Feb. 27, 1934. R. J. STEVENS 1,948,685

ELECTRIC CONTROL SYSTEM

Filed July 3, 1931 3 Sheets-Sheet 1

Fig. 1.

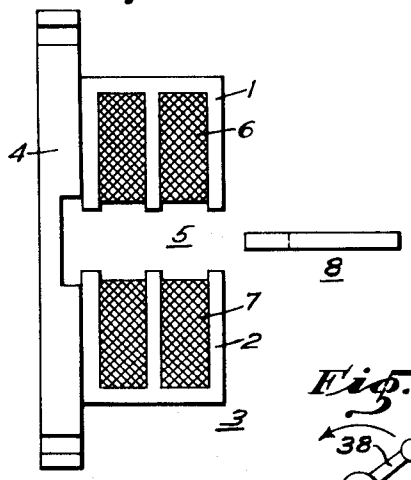


Fig. 2.

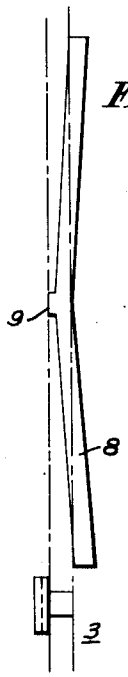


Fig. 4.

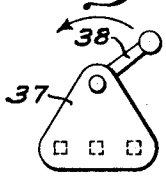
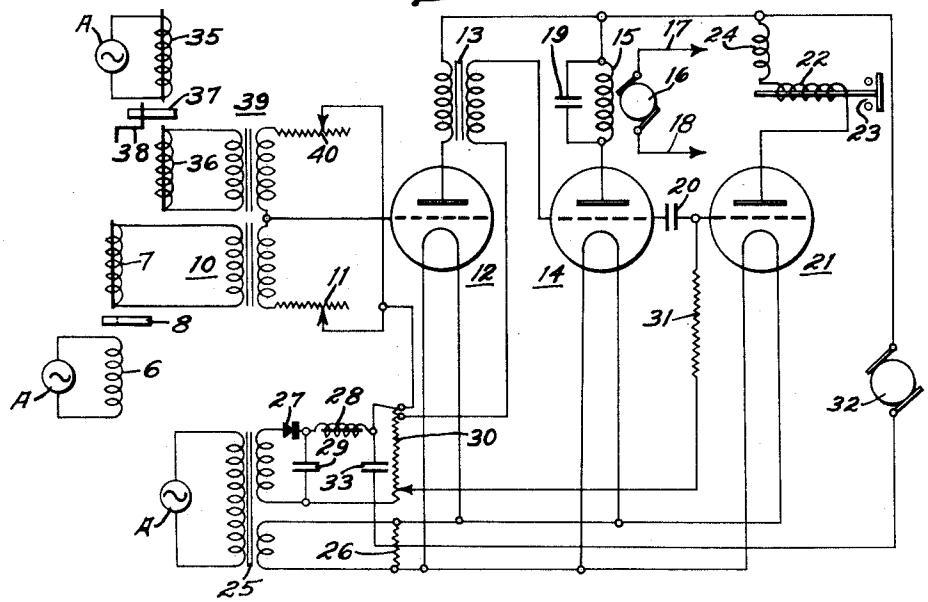


Fig. 3.



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ELECTRIC CONTROL SYSTEM

Filed July 3, 1931 3 Sheets-Sheet 2

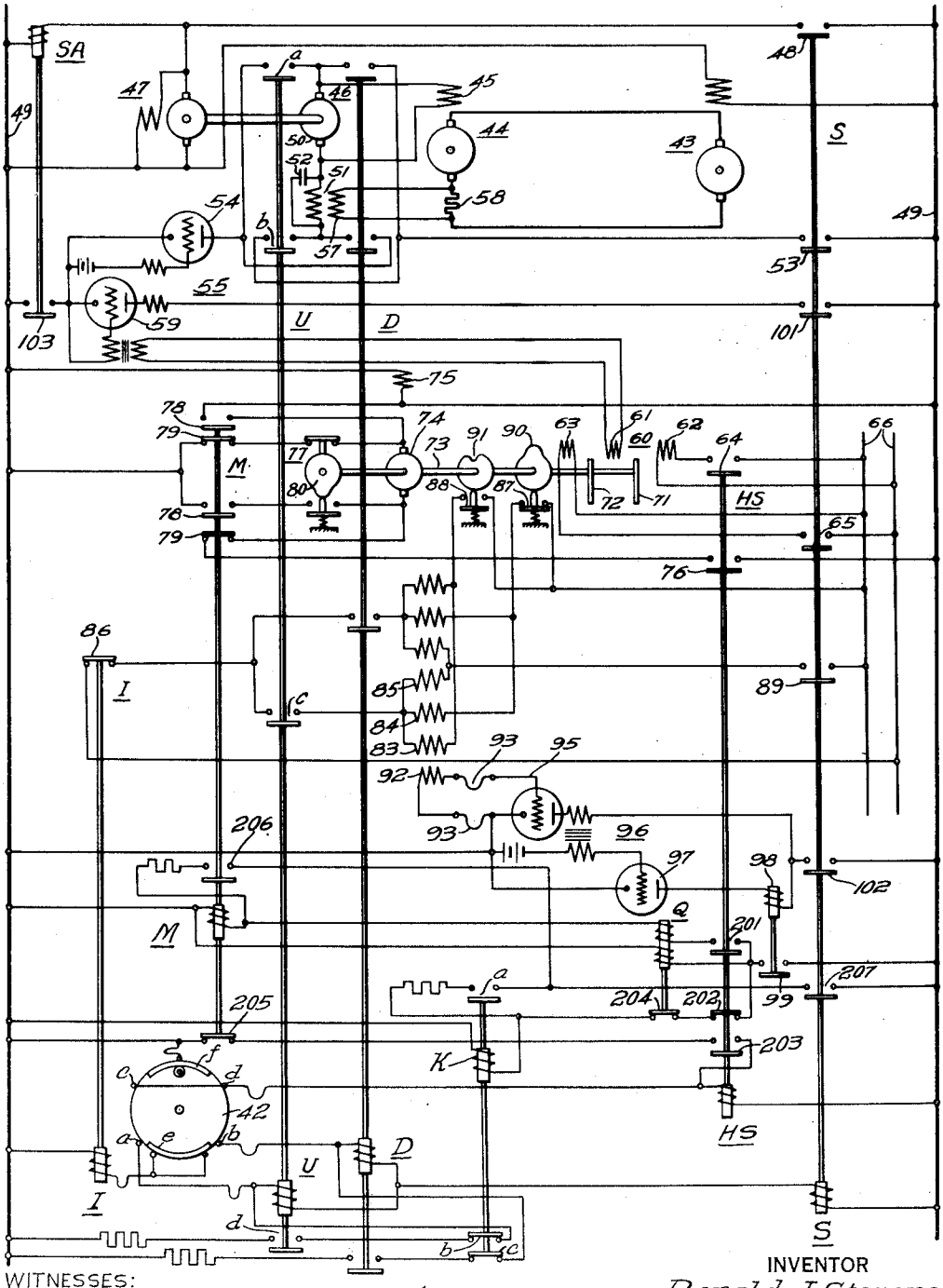


Fig. 5.

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ELECTRIC CONTROL SYSTEM

Filed July 3, 1931 3 Sheets-Sheet 3

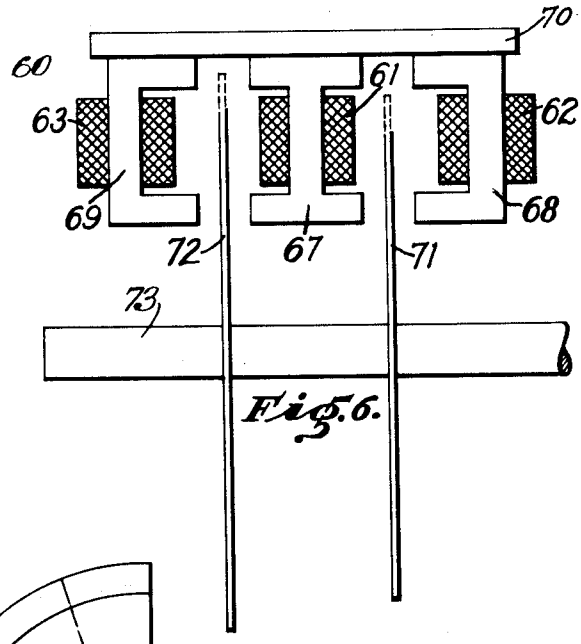


Fig. 6.

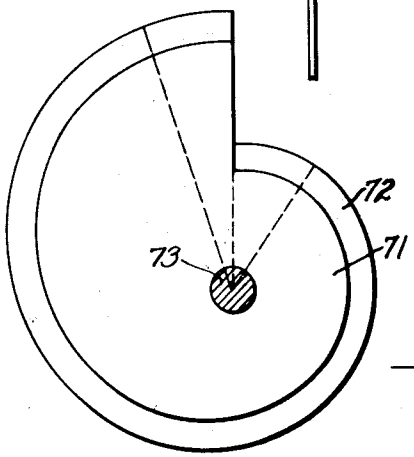


Fig. 7.

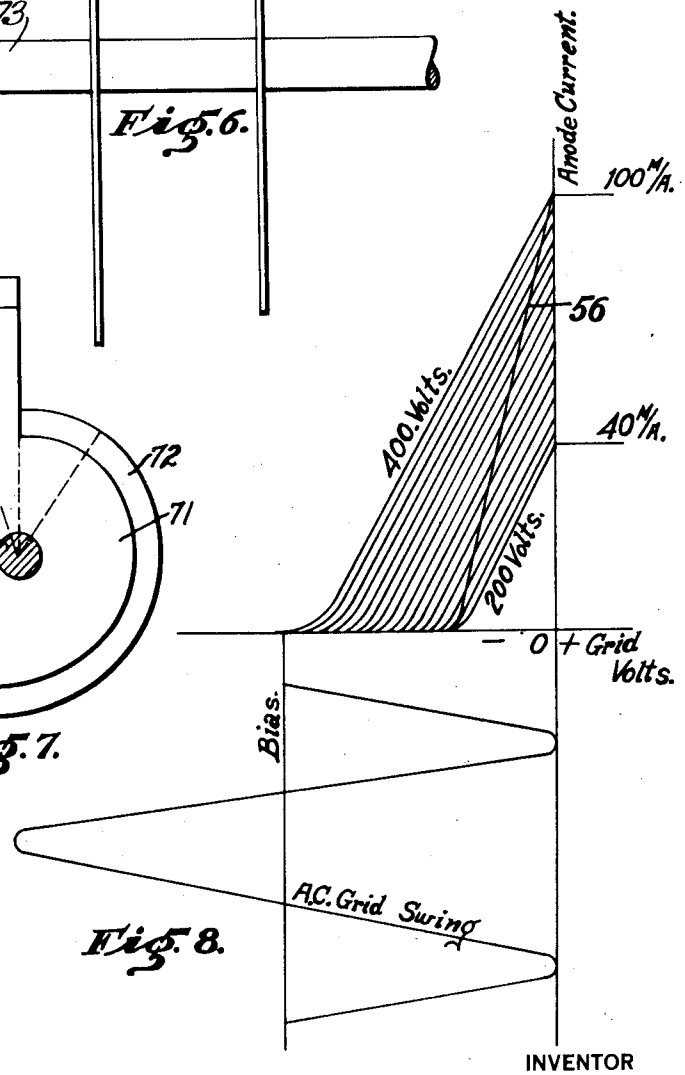


Fig. 8.

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UNITED STATES PATENT OFFICE

1,948,685

ELECTRIC CONTROL SYSTEM

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Application July 3, 1931, Serial No. 548,573
In Great Britain July 7, 1930

11 Claims. (Cl. 172—152)

This invention relates to control or signalling systems for objects movable in a definite path, as for example, lifts, elevators, railway cars, and like vehicles, and particularly to such systems of the character in which are employed relays operated by a relatively moving magnetizable member for effecting controlling or signalling operations in accordance with variations in the displacement of the relatively movable objects.

In systems of the above-mentioned character a magnetizable member and a co-operating relay device are generally mounted on the relatively movable objects, for example, on the lift and in the lift shaft respectively, the relay device being equipped with means for maintaining an electric or magnetic field of force in its vicinity and adapted to be rendered operative to effect a desired signal or control operation by the passage of the magnetizable member through said field.

The present invention provides a control or signalling system of the above-mentioned character in which the relay device comprises an inductance, preferably in the form of a transformer, the magnetic reluctance of the core of which can be varied by a magnetizable member or shield formed with a specific graduated profile and the progressive variation of the magnetic reluctance, with the corresponding variation in the voltage in one winding of the transformer for example, during the relative movement of said inductance or transformer and said profiled member, is utilized to cause the continuous variation of the condition of associated control or signalling apparatus or to effect a plurality of specific operations of associated control or signalling apparatus in a predetermined sequence.

Conveniently, the transformer is constructed with an air gap into which the profiled magnetizable member, hereinafter referred to simply as "shield", is adapted to extend by varying amounts during relative movement of the objects with which said transformer and said shield are adapted to be operatively associated.

The transformer may be equipped with two or more windings arranged so that the mutual inductance between the windings or pairs of windings is a maximum when the amount of the shield extending into the air gap is a minimum, so that by increasing or reducing the amount of the shield in the air gap the voltage across a secondary winding of the transformer is correspondingly varied. Alternatively, the transformer may be so arranged that the windings thereof are substantially mutually noninductive when the magnetizable member does not extend within the air gap, the mutual inductance between said windings being varied as the amount of the member projecting into the air gap varies thereby to cause corresponding changes in the voltage across the secondary winding.

In applying the invention by way of example to the control of an electrically operated lift or elevator, the transformer may be mounted on the lift car so that the cores project horizontally away from the side wall of the car, the primary winding or windings of the transformer being adapted to be connected to a source of alternating current preferably of ordinary commercial supply frequency.

The shield may comprise an iron strip which is vertically mounted in the lift shaft in longitudinal alignment with the air gap of the transformer. The strip being inclined or bowed so that during movement of the transformer relatively to the strip, the amount of the latter which projects into the air gap increases progressively to a maximum and then preferably progressively decreases.

Alternatively and preferably the shield and the inductance or transformer are not disposed in the lift shaft or on the lift, but are located in a control room, the inductance or transformer being conveniently fixed in position whilst the profiled magnetizable member or shield, which may be of relative small dimensions, is either gear-driven from the lift or is adapted to be clutched to some other rotating or moving member or is moved by electric means during such times that continuous acceleration and deceleration are required.

According to an important feature of the invention the one or more secondary windings are connected to the input side of a thermionic valve amplifier, the output circuit of which includes the field winding of the generator of the Ward-Leonard motor-generator set employed for hauling the lift or elevator. Usually it will be found more convenient to employ an auxiliary or pilot amplifier exciter generator to supply the field of the Ward-Leonard generator and itself excited by the anode current of the amplifier. The grids of the thermionic valves are negatively biased to give a suitable current in the output circuit of the amplifier, the field winding in the anode circuit of the last valve of the amplifier being excited during the positive half-cycles of the alternating current induced in the secondary winding of the transformer.

According to a further and important feature of the invention, the armature of the exciter generator, or preferably of the pilot exciter gener-

ator, of the Ward-Leonard system, is serially included, as well as the exciter-field winding, in the anode circuit of the output valve of the thermionic amplifier to the input of which the secondary of the variably shielded transformer is connected as hereinbefore set forth, the arrangement being such that as the shielding is reduced the increasing exciter voltage due to the increase in anode current flowing in the exciter field is added, so to speak, to the usual anode potential of the output valve. This in itself is advantageous in several respects. Thus the usual anode supply can be obtained from ordinary supply mains or other convenient source such as an auxiliary generator for supplying brakes and other control gear at, say 200 volts, and the pilot exciter generator conveniently generates at a similar voltage on full excitation, so that at starting the anode voltage is 200 whilst at full speed it is 400, which is a convenient value for giving an anode current of say 12 to 15 watts which is suitable for the field excitation of the pilot generator. Furthermore such increase in anode volts with speed has an important effect in compensating for speed-load drop since the valve is operating on the resulting steepened characteristic which counteracts the effect of the field of the main generator becoming partially and increasingly saturated with increase in load.

If now the pilot generator has added to it a small additive series field winding excited in accordance with the main motor current a further cumulative effect can be obtained, according to a further feature of the invention, in compensating for the speed-load drop, whereby the correct landing speed can be obtained irrespective of the load since the main and pilot generators are relatively unsaturated at such slow reduced speed. Such series winding being small will not give rise to irregularities or delay in changes in the field of the pilot generator. The voltage in such auxiliary field winding is moreover added to the anode voltage of the valve thus producing a still further increased current in the desired sense in the shunt field of the pilot generator.

It will be appreciated that if a valve of the amplifier fails the lift or other moving object will automatically be brought to rest by reason of the voltage on the field winding failing. It will also be appreciated that the amplifier can be omitted if the alternating current in the shielded winding of the transformer is made sufficiently strong to operate, after being passed through a rectifier, the field winding or other controlled apparatus direct.

In lift or elevator practice it is particularly desirable that the controlling apparatus should be capable of producing accurate stoppage of the lift or elevator at a floor or landing. For this purpose the profile shield may be provided at its effective center portion with a pronounced projection or hump which may be of rectangular shape, so that when the lift has been progressively decelerated as above set forth, it may be stopped through the operation of one or more suitable electrically controlled or "contactor" switches consequent upon the introduction of a relatively large amount of iron at the hump into the air gap.

In the preferred arrangement however the lift is decelerated through the agency of the aforesaid profiled shield to a steady minimum and relatively slow speed just before the car reaches the selected floor, and when the car, thus traveling slowly, is level with the floor, control gear is caused to operate to stop the car by means of cam switches or inductor relays located appropriately in the lift shaft, but preferably by means of a system of "pick-up" winding and controlling electromagnet or "inducer", similar means being also preferably employed to initiate automatically at the correct moment the deceleration of the lift so that it shall travel at the slow speed when closely approaching the selected floor or landing as above mentioned.

A preferred embodiment of the invention as applied to lift control is briefly as follows. The profiled shield is of disc form with a spiral or approximately spiral periphery or profile and is rotatably mounted and rotated by an electric motor which is adapted, when required, normally to run at constant speed, and which, in the arrangements hereinafter set forth, is adapted to be reversed so that the shield produces the deceleration and is returned to the innermost or "starting" position in readiness for producing an acceleration or deceleration of the lift again.

Two spiral discs or other shields are conveniently provided, namely, one for producing acceleration and the other for producing deceleration, the effect of one of them being precluded according to which kind of change of speed is required at any time. The shield motor is adapted to be started such as by means of a controller or press button on the lift or landing and to be reversed and finally stopped by cam switches or inductor relays or pick-up coil and inducer windings as hereinbefore briefly set forth and as hereinafter more fully described.

Thus, when the lift is required to pass floors or landings the shield motor may be started by hand operations of the car controller or of a press-button and the lift motor automatically accelerated up to full speed, whereupon the shield motor is automatically stopped, such as by means of a switch operated by a cam associated with the accelerating shield, the lift motor continuing to run at its maximum speed until deceleration is required as the lift approaches the selected floor. It will be appreciated that the acceleration can thus always be the permissible maximum. When the lift traveling at full speed arrives at a certain predetermined distance from the selected floor or landing the shield motor is automatically reversed to cause the lift to be decelerated to a minimum speed just before it reaches said floor or landing whereby the maximum permissible rate of deceleration can be always obtained. The lift traveling at the minimum speed can then be stopped exactly at the floor, preferably by the selectively energized controlling electro-magnet or inducer which excites the pick-up coil and thereby effects the deenergization of all necessary control circuits and main circuits so that the lift is held stationary at the floor.

When, however, floor to floor travel of the lift is only required it will usually not be possible to accelerate the lift to the maximum speed before deceleration is again required, but under such circumstances the maximum permissible rates of both acceleration and deceleration can still be obtained by means of the retarding inducer and the pick-up winding arranged to cause the shield motor to reverse when the lift is a predetermined distance from the floor, less than required for full speed, no matter what the actual speed may be at the particular moment when deceleration is required to bring the lift to rest at the floor. Thus the rate of deceleration may be the same, or substantially the same, although the distance in which the lift decelerates to the

floor is less than in the case where the lift is traveling at full speed. Such additional inducer is located in the lift shaft adjacent the floor but intermediate between the stopping inducer and the inducer which initiates deceleration from full speed. Such two retarding inducers as well as the stopping inducer adjacent any one floor are selectively energized in accordance with the position of the shields, conveniently by means of cam-operated switches associated with the shields.

Preferably the two rotating shields are on the same shaft and arranged so that the shielding between the primary and secondary members of the transformer is never complete so that the aforesaid minimum speed is obtained at starting and also just previously to stopping by means of the action of the stopping controlling electromagnets. The decelerating shield will usually be designed so as to provide greater shielding than does the accelerating shield. It has been found that the resultant induced voltage in the secondary, which is conveniently common to two primaries, when both primaries are energized does not differ appreciably from the voltage induced by the separately connected primary which is the less shielded. Provision may be also made for automatically connecting a resistance in the circuit of the shield motor during deceleration so as to cause the motor then to run at a lower speed than during acceleration.

The invention above set forth, at least in the preferred form described, provides an electric lift control system having desirable characteristics permitting smooth and economical service and involving in particular complete or substantially complete dynamic control of acceleration and deceleration. The invention permits the attainment of the maximum permissible speed between any two floors or landings, the automatic initiation of deceleration at the latest possible moment on approaching a floor or landing, and the automatic stopping of the lift or hoist substantially exactly at the floor or landing level without any creep or the necessity for re-levelling, and independently of the load.

To enable the invention to be more fully understood and carried into effect reference will now be made to the accompanying drawings, which illustrate embodiments of the invention by way of example.

In the drawings Fig. 1 illustrates in section a controlling transformer and co-operating magnetizable member or shield constructed and arranged according to the invention.

Fig. 2 is an elevational view to a reduced scale of the transformer and the co-operating magnetizable member, illustrating the specific profile of said magnetizable member.

Fig. 3 is a schematic diagram illustrating a system suitable for the control of an electrically operated lift, arranged according to the invention.

Fig. 4 is an elevational view of a manually adjustable magnetizable member for co-operating with a transformer such as is illustrated in Fig. 1.

Fig. 5 is a schematic diagram of a modified and preferred lift control system in accordance with the invention.

Fig. 6 is a sectional view of a controlling transformer and profiled shield used in the system illustrated by Fig. 5.

Fig. 7 is a view illustrating the profiled shields shown in Fig. 6, and

Fig. 8 is the grid volts—output current characteristic of the amplifier which feeds the field of the pilot generator as shown in Fig. 5, such characteristic being modified by the inclusion of the armature of the pilot generator in the anode circuit.

Referring to the drawings, in Fig. 1 is shown the E-shaped magnetic core members 1 and 2 of the transformer which is designated generally at 3. The cores 1 and 2 are mounted on a non-magnetic base 4 with an air gap 5 defined by their pole pieces. The core 1 is equipped with the primary winding 6 and the core 2 with the secondary winding 7. At 8 is shown one form of the profiled shield which is adapted to register with the air gap 5 and to extend thereinto by varying amounts. The shield 8 is doubly inclined as shown in Fig. 2 and is formed, intermediate its ends, along the forward edge which projects into the air gap 5, with a rectangular projection or hump 9. In Fig. 2 the broken lines, indicate the path along which the air gap 5, as defined by the pole pieces of the cores 1 and 2 of the transformer 3, moves relatively to the shield 8. The transformer 3 is adapted to be secured on a lift car and the shield 8 is adapted to be secured in the lift shaft in appropriate position in relation to a floor or landing.

Referring to Fig. 3 the transformer primary winding 6 is connected to a source of alternating current indicated as an alternator A operating at ordinary commercial supply frequency while the secondary winding 7 is connected to the primary winding of the step-up transformer 10 the secondary winding of which in series with adjustable resistance 11 is connected in the input or grid circuit of a thermionic amplifier valve 12. The output or anode circuit of the valve 12 includes the primary winding of a transformer 13 the secondary winding of which is connected in the grid circuit of a second amplifying valve 14. The output or anode circuit of the valve 14 includes the field winding 15 of the electric generator the armature 16 of which is adapted to be connected by leads 17 and 18 to the armature of the motor (not shown) for hauling the lift or to the field winding of the main generator supplying that motor. The field winding 15 is shunted by a condenser 19 of a few microfarads capacity.

In the example being described the grid of the amplifier valve 14 is connected through a grid condenser 20 to the grid of a third amplifier valve 21 the output or anode circuit of which includes a contactor switch operating coil 22 having associated contactor contacts 23 which are adapted to control the stopping gear (not shown) of the lift. This third valve 21 is normally biased at zero or positive potential so as to operate on the reduced negative half cycles of the electromotive force induced in the secondary 7 of the transformer. Under normal conditions, that is during operation of the lift, the current through the contactor operating coil 22 will be at a minimum so that the contactor switch 22 will be in the open position. When the travel of the lift is such as to bring the transformer air gap into register with the aforesaid projection 9 of the shield 8, the induced electromotive force will be suddenly reduced so that the current through the contactor operating coil will increase suddenly thereby to operate the contactor switch for stopping the lift. The output circuit of the valve 21 also includes the electromagnetic operating coil

24 for releasing the auxiliary control device described hereinafter.

The cathodes of the valves 12, 14 and 21 are energized from a source A of current of ordinary commercial supply frequency, through the transformer 25 the legs of the cathode being shunted by a suitable resistance 26. The transformer 25 is equipped with a tertiary winding which is connected through a suitable rectifier 27 and choke 28 associated with a blocking condenser 29 across the outer terminals of the resistance potentiometer 30 which is provided with tapping points whereby the grids of the amplifying valves 12, 14 and 21 are maintained at appropriate biasing potential. The lead from the potentiometer 30 to the grid of the valve 21 includes a suitable grid leak 31. As hereinbefore mentioned the valves 12 and 14 are normally biased at zero or negative potential while the valve 21 is normally biased at zero or positive potential. The anodes of the valves 12, 14 and 21 are supplied from a high tension source which is indicated at 32, through a smoothing condenser 33.

With the arrangement so far described, with reference to Fig. 3, the starting operation can be effected by bodily shifting either the transformer, or the shield or both, in such manner that the amount of the magnetizable member extending into the air gap is temporarily considerably reduced and a correspondingly large current is temporarily caused to flow in the controlled field winding in the manner hereinbefore described.

Alternatively, the same effect may be obtained by temporarily varying the grid bias of one or other of the amplifying valves connected between the transformer and the field winding, such variation being effected, for example, through the intermediary of one or more push buttons suitably mounted, say, on the lift and connected in the grid circuit of the valve.

As another alternative, the starting operation can be effected through the intermediary of an auxiliary controlling device, comprising a transformer and a co-operating shield similar to the main controlling device. In this case both the auxiliary transformer and the shield are suitably positioned on the lift, the former being also connected to the amplifier, and the shield being mounted so as to be manually movable into and out of the air gap. A disadvantage of this arrangement is that, when the magnetizable members for the main and auxiliary control devices are conditioned so as to extend fully into their respective air gaps, the voltage applied to the input side of the amplifier will be double that applied when only the magnetizable member for one or other of said control devices is so conditioned. This disadvantage however is readily obviated by the provision of loading means in the circuit of one or other of the control transformers whereby a phase displacement in the voltages applied to the amplifier by the respective transformers may be produced.

The auxiliary device for controlling the starting of the lift is shown in Fig. 3 and comprises a transformer similar to the transformer 3, having a primary winding 35 and a secondary winding 36. The magnetizable member for the auxiliary control device is indicated at 37 having a suitable handle 38 whereby said member may be moved relatively to the windings 35 and 36. The form of the magnetizable member 37 is illustrated more particularly in Fig. 4, the broken lines in this figure indicating the position which is normally occupied by the pole pieces of the transformer. The primary winding 35 is supplied from the source A and the secondary winding 36 is connected to the primary winding of the step-up transformer 39 the secondary winding of which, in series with an adjustable resistance 40, is connected in parallel with the secondary winding of the step-up transformer 10 and its series resistance 11 in the input circuit of the valve 12. The resistance 40 affords means for varying the phase relationship between the currents induced in the secondary windings of the transformers 10 and 39 respectively while the resistance 11 may be utilized to vary the rate of acceleration and deceleration.

It will be appreciated that where the auxiliary controlling device is employed in a lift system it may, in addition to being arranged for controlling the field winding of the hauling motor, generator, or exciter therefor, be utilized to govern the operation of the "up" and "down" direction switches which are usually to be found in a lift system for determining the direction of operation of the lift.

Where both main and auxiliary controlling devices as described are employed, it is desirable, in certain circumstances, that only one or other of said devices should be rendered operative at any particular instant. For example, in the case of the lift system, when automatic deceleration of the lift is being effected by the progressive introduction of the shield for the main transformer into the air gap, it would be very undesirable if the decelerating operation could be interfered with by manipulation of the auxiliary controlling device. Such interference may be prevented by suitably interlocking the main and auxiliary controlling devices. In one form, the auxiliary controlling device may be provided with retaining means (not shown) which is normally operative, when the lift is in motion, to prevent relative movement of the auxiliary transformer and its co-operating shield and is only released when the lift has been brought to rest. Thus the retaining means may be provided with a releasing electromagnet which is energized, when the current in the operating coil 24 attains a value sufficient to cause the operation of the stopping contactor 22, 23, so as to condition the auxiliary controlling device either at the same time as, or at the end of a suitable interval of time after, the operation of said stopping contactor 22, 23.

Referring now to Figs. 5 to 8, inclusive of the accompanying drawings by which the preferred arrangement of the invention is illustrated, in Fig. 5 is shown schematically a lift control system embodying the invention. A hauling motor 43 for raising and lowering a lift car (not shown) in a usual manner is supplied by the Ward-Leonard generator 44 the field winding 45 of which is excited by the pilot generator 46 driven at constant speed by a motor 47 adapted to be connected by a switch 48 to direct current supply mains 49 or other convenient source of suitable voltage, such as a generator which supplies brakes and other control gear. A controller 42 may be mounted on the car for controlling the starting and stopping of the car.

The armature 50 of the pilot generator 46 is serially connected with its field winding 51 (bridged by a condenser 52) between the positive supply main (through a switch 53) and the anode of the output valve 54 of the amplifier 55 so that the voltage generated by the pilot generator is added to the potential of the supply

mains giving the valve 54 an operating characteristic such as shown by way of example in Fig. 8, with the effect hereinbefore set forth. The valve is suitably negatively biased and the apparent resultant voltage characteristic may be as shown at 56 in Fig. 8.

An up direction switch U and a down direction switch D operated by the controller 42 are provided for controlling the direction of operation of the pilot generator 46 and consequently the direction of operation of the car. A starting relay S is also provided for preparing the control circuits for operation.

Referring again to Fig. 5, the pilot generator 46 also has a small assisting series winding connected across a resistive shunt 58 in the main motor circuit, with the effects hereinbefore set forth.

The grid of the output valve 54 is supplied during certain times with an alternating voltage from a preceding or input amplifier stage valve 59 the grid of which is excited by means of the controlling transformer 60 which is shown separately in Fig. 6. Said transformer 60 has the secondary winding 61 and the two primary windings 62 and 63 adapted to be connected by switches 64 and 65 respectively to a source of alternating current of ordinary commercial frequency represented by the supply mains 66. The windings of the transformer 60 are mounted on separate respective cores 67, 68 and 69 (Fig. 6) secured to the non-magnetic base board 70, with air gaps between the cooperating cores with which cooperate the two magnetic disc shields 71 and 72 (Fig. 7) mounted on the shaft 73.

The switch 64 is controlled by a high speed relay HS and the switch 65 by the starting relay S.

The shaft 73 (Fig. 5) is rotated, preferably through reduction gearing (not shown) by the constant speed motor 74 having a shunt field winding 75 and adapted to be connected to the supply mains 49 through two switches 76 and 77 whilst the armature of said shield motor 74 is adapted to be reversely connected by coupled pairs of reversing switches 78 and 79 of which 79 are normally closed. The operation of the switch 77 is controlled in part by means of a cam 80 secured in proper "timing" position on the shaft 73 of the shield motor 74.

The operation of the reversing switches 78—79 is controlled by a reversing relay M, which relay also holds the high speed.

Considering only the upward travel of the lift, there are provided adjacent each floor and in vertical alignment the three controlling electromagnets or "inducers" 83, 84 and 85 the windings of which are connected on the one hand by a switch 86, controlled by an inducer relay I to one of the A. C. mains 66 and on the other hand to the other of said mains 66 through respective switches 87, 88 and 89. The operation of the switches 87 and 88 is controlled in part by respective cams 90 and 91 on the shaft 73 of the sheld motor 74 whilst the switch 89 is controlled by the starting relay S. The inducers 83 and 85 are energized when stopping from high speed and the inducers 84 and 85 when stopping from a short or low speed run.

Fixed on the lift (not shown) so as to be successively excited by the inducers 83 and 85 or 84 and 85 is the pick up winding 92 which is connected by a pair of conductors in a trailing cable 93 through a wire 95 with the input grid of the pulse amplifier 96.

The output valve 97 of the amplifier 96 has in its anode circuit a coil or pulse relay 98 operating a contactor switch 99 which by successive operations and through the medium of a system of sequence switches or equivalent interlocks effects the different operations as hereinafter described.

A description of the operation of the system shown in Fig. 5 in conjunction with further description of that figure will now be given.

The controller 42 has an "off" position and two notches or positions on either side thereof for upward and downward travel of the lift, the first notch *a* or *b* causing the lift to travel at the minimum slow speed and the second notch *c* or *d* causing the lift to be accelerated automatically towards the maximum speed. The arrangement is such that, when the controller is returned to the "off" position, deceleration will be automatically effected to bring the lift to rest at the next floor in the direction of travel, it being necessary in order to pass floors to hold the controller in one of its operative positions or notches.

Assuming now that the controller is moved in a clockwise direction to the first or slow speed notch for upward travel of the car, then the contact members *a* and *e* of the controller will close to energize the starting relay S, the up direction relay U, and the inducer relay I.

The energization of the starting relay S closes its switches 84, 53, 101 and energizes the relay SA for closing switch 103 to energize the appropriate control circuits and start the motor generator set 47, 46.

The energization of the up direction relay U closes its contact members *a* and *b* for operating the pilot generator 46 in the up direction and closes its contact members *c* for preparing a circuit for connecting the up decelerating inducers 83, 84 and 85 when the car is to be stopped on its up trip. The closing of the contact members *d* of relay U completes a self-holding circuit for relays U and S whereby these relays are maintained energized during deceleration of the car to a stop by the inducers 83, 84 and 85 until the final stopping operation is completed.

The energization of the inducer relay I opens the switch 86 and thereby prevents operation of the inducers 83, 84 and 85 to stop the car until after the controller 42 is moved to its "off" position for a stop.

Whenever the car is at rest at a floor or landing, the shields 71 and 72 provide a maximum but incomplete shielding between the primary windings 62 and 63 on the one hand and the secondary winding 61 on the other hand of the transformer 60, so that a small current flows in the anode circuit of the valve 54 by reason of the switch 65 of the primary winding 63 being closed due to the energization of the starting relay S. If the controller is held in the first notch, the lift will continue to travel at the aforesaid minimum slow speed, but if now the controller is moved to the second notch, the contact members *f* and *d* of the controller close thereby energizing the high speed relay HS to cause the car to accelerate to high speed.

The energization of the high speed relay HS closes switches 64, 76, 201, and 203. Closing the switch 203 completes a self-holding circuit for the high speed relay HS. The opening of the switch 202 prevents energization of the relay K until the car is again brought to a stop. The closing of

the switch 201 prepares a circuit for energizing the relay Q to be used later in stopping the car.

The closing of the switch 64 connects the primary 62 of the transformer 60 to the supply line 66 and the closing of the switch 76 completes a circuit for operating the shield motor 74. Thereupon the shield motor is caused to rotate at constant speed in the accelerating direction, so that the car will be accelerated at the predetermined maximum rate by reason of the movement of the shields 71 and 72 through the air gaps between the primary windings 62 and 63 and the secondary winding 61 of the transformer 60, thus controlling the circuit to the amplifier 55. When the shield motor 74 reaches a predetermined position, the cam 80 opens the switch 77 thereby stopping the motor and causing the car to continue to run at its maximum speed so long as the controller 42 is held in the second notch position.

Assuming now that it is desired to bring the car to a stop at the floor corresponding to the inducers 83, 84 and 85, the controller 42 is returned to its "off" position while the car is more than the predetermined decelerating and stopping distance from the floor. Upon the centering of the controller, the inducer relay I is deenergized to close its switch 86, which closing completes a circuit energizing the inducers 83 and 85 to decelerate and stop the car when the pick-up coil 92 passes them. (The inducer 84 is not energized because cam switch 87 remains open by reason of the position of the shield motor, inasmuch as the stop is to be made from high speed and not from intermediate speed.)

It should also be noted although the controller 42 is now in its "off" position; the up direction relay U, the starting relay S and the high speed relay HS still remain energized because of their holding circuits and will now be deenergized in sequence as the car passes the inducers 83 and 85 to decelerate and stop the car level with the floor.

Hence, when the lift car, travelling at full speed, is at a certain distance from the selected floor, at which it is to stop, the pick-up winding 92 on the car passes the now energized inducer coil 83 and is excited thereby. The excitation of the coil 92 operates through the amplifier 96 to energize the pulse relay 98 to close the switch 99 to effect deceleration of the car. The closing of the switch 99 energizes the relay Q to open its contact members 204 and also energizes the relay M to open the switch 205. The opening of the switch 205 opens the self-holding circuit of the high speed relay, thereby deenergizing that relay to open switch 64 to deenergize the primary coil 62 and to open switch 76 leading to the shield motor 74.

The energization of the relay M opens the reversing switches 79 and closes the reversing switches 78, thereby causing the motor 77 to start rotating in the reverse direction. The opening of the switch 64 results in an initial drop in volts induced in the secondary winding 61 of the controlling transformer 60.

The shields 71 and 72 are now gradually entered into the transformer air gaps by the rotation of shaft 73 effected by the reverse operation of the shield motor 74 so that the lift is automatically decelerated at the predetermined rate to the minimum slow speed prior to the car reaching the floor landing level.

Just before the car reaches the landing floor level, the pick-up winding 92 comes adjacent to the "stop" inducer 85 and is thereby energized to operate the pulse relay 98 a second time to effect the stopping of the car.

The energization of the pulse relay 98 closes its contact members 99, thereby energizing the relay K to close its contact members *a* and open its contact members *b*. The closing of the contact members *a* of relay K completes a self-holding circuit for that relay and the opening of its contact members *b* deenergizes the up-direction relay U and the stopping relay S, which deenergized relays open the circuits for the generator 46 and the control circuits, thereby bringing the car to a stop.

The deenergization of the starting relay also opens the switch 207, thereby opening the self-holding circuit of the relay K to prepare that relay for future operation, and also opens the self-holding circuit of the relay M to prepare a reversing circuit for operating the shield motor 74 in the accelerating direction when the car is to be again accelerated.

In the case where the lift is required only to travel from one floor to the next so that full speed cannot be attained, the lift is started by moving the controller 42 to the second notch and the controller is then returned to the "off" position whereupon the aforesaid holding or maintaining circuits and switches and additional interlocks cause the inducers 84 and 85 (and not the inducer 83) to be connected to the supply main 66 through the switch 87 under the control of the cam 90 which becomes effective whenever the shields 71 and 72 have moved out of the normally fully in position. Thus no matter what may be the speed of the lift under these conditions the excitation of the pick-up winding 92 by the inducer 84 (medium inducer) and then by the stop inducer 85 will cause two successive operations of the pulse relay 98 which thus results in the motor 74 being reversed immediately deceleration is required so that the lift is decelerated at the predetermined maximum rate, and eventually brought to rest in the manner previously described.

Referring finally to Fig. 7 of the drawings, it will be appreciated that the nature of the acceleration and deceleration is governed by the profile of the shields 71 and 72 such as shown in that figure and by the speed of rotation of said shields. The shape can easily be determined by experiment to suit any given site conditions. The shape of the shields is of course dependent upon the time constant of the generator field but the shields are in full control of that field, thus avoiding the necessity for large time constants. The shields may be of ordinary spiral shape as shown in Fig. 7, each with end portions of constant radius between the dotted radii shown. The decelerating shield 72 is preferably larger than the accelerating shield 71, as shown in Fig. 7.

It will be appreciated that in either of the systems shown, if a valve of an amplifier fails, the lift will be automatically brought to rest. In order to protect against failure of the grid biasing potential on any of the valves in the system, high resistance relays may be employed arranged to cut off for example the cathode supply current so that the whole system becomes de-energized and the lift stops until the grid biasing potential is restored.

It will be further appreciated that the pulse amplifier 96 can be omitted if the alternating current induced in the pickup windings is sufficiently strong to operate, after being passed through a

rectifier, the pulse relay 98. Ordinarily the induced currents will be comparatively weak so as to necessitate amplification and this it will be appreciated is an important advantage of the system which it will be further appreciated obviates mechanical contact between the moving lift and the fixed devices; no switches, other than those of the controller, are provided on the car or in the shaft; the automatic control is obtained by inductive and leakage operation with devices energized by low frequency alternating current of relatively low voltage and current strength; the inductive apparatus need only be small and relatively inexpensive, and relatively large air gaps can be employed.

It is to be understood that various further modifications and additions may be made within the scope of the invention. For example the manual controller may be replaced by press-button control. The shield or shields may be rotated from any convenient rotating member through the intermediary of one or more clutches adapted to be operated at appropriate times; thus the accelerating shield 71 may be clutched to the shaft of the motor generator set 47, 46 whilst the decelerating shield 72 may be clutched to the pulley shaft of the main hauling motor 43; the shield motor may be provided with a small adjustable series field excited in accordance with the main motor current so as to adjust the speed of deceleration with load whereby to produce the required landing speed.

In the appended claims the expressions "control systems" and "control apparatus" are intended to embrace signalling systems or apparatus alternatively or in addition to control systems or apparatus such as for the motors or auxiliary equipment of lifts, elevators, railway cars and the like.

I claim as my invention:

1. In a motor-control system of the class in which a separately excited motor is supplied by means of a separately excited variable voltage generator, a vacuum tube having output electrodes and a control element, means responsive to the current of said output electrodes for varying a component of excitation of said generator, an alternating-current source, and means interconnecting said source and said control element including a variable mutual inductance device having a movable element for gradually varying the voltage applied to said control element, whereby said component of excitation of said generator may be varied uniformly throughout a predetermined range of values.

2. In a motor-control system of the class in which a separately excited motor is supplied by means of a separately excited variable-voltage generator, means responsive to the armature current of said motor for varying a component of excitation of said generator to correct the speed regulation of said motor, a vacuum tube having output electrodes and a control element, means responsive to the current of said output electrodes for varying a second component of excitation of said generator to vary the speed of said motor, an alternating-current source, and means interconnecting said source and said control element including a variable mutual inductance device having a movable element for gradually varying the voltage applied to said control element, whereby the speed of said motor may be varied uniformly throughout a predetermined range of values regardless of the load on said motor.

3. In a motor-control system of the class in which a separately excited motor is supplied by means of a separately excited variable-voltage generator, an exciter for varying a component of excitation of said generator, a source, a vacuum tube having output electrodes energized in accordance with the voltage of said source and the armature voltage of said exciter for controlling a component of excitation of said exciter, said vacuum tube having a control element, and means for variably energizing said control element to thereby vary the speed of said motor.

4. In a motor-control system of the class in which a separately excited motor is supplied by means of a separately excited variable-voltage generator, an exciter for varying a component of excitation of said generator, a source, a vacuum tube having output electrodes energized in accordance with the voltage of said source and the armature voltage of said exciter for controlling a component of excitation of said exciter, said vacuum tube having a control element, means responsive to the armature current of said motor for controlling a second component of excitation of said exciter to correct the speed regulation of said motor, and means for variably energizing said control element to thereby vary the speed of said motor.

5. In a motor-control system of the class in which a separately excited motor is supplied by means of a separately excited variable-voltage generator, an exciter for controlling a component of excitation of said generator, a source, a vacuum tube having output electrodes energized in accordance with the voltage of said source and the armature voltage of said exciter for controlling a component of excitation of said exciter, said vacuum tube having a control element, an alternating-current source, and means including a variable mutual inductance device interconnecting said alternating-current source and said control element, for varying the speed of said motor.

6. In a motor-control system of the class in which a separately excited motor is supplied by means of a separately excited variable-voltage generator, an exciter for controlling a component of excitation of said generator, a source, a vacuum tube having output electrodes energized in accordance with the voltage of said source and the armature voltage of said exciter for controlling a component of excitation of said exciter, said vacuum tube having a control element, means responsive to the armature current of said motor for varying a second component of excitation of said exciter to correct the speed regulation of said motor, an alternating-current source, and means including a variable mutual inductance device interconnecting said alternating-current source and said control element for varying the speed of said motor.

7. In a control system, an exciter, a source, a vacuum tube having output electrodes energized in accordance with the voltage of said source and the armature voltage of said exciter for controlling a component of excitation of said exciter, said vacuum tube having a control element, a main dynamo-electric machine having a field winding responsive to the armature voltage of said exciter and means for variably energizing said control element to thereby vary the excitation of said main dynamo-electric machine.

8. In an elevator system, an elevator car operable in a hatchway, a motor for driving said car, a variable-voltage generator for supplying said motor, an inductance device having a pair of mutually inductive circuits and having a mov-

able magnetic member for varying the mutual inductance of said circuits, means for energizing one of said circuits with alternating-current, an electric discharge device having electrodes energized in accordance with the voltage induced in the other of said circuits, means responsive to the discharge current of said device for controlling a component of excitation of said generator, and means for varying the position of said magnetic member to thereby control the speed of said motor.

9. In an elevator system, an elevator car operable in a hatchway, a motor for driving said car, a variable-voltage generator for supplying said motor, an inductance device having a pair of mutually inductive circuits and having a movable magnetic member for varying the mutual inductance of said circuits, driving means for said magnetic member, means for energizing one of said circuits with alternating-current, an electric discharge device having electrodes energized in accordance with the voltage induced in the other of said circuits, means responsive to the discharge current of said device for controlling a component of excitation of said generator, and means responsive to the position of said car for controlling the operation of said driving means.

10. In an elevator system, an elevator car operable in a hatchway past a landing, a motor for driving said car, a variable-voltage generator for supplying said motor, an inductance device having a pair of mutually inductive circuits and having a movable magnetic member for varying the mutual inductance of said circuits, driving means for said magnetic member, means for energizing one of said circuits with alternating-current, an electric discharge device having electrodes energized in accordance with the voltage induced in the other of said circuits, means responsive to the discharge current of said device for controlling a component of excitation of said generator, means responsive to the armature current of said motor for controlling a second component of excitation of said generator to correct the speed regulation of said motor and means responsive to the position of said car for controlling said driving means to decelerate said car in advance of said landing and to bring said car to rest at said landing.

11. In an elevator system, an elevator car operable in a hatchway past a landing, a motor for driving said car, a variable-voltage generator for supplying said motor, an alternating-current source, an electric discharge device, means including a variable mutual inductance device interconnecting said source and said discharge device for controlling the discharge current of said discharge device, means responsive to the discharge current of said device for controlling a component of excitation of said generator, means responsive to the armature current of said motor for controlling a second component of excitation of said generator to correct the speed regulation of said motor, a pick-up coil mounted on said car, means for establishing an alternating field at predetermined points in said hatchway to influence said pick-up coil, and means responsive to currents induced in said pick-up coil for controlling said variable mutual inductance device.

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