R. C. SMITH.

TRACTION ELEVATOR CONTROL.

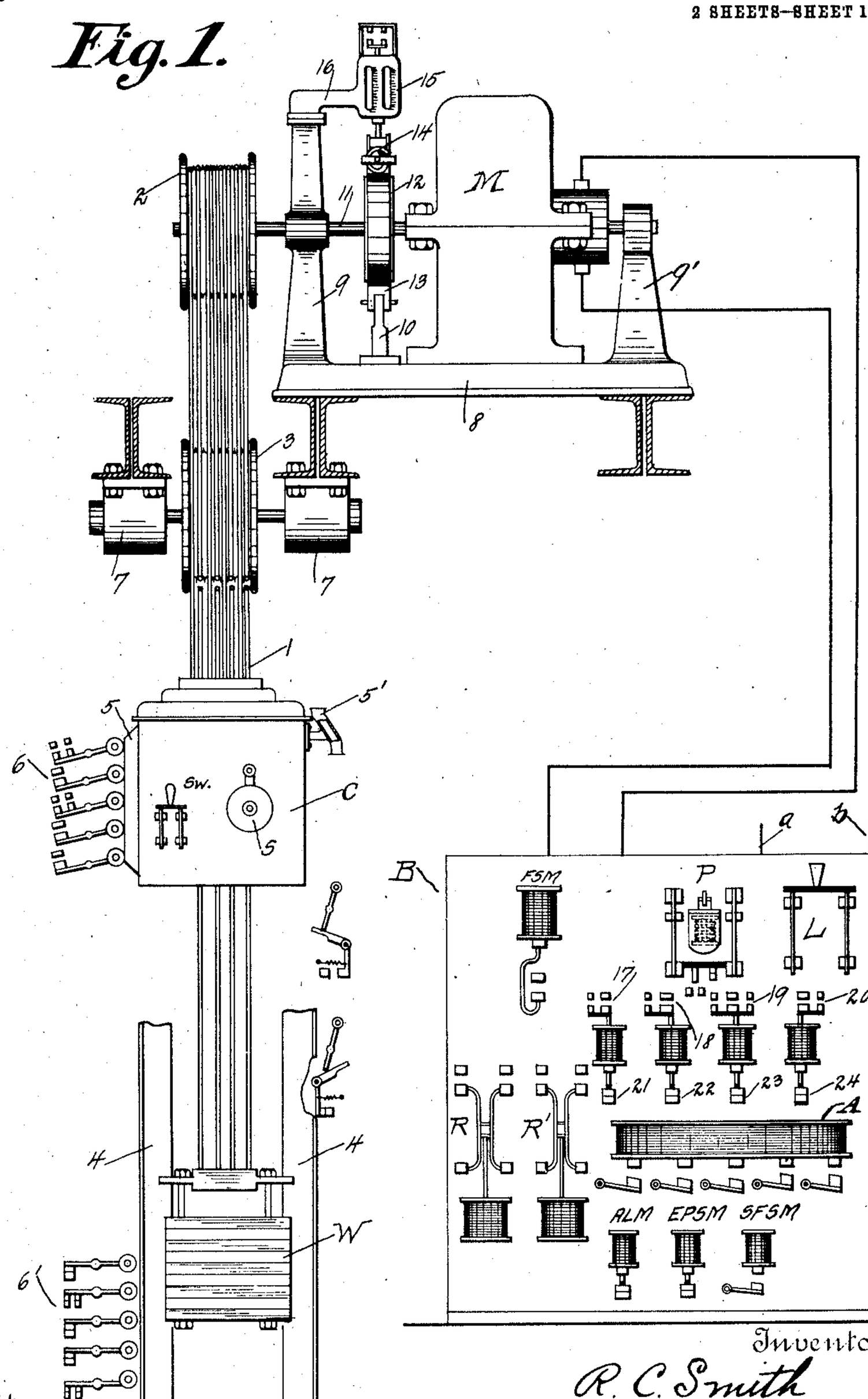
APPLICATION FILED SEPT. 23, 1907.

981,806.

Patented Jan. 17, 1911.

2 SHEETS—SHEET 1.

Fig. 1.



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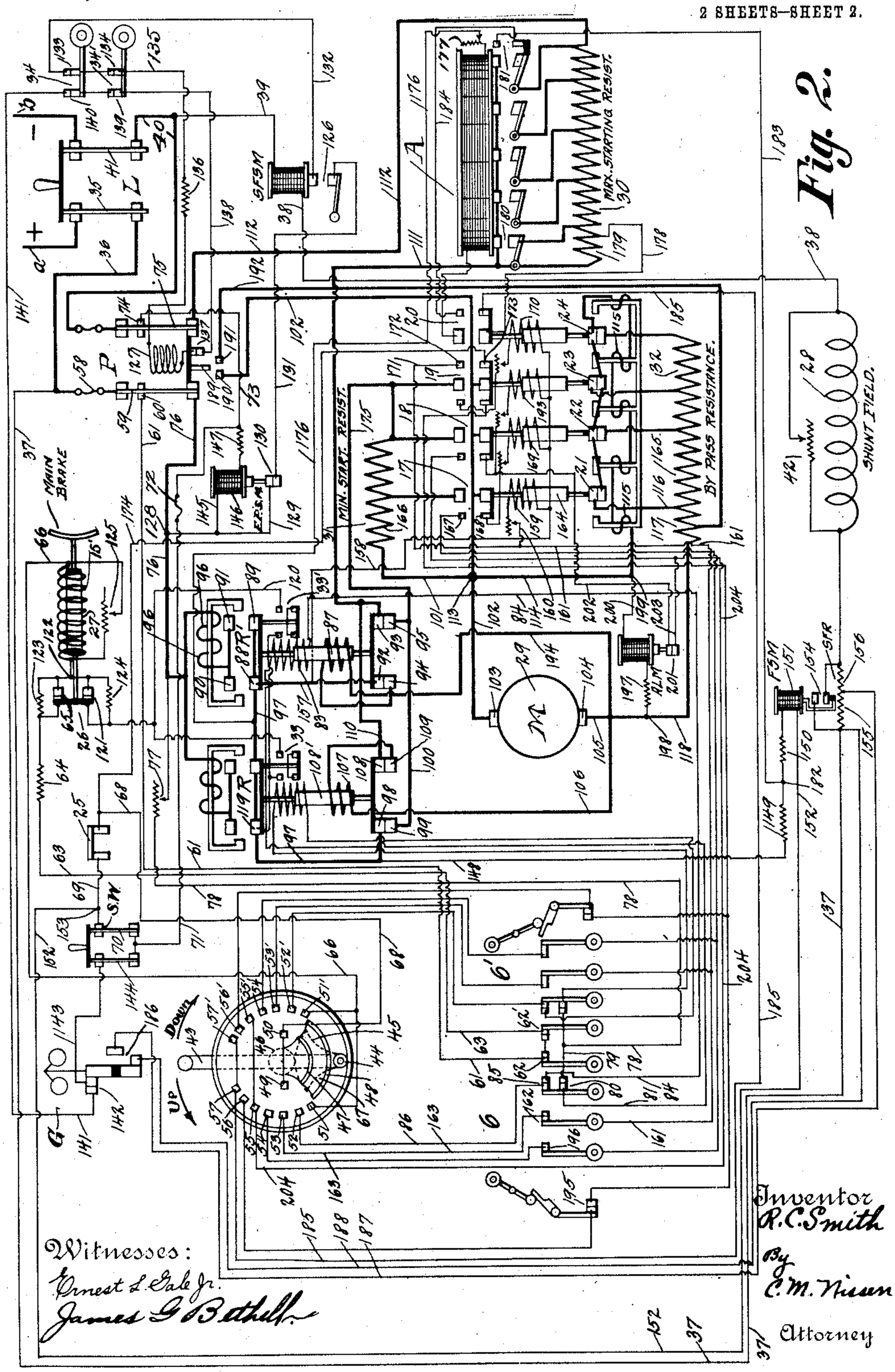

Fig. 2.

UNITED STATES PATENT OFFICE.

RUDOLPH C. SMITH, OF YONKERS, NEW YORK, ASSIGNOR TO OTIS ELEVATOR COMPANY, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

TRACTION-ELEVATOR CONTROL.

981,806. Specification of Letters Patent. Patented Jan. 17, 1911.

Application filed September 23, 1907. Serial No. 394,179.

To all whom it may concern:

Be it known that I, RUDOLPH C. SMITH, a citizen of the United States, residing at Yonkers, in the county of Westchester and State of New York, have invented a new and useful Improvement in Traction-Elevator Control, of which the following is a specification.

My invention relates to motor controlling apparatus, particularly that used for traction elevators or frictional driving apparatus, although it may have a general application.

One of the objects of my invention is the provision of improved and efficient apparatus for controlling electric motors.

The specific objects of the invention will appear hereinafter, the novel combinations of elements being set forth in the appended claims.

In the accompanying drawings, Figure 1 represents a traction elevator system to which my invention may be applied; and Fig. 2 represents a wiring diagram and a system of control including my invention.

Referring to Fig. 1, C designates an elevator car which may be suitably guided to move up and down in the elevator hatchway or elevator well in the usual way. S designates a controlling switch in the car, and SW a manual safety switch in the car. 1 are the cables which are secured to the top of the car and extend upwardly over the frictional driving sheave or drum 2 and thence downwardly over the direction sheave 3, upwardly over the sheave 2 and finally downwardly to the counterweight W which is associated with the fixed guides 4, 4. In some instances the driving sheave 2 may be at the lower end of the elevator well, instead of at the upper end as shown. Furthermore, the sheave 3 for securing additional friction may sometimes be omitted. It should be noted that this sheave 3 is preferably placed at one side, so as to act also as a deflection sheave for the cables extending from the car upwardly or those extending downwardly to the counterweight.

Arranged in the path of travel of a moving part of the elevator, in this instance the cams 5 and 5′ carried by the car, are a series of limit switches 6 at the upper limit of travel of the car and a series of additional limit switches 6′ at the lower limit of the car travel.

The journals of the shafts of the direction sheave 3 are provided with fixed bearings 7, 7 at the upper end of the hatchway or elevator well. Adjacent thereto is the fixed bed-plate 8 for the electric motor M and for the standards 9, 9′ and 10. The standards 9, 9′ are provided with bearings for the motor shaft 11, to which are connected the driving drum 2 and the brake pulley 12. To the standard 10 are pivoted the brake bands 13 which carry the brake shoes arranged to be brought against the pulley 12 by the brake springs 14 and released therefrom by the electro-magnet 15. The latter may be supported by a bracket 16 fastened to and extending from the uppermost end of the standard 9. It should be understood that the frictional driving apparatus associated with the power transmitting cables connecting the car and counterweight may be varied in details and arrangement as desired; so also the brake apparatus and the type of the motor. Preferably, however, the motor is of the multipolar type with a series connected armature and a shunt field. On account of the slow motor speed, and consequent small momentum of the armature, comparatively little power is needed for accelerating the armature up to full speed.

B designates the controller board of slate or other insulating material for carrying most of the switches, electro-magnets, and the circuits and connections illustrated in Fig. 2.

L is the main line switch for controlling the continuity of the main circuit from the source of current supply through the main lines *a*, *b*.

P designates the potential switch, R, R′ the reversing switches, A the accelerating magnet, ALM the auxiliary load magnet, EPSM the excess potential safety magnet, SFSM the shunt field safety magnet, and FSM the fast speed magnet.

17, 18, 19 and 20 and 21, 22, 23 and 24 are speed controlling switches arranged to be operated by electro-magnets.

Similar characters of reference are used on both figures of the drawing.

Referring now to Fig. 2, it will be seen that in addition to the parts already mentioned there are represented a governor G for controlling the shunt field resistance SFR and the potential switch P; also a switch 25 which may be associated with

safety apparatus carried by the car and comprising clamping jaws associated with the car guide rails. 15′ designates the main brake solenoid, and 26 designates an electric switch operated by movement of the plunger 27. 28 designates the shunt field winding, 29 the motor armature, 30 the main or maximum starting current resistance, 31 the minimum starting current resistance and 32 the by-pass resistance. 33 and 33′ are auxiliary switches associated with the reversing switches to control the brake magnet. 34 and 34′ designate limit switches which are operated when the car goes beyond its normal limits of travel.

When the motor is at rest I prefer to have the shunt field winding 28 connected in series with the shunt field resistance SFR, so that when the main line switch L is closed as indicated a circuit may be traced from the positive main *a* through the blade 35, conductors 36, 37, shunt field resistance SFR, shunt field winding 28, conductor 38, shunt field safety magnet SFSM, conductor 39, conductor 40, switch blade 41, out to the negative main *b*. The shunt field will therefore be permanently excited, but its strength will vary according to the amount of the resistance SFR and the potential across the mains. The shunt field corresponding to full car speed is left on permanently for the sake of safety, and also to prevent too sudden acceleration with heavy load on down motion of the car or light load on up motion.

Connected across the shunt field winding 28 is a high resistance 42 to take up the shunt field discharge in the event that the shunt field circuit should be interrupted. This high resistance is shown variable, for the reason that it may be omitted if desired. Some of the other resistances in Fig. 2 are also shown as variable to indicate that they may be omitted if desired.

On account of the self-induction in the shunt field and the retarding effect when solid steel poles are used in the motor, it is possible to make a whole change in the excitation in the shunt field in one step without any jar or too sudden change in speed. The shunt field resistance SFR being in circuit with the shunt field winding when the motor is at rest, the field will be comparatively weak, and it will therefore take sufficient time for the shunt field to build up to its full strength to insure the acceleration of the motor not being too sudden and therefore insuring a smooth and easy start of the car.

The construction of the motor is such that the constant losses are small and the efficiency of the motor therefore high at light load, the maximum efficiency occurring at about one-half load which is about the average load in general elevator practice. Almost all losses in the motor at full load are in the armature winding. The resistance of the latter can therefore be comparatively high, which permits a saving of copper but still maintaining high efficiency. The purpose of the high armature resistance, furthermore, is to reduce the number of accelerating magnets necessary to short circuit or cut out the starting resistance, and also to decrease liability of injury to the armature in case the full line voltage were applied by a faulty operation of the controller, or otherwise, directly to the brushes of the armature while the latter is at a standstill.

The car switch S is preferably like that shown in the patent to Carichoff, No. 772,086, granted October 11, 1904, for an improvement in electric elevator apparatus, although any other type of switch may be used if desired, the one herein shown being merely for illustrative purposes.

43 designates the controller lever which is pivoted at 44 and connected thereto so as to oscillate therewith is the arc-shaped rack 45 which is in engagement with the gear 46. The latter is pivoted to the casing and is operatively connected to the conducting segments 47 and 48, the former being arranged to move into engagement with the fixed contacts or spring-pressed contacts 49 and 50 and the latter being arranged to engage the fixed contacts or spring-pressed contacts 51, 52, 53, 54, 55, 56, 57 and 51′, 52′, 53′, 54′, 55′, 56′ and 57′. It will therefore be seen that when the lever 43 is moved in the direction of the arrow marked "Up" the segment 47 will engage the contact 49 and the segment 48 will engage one or more of the contacts 51 to 57, inclusive.

Let it be assumed that the main line switch L is closed, as also the potential switch P, and that there is proper potential across the mains for the desired operation of the electric motor. Then if the lever 43 is moved for operating the car in the up direction segment 48 will first engage the contact 51, and thereafter or at substantially the same time segment 47 will engage the contact 49, when a circuit will be closed from the positive main *a* through the blade 35 and conductor 36, and thence through the fuse 58, blade 59, contact 60, conductor 61, limit switches 62, 62′, conductor 63, resistance 64, individual switch 65, solenoid 15′ of the brake magnet, conductor 66, contact 51, segment 48, plate 67, segment 47, contact 49, conductor 68, switch 25, conductor 69, blade 70 of the safety switch SW, conductor 71, fuse 72, conductor 73, contact 74, blade 75 of the potential switch P, conductor 40, blade 41 of the main line switch L, out to the negative main *b*. The relative position of the contact 49 is shown however, such that segment 47 does not engage the same until the

segment 48 engages the contact 52, so that the brake apparatus will be released substantially at the same time that the reversing switch is operated to establish the motor circuits in a direction corresponding to the desired direction of the car. When the segment 48 engages the contact 52, a circuit may be traced from the positive main *a* to and through the blade 59, conductor 76, resistance 77, conductors 78, 79, limit switch 80, conductor 81, the solenoid 83 of the electro-magnet for operating the switch R′, conductor 84, limit-switch 85, conductor 86, contact 52, plate 67, contact 49, conductor 68, switch 25, conductor 69, blade 70, conductors 71, 73, contact 74, and thence to the negative main. It will now be seen that the brake magnet solenoid 15′ is placed across the mains with the resistance 64 in series therewith and that the solenoid 83 is placed across the mains. When the latter receives current it will actuate its core or plunger 87, and thereby lift the contacts 88 and 89 into engagement with the contacts 90 and 91, respectively, and separate the contacts 92 and 93 from the contacts 94 and 95. The motor circuit indicated by the heavy lines will now be closed and may be traced from the positive main to conductor 76 and thence through the windings of the blow-out coil 96, contacts 90, 88, conductor 97, contacts 98, 99, conductor 100, minimum starting resistance 31, conductors 101, 102, brush 103 of the motor armature 29, brush 104, conductors 105, 106, coil 107 for holding the plunger 108′ in its lowermost position to secure firm connection between the contacts 98, 99 and contacts 108 and 109. Thence the circuit continues through the latter contacts and by conductor 110 to and through conductor 111, main starting resistance 30, conductor 112 to the blade 75 which is connected to the negative main. From the junction 113 a shunt path leads by conductor 114 through the plurality of blow-out coils 115, the series of closed switches 24, 23, 22 and 21, conductor 116, section 117 of the by-pass resistance 32, and thence by conductor 118 to the motor armature brush 104. It will now be seen that the starting resistances 31 and 30 are placed in series with the motor armature and that the section 117 of the by-pass resistance 32 is placed in shunt to the motor armature.

When the switch R′ is closed the auxiliary switch 33′ is also closed, in this instance being connected to operate substantially at the same time. The circuit controlled by the switch 33′ may be traced from the positive main to and through conductor 76, contacts 90, 88, conductor 97, contact 119, switch 33′, conductor 120, individual switch 121, and through the brake solenoid 15′ and thence by conductor 66 to contact 51, plate 67, contact 49, conductor 68, switch 25, conductor 69, blade 70, conductors 71, 73, contact 74, blade 75, and thence to the negative main. It will therefore be seen that a path is established in parallel to the resistance 64 and that therefore the latter is short circuited so that the brake magnet is not operated until the reversing switch R′ is closed. As soon as the brake magnet is operated the switches 65 and 121 are opened to insert the resistances 123 and 124 in the respective branches of the brake magnet circuit leading from the positive main to the junction 122. It should be noted therefore that the resistance 64 may be sufficient to prevent the brake from being released when the controlling switch in the car is initially operated, and that not until the reversing switch R′ is operated does the brake magnet solenoid receive sufficient current to operate the brake apparatus. After the brake has been operated, however, the resistances 123 and 124 are inserted in series therewith so as to minimize the consumption of current after the brake magnet has done its work, as it requires less power for the brake magnet to hold its plunger in its uppermost position, and consequently the brake mechanism in released position, than to initially lift the said plunger and actuate the brake mechanism connected thereto. It should also be noted that the terminals of the brake magnet circuit are at the contacts 60 and 74 which are isolated with respect to the other contacts of the potential switch P, so that when the latter is opened the brake magnet circuit will be entirely disconnected from both mains and also from the motor. The brake magnet is therefore entirely disconnected from any possible source of current which would tend to hold the brake mechanism released, for instance, when the motor acts as a generator although the potential switch is open. This arrangement insures the application of the mechanical brake to stop the motor shaft and the frictional driving drum connected thereto, in any event.

The insertion of the resistances in series with the brake magnet coil decreases the amount of current taken by the brake magnet, thereby lessening the current consumption and decreasing heating. Furthermore, when the resistances are thus inserted the magnet will release the brake apparatus more quickly when the current from the mains thereto is interrupted. In order to apply the brake shoes gradually the motion of the magnet cores is electrically retarded by shunting the brake coil with the high resistance 125. Upon the interruption of the brake magnet circuit the counter-electromotive force of self-induction of the brake magnet will produce a current through the resistance 125. This will tend to maintain the brake magnet energized so that the brake

shoes will be applied gradually. Such brake resistance around the brake magnet may be a variable resistance, or omitted if desired, or such resistance may be in an open circuit and automatically controlled to produce the effect desired at the proper time. In order to effect a quick release of the brake mechanism when the brake-magnet is energized the plunger or core of the latter is preferably slotted longitudinally.

When the main line switch L is closed and current flows through the shunt field resistance SFR and the shunt field winding 28, the shunt field safety magnet will also receive current to close the switch 126 which controls the continuity of circuit of the magnet 127 which holds the potential switch in closed position. The circuit controlled by the switch 126 may be traced from the junction 128 through conductor 129, switch 130, conductor 131, switch 126, conductor 132, individual switches 133 and 134, conductor 135 and the resistance 136 therein, and thence through the electro-magnet 127, switch 137, conductor 138, individual switches 139 and 140, conductor 141, governor switch 142, conductor 143, blade 144 of the safety switch SW in the car, conductors 71, 73, to the contact 74. It will therefore be seen that this circuit is connected across the positive and negative terminals and includes the switches 130, 126, 137, 133, 134, 142, SW, and the electro-magnet 127. The opening of any one of these switches, therefore, will effect the deënergization of the potential switch magnet 127 and the consequent opening of the potential switch which will cause a slowing down and the stopping of the motor and the car. If the current through the shunt field should decrease to a predetermined value such that the operation of the car should become unsafe and that the speed would tend to become excessive, the shunt field safety magnet SFSM would not have sufficient strength to maintain the switch 126 closed. Upon the opening of the latter the potential switch magnet 127 would be deënergized, with the result already stated. Furthermore, if the car should travel beyond its normal limits of travel the cam 5 on the car would strike the roller on the lever operating the switch 34 on up motion or on the roller of the lever for the switch 34′ on down motion, and therefore either the switch 133 or 134 would be opened and consequently the circuit of the potential switch magnet interrupted. Should the operator in the car lose control of the hoisting apparatus, the opening of the safety switch SW in the car would also open the potential switch magnet circuit and cause the stopping of the car. If during the normal running of the car the speed should exceed a predetermined limit, the governor device G would open the switch 142 to break the circuit of the potential switch magnet and thereby bring the car to rest.

Should the potential applied to the mains *a* and *b* from the source of electric current supply exceed a predetermined limit then the excess potential safety magnet EPSM would be sufficiently energized to open the switch 130 and thus break the circuit of the potential switch magnet. The circuit for the magnet EPSM may be traced from the junction 128 through the conductors 129, 145, solenoid 146, resistance 147 and conductor 73 to the contact 74. The solenoid 146 is therefore connected across the mains. It should be noted that when one of the limit switches 34 or 34′ is operated to opened position both terminals of the potential switch magnet 127 are entirely disconnected from other conductors so that there will be no possibility of maintaining the magnet 127 energized by the motor acting as a generator.

Should the main line current become interrupted while the motor is operating, the latter might be converted into a generator and tend to supply current to the potential switch magnet 127 to hold the potential switch P closed, but the current through the shunt field safety magnet SFSM will be decreased at this time to permit the opening of the switch 126 so that the circuit of the potential switch magnet will be interrupted, with the consequent effect of stopping the car gradually. Should it happen, however, that the switch 126 is not opened before the car gains excessive speed or before the motor acting as a generator furnishes sufficient current to the magnet SFSM to cause the latter to hold the switch 126 closed, then the excess potential from the motor as the same speeds up will operate the magnet EPSM. The switch 130 will be opened by the latter and the motor stopped. Should the acquired speed become excessive then the governor will be operated. This is the preferred arrangement but the order of operation may be varied by readjustments, as desired.

Upon the closing of the reversing switch R′ in the manner heretofore stated, a circuit will be immediately closed through the fast speed magnet FSM from the conductor 97 through the conductor 148, resistances 149 and 150, solenoid 151, conductor 152, to the junction 153, and thence by the conductor 69 to the blade 70 of the safety switch SW and through the same to conductors 71, 73 and finally to the contact 74. The fast speed magnet FSM will therefore be connected across the mains and will operate the switch 154 to close the same and short circuit the resistance SFR which is divided into two sections 155 and 156, but the switch 154 controls the entire resistance. It is therefore evident that when the reversing switch is operated the shunt field resistance is immediately short circuited, and therefore

after the brake apparatus has been released, and the shunt field resistance short circuited, the shunt field will be at its maximum strength, all the series resistance will be in circuit with the motor armature and most of the by-pass resistance short circuited. Hence when the lever 43 of the car switch S is moved in the direction of the up arrow and the contacts 51, 52 and 49 are electrically connected together, the motor may start at slow speed and will continue to operate at such speed until the lever receives additional actuation to cause the segment 48 to engage the contact 53. When this occurs a circuit will be closed from the positive main through the conductor 76, contacts 90, 88, conductors 157, 158, solenoid 159, resistance 160, conductor 161, limit switch 162, conductor 163, contact 53, car switch plate 67, contact 49, conductor 68, switch 25, blade 70, conductors 71, 73, to contact 74 and thence to the negative main. When the solenoid 159 is thus supplied with current it will lift its plunger 164 and close the switch 17 and open the switch 21. The opening of the switch 21 will insert an additional section 165 of the by-pass resistance in parallel to the motor armature, and the closing of the switch 17 will short circuit a section 166 of the minimum starting resistance 31. The motor will therefore increase in speed to another predetermined value. When the switch 17 is closed the auxiliary contacts 167 and 168 are brought into engagement with each other so that when the lever 43 receives an additional movement to bring the plate 67 into engagement with the contact 54, the next solenoid 169 will receive current to close the switch 18 and open the switch 22. The remaining section of the minimum starting resistance 31 will therefore be short circuited and an additional section of the by-pass resistance inserted. The closing of the switch 18 will permit the closure of the switch 19 when the plate 67 engages the contact 55; and the closure of the switch 19 will permit the solenoid 170 to receive current to close the switch 20 and open the switch 24 when the plate 67 engages the contact 56. Upon the closure of the switch 19 the solenoid 159 receives current independently of the car switch through the circuit from the positive main through the reversing switch R′, conductor 158, solenoid 159, resistance 160, conductor 171, contacts 172, 173, conductor 174, switch 25, conductor 69, blade 70, conductors 71, 73, to the contact 74 and thence to the negative main. When the switch 19 is closed and the switch 23 opened the entire by-pass resistance is inserted across the armature, and when the switch 20 is closed and the switch 24 opened the by-pass resistance circuit is entirely interrupted.

When the switch 20 is closed the circuit of the accelerating magnet A is closed across the armature when the switch plate 67 engages the contact 57. This circuit may be traced from the armature brush 103 through the conductors 102, 175, contacts 99, 98, conductors 97, 176, resistance 177, accelerating magnet A, switch 20, conductor 178, section 179 of the main starting resistance 30, conductors 111, 110, contacts 108, 109, solenoid 107, and conductors 106, 105 to the other armature brush 104. Now after the by-pass resistance circuit has been opened the motor will increase in speed while the accelerating magnet is connected across the armature. Associated with the accelerating magnet are a series of switches 180, &c., for gradually cutting out the main starting resistance as the motor increases in speed in the well known manner. When the last switch is closed an auxiliary switch 181 is also closed so as to short circuit the fast speed magnet FSM and cause the latter to open the switch controlled thereby and thus insert the shunt field resistance SFR and still further increase the speed of the motor by weakening the shunt field. The short circuit around the solenoid 151 may be traced from the junction 182 through the conductor 183, switch 181, conductor 184, the auxiliary contacts of the switch 20, conductor 185, contact 57, switch plate 67, contact 49, conductor 68, switch 25, conductor 69, to the junction 153. The motor, hoisting apparatus and car will now operate at full speed, but if this speed should exceed a predetermined value the governor G will close the switch 186 and thus short circuit the section 155 of the shunt field resistance by the conductors 187 and 188. The short circuiting of the section 155 will have the effect of strengthening the field and thus slowing down the motor. If, however, this slowing down is not sufficient the continued speeding of the car will cause the governor G to open the switch 142 after the switch 186 has been closed. As before explained, when the switch 142 is opened the circuit of the potential switch magnet 127 is interrupted, and when this occurs the potential switch will drop open and the conductor 189 connected thereto will electrically connect the clips 190 and 191. This will close a short circuit or local circuit across the motor armature through the conductors 102, 192, 118, 105, and a small section of the by-pass resistance 32. This will cause an electro-dynamic braking action to slow down the motor while the mechanical brake is being gradually applied, the contacts 60 and 74 being entirely disconnected from any source of current supply when the potential switch P is opened.

I prefer to permanently connect the shunt field terminals between the main line switch L and the potential switch P so that a weak shunt field is left on continuously to lessen

the liability of accidental opening of the field circuit, and, furthermore, leaves the shunt field excited even when the potential switch opens, thereby always insuring a strong electro-dynamic braking effect in bringing the car automatically to a gradual stop. It should also be noted that when the potential switch P opens and the current is cut off from the electro-magnets controlling the switches 21, 22, 23 and 24 a local circuit is also closed from the armature brush 103 by way of conductors 102, 114, switches 24, 23, 22 and 21, conductor 116, section 117 of the by-pass resistance 32, conductors 118, 105, to the other armature brush 104. The local armature circuit just traced insures additional electro-dynamic braking action upon stopping and also when the car switch is moved back toward central position to reduce the speed of the motor. It should be particularly noted that not only are the terminals of the brake magnet at the contacts 60 and 74, but that the negative terminal of the reversing switch magnet solenoids and of the speed controlling solenoids are also at the contact 74, so that when the potential switch is opened all current is entirely cut off from such solenoids.

The circuits thus far traced have been upon the operation of the lever 43 in the direction of the up arrow for the operation of the reversing switch R′, but it will be apparent that upon movement of the lever 43 in the direction of the down arrow the reversing switch R will be operated to establish motor circuits in the opposite direction, but the successive operation of the speed controlling electro-magnets and the consequent insertion of the by-pass resistance and the cutting out of the minimum starting resistance will be the same, and that finally the accelerating magnet will gradually cut out the starting resistance and effect the operation of the fast speed magnet to insert the shunt field resistance.

After the switch lever 43 has been moved to its extreme limit so that the plate 67 engages the contact 57 and it is desired to reduce the speed of the car the segment 48 is moved off the contact 57 but still left in engagement with the contact 56. The short circuiting path around the fast speed magnet will thereupon become broken and the latter will therefore again be energized to short circuit the shunt field resistance and thereby strengthen the field and cause the motor speed to decrease. Further movement of the switch lever 43 toward central position leaving the segment 48 in engagement with the contact 55 will effect the interruption of the circuit for the solenoid 170 and the consequent opening of the switch 20 and the closure of the switch 24. The opening of the switch 20 will interrupt the circuit of the accelerating magnet, and consequently the entire maximum starting resistance 30 will be reinserted in series with the motor armature. The closure of the switch 24 will insert the entire by-pass resistance 32 across the motor armature. This will still further reduce the speed of the motor. Upon the movement of the segment 48 off the contact 55 the circuit of the solenoid 193 will be interrupted to open the switch 19 and close the switch 23. This operation may insert a section of the minimum starting resistance or by the closure of the switch 23 only short circuit a portion of the by-pass resistance, with the result of still further reducing the speed of the motor.

Upon the segment 48 leaving the contact 54 the circuit of the solenoid 169 will be interrupted to effect the opening of the switch 18 and the closure of the switch 22. The opening of the switch 18 will insert in series with the armature a portion of the minimum starting resistance and the closure of the switch 22 will short circuit an additional section of the by-pass resistance. When the segment 48 leaves the contact 53 the circuit of the solenoid 159 is broken, the path from the conductor 174 having already been broken by the opening of the switch 19. The switch 17 will therefore open to insert the remaining section of the minimum starting resistance and the switch 21 will close to short circuit the section 165 of the by-pass resistance, leaving only the section 117 in shunt to the armature. When the switch plate 67 electrically connects the three contacts 49, 51 and 52, the minimum by-pass resistance is connected across the armature and all of the starting resistances are connected in series with the motor armature and the shunt field resistance is short circuited, so that the motor will run at minimum speed at such time.

When the car switch is moved toward central position to stop the motor and the segment 48 leaves the contact 52 the circuit of the reversing switch solenoid 83 will be interrupted and the main line current supply to the motor therefore cut off upon the opening of the switch R′. At the same time that the reversing switch R′ is opened the switch 33′ is opened, thereby interrupting the path including the conductor 120 and the resistance 124. Preferably when the segment 48 leaves the contact 52 the segment 47 also leaves the contact 49, so that when the switch 33′ is opened the circuit of the brake magnet is also opened, and as heretofore explained, if the shunt resistance 125 is employed the brake shoes will be applied gradually. Preferably the switches 33 and 33′ comprise contacts separated or isolated from the reversing switch contacts so that the counter-electro-motive force of the armature cannot effect the energization of the brake magnet and the consequent

holding off of the brake apparatus. It will be evident, however, that after the segment 48 leaves the contact 52, the contacts 49 and 51 may still be electrically connected by the switch plate 67 and the brake magnet still receive current through the resistances 64 and 123. If this current is sufficient the brake apparatus will still be held in released position, but it will be seen that when the reversing switch R′ is opened the local circuit including the armature and the minimum starting resistance is closed to establish an electro-dynamic brake circuit. This brake circuit may be traced from the brush 103 through the conductor 102 to the junction 113, and thence through conductor 101, resistance 31, conductor 175, contacts 95, 93, conductor 110, contacts 108, 109, holding solenoid 107, conductors 106, 105, to the brush 104; also through conductor 100, contacts 99, 98, conductor 97, conductor 157, contacts 92, 94, solenoid 87 and conductors 194, 105, to the armature brush 104. Therefore the electro-dynamic brake may be applied either while the mechanical brake is being applied or before the same is released to permit its application. In the latter event when the circuit of the brake magnet is interrupted at the contact 51 the current will be reduced from a value dependent upon the resistance 64. The higher this resistance, the less current will be flowing for holding the brake in released position, but when the circuit is interrupted the current will be reduced to the point where the solenoid 15′ will release its core in a shorter space of time than if the resistance 64 were lower, it being understood that the brake shoes are retarded nevertheless, due to the local current in the brake solenoid, while being applied.

The series of limit switches 6 and 6′ are so connected to the car switch that they will have substantially the same effect as the movement of the car switch from its extreme position to its limiting position. These limit switches are arranged to be operated by some moving part of the hoisting apparatus and in this instance I have shown them arranged in the hatchway so as to be operated successively by cams 5, 5′ carried by the car. When the car approaches the upper limit of its travel the switch 195 will be opened first by the cam 5′ which has the same effect as the moving of the switch plate 67 off the contact 56. The next limit switch to be operated by the cam 5, is that designated 196 which effects a further reduction in speed of the motor as explained when the segment 48 leaves the contact 54 of the car switch. When the switches 80 and 85 are opened both terminals of the reversing switch solenoid 83 will be disconnected from any source of current supply and the reversing switch R′ will be opened and the brake magnet deënergized sufficiently to cause the application of the brake apparatus to positively stop the car at its upper limit of travel. Or in case the path including the resistance 64 is employed, an additional limit switch 62 is opened upon further movement of the car after being slowed down to very slow speed. The opening of the switch 62 will entirely disconnect the brake magnet from the positive main and the brake apparatus will therefore be applied. Should the car have obtained such great momentum that the force of slowing down and stopping is not sufficient to bring the car to rest at its normal limit of travel, but the car goes beyond a short distance, the cam 5 will open the switches 133 and 140 to disconnect both terminals of the potential switch magnet 127 from the mains and thus effect the opening of the potential switch magnet.

It will be noticed that an auxiliary load magnet ALM and a resistance 197 in series therewith are connected across the motor armature between the junctions 198 and 199 by means of the conductor 200. This magnet controls a switch 201 which is connected by the conductor 202 to the solenoid 193 and by the conductor 203 to the conductor 204 which leads to the contact 55 of the car switch. Ordinarily when the motor is operating or stopping for average loads the switch 201 is kept open by the magnet ALM. If, however, the load is heavy and exceeds a predetermined value when the car is going up, and is being stopped, or if the car is going down empty and is being stopped, or has a light load less than a predetermined value, the car would tend to stop before reaching the level of the floor landing. The armature would be slowed down to such a speed, however, that the potential across the latter would not be sufficient to cause the auxiliary load magnet ALM to hold the switch 201 open. Therefore upon the closing of the latter a circuit would be established from the positive main through the reversing switch R′, conductor 158, solenoid 193, conductor 202, switch 201, conductors 203, 204, contact 55, plate 67, contact 49, conductor 68, switch 25, conductor 69, blade 70, conductors 71, 73, to the negative main. It should be noted that the conductor 204 has no limit switch therein. Therefore when the switch 201 is closed and the solenoid 193 receives current the switch 19 is closed or held closed so that the minimum starting resistance 31 will remain short circuited and the opening of the switch 23 will cause the entire by-pass resistance to be inserted if the switches 22 and 21 are still open. If the switch 22 or 21, or both, are already closed, then only the closing of the switch 19 will cause the resistance 31 to be short circuited.

The purpose of maintaining current in the solenoid 193 or reëstablishing current therein is to vary the slowing down resistance so that more current can be received by the motor armature than when an average load is being moved, so that the car will be carried automatically to its normal limits of travel although the load in the car may exceed a predetermined value on the up motion or fall below a predetermined value on the down motion. This is particularly advantageous in stopping automatically at the limits of travel, and also at intermediate landings when embodied in an automatic push-button system of control. In the system illustrated the car may be slowed down when approaching an intermediate landing, by manipulating the car switch and the motor may then be stopped when the car almost reaches the desired position, by bringing the switch lever to central position to interrupt the brake magnet circuit and the reversing switch solenoid circuit.

It should be particularly noted that the resistances, electro-magnets, and circuits and connections are so proportioned and designed that no matter how quickly the manual switch lever in the car is moved, the motor will be accelerated from rest to full speed or from any of its speeds to rest without shock or jar and without slipping between the driving sheave 2 and the power-transmitting cables 1, within wide variations of load. That is to say, the controlling apparatus and accelerating mechanism are so arranged that the inertia of the parts to be moved is overcome gradually and the car brought to any desired speed without shock or jar and with minimum slipping between the driving cables and the driving sheave. This may be better understood by considering the various steps of speed control and the auxiliary switches insuring the successive operation of the speed-controlling magnets, the accelerating magnet and the field resistance magnet in starting, and in noting the automatic limit switches in stopping the motor at the limits of the car travel by electro-dynamic brake action. Between limits of travel the car may be brought to a gradual stop by moving the switch lever in the car slowly back to initial position. However, if the car switch is brought quickly back to central position the electro-dynamic brakes may be depended upon to gradually stop the car in the desired position with little or no slipping between the driving sheave and the driving cables.

The specific features of excess potential control, shunt field safety magnet control, governor connections, brake control, limit switches for interrupting both terminals of the reversing switch and of the potential switch magnet, are the inventions of David L. Lindquist and are covered by his pending application Serial No. 382,498, filed July 6, 1907, for an improvement in motor controlling apparatus. But the auxiliary load magnet control and other sub-combinations as well as the general arrangements, as defined by the appended claims, are of my own invention.

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

Having thus fully described my invention and the mode of its application, what I desire to have protected by Letters Patent of the United States is:—

1. In an elevator, the combination with a shunt wound electric motor, of resistance in a circuit in series with the motor armature, resistance in a circuit in parallel with the motor armature, a reversing switch operable when open to close a partial short circuit to the armature, a series of electro-magnetic relays each comprising a contact breaker controlling a section of the series resistance and a contact maker controlling a section of the parallel resistance, the amount of resistance in said sections being proportioned to effect a definite speed of the motor, operating circuits for said relays, a manual switch having contacts in said operating circuits and operative to successively close the circuits, switches in the operating circuits and each closed by the operation of the relay of the preceding circuit, an accelerating magnet comprising a series of switches controlling a definite portion of the resistance, a switch in the operating circuit of the accelerating magnet and operated by the last relay of the series, and an automatic device controlled by the last switch of the accelerating magnet for varying the strength of the motor field.

2. In motor-controlling apparatus, the combination with a motor, of sectional resistance in series with the motor armature, sectional resistance in parallel to the motor armature, a plurality of electro-magnetic switches for inserting sections of the parallel resistance and cutting out sections of the series resistance, a manual switch for controlling said electro-magnetic switches, an accelerating magnet, an additional switch dependent upon the operation of all of said electro-magnetic switches to automatically connect said accelerating magnet across the motor armature, sectional safety resistance, and switches operated by said accelerating magnet to automatically increase the speed of the motor further.

3. In motor-controlling apparatus, the combination with a motor, of sectional resistance initially in shunt to the motor armature, switch mechanism controlling such

shunt, reversing switch apparatus for directing the current through the motor armature and operating said switch mechanism to connect said sectional resistance in series with the motor armature, additional sectional resistance initially having only a portion thereof connected across the motor armature, one or more electro-magnetic switches for cutting out the series resistances and inserting additional sections of said additional sectional resistance.

4. In motor-controlling apparatus, the combination with a motor, of a reversing switch therefor, electro-magnets for operating said reversing switch, a sectional resistance initially connected in shunt to the motor armature, a plurality of auxiliary switches, one associated with each of said reversing switch magnets and interrupting such shunt upon the operation of the reversing switch to control current to the motor armature, an additional sectional resistance having a portion thereof initially connected across the motor armature, a series of electro-magnetic switches for gradually cutting out said first-named resistance and for gradually inserting said last-named resistance and finally cutting out the same also, and an electric switch for controlling the reversing switch magnets and said electro-magnetic switches.

5. In motor-controlling apparatus, the combination with an electric motor, of a series starting resistance, a by-pass resistance, a plurality of double electro-magnetic switches for varying said resistances to control the speed of the motor, a main line switch, and an auxiliary switch closed upon the opening of said main line switch to close an electro-dynamic brake circuit including the motor armature and a portion of one of said resistances.

6. In motor-controlling apparatus, the combination with an electric motor, of a sectional starting resistance, a reversing switch having two portions, two electro-magnets connected respectively to said portions, two auxiliary switches initially connecting said resistance in shunt to the armature and interrupting said shunt when either portion of the reversing switch is operated to direct current to the motor armature, a sectional by-pass resistance initially having only a portion thereof connected across the motor armature, electro-magnetic switches for cutting out said starting resistance and inserting said by-pass resistance and finally cutting out the latter also, a main line switch, and an auxiliary switch closed upon the opening of said main line switch to effect an electro-dynamic brake circuit through a portion of said by-pass resistance in addition to the electro-dynamic brake circuit closed by said first-named auxiliary switches upon the restoration of the reversing switch to initial position.

7. In motor-controlling apparatus, the combination with an electric shunt motor, of apparatus for controlling the speed of the motor within predetermined limits, mechanism for accelerating the motor beyond the limit of speed control, and means co-acting with such mechanism to further increase the speed of the motor by increasing the resistance of the field winding circuit.

8. In motor-controlling apparatus, the combination with an electric shunt motor, of sectional resistance in series with the motor armature and additional resistance in parallel to the motor armature, one or more electro-magnetic switches for varying said resistance to change the speed of the motor, a manual electric switch for controlling said electro-magnetic switches, a sectional safety resistance in series with the motor armature, accelerating mechanism dependent upon armature potential for gradually cutting out said safety resistance to effect an automatic acceleration of the motor, and means operated at the end of the cutting out of said safety resistance to increase the resistance of the field winding circuit to further accelerate the speed of the motor.

9. In motor-controlling apparatus, the combination with an electric shunt motor, of a resistance initially in series with the shunt field winding, an electric switch connected to said resistance, an electro-magnet, circuits and connections for effecting the energization of said electro-magnet to cause the latter to close said switch and short-circuit said resistance when current is directed through the motor armature, accelerating apparatus for the motor, and means co-acting with said accelerating apparatus to short-circuit said electro-magnet to permit the latter to open said switch and reinsert said resistance to further increase the speed of the motor.

10. In motor-controlling apparatus, the combination with an electric shunt motor, of resistance in series with the shunt field winding, a switch for controlling said resistance, an electro-magnet for operating said switch, means for closing a circuit through said electro-magnet upon the starting of the motor, accelerating mechanism for said motor, and a switch for short-circuiting said electro-magnet.

11. In motor-controlling apparatus, the combination with an electric shunt motor, of a reversing switch therefor, a resistance in circuit with the shunt field winding, a switch for controlling said resistance, an electro-magnet for operating said switch, circuits and connections for effecting the energization of said electro-magnet when the reversing switch is operated, a sectional

starting resistance, an accelerating magnet dependent for its operation upon armature potential, a plurality of electric switches operated successively by said accelerating magnet to cut out said starting resistance step-by-step, and an auxiliary switch operated by said accelerating magnet upon the cutting out of the last section of the starting resistance to short-circuit the said first-named magnet.

12. In motor-controlling apparatus, the combination with an electric shunt motor, of a reversing switch therefor, a resistance in series with the shunt field winding, an initially open switch controlling said resistance, an electro-magnet, a circuit for said electro-magnet dependent for its completion upon the operation of said reversing switch, a sectional resistance in series with the motor armature, an additional sectional resistance in parallel to the motor armature, electro-magnetic switches for varying said resistances to change the speed of the motor, a manual switch for controlling said electro-magnetic switches, an accelerating magnet dependent for its energization upon the operation of all of said electro-magnetic switches, a sectional safety resistance, a plurality of switches operated by said accelerating magnet to cut out said safety resistance step-by-step, and an auxiliary switch operated at the end of such cutting out to short-circuit the said first-named electro-magnet to permit the re-insertion of said field resistance to accelerate the motor to maximum speed.

13. In motor-controlling apparatus, the combination with a motor, of a reversing switch therefor, electro-magnets for operating said reversing switch, series and parallel resistances, switches for controlling said resistances, electro-magnets for operating said last-named switches two at a time, a manual switch for controlling the aforesaid magnets to effect the operation of the motor at a speed dependent upon the position of said switch, and a manual switch controlling the common conductor of all of the circuits of the aforesaid electro-magnets.

14. In motor-controlling apparatus, the combination with an electric shunt motor, of a reversing switch therefor, electro-magnets for operating said reversing switch, series and parallel resistances as to the motor armature, electro-magnetic switches for varying said resistances to control the speed of the motor up to a predetermined limit, a manual switch for controlling said electro-magnetic switches, accelerating mechanism for automatically increasing the speed of the motor beyond such limit, a resistance in the shunt field circuit, an electro-magnetic switch controlled by said accelerating mechanism to vary said shunt field resistance to increase the speed of the motor to a maximum, and a manual safety switch in the common conductor of the circuits of the electro-magnets.

15. In motor-controlling apparatus, the combination with an electric motor, of an electro-magnet connected across the motor armature, speed controlling apparatus for the motor, means for operating such speed controlling apparatus to gradually reduce the speed of the motor, a switch held open by said electro-magnet while the potential across the armature exceeds a predetermined value, and circuits and connections co-acting with said switch when the latter is permitted to be closed by said electro-magnet upon drop of potential across the motor armature below said value to effect a variation in said speed-controlling apparatus to prolong a slowing down of the motor.

16. In motor-controlling apparatus, the combination with an electric motor, of resistance in series therewith, an electro-magnetic switch for controlling said resistance, accelerating mechanism, an additional electro-magnetic switch controlling said accelerating mechanism, a device for automatically effecting the opening of said additional switch and the restoration of said accelerating mechanism to initial position to decrease the speed of the motor, a magnet connected across the motor armature, and a switch controlled by said magnet to maintain said first-named electro-magnetic switch in closed position when the armature potential drops below a predetermined value.

17. In motor-controlling apparatus, the combination with an electric motor, of a minimum starting resistance in series with the motor armature, a switch for cutting out said resistance, an electro magnet for closing said switch, maximum starting resistance, switch mechanism for gradually cutting out said maximum starting resistance, an additional switch for controlling said switch mechanism, an additional electro-magnet for closing said additional switch, an automatic device for interrupting the circuit of said additional electro-magnet to effect the re-insertion of said maximum starting resistance to slow down the motor, a load magnet connected across the motor armature, and an auxiliary switch held open by said load magnet while the potential across the motor armature exceeds a predetermined value but permitted to be closed when such potential falls below said value to maintain said first-named electro-magnet energized when said minimum starting resistance is cut out.

18. In motor-controlling apparatus, the combination with an electric motor, of resistances, a series of switches for controlling said resistances, a corresponding series of electro-magnets for operating said switches, auxiliary switches co-acting with said first-named switches to insure the successive en-

ergization of said electro-magnets, and a series of automatic switches for successively interrupting the circuits of said electro-magnets to slow down the motor.

19. In motor-controlling apparatus, the combination with an electric motor, of a resistance associated with the motor armature, one or more switches for varying said resistance, one or more electro-magnets for operating said switch or switches, an additional switch for establishing a holding circuit for one of said electro-magnets, an additional electro-magnet for operating said last-named switch, an auxiliary electro-magnet connected across the motor armature, and an auxiliary switch operated by said auxiliary electro-magnet to control said additional electro-magnet.

20. In motor-controlling apparatus, the combination with an electric motor, of sectional resistance connected to the motor armature, a plurality of electro-magnetic switches for varying said resistance to change the speed of the motor, an auxiliary switch operated in conjunction with one of said electro-magnetic switches to close a holding circuit for the electro-magnet of the electro-magnetic switch first to operate, and an electro-magnetic switch for closing a holding circuit through the electro-magnet of said one electro-magnetic switch when the armature potential falls below a predetermined value.

21. In motor-controlling apparatus, the combination with an electric motor, of sectional minimum starting resistance, sectional by-pass resistance, a reversing switch for directing current through said minimum starting resistance and the motor armature in series and through a portion of the by-pass resistance in parallel to the motor armature, a plurality of initially open switches connected to said minimum starting resistance, a plurality of initially closed switches connected to said by-pass resistance, a plurality of corresponding electro-magnets for closing the open switches and opening the closed switches to remove the minimum starting resistance gradually and insert the remaining portions or sections of the by-pass resistance, and an electro-magnetic switch dependent for its operation upon armature potential to maintain one of said electro-magnets energized to prolong the slowing down of the motor before stopping.

22. In motor-controlling apparatus, the combination with an electric motor, of resistance connected thereto, a plurality of electro-magnetic switches for varying said resistance to control the speed of the motor, and an electro-magnetic switch dependent upon armature potential to prevent the return of one of said electro-magnetic switches to initial position.

23. In motor-controlling apparatus, the combination with an electric motor, of a sectional starting resistance, a plurality of electric switches connected to said starting resistance, a plurality of electro-magnets, one for each of said switches, auxiliary switches to insure the successive operation of said electro-magnets, an additional switch for establishing a holding circuit for the first magnet operated, an additional electro-magnet for operating said additional switch, and an electro-magnetic switch dependent upon armature potential for controlling said additional electro-magent.

24. In motor-controlling apparatus, the combination with an electric motor, of minimum starting resistance, by-pass resistance, electro-magnetic switches for gradually cutting out said minimum starting resistance and gradually inserting said by-pass resistance, auxiliary switches for insuring the successive operation of said electro-magnetic switches, accelerating mechanism, an additional switch co-acting with said electro-magnetic switches for controlling said accelerating mechanism, and an electro-magnetic switch dependent upon armature potential for controlling one of said electro-magnetic switches while the motor is slowing down.

25. In motor-controlling apparatus, the combination with an electric motor, of a reversing switch therefor, electro-magnets for operating said reversing switch, speed-controlling apparatus, a manual switch connected to said electro-magnets and said speed-controlling apparatus, and circuits and connections associated with said speed-controlling apparatus for increasing the minimum speed of the motor in stopping over that of starting.

26. In motor-controlling apparatus, the combination with an electric motor, of starting mechanism therefor, speed-controlling apparatus, a manual switch connected to said starting mechanism and said speed-controlling apparatus, said manual switch having a plurality of contacts in different positions corresponding to various motor speeds, and circuits and connections associated with said speed-controlling apparatus for cutting out one of said contacts after a higher speed than that corresponding thereto has been attained.

27. In an elevator, the combination with a car, hoisting mechanism, and an electric motor, of a reversing switch for the motor, electro-magnets for operating said reversing switch, a minimum starting resistance in series with the motor armature, a by-pass resistance in parallel to the motor armature, a plurality of electro-magnetic switches for varying said resistances to control the speed of the motor, a manual electric switch connected to said electro-magnets and to the electro-magnets of said electro-magnetic

switches, a maximum starting resistance, a plurality of switches for gradually cutting out said resistance, an accelerating magnet dependent for its energization upon the operation of all of said electro-magnetic switches to operate the switches connected to the maximum starting resistance, and automatic switches to slow down the motor as the car approaches the limits of its travel.

28. In an elevator, the combination with an electric motor, of a reversing switch therefor, electro-magnets for operating said reversing switch, a minimum starting resistance in series with the motor armature, a by-pass resistance in parallel to the motor armature, electro-magnetic switches for varying said resistances to increase or decrease the speed of the motor, a manual electric switch to effect the operation of said reversing switch and the operation of said electro-magnetic switches, accelerating apparatus operated automatically at the end of the operation of said electro-magnetic switches to further increase the speed of the motor, and limit switches to automatically decrease the speed of the motor gradually as the car approaches the limits of its travel.

29. In an elevator, the combination with a car, hoisting apparatus, and an electric motor, of electric starting switches for said motor, a manual electric switch in the car, speed-controlling apparatus dependent for its operation upon various positions of said manual switch, a sectional safety resistance, an accelerating electro-magnetic switch device operated at the end of the operation of the entire speed-controlling apparatus to gradually and automatically cut out said safety resistance, a resistance in the field circuit, and means dependent upon the movement of the manual switch to fast speed position and upon the cutting out of said safety resistance to insert said resistance in series with the field winding to further increase the speed of the motor.

30. In an elevator, the combination with a car, hoisting apparatus, and an electric motor, of starting switches therefor, speed-controlling apparatus comprising series and parallel resistances and electro-magnetic switches for varying the same, an electric switch in the car having a plurality of positions for various speeds, limit switches connected respectively between contacts of the car switch and the speed-controlling apparatus with the exception of one of said contacts, an auxiliary load magnet connected across the motor armature, and an auxiliary switch controlled by said load magnet to establish a holding circuit through one of the electro-magnets of said electro-magnetic switches and the excepted contact of the car switch to cause the car to stop substantially at a predetermined point with varying loads.

31. In an elevator, the combination with a car, hoisting apparatus, and an electric motor, of starting switches for the motor, speed-controlling apparatus, accelerating mechanism operated automatically at the end of the operation of said speed-controlling apparatus, an electric switch in the car, automatic means operated by some moving part of the elevator to restore the accelerating mechanism and the speed-controlling apparatus to initial position to effect a gradual reduction of speed of the motor before stopping, an auxiliary electro-magnetic switch, and circuits and connections controlled by said auxiliary electro-magnetic switch and co-acting with a portion of said speed-controlling apparatus to effect a variation in the reduction of speed of the motor and cause the car to stop substantially at a predetermined point or landing irrespective of the load or direction of travel.

32. In an elevator, the combination with a car, hoisting apparatus, and an electric motor, of a reversing switch for the motor, electro-magnets for operating said reversing switch, speed-controlling apparatus, automatic accelerating mechanism, a brake magnet, a manual switch to effect the operation of said reversing switch to direct current to the armature and the release of the brake to permit the motor to start, further movement thereafter of the manual switch successively effecting the operation of said speed-controlling apparatus and said accelerating mechanism, and a series of automatic switches operated by some moving part of the elevator to successively restore the accelerating mechanism to initial position, the speed-controlling apparatus to initial position, to interrupt the reversing switch magnet circuit, and finally to interrupt the brake magnet circuit to stop the motor and the car.

33. In an elevator, the combination with a car and rope drive apparatus, of an electric motor having a shunt field winding, starting switches for said motor, speed-controlling apparatus, accelerating mechanism operated at the end of the operation of said speed-controlling apparatus, means operated at the end of said accelerating mechanism to decrease the strength of the shunt field, and a manual electric switch for controlling said speed-controlling apparatus and the weakening of the shunt field.

34. In an elevator, the combination with a car and rope drive apparatus, of a shunt wound electric motor, a reversing switch for said motor, electro-magnets for operating said reversing switch, a sectional resistance in series with the motor armature, a by-pass resistance in parallel to the motor armature, normally open switches connected to the said series resistance, normally closed switches connected to said parallel resistance, additional electro-magnets for closing the open switches and opening the closed

switches, accelerating switches to insure the successive operation of said additional electro-magnets, a sectional safety resistance, a multiple switch device for gradually cutting out said safety resistance after all of the said additional electro-magnets have been energized, means controlled by said multiple switch device to decrease the field strength, an electric switch in the car, and circuits and connections between said last-named switch and the electro-magnets of the reversing switch, the said additional electro-magnets and said field-controlling means.

35. In an elevator, the combination with a car and rope drive apparatus, of an electric motor, starting switches for said motor, speed-controlling apparatus, accelerating mechanism operating at the end of the operation of said speed-controlling apparatus, means operated at the end of said accelerating mechanism to decrease the field strength, a manual electric switch for controlling said speed-controlling apparatus and the weakening of the shunt field, and a plurality of limit switches operated independently of the operator and successively to increase the field strength, restore said accelerating mechanism to normal and said speed-controlling apparatus gradually to initial position.

36. In an elevator, the combination with a car and rope drive apparatus, of an electric motor, an electric switch in the car, means dependent upon the position of said switch for operating the car at predetermined steps of speeds, both increasing and decreasing, and a plurality of automatic switches operated successively to restore said means to initial position gradually and thus slow down the motor and car independently of said electric switch in the car.

37. In an elevator, the combination with an elevator car and rope drive apparatus, of an electric motor, resistances, a series of switches for controlling said resistances, a corresponding series of electro-magnets for operating said switches, auxiliary switches co-acting with said first-named switches to assure the successive energization of said electro-magnets, and a series of switches operated by some moving part of the elevator for successively interrupting the circuits of said electro-magnets to automatically slow down the motor and stop the car substantially in a predetermined position.

38. In an elevator, in combination with a shunt wound electric motor, of resistance in a circuit in series with the motor armature, resistance in a circuit in parallel with the motor armature, a series of electro-magnetic relays each comprising a contact breaker controlling a section of the series resistance, and a contact maker controlling a section of parallel resistance, said resistances being proportioned to effect a definite speed of the motor, operating circuits for said relays, limit switches in said operating circuits, a manual switch having contacts in said operating circuits and operative to successively close the circuits, switches in the operating circuits and each closed by the operation of the relay of the preceding circuit, an accelerating magnet comprising a series of switches controlling a definite portion of resistance, and a switch in the operating circuit of the accelerating magnet and operated by the last relay of the series.

39. In combination, a shunt wound electric motor, resistance in series with the motor armature, resistance in parallel with the motor armature, a series of electro-magnetic relays each comprising a switch contact controlling a section of the series resistance and a contact controlling a section of the parallel resistance, the amount of resistance in said sections being proportioned to effect a definite speed of the motor, operating circuits for said relays, limit switches in said operating circuits, a manual switch having contacts in said operating circuits and operative to successively close the circuits, switches in the operating circuits and each closed by the operation of the relay of the preceding circuit, an accelerating magnet comprising a series of switches controlling a definite portion of resistance, a switch in the operating circuit of the accelerating magnet and operated by the last relay of the series, and an automatic device controlled by the last switch of the accelerating magnet for varying the strength of the motor field.

40. In a traction elevator, the combination with an elevator car, of frictional driving apparatus, a shunt wound electric motor, resistance in a circuit in series with the motor armature, a series of electro-magnetic relays each comprising a contact breaker controlling a section of the series resistance and a contact maker controlling a section of the parallel resistance, the amount of resistance in said sections being proportioned to effect predetermined speeds of the motor, operating circuits for said relays, a manual switch having contacts in said operating circuits and operative to successively close the circuits, switches in the operating circuits and each closed by the operation of the relay of the preceding circuit, an automatic electro-responsive accelerating apparatus controlling a portion of the resistance, and a switch in the operating circuit of said accelerating apparatus and operated by the last relay of said series.

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

RUDOLPH C. SMITH.

Witnesses:
W. H. BRADY,
JAMES G. BETHELL.