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ELEVATOR CONTROL SYSTEM

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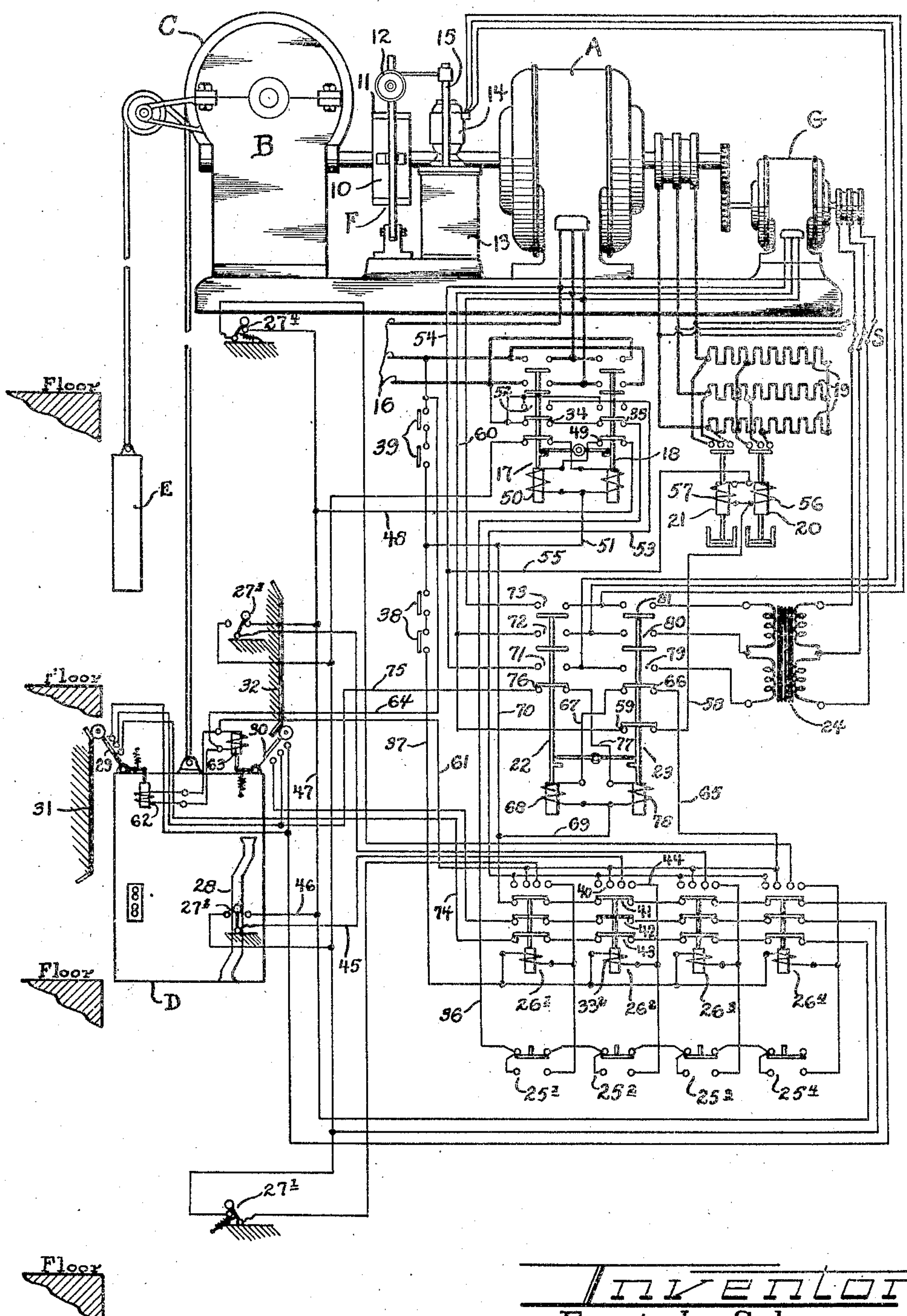

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ELEVATOR CONTROL SYSTEM

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The present invention relates in general to the control of load raising and lowering equipment and is particularly concerned with a control system which may be advantageously applied to the control of passenger elevators, freight elevators, skip hoists such as may be utilized with blast furnaces, etc., and especially equipment of this type wherein smoothness of operation, accurate landings, and maintenance of the load carrying means at a desired level during loading and unloading may be desired.

One of the most important problems in the design of elevators has to do with speed regulation, since the attainment of proper regulation materially lessens the subjection of the main hoisting motor, the mechanical parts, and the electrical control to undue stresses, and results in decrease of the required time for making a round trip, as well as increase and improve the service and smoothness of operation. Speed regulation is of particular importance in high-speed elevators for accurate landing without inching and for maintenance of the car level during loading and unloading. A high degree of speed regulation is therefore desirable, and this degree of regulation must be practically constant, independent of the weight of the car load and for both up and down directions of movement of the elevator.

For alternating current installations, there have been several systems which have come into general use.

One system which has been extensively utilized makes use of the well known Ward-Leonard control in which a motor-generator set is interposed between the main hoisting motor and the system from which it is supplied. This system is particularly advantageous for elevators due to its excellent speed regulation. Any desired variation in the speed of the hoisting motor may be effected. This equipment, however, is objectionable in that it is not only expensive, but requires additional space for installation of the motor-generator sets. Each elevator motor requires a separate motor-generator set of full capacity for the hoisting motor and also a reserve motor-generator set for emergency use. Moreover, the motor-generator sets must be kept running, whether or not the elevator motors are being operated. Therefore, the relative high power consumption for stand-by is wasted. Also, the total efficiency of each motor-generator set is very low, due to having to design the same to be capable of taking care of the peak loads which might be imposed.

In certain installations, it has been the practice to utilize an alternating current two-speed squirrel cage elevator motor. Such arrangements have proved fairly satisfactory with motors capable of operating at suitable normal and low speeds, but this practically limits such installations to a motor speed ratio of about 3:1 between their normal and low speeds, as efficient alternating current motors having a higher speed ratio are not usually obtainable. In high speed elevators, the low speed of the motor is too high for satisfactory leveling if this ratio between the motor speeds be observed, and if it is enlarged so as to afford a sufficiently low leveling speed and a sufficiently high normal speed, the large number of poles required for the low speed winding of the motor results in extreme magnetic leakage and low efficiency and would necessitate the use of an unsuitable oversize motor. The regulation of motors obtainable for such purpose is very poor for higher speeds, and they, therefore, are unsuitable for high speed installations. Moreover, motors of this type have an unsatisfactory high rate of acceleration and retardation which becomes unpleasant particularly for passenger service.

Still another system which has been successfully utilized makes use of an alternating current wound rotor hoisting motor equipped with micro-drive. With such control, a regulated speed of about ten per cent of the full speed has been found to be satisfactory, but the micro-drive with its coupling arrangement and the utilization of alternating current solenoid brakes constitute a costly installation having inherent objectionable operating characteristics.

In the system of the present invention, it is proposed to provide an arrangement embodying the most desirable features of the above noted systems, and yet a system which may be more economically installed and operated.

More specifically, my improved system utilizes an alternating current hoisting motor of the slip ring or wound rotor type. Practically any speed regulation can be secured with this type of motor, so that it is possible to meet the most desirable full speed and low speed conditions of operation. For example, a regulated speed of about five to ten per cent of the full speed is very satisfactory, and the speed differences under different car loadings have been found to not vary greatly.

It has been found, for example, that by utilizing a counterweight equal to the weight of the elevator car plus approximately forty per cent of the full car load, the extreme values would be substantially as follows:

Regulated speed for car, full load, up	5% of full speed
Regulated speed for empty car, up or down	7½% of full speed
Regulated speed for car, full load, down	10% of full speed

From the above, it will be apparent that the differences in the regulated speed under different conditions of car loading compares favorably with systems utilizing the Ward-Leonard control, eliminates the disadvantages of the micro-drive, and since any desired rate of acceleration may be utilized with the wound rotor type of motor, the shocks attending the high rate of acceleration, when squirrel cage type of motors are used, are eliminated.

Further improvements in operation have been secured by eliminating the usual alternating current solenoid brake. In my improved system, the brake for the hoisting motor is controlled by means of a centrifugal fluid frictional device which has the characteristic of being responsive in its operation to variations in frequency. This device, which is commonly termed a "Thrustor," broadly comprises a closed tank or cylinder having a piston mounted for reciprocable movement therein, this piston being connected to a linkage mechanism for operating the brake shoes against the usual closing spring. This piston carries a motor driven impeller which is adapted to force a fluid such as oil from above the piston to that portion of the cylinder below the piston. This action increases the pressure of the fluid below the piston, with the result that the piston is forced upwardly and the brake shoes moved in an opening direction against the closing spring. Deenergization of the impeller motor enables the pressure of the fluid above and below the piston to become equalized; and the brake closing spring then becomes active to restore the brake shoes to closed or braking position, and the piston of the power device is permitted to move to its normal position in the lower part of the cylinder. It will be appreciated that in such an arrangement the actuating force of the device will be dependent upon the frequency at which its motor is energized.

For normal operation in my system, means are provided for connecting the brake operating device motor with the stator supply of the hoisting motor, whereas during regulating or slow operation of the hoisting motor, the device is connected with a variable frequency source such as the rotor circuit of the hoisting motor, or the rotor of an auxiliary motor driven at a different speed than the main hoisting motor.

With the foregoing in mind, it is a primary object of the herein described invention to provide an improved elevator control system which may be utilized with a main alternating current hoisting motor of the wound rotor or slip ring type for the attainment of normal full speed, regulating and leveling speeds of the elevator.

It is another object of the invention to provide an improved elevator control system wherein novel braking mechanism is utilized for the hoisting motor, and in which the braking mechanism is arranged to be selectively connected to different energizing circuits during various operating conditions of the elevator, these circuits respectively having characteristics adapted to control the brake operation in a pre-determined manner most suitable for a particular condition of elevator operation.

Still other objects of the invention are to provide an improved elevator control system which may be readily adapted for all automatically controlled elevators, which is sufficiently flexible to permit of its being utilized with high speed, as well as low speed elevator installations, which may be readily adjusted to secure the most desirable accelerating, regulating and leveling speeds for a particular installation, and which will at the same time be economical both as to installation and operation.

Yet another and most important object of the invention is to provide in an elevator system improved means which will act to maintain automatically a desired reduced speed of the hoisting motor by loading the motor with a braking torque of such value in addition to the effective load that, with full resistance in the rotor circuit, the reduced speed will be the value desired.

Other objects, purposes, and advantages of the invention will hereinafter more fully appear or will be understood from the following description of the system embodying the principles thereof which is illustrated diagrammatically in the single figure of the accompanying drawing in association and combination with elevator apparatus in which three-phase alternating current is employed.

Elevator apparatus in general

For purposes of illustrating my improved control system, I have chosen to illustrate the system as being applied to an alternating current installation in which the main apparatus embodies a main hoisting motor A of the slip ring or wound rotor type. This motor is connected through a suitable transmission contained in the casing B for driving the usual traction sheave or hoisting drum C. As is the usual practice, an elevator car D is suspended in a hatchway from a hoisting cable which is passed over the traction sheave and suitable idler pulley and connected to the usual counterweight as shown at E. The main hoisting motor has associated with it a braking mechanism as generally indicated at F, and which will subsequently be described in particular. The main hoisting motor may or may not be connected with an auxiliary motor G of the slip ring or wound rotor type for a purpose hereafter to be explained.

The hoisting apparatus for each elevator may be mounted on a common bed plate so as to be positionable as a unit in the most suitable position for performing its function.

Braking mechanism

In my present system, the brake acts to maintain automatically a desired reduced speed of the hoisting motor by loading the motor with such a brake torque in addition to the effective motor load that the reduced speed of the wound rotor motor, with full resistance cut in circuit, has the value desired. The alternating current solenoid brakes, as generally heretofore used, were inherently unfit for such purpose.

As employed herein, the braking mechanism more specifically comprises, as more or less diagrammatically illustrated on the drawing, a pair of brake shoes **10** which are associated with a braking drum **11**, each of these shoes being associated with the usual toggle mechanism arranged to be actuated in a brake setting direction by means of a spring **12**. In practice, I have found it desirable to provide the brake of such size as to be capable of producing a brake torque of approximately 1.6 to 1.7 times the rated motor torque.

For actuating the toggle mechanism to release the brake shoes relative to the braking drum, I have utilized a centrifugal fluid frictional device 13, commonly known as a "Thrustor," which includes in its assembly an electric motor 14. The operation of this device is well known, so that it is thought that a detailed description thereof will be unnecessary. It may be stated, however, that when the motor 14 is operated, power is transmitted through a fluid medium to a push rod 15 supported for reciprocable movements, the amount of power delivered to the push rod depending upon the speed or the frequency at which the motor 14 is operated. In the present arrangement, the push rod 15 is connected through a suitable linkage to operate the brake toggle mechanism in a releasing direction against the action of the brake closing spring 12.

If the motor 14 is connected to a normal 60 cycle electric circuit, the brake will be immediately released, and when the motor 14 is disconnected, the brake will be applied immediately. On the other hand, it will be apparent that, if the motor 14 is connected to a circuit in which the frequency is being gradually increased or decreased, the brake can be so controlled as to gradually release or gradually apply the brake shoes to the braking drum. Advantage has been taken of these characteristics to secure the most desirable braking effects during the different operating conditions of the main hoisting motor, as will hereafter be explained.

Control system in general

For purposes of illustrating my improved control system, the various contactors and control devices are disclosed as being arranged for A. C. operation. I do not, however, wish to be limited in this respect, as D. C. operating coils may be utilized with the various contactors without departing from the invention. Also, it is to be understood that any suitable type of automatic starter for the main hoisting motor may be utilized, and it is not necessary to utilize the particular arrangement disclosed in the drawing.

The system has been further illustrated as being associated with a "push button" control for the elevator. However, other types of controls may be utilized. No attempt has been made to show a complete "push button" control system, and only such parts of the system are shown as are considered desirable in order to fully explain the principles of the present invention. Door and gate contacts, safety and protective switches and the like, as well as certain other parts of the system have been omitted or only schematically represented where found desirable.

The circuit for a four-floor installation has been illustrated, and in the drawing, the elevator is shown as being at the floor level of the second floor.

The main hoisting motor has its stator connected to a main three-phase power supply 16 and is controlled as to direction of rotation by mechanically and electrically interlocked up and down contactors 17 and 18 respectively. The rotor or secondary of the main hoisting motor is brought out to slip rings in the usual manner and connected to external resistors 19 connected in Y. These resistors are so proportioned as to provide the desired regulating speed or slow speed of the motor, when all the resistance is cut in, and be of sufficient value to assure starting with the maximum motor torque required. Sections of the resistors are successively cut out by means of suitable accelerating contactors 20 and 21 which are arranged for successive time delay closing and instantaneous opening by the provision of suitable dash pots or otherwise.

Another pair of mechanically and electrically interlocked contactors 22 and 23 are provided for selectively connecting the motor 14 of the braking mechanism either with the main power supply to the hoisting motor or with the secondary circuit of the hoisting motor, when the auxiliary motor G is not being utilized. If the auxiliary motor G is being utilized, then instead of connecting the motor 14 to the secondary of the main hoisting motor, the connection is made to the slip rings of the auxiliary motor. In either case, the latter connections are made through a suitable transformer 24.

For control by an operator, a plurality of push buttons 25^1, 25^2, 25^3, and 25^4 are provided, the superscript in each case indicating the particular floor for which the push button is designated. Floor relays 26^1, 26^2, 26^3, and 26^4 are respectively provided for the different floors. Push buttons and floor switches may be mounted in any suitable location. Within the hatchway, for each floor there is provided the usual selector direction switch, these switches for the respective floors being designated 27^1, 27^2, 27^3, and 27^4.

The selector direction switches are of the usual construction, being arranged as single pole, double throw switches, except for the first floor and top floor, which are respectively retained closed in one direction only by a suitable spring. For the other floors, however, the switches may be actuated into one position or the other by means of a suitable cam member 28 carried by the elevator car. It will be noted that when a car is at the floor level of a particular floor, the selector direction switch for that floor will be held in mid-position and will thus become ineffective.

There is also provided on the car a pair of car leveling switches 29 and 30 which are arranged to be held in open position by means of associated springs, but which may be mechanically actuated to closed position by means of hatchway cams 31 and 32. In order to prevent unnecessary and inconvenient operation of these switches, when passing non-selected floors, solenoids are provided for retaining the switches in such position as to be unaffected by the cams 31 and 32. It will be noted that with the elevator at the proper floor level, the leveling switches will be in opened position, but the associated cam ends are so disposed that with only slight upward movement of the elevator car, the leveling switch 30 will be closed. On the other hand, by a slight movement of the elevator car in a downward direction, the leveling switch 29 will be closed.

The cam 28 and the cams 31 and 32 are so proportioned that the cam 28 will open the selector direction switch for a particular floor, while the leveling switch 29 is being held closed by the cam 31, if the elevator is moving upwardly to the floor, or the leveling switch 30 is held closed by the cam 32 in the event that the elevator is moving downwardly to the floor.

In general, the control system of the present invention provides for initial starting of the elevator from rest under the control of the operator, but once the elevator has started, it will be automatically accelerated to full speed. As the elevator approaches a selected floor, it will pass into a regulating zone at a fixed distance from the selected floor level and the control will automatically connect the elevator hoisting motor and associated apparatus for slow speed operation and retardation until the elevator enters a leveling zone, where it will come to stop at the selected floor level. At rest at a particular floor, the leveling switches are arranged to be automatically actuated to maintain the floor level, due to cable stretch, changes in elevator load during loading and unloading, etc. The operation of my control system to secure the different operating conditions of the elevator will now be described in detail.

Normal operation

Let it be assumed that the elevator car is disposed on the first floor and that it is desired to take the car to an upper floor, for example, the second floor. When the car is in the first floor position, the cam **28** retains the selector direction switch **27^1** in open position, so that if the push button for this floor is depressed by the operator, it will have no effect on the control system. Moreover, with the elevator at the first floor, the selector direction switch **27^2** will have been left in a position thrown towards the right. To start the elevator, the operator pushes push button **25^2** which will energize the operating coil **33^2** of the floor relay **26^2** through the following circuit: From one side of the supply circuit through the normally closed contacts **34** and **35** of the main contactors **17** and **18**, through conductor **36**, the lower contacts of push button **25^2**, the operating coil **33^2**, and thence through conductor **37** and the contacts of normally open but now closed safety devices **38** and **39** to the other side of one phase of the supply circuit. The contacts **38** schematically represent safety devices which are arranged to function during travel of the elevator, but not during leveling movements thereof, while the contacts **39** represent safety devices such as stop buttons and the like which are arranged to function at all times.

Energization of the operating coil of the floor relay **26^2** causes this relay to close its contacts **40** and open contacts **41**, **42** and **43**. Conductor **36** being connected with a conductor **44** to one of the contacts **40**, closure of the floor relay **26^2** will energize the "up" main contactor **17** through the following circuit: From the energized conductor **36**, through the lower contacts of push button **25^2**, conductor **44**, contacts **40**, conductor **45**, the right hand contact of selector direction switch **27^2**, conductor **46**, conductor **47**, conductor **48**, through the normally closed contacts **49** of main contactor **18** to operating coil **50** of main contactor **17**, conductor **51**, and thence to conductor **37** through contacts **39** to the other side of one phase of the supply circuit.

The main contactor **17** now closes to connect the stator of the hoisting motor to the power supply circuit and at the same time will close its contacts **52** to establish through conductor **53** a holding circuit for the operating coil of floor relay **26^2**. At the same time contacts **34** of main contactor **17** are opened so as to de-energize conductor **36** feeding the push button, the push button thus being rendered ineffectual for further operation to control the elevator until after the operation which has now been started is completed.

The hoisting motor being now energized will start and attain a speed determined by the secondary resistors **19** which are now all cut in. As soon as the contactor **17** closes, the accelerating relays **20** and **21** will have their operating coils energized through the following circuit: From one phase wire of the power circuit through conductor **54**, conductor **55** to one side of the parallel connected operating coils **56** and **57** of the relays **20** and **21**, from the other common connection of these coils through conductor **58**, normally closed contacts **59** of contactor **23**, and thence through conductor **60** to another phase wire of the motor supply circuit. The relays **20** and **21** are arranged to successively close at the expiration of predetermined time intervals to accelerate the hoisting motor by successively cutting out sections of the resistance in its rotor circuit, operation of the relay **21** acting to short circuit the slip rings of the motor and cause it to operate at full speed.

Simultaneously with the starting up of the motor, as soon as the floor relay **26^2** closes its contacts **40**, the leveling switches **29** and **30** are energized and closed through the following circuit: From one of the contacts **40** which is now energized from one phase wire of the power circuit, through conductor **61** to one side of the parallel connected operating coils **62** and **63** of the leveling switches **29** and **30**, from the other common connection of these coils through conductor **64** back to the other side of one phase of the supply circuit.

Closing of the contacts of the leveling switches will at this time have no effect upon the operation.

Closing of the contacts **40** of the floor relay further energizes the contactor **22** through the following circuit: From contacts **40**, which are energized, through conductor **65**, a normally closed contact **66**, conductor **67** to the operating coil **68** of contactor **22**, conductor **69**, conductor **70**, and thence to conductors **51** and **37**, and then through contacts **39** to the other side of the supply circuit. Closure of contactor **22** operates to close contacts **71**, **72**, and **73**, which operate to connect the motor **14** of the brake mechanism directly to the stator circuit of the hoisting motor. Since the frequency of this circuit is constant, the motor **14** will operate immediately and release the brake.

The elevator will now have been brought up to full speed and will be approaching the selected floor, in this instance the second floor. After the initial selection of the desired floor by the operator, and from the time that the proper push button is manipulated, further operation of the elevator is automatic.

Normal operation of the elevator in starting to go to a lower selected floor would be the same as described above, except that the main contacts of the contactor **18** would be closed, the operation of the contactor **18** being determined by the position of the selector direction switch of the floor selected, this switch being in such position as to close or engage the left hand contact.

The floor relays, the leveling relays, the contactor **22**, accelerating relays **20** and **21** would all operate in the same manner as described above.

Regulating operation

Regulating operation, as considered herein, relates to the low speed operation of the elevator during which time all of the resistance 19 is in the secondary or slip ring circuit of the hoisting motor rotor. The regulating operation may therefore take place during the retardation until the elevator is brought to rest at a selected floor or during leveling operation.

Continuing with the previously assumed movement of the elevator to the second floor, as soon as the elevator reaches a predetermined position approaching the second floor level, such position being determined by the length of the cams 31 and 28, the leveling switch 29 which is in closed position will ride upon the cam 31. Up to this time the switch was held closed by the energization of its coil 62 and will now be held in closed position by the cam 31. As the movement of the car continues, the action of the cam 28 will operate to open the selector direction switch 27^2, the switch assuming a position as shown on the drawing.

Opening of the selector direction switch 27^2 interrupts the energizing circuit to the operating coil 50 of the contactor 17, so that this contactor will now open its main contacts. Dropping out of the main contactor 17 interrupts the holding circuit of the floor relay 26^2 so that this relay now drops out. As soon as the floor relay drops out, it opens its contacts 40 to de-energize the coils 62 and 63 of the floor leveling switches. The floor leveling switch 30 will then be actuated to open its contacts, but the leveling switch 29 will be retained in closed position by the cam 31. At the same time the contactor 22 is de-energized, so that it will operate and disconnect the braking mechanism motor 14 from the stator circuit of the hoisting motor. It will also be noted that when the main contactor 17 drops out, the circuit to the accelerating relays 20 and 21 is interrupted, so that these relays, which are instantaneous in opening, will have opened and inserted the entire resistance 19 into the rotor circuit of the hoisting motor to provide slow speed operation, when the motor is again connected to the power circuit.

When the floor relay 26^2 dropped out, it closed its contacts 41, 42, and 43. The contacts 41 function to connect the energized conductor 70 with the contacts of the closed leveling switch 29, so that these contacts now function to complete an energizing circuit to the operating coil of contactor 17 through conductor 74, the contacts 43 of the floor relays, which are in series, conductor 47, conductor 48, contacts 49, the operating coil 50, conductor 51, and thence through conductor 47 and the contacts 39 to the other side of the phase of the power circuit from which energization of this control circuit is taken.

Thus, the main contactor 17 again closes, and at the same time the contactor 23 is energized from the contacts of leveling switch 29 through conductor 75, the closed contact 76 of contactor 22, conductor 77, operating coil 78, and thence through conductor 69, conductor 70, conductor 37 and contacts 39 to complete the circuit.

Closing of contactor 23 opens contacts 59 and prevents energization of the accelerating relays so that the resistance 19 is entirely in circuit for slow speed operation.

The closing of contactor 23 operates to close contacts 79, 80 and 81 to connect the motor 14 of the braking mechanism either to the rotor circuit of the main hoisting motor or to the rotor circuit of the auxiliary motor G, depending upon the position of a switch G which determines whether or not the auxiliary motor arrangement is being utilized. The connection of the motor 14 feed circuit is made through the transformer 24 so that the same motor for the braking mechanism may be supplied by its proper voltage irrespective of whether the motor 14 is connected to the stator side of the hoisting motor or to a rotor circuit of other voltage, which may be either the rotor of the hoisting motor or the rotor of the auxiliary motor.

During the change over from full speed to slow speed operation, at which time the feed circuit of motor 14 is temporarily disconnected, the spring 12 of the braking mechanism will act to apply the brake. However, as soon as the motor 14 is connected with one of the rotor circuits, the frequency of these circuits now increasing as the hoisting motor slows down to regulated speed, the braking effect will be gradually diminished in accordance with the increasing frequency, which will be noted corresponds to the decreasing speed of the hoisting motor. With this arrangement there will be no sudden braking, but the car will be gradually reduced to the regulated speed.

As the car now arrives substantially at the desired floor level, the cam 31 permits opening of the leveling switch 29 and the car is now at the floor level.

Opening of the switch 29 interrupts the energizing circuit to the main contactor 17 as well as the contactor 23 so that these contactors will now open to disconnect the hoisting motor and the brake motor 14. The spring 12 of the braking mechanism thereupon actuates the brake to stop the car at the floor level.

The above describes the regulating operation when approaching a selected floor from below. In approaching the selected floor from above, the operation will similarly reduce the speed of the car, except that in this case it will be the cam 32 at the selected floor and the leveling switch 30 which will in this case control the operation of the main contactor 18 instead of contactor 17. The contactor 23 will operate in the same manner to connect the braking mechanism to the rotor circuit.

Leveling operation

My improved system is arranged to automatically maintain the car level during loading and unloading, changes in length of the cable suspending the elevator car and for any other reason in which the elevator car may be displaced from the floor level due to reasons that may result from the operation of the control mechanism.

With the car at rest at a floor level, the respective control devices and the hoisting equipment are all deenergized. Let it now be assumed, for example, that the car is moved downwardly a slight amount below the floor level. Under these conditions, the switch 29 will be closed due to the action of cam 31.

Closure of this leveling switch will energize the "up" main contactor 17 and the contactor 23 to connect the hoisting motor for slow speed operation and the braking mechanism to the rotor circuit in the same manner as described in connection with the regulating operation.

The elevator car will thereupon be returned to floor level and the leveling switch 29 will open to deenergize the control devices and shut down the hoisting equipment.

A similar operation takes place upon upward movement of the car from the floor level, except that in this case it is the leveling switch 28 which will be closed to actuate the "down" contactor 18, together with the control contactor 23 for the brake motor. The elevator is thus returned to floor level and the control devices and hoisting motor deenergized.

General considerations

The cams 28, 31 and 32 and the selector direction switches at each floor are so arranged in the hatchway that, when approaching a selected floor, the leveling switches will be operated by the cam 31 or cam 32, as the case may be, before the cam 28 operates the associated selected switch. Moreover, the length of the cam 28 must be such that one-half of its length is larger than the maximum stopping distance of the car under normal speed with fully loaded car going "down" or empty car going "up" and full braking torque applied.

With reference to the brake operating mechanism, the brake when connected to the stator side of the hoisting motor will be actuated to fully released position, and when disconnected will be actuated to full braking position.

The frequency in the hoisting motor rotor circuit will vary substantially inversely as the speed of movement of the rotor. That is, when the motor is operating at full speed, the frequency in the rotor circuit will be substantially zero or will be proportional to the slip. As the motor is slowed down, this frequency is gradually increased accordingly until with the rotor stationary, the frequency of the motor circuit would be the same as that of the stator circuit. Since the motor 14 of the braking mechanism is responsive to frequency, advantage may be taken of the variable frequency characteristic of the rotor circuit to secure braking effects which vary according to the speed of the motor and consequently the speed of the elevator. If the brake motor 14 during the regulated speed operation is connected to the rotor circuit as shown by dotted lines on the drawing, then the regulation between the frequency of the rotor circuit and the speed of the motor rotor will be varied in direct proportion. On the other hand, in order to secure another regulated speed, another frequency which may be either above or below that of the rotor frequency of the hoisting motor must be applied to the brake. For such purposes the auxiliary motor G is utilized and the rotor of this motor is connected to the rotor of the main hoist motor through gears of suitable ratio to obtain the desired frequency. The auxiliary motor is provided with the same number of poles as the main slip ring motor, and since the auxiliary motor will act as a frequency changer to feed the motor 14, the auxiliary motor may be of relatively small size.

With the above manner of energizing the motor 14, the voltage of the rotor circuit, irrespective of whether this circuit is from the rotor of the main hoisting motor or the auxiliary motor G, will change in the same proportion as the rotor frequency applied to the circuit. Therefore, the brake motor operates electrically in the entire range from zero to full frequency and full voltage under rated conditions.

By connecting the rotor of the auxiliary motor so that it is driven from the main hoisting motor at one-half speed, it will be apparent that the frequency in the rotor circuit of the auxiliary motor will be 30 cycles when the frequency of the rotor circuit of the main hoisting motor would be substantially zero, where the main power supply is of 60 cycle character. On the other hand, if the auxiliary motor is driven at twice the speed of the hoisting motor, the frequency in the auxiliary motor rotor circuit will have been reduced to zero when the main hoist motor is operating at 50 per cent speed.

From the foregoing, it will be noted that the rate of change in the frequency when going from full speed of the hoisting motor to slow speed may be varied depending upon whether the auxiliary motor is driven at a greater or lesser speed than the hoisting motor, or whether the motor 14 is energized from the rotor circuit of the hoisting motor. Of course, the rate of change in the frequency will likewise change the braking effect obtainable on the hoisting motor. It is therefore possible to obtain the most desirable braking effect for the particular regulated speed which is to be used.

From the foregoing description, it will be apparent that the present invention provides an improved elevator control system which may be utilized with a main alternating current hoisting motor of the wound rotor type for the attainment of normal full speed, regulated and leveling speeds of the elevator; which embodies an improved braking mechanism on the hoisting motor, this braking mechanism being arranged to be selectively connected to different energizing circuits for various operating conditions of the elevator, these circuits having characteristics adapted to control the brake operation in a predetermined manner most suitable for a particular condition of elevator operation; a system which may be readily adapted for all automatically controlled elevators, which is sufficiently flexible to permit of its use with high speed, as well as slow speed elevator installation, which may be readily adjusted to secure the most desirable accelerating, regulated and leveling speeds for a particular installation, and which will at the same time be economical both as to installation and operation.

It is, of course, to be understood that although I have described in detail a preferred embodiment of my invention, the invention is not to be thus limited but only insofar as defined by the scope and spirit of the appended claims.

I claim as my invention:

1. In an elevator control system the combination comprising, load elevating and lowering means, a hoisting motor therefor of the slipring type, electro-responsive devices for controlling said motor, braking means for said motor actuatable in response to frequency changes in a single energizing circuit therefor, and means selectively operable under different operating conditions of said first means to energize said circuit from the primary side of said motor and from the secondary side of the motor.

2. In an elevator control system the combination, comprising, load elevating and lowering means, an alternating current hoisting motor therefor, electro-responsive devices for controlling said motor, an auxiliary motor of the slipring type having its rotor mechanically coupled with the hoisting motor through a speed changing device and its primary electrically paralleled with the hoisting motor primary, braking means for said motor actuatable in response to frequency changes in an energizing circuit therefor, and means selectively operable under dif-

ferent operating conditions for energizing said circuit from the primary side of said motors and the secondary side of the auxiliary motor.

3. In combination; an elevator car adapted to serve a plurality of landings; a hoisting motor therefor, a source of current for the motor, a frequency responsive brake for said motor, means for initiating operation of said motor and simultaneously completely releasing said brake, means operable upon the arrival of said car at a certain distance from a landing at which a stop is to be made to connect the motor for slow speed operation and apply the brake, and means for applying to said brake a frequency variable in accordance with the motor speed to gradually release the braking effect as the motor speed is reduced.

4. In combination; an elevator car adapted to serve a plurality of landings; a hoisting motor therefor of the wound-rotor type, a source of current for the motor, a frequency responsive brake for said motor having an energizing circuit, means for causing connection of the motor and said energizing circuit of said brake directly to said source to completely release the brake and simultaneously start the motor, means operable upon the arrival of the car at a certain distance from a landing at which a stop is to be made to connect the motor for slow speed operation and apply the brake, and means for disconnecting said energizing circuit of said brake from said source and for connecting said energizing circuit of the brake to the variable frequency of the motor rotor to gradually release the braking effect as the motor speed is reduced.

5. In combination; an elevator car adapted to serve a plurality of landings; a hoisting motor therefor of the wound-rotor type, a source of current for the motor, a frequency responsive brake for said motor, said brake having a single energizing circuit, means for causing connection of the motor and the energizing circuit of said brake to said source to release the brake and start the motor, and mechanism for automatically stopping the car at a desired landing, said mechanism comprising means controlled by the car movement for connecting the motor for a pre-determined slow speed operation at a fixed distance from said landing and applying said brake, means for connecting said energizing circuit of said brake to the variable frequency of the motor rotor to gradually decrease the braking as the motor speed is reduced, and means controlled by the car movement for disconnecting the motor from said source and said brake from said rotor at a fixed distance nearer the landing to apply the brake and stop the motor.

6. In combination, an elevator car, an alternating current variable speed hoisting motor therefor, a frequency responsive brake for said motor, said brake having a single energizing circuit therefor, means including a leveling circuit for connecting and selectively energizing the motor for operation in opposite directions at slow speed and connecting said energizing circuit of said brake with the rotor circuit of the motor, said means being de-energized when the car is at a floor level, means responsive to car movements for controlling said circuit to automatically return the car to floor level, when the car is moved away therefrom, and manually controlled means for rendering said latter means ineffectual, connecting and energizing the motor for acceleration to full speed, and for connecting said energizing circuit of said brake with the stator circuit of the motor.

7. In an elevator control system the combination comprising, a load elevating and lowering means, a wound rotor induction motor for elevating and lowering said means, said motor having primary and secondary circuits, braking means for said motor including a second induction motor for releasing said brakes, said second motor having a primary winding and a secondary winding, and means operable under different operating conditions for selectively connecting one of said windings only to the primary circuit of said first motor and to the secondary circuit of said first motor.

8. In an elevator control system the combination comprising, a load elevating and lowering means, a wound rotor induction motor for elevating and lowering said means, said motor having primary and secondary circuits, braking means for said motor including a second induction motor for releasing said brakes, said second motor having a stator circuit and a rotor circuit, and means operable under different operating condition for selectively connecting said stator of said second motor to the primary circuit of said first motor and to the secondary circuit thereof.

9. In an elevator control system, the combination comprising a load elevating and lowering means, a wound rotor induction motor for elevating and lowering said means, an auxiliary motor of the slip ring type having its rotor mechanically coupled with and driven by said first motor through a speed changing device, said auxiliary motor having its primary electrically connected in parallels with the primary of said first motor, braking means for said first motor including a third induction motor for releasing said brakes, and means selectively operable under different operating conditions for energizing the primary of said third motor from the primary of said first motor and from the secondary of said second motor.

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