A. M. COYLE.

MULTIPLE DROP HOIST SYSTEM OF CIRCUITS.

APPLICATION FILED JULY 29, 1907.

965,442. **Patented July 26, 1910.**

2 SHEETS—SHEET 1.

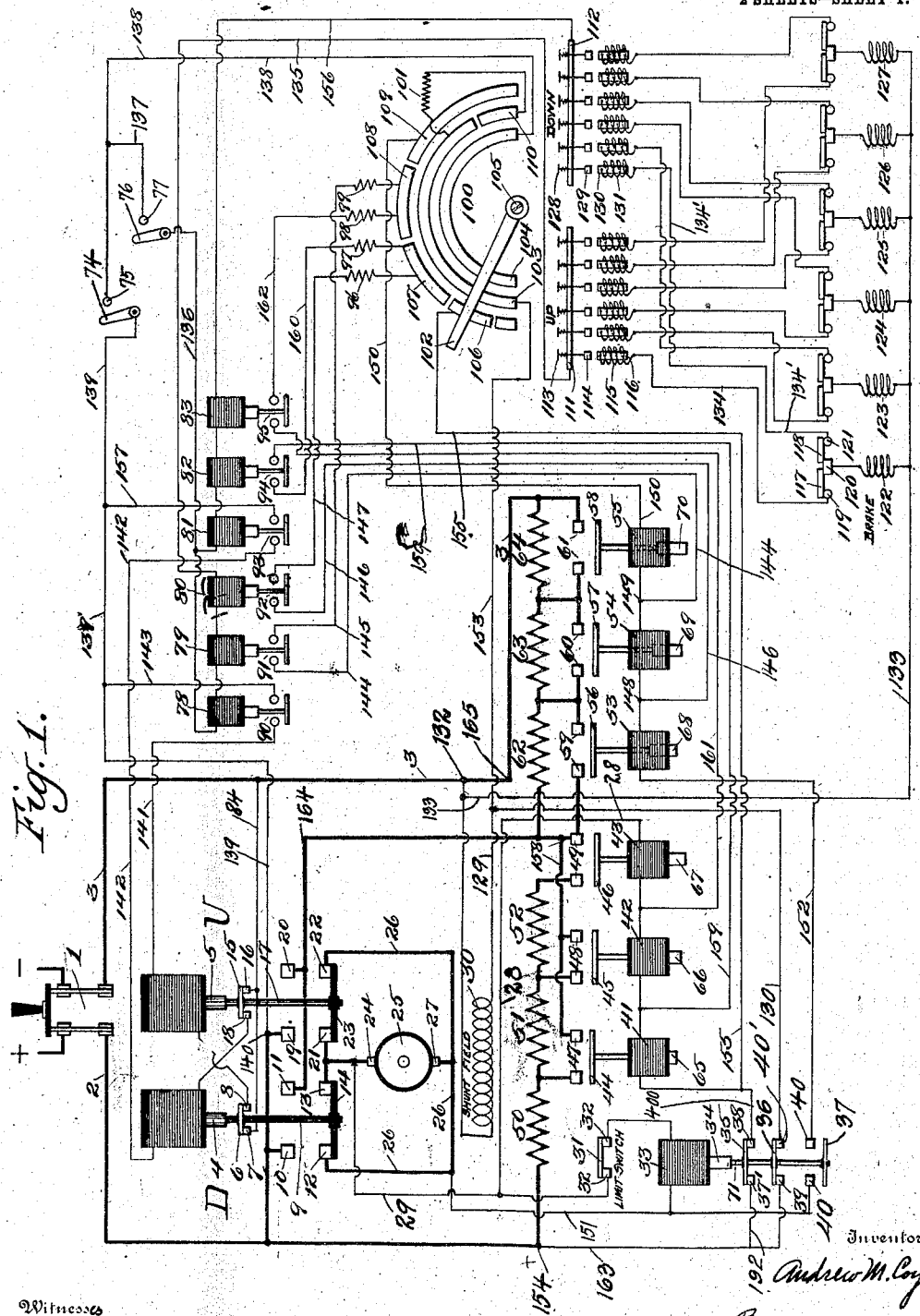

Fig. 1.

Witnesses

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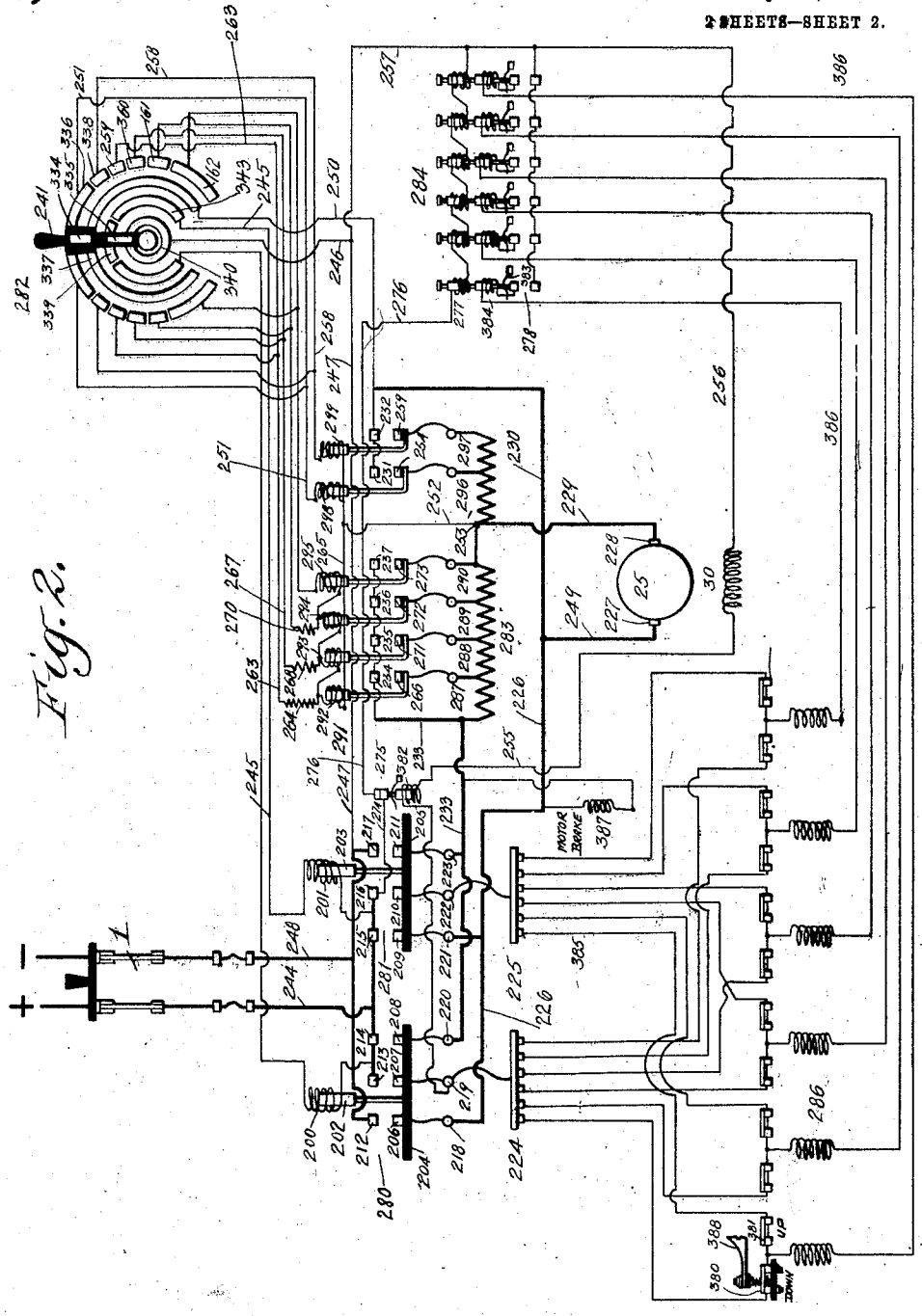

Fig. 2.

WITNESSES

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MULTIPLE DROP-HOIST SYSTEM OF CIRCUITS.

965,442. Specification of Letters Patent. **Patented July 26, 1910.**

Application filed July 29, 1907. Serial No. 386,080.

To all whom it may concern:

Be it known that I, ANDREW M. COYLE, a citizen of the United States, residing in New York, in the county of New York and State of New York, have invented a new and useful Improvement in Multiple Drop-Hoist Systems of Circuits, of which the following is a specification.

My invention relates to an improved system of push button motor control, and has for one of its objects the provision of means for selecting or controlling a plurality of hoisting machines by push buttons or switches, the speed at which same shall be operated being determined by a manually operated switch.

A further object of the invention is to regulate the speed of the hoisting mechanism while lowering by introducing more or less resistance in shunt to the armature circuit, and thereby utilizing the dynamic braking action of the motor when the same is acting as a generator due to the unbalanced descending load.

Other objects will appear hereinafter.

The accompanying drawings illustrate my invention as applied to a multiple curtain hoist and while the same is particularly adapted to a hoisting mechanism of this character, it is equally well adapted to hoisting machines of all kinds in which an electric motor is used for hoisting and lowering. Generally speaking, a multiple curtain hoist belongs to that class of hoisting machines in which a single motor operates through friction mechanism a number of hoisting drums, each of which controls a drop curtain such as is used in theaters, etc.

Referring now to the drawings, Figure 1 is a diagrammatic view, showing the preferred form of my invention, and Fig. 2 is a similar view of a modification.

Fig. 1 will first be described. In this form, a main line switch 1 serves to connect the source of electrical supply to the feed wires 2 and 3, respectively, designated by + and —.

D and U are the motor reversing switches, and since they are similar in construction a description of one applies equally well to the other. The switch D comprises a solenoid and a plunger 4 movable therein, a motor armature reversing switch and an auxiliary switch. To the plunger 4 is connected a rod 9 carrying a contact plate 6 and an insulating bar 14. The latter carries two contacts 12 and 13 which are in line with and arranged to engage two stationary contacts 10 and 11, respectively. The contact plate 6 bridges two fixed contacts 7 and 8 when the electro-magnet is deënergized. When energized, however, the plunger 4 is lifted, carrying with it the rod 9, contact plate 6 and the insulating bar 14. The stationary contacts 7 and 8 will then be electrically disconnected and the movable contacts 12 and 13 will be brought into engagement with the stationary contacts 10 and 11, respectively. The magnet of switch U when energized operates in the same way; that is, when the solenoid receives current the plunger 5 is lifted, carrying with it the rod 17, contact plate 15 and insulation piece 23. This operation will disconnect the contacts 18 and 16 and connect the contacts 19, 20 and 21, 22, respectively.

25 designates the motor armature, which may be connected to curtain hoisting apparatus as illustrated in my copending application, Serial No. 282,234, filed October 11, 1905, for an improvement in multiple hoisting apparatuses. It should be understood however, that the present system of controlling apparatus for electric motors may be applied to hoisting machinery other than that for hoisting curtains, for example, furnace hoists, where a load is lifted and the empty car then permitted to descend, driving the motor forward.

30 designates the shunt field winding.

50, 51 and 52 designate sections of a resistance which are controlled by the switches operated by the magnets 41, 42 and 43.

31 designates a slow-down switch shown in the drawing diagrammatically as comprising a contact-maker or plate which normally bridges two fixed contacts 32.

33 designates a magnet solenoid in which is movable a plunger 34. To the latter is connected a rod 71 which in turn is connected to, but isolated from, three contact plates 35, 36 and 37. The plates 35 and 36 normally rest on the contacts 37′, 38 and 39, 40′, respectively. When the solenoid 33 receives current to lift its plunger 34, the plate 37 will electrically connect the contacts 40, 40.

62, 63 and 64 designate the starting resistances, and 53, 54 and 55 are magnets for

operating switches to control said resistances.

74 and 76 designate manual switches.

100 designates an operating or speed controlling switch which comprises a rheostat arm 102 pivoted at 105, which is arranged to make contact with fixed segmental conductors or contact strips 106, etc. Directly under this switch in Fig. 1 are shown diagrammatically a series of "up" push buttons and a series of "down" push buttons. These push button switches are self-holding in that when a button is pushed a circuit is completed through a magnet forming a part of the push button device and operating to hold the button in against the action of a spring or equivalent device, the parts remaining in this position until the magnet is deënergized, whereupon the button assumes its original position automatically. These push button switch devices are alike in construction and may be constructed in many specifically different ways. In this instance one of the terminals of each of the brake magnets is connected through an automatic stop motion switch to the solenoids 115 and 131, and thence to the core 116 of the push button electro-magnet.

The brake magnets are designated by the numbers 122 to 127, inclusive, and are for the purpose of actuating brake apparatus to release the same and permit the hoisting apparatus to be connected to the electric motor. When the brake magnet is deënergized the brake will at once be applied by a brake spring and the hoisting mechanism disconnected from the electric motor. The brake apparatus, however, may be of the usual well known type in connection with ordinary hoisting apparatus. I prefer, however, when applying my improved controlling apparatus as herein disclosed to curtain hoisting apparatus, to use the brake apparatus illustrated in my co-pending application hereinbefore referred to.

It should be understood that each unit of the multiple hoisting apparatus is provided with stop motion mechanism for the purpose of preventing any possible over-running of the hoisting apparatus. I have herein shown diagrammatically the switches of the stop motion mechanism, such switches comprising fixed contacts 119, 120 and 121 and movable contact plates 117 and 118, one to be lifted when the curtain approaches its upper limit of travel and the other to be lifted when the curtain approaches its lower limit of travel to effect the deënergization of the corresponding brake magnet and the consequent stopping of the corresponding unit of the multiple hoisting apparatus.

The direction of rotation of the motor is controlled by the reversing switches D and U. The acceleration of the motor when operating the hoisting apparatus, to lift a curtain for example, and the various speeds of the motor are controlled by varying the resistance in circuit with the motor armature and by changing the field strength. In lowering the curtain a fixed resistance is included in the armature circuit while a variable resistance is placed in shunt thereto, the strength of the field being also varied. The heavy lines in the accompanying drawings denote the main or motor circuits, while the lighter lines denote the shunt field and operating circuits.

Assuming that the main line two-pole switch 1 is closed and that the positive and negative mains are connected to a source of current supply having proper potential for the operation of the motor, the leads 2 and 3 will be alive. The drawing shows the system in a position of inaction or rest. In order to trace the various circuits, it will be necessary to operate one of the selected push buttons, such as 113. If at this time the arm 102 is in the position shown a circuit will be completed from the positive lead 2 by wire 139, switch 72, conductor 137, switch 73, conductor 136, the three relay magnets 78, 79 and 80, conductor 135, connecting bar 111, contact 114, core 116, winding 115, conductor 134, contacts 119, 120 and bridge piece 117, brake magnet 122 and conductor 133 to the negative lead 3. This circuit from the positive main to the negative main includes the relay magnets 78, 79 and 80, the push button magnet at the extreme left, and the brake magnet 122. The brake mechanism will now be released by the magnet 122 and the magnet core 116 will hold the contact 114 in circuit-closing position, as an armature, since said contact 114 is composed of magnetic material such as soft iron. Substantially at the same time the magnets 78, 79 and 80 will close the switches 90, 91 and 92. The switch 90 controls a circuit to the magnet of the reversing switch U. Therefore when the switch 90 is closed a circuit may be traced from the positive lead 2 through the conductors 139, 143, switch 90, conductor 141, solenoid of the reversing switch U, contacts 8, 7 and bridge piece 6, and thence by conductor 84 to the negative lead 3. It should be noted that when the plunger 5 is lifted the contacts 16 and 18 are separated so that the circuit of the solenoid of the reversing switch D cannot possibly be excited with current so long as the reversing switch U is in closed position. The switch U having operated, the motor now receives current, the circuit being as follows: from the conductor 2 to and through contacts 19, 21, brush 24, armature 25, brush 27, conductor 26, contacts 22, 20, conductor 164, starting resistances 62, 63, 64, and thence to the negative lead 3.

The shunt field winding 30 is connected by conductors 163, contacts 39, 40′ and plate

36, and conductors 130, 129 across the leads 2 and 3. The motor may now start and accelerate to a predetermined slow speed.

Substantially at the same time that the switch 90 is closed the switches 91 and 92 are also closed. The closing of the switch 91 connects point 149 with the segmental strip 108 of the speed controlling switch 100 by means of the conductors 144, 145 and the resistance 99. Similarly the closing of the switch 92 forms a connection between the point 148 and the segmental strip 107 through the conductors 146, 147 and the resistance 96. The magnets 53, 54 and 55 are accelerating electro-magnets, in that they operate switches to control the resistances 62, 63 and 64. They may, however, also be termed speed-controlling electro-magnets. These magnets are connected together as shown. The left-hand terminal of the magnet 53 is connected to the contact 40 by the conductor 152, while the right-hand terminal of magnet 55 is connected by conductor 150 directly to the segmental strip 109. When the arm 102 is in the position shown and the button 113 has been actuated to effect the operation of the motor to a predetermined slow speed, the magnets 53, 54 and 55 are not energized since all their terminals are still connected to isolated contacts; nor are the magnets 41, 42 and 43 energized at this time, since no circuit for current flow through them is provided. It should be noted that at this time the shunt field winding 30 not only receives current from the positive lead through the conductor 130, but also from a parallel circuit by way of conductor 139, switch 72, conductor 138, segment 104, arm 102, segment 103 and conductor 153.

When the motor attains a predetermined slow speed, or when the motor has built up a sufficient counter-electro-motive force, the solenoid 33 will lift its core 34 and cause the plates 35 and 36 to be lifted out of engagement with the contacts on which they are resting, and move the plate 37 into engagement with the contacts 40, 40. The conductors 130 and 163 being disconnected from each other by the plate 36, the shunt field winding 30 can receive current only by way of the switch 100 and conductor 153. Otherwise lifting of the plunger 34 and the operation of the switches connected thereto have no further immediate effect. The relay magnets 81, 82 and 83 remain inoperative, since they are open-circuited at the conducting strip 112.

In order to increase the speed of the motor the rheostat arm 102 must be moved to the right. When it connects together the segmental strips 104, 103 and 107 current will flow from the positive main through wires 139, 138, strip 104, arm 102 to contact strip 107, and thence through resistance 96, conductor 147, switch 92, conductor 146, to the point 148 which is one terminal of the magnet 53. The other terminal of this magnet being connected by conductor 152 to the contact 40, the current will continue to flow through the latter and the bridge piece 37, and thence through conductors 151, 26, contacts 22, 20, conductor 164, resistances 62, 63, 64, to the negative lead 3. The magnet 53 will therefore be connected across the motor armature 25, and if the counter-electro-motive force in the latter is sufficient the magnet 53 will be energized to cause the plate 56 to electrically connect the contacts 59 and short-circuit the resistance 62 to cause increased potential to be applied to the motor armature. The motor will now accelerate to a higher speed. It should be noted that when the rheostat arm 102 passes from the strip 106 the left-hand terminal of the magnet 41 is entirely isolated. The left-hand terminals of the magnets 42 and 43 are already isolated.

By moving the rheostat arm 102 off the contact strip 107 and onto the confact strip 108 a circuit will be closed for the magnet 54 from the positive lead 2 by way of conductor 139, switch 72, conductor 138, strip 104, arm 102, strip 108, resistance 99, conductor 145, switch 91, conductor 144 to the point 149, and thence through the magnet 54, magnet 53, conductor 152, the switch comprising the plate 37, conductors 151, 26, contacts 22, 20, conductor 164, contacts 59 and switch plate 56, resistances 63, 64, to the negative lead 3. The magnets 53, 54 and resistance 99 are now connected in series with each other across the motor armature, and if the counter-electro-motive force of the latter is sufficient the magnet 54 will effect the plate 57 to connect the contact 60 and thereby short-circuit the resistance 63. The motor will then run at increased speed, due to an increase of potential across its armature brushes. A further movement of the rheostat arm 102 causes it to pass off the strip 108 onto the strip 109. By reason of the direct connection through the conductor 150 from the strip 109 to the magnet 55, all three of the magnets 55, 54 and 53 will now be connected in series with each other across the motor armature, so that if the speed of the latter is sufficient the magnet 55 will also be energized to cause the plate 58 to electrically connect the contacts 61 and thus short-circuit the resistance 64. All the starting resistance having been short-circuited or cut out, the armature is connected directly across the mains and will accelerate to full speed.

The resistances 96 and 99 are so proportioned that the amount of current furnished to the magnets 53, 54 and 55 is the same, whether one, two or all three are energized. The resistance 96 is substantially twice as

great as the winding of one of the magnets 53, 54 or 55, while the resistance 99 is substantially equal to the resistance of such winding. By this arrangement the operation of the magnets 53, 54 and 55 is made consecutive, producing a corresponding short-circuiting or cutting out of the resistances 62, 63 and 64 step by step. Furthermore, the magnets 53, 54 and 55 are set or adjusted so that they do not close their respective switches until a difference of potential proportionate to a predetermined amount is reached. This adjustment may be secured in many specifically different ways, but in this instance, I have shown the plungers 68, 69 and 70 projecting into the cores different distances so that the magnet 53 will be first to operate, then 54, and finally 55, even though the switch arm 102 be immediately thrown into connection with the strip 109. Upon moving the rheostat arm 102 to its extreme right-hand position it will connect together segmental strips 104, 110 and 109 and will leave the contact strip 103. Now the latter is connected by conductors 153, 129 to the shunt field winding 30. Therefore when the rheostat arm passes off the strip 103 the circuit of the shunt field winding would open at that point were it not for the fact that the strip 110 which is now in electrical engagement with the rheostat arm 102, is connected through a resistance 101 to the strip 103. It will therefore be seen that the resistance 101 is placed in series with the shunt field winding. This will cause the field to become weakened and the speed of the motor to accelerate still further.

As the load on the electric motor approaches its limit of travel the stop motion switch will be opened by the lifting of the contact bar 117 out of engagement with the stationary contacts 119 and 120. This will at once effect the stopping of the hoisting mechanism by reason of the deënergization of the brake magnet 122. The three relay magnets, 78, 79 and 80 will also be deënergized by their circuit being opened at the push button contact 114, for when the bar 117 is lifted current is cut off from the solenoid 115 and the armature 114 is therefore released. The deënergization of the magnets 78, 79 and 80 causes the switches 90, 91 and 92 to automatically open. The opening of the switch 90 causes the current to be cut off from the magnet of the reversing switch U, and the latter will therefore operate automatically to open position and cut off the main current supply from the motor. It should be observed, however, that the shunt field winding still receives current through the speed controlling switch 100 and resistance 101. As soon as the reversing switch U operates to open position, the magnets 53, 54 and 55 are deënergized, since they are open-circuited at the contacts 22, 20. The resistances 62, 63 and 64 will therefore be reinserted. As the motor comes to rest the potential across its armature will decrease until the magnet 33 becomes deënergized and drops its core 34 to reëstablish the normal positions of the switches controlled thereby. The field resistance will be short-circuited so that the motor will have maximum field strength when again started. Instead of first pushing the selected button 113 and then bringing the motor up to full speed by moving the rheostat arm 102 to the right from its left-hand position, if desired the switch 100 may be placed in such position as to give the speed required and then a selected push button operated. In such case the motor would start and accelerate automatically to the desired speed, the magnets 53, 54 and 55 automatically operating in succession to cut out or short-circuit the resistances 62, 63 and 64.

In lowering the curtain the operation is somewhat different. To explain this, let it be assumed that the switch arm 102 is in the position shown in Fig. 1. Then if a "down" push-button, such as that designated 128 for example, is actuated a circuit will be closed from the positive lead 2 by way of conductor 139, switch 72, conductor 137, switch 73, conductor 136, relay magnets 81, 82 and 83, conductor 156, conducting bar 112, contact 129, core 130, solenoid or holding coil 131, conductor 134', stop motion switch, brake magnet 122, and thence by the conductor 133 to the negative lead 3. The brake apparatus will be released and the push-button 128 held in by its magnet and the relay magnets 81, 82 and 83 will be energized to close their respective switches 93, 94 and 95. The switch 93 controls the electro-magnet of the reversing switch D, and when closed forms a circuit for such magnet from the positive lead 2 by conductors 139, 157, 142 to and through the magnet of reversing switch D, and thence through the auxiliary switch of the reversing switch U to the negative lead 3. The magnet of the reversing switch D is now in a circuit across the mains and the contacts 12 and 13 are brought into engagement with the fixed contacts 10 and 11, respectively, and the contacts 7 and 8 are electrically disconnected to prevent any possible circuit through the magnet of the reversing switch U. Upon the closing of the reversing switch D the motor circuit will be closed from the positive main 2 by way of contacts 10 and 12, conductor 26, armature brush 27, armature 25, brush 24, contacts 13, 11, conductor 164, and resistances 62, 63 and 64 to the negative lead 3. It will be observed that the current is now sent through the armature in a reversed direction to that when the reversing switch U is closed.

The shunt field being excited and the

brake apparatus being released from the hoisting unit controlled by the brake magnet 122, the load controlled by the latter is permitted to descend. At this time the closing of the switches 94 and 95 by the magnets 82 and 83, respectively, has no further effect. When the reversing switch D is operated a circuit is closed also from the positive main 2 through conductors 163, 192, contacts 37', 38 and bridge piece 35, conductor 400, electro-magnets 41, 42 and 43, conductors 28, 29, contacts 13, 11, conductor 164, and resistances 62, 63, 64, to the negative lead 3. The magnets 41, 42, 43 are therefore energized by being placed in a circuit across the armature and will operate to close their switches, the plunger 65 being first lifted to bring the plate 44 into engagement with the contacts 47, the plunger 66 then being lifted to bring the plate 45 into engagement with the contacts 48, and finally the plunger 67 being lifted to bring the plate 46 into engagement with the contacts 49. The electrical connection of the contacts 47 places the resistance 50 in parallel with the motor armature in the circuit from brush 24 through contacts 13, 11, conductors 164, 158, contacts 47 and plate 44, resistance 50, a portion of the negative lead 2, contacts 10, 12, conductor 26 to the other brush 27. This parallel circuit thus formed is of such low resistance that the current received by the armature will be comparatively small and therefore the motor will operate at slow speed. It should be also noted that the resistances 62, 63 and 64 are in series with the motor armature, which effects a still further reduction in speed of the motor. The latter resistances are always in series with the motor when the latter is lowering its load. The potential across the motor armature brushes, however, is at this time sufficient to effect the energization of the magnet 33 and cause the latter to lift its plunger 34 and the plates 35, 36 and 37 connected thereto. A circuit for the magnet 41 is opened at the contact 38, but another circuit for this magnet is still closed by the switch 100 through the conductor 155 at the contact segment 106. However, as soon as the rheostat arm of switch 100 is moved out of engagement with the segmental strip 106, the magnet 41 has its circuit opened and the plunger 65 will therefore drop. The resistances 50, 51 will then be placed in series with each other and in parallel with the armature. More current will then flow through the armature, owing to the increased resistance of the parallel circuit, and consequently the motor will be accelerated. The magnets 42 and 43 still receive current at this time from the positive lead 2 through conductors 139, 138, segment 104 of the switch 100, arm 102, contact strip 107, resistance 97, switch 94, conductor 159, magnets 42 and 43, conductors 28, 29, contacts 13, 11, conductor 164, and resistances 62, 63, 64, to the negative lead 3. The resistance 97 is for the purpose of taking the place of the magnet 41 and maintaining the current in the magnet 42 and 43 substantially the same as before.

When the rheostat arm 102 is moved onto the segment 108 the magnet 42 is open-circuited at the strip 107 and the magnet 43 is alone excited by current passing through a circuit including the resistance 98 and the switch 95, the current in this circuit remaining substantially the same as before, owing to the resistance 98 being equal to the sum of the resistances of both magnets 41 and 42. Upon the opening of the circuit supplying the magnet 42 the resistance 52 is added to the resistances 50 and 51 in the circuit parallel to the armature. The motor will therefore accelerate to a higher speed. A further movement of the arm 102 causes it to run off the strip 108 onto the strip 109. This operation opens the circuit of the magnet 43, causing the contacts 49 to become disconnected by the dropping of the plate 46. The parallel circuit to the motor armature will then be opened. The arm 102 when placed in its extreme position on the segment 110 inserts the resistance 101 in the shunt field circuit, thus bringing the motor to its normal lowering speed. It will thus be seen that after the motor has been accelerated to full speed in lowering, the resistances 62, 63 and 64 are in series with the motor armature, the resistances 50, 51 and 52 are entirely cut out and the resistance 101 is in series with the shunt field winding 30.

As the curtain approaches the lower limit of its travel, a cam, for instance, of the stop motion mechanism, lifts the bridging member 31 out of engagement with the contacts 32, thereby opening the circuit of the magnet 33. The plunger of the latter will therefore drop, permitting the plate 35 to connect the contacts 37', 38 and the plate 36 to connect the contacts 39, 40', and the plate 37 to electrically disconnect the contacts 40, 40. The connection of the contacts 39, 40' short-circuits the field resistance 101 by the conductors 163 and 130. The connection of the contacts 37' and 38 places the magnets 41, 42 and 43 across the motor armature. These magnets will therefore receive current from the line and will operate successively their switches to effect the insertion of the resistance 50 in parallel to the armature and causing the latter to be retarded. This retarding action is increased by the strengthening of the shunt field, due to the cutting out of the resistance 101. The hoisting machine will then lower the curtain at a reduced speed until when the curtain almost reaches its extreme limit of travel, the stop motion switch is opened by lifting the mem-

ber 118 from the contacts 120 and 121, thus deënergizing the brake magnet 122 and effecting the application of mechanical brake apparatus and the disconnection of the corresponding unit of the multiple hoisting apparatus from the driving motor. If desired, the magnets 43, 42 and 41 may be adjusted to operate successively in the reverse order, so that if the curtain drives the motor forward as a generator one or more of the sections of resistance 50, 51 and 52 may be inserted in a circuit parallel to the armature, thus obtaining a reduction in speed in proportion to the load. That is, if the load is heavy and descending rapidly the momentum may be sufficient to cause the motor, acting as a generator, to energize all three of the electro-magnets 43, 42 and 41 to secure maximum electro-dynamic brake action, since the resistance 50 alone is in series with the motor armature in a local circuit. If the momentum is not so great then the magnets 43 and 42 alone would operate and the retarding action would be that due to both the resistances 50 and 51. When descending with a light load, although still driving the motor as a generator, there will be less retarding action, and therefore only the magnet 43 will be energized and all the resistances 50, 51 and 52 kept in the electro-dynamic brake circuit.

The slow-down switch comprising the contacts 32 is operated to open position both when the curtain approaches its upper limit of travel and when it approaches its lower limit of travel, and is operated to such open position before the stop motion switch, comprising the member 118 for instance, is lifted. After the member 118 is lifted and the brake mechanism applied to stop the multiple curtain hoisting unit, the member 31 is again permitted to connect the contacts 32, 32. This operation may be secured by any well known stop motion apparatus, but I prefer to employ that illustrated in my co-pending application Serial No. 282,234 hereinbefore referred to.

As indicated in Fig. 1 by the push button switches and the brake magnets, the controlling system is designed for a multiple hoisting apparatus having six different units, each controlled by an "up" and "down" manual switch, and "up" and "down" stop motion switch and by a brake magnet. Furthermore, as before pointed out, the control of the hoisting units may be effected in two ways: First, the rheostat arm 102 is placed in a position corresponding to the desired speed and then a button selected for effecting the operation of a corresponding unit. The motor then starts and carries the load up or down as described. Second, the button is first pressed and the rheostat arm then moved from its initial position to a position corresponding to the desired speed. The switches 72 and 73 are safety switches and may be placed in any of the controlling circuits desired for the purpose of stopping the hoisting units or the motor quickly in case of an emergency. In this instance the safety switches 72 and 73 are respectively placed in the circuit including the conductors 139 and 138 and in the circuit including the conductors 136 and 137.

Referring now to the modification shown in Fig. 2, it will be seen that the general arrangement is substantially the same as that set forth in Fig. 5 of my co-pending application Serial No. 282,235 already referred to. 25 designates the motor armature; 30, the shunt field winding; 280 and 281, the reversing switches; 284, a bank of push buttons for selecting one of the brake magnets 286; 282, a manual controlling switch; 283, starting resistance; 268, the switch mechanism for controlling the starting resistance; and 387, a brake magnet for the electric motor itself.

In the main motor circuit are four sections of the starting resistance 287, 288, 289 and 290 which are controlled by the accelerating magnets 292, 293, 294 and 295. These controlling magnets are in turn controlled by the manual switch 282. The main circuit also contains the slow speed resistances 296 and 297 which are controlled by the slow speed magnets 298 and 299, the latter being also connected to the manual switch 282.

The reversing switches 280 and 281 are arranged to be operated by electro-magnets comprising solenoids 200, 201 and plungers 202, 203 movable therein. The plunger 202 is connected to an insulating bar 204 which carries three contacts 206, 207 and 208. The latter contacts are arranged to be moved into engagement with the contacts 212, 213 and 214, respectively, when the solenoid 200 receives current. In a similar manner the insulating bar 205 is connected to the plunger 203 and carries the contacts 209, 210 and 211, above which are the fixed contacts 215, 216 and 217. The movable contacts 206, 207 and 208 are connected to the binding posts 218, 219 and 220, respectively, and the movable contacts 209, 210 and 211 are connected to the binding posts 221, 222 and 223. The binding posts 219 and 222 are connected respectively to the binding posts 224 and 225 of the stop motion and brake circuits hereinafter described. The binding post 218 is connected by the conductor 226 to the brush 227 of the motor armature 25, the other brush 228 being connected by the conductor 229 to the resistances 290 and 296 at the point 253. The binding posts 220 and 223 are connected together and to the resistance 287 and to the fixed contacts 234 to 237, inclusive, by the conductor 233. It

should be noted that conductors 226 and 230 lead from the binding post 218 to the fixed contacts 231 and 232.

Referring now to the manual controlling switch 282, it will be seen that the same comprises a plurality of arc-shaped fixed contact strips consecutively arranged. These contacts may be secured to a base of slate or other insulating material. The switch lever is here shown made of insulating material with contact strips or bridging pieces 334 and 335 secured to it. This lever may be of other material, however, and the bridging pieces separated electrically from it by means of insulation, or otherwise constructed.

In order to start the motor the lever 241 is moved to the right or left, depending upon the direction in which the motor is to be run. Normally, that is, when the lever 241 is in central position as shown, the pieces 334 and 335 bridge respectively the strips 336, 337 and the strips 339 and 340. The strip 339 is electrically isolated. When the lever 241 is moved to the right the conductor 335 will engage the strip 343. This will result in closing the following circuit: from the positive main by way of conductor 244 to and through the solenoid 201, conductor 245, strip 343, bridging contact 335, circular contact strip 340, conductors 246, 247 and 248 to the negative main.

The closing of the circuit just traced effects the closing of the reversing switch 281 which establishes a circuit through the motor armature as indicated by the heavy lines which may be traced as follows: from the positive lead 244 to and through the contacts 215, 209, conductors 226, 249, brush 227, motor armature 25, brush 228, conductor 229, resistances 290, 289, 288 and 287, conductor 233, contacts 211, 217, and conductor 248 to the negative main. There is also established a circuit in shunt to the armature from conductor 226 by conductor 250 to contact strip 337, bridging contact 334, strip 336, conductor 251, magnet 298, conductor 252, to the point 253 where the conductor 229 from the brush 228 joins the resistances 296 and 290. The energization of the slow speed magnet 298 will cause the movable contact 254 to engage the fixed contact 231 and insert the resistance 296 in parallel with the armature through the conductors 229, 230 and 249. The circuit of the shunt field winding 30 is also established and may be traced from the binding post 219 through the conductors 255, 256, 257, 247 and 248 to the negative main. The motor will now start with the starting resistance 283 in series with the armature and the resistance 296 in parallel therewith, this being the condition of slowest speed. Let the switch lever 241 now be moved a little farther toward the right so that the bridging member 334 shall engage the strip 338. The space between the strips 336 and 338 is preferably a little less than the width of the bridging member 334 so that the latter will engage the strip 338 before it leaves the strip 336. As soon as the member 334 engages the strip 338 current may flow through the conductor 250, strip 337, member 334, strip 338, conductor 258 to the other slow speed magnet 299, and by way of the conductor 252 to the point 253. It will thus be seen that the magnet 298 is first connected across the armature and then also the magnet 299 in parallel therewith, but as soon as the contact 334 leaves the strip 336 the magnet 298 is deënergized and the contacts 231 and 254 are separated. Before this occurs, however, the contacts 232 and 259 will have been connected by the magnet 299 so that when the member rests on the strip 338 alone both the resistances 296 and 297 will be placed in series with each other in a circuit parallel to the motor armature. The resistance parallel to the armature is therefore increased and the speed of the motor accelerated somewhat. A further movement of the lever 241 to the right onto contact strip 259 will cause current to flow by way of conductor 263 through the resistance 264 and the accelerating magnet 292, conductors 265, 252 to the point 253. The movable contact 266 will be drawn up against the fixed contact 234 and thus short-circuit the resistance section 287. The next step occurs when the member 334 leaves the strip 338, whereupon the magnet 299 will be deënergized and the resistance sections 296, 297 removed from the parallel circuit. The resistances 288, 289 and 290 are now in series with the motor armature, the motor running at an increased speed. When the member 334 is moved onto contact 360 current will flow through the conductor 267, resistance 268, the magnet 293, magnet 292, conductors 265, 252 to the point 253. It will be noticed that although the resistance 264 is cut out by this last operation the magnet 292 remains in circuit. The value of the resistance 268 is less than that of the resistance 264 an amount approximately equal to the resistance of the solenoid of the magnet 293 so that the current shall be about the same as before. When the magnet 293 is energized the contacts 235, 271 will be connected and both the resistances 287 and 288 short-circuited. This will still further increase the speed of the motor. In a similar manner also the resistances 289 and 290 are short-circuited by a further movement of lever 241 to bring the motor up to full speed.

It should be noted that the resistances 264, 268 and 270 are so proportioned with respect to the resistances of the solenoids of the magnets 292, 293, 294 and 295 that the com-

bined resistance of the solenoids and the resistances that are in circuit at any time remain substantially the same. That is, when only the magnet 292 is energized the resistance 264 is sufficient to cut down the current to what it will be when all the magnets are connected in series and all of them energized. The difference between the resistances 264 and 268 is equal to the resistance of the solenoid of the magnet 293, and the difference between the resistances 264 and 270 is equal to the combined resistances of the solenoids of the magnets 293 and 294. Also the combined resistances of the solenoids of the magnets 293, 294 and 295 is equal to the resistance 264. It should be also noted that with this arrangement of accelerating magnets, I am enabled to bring the motor up to any speed desired, dependent upon the position of the manual controlling switch. Furthermore, by returning the switch lever 241 I am enabled to reduce the speed of the motor to any point corresponding to the position of the switch lever. In other words, the speed of the motor is always dependent upon the position of the switch lever 241 and may be increased or decreased at will. Preferably the starting resistance should be so proportioned as to give a wide range of speed for the motor. The number of sections of the starting resistance may be varied as desired, the greater the number the greater the refinement of speed control.

Referring to the bank of push buttons 284, it will be noticed that each is provided with two electro-magnets, each of which tends to operate the button in the same direction. The series of electro-magnets 277 are connected in series with each other and are normally energized by current passing from the positive main to and through the contact 216, conductor 274, switch 275, conductor 276, electro-magnets 277, conductors 257 and 247 to the negative main. Current is always passing through this circuit when the main line switch 1 is closed, but the energization of the electro-magnets 277 is insufficient to close the series of switches 278. When, however, a push button is pressed in to close one of the switches 278 against the action of a spring 383, the corresponding electro-magnet 277 will have sufficient strength to hold it closed. So long as the manual controlling switch 282 remains in normal position and neither reversing switch is closed, the switch 275 will remain closed and the operation of one or more of the push buttons 284 will have no operative effect except to set them in readiness to cause the brake magnet to be energized, and thus automatically connect a hoisting apparatus and a rotating friction disk. That is, the circuit through the upper series of solenoids being a holding or retaining circuit, will serve to hold a button pressed in after having once been operated so that any particular group of hoisting devices may be selected beforehand to be operated together. Upon the operation of the automatic limit switches the buttons will be released to return to their normal positions, provided the switch 275 is in open position at such time.

Each of the brake magnets 286 is provided with a "down" limit switch 380 and an "up" limit switch 381, the solenoids of the magnets 286 being connected to them at intermediate points. All of the "down" limit switches are connected to the binding posts 224 and the "up" limit switches to the binding posts 225. It will be apparent that when one limit switch is opened the other still remains closed. Also when one reversing switch is closed the other is in opened position, and the latter may be operated although one of the limit switches is open. The "down" limit switches cannot convey current when the movement of the load is upward; the same condition holds with regard to the "up" limit switches whose circuits are broken when the "down" reversing switch is closed.

As soon as the current begins to flow in the shunt field circuit the magnet 382 therein will open the switch 275 and this has the effect of deënergizing the upper series of electro-magnets 277 of the push button apparatus 284. The push buttons that had been operated would then fly out of their normal positions by reason of the springs 383, unless held in by one of the electro-magnets 384 in one of the brake magnet circuits.

Assuming that all the push buttons have been operated and are held in circuit-closing position by the upper series of magnets 277, let the switch lever 241 be moved to the right to operate the "up" reversing switch. The shunt field circuit being closed, the magnet 382 will be energized to open the switch 275 to break the circuit of the magnets 277. But before this can take place current flows from the positive main through the contacts 216, 210, binding posts 222, 225, and in parallel through the circuits 385, the "up" limit switches 381, brake magnets 286, circuits 386, electro-magnets 384, switches 278 to the conductors 257, 247, and thence to the negative main. The electro-magnets 384 will therefore be energized to hold the push buttons in their pressed in positions and consequently maintain the selected brake magnets energized. If only one or less than all of the push buttons have been actuated, those which have not been operated will remain inoperative, by reason of the switches controlled thereby remaining in opened position, the lower electro-magnets 384 thereof therefore not receiving current.

The motor having started, its speed may be varied as desired and the brake magnets

corresponding to the operated push buttons will release the brake apparatus to effect the actuation of corresponding hoisting units. Such hoisting units will continue to operate until the brake circuit is broken by stop motion apparatus. The push button corresponding thereto is then automatically released, but the motor may continue to rotate, leaving the hoisting unit and consequently the curtain connected thereto in the position determined by the setting of the stop motion mechanism. When the controlling switch 282 is operated back to normal position the motor will of course be brought to rest, a brake being applied automatically to the motor shaft, which brake may be released by means of a brake magnet 387 whenever one of the reversing switches is closed. When the switch 282 is in its normal position the shunt field circuit is interrupted at the reversing switches and the magnet 382 therefore again permits the switch 275 to be brought to closed position. The circuit through the holding electromagnets 277 is therefore again established.

Obviously those skilled in the art may make various changes in details and arrangement of parts without departing from the spirit and scope of my invention as defined by the appended claims, and I desire therefore not to be limited to the precise construction and connections herein disclosed.

What I claim and desire to have protected by Letters Patent of the United States is:—

1. The combination with an electric motor, of starting and stopping apparatus therefor, a switch, means dependent upon the position of said switch for varying the speed of said motor without stopping the same, a multiple of brake electro-magnets, and means for selecting one or more of said electro-magnets.

2. The combination with an electric motor, of sectional starting resistance, a manual electric switch, means controlled by said switch for varying said resistance to effect a variation in the speed of said motor, the speed of the motor at any time corresponding to predetermined positions of said switch, a multiple of brake magnets, and a selective system for the latter.

3. The combination with an electric motor, of sectional starting resistance in series therewith, additional resistance in a normally open circuit and parallel with the armature, and means comprising a manual switch for controlling said resistances to vary the speed of the motor at will, whether the motor acting as such is rotating in one direction or the other.

4. The combination with an electric motor, of resistance in a normally open circuit and parallel to the motor armature, starting resistance in series with the armature, separate electro-magnetic mechanism for controlling the respective resistances, and a manual switch for effecting the operation of said mechanism to vary the speed of the motor dependent upon the position of said switch irrespective of the direction of rotation of the motor armature.

5. In multiple curtain hoisting apparatus, the combination with an electric motor, of starting and stopping apparatus therefor, speed controlling mechanism, a series of electro-magnetic push button switches, a corresponding series of devices to be controlled by said switches, and means for retaining selected switches in closed position.

6. In motor controlling apparatus, the combination with an electric motor, of reversing switches therefor, of sectional starting resistance, a series of switches for controlling said resistance, a series of electromagnets for operating said switches, a manual switch for controlling the operation of said electromagnets and effecting a variation of speed of the electric motor, a relay for controlling the circuit of said electromagnets, and a switch for causing said relay to open the magnet circuit and re-insert the starting resistance to slow down the motor.

7. In motor controlling apparatus, the combination with an electric motor, of reversing switches therefor, electro-magnets for operating said reversing switches, relays for controlling said electro-magnets, accelerating apparatus, additional relays, a manual switch co-acting with said additional relays to control said accelerating apparatus, and additional switches for controlling all of said relays.

8. In motor controlling apparatus, the combination with an electric motor, of reversing switches therefor, starting resistance, electro-magnetic switches and controlling means for varying said resistance to accelerate the motor when operating in one direction, additional resistance, and another series of electro-magnetic switches operated to insert said additional resistance in parallel to the motor armature when the motor is being rotated in the opposite direction.

9. In motor controlling apparatus, the combination with an electric motor, of starting and accelerating apparatus therefor, means for controlling the speed of the motor in a predetermined direction, and a relay dependent upon armature potential for controlling both the accelerating apparatus and the said speed varying means.

10. In motor controlling apparatus, the combination with an electric motor, of starting apparatus therefor, electro-magnetic accelerating devices, a resistance and a switch for inserting said resistance in the shunt field circuit of the motor to increase the

speed thereof, an electro-magnet connected across the motor armature, and switches operated by said magnet to render the accelerating devices inoperative and to cut out said field resistance to automatically reduce the speed of the motor

11. In motor controlling apparatus, the combination with an electric motor, of accelerating apparatus therefor, a resistance, a means for inserting said resistance in the shunt field circuit to increase the speed of the motor, a magnet connected across the armature, and a switch for short-circuiting said resistance when closed but normally held open by said magnet.

12. In motor controlling apparatus, the combination with a motor, of controlling means therefor, electro-dynamic appliances entirely electrical for retarding the operation of said motor, a series of electro-magnets for operating said appliances, a manual switch for connecting one or more of said magnets in series with each other across the motor armature, and a relay dependent upon armature potential for controlling the operativeness of said magnets and appliances.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

ANDREW M. COYLE.

Witnesses:
W. H. BRADY,
A. M. ZABRISKIE.