No. 743,426. PATENTED NOV. 10, 1903.

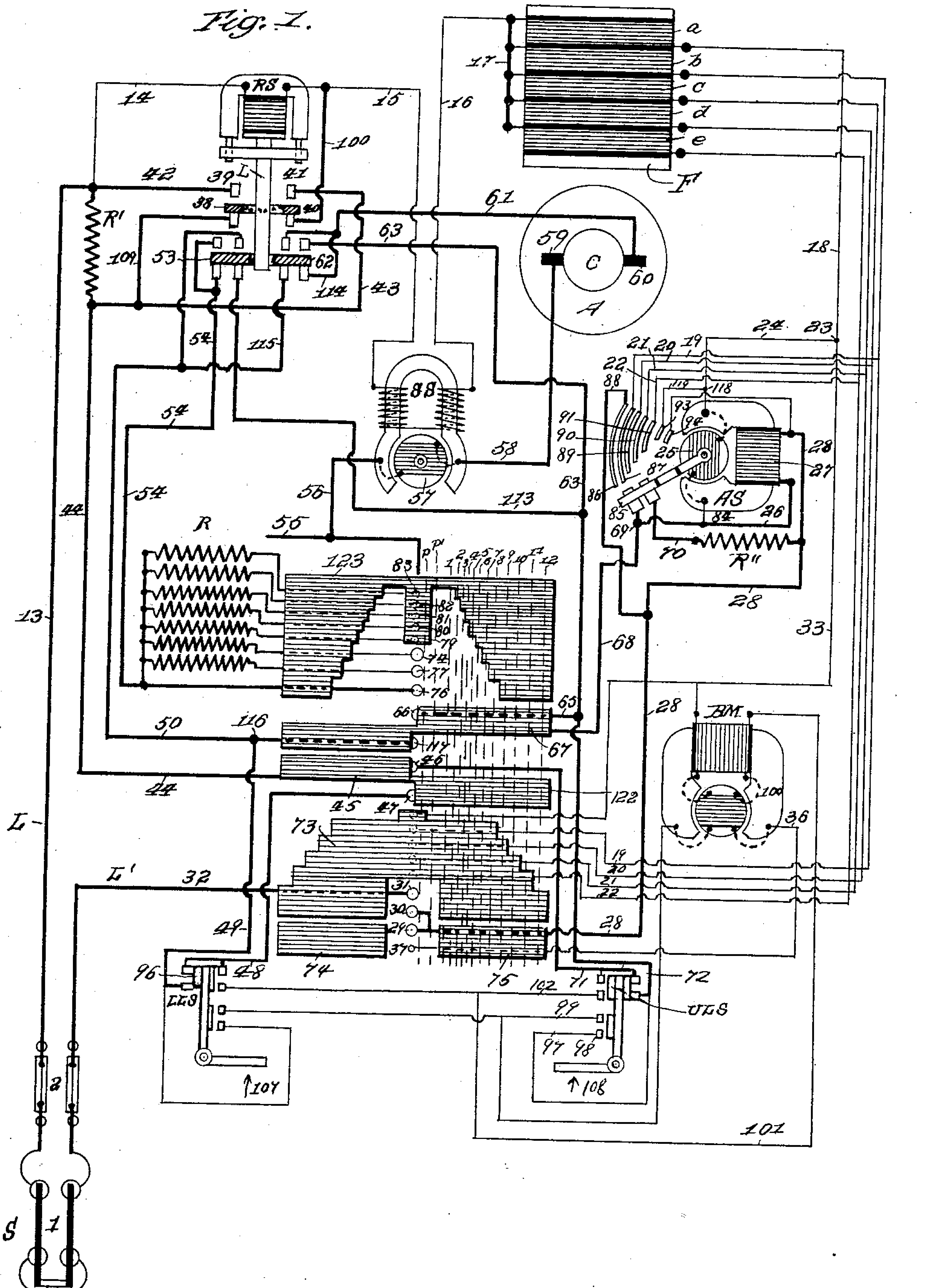
W. BAXTER, Jr.

SYSTEM FOR OPERATING ELECTRIC ELEVATORS.

APPLICATION FILED JAN. 17, 1899.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.



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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 2.

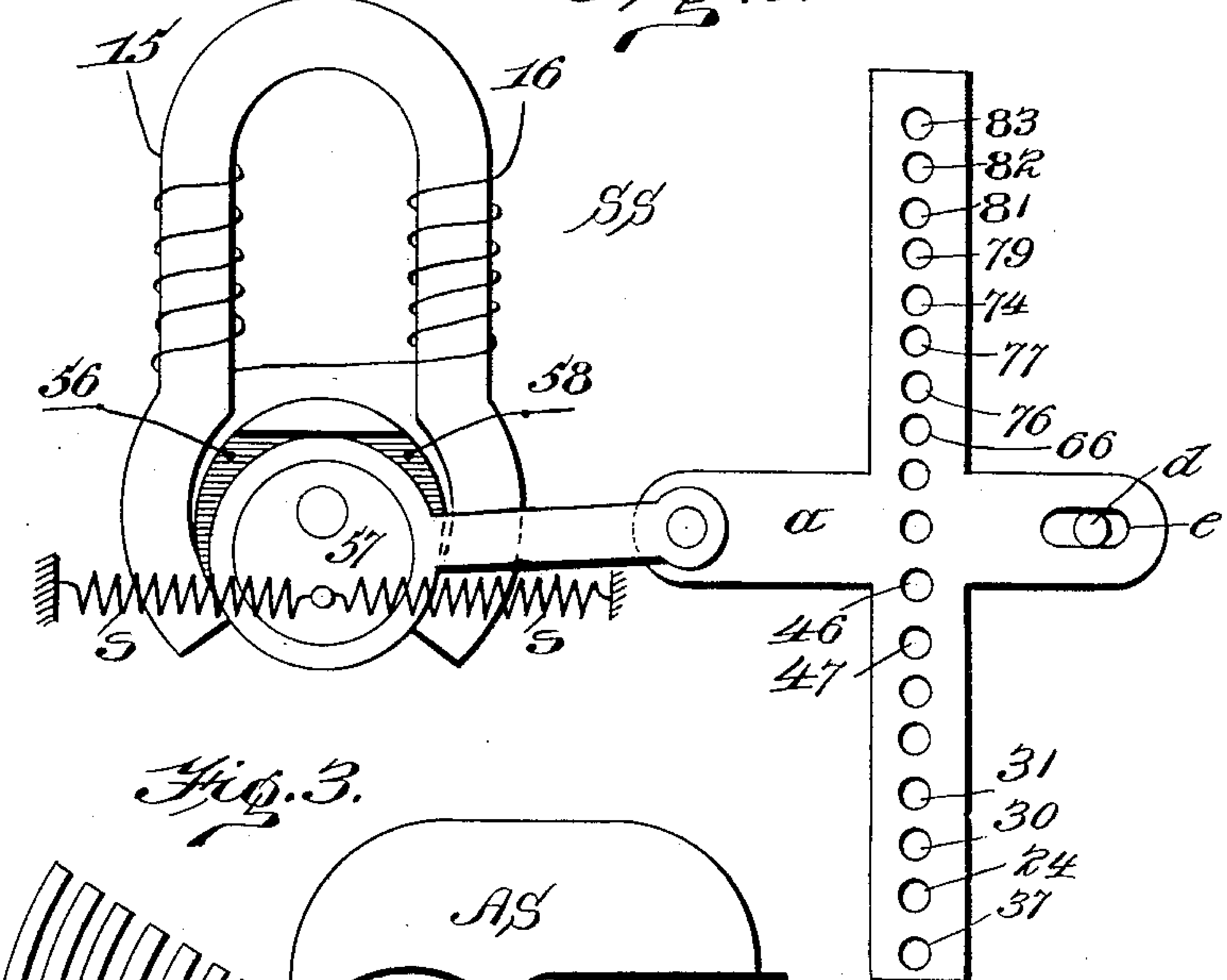


Fig. 3.

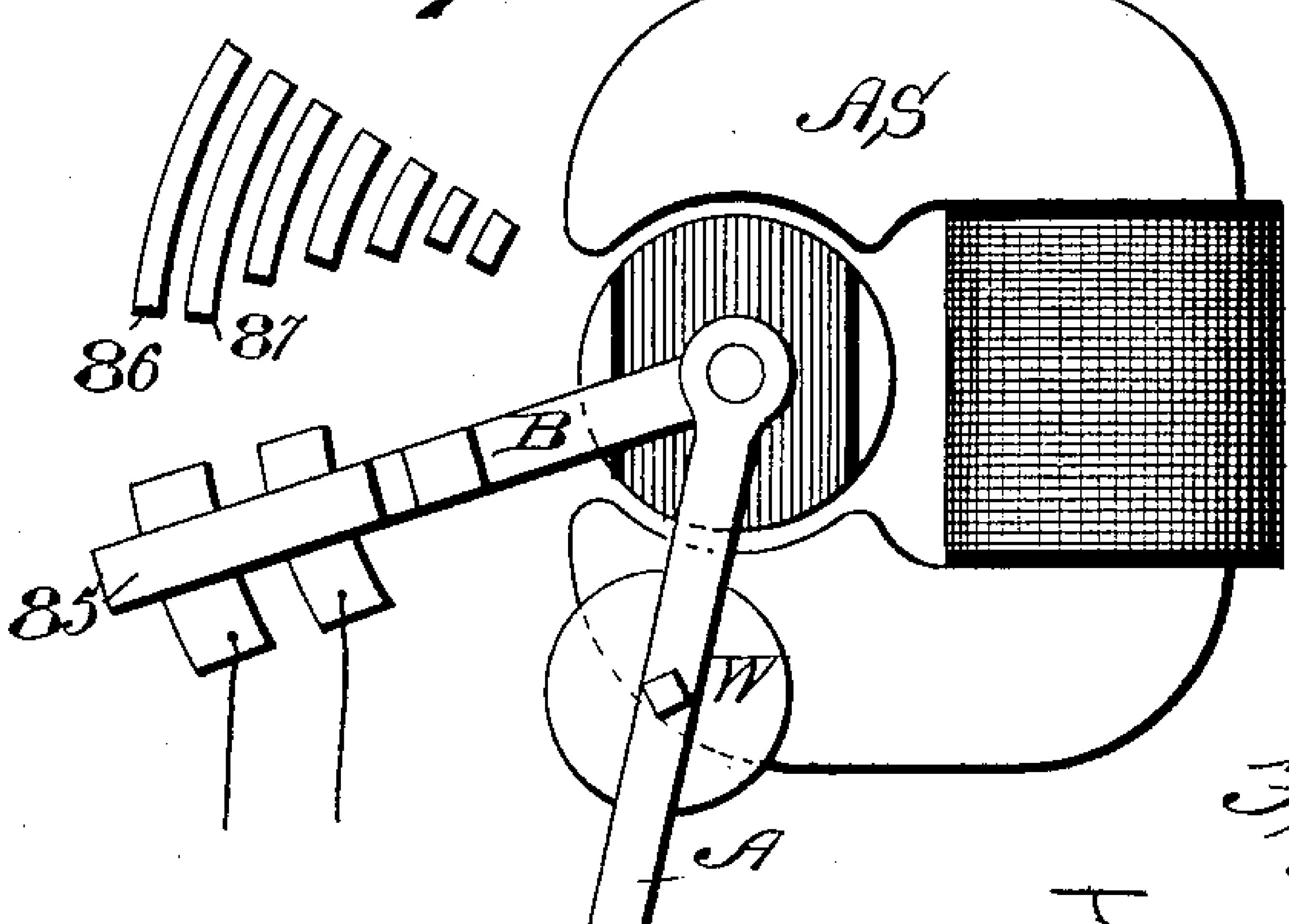
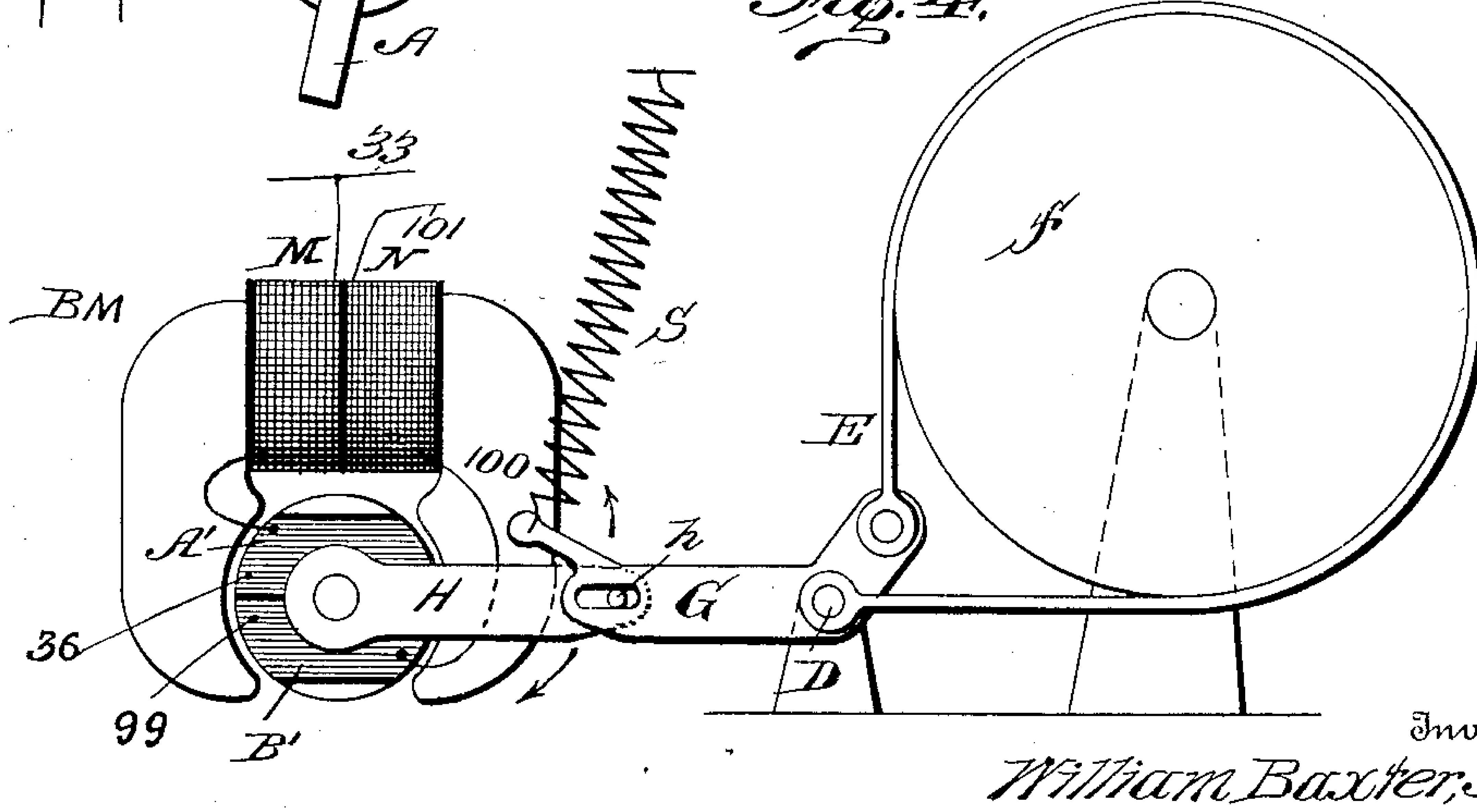


Fig. 4.



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No. 743,426. Patented November 10, 1903.

UNITED STATES PATENT OFFICE.

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SYSTEM FOR OPERATING ELECTRIC ELEVATORS.

SPECIFICATION forming part of Letters Patent No. 743,426, dated November 10, 1903.

Application filed January 17, 1899. Serial No. 702,425. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM BAXTER, Jr., a citizen of the United States, and a resident of Jersey City, in the county of Hudson and State of New Jersey, have invented a certain new and useful System for Operating Electric Elevators, of which the following is a specification.

This invention relates to arrangements of switches and circuits whereby the motion of an elevator-car is directly under the control of the elevator operator, and also to arrangements of circuits and switches which prevent the car from attaining a dangerous velocity in either direction under certain abnormal conditions that occur with more or less frequency.

Electric elevators are ordinarily controlled by a main switch for opening and closing the main line, a reversing-switch for reversing the direction of rotation of the motor and the direction of travel of the car, and a switch for cutting out of the circuit the resistance which is used in starting the motor. The main and reversing switches are sometimes combined in one. The motor is either shunt or differentially wound, and the starting resistance is placed in the armature-circuit. The resistance-switch is so arranged that when the elevator is stopped all the resistance is in the armature-circuit, and the switch is held in this position. When the elevator is started, the resistance-switch is released and slowly moves (generally automatically) to the position in which all the resistance is cut out of the armature-circuit. The motion of this switch is controlled generally by a dash-pot, which is adjusted so as to control the speed of cutting in and out the resistance, and consequently the rate of developing full speed in the car's travel. In some cases the motion of the switch is controlled by an electromagnetic device that regulates the speed of the switch in accordance with the strength of the current flowing through the armature. In such old arrangements when the elevator operator desires to start the car he turns the operating-wheel or lever in the car, and this motion throws the main and reversing switch into the active position and at the same time releases the resistance-controlling switch. The operator has no further control over the starting or over the rate at which the resistance is cut out of the circuit of the armature, and therefore no control over the rate of acceleration in the movement of the car. Furthermore, as the operator can only move the main and the reversing switches he cannot in any way control the speed of the car after it is in motion, and the velocity will depend upon the load and upon the closeness with which the motor regulates, or, in other words, upon the variation in speed caused by variations in the load. When the operator desires to stop the car, he moves the lever or wheel to the stop position, and this motion disconnects the motor from the line and applies the brake. The distance in which the car will stop after the switch has been turned is dependent wholly upon the frictional resistance of the brake and the machinery and the momentum of the moving parts and is entirely beyond the control of the operator.

From the foregoing it will be seen that the operator has no control over the rate at which the car will accelerate its motion in starting, no control over the speed of the car after it is in motion, and no control over the rate at which it will retard its velocity in stopping.

This invention provides means whereby the rate at which the speed of the car is accelerated in starting, the speed at which it runs thereafter, and the rate at which it is retarded in stopping are all directly under the control of the operator, as will now be briefly outlined.

If the load is moved in the direction in which gravity acts, the energy developed by the descent will assist the motor. If the load is light, gravitation may not be sufficient to overcome the frictional resistance of the mechanism, and in that case the deficiency will be made up by the motor, the armature of which will rotate at such a velocity that its counter electromotive force will be sufficient to cut the current passing through it down to the required strength. If the load is sufficiently heavy, the energy of descent will be more than enough to overcome the frictional resistance of the elevator machinery, and then the motor will act as a generator, the current induced in its armature passing through the field-coils, the brake-coil, and, if necessary, through the main line, flowing in this in a direction opposite to the normal direction of the operating-current. Under these conditions the armature of the motor will run at a slightly-increased velocity, the increase being as much as may be required to raise the counter electromotive force of the motor above the line electromotive force to an extent corresponding to the excess of gravitation over the energy absorbed by the friction of the machinery. If the electromotive force of the generator is reduced to zero, the speed of the motor will be reduced, because the flow of current back into the line will then be resisted only by the ohmic resistance thereof instead of by the opposing current. Hence the current through this part of the motor-circuit will be increased, and to cut down the energy developed the counter electromotive force will have to be reduced. If the line-circuit is opened, the case will become very different, for the resistance of the main line will become infinite, and the current generated in the motor-armature will be compelled to flow exclusively through the field and brake coils, and as these have a very high resistance the current through them with a voltage slightly above the line electromotive force will be very weak and the energy thereof very small. Under these conditions it will be necessary for the armature speed to increase greatly before the necessary work to be imposed by the (now generating) motor upon the gravitating load to balance the energy of said load will be developed by an increase in the counter electromotive force of the motor. This velocity of armature would in most instances allow the elevator-car to attain a dangerous speed. Hence one of the objects of this invention is accomplished by providing means whereby the motor may be prevented from attaining an abnormal velocity under the conditions just explained. It is sometimes assumed that in these cases the brake will hold the mechanism; but, as will be noticed, the brake is held in the inactive position by the current generated by the motor.

If the car is being raised against gravity and the line electromotive force reduced to zero, the motor will stop, and there being no difference of potential between p and n no current will pass through the brake-magnet. Hence the brake will go on and prevent the elevator mechanism from running backward. If the brake fails to act and the force of gravity is sufficient to overcome the frictional resistance, the motor will be driven in the reverse direction, and it may attain a velocity that would be dangerous. In this case the motor will not act as a generator, because the direction of rotation of the armature is reversed, and the electromotive force induced therein will not send a current in the right direction through the field-coils.

Another object of my invention, therefore, is accomplished by providing means whereby the motor connections will be changed in such a case as just described, so that it may generate a current, and thus hold the car if the brake fails to act.

When an elevator is standing at a floor intermediate between the top and bottom, it is held from moving in the direction of gravity by the brake and the frictional resistance of the machinery. If the brake fails and the friction of the machinery proves insufficient to hold the load, the car will be carried in the direction of gravity and attain a dangerous velocity before the end of the elevator-shaft is reached.

A further object of this invention, therefore, is attained through means whereby the speed of the car under the above conditions can be controlled and be kept within safe limits automatically.

If the operator fails to throw the switch in time when nearing the top or bottom landing, the car will run into the overhead framing or strike the ground, and possibly with destructive force. To prevent this, it is customary to provide some kind of automatic stop. This generally consists of an arrangement to throw the switch should the operator fail to act in time. In order that this device may not come into action too often, the retarding force applied to stop the car at the ends of its travel is greater than that applied at other landings and is applied much later. It is obtained in some cases by short-circuiting the motor-armature and in others by mechanically increasing the pressure of the brake.

A further object of this invention, therefore, results from means for increasing the brake-pressure electrically when the car is stopped by the action of the top and bottom limit stops.

The various features of my invention will now be specifically described with reference to the accompanying drawings, in which—

Figure 1 is a schematic representation of the invention, and Figs. 2, 3, and 4 are enlarged detail views respectively showing the safety-switch, the automatic switch which controls the velocity of the motor, and the brake-magnet.

A is the motor-armature; F, the field-magnet coils; R, the starting resistance, and RS an electromagnetic switch which acts to reverse the connections between the armature and field when such reversal becomes necessary to make the motor act as a generator.

AS is an automatic switch which acts to control automatically the velocity of the motor.

BM is the brake-magnet.

LLS and ULS are the top and bottom limit switches.

SS is a motor that moves the operating-switch to bring the terminals in the proper relation to cause the motor to act as a generator if it should move away from a landing under the influence of gravity when the operating-switch is in the inoperative position and the motor is disconnected from the line.

S is the switch that connects the motor-circuit with the line; but the closing of this switch does not close the circuit through the motor.

The main operating-switch is shown projected on the drawings, and consists of the contact-plates 74 75 73 45 67 122 123 and the row of contacts standing at the off point along the central line and numbered from bottom to top 37 29 30 31 47 46 117 66 76 77 78 79 80 81 82 83. The row of contacts is stationary and the contact-plates are movable. The contacts, it will be understood, are located near enough to the cylinder to press upon the plates.

As will be seen, the main wire 32 runs to contact 31, and with the switch in the position shown this contact does not connect with the contact 30; therefore there is a break in the circuit at this point.

To start the elevator, the contact-plates are moved to one side or the other, according to the direction of travel desired. If these plates are mounted upon the surface of a cylinder in the manner common with electric controllers, the rotation of the cylinder will effect the motion of the contact-plates.

If it is desired to run the elevator down, the cylinder is revolved until the contacts come on the line 1. With this position of the switch it will be found that the line-current in wire 13 will pass to wire 14, thence through the coil of RS to wire 15, and through the coils of SS to wires 16 and 17, which connect in parallel the ends of the several coils wound upon the field, thence, as hereinafter described, to plate 73, contact 31, and by wire 32 to main line. The current passing through the coil of RS energizes the magnet, and thus the lever L is raised. The contacts 38 and 40, carried by the lever, are electrically connected with each other, and by being drawn up against contacts 39 and 41 close the circuit between wires 42 and 43. Through this route the current reaches wire 44 and contact-plate 45. As the contacts are on the line 1, 47 will be in contact with the plate 45 and 46 will not. Hence the current will flow to wire 48, and through the connecting-plate 96 of the LLS switch will pass to wire 49, thence to wire 50, and through the connecting-plate 53 of the RS switch to wire 54 and to the rheostat R; from here by wires 55 and 56 to the armature of SS and to wire 58 and brush 59 of the motor-commutator C; from brush 60 by wire 61 and connecting-plate 62 to wire 63 and wire 65 to contact 66 and contact-plate 67. From here the current passes to wire 68, and at junction 69 it divides, part passing to wire 70 and part to 26, this latter passing through coil 27 of switch AS to wire 28, and thence to contact 29 and 30 and through the cylinder contact-plate 73 to contact 31 and to wire 32, thus reaching the switch S. A low resistance R″ connects a shunt around the switch AS from wire 70 to wire 28 for the purpose of reducing the current passing through coil 27.

Of the currents passing through the field-coils that in wire 18 divides at junction 23, part going through the armature 25 by wire 24, thence to wire 28, and part going by wire 33 to and through the brake-magnet BM, coming out by wire 36, and thence to contact 37, where it joins the current from wire 28. The current entering wire 19 from the field-coil, as well as those entering wires 20, 21, and 22, pass to the small contacts under contact-plate 73, and thus join the current from wire 28.

From the foregoing, it will be seen that the field-coils *a b c d e* are in parallel. The sections of the rheostat R are also in parallel; but, as will be readily understood when the action is further explained, it is immaterial whether the field and rheostat sections are placed in parallel or series, providing the switch connections are made to suit either type that may be used. If the main switch is moved successively to lines 2 3 4, &c., it will result in placing more sections of R in the circuit in parallel with each other. When the switch is on line 1, the top section is the only one in the circuit. When line 8 is reached, all the sections of R will be in the circuit in parallel with each other. When the line 9 is reached, the contact to which wire 19 is connected will pass from under contact-plate 73, and thus open the circuit through field-coil *b*. The next step will uncover the contact of wire 20, and thus open the circuit of field-coil *c*. When line 11 is reached, coil *d* will be cut out, and when line 12 is reached coil *e* will be cut out, thus leaving only the coil *a* in the circuit. From this explanation it can be seen that the resistance-sections being in parallel when the main switch is moved to the first position (line 1) the resistance in the armature-circuit will be the maximum and the current passing around the field-coils will also be the maximum, the field being unaffected by the resistance. Hence the electromotive force to be balanced by the armature counter electromotive force will be the minimum and the magnetomotive force acting in the field will be the maximum. Therefore the speed of the armature will be the lowest. When the main switch is turned around to the position of line 12, the rheostat resistance will be all out of the circuit and the magnetomotive force acting upon the field will be only that of one coil—that is, coil *a*. Hence the counter electromotive force required will be the maximum and the field strength the minimum. Therefore the armature speed will be the maximum. In starting the elevator the rate of acceleration can be adjusted—made high or low—by the rapidity with which the switch is moved from position line 1 to position line 12. After the elevator is in motion any desired speed can be obtained between the maximum and the minimum by leaving the switch upon any line intermediate between 1 and 12. In stopping the elevator the rate at which the speed is checked can be varied by the rapidity with which the main switch is moved back to the stop position.

As shown, in tracing the course of the current through the wires the direction through the coil 25 on the armature of AS is from top to bottom from junction 118 to junction 84. The direction of the current through coil 27 of AS is from wire 26 to wire 28. With the current flowing through these coils in this direction the torque of the armature is in such a direction as to force the lever 85 toward and keep it upon the contacts that form the terminals of wires 26 and 70. Now the wires 28 and 36 meet at contacts 37 and 29 when these are covered by either plates 74 or 75, and so long as the motor is drawing current from the line the currents in these two wires will pass to wire 32; but when the motor counter electromotive force overbalances the line electromotive force then the current in wire 36 will pass into wire 28 and run back through coil 27 and wires 26 and 68 to contact-plate 67, so as to get back to the armature through wire 63, from whence it came. Under these conditions the torque of the armature of AS will be reversed in direction, as the direction of the flow of current through field 27 will be reversed. When this torque reaches a certain point, the lever 85 will be forced upward, against a suitable resisting force—such, for instance, as the weight W adjustably secured on the arm A—the moment of which continually increases at a rate that can be varied by changing the angular position of the arm relative to the lever 85; and this upward movement of the lever 85 will connect the contact-curves 86 and 87, thus connecting wire 19 with wire 88, and thereby placing field-coil *b* in the circuit. The field strength will now be increased, and the resistance of the circuit into which the motor is feeding will be reduced, and as a consequence the current will be increased and the speed retarded. If this movement of the lever 85 does not prevent the motor velocity from rising beyond the prescribed limit, the increased current will increase the torque of the armature of AS and cause the lever 85 to move farther and connect curve 89 with the other two and, if necessary, also curves 90 and 91. In this way all the field-coils will be connected in the circuit one after the other. It can be readily understood that by a proper adjustment of the coils wound on AS and of the resistance opposing the movement of the lever 85 the movement of the latter throughout its entire range can be effected with but a slight variation in velocity; but if from any cause the movement of this switch fails to keep the motor velocity within the predetermined limit then the further motion of lever 85 will connect wires 24 and 28 through contacts 93 and 94 and wires 119 and 120, and this connection will short-circuit the brake-magnet, and thus allow the brake to act to stop the elevator. Since the torque of the armature of AS depends upon the strength of the current flowing through the coils 25 and 27, and since the current strength is not dependent upon the velocity of the motor, it follows that the action of AS can be adjusted, so as to reduce the speed of the motor, if this is desired. The strength of the current generated by the motor when acting as a generator will depend upon the counter electromotive force and the resistance of the circuits into which it feeds, and if these are properly proportioned the increase in current strength as the coils *b c d e* are cut in can be sufficient to balance the energy developed by the descent of the elevator even with a reduced electromotive force, and as the strength of the field will be increased by the increase in current strength it follows that the required voltage may be obtained at a velocity of the motor-armature much lower than that obtained when only coil *a* is in the circuit. Thus it will be seen that switch AS can be adjusted, so as to allow the car speed to increase or to remain practically constant or to decrease. It will also be seen that so long as the current through coil 27 flows upward from wire 26 to wire 28 the lever 85 will remain in the position shown in the diagram, as the torque of the armature will be counter-clockwise. This being the case, switch AS will not come into action so long as the current passes from wire 26 to 28, and this will be the direction so long as the motor draws current from the line. Switch AS therefore only comes into action when the motor acts as a generator. As already explained, the motor acts a generator only when the load is moving in the direction in which gravity impels it, and under these conditions if the line-circuit breaks the speed will increase, and possibly to a dangerous limit, owing to the fact that the normal motor-circuit resistance is so high. From this it will be seen that AS is an automatic safety-switch which acts to prevent the car from attaining a dangerously-high velocity if the line-circuit opens when gravity is the impelling force.

When the main switch is in the central or "off" position, the armature with the rheostat R in circuit is in a closed circuit, and so are all the field-coils. When the current does not flow through the system, the magnet RS is inactive, and the lever L and its contact-pieces are in the position shown. Hence the wire 61 from brush 60 connects with wire 114 to 115 and through 50 to contact 117. Wire 58 from brush 59 connects, through armature 57 of switch-motor SS, wires 56 and 55 and rheostat R to wire 54 and thence to wire 113, to wire 63, to 65, and to contact 66, thus short-circuiting the armature with R in its circuit. Wire 16, leading from the field-coils, connects, through intermediate connections, with 44 and through contact-plate 45, contact 47, wire 48, and connecting-plate 96, and wire 49 reaches junction 116 and passes through contact 117 to plate 67. The wires 18, 19, 20, 21, and 22 are all connected by contact-plate 73, wire 18 connecting through wires 33 and 111. Wire 18 connects, through wire 24, armature 25 and wire 26, with wire 68, which is attached to contact-plate 67. Thus the field-coils are short-circuited, as wires 111 and 33 serve to connect all the field-coil ends with 24, which we have just seen is connected with 67. From 64 wire 72 runs to switch ULS and through the connecting-plate 95 connects with wire 71, which leads to contact 46. From this it will be seen that the armature and field circuits are closed when the motor is stopped and that all the terminals are connected with each other by the contact-plates 45 and 67 and the contacts 66, 117, 46 and 47 and also the contact-plate 73 and the contacts covered by it, to which the several field-coil ends are attached. The contacts 66, 117, 46, and 47 are just covered by the edges of the plates 45 and 67. Therefore if the switch is moved slightly from the central position—say to line p or p'—46 and 117 will be disconnected, and then the field-coils and the armature will be placed in series with each other, and the short-circuit of each will be destroyed.

When the elevator is standing at a landing, it is held by the friction of the brake and of the mechanism. If the brake fails to act, the car may be set in motion by the action of gravity; but if we can move the switch to the line p or an equal distance in the opposite direction we can connect the field and armature, so that the motor will act as a generator, and thus resist the motion of the car. The switch-motor SS is for this purpose. The field is made of hardened steel, so as to be a permanent magnet. The coils wound upon it are so connected with the wires 15 and 16 that the current passing therethrough tends to strengthen the magnet, and as the current always flows in the same direction the polarity of the field of SS will never change. This being the case the direction of the torque of the armature 57 will depend upon the direction of the current through it, and this will depend upon the direction in which the armature A of the motor rotates. Thus the armature 57 of SS will exert a torque in in either direction. Hence if it is used to shift the contacts of the main switch through the short distance to line p it will produce this movement either to the right or to the left, according to the direction of the current through its armature-coil. From this it will be seen that all that is necessary to enable SS to move the main switch or its contacts in the direction required to cause the motor to act as a generator is to make the proper connections between the ends of the coil 57 and the wires 56 and 58 and to connect the armature 57 through an eccentric c with the frame a, that carries the row of terminals 37 24 30 31, &c., and to permit said frame to have a limited movement in either direction by means of slot-and-pin connection d e, the contacts being held in normal intermediate position by the oppositely-acting return-springs s s on the eccentric c.

From the foregoing it will be seen that SS is a safety magnetic device to prevent the car from running away when at a landing and that it acts to move the main switch far enough to break the short circuits in the armature and field-circuits of the motor and to connect these two parts in series in the proper relation to enable the motor to act as a generator, the electromotive force under these conditions being developed by the residual magnetism of the field F.

If the elevator-car is being moved against the resistance of gravity, it will come to a stop if the line-current fails, and if the force of gravity is sufficient the direction of motion will be reversed, and under these conditions the motor will not act as a generator, for the reversal of direction of rotation of the armature will reverse the direction of the counter electromotive force. To enable the motor to act as a generator under such conditions, it will be necessary to reverse the connections between the armature and field-coils, so that the reversed counter electromotive force may serve to send the current through the field-coils in the same direction as it flowed when coming from the line. The object of the switch RS is to accomplish this reversal of the field and armature connections. To illustrate its action, suppose the main switch is turned to the right, as in the previous explanations, and that the contacts are on the line 12. The line-current will then flow through the coil of RS, and as a consequence the lever L will be raised, and the connection-plates 38, 40, 53, and 62 will be in contact with the upper contacts. As long as the line-current flows the magnet RS will be energized; but if this current fails the current through its coils will die out, and the lever L will drop, and the connecting-plates will make contact with the contacts below them. With the main switch in the position of the line 12 the current from the line passes through the armature A of the motor from brush 59 to brush 60 and the counter electromotive force acts from brush 60 to brush 59; but when the direction of rotation of the armature is reversed the counter electromotive force will be reversed in direction, acting from brush 59 to brush 60—that is, in the same direction as the line-current flowed. The current generated by the armature then will flow out through brush 60 and through wires 61 and 114 and connecting-plate 62 to wires 115 and 50. Contact 117 being uncovered, the current will pass at junction 116 to wire 49 and thence to wire 48 and through contact 47, contact-plate 45, and wire 44 to wire 109. By means of connecting-plates 38 and 40 it will pass to wire 100 and thence to 15 and to the field, entering the latter in the same direction as the line-current. To prevent the current from passing through the coil of RS with sufficient strength to enable the magnet to lift the lever L, the resistance R′ is inserted in wire 44. It will thus be seen that the object of wires 42 and 43 is to cut this resistance out of the circuit when the current comes from the line and that the object of the resistance is to divert the current from the coil of RS when the current comes from the motor-armature.

The action of the switch RS does not in any way disturb any other portion of the circuits. Therefore if the car be running under the conditions now being considered its velocity can be regulated by the operator by turning the main switch back to points intermediate between line 12 and line 1 just as when the current comes from the line. It will also be seen that the automatic action of switch AS will be the same as when the operating-current comes from the line.

The brake-magnet B M is wound with two independent circuits m n on the field and A′ B′ on the armature, (see Fig. 4,) through one of which the current passing through the motor field-coils is passed, it coming by way of wire 33. The coils through which this current passes are arranged so as to cause the magnetic force to release the brake, and thus allow the motor to run without the resistance of the brake. The other coils are wound upon the brake-magnet so as to act in opposition to the first ones—that is, they act to put the brake on. Normally there is no current flowing through these coils, as the circuit is broken at the top and bottom switches LLS and ULS, these being held up in the inactive position, as is indicated by the arrows 107 and 108. If the switch ULS is moved so that the contacts on the left side are connected then the current from wire 71 will pass to 102, thence to 101 through a coil N on the field of the brake-magnet to wire 100 and through a coil B on the armature to wire 99, thence by connection 98 to wire 97 and to wire 72. From this it will be seen that the coils in this circuit wound upon the brake-magnet will be placed in series with the motor-armature.

The mechanical connections through which the brake and its controlling-magnet operate are as follows: The strap E is tightened upon the drum f of the brake-shaft by a lever G, fulcrumed at D, and said lever G is biased to the "on" position by means of a spring S. The armature of the brake-magnet B M carries a lever H, having slot-and-pin connection h with the lever G, through which when the coils M and A′ are energized by the application of the main operating-current through the controller the lever G is depressed and the brake-band E released; but if the coils N and B′ are energized the torque induced by the coils M and A′ is not only overcome, so as to leave the spring S free to apply the brake, but the braking action of said spring is augmented by the excess of torque induced by the current through the coils M and B′.

The brake is biased toward the on position—that is to say, it is forced against the brake-wheel by means of a spring or other suitable force—and the coils in series with wire 33 act in opposition to this spring. When the car is stopped at an intermediate landing, the current through the brake-coils is shut off, and the brake is applied with such force as the spring can exert; but when either one of the limit-switches acts the force with which the brake is applied is not only that of the spring, but in addition to this all the force that the coils in the circuit between the wires 101 and 99 can exert over that required to balance the force of the coils in circuit with the wire 33. The coils in circuit with wire 101 can be made to overbalance the coils in circuit with wire 33 as much as desired. Hence the retarding force of the brake when the limit-switch acts can be as much in excess of the normal as may be necessary to enable it to perform its functions properly. In order that the action of these limit-switches may not be misunderstood, it should be borne in mind that the main operating-switch will be moved to the central position automatically before the limit-switch is closed. If this were not done, the line-current would pass through the motor-armature and the brake-magnet coils in series with it as long as the car remained at the landing.

The means by which the limit-switches are moved and the means by which the main switch is moved at the top and bottom landings are not shown, as they form no part of this invention. The means by which the main switch is moved by the operator is also not shown, as any of the arrangements used for operating the starting-switches of electric elevators or the controlling-valve of hydraulic elevators can be used for the purpose, and these form no part of the invention herein explained. For the same reason no arrangement is shown by means of which the magnet SS effects the movement of the main switch; but it is obvious that such movement can be produced in a variety of ways. The switches RS and AS and the brake-magnet are shown diagrammatically. All the actions of the various parts of the system have been made upon the assumption that the contacts of the main switch are thrown to the right-hand side of the center line; but the motion of the car has been assumed to be either up or down. This course has been followed, because the switches and circuit connections are arranged to operate with overbalanced as well as underbalanced elevators. If an elevator is underbalanced, the car will always weigh more than the counterbalance, and therefore gravity will always act to pull it down; but if the car is overbalanced gravity will act to pull the car up when the load is light and to pull it down when the load is heavy, and hence in this case the action must be the same regardless of which side of the center the switch is thrown. With an underbalanced elevator the RS switch would only come into action when the main switch is thrown in the direction that causes the car to run up; but with an overbalanced car the RS switch must act with the main switch thrown in either direction.

The current through the brake-magnet coils in series with wire 33 will always be in the same direction, and hence a simple magnet with one coil would serve to hold the brake off; but the current through the coils in series with wire 101 can flow in both directions, and hence a single coil would at times act with the coil in series with wire 33 and at times in opposition to it. By using a motor-magnet and providing a field and an armature coil the torque developed by the current from wire 101 will always be in the same direction regardless of the direction of the current through the wire.

When the main switch is in the central position or upon the line p or p', the contact 37, to which the terminal of the brake-coil is attached, is disconnected. Hence in these positions no current can pass through the main brake-coils, and therefore the brake will not be raised.

As the action of the switches RS and AS is independent of the main switch, it follows that the latter can be considerably modified, if desired. Thus it can be made so as to simply connect the motor with the line with the field and armature connections proper for the direction of rotation desired. In such a case the resistance of R could be cut out by a separate switch actuated by the operator or by a solenoid or similar automatic device. Another switch, automatic or otherwise, could connect and disconnect the field-coils, or such a switch could be entirely discarded, these coils being acted upon only by AS.

The rheostat R′ is necessary to enable RS to act properly; but the rheostat R″ is only used so as to cut down the permanent resistance in the main circuit, this rheostat being of much lower resistance than coil 27.

In this system of connections it will be noticed that the field and armature circuits are never opened. When the main switch is in the inactive position, the armature and field circuits are closed upon themselves. When the switch is moved far enough to break the contact with one set of field and armature terminals—as to line p, for example—the armature and field are in series with each other, and when the switch is moved far enough for the contacts 30, 31, 29, and 37 to connect with the contact-plates 73 and 74 or 75 then the field and armature will be connected in parallel across the main line.

I have used herein the term "manually-operated controlling-switch;" but I do not intend to convey by this expression the idea of a switch directly in the hand of the operator, but such expression is intended to cover that portion of the controlling mechanism which is moved at the will of the operator as the means for setting in motion or arresting the movement of the elevator-motor, whether such switch is carried on the car or located at a distant point and brought under control of the operator through intermediate connections in a manner well understood in the operation of elevators.

Having thus described my invention, the following is what I claim as new therein and desire to secure by Letters Patent:

1. In combination with an electrically-operated elevator, a manually-operated controller by which to determine the speed of the elevator, and an automatically-operated controlling-switch normally under control of current through said motor also controlling the speed of the motor, substantially as herein explained.

2. In combination with an electrically-operated elevator, a motor having sectional field-coils, a manually-operated controller for regulating the speed of the motor by cutting in and out the sections of the field-coil, and an automatically-operating switch also cutting in and out the sections of the field-coil, substantially as herein explained.

3. In combination with an electrically-operated elevator having a sectionally-wound motor-field, an automatic switch for cutting in and out sections of the motor-field, and electrical connections whereby said automatic switch is actuated by the ascendancy of the current generated by the motor acting as a generator over that supplied for operating the motor, substantially as herein explained.

4. In combination with an elevator-motor having its field-coils divided into sections; a switch receiving current which passes through the motor-armature and which is held thereby in one position, but is moved in the opposite direction by current generated by the motor-armature, and conductors in connection with the switch and motor-field whereby sections of the field are cut out by the movement of the switch under the influence of the current generated by the motor-armature, substantially as herein explained.

5. In combination with an electric motor having its field-winding divided into sections; the switch actuated by current generated by said motor when the motor is moved by the ascendancy of the work to be performed over the energy of the actuating-current, connections whereby the movement of said switch successively cuts in or out the sections of the field-winding, and means for resisting the movement of the switch so as to render the cutting out of the field-sections proportional to the increase of current generated by the motor, substantially as herein explained.

6. In combination with an elevator-motor having its field wound in sections; a controller for cutting out the sections of the field, and an automatic switch actuated by current gen-

erated by the motor acting as a generator and having connections for successively cutting in the sections of the field for reducing the resistance of the circuit into which the motor feeds when acting as a generator, and at the same time increasing the magnetizing force of the field and imposing an increased load upon the motor acting as a generator when driven by gravitation of the elevator, substantially as herein explained.

7. In combination with an electric-elevator motor and an automatic brake held normally out of action by current employed for running the motor; an automatic switch for short-circuiting the motor-magnet operating under an abnormal increase in speed of the motor, substantially as herein explained.

8. In combination with an electric-elevator motor having a sectional field, an automatic switch operating by current generated by the motor and having connections for successively cutting in the sections of the field, an automatically-operating brake held inactive by current through the motor; said automatic switch also having contacts for short-circuiting the brake-magnet after exhausting the retarding influence of cutting in sections of the field, substantially as herein explained.

9. In combination with a motor of an electrically-operated elevator, an automatic circuit-reversing switch adapted to reverse the connection between the armature and field terminals of the motor, thereby enabling the motor to act as a generator should the elevator, through a sudden failure of the line-current, be moved by gravity in a direction opposite to that in which it is being moved by the motor.

10. In combination with the motor of an electrically-operated elevator, the reversing-switch for reversing connections through one element of the motor, to permit the motor to act as a generator, and an automatic controlling-switch for increasing the load upon the generating-motor proportionally to the increase in speed of the latter, substantially as herein explained.

11. In combination with an electric-elevator motor, the automatic reversing-switch RS for changing the connections through one element of the motor, and the resistance R′ inserted in the motor-circuit to prevent current passing through the coil of the reversing-switch, substantially as and for the purposes set forth.

12. In combination with an electric-elevator motor, a main switch short-circuiting the connections through the motor when at the "off" point, and an automatic electrically-operated switch SS acting to throw the main switch away from the "off" point when the motor acts as a generator and to connect the field and armature in series, substantially as herein explained.

13. In combination with an electric-elevator motor having a manually-operated main controlling-switch, a safety-switch for shifting said main switch from the "off" point, comprising a permanent magnetic field wound with a coil connected with the field-coils of the motor, and an armature wound with a coil connected with the motor-armature coils, substantially as herein explained.

14. In combination with an electric elevator, a limit-switch and a brake-magnet wound with two independent circuits suitably connected with an electrical source to cause current passing through one winding to act to hold the brake off, and the current passing through the other winding to act to put the brake on, the circuit through the latter winding being opened or closed by the movement of the limit-switch.

15. In combination with an electric-elevator motor, a limit-switch, a brake-magnet, and connections whereby said limit-switch breaks the running connections of the motor and closes a circuit through the brake-magnet in a direction to cause the latter to exert its force in applying the brake with pressure greater than when the brake is actuated normally.

16. In combination with an electric-elevator motor, upper and lower limit-switches through which normal operating connections are established for moving the car in the respective directions, and contacts in connection with each switch arranged for opening the circuit by which the motor is driven in the direction to be arrested while the brake-magnet is simultaneously cut into said circuit and energized, substantially as herein explained.

17. In combination with an electric-elevator motor, a main operating-switch provided with contacts arranged for keeping the field and armature circuits closed when the motor is at rest, as well as when it is in motion, and automatic safety devices operating through said constantly-closed circuits.

18. In combination with an electric-elevator motor and a brake-magnet therefor, holding the brake off by the passage of current therethrough, a main controlling-switch having contacts which close the armature and field circuits and break the connection between the brake-magnet circuit and the other parts of the motor-circuit when at the off position.

19. In combination with an electric-elevator motor having a brake with a controlling-magnet for holding it normally inactive, and with a suitable starting resistance; a controller for closing the circuits of the elements of the motor and opening the brake-circuit when at the "off" point and for closing the brake-circuit, connecting the motor elements with the line and cutting in or out the resistance when moved from the "off" point, substantially as explained.

20. In combination with an electric-elevator motor and the working circuits thereof, the automatic controlling-switch AS for cutting in and out the sections of the motor-

field, and the resistance R″ connected in shunt around the field-coil of said automatic switch, substantially as explained.

21. In combination with an electric-elevator motor having a sectionally-wound field, and the working circuits thereof; the automatic controlling-switch AS normally included in a closed circuit with said motor and having connections for cutting in and out the sections of the motor-field, substantially as explained.

22. In an electrically-operated elevator system having a sectionally-wound motor-field and a suitable resistance, a manually-operated controlling-switch provided with contacts through which, by the progressive movement of the switch-handle, the starting resistance is cut out and the ampere-turns upon the field are reduced, contacts acting to break the circuit between the motor-terminals and the main line, when the handle is turned to the inactive position, and contacts arranged to maintain the motor-circuit closed when the controlling-switch is in the off position as well as when in any working position, substantially as and for the purpose set forth.

23. In an electrically-operated elevator, the combination of a manually-operated controlling-switch, an electrically-actuated brake, and contacts on the controlling-switch whereby the circuit through the brake-operating magnet is opened and the main-line connection is broken when the handle is turned to the inactive position, while the motor-circuit remains closed, substantially as set forth.

24. In an electric-elevator system, the combination of a manually-operated controlling-switch and an automatically-operating reversing-switch acting to reverse the connections between the field and armature terminals to enable the motor to act as a generator, substantially as and for the purpose set forth.

25. In an electrical-elevator system, the combination of a controlling-switch, an automatic reversing-switch arranged to reverse the connections between the field and armature terminals to permit the motor to act as a generator, and the resistance R′ acting to divert the current from the reversing-switch magnet, substantially as and for the purpose set forth.

26. In an electric-elevator system, the combination of the controlling-switch, the automatic reversing-switch, the resistance R′ diverting the line-current from said reversing-switch, and contacts upon the reversing-switch through which the current is shunted around the resistance R′ when the elevator is running under normal conditions, substantially as and for the purpose set forth.

27. In combination with an electric-elevator motor, a main controlling-switch having a series of terminals, and bridging contacts connecting the armature and field of the motor in series and permitting them to act as a generator when said switch is moved slightly from the "off" point, substantially as explained.

28. In combination with an electric-elevator motor; a brake biased to the "on" position, a brake-magnet having two windings, one of which operates normally by the flow of current to hold the brake off, and the other of which windings, when operating upon the brake-magnet overcomes the holding-off winding, and acts positively in assistance to the application of the brake, and a switch closing the circuit through the additional winding, under abnormal conditions, substantially as explained.

29. In combination with an electric-elevator motor, and a main brake-magnet for holding the brake normally off, two windings upon said brake-magnet, one of which is in the normal operating-circuit and the other of which is in the additional circuit, and upper and lower limit switches both arranged to actuate the additional brake-winding, substantially as and for the purposes set forth.

30. In combination with an electric-elevator motor; a brake biased to the "on" position, and a brake-magnet having two windings upon its field and armature respectively, connected so that each imparts the same torque to the armature regardless of the direction of the main current; one of the windings inducing a torque greater than, and in the opposite direction to the other, and exercising its superiority of torque in the direction of positively augmenting the application of the brake, and suitable switches for controlling the flow of current through the respective windings, substantially as explained.

31. In an electric elevator, the combination with a brake biased to the "on" position, a brake-magnet having a winding in circuit with the main operating-switch, releasing the brake when the main actuating-current is applied to the elevator, also a winding inducing a torque opposed to and overcoming the torque induced by the winding first named, and an independent switch operating on emergency, controlling the second-named winding.

32. In an electric elevator, the combination of a brake, a magnet releasing said brake, a main operating-switch controlling said magnet, an additional winding on the magnet overcoming the releasing effect thereof, and an additional independently-operated switch controlling the circuit of said additional winding.

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Witnesses:
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