitive device 1L is moved out of range of magnetizable plate 2Ub (or 2Ua, depending upon the floor selected) before slow-down switch 2L is brought into range thereof. In either case, however, the only requirement is that relay 17 shall have resumed the illustrated position before the shields are reached. In practice, to accommodate conditions which may arise during a late-stop, described hereinafter, the time delay is made sufficiently long to persist during from three to four feet of car travel.

When car C brings light sensitive device 1L into range of shield 1DB, the light passing between source X and cell DX is interrupted, and the grid potential of amplifier DA is reduced, thereby reducing the plate current of amplifier DA. As previously described, the reduction in plate current is sufficient to cause leveling relay DL to return to the illustrated position, opening contact members a and b and closing contact members c and d.

Closure of contact members c is without effect, since contact members c of up direction relay 6, connected in parallel therewith, are closed. Closure of contact members d is without effect since contact members a of door relay 16, now closed, are connected in parallel therewith. Opening of contact members b is without effect, since down-direction relay 7 is not energized during upward travel. Opening of contact members a of leveling relay DL, however, interrupts the circuit for high-leveling-speed relay 8. The resultant opening of the contact members of high-leveling-speed relay 8 reincludes resistor Rf in the circuit of field winding Gf, thereby initiating the reduction of voltage of the generator G and the speed of the motor M to the lowest or landing value.

When car C brings light sensitive device 1L into range of shild 1Ub, the light passing between source X and cell UX is interrupted, and in response to the resultant reduction in grid potential of amplifier UA, leveling relay UL is deenergized and resumes the illustrated position, opening contact members a and b and closing contact members c and d. Opening of contact members a is without effect since the circuit for high-leveling-speed relay 8 has been previously interrupted. Closure of contact members c is without effect, since these contact members are connected in parallel with the now closed contact members d and a of relays DL and 16 respectively. Closure of contact members d is without effect, since the circuit for down-direction relay 7 is interrupted elsewhere. Opening of contact members b of leveling relay UL, however, interrupts the previously traced holding circuit for up-direction relay 6. Upon interruption of this circuit, contact member a, b and c thereof are opened and contact members d thereof are closed. The operation of contact members a, c and d is without effect, but the opening of contact members b interrupts the circuit for main switch 5 and reversing switches 1 and 3, all of which return to the illustrated position.

The opening of contact members a of reversing switches 1 and 3 interrupts the circuit for field winding Gf thereby initiating the reduction of the voltage of generator G to a value determined by the residual magnetism thereof. The opening of contact members d and e of reversing switch 1 is without effect since the circuits controlled thereby have been previously interrupted. The opening of contact members b of reversing switch 1 and line switch 5 interrupts the circuit for release coil Br, thereby causing the application of brake B. Closure of contact members a of main switch 5 completes the circuit for the demagnetizing field winding GAF which, as previously described, is wound to produce a magnetomotive force in opposition to the residual magnetism of generator G, and to thereby reduce the voltage of that machine quickly to substantially zero. The opening of contact members d, f and e deenergizes the coils of slow-down switches 3L and 2L, and of relay 15, respectively. The opening of contact members c is without effect.

As previously described, due to the action of series field winding GSf, the speed of the motor M is maintained substantially constant independent of load. Accordingly in the majority of cases, deenergization of relay UL to interrupt the reversing circuit, apply the brake, and apply the demagnetizing field, results in the stoppage of the elevator car at a position accurately level with the floor landing.

Assuming, however, that for some reason, elevator car C failed to stop accurately level with floor landing b, or that, after having stopped level therewith drifted to a point sufficiently above the floor to move light sensitive device 1L out of range of plate 1Db, light sensitive cell DX is again illuminated to effect the following leveling operations.

As previously described, illumination of light sensitive cell DX results in a sufficient increase in the plate current of amplifier DA to cause actuation of leveling relay DL. Upon actuation of relay DL, contact members a and b thereof are closed and contact members c and d thereof are open. Closure of contact members a prepares a circuit for high-leveling-speed relay 8. Opening of contact members c of relay DL prevents energization of up-direction relay 6. Opening of contact members d of relay DL is without effect, since the now closed contact members c of relay UL are connected in parallel therewith.

Assuming the doors are closed, relay 16 is still energized and the contact members a thereof complete a second circuit in parallel to contact members c of relay UL. Closure of contact members b of relay DL completes a circuit for the coil of down-direction relay 7, which extends from line conductor M1 through the coil of down-direction relay 7, the now closed contact members d of up-leveling relay UL, contact members b of down-leveling relay DL, the now closed contact members d of up-direction relay 6, and thence to line conductor M2 through either the normally closed contact members c of relay UL or contact members a of relay 16.

Upon completion of this circuit, down-direction relay 7 is actuated to open contact members c and to close contact members a, b and d. Closure of contact members d of relay 7 completes a self-holding circuit therefor, which is independent of contact members d of up-leveling relay UL. Opening of contact members c of relay 7 is without effect since the circuit for up-direction relay 6 is interrupted elsewhere. Closure of contact members a of relay 7 is without effect since the circuit for accelerating relay 11 is interrupted at car switch contact members HS. Closure of contact members b of relay 7 completes a circuit for the coil of main switch 5 and down reversing switches 2 and 4, which extends from the line conductor M1 through the coil of main switch 5, contact members a of voltage-relay 14, the coils of switches 2 and 4, and contact members b of relay 7 to line conductor M2. Upon completion of this circuit, main switch 5 functions as in the previously described accelerating operation, and reversing switches 2 and 4 close to perform the functions attributed to switches 1 and 3 in the previous operation, with the exception that field winding Gf is connected between line conductor M1 and M2 in the reverse direction. Accordingly, upon closure of down-leveling relay DL, the voltage of generator G rises to the minimum value, the brake is released and elevator car C is returned slowly to the floor landing.

It will be obvious from the above description that had the elevator car drifted below the floor landing, in response, for example, to the placing of a sufficient load thereon to stretch the hoisting cables, leveling relay UL would have been energized to initiate a leveling movement in the upward direction.

In the above paragraphs, it is assumed that the upward drift of the elevator car is arrested, and the downward leveling movement initiated, while light sensitive device 1L is darkened by shield 1Ub. Under these circumstances, up-leveling relay UL is not energized and contact members c thereof remain closed. Similarly, in the event of upward leveling movement initiated from a point at which shield 1Db prevents illumination of light sensitive cell DX, down leveling relay DL remains deenergized throughout the leveling movement. Noting that contact members c of relay UL, contact members d of relay DL and contact members a of door relay 16 are all connected in parallel, it becomes obvious that leveling movement of car C between the upper limits of shield 1Ub or the lower limit of shield 1Db (or shields 1Ua and 1Da, depending upon the floor at which the car is located) can be effected while a door, or the elevator car gate is open.

In the above paragraphs, the decelerating operation was described as being entirely automatic in operation. As further described, in a system of this character, the stoppage of the car level with the floor usually occurs in the first instance, and the need of a leveling movement occurs as the result of the car drifting away from the floor in response, for example, to the stretching or contracting of the hoisting cables when heavy loads are placed on, or removed from, the car. Since the drift normally occurs at a relatively low rate, the return movement is almost always initiated before light sensitive device 1L is moved out of range of shield 1Ub, in the case of an upward drift, or out of range of shield 1Db in the case of a downward drift.

In systems, however, in which the intermediate and high-speed, steps are controlled entirely by the car switch, a more extensive leveling movement is frequently required, and a higher leveling speed desirable during the initial portion thereof.

The system illustrated in Fig. 1 may be transformed from one in which the entire decelerating operation is automatic to one in which the intermediate- and high-speeds, steps are manually controlled, by opening the manual-and-automatic switches S1, S2 and S3. As will be obvious, opening manual-and-automatic switch S1 prevents completion of a maintaining circuit for relays 9 and 17 and places these relays exclusively under the control of accelerating relay 11. Similarly, opening manual-and-automatic switch S2 prevents completion of a self-holding circuit for high-speed relay 10, thereby placing this relay under the exclusive control of accelerating relay 11. Opening manual-and-automatic switch S3 prevents completion of the circuits for the coils of slow-down switches 3L and 2L, thereby rendering these devices ineffective.

With the exception, however, that the above maintaining circuits are not completed, if switches S1, S2 and S3 are opened, the accelerating operation is as previously described. Assuming, accordingly, that the elevator car is traveling at high speed, and, as before, that it is desired to stop at floor landing b, car switch Cs is maintained in the extreme position until the elevator car reaches a point approximately the normal slow-down distance in advance of floor b. As previously described, the opening of car switch contact members U is without effect, and the opening of car switch contact members HS results in the deenergization of accelerating relay 11. In this case, however, the deenergization of accelerating relay 11 results in the immediate interruption of the circuit for the coil of relay 10 (contact members b of relay 11) and the immediate interruption of the circuit for the coils of intermediate speed relay 9 and sequence relay 17 (contact members d of relay 11). As previously described, high-leveling-speed relay 8 is maintained energized through the now closed contact members a of relays DL and UL.

As previously described, the opening of contact members a of relays 10 and 9 reduces the excitation of winding Gf, and initiates a reduction of the voltage of generator G and the speed of motor M to the high-leveling value.

In practice, elevator operators are able to identify approximately the point in advance of the floor at which the car switch should be centered. It will be observed, however, that in systems operating at, for example, 600 feet per minute, a delay in the centering of the car switch for even a fraction of a second results in a variation of a foot or more, in either direction, of the point at which deceleration is initiated.

If deceleration is prematurely initiated, the elevator car normally attains the high-leveling-speed at some distance in advance of the floor and is then stopped therewith accurately in the first instance, as in the case of an entirely automatic deceleration. In case the deceleration is initiated too late, the car may be expected to approach the floor at too great a rate to be stopped accurately level therewith in the first instance and either a low speed, or perhaps a high speed, leveling movement becomes necessary.

In either case, it is necessary that the car travel a greater distance between the time the circuit for the coil of sequence relay 17 is interrupted and the time contact members a thereof are open, than is necessary when the car is being operated with fully automatic deceleration. The additional distance of car travel is required, since, while in an automatic deceleration, the circuit for the coil of sequence relay 17 is interrupted when the car reaches the intermediate speed magnetizable plates, in a manual deceleration the corresponding circuit is interrupted at the time deceleration is initiated.

In the usual case, assuming an automatic deceleration requires from 10 to 11 feet of car travel, it may be expected that a manually initiated deceleration will require from 8 to 9 feet of car travel. It is desirable therefore to provide that contact members of relay 17 will remain closed while the car is traveling a distance of from 5 to 6 feet, in order to insure that light sensitive device 1L will have passed the intermediate speed magnetizable plates before relays UL and DL are rendered subject to the cells UX and DX.

In practice, it is usually found that an adjustment of the discharge circuit of relay 17 which is appropriate during fully automatic operation is also appropriate during manual operation, since, although the latter case requires a greater distance of car travel, it will be observed that the elevator car operates at a higher average speed throughout the time interval. As will be obvious, the timing of relay 17 may be adjusted, if necessary, by varying the value of resistor R8 or in any other suitable manner as by the use of dash pots or the like.

Assuming that the deceleration was initiated sufficiently late to require a high speed leveling movement and that the car has been decelerated to the high leveling speed by the opening of relays 9 and 10, as described, the following operations occur.

When car C brings light sensitive device 1L into the range of shield 1D*b*, leveling relay DL is deenergized in the manner previously described, thereby deenergizing high-leveling-speed relay 8, the opening of which tends to reduce the speed of motor M to the lowest or landing value. As also previously described, when car C brings light sensitive device into range of shield 1U*b*, leveling relay UL is deenergized, thereby deenergizing up-direction relay 6, main switch 5 and reversing switches 1 and 3, the opening of which tends to bring the car to rest. As the car continues past the floor, and light sensitive device 1L passes out of range of shield 1D*b*, down-leveling relay DL is energized in the manner previously described, to complete a circuit for the coil of down-direction relay 7. Energization of relay 7, in turn, causes actuation of main switch 5 and down-reversing switches 2 and 4, operations of which condition the system for downward movement at the lowest or landing speed.

As the elevator car continues past the floor and light sensitive device 1L is moved out of range of shield 1U*b*, up-leveling relay UL is energized to close contact members *a* and *b* and to open contact members *c* and *d*. Closure of contact members *a* of up-leveling relay UL completes a circuit for high-levelling-speed relay 8, closure of which increases the excitation of field winding G*f* to a value corresponding to the high-leveling-speed of motor M. Closure of contact members *b* of relay UL is without effect since the circuit for up-direction relay 6 is interrupted elsewhere. Provided door relay 16 is still closed, the opening of contact members *c* of relay UL is without effect.

In the previously described low speed leveling operation, it was noted that the opening of the doors was without effect. While car C is in the high-leveling-speed zone, however, it will be observed that the doors must be maintained in the closed position, it being undesirable to permit more than a very limited amount of movement on either side of the floor with the doors open. The opening of contact members *d* of relay UL is without effect, since contact members *a* of down direction relay 7, connected in parallel therewith, are now closed.

As a result of the completion of the above described circuits, generator G generates voltage of proper polarity and of sufficient value to cause motor M to move car C downwardly at high-leveling-speed. As shown, accordingly, as soon as the upward movement is arrested, the downward movement is initiated. As car C approaches the floor landing, light sensitive cells UX and DX are sequentially darkened to first reduce the speed of the car to the lowest or landing value, and to then bring the car to rest in the manner previously described.

It is believed to be obvious from the above example that it is immaterial how far the car drifts past the floor landing before the return movement is initiated, and that the only manner in which the length of the shield 1U*b* effects the leveling movement is to determine the point at which the elevator speed changes from high-leveling-speed to the lowest or landing-speed, and to limit the region above the floor throughout which the car may be moved with the doors open.

It is also believed to be obvious that, had the car been moving downwardly, and an upward leveling movement become necessary, during such return movement the deenergization of relay DL would have caused the reduction from high-leveling-speed to low-leveling speed and up-leveling relay UL would have caused the stopping of the car. It will be observed, accordingly, that relays UL and DL may perform either a decelerating function or a stopping function. In the case of downward leveling movement, relay UL controls the deceleration from high-leveling-speed to low-leveling speed, while in the case of an upward leveling movement, this relay controls the stopping; in the case of an upward leveling movement, relay DL controls the deceleration from high-leveling-speed to low-leveling speed while in the case of a downward leveling movement, this relay controls the stopping of the car.

In the above-described examples of manually initiated decelerating operations, it was assumed that the time interval of sequence relay 17 expired before either of the shields associated with the selected floor landing were reached. It is believed to be obvious, however, that if deceleration is initiated at a point such that relay 17 times out before shield 1U*b* is reached but after shield 1D*b* is reached, the deceleration from high-leveling-speed to low-leveling-speed will be delayed until the opening of contact members *a* of sequence relay 17. Similarly, if deceleration is initiated at such a point that sequence relay 17 times out before shield 1D*b* is passed but after shield 1U*b* is reached, the interruption of both the high-leveling-speed circuit and the reversing circuits will occur at the time contact members *a* of relay 17 open.

In the relatively unusual case in which deceleration is initiated so late that sequence relay 17 does not time out until after shield 1D*b* is passed, during upward travel, or until after shield 1U*b* is passed during downward travel, the late-stop feature of the present invention, next to be described, may be relied upon.

In the stopping operations thus far described, it has been assumed, in the case of the automatic slow-down, that the car switch was centered sufficiently early to permit proper operation of slow-down switch 3L, in the case of manual slow-down, that the car switch was centered at a point near the normal point of slow down. It sometimes happens, however, that the operator does not become aware that a stop should be made until the car has approached the selected floor too closely for the slow-down mechanism to function in the normal and above described manner.

The present invention further comprises an arrangement of apparatus whereby, under the latter conditions, the elevator car may be brought to rest more promptly than in the usual cases of either manual or automatic deceleration.

As previously described, in a representative system of the illustrated type, arranged for operation at 600 feet per minute, the slow-down distance, during automatic operation is of the order of from ten to eleven feet; the slow-down distance, during manual operation, is of the order of from eight to nine feet. In a representative system embodying what may be termed the "late-stop" feature of the present invention, however, the car may be expected to travel only a distance of from six to seven feet in the course of the stopping operation. For descriptive purposes, late-stop operations may be classified into those in which first, the stopping operation is initiated sufficiently early to permit the car to come to rest before either of the shields associated with the selected floor are reached; and second, those in which the stopping operation is initiated so late that the car continues in motion after the shields are reached.

As previously described, assuming the associated circuit for relay 17 is interrupted when the car is traveling at high speed, an adjustment of the timing of contact members *a* thereof whereby these contact members are maintained closed while the car is traveling a distance of from five to six feet is appropriate. With such an adjustment, it will be observed that the time interval of relay 17 will have expired before the car comes to rest in a late-stop operation of the first of the above two classes.

In the case of a late stop operation of the second of the above two classes, the switching sequence depends upon the position of the car with respect to the shields at the time the contact members *a* of relay 17 open. Accordingly, for purposes of description, late-stops of the second class may be reclassified into those in which relay 17 times out while light sensitive device is opposite shield 1D*b* (or 1D*a*), during upward travel, or shield 1U*b* (or 1U*a*) during downward travel; and those in which during upward travel, shield 1D*b* (or 1D*a*), during downward travel, shield 1U*b* (or 1U*a*) is passed before relay 17 times out.

Accordingly, assuming that car C is moving upwardly at full speed and that, while the car is more than six or seven feet in advance of floor *b*, the operator becomes aware that a stop should be made at floor *b*, a late stop of the first class is in order, and involves the following sequence.

In accordance with the present system, the late-stops are initiated by centering the car switch and momentarily closing the opposite direction contact members. As previously described, the opening of car switch contact members U is without effect, and, assuming switches S1, S2 and S3 are again closed, the opening of car switch contact members HS has no effect other than to deenergize accelerating relay 11, which in turn, energizes the coil of slow-down switch 3L.

Closure of car switch contact members D completes a circuit for the coil of down-direction relay 7. Upon completion of this circuit, relay 7 is actuated to close contact members *a*, *b* and *d* and to open contact members *c*. Closure of contact members *a* and *d* is without immediate effect. The opening of contact members *c*, however, interrupts the circuit for the coil of up-direction relay 6, contact members *a*, *b* and *c* of which open and contact members *d* of which close.

Closure of contact members *b* of down-direction relay 7 completes a circuit for the coils of main switch 5 and down reversing switches 2 and 4. Main switch 5, which has been previously energized is maintained in the energized position through this circuit, but reversing switches 2 and 4 are not energized, since contact members *a* of anti-plugging relay 14 are now open, and the drop across resistor R9, while permitting passage of sufficient current to maintain any of the switches in circuit therewith in the closed position, permits the passage of insufficient current to initially actuate any of such switches.

The coil of anti-plugging relay 14 is connected directly across the terminals of generator G, and is designed to be maintained in the circuit opening position until the voltage of generator G has fallen to a value sufficiently low to permit reversal of the voltage of generator G without undue disturbance to the system. Preferably, although not necessarily, relay 14 is so designed that the contact members thereof are maintained open until the car comes to rest. The point, during acceleration, at which anti-plugging relay 14 is actuated is immaterial, in the present system.

The opening of contact members *a* and *c*, and closure of contact members *d* of up direction relay 6, is without effect. The opening of contact members *b*, however, interrupts the circuit for the coils of reversing switches 1 and 3, the circuit for the coil of main switch 5 being maintained in the manner described above. The opening of contact members *b*, *d*, *e* and *f* of reversing switch 1 interrupts the circuits for the coils of the electromagnetic brake, of high-speed relay 10, of intermediate-speed relay 9 and sequence relay 17, and of high-leveling-speed relay 8, respectively. The opening of contact members *a* of switches 1 and 3 interrupts the circuit for field winding G*f* and for the coil of auxiliary relay 12.

Upon interruption of the above circuits, the current in winding G*f* and through the coil of relay 12 decays at a rate determined by the ratio of the inductance of these windings to the resistance of resistor R4, and the voltage of generator G and speed of motor M are reduced at a corresponding rate, the deceleration of motor M being further assisted by the action of brake B.

Since the contact members of relay 12 do not open immediately upon interruption of the reversing circuit, closure of contact members *c* of reversing switch 1 completes a circuit for the coil of speed-limiting relay 13, which extends from line conductor M1 through the coil thereof, through contact members of current relay 12, in series through normally closed contact members *c* of reversing switches 2 and 1, and through contact members *c* of main switch 5, to line conductors M2. Upon completion of this circuit, speed-limiting relay 13 is actuated to close contact members *a* and to open contact members *b*. Closure of contact members *a* completes a self-holding circuit for relay 13, which remains complete until main switch **5** is deenergized, at the expiration of the stopping operation. The opening of contact members *b* prevents completion of the circuits for relays **10**, **9** and **17**. In view of the interlock provided by contact members *b* of relay **13**, it will be observed that, even though the late-stop is initiated by moving car switch C*s* to the extreme position in the opposite direction, thereby reclosing contact members HS, the only effect of such reclosure is to energize accelerating relay **11**, closure of which is without effect.

Upon being energized, down-direction relay **7** completes a self-holding circuit, which extends from the coil thereof, through contact members *d* thereof, contact members *b* of leveling relay DL, the now closed contact members *d* of up-direction relay **6** and through contact members *a* of door relay **16** to line conductors M2. It is seen, therefore, that the reverse direction contact members need be closed only momentarily to initiate the late-stop.

It will be observed that the late-stop is effected by removing the external source of excitation for field winding G*f* and by causing the application of brake B, thereby initiating a relatively high rate of deceleration of the elevator car, but that, although this operation is initiated by closing the opposite direction relay (down-direction relay **7**), anti-plugging relay **14** prevents completion of the down-direction generator field circuit, and speed-limiting relay **13** prevents recompletion of the several accelerating circuits.

In the present example, it was assumed that the late-stop was initiated sufficiently early to permit the elevator car to come to rest at a point in advance of the shields associated with floor landing *b*. Accordingly, in order to cause the car to continue to a position level with floor landing *b*, car switch C*s* may again be actuated either to momentarily close only contact members U or to also momentarily close contact members HS.

Closure of contact members HS is effective only to energize accelerating relay **11**, closure of which is without effect, since contact members *a* of speed limiting relay **13** are now open. Closure of contact members U completes a circuit for the coil of up-direction relay **6**.

Upon completion of this circuit, up-direction relay **6** is again actuated to close contact members *a*, *b* and *c* and to open contact members *d*. Closure of contact members *a* of relay **6** is without effect. The opening of contact members *d* of relay **6** interrupts the previously traced self-holding circuit for the coil of down-direction relay **7**, thereby causing contact members *a*, *b* and *d* thereof to reopen and contact members *c* thereof to reclose. Closure of contact members *c* of relay **6** completes a self-holding circuit therefor, in the manner previously described. Closure of contact members *b* of relay **6**, which precedes the opening of contact members *b* of relay **7**, maintains main switch **5** in the actuated position, and prepares a circuit for the coils of reversing switches **1** and **3** which is, however, subject to anti-plugging relay **14**.

Since the only effect of the momentary reclosure of contact members U is to destroy the previously prepared circuit for down-direction reversing switches **2** and **4**, and to prepare a circuit for up-reversing switches **1** and **3**, it will be observed that this operation may occur at any time after the late-stop is initiated, and before elevator car C comes to rest.

At substantially the same time that elevator car C comes to rest, contact members *a* of anti-plugging relay **14** are released to the illustrated position, thereby causing reversing switches **1** and **3** to close. Main switch **5** and reversing switches **1** and **3** now being closed, elevator car C accelerates to the high-leveling-speed in the manner described in the first accelerating operation. When light sensitive cell DX is darkened by shield **1**D*b*, leveling relay DL is deenergized to interrupt the circuit for high-leveling-speed relay **8**, and when light sensitive cell UX is darkened by shield **1**U*b*, leveling relay UL is deenergized to cause interruption of the circuit for field winding G*f*, apply brake B and apply the demagnetizing field winding GA*f* and thereby bring the car to rest.

In a case in which the late-stop is initiated so late that elevator car C cannot be brought to rest until after the shields associated with the selected floor landing are reached, the late-stop is initiated in the manner described above, with the exception that the momentary reclosure of the up direction car switch contact members U is unnecessary. Assuming, accordingly, that the down direction contact members D of car switch C*s* have been momentarily closed to deenergize up-direction relay **6** reversing switches **1** and **3**, speed relays **10**, **9** and **8** and sequence relay **17**, and to prepare circuits for down-direction reversing switches **2** and **4**, the late-stop may be completed in any one of the following manners.

If sequence relay **17** times out, at any time before light sensitive device **1**L is brought adjacent shield **1**D*b*, the opening of contact members *a* of relay **17** will have no effect other than to render leveling relay DL subject to the shield. In this case, when shield **1**D*b* darkens cell DX, leveling relay DL is deenergized, thereby deenergizing down-direction relay **7**, the opening of which deenergizes main switch **5** and destroys the previously prepared circuit for down reversing switches **2** and **4**, thereby tending to bring the car immediately to rest.

If the opening of contact members *a* of sequence relay **17** occurs after light sensitive cell DX has been darkened, the opening of these contact members results in the immediate deenergization of leveling relay DL, to thereby deenergize down direction relay **7**.

If the deenergization of relay **7** occurs at any time before light sensitive cell UX is darkened by shield **1**U*b*, leveling relay UL will be in the actuated position. Accordingly, upon deenergization of down-direction relay **7**, up-direction relay **6** will again be actuated to recomplete the circuits for main switch **5** and reversing switches **1** and **3** to thereby cause the elevator car to continue to the floor landing at low-leveling-speed. As previously described, when cell UX is darkened by shield **1**U*b*, leveling relay UL is deenergized and the elevator car brought to rest level with the floor.

If contact members *a* of sequence relay **17** remain closed until after light sensitive device **1**L is moved completely past shield **1**D*b*, down direction relay **7** will remain energized, and as soon as the car is brought to rest and anti-plugging relay **14** resumes the illustrated position, down reversing switches **2** and **4** will be actuated to cause the elevator car to start downwardly. If the return movement is initiated while light sensitive device **1**L is within range of shield **1**U*b*, such return movement will be effected at low speed, since the circuit for high-leveling-speed relay 8 will be open at contact members *a* of leveling relay UL. If, however, the return movement is not initiated until after light sensitive cell UX has again become illuminated, leveling relay UL will also be energized, thereby energizing high-leveling-speed relay 8, and the car will travel at high-leveling-speed until light sensitive cell UX is again darkened. In either case, the return movement will be interrupted and the car brought to rest level with floor landing *b* when light sensitive cell DX is again darkened by shield 1D*b*.

In the extreme case, in which the late-stop is initiated so late that the car not only continues past the selected floor landing, but also past the magnetizable plates associated with slow down switch 2L, it is only necessary that the down-direction car switch contact members be maintained in the closed position until the car has restarted, and has repassed these magnetizable plates. At any time after the magnetizable plates are passed, car switch C*s* may be returned to the neutral position and the car will continue toward the floor at high-leveling-speed, the deceleration to low landing speed and the stopping operation taking place as previously described.

In the previously described examples of late-stops, it is assumed that manual-and-automatic switches S1, S2 and S3 occupy the closed positions. It will be observed however, that if these switches are opened and the car operated with manual control of the higher speed steps, late-stops are effected in exactly the same manner, and involve essentially the same switching operations, the only difference being that the deenergization of high-speed relay 10, of intermediate-speed relay 9 and sequence relay 7, and of high-leveling-speed relay 8 occurs as the result of the opening of accelerating relay 11 rather than the opening of reversing switch 1, or reversing switch 2, depending upon the direction of travel.

In the above described examples, it is assumed that deceleration is initiated from high speed. In a system operating at 600 feet per minute, an elevator car cannot be accelerated and decelerated, to and from, full speed in the distance between two adjacent floors of the usual building structure. In the present system, however, it will be observed that the closure, during acceleration, of high-speed relay 10 is delayed by auxiliary accelerating relay 15. Accordingly, if it is desired to cause the car to travel only the distance between two adjacent floors, the speed of the elevator car may be limited to the intermediate value by reopening car switch contact members HS before auxiliary relay 15 has timed out to permit closure of high-speed relay 10.

With the exception of the detailed description of both high and low-speed leveling movements in both directions, the present description has been limited to switching operations involved in upward travel of the car. It is believed obvious, however, that the acceleration of the elevator car to high speed in the downward direction, and the deceleration of the car from high speed, when moving downwardly, are identical with the corresponding up-direction operations with the exception that car switch contact members U, up-direction relay 6, reversing switches 1 and 3, and contact members 2UL and 3UL of slow-down switches 2L and 3L are replaced, respectively, by car switch contact members D, down-direction relay 7, reversing switches 2 and 4, and contact members 2DL and 3DL of slow-down switches 2L and 3L.

While I have described and illustrated a preferred embodiment of the present invention, it is to be understood that various modifications and changes may be made without departing from the scope thereof. Accordingly, I desire that only such limitations shall be placed thereon as are imposed by the prior art and defined in the appended claims.

I claim as my invention:

1. In an elevator system, an elevator car operable in a hatchway, a plurality of sets of contact members associated with said system, an operator for each of said sets of contact members, each of said operators comprising a first element and a second element, certain of said first elements having characteristics such that they cooperate only with corresponding second elements, means for mounting said first elements on said car in substantially the same vertical line and means for mounting said second elements at predetermined points in said hatchway in substantially a vertical line for cooperation with said first elements, whereby said contact members may be selectively controlled in accordance with the position of said car by operators occupying a small cross-sectional area of said hatchway.

2. In an elevator system, an elevator car operable in a hatchway, two members relatively movable in accordance with the position of said car in said hatchway, a plurality of circuit controlling devices associated with said system, means for mounting said devices on one of said members at predetermined points in substantially the same vertical line, a plurality of elements for operating said devices when said devices are in predetermined condition of energization, certain of said elements having characteristics such that they are operably cooperative with only certain of said devices, means for establishing said predetermined conditions of energization of said devices and means for mounting said elements on the other of said members at predetermined points in substantially said same vertical line for cooperation with said devices, whereby said devices may be selectively operated in accordance with the position of said car with small lateral space requirements.

3. In an elevator system, an elevator car operable in a hatchway, a plurality of circuit controlling devices associated with said system, means for mounting said devices on said car in substantially the same vertical line, a plurality of elements for operating said devices where said devices are in predetermined conditions of energization, certain of said elements having characteristics such that they are operably cooperative with only certain of said devices, means for establishing said predetermined conditions of energization of said devices, and means for mounting said elements in said hatchway at predetermined points in substantially said same vertical line for cooperation with said devices, whereby said devices may be selectively operated in accordance with the position of said car with small lateral space requirements.

4. In an elevator system, an elevator car operable in a hatchway, a plurality of circuits associated with said system, and means to commutate said circuits comprising a circuit controlling device individual to each of said circuits, means for mounting said devices on said car in substantially the same vertical line, a plurality of elements effective to operate said devices when said devices are in predetermined conditions of energization, certain of said elements having characteristics

such that they are operably cooperative with only certain of said devices, means for establishing said predetermined conditions of energization of said devices, and means for mounting said elements in said hatchway at predetermined points in substantially said same vertical line for cooperation with said devices, whereby said circuits may be selectively commutated in accordance with the position of said car with small lateral space requirements of said devices, and said operating elements.

5. In an elevator system, an elevator car operable in a hatchway, driving means for said car, means to decelerate said car including a plurality of circuits, and means to commutate said circuits including a circuit controlling device individual to each of said circuits, means for mounting said devices on said car in substantially the same vertical line, a plurality of elements effective to operate said devices when said devices are in predetermined conditions of energization, certain of said elements having characteristics such that they are operably cooperative with only certain of said devices, means for establishing said predetermined conditions of energization of said devices, and means for mounting said elements in said hatchway at predetermined points in substantially said same vertical line for cooperation with said devices, whereby said decelerating means may be selectively controlled in accordance with the position of said car with small lateral space requirements of said devices and said operating elements.

6. In an elevator system, an elevator car operable in a hatchway, a plurality of sets of contact members associated with said system, an operator for one of said sets of contact members comprising apparatus having two cooperating magnetic elements, an operator for another of said sets of contact members comprising apparatus having two elements, one of said elements comprising a light sensitive cell, the other of said elements comprising means to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, said last named means having characteristics such that it is not operably cooperative with elements of said first named operator, means for mounting one element of each of said operators on said car in substantially the same vertical line, means for mounting the remaining element of each of said operators in said hatchway at predetermined points in substantially said same vertical line for cooperation with said car-carried elements, whereby said contact members may be controlled in accordance with the position of said car with small lateral space requirements of said operators.

7. In an elevator system, an elevator car operable in a hatchway, a plurality of sets of contact members associated with said system, an operator for a set of said contact members comprising apparatus having magnetizing and magnetizable elements, an operator for another set of said contact members comprising apparatus having a light sensitive cell element and a cooperating element adapted to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, said cooperating element having characteristics such that it is not operably cooperative with the elements of said first named operator, means for mounting said light sensitive and magnetizing elements on said car in substantially the same vertical line, means for mounting said magnetizable and cooperating elements in said hatchway at predetermined points in substantially said same vertical line for cooperation with said car carried elements, whereby said contact members may be controlled in accordance with car position with small lateral space requirements of said operators.

8. In an elevator system, an elevator car operable in a hatchway, a plurality of sets of contact members associated with said system, an operator for a set of said contact members comprising apparatus having two cooperating magnetic elements, an operator for another set of said contact members comprising apparatus having two elements, one of said elements including a light-sensitive cell and a source of light disposed to illuminate said cell, the other of said elements including means to control the passage of light between said source and said cell in accordance with the relative positions of said two elements, said last named element having characteristics such that it is not operably cooperative with the elements of said first named operator, means for mounting one element of each of said operators on said car in substantially the same vertical line, means for mounting the second element of each of said operators in said hatchway at predetermined points in substantially said same vertical line for cooperation with said car-carried elements, whereby said contact members may be controlled in accordance with car position with small lateral space requirements of said operators.

9. In an elevator system, an elevator car operable in a hatchway, a plurality of sets of contact members associated with said system, an operator for one of said sets of contact members comprising apparatus having magnetizing and magnetizable elements, an operator for another of said sets of contact members comprising apparatus having two elements, one of said elements including a light sensitive cell and a source of light disposed to illuminate said cell, the other of said elements including means to control the passage of light between said source and said cell in accordance with the relative positions of said two elements, said last named element having characteristics such that it is not operably cooperative with the elements of said first named operator, means for mounting said magnetizing and light sensitive elements on said car in substantially the same vertical line, means for mounting said magnetizable and light-controlling elements in said hatchway at predetermined points in substantially said same vertical line for cooperation with said car carried elements, whereby said contact members may be controlled in accordance with car position with small lateral space requirements of said operators.

10. In an elevator system, an elevator car operable in a hatchway, a plurality of sets of contact members associated with said system, and means for sequentially operating said sets of contact members in accordance with the position of said car in said hatchway, said operating means comprising an operator for each of said sets of contact members, each of said operators comprising a first element, a second element and means to condition said operator for operation through cooperation between said first and second elements, certain of said first elements having characteristics such that they are operably cooperative only with certain of said second elements, means for mounting said first elements on said car in substantially the same vertical line, means

for mounting said second elements in said hatchway in accordance with said sequence at predetermined points in substantially said same vertical line, whereby said sets of contact members may be sequentially controlled with small lateral space requirements of said operators.

11. In an elevator system, an elevator car operable in a hatchway, two sets of contact members associated with said system, and means for sequentially operating said sets at predetermined points comprising an operator for each of said sets, each operator comprising a first element, a second element and means to condition said operator for operation through cooperation between said first and second elements, the second element of one of said operators having characteristics such that it is not operably cooperative with the elements of said other operator, means for mounting the first elements of said operators on said car in substantially the same vertical line and means for mounting the second elements of said operators in said hatchway at predetermined points in substantially said same vertical line for cooperation with said car carried elements, whereby said sets of contact members may be alternately controlled with small lateral space requirements of said operators.

12. In an elevator system, an elevator car operable in a hatchway, two sets of contact members associated with said system, means for operating one of said sets of contact members when said car reaches certain positions in said hatchway, and for operating the other of said sets of contact members when said car reaches certain other positions in said hatchway, said operating means comprising an operator for each of said sets, each of said operators having a first element, a plurality of second elements, and means to condition each operator for operation through cooperation between the associated first and second elements, the second elements associated with one of said operators having characteristics such that they are operably cooperative with only the first element of that operator, means for mounting said first elements on said car in substantially the same vertical line, means for mounting the second elements associated with the operator for said one of said sets of contact members in said hatchway at said certain positions in substantially said same vertical line, and means for mounting the second elements associated with the operator for said other set of contact members in said hatchway at said certain other positions in substantially said same vertical line, whereby said contact members may be controlled with small lateral space requirements of said operators.

13. In an elevator system, an elevator car operable in a hatchway, a plurality of sets of contact members associated with said system, means for sequentially operating said sets of contact members in accordance with car position comprising an operator for each of said sets of contact members, each of said operators having two elements, the elements of one of said operators being arranged to cooperate magnetically, one element of a second of said operators comprising a light sensitive cell, the other element of said second operator comprising means to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, said last named element having characteristics such that it is not operably cooperative with elements of said one of said operators, means for mounting one element of each of said operators on said car in substantially the same vertical line and means for mounting the other elements of each of said operators in said hatchway in accordance with said sequence at predetermined points in substantially said same vertical line, whereby said sets of contact members may be sequentially controlled with small lateral space requirements of said operators.

14. In an elevator system, an elevator car operable in a hatchway, two sets of contact members associated with said system, an operator for each of said sets of contact members, each of said operators having first and second elements, the second element associated with one of said operators having characteristics such that it is operable cooperative with only the first element associated with that operator, means for mounting said first elements on said car in substantially the same vertical line, means for mounting said second element in said hatchway at predetermined points in substantially said same vertical line for cooperation with said car carried elements, and means to prevent operative cooperation between the first element of said one of said operators and the second element associated with the other of said operators, whereby each of said sets of contact members may be operated at different predetermined points with small lateral space requirements of said operators.

15. In an elevator system, an elevator car operable in a hatchway, two circuit controlling devices associated with said system, means for mounting said devices on said car in substantially the same vertical line, an operating element associated with each of said devices, the operating element associated with one of said devices having characteristics such that it is operably cooperative with only that device, means for mounting said elements in said hatchway at predetermined points in substantially said same vertical line for cooperation with said devices, and means for preventing operative cooperation between said other device and the element associated with said one of said devices, whereby said devices may be operated at different points with small lateral space requirements of said devices.

16. In an elevator system, an elevator car operable in a hatchway, two circuits associated with said system, means for commutating said circuits comprising an operator individual to each circuit, each operator having first and second elements, the second elements associated with one of said operators having characteristics such that it is operably cooperative with only the first element of that operator, means for mounting said first elements on said car in substantially the same vertical line, means for mounting said second elements in said hatchway at predetermined positions in substantially said same vertical line for cooperation with said first elements, and means to render said one operator ineffective to commutate the associated circuit when the first element associated therewith is in cooperative relation with the second element associated with said other operator, whereby said circuits may be commutated at different points with small lateral space requirements of said operators.

17. In an elevator system, an elevator car operable in a hatchway, two sets of contact members associated with said system, an operator for one of said sets comprising two magnetic elements, an operator for the other set comprising a light sensitive cell element and an element adapted to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, said last named ele-

ment having characteristics such that it is not operably cooperative with the elements of said first named operator, means for mounting one element of each of said operators on said car in substantially the same vertical line, means for mounting the other element of each of said operators in said hatchway at predetermined points in substantially said same vertical line, and means for preventing operative cooperation between said light sensitive cell element and a magnetic element, whereby said sets of contact members may be selectively operated at different points with small lateral space requirements of said operators.

18. In an elevator system, an elevator car operable in a hatchway, two sets of contact members associated with said system, an operator for one of said sets comprising magnetizing and magnetizable members, an operator for the other of said sets comprising a light sensitive cell element and an element adapted to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, said last named elements having characteristics such that it is not operably cooperative with the elements of said first named operator, means for mounting said magnetizing and cell elements on said car in substantially the same vertical line, means for mounting said magnetizable and conditioning elements in said hatchway at predetermined points in substantially said same vertical line, and means to prevent operative cooperation between said cell element and said magnetizable element, whereby said sets of contact members may be selectively operated at different points with small lateral space requirements of said operators.

19. In an elevator system, an elevator car operable in a hatchway, two sets of contact members associated with said system for controlling circuits of the system, an operator for controlling one of said sets having magnetizing and magnetizable elements, an operator for controlling the other of said sets having two elements, one of said elements comprising a light sensitive cell and a source of light disposed to illuminate said cell, the other of said elements comprising a non-magnetic shield disposed to control the passage of light between said source and said cell in accordance with the position of said car in said hatchway, means for mounting said magnetizing and said cell elements on said car in substantially the same vertical line, means for mounting said magnetizable and said light-controlling elements in said hatchway at predetermined points in substantially said same vertical line for cooperation with said car-carried elements, and means to prevent operative cooperation between said cell element and said magnetizable element, whereby said sets of contact members may be selectively operated at different points with small lateral space requirements of said operators.

20. In an elevator leveling control system, an elevator car operable in a hatchway past a floor landing, up-leveling mechanism and down-leveling mechanism, each of said leveling mechanisms having first and second elements, means for mounting said first elements in said hatchway, means for mounting said second elements on said car for movement into cooperative relation, respectively, with said first elements when said car is substantially level with said landing, and means rendered effective upon said elements of one of said mechanisms being moved out of cooperative relation to cause said car to move in the corresponding direction, regardless of the relative positions of the elements of said other mechanism during such movement.

21. In an elevator control system, an elevator car operable in a hatchway past a landing up-leveling connections, down-leveling connections, means effective while said connections are complete, respectively, to cause said car to move in the corresponding direction, up-leveling mechanism and down-leveling mechanism for controlling the leveling connections, each of said mechanisms having first and second elements, means for mounting said first elements in said hatchway, means for mounting said second elements on said car for movement into cooperative relation, respectively, with said first elements when said car is substantially level with said landing, and means rendered effective upon the elements of one of said mechanisms being moved out of cooperative relation to cause completion of the corresponding connections until said elements are again brought into cooperative relation, regardless of the relative positions of the elements of said other mechanism during such movement.

22. In an elevator control system, an elevator car operable in a hatchway past a landing, leveling connections, means responsive to completion of said leveling connections to cause said car to start and responsive to interruption of said leveling connections to cause said car to stop, a first leveling mechanism and a second leveling mechanism for controlling the leveling connections, each of said mechanisms having main and cooperating elements, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other elements of each of said mechanisms on said car in such positions that the elements of said first mechanism are brought into cooperative relation when said car is one distance in advance of said landing and the elements of said second mechanism are brought into cooperative relation when said car is a greater distance in advance of said landing, means rendered effective upon the elements of said first mechanism being moved out of cooperative relation to cause completion of said leveling connections, means adapted upon the elements of said second mechanism being moved out of cooperative relation to interrupt said leveling connections, and additional means operable to prevent interruption of said leveling connections by said last-mentioned means.

23. In an elevator control system, an elevator car operable in a hatchway past a landing, leveling connections, means responsive to completion of said leveling connections to cause said car to start and responsive to interruption of said leveling connections to cause said car to stop, a first leveling mechanism and a second leveling mechanism for controlling the leveling connections, each of said mechanisms having main and cooperating elements, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other elements of each of said mechanisms on said car in such positions that the elements of said first mechanisms are brought into cooperative relation when said car is one distance in advance of said landing and the elements of said second mechanism are brought into cooperative relation when said car is a greater distance in advance of said landing, means rendered effective upon the elements of said first mechanism being moved out of cooperative relation to cause completion of said leveling connections, means adapted upon the elements

of said second mechanism being moved out of cooperative relation to interrupt said leveling connections, a closure associated with said elevator, and means controlled by said closure to prevent interruption of said leveling connections by said last-mentioned means.

24. In an elevator control system, an elevator car operable in a hatchway past a landing, leveling connections, means responsive to completion of said leveling connections to cause said car to start and responsive to interruption of said leveling connections to cause said car to stop, a first leveling mechanism and a second leveling mechanism for controlling the leveling connections, each of said mechanisms having main and cooperating elements, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other elements of each of said mechanisms on said car in such positions that the elements of said first mechanism are brought into cooperative relation when said car is one distance in advance of said landing and the elements of said second mechanism are brought into cooperative relation when said car is a greater distance in advance of said landing, means rendered effective upon the elements of said first mechanism being moved out of cooperative relation to cause completion of said leveling connections, means adapted upon the elements of said second mechanism being moved out of cooperative relation to interrupt said leveling connections, a closure associated with said system, and means effective while said closure is closed to prevent interruption of said leveling connections by said last-mentioned means.

25. In an elevator control system, an elevator car operable in a hatchway past a landing, leveling connections, means responsive to completion of said connections to cause said car to start upwardly and responsive to interruption of said connections to cause said car to stop, up-leveling mechanism and down-leveling mechanism for controllling the leveling connections, each of said mechanisms having first and second elements, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other element of said up-mechanism on said car in such positions that said elements of that mechanism are in cooperative relation when said car is in a predetermined region below said floor, means for mounting the other element of said down mechanism on said car in such position that said elements of that mechanism are in cooperative relation when said car is in a greater predetermined region below said floor, means rendered effective upon the elements of said up mechanism being moved, by downward movement of said car, out of cooperative relation to cause completion of said connections, means adapted upon the elements of said down mechanism being moved, by downward movement of said car out of cooperative relation to interrupt said connections, and additional means operable to prevent interruption of said connections by said last-mentioned means.

26. In an elevator control system, an elevator car operable in a hatchway past a landing, leveling connections, means responsive to completion of said connections to cause said car to start downwardly and responsive to interruption of said connections to cause said car to stop, down-leveling mechanism and up-leveling mechanism for controlling the leveling connections, each of said mechanisms having first and second elements, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other element of said down mechanism on said car in such positions that said elements of that mechanism are in cooperative relation when said car is in a predetermined region above said floor, means for mounting the other element of said up mechanism on said car in such position that said elements of that mechanism are in cooperative relation when said car is in a greater predetermined region above said floor, means rendered effective upon the elements of said down mechanism being moved, by upward movement of said car, out of cooperative relation to cause completion of said connections, means adapted upon the elements of said up mechanism being moved, by upward movement of said car out of cooperative relation to interrupt said connections, and additional means operable to prevent interruption of said connections by said last-mentioned means.

27. In an elevator control system, an elevator car operable in a hatchway past a landing, leveling connections, means responsive to completion of said connections to cause said car to start upwardly and responsive to interruption of said connections to cause said car to stop, up-leveling mechanism and down-leveling mechanism for controlling the leveling connections, each of said mechanisms having first and second elements, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other element of said up mechanism on said car in such position that said elements of that mechanism are in cooperative relation when said car is in a predetermined region below said floor, means for mounting the other element of said down mechanism on said car in such position that said elements of that mechanism are in cooperative relation when said car is in a greater predetermined region below said floor, means rendered effective upon the elements of said mechanism being moved, by downward movement of said car, out of cooperative relation to cause completion of said connections, means adapted upon the elements of said down mechanism being moved, by downward movement of said car out of cooperative relation to interrupt said connections, a closure associated with said system, and means controlled by said closure to prevent interruption of said connections by said last-mentioned means.

28. In an elevator control system, an elevator car operable in a hatchway past a landing, leveling connections, means responsive to completion of said connections to cause said car to start downwardly and responsive to interruption of said connections to cause said car to stop, down-leveling mechanism and up-leveling mechanism for controlling the leveling connections, each of said mechanisms having first and second elements, means for mounting one element of each of said mechanism in said hatchway, means for mounting the other element of said down mechanism on said car in such positions that said elements of that mechanism are in cooperative relation when said car is in a predetermined region above said floor, means for mounting the other element of said up mechanism on said car in such position that said elements of that mechanism are in cooperative relation when said car is in a greater predetermined region above said floor, means rendered effective upon the elements of said down mechanism being moved, by upward movement of said car, out of cooperative relation to cause completion of said connections, means

adapted upon the elements of said up mechanism being moved, by upward movement of said car out of cooperative relation to interrupt said connections, a closure associated with said system, and means controlled by said closure to prevent interruption of said connections by said last-mentioned means.

29. In an elevator control system, an elevator car operable in a hatchway past a landing; first leveling connections, second leveling connections, means responsive to completion of said first connections to cause said car to travel at a certain speed, means responsive to completion of said second connections to cause said car to travel at a higher speed; a first leveling mechanism and a second leveling mechanism for controlling the leveling connections, each of said mechanisms having first and second elements, means for mounting one element of each said mechanisms in said hatchway, means for mounting the other elements of said mechanisms on said car in such positions that the elements of said first mechanism are brought into cooperative relation when said car is a certain distance in advance of said floor and the elements of said second mechanism are brought into cooperative relation when said car is a greater distance in advance of said landing, means rendered effective upon the elements of said first mechanism being moved out of cooperative relation to cause completion of said first connections, and means rendered effective upon the elements of said second mechanism being moved out of cooperative relation to cause completion of said second connections.

30. In an elevator control system, an elevator car operable in a hatchway past a landing; first leveling connections, second leveling connections, means responsive to completion of said first connections to cause said car to travel at a certain speed, means responsive to completion of said second connections to cause said car to travel at a higher speed; a first leveling mechanism and a second leveling mechanism for controlling the leveling connections, each of said mechanisms having first and second elements, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other elements of said mechanisms on said car in such positions that the elements of said first mechanism are in cooperative relation while said car is in a region extending one distance below said floor and a greater distance above said floor and the elements of said second mechanism are in cooperative relation while said car is in a region extending said one distance above said floor and said greater distance below said floor; means, rendered effective upon the elements of said first mechanism being moved out of cooperative relation, by downward car movement, to cause completion of said first connections and, by upward car movement, to cause completion of said second connections; and means, rendered effective upon the elements of said second mechanism being moved out of cooperative relation, by upward car movement, to cause completion of said first connections and, by downward car movement, to cause completion of said second connections.

31. In an elevator control system, an elevator car operable in a hatchway past a floor landing, means to control said car including up-leveling connections and down-leveling connections means responsive to completion of said connections, respectively, to cause said car to start in the corresponding direction and responsive to interruption of said connections to cause said car to stop, mechanism associated with said up-connections and mechanism associated with said down-connections for controlling said connections, each of said mechanisms having first and second elements, said first elements including a light sensitive cell, said second elements including means to effect, respectively, predetermined different conditions of illumination of said cells when in corresponding predetermined positions with respect thereto, means for mounting one element of each of said mechanisms on said car, means for mounting the other elements of each of said mechanisms in said hatchway in such positions that the associated cell is subjected to one of said predetermined conditions of illumination when said car is substantially level with said landing; and means comprising switching mechanism responsive to that condition of illumination of said cells to interrupt said leveling connections and responsive to another of said conditions of illumination of either of said cells to cause completion of the leveling connections associated with that cell, said switching mechanism comprising interlocking means associated with each cell and disposed to prevent completion of the connections associated with the opposite direction of movement, and means effective upon completion of the leveling connections associated with either of said cells to render the interlocking means associated with the other of said cells ineffective.

32. In an elevator control system, an elevator car operable in a hatchway past a floor landing, means to control said car including up-leveling connections and down-leveling connections, means responsive to completion of said connections, respectively, to cause said car to start in the corresponding direction and responsive to interruption of said connections to cause said car to stop, mechanism associated with said up-connections and mechanisms associated with said down-connections for controlling said connections, each of said mechanisms having a light sensitive cell element, and an element adapted to effect predetermined different conditions of illumination of said cell when in corresponding different positions with respect thereto, means for mounting said cell elements on said car, means for mounting said other elements in said hatchway in such positions as to subject the associated cells to one of said conditions of illumination when said car is substantially level with said landing, means including switching mechanism responsive to the condition of illumination of said cells, and effective, while said cells are subjected to said one condition of illumination to cause interruption of said leveling connections, and effective, upon movement of said car to a position in which one of said cells is subjected to another of said conditions of illumination to cause completion of the associated leveling connections, said switching mechanism comprising interlocking means associated with each cell and disposed to prevent completion of the connections associated with the opposite direction of movement, and means effective upon completion of the leveling connections associated with either of said cells to render the interlocking means associated with the other of said cells ineffective.

33. In an elevator control system, an elevator car operable in a hatchway past a floor landing, means to control said car including up-leveling connections and down-leveling connections, means responsive to completion of said connec-

tions, respectively, to cause said car to start in the corresponding direction and responsive to interruption of said connections to cause said car to stop, mechanism associated with said up-connections and mechanism associated with said down-connections for controlling said connections, each of said mechanisms having a light sensitive cell element and an element adapted to effect a predetermined degree of illumination of said cell when in one position with respect thereto and to effect a lesser degree of illumination of said cell when in another position with respect thereto, means for mounting one element of each of said mechanisms in said hatchway in such positions as to subject the associated cell to said lesser degree of illumination when said car is substantially level with said landing, means including switching mechanism responsive to the condition of illumination of said cells and effective while said cells are subjected to said lesser degree of illumination to interrupt said leveling connections, and effective, upon movement of said car to a position in which one of said cells is subjected to said predetermined degree of illumination to cause completion of the associated leveling connections, said switching mechanism comprising interlocking means associated with each cell and disposed to prevent completion of the connections associated with the opposite direction of movement, and means effective upon completion of the leveling connections associated with either of said cells to render the interlocking means associated with the other of said cells ineffective.

34. In a control system for an elevator car operable in a hatchway past a floor landing, up-leveling connections, and down-leveling connection means responsive to completion of said leveling connections, respectively, to cause said car to start in the corresponding direction and responsive to interruption of said leveling connections to cause said car to stop, mechanism associated with said up-connections and mechanism associated with said down-connections for controlling said connections, each of said mechanisms having first and second elements, each of said first elements including a light source and a light sensitive cell disposed to receive light from said source and each of said second elements comprising a shield, means for mounting one element of each of said mechanisms in said hatchway, means for mounting the other element of each of said mechanisms on said car whereby said shields interrupt the light falling on the associated cells when said car is substantially level with said landing, and means including switching mechanism responsive to the condition of illumination of said cells, and effective, while said light is interrupted, to cause interruption of said connections, and effective, upon movement of said car to a position in which one of said cells is illuminated, to cause completion of the associated connections said switching mechanism comprising interlocking means associated with each cell and disposed to prevent completion of the connections associated with the opposite direction of movement, and means effective upon completion of the leveling connections associated with either of said cells to render the interlocking means associated with the other of said cells ineffective.

35. In a control system for an elevator car operable in a hatchway past a landing, up-leveling connections and down-leveling connections, means responsive to completion of said connections, respectively, to cause said car to start in the corresponding direction and responsive to interruption of said connections to cause said car to stop, mechanism associated with said up-connections and mechanism associated with said down-connections for controlling said connections, each of said mechanisms comprising a source of light and a light sensitive cell disposed to receive light from said source, and a shield, means for mounting the cell and light source associated with each of said mechanisms on said car, means for mounting the shields associated with each of said mechanisms in said hatchway in such position that said up shield is effective to prevent illumination of said up cell while said car is in a region extending one distance above said floor and a lesser distance below said floor, and that said down shield is effective to prevent illumination of said down cell while said car is in a region extending said one distance below said floor and said lesser distance above said floor, means adapted to respond to an illuminated condition of said up cell to complete said up connections and comprising interlocking means to prevent completion of said down connections, means adapted to respond to an illuminated condition of said down cell to complete said down connections and comprising interlocking means to prevent completion of said up connections, and additional means, rendered effective in response to an illuminated condition of one of said cells to render the interlocking means associated with the other of said cells ineffective.

36. In an elevator system, an elevator car operable in a hatchway, a first circuit and a second circuit associated with said system, an operator adapted to selectively control both of said circuits, said operator having an element mounted on said car and an element mounted in said hatchway for cooperation with said car-carried element, and means, comprising means responsive to the direction of movement of the car to determine which of said circuits is to be controlled by said operator.

37. In an elevator system, an elevator car operable in a hatchway, up-and-down control means for said car, a first circuit and a second circuit associated with said system, an operator adapted to selectively control both of said circuits, said operator having an element mounted on said car and an element mounted in said hatchway for cooperation with said car-carried element, and means controlled by said up-and-down control means for determining which of said circuits is to be controlled by said operator.

38. In an elevator control system, an elevator car operable in a hatchway, control mechanism for said elevator car comprising a decelerating circuit and a stopping circuit, an operator adapted to control both of said circuits, said operator having an element mounted on said car and an element mounted in said hatchway for cooperation with said car-carried element, and means, comprising means responsive to the direction of movement of the car to determine which of said circuits is to be controlled by said operator.

39. In an elevator control system, an elevator car operable in a hatchway, up and down control means for said car including a decelerating circuit and a stopping circuit, an operator adapted to control both of said circuits, said operator having an element mounted on said car and an element mounted in said hatchway for cooperation with said car-carried element, and additional means controlled by said up-and-down

control means to determine which of said circuits is to be controlled by said operator.

40. In an elevator control system, an elevator car operable in a hatchway past a floor, up-and-down control means for said car including a decelerating circuit and a stopping circuit, an operator having an element mounted in said hatchway and an element carried on said car, said car-carried element being disposed to be brought into cooperative relation with said hatchway element, during travel of said car in one direction, when said car is one distance from said floor, and, during travel of said car in the other direction, when said car is a lesser distance from said floor, and means comprising circuit connections to render said operator effective, during travel of said car in said one direction to interrupt said decelerating circuit when said elements are brought into cooperative relation, and during travel of said car in said other direction, to interrupt said stopping circuit when said elements are brought into cooperative relation.

41. In an elevator control system, an elevator car operable in a hatchway, circuit controlling apparatus having first and second elements associated with said system, said first element comprising a light sensitive cell, said second element comprising means to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, means for mounting one of said elements on said car, means for mounting the other of said elements in said hatchway for cooperation with said car-carried element, relay mechanism, means to operate said car at a plurality of speeds, and means effective during operation of said car at certain of said speeds to render said relay mechanism subject to control in accordance with the condition of illumination of said cell.

42. In an elevator control system, an elevator car operable in a hatchway, circuit controlling apparatus having first and second elements associated with said system, said first element comprising a light sensitive cell, said second element comprising means to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, means for mounting one of said elements on said car, means for mounting the other of said elements in said hatchway for cooperation with said car-carried element, relay mechanism, means to operate said car at a plurality of speeds, and means effective during operation of said car at certain of said speeds to render said relay mechanism subject to control in accordance with the condition of illumination of said cell, said last named means being effective during operation of said car at others of said speeds to render said circuit controlling apparatus ineffective to control said relay mechanism.

43. In an elevator control system, an elevator car operable in a hatchway, circuit controlling apparatus having first and second elements associated with said system, said first element comprising a light sensitive cell, said second element comprising means to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, means for mounting one of said elements on said car, means for mounting the other of said elements in said hatchway for cooperation with said car-carried element, relay mechanism, decelerating mechanism for said car, and means responsive to operation of said decelerating mechanism to render said relay mechanism subject to control in accordance with the condition of illumination of said cell.

44. In an elevator control system, an elevator car operable in a hatchway, circuit controlling apparatus having first and second elements associated with said system, said first element comprising a light sensitive cell, said second element comprising means to effect a predetermined condition of illumination of said cell when in a predetermined position with respect thereto, means for mounting one of said elements on said car, means for mounting the other of said elements in said hatchway for cooperation with said car-carried element, relay mechanism, decelerating mechanism for said car, and timing means rendered effective, at the expiration of a predetermined time interval, in response to operation of said decelerating means to render said relay mechanism subject to control in accordance with the condition of illumination of said cell.

45. In an elevator control system, an elevator car operable in a hatchway, a high speed circuit and a low speed circuit associated with said system, means to decelerate said car comprising means to interrupt said high speed circuit, an operator adapted to interrupt said low speed circuit, said operator having first and second elements, said first elements comprising a light sensitive cell, said second element comprising means to effect a predetermined condition of illumination when in a predetermined position with respect thereto, means to mount one of said elements on said car, means to mount the other of said elements in said hatchway for cooperation with said car-carried element, and means to prevent interruption of said low speed circuit until after interruption of said high speed circuit comprising means effective while said high speed circuit is complete to render said operator ineffective to interrupt said low speed circuit.

46. In an elevator system, an elevator car operable in a hatchway, apparatus including a plurality of electric circuits associated with said system, a plurality of devices for controlling certain of said circuits, each of said devices comprising a first element and a second element, certain of said first elements having characteristics such that they cooperate only with corresponding second elements, means for mounting said first elements on said car in substantially the same vertical line and means for mounting said second elements at predetermined points in said hatchway in substantially a vertical line for cooperation with said first elements, whereby said certain circuits may be selectively controlled in accordance with the position of said car by devices having small lateral space requirements.

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