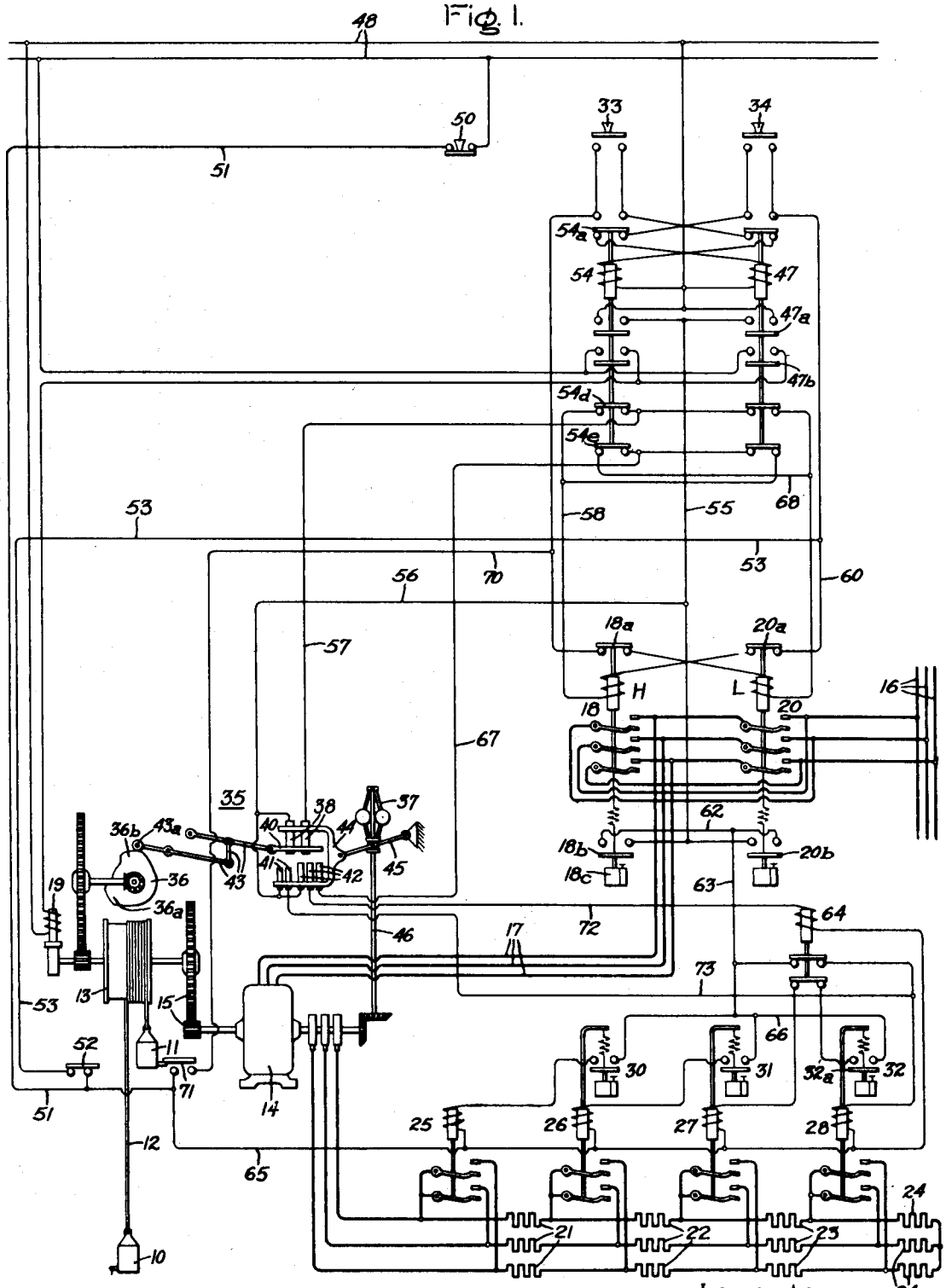
April 3, 1934. F. L. STONE 1,953,783

ELECTRICALLY OPERATED HOIST

Filed July 28, 1933 2 Sheets-Sheet 1

Fig. 1.



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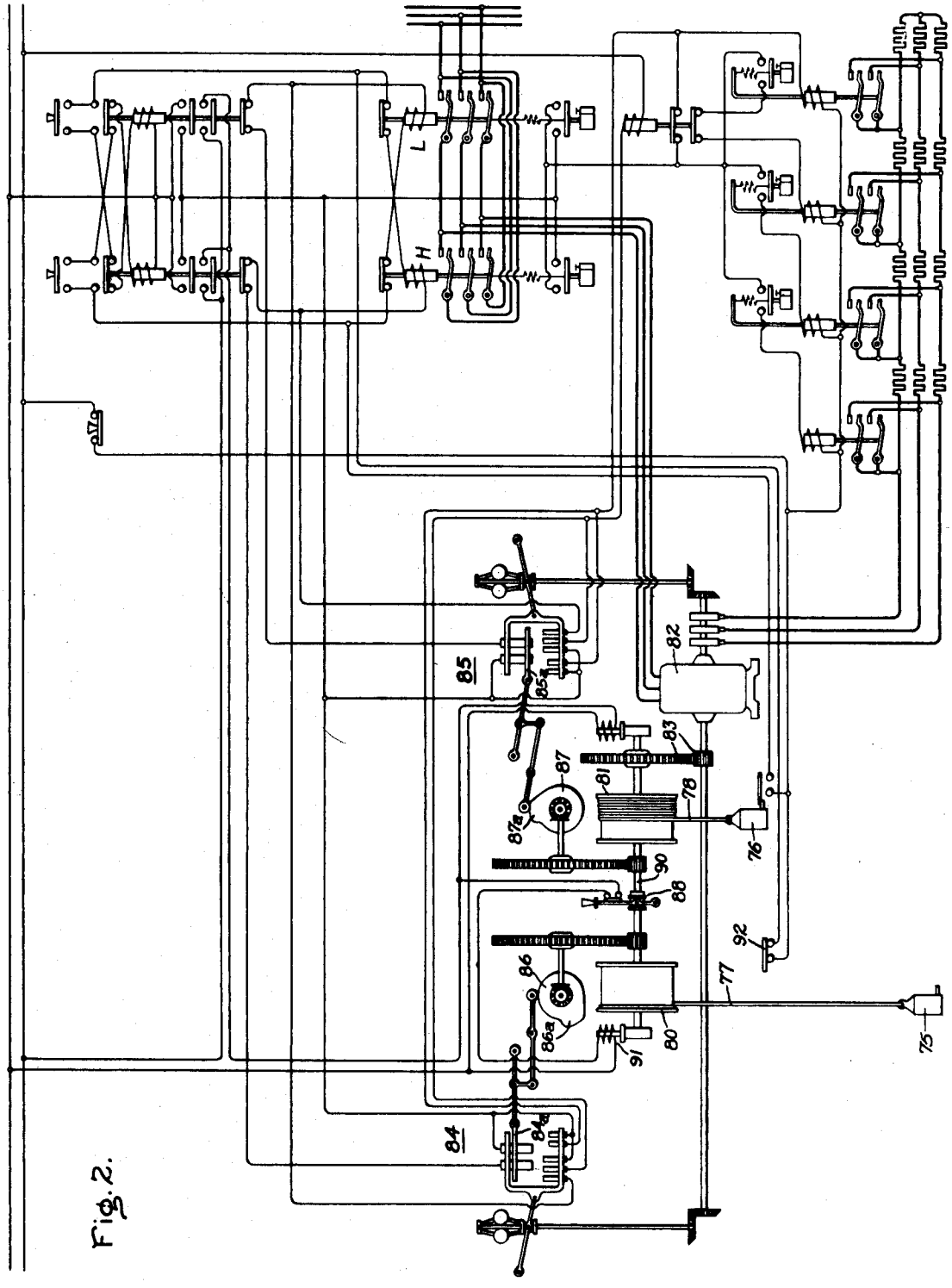


Fig. 2.

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UNITED STATES PATENT OFFICE

1,953,783

ELECTRICALLY OPERATED HOIST

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Application July 28, 1933, Serial No. 682,619

9 Claims. (Cl. 172—153)

This system relates to control systems, more particularly to systems for controlling the operation of electrically operated hoists and the like, and it has for an object the provision of a simple, reliable, inexpensive and improved system of this character.

A further object of the invention is the provision of an automatic hoist control system in which an induction motor is employed as the driving motor. The inherent characteristics of the induction motor make the problem decidedly complicated because the speed-torque characteristics of an induction motor with resistance in the secondary circuit is similar to that of a series wound direct current motor. Consequently the deceleration of an induction motor driven hoist with an over-hauling load cannot be accomplished by inserting resistance in the secondary, because under such conditions the speed of the motor actually increases. The problem is further complicated by the high rate of speed at which the hoists are operated. Frequently the operating speed of a mine hoist exceeds four thousand feet per minute. When the inertias of the load and rotating elements of the system at such a high speed are considered, it is seen that if the load is over-hauling the motor and resistance is inserted in the secondary to effect deceleration, the speed will be increased when it should be decreased and it may be increased to such an extent that the hoist cannot be stopped at the landing, with the result that the hoist will be wrecked. Accordingly, a further object of the invention is the provision of means for automatically effecting deceleration of an induction motor driven mine hoist so that the speed of the cage is caused to follow a predetermined rate of deceleration in the landing range.

In carrying the invention into effect in one form thereof, means responsive to the speed and position of the cage are provided for plugging the motor and causing it to exert a braking torque if the speed exceeds a predetermined maximum permissible value at each point in the landing range. More specifically, a control device is provided which includes a pair of cooperating contact members. One of these members is actuated by a cam driven from the hoist drum and the other contact member is actuated by a speed responsive device driven by the hoist drum. These contacts control means for reversing the power connections to the driving motor and thus cause the speed of the motor to follow a predetermined speed—position curve in the landing range of the hoist.

In illustrating the invention in one form thereof, it is shown as embodied in a hoist in which two skips or cages are simultaneously driven in opposite directions by the same driving motor.

For a better and more complete understanding of the invention reference should now be had to the following specification and to the accompanying drawings in which Fig. 1 is a simple, diagrammatic representation of an embodiment of the invention and Fig. 2 is a simple, diagrammatic representation of a modification.

Referring now to the drawings, a pair of skips or hoist cages 10 and 11 are secured to a cable (or two separate cables) 12 wound about the hoisting drum 13 in such a manner that when the drum is rotated to raise one of the cages the other cage is lowered. The winding drum 13 is driven by a suitable driving means 14 illustrated as an induction motor of the wound rotor type to the drive shaft of which the winding drum is connected through a suitable reduction gearing 15. Power is supplied to the motor 14 from any suitable source such for example as that represented by the three supply lines 16 to which the primary terminals of the motor are connected by means of conductors 17 and suitable reversing switching mechanism illustrated as a pair of electromagnetic contactors 18 and 20 respectively.

For the purpose of controlling the speed and torque of the driving motor 14, a variable resistance illustrated as comprising a plurality of resistance sections 21, 22, 23, 24 are connected in the secondary circuit of the motor and suitable means illustrated as a plurality of electromagnetic contactors 25, 26, 27 and 28 are provided for respectively short-circuiting and excluding the resistance portions 21, 22, 23 and 24 from the secondary circuit of the motor 14. The sequential operation of the contactors 25, 26, 27 and 28 may be controlled either by a time element or current limit control means. In the drawings, the closing operation of these contacts is illustrated as being under the control of time element devices 30, 31 and 32 which serve to introduce a time delay between the successive closing operations of the contactors.

The starting of the equipment when one of the skips is at the bottom of the shaft is under the control of a suitable manually operated control device illustrated as a push button type switch 33, whilst the starting of the equipment when the other cage is at the bottom of the shaft is under the control of a similar device 34. If desired, the starting may be automatically controlled by a time relay or the like.

In order to cause the cage to follow a predetermined speed-position curve throughout the decelerating range, a suitable control device 35 is provided. This device is illustrated as comprising a cam member 36 geared to the hoist drum 13, a speed responsive device 37 illustrated as a centrifugal fly ball governor and a system of electrical contacts 38, 40, 41 and 42. As shown, the movable contact member 40 is arranged for movement in a vertical direction by means of the leverage system 43 in response to actuation by the cam member 36. The contacts 38, 41 and 42 are arranged in cooperative relationship with the contact member 40. As shown, these contacts 38, 41 and 42 are supported in a movable supporting member 44 which is connected by means of a lever 45 to the fly ball governor 37 which in turn is connected by means of a shaft 46 to the drive shaft of the motor 14. It will thus be seen that the supporting member 44 and the contacts carried thereby are caused to move in a vertical direction in response to changes in the speed of the motor and consequently in response to changes in the speed of the hoist cages. It will also be seen that for each speed of the motor or the cage the supporting member 44 and its contact occupy a predetermined position whereby the element of speed is introduced into the control of the deceleration of the hoist.

With the above understanding of the apparatus and its organization in the complete system, the operation of the system itself will readily be understood from the following detailed description:

The apparatus is shown in the position which it occupies at the end of the trip when the cage 11 is at the top or at the dumping position and the cage 10 is at the bottom of the shaft or at some predetermined level in the shaft. Therefore, the next operation of the hoist is the hoisting of the cage 10 and the lowering of the cage 11. To start the trip, the start push-button 34 is operated to the closed position in which it completes an energizing circuit for the operating coil of control relay 47. This circuit is traced from the lower supply line 48 through the emergency stop push-button switching device 50 by conductor 51, to and through limit switch 52 (in the closed position when the cage 10 is beneath the dumping level), conductor 53, contacts of start push-button 34 in the depressed position thereof, normally closed interlocks 54_a, operating coil of relay 47 and thence to the upper supply line 48. Relay 47 closes in response to the energization of its operating coil and closes a circuit through the coil of the solenoid brake 19 to release the brake and simultaneously closes a control circuit through the upper contacts 38 of the control device 35, which circuit is traced from the upper supply line 48 through the interlock 47_a in the closed position thereof, through conductors 55 and 56, contacts 38 and 40 of the control device, conductor 57, normally closed interlock 54_d, conductor 58, operating coil of directional contactor 18, interlock 20_a, conductors 60 and 53, limit switch 52 and thence by conductors 51 and stop switch 50 to the lower supply line 48.

As a result of the energization of its operating coil, the directional contactor 18 is operated to the closed position in which it connects the terminals of the driving motor 14 to the supply source 16 in such a manner that the motor rotates in a direction to raise the cage 10. At this instant all of the secondary resistance 21, 22, 23, and 24 is included in the secondary circuit of the driving motor with the result that the motor rotates at a very low speed.

After a predetermined interval of time, the duration of which is determined by the setting of the time element device 18_c which is set in operation in response to the closing operation of the contactor 18, the interlock 18_b completes an energizing circuit for the operating coil of secondary resistance contactor 28; this circuit being traced from the upper supply line 48 to the conductor 55 as before and thence through the interlock 18_b, conductors 62 and 63, upper contact of the control relay 64 in the closed position thereof, operating coil of contactor 28, thence by conductors 65, 51 and stop button 50 to the lower supply line 48. Contactor 28 closes in response to the energization of its coil and short-circuits resistance section 24, as a result of which the torque and speed of the motor 14 is increased by a proportionate amount. A predetermined interval of time after the closing operation of the contactor 28 which interval of time is determined by the setting of the time element device 32, the interlock 32_a is actuated to its upper closed position in which it completes an energizing circuit for the operating coil of secondary contactor 27. This circuit is traced from the upper supply conductor 48 to the conductor 63 as before, thence by conductor 66, interlock 32_a, lower contact of relay 64 in the closed position thereof, operating coil of contactor 27 and thence by conductors 65, 51 and stop button 50 to the lower supply line 48. As a result of the energization of its operating coil, the contactor 27 is operated to its closed position in which it excludes the resistance section 23 from the secondary circuit of the motor 14 and the speed of the motor is further accelerated. In a similar manner, the contactors 26 and 25 are closed in the order named and suitable time intervals are introduced in the operation by means of the time element devices 31 and 30 in a manner of operation that is similar to that described in connection with the time element device 32.

When the secondary contactors are all closed, the hoist is operating at full speed and will continue to run at full speed until the raised portion 36_a of the cam 36 engages the roller 43_a. This occurs at the point in the travel of the cage at which it is desired that the slow down or deceleration should commence. The first effect of the engagement of the raised portion of the cam with the roller 43_a is to disengage the contact member 40 from the upper contacts 38 of the control device and this opens the energizing circuit for the operating coil of the hoisting contactor 18 which circuit was previously traced through the contacts 40 and the contacts 38. As a result the contactor 18 descends to the lower open position in which it is illustrated and it disconnects the motor 14 from the supply source 16. Likewise, when the contactor 18 opens, the movable interlock contact member 18_b becomes disengaged from the cooperating stationary contacts and thus interrupts the energizing circuits for the operating coils of the secondary contactors 25, 26, 27 and 28 so that these contactors are operated to their open position in which the secondary resistance sections 21, 22, 23, and 24 are reinserted in the secondary circuit of the motor.

The removal of power from the motor 14 tends to cause the hoist to slow down and if this slow down takes place at the proper and predetermined rate, the contact supporting member 44 which is actuated by the centrifugal fly ball governor 37

will tend to move downwardly at the same rate as that at which the contact member 40 is moved downwardly in response to the rotation of the cam member 36. The cam member 36 is so designed and shaped that when the load conditions of the hoist are normal the hoist will drift to rest without any further action of the contactors. If, however, the load on the hoist is such that it slows down faster than is desired the contact supporting member 44 which is actuated by the fly ball governor will overtake the lever arm 43 which is actuated by the cam, and the contact members 38 and 40 will again be brought into engagement to recomplete the energizing circuit for the operating coil of the hoisting contactor 18. The motor is thus reconnected to the supply source 16 and its speed is increased. As the speed increases, the fly ball governor 37 tends to raise the contact supporting member 44 until the contacts 38 and 40 again become separated. This action may be repeated several times during the retardation of the hoist.

If the load on the hoist is such that when the motor is first deenergized it does not slow down at the desired predetermined rate, the contact supporting member 44 actuated by the fly ball governor will not move downwardly at the same rate as the lever 43 actuated by the cam and eventually the contact member 40 will engage the contact members 42 to complete an energizing circuit for the coil of the reversing contactor 20. This circuit is traced from the upper supply conductor 48 to the conductor 55 as previously, thence by conductor 56, left-hand contact 42, contact 40, right-hand contact 42, conductor 67, lower interlocks 54_e in the closed position thereof, conductor 68, operating coil of lowering contactor 20, upper interlock 18_a in the closed position thereof, conductor 70, limit switch 71 (which is operated to the closed position when the cage 11 starts downwardly) and thence by conductor 51 and stop button 50 to the lower supply line 48. Contactor 20 in closing connects the motor 14 to the supply source 16 for rotation in the reverse direction in which it is rotating. This operation is known as "plugging" the motor and causes the motor to exert a powerful braking torque. Simultaneously, the engagement of the contact member 40 with the middle contact member 42 completes an energizing circuit for the operating coil of the control relay 64 which circuit is traced from the upper supply line 48 to the conductor 56 as before, thence through the left-hand and middle contact 42 (bridged by the contact 40) conductor 72, operating coil of relay 64, thence by conductors 65, 51 and stop button 50 to the lower supply line 48. As a result of its energization the relay 64 is operated to its upper position in which its upper and lower contacts open the circuit to the operating coils of the secondary contactors 25, 26, 27 and 28 that would otherwise be completed and established by the operation of the interlocks 20_b to its upper closed position in response to the closing of the lowering contactor 20. This prevents the secondary contactors from closing in their normal sequence, short-circuiting the secondary resistance and thus causing the motor to exert an excessive braking torque.

However, if the hoist does not decelerate as rapidly as it should under the plugging torque exerted by the motor 14 with all of the secondary resistance in circuit, the movable contact member 40 will move downwardly more rapidly than the contact supporting member 44, until it finally engages and bridges the contacts 41 thereby completing an energizing circuit for the operating coil of secondary contactor 28. This circuit is traced from the upper supply line 48 to the conductor 56 as before, then through the contact 41 bridged by the contact 40, conductor 73, operating coil of contactor 28 and thence by conductors 65, 51 and stop button 50 to the lower supply line 48. As a result, the contactor 28 is closed to exclude the resistance section 24 from the secondary circuit of the motor 14 thereby increasing the plugging torque and consequently the rate of deceleration of the hoist.

As the speed of the hoist decreases, the contacts 41 will become disengaged from the contact member 40 and the contactor 28 will again be deenergized, opened, and the resistance section 24 reinserted in the secondary circuit of the motor. And finally if the hoist continues to decelerate at the desired rate, the contact member 40 will become disengaged from the contact 42 so that the energizing circuit for the operating coil of lowering contactor 20 will be interrupted and the contactor caused to open and disconnect the motor 14 from the supply source.

This operation may of course be repeated several times during the retardation and thus it will be seen that the cooperation of the contacts actuated by the cam member 36 and those actuated by the speed responsive device 37 insure that the speed of the hoist will be at the required value at each point in the decelerating range for causing the cage to come in to the landing at a predetermined low rate of speed. As the cage 10 approaches the landing, the limit switch 52 is operated to its open position in which it interrupts the energizing circuit for the operating coil of the control relay 47 thereby causing the latter to descend to the lower open position in which it is illustrated. In the open position of this relay its intermediate interlock 47_b opens the circuit for the operating coil of the brake 19 and the brake shoe is set against the brake drum by means of its operating spring. As a result the hoist is brought to rest with cage 10 level with its landing and the system is left in the reset condition in which it is illustrated, ready for a repetition of the above-described operation, with the sole exception that the cage 11 is now at the bottom and the cage 10 at the top. The operation in the reverse direction is substantially identical with that above described for the hoisting operation of the cage 10 and a repetition is therefore unnecessary.

In the modification of Fig. 2 the driving motor, the accelerating control and directional, control are identical with that shown in Fig. 1 and consequently a description of this part of the apparatus will not be repeated. This modification differs from the system shown in Fig. 1 in that the two hoist cages 75 and 76 are each secured to separate cables 77 and 78 which in turn are secured to individual winding drums 80 and 81 respectively. These two drums are driven from the same driving motor 82 through suitable reduction gearing 83. Two control devices 84 and 85, both identical with the control device 35 in Fig. 1, are respectively associated with the drums 80 and 81. A movable contact member 84_a of control device 84 is actuated through suitable lever mechanism by means of a cam 86 driven through reduction gearing from the drum 80. This cam 86 is similar to the cam 36 in the system of Fig. 1 but it will be observed that it has but one raised portion 86_a which corresponds to the raised portion 36_b of the cam 36.

Similarly the contact member 85_a of the control device 85 is actuated through lever mechanism by means of a cam 87 which as illustrated is driven through a suitable reduction gearing from the hoist drum 81. This cam, it will be observed, is likewise similar to the cam member 36 of the system of Fig. 1 but it is different in that it only has one raised portion 87_a which corresponds in position to the raised portion 36_a of the cam 36.

In order to provide for changing the level to which the hoist cages descend, a clutching device 88 is included in the connections between the two drums 80 and 81. Let it be assumed for example that it is desired to change the level from the present level to a lower level. This is accomplished for example by operating the system until the hoist 75 is at its upper or stopping level. The clutch 88 is then operated to disconnect the drum 80 from the drive shaft 90. At this instant, of course, the system is in its deenergized condition and the brake 91 is set so that the cage 75 remains at its upper landing level. The system is then set in operation to continue lowering the cage 76 until it is at the desired new low level. This can be accomplished for example by by-passing the limit switch 92. The clutch member 88 is then reengaged and the system is then ready for operation at the new level.

The operation of the system of Fig. 2 is in all respects identical with the operation described in connection with the system of Fig. 1 with the exception that the functions performed by the raised portion 36_a of the cam 36 in Fig. 1 are now performed by the raised portion 87_a of the cam member 87 of Fig. 2 and the functions performed by the raised portions 36_b of the cam 36 are now performed by raised portion 86_a of the cam 86.

Although, in accordance with the provisions of the patent statutes, this invention is described as embodied in concrete form, it will be understood that the specific apparatus and connections shown are merely illustrative and that the invention is not limited thereto since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of this invention or from the scope of the annexed claims.

What I claim as new and desired to secure by Letters Patent of the United States, is:

1. A system of motor control for hoists and the like comprising a motor for driving the hoist, means for plugging said motor, and means controlled by the position of the hoist and the speed of said motor for controlling said plugging means.

2. A system of motor control for hoists and the like comprising a motor for driving the hoist, means for controlling the speed of said motor, means for controlling the direction of rotation of said motor, and means responsive to the speed of said motor and the position of the hoist for controlling said speed controlling means and said direction controlling means.

3. A control system for hoists and the like comprising a cage, a motor for driving said cage, a resistance connected in circuit with said motor for controlling the speed thereof, means for plugging said motor, and a device responsive to the speed of said motor and the position of said cage for controlling said resistance and said plugging means.

4. A control system for hoists and the like comprising a cage, an alternating current motor for driving the cage, a variable resistance for controlling the speed of said motor, means for plugging said motor, and a device responsive to the speed of said motor and to the position of said cage for controlling said plugging means and for varying the said resistance to provide a predetermined deceleration of said cage.

5. A control system for hoists and the like comprising a cage, a wound rotor induction motor for driving said cage, a variable resistance connected in the secondary circuit of said motor, reversing means for controlling the direction of rotation of said motor, and a device responsive to the speed of said motor and responsive to the position of said cage for actuating said reversing means to cause said motor to exert a plugging torque and for varying said resistance to control the value of said plugging torque.

6. A control system for an electric hoist and the like comprising in combination with a hoist cage, an alternating current motor for driving said cage, a variable resistance connected in circuit with said motor reversing switching mechanism for controlling the direction of rotation of said motor, a contact device actuated in accordance with the position of said cage, a second contact arranged in cooperative relationship with said first contact and actuated in accordance with the speed of said motor, and electrical connections controlled by said contacts for actuating said reversing means to cause said motor to exert a plugging torque if the deceleration of said motor differs from a predetermined value and for varying said resistance and controlling said plugging torque so that the speed of said motor is changed in accordance with the position of said cage.

7. A control system for electric hoists and the like comprising in combination with a cage, an alternating current motor for driving said cage, reversing switching means for said motor, a variable resistance connected in circuit with said motor, a control device comprising a pair of cooperating contact devices, a cam driven by said motor for actuating one of said contact devices in accordance with the position of said cage, a centrifugal device driven by said motor for actuating the other of said contact devices, and control circuits controlled by said contacts for actuating said reversing switching means to cause said motor to exert a plugging torque and for varying said resistance to control said torque whereby the speed of said motor is caused to have a predetermined value at each point in the landing range of said cage.

8. A control system for electric hoists and the like comprising in combination with a cage, an alternating current motor for driving said cage, a plural section resistance connected in circuit with said motor, a plurality of contactors for excluding said resistance sections from the motor circuit, reversing switching means for said motor, a control device comprising a pair of movable cooperating contacts, a cam driven by said motor for moving one of said contacts in accordance with the position of said cage, a centrifugal device responsive to the speed of said motor for moving the other of said contacts, electrical connections controlled by said contacts for actuating said reversing switching means to cause said motor to exert a plugging torque and for initiating operation of said contactors to exclude said resistance sections, and a relay controlled by said contacts for preventing the operation of a certain

number of said contactors so that the speed of said motor is caused to follow a predetermined rate of deceleration in the landing range of said cage.

9. A control system for hoists and the like comprising in combination with a pair of cages, a separate winding drum for each of said cages, an electric motor connected to drive both of said drums simultaneously so that one cage is hoisted while the other is lowered, a control device operatively associated with one of said cages, said device comprising a pair of cooperating contacts, means for moving one of said contacts in accordance with the speed of said motor, means for moving the other of said contacts in accordance with the position of its associated cage, a similar control device operatively associated with the other of said cages, and connections controlled by both of said control devices for causing said motor to exert a plugging torque and for controlling said torque so that the speed of said motor is caused to follow a predetermined rate of deceleration in the landing range of said cages.

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