No. 720,605. PATENTED FEB. 17, 1903.

J. F. McELROY.

ELECTRIC TRAIN LIGHTING SYSTEM.

APPLICATION FILED SEPT. 9, 1901.

NO MODEL. 4 SHEETS—SHEET 1.

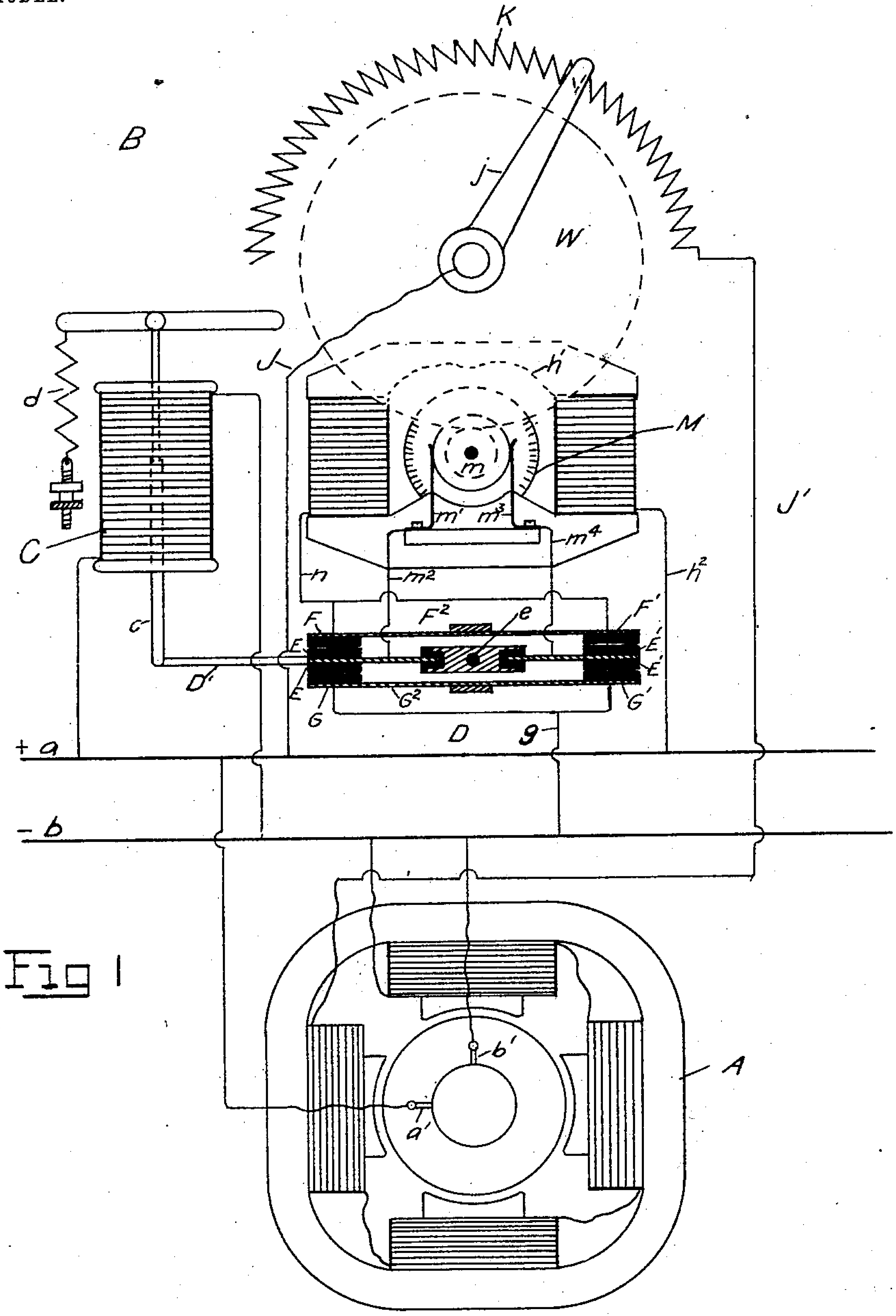

Fig 1

Witnesses

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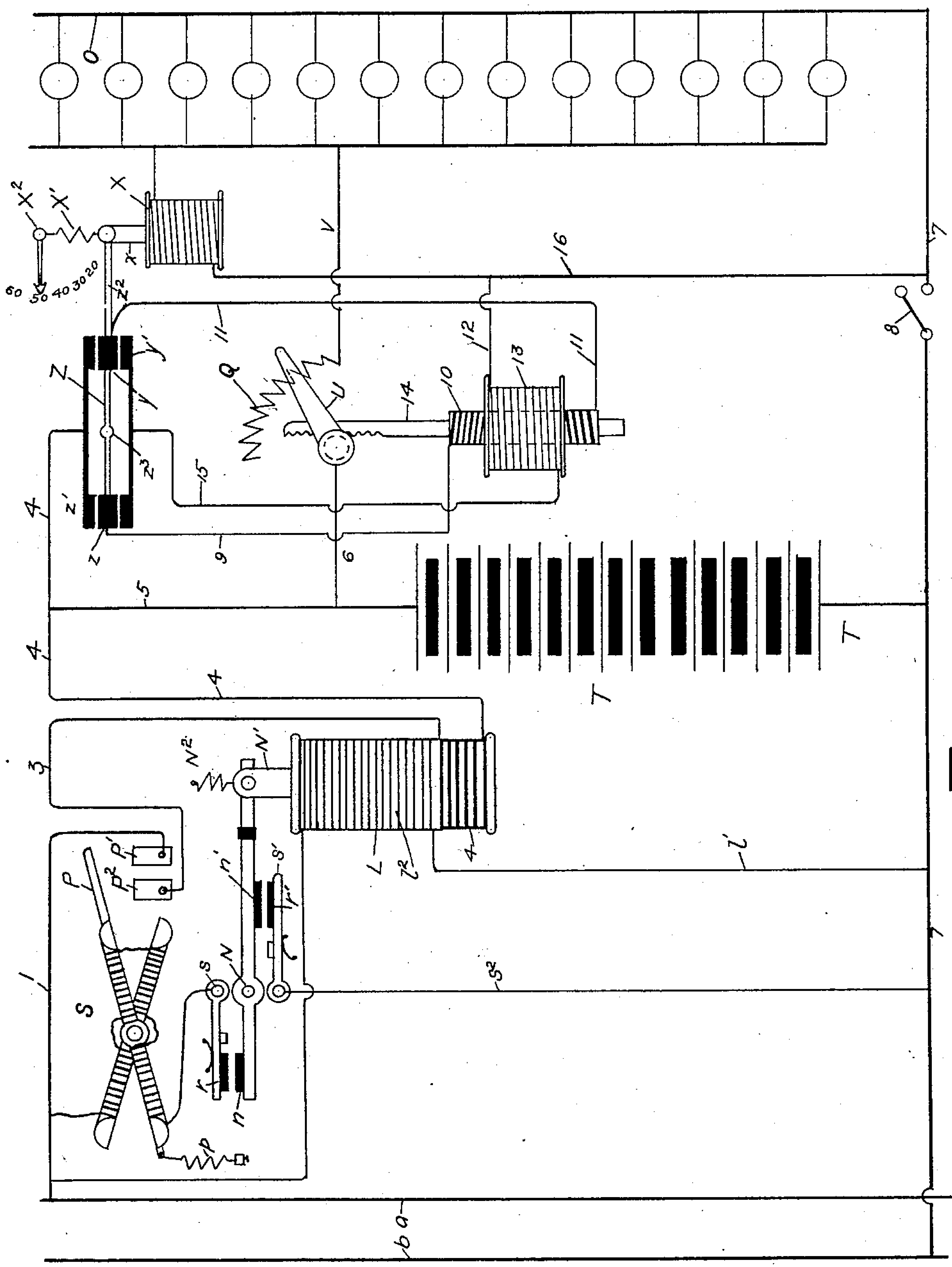

Fig 2

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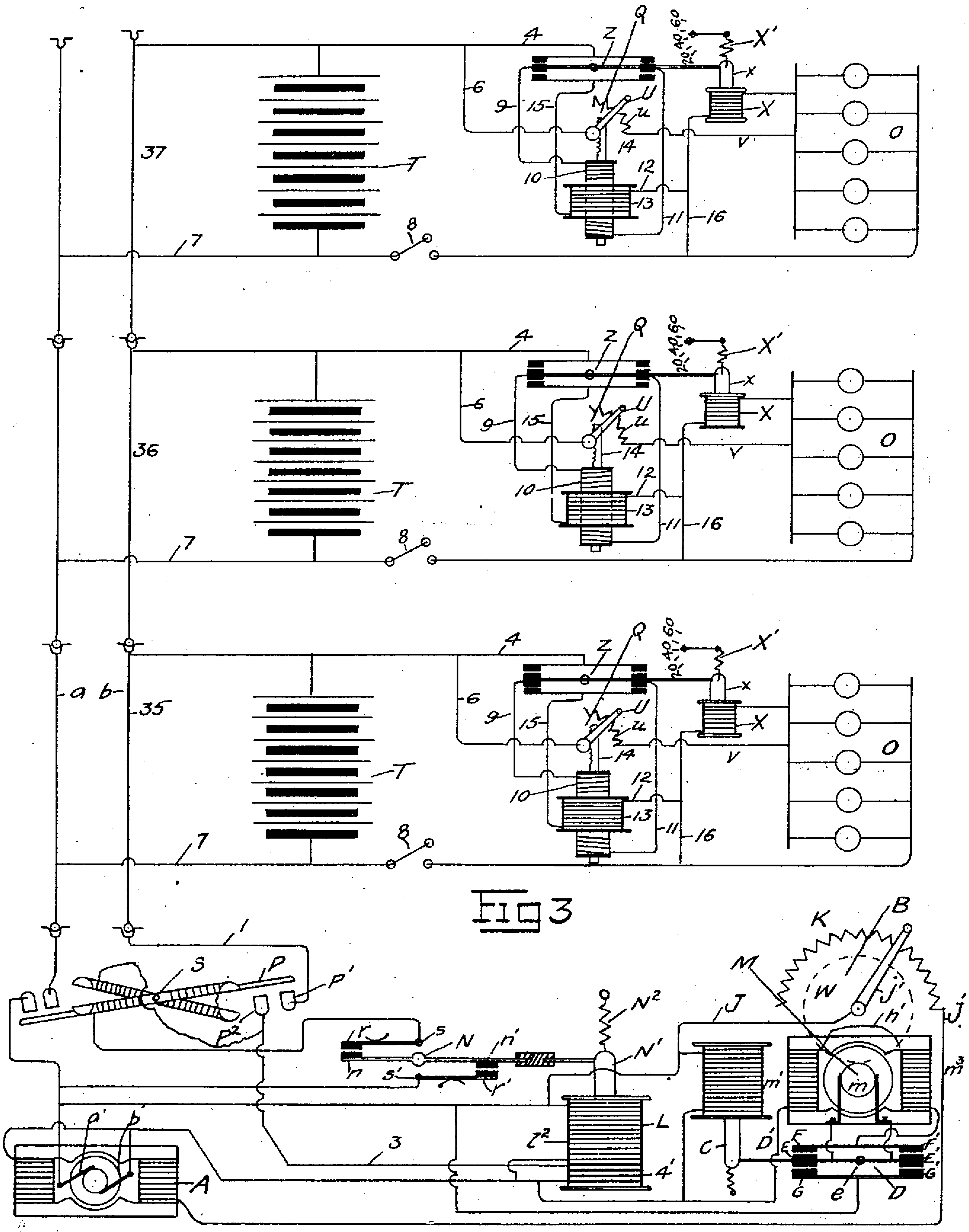
NO MODEL. 4 SHEETS—SHEET 3.



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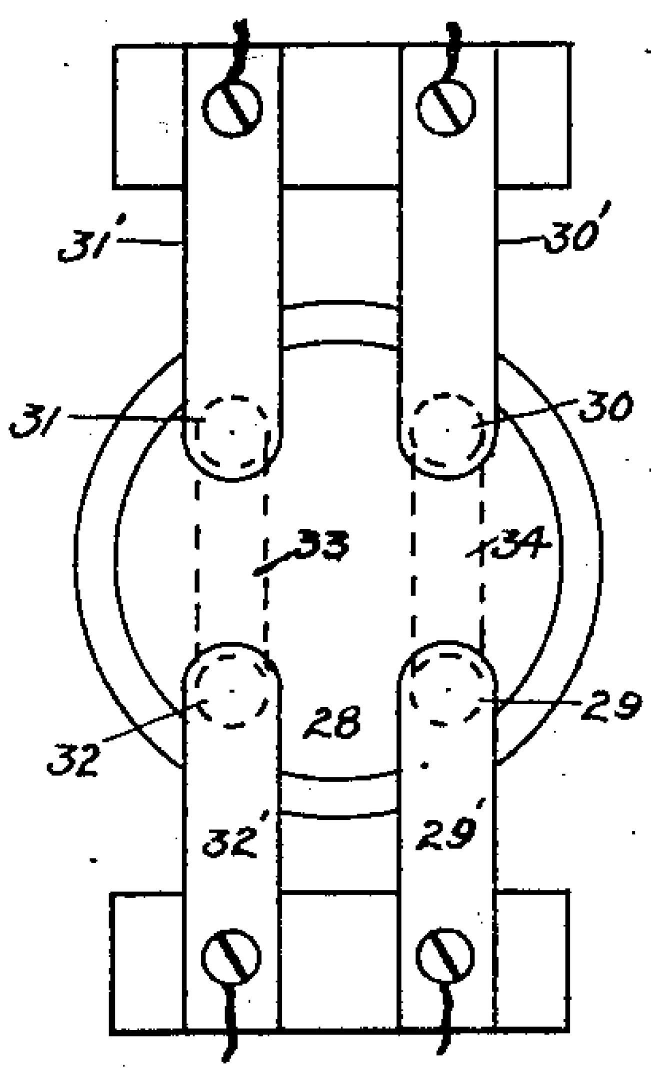

Fig 5

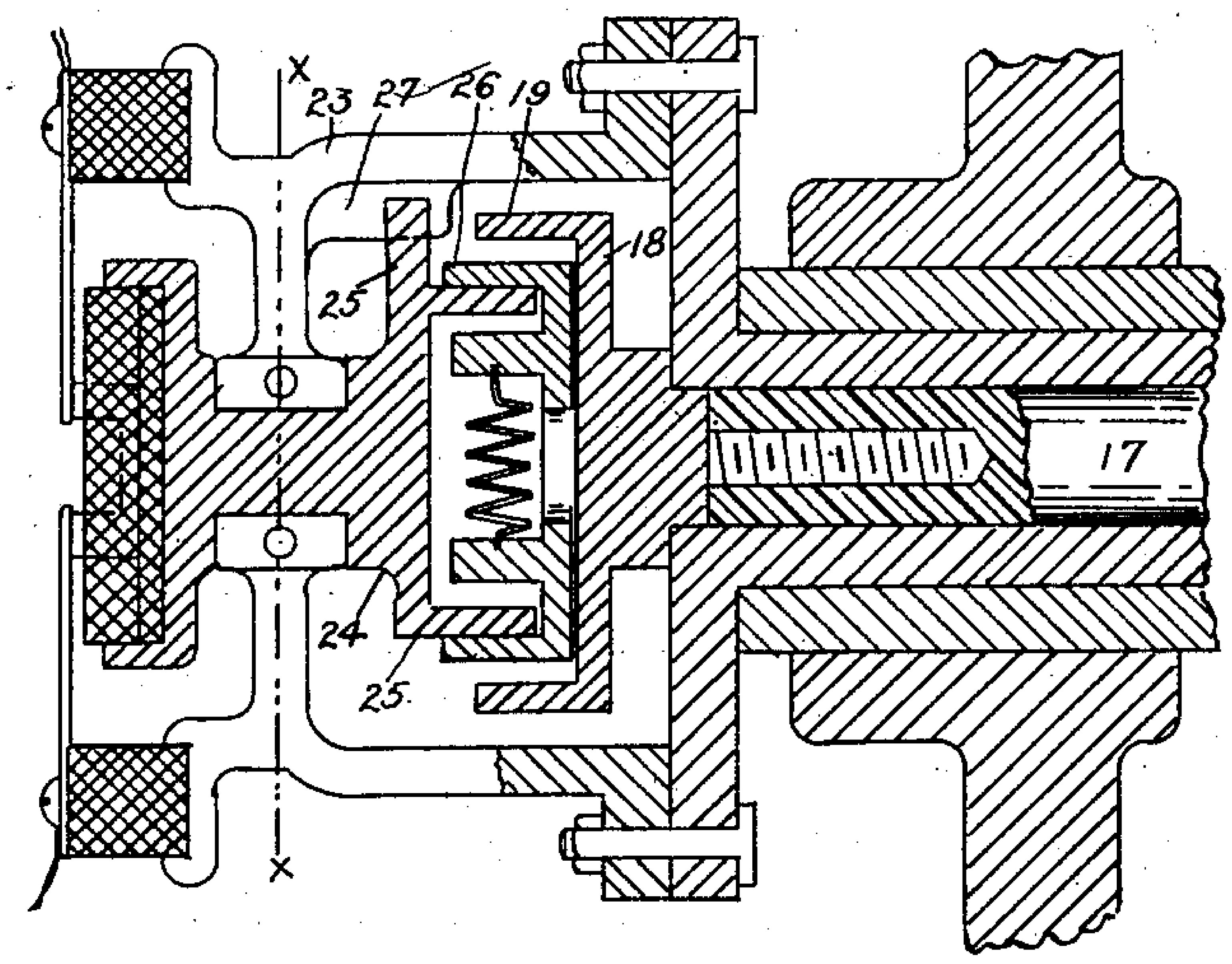

Fig 4

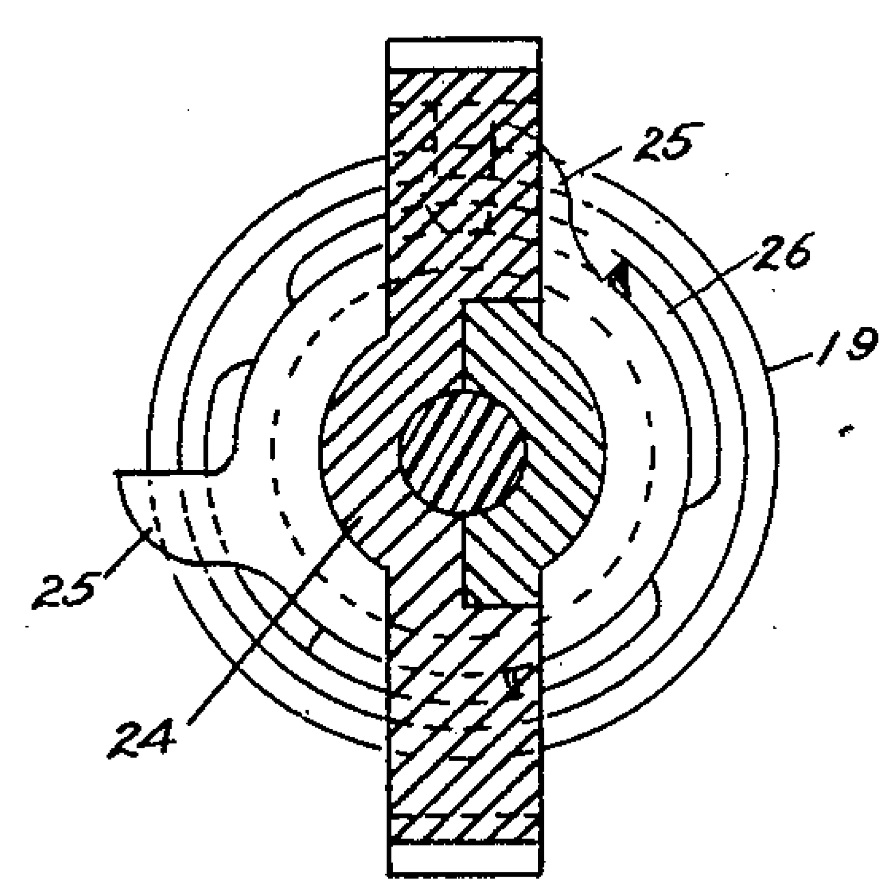

Fig 7

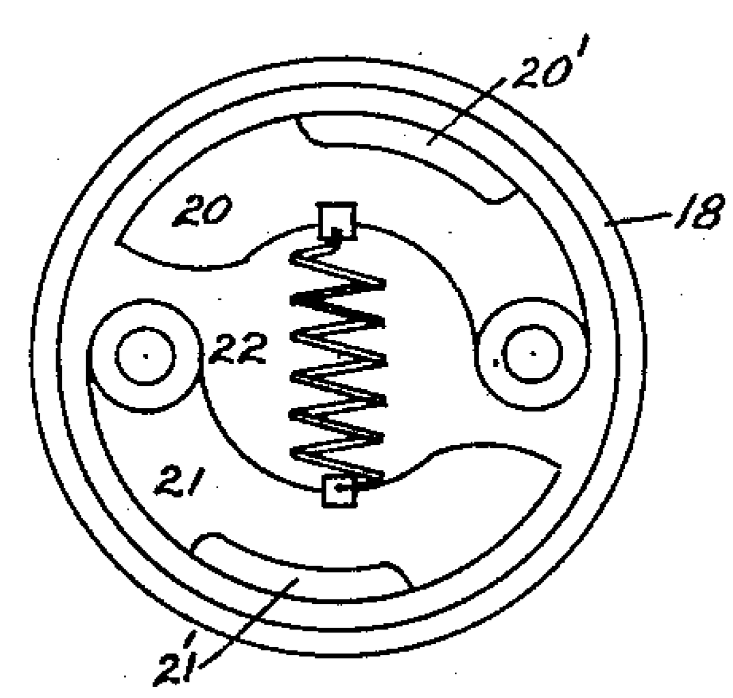

Fig 6

Witnesses

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UNITED STATES PATENT OFFICE.

JAMES F. McELROY, OF ALBANY, NEW YORK.

ELECTRIC TRAIN-LIGHTING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 720,605, dated February 17, 1903.

Application filed September 9, 1901. Serial No. 74,769. (No model.)

To all whom it may concern:

Be it known that I, JAMES F. McELROY, a citizen of the United States, residing at Albany, county of Albany, State of New York, have invented certain new and useful Improvements in Electric Train-Lighting Systems, of which the following is a specification, describing as an illustration of the invention that form thereof which I now regard as the best one out of the various forms in which it may be embodied.

Reference is made to the accompanying drawings, wherein—

Figure 1 is a conventional representation of a dynamo and regulator therefor, showing circuits and connections. Fig. 2 is a diagrammatic view of a car equipment. Fig. 3 is a diagrammatic view of the dynamo, regulator, and switching device, shown as placed in one car, with the local circuits connected with the lights connected therewith in separate cars in the train. Fig. 4 is a section of the current-reverser connected with the dynamo. Fig. 5 is an end elevation of said current-reverser. Fig. 6 is a plan of the wheel 18. Fig. 7 is a section along the lines *x x* on Fig. 4.

Similar letters refer to similar parts throughout the several views.

The present application is a continuation of my application, Serial No. 706,165, filed February 20, 1899.

My invention relates to a system in which the electricity required for lighting a car or train is derived from a generator driven by one of the car-axles, a storage battery being employed which will be charged by the generator whenever the lamps are not in use and whenever the charge in the battery falls below the normal potential of the system and which will also serve to operate the lamps when the train is standing still or when for any other reason the electric pressure of the generator falls below the normal pressure of the system or the pressure of the battery rises above that of the dynamo. In providing a practical system of this type it is manifest that a serious difficulty is presented by the extraordinary range of speed variation to which the generator is subjected, since the speed of the train varies from standstill up to ninety miles an hour, it being necessary in practice to provide for the contingency of the train reaching the latter speed under certain conditions more or less temporary. In order to meet this situation, it has been heretofore proposed to employ a centrifugal device responding to the speed variation of the generator, which should reversely regulate the field-magnet strength of the generator, reducing it as the speed increases, and vice versa. This has been found impracticable, however, since speed variations may occur more rapidly than the generator can respond to the regulating action of the governor, and particularly when the centrifugal governor is employed to determine the point of speed at which the generator shall be thrown into action it has been found that at the chosen speed the generator might or might not be in the proper condition to begin action. It has also been heretofore proposed to regulate the generator and determine its point of action by means of a series magnet contained in the armature-circuit and responding to the volume of current generated by the machine. It is, however, impracticable to make the current volume the determining factor of regulation. The current is a variable factor and is not a constant, nor is it feasible to employ a constant current. For instance, a current required for a train of eight cars is four times that required for two cars, while in each car the amount of current required depends upon the condition of the storage battery and upon the number of lamps which happen to be turned on. Therefore a series magnet which can only regulate to produce a constant current from the generator is not a desirable determining factor for the regulation. In my system I employ in connection with other features to be hereinafter described a shunt-magnet responding to the electromotive force or pressure of the system as the determining factor for the regulation and also for the bringing of the generator into action. This shunt-magnet is independent of the armature-current and responds to the pressure or electromotive force as distinguished from the current volume or amperage of the system and acts to correct any departure from the normal pressure by setting agencies at work which will raise the pressure if it falls too low or reduce it if it rises too high. This use of a shunt or potential magnet as the determining factor for regulation and for the coming into action of the generator is one of the characteristic features of my system. Again, it has been proposed to employ a "series" dynamo or a "compound" dynamo for lighting railway-trains from a car-axle in distinction from a "shunt" dynamo, in which the field-magnet is in a shunt-circuit and dependent only upon the pressure or voltage of the system. Such series or compound generators are, however, impracticable on account of the speed variation to which they are subjected. In a machine having its field-magnet energized wholly or partly by a series coil the electromotive force does not vary directly with the speed, but increases more rapidly than the speed and decreases more slowly than the speed. Therefore it will not automatically regulate itself for constant potential under such wide variations of speed, nor is it feasible to employ an external regulator therefor responding to speed variations or to variations from a constant potential and acting upon the series field-magnet coil wherein there is a widely-varying current or upon a multiplicity of shunt and series field-magnet coils in which the currents vary according to widely-differing laws. Moreover, in many cases the attempt to employ a generator having a series field-magnet coil has been so carried out as to insure the reversal of the generator by the storage battery. For the foregoing reasons and for others which it is not necessary to mention another characteristic of my system is the employment of a shunt-generator as distinguished from a series or compound generator. Again, with a generator subjected to such violent fluctuations in speed it is impracticable to make the regulating-coil itself the immediate agency for correcting the departures from the normal conditions determined by the coil. Thus, assuming that the regulating-coil in a shunt-circuit is set for a given voltage, if the coil itself acts immediately upon the generator field-magnet to strengthen it when the voltage is too low or weaken it when the voltage is too high the action of the magnet tends to destroy the very conditions upon which its action depends and with the violent fluctuations in speed produces an unstable situation, which causes wide fluctuations in the voltage instead of the constant voltage desired. Therefore in my system I provide that the shunt-magnet, which determines the regulation, is made to set into action (by means of a director) a motor, which in turn acts upon the field-magnet of the generator. The shunt-magnet also acts to maintain such motor in operation until the departure from normal voltage is corrected. Again, it is evident that the system must be capable of action whether the train and generator run in one direction or the other. It has been heretofore proposed to place a reversing-switch in the main circuit of the generator, which should reverse the connection of the brushes with respect to the main line; but it has not been conceived that with a shunt-dynamo such as I have employed in my system there must be also provided an arrangement whereby the connection of the field-magnet circuit of the generator shall remain unchanged. If this is not provided for, it is uncertain whether the machine will generate or not, or if it does in which direction the generated current will start, and if it starts in the wrong direction both the battery and the dynamo will be short-circuited upon each other with disastrous results as soon as the battery is connected in. To avoid this difficulty, I provide means for reversing the relations of the generator-armature with respect to the field-magnet terminals, as well as with respect to the main lines, such means comprising a reversing-switch located in the main circuit of the dynamo between the brushes and the point at which the field-magnet shunt-circuit is derived from the main circuit. This will maintain the polarity of the field-magnets unchanged for both directions of rotation of the generator, it being also remembered that the field-magnet must be fully energized at the moment when the armature is connected to the storage battery or there will be a short circuit of the latter. This reversing-switch I prefer to operate mechanically by a frictional device on the armature-shaft. In the mechanical operation of the reversing-switch just mentioned it has been heretofore proposed to have a clutch or other frictional device which would engage the driven shaft and also be connected with the reversing-switch, so as to throw it in one direction or the other, according to the direction of the shaft, such device being left in frictional engagement during the running of the machine, with the result that it becomes worn and fails to operate. I therefore provide my friction-clutch with a centrifugal governor, which will throw it out of engagement when the proper speed is reached and after its operation of the switch has been completed. I do not, however, make claims to this feature in the present application, it being embraced in another application forming a division hereof. Again, in the energizing of the field-magnet of the generator by a shunt-circuit having a constant potential maintained thereon by the joint action of the generator and the storage battery it has been found that the charge of the storage battery will leak away if the car be left standing for a few hours or more by the small flow of current from the battery through the field-magnet coils, and to avoid this difficulty I provide for automatically disconnecting the field-magnet coils from the storage battery whenever the car stops. Moreover, I provide that when the battery becomes fully charged its connection with the dynamo will remain unbroken; but if for any reason the pressure of the battery exceeds that of the dynamo the connection will be broken automatically. Finally, in connection with a train system wherein storage batteries on different cars are all charged from one dynamo on the train by means of line-wires extending from car to car through train-couplers I have found that trouble may be caused by leaving individual cars standing in the train-yard or elsewhere with their storage batteries connected to the train-wires terminating at the coupling. The possibilities of mischief thus presented has not escaped the discovery of boys and other persons who can with a wire or nail or any other metallic article connect the exposed terminals in the coupler, and thereby produce an arc or short circuit, which is destructive to the battery. Therefore I preferably provide in my system that the battery shall be automatically disconnected from the train-wires terminating at the couplers whenever a car comes to a standstill. I have also provided other useful details of construction, which will be hereinafter described. It may be also noted that my system is one in which but one storage battery is employed, which is used only to supplement the generator. By far the greater portion of the electrical energy is thus supplied directly from the dynamo to the lamps, which avoids the loss that is characteristic of systems in which the lamps are supplied from the storage batteries alone, and the generator is employed only for charging the battery and not for operating the lights directly. More particularly, this feature of my system reduces the wear upon the batteries to an insignificant point as compared with the systems just mentioned. This is a matter of importance, since it largely eliminates the matter of battery depreciation, which is recognized as a serious defect in batteries under all conditions, and particularly when they are employed upon a moving vehicle.

Turning to the accompanying drawings, I now proceed to describe my electric train-lighting system in detail.

I place a constant-potential dynamo A, Figs. 1 and 3, in the baggage-car or the locomotive or other convenient place and connect the same in any suitable manner (not shown) to the running-gear of the train in such a manner that the revolution of the wheels will tend to operate the dynamo. I connect the commutator-brushes of the dynamo a' b', respectively, to the main circuit, composed of the wires a and b. The constant potential is secured by means of a device which I term a "governor," operating upon the principle already outlined. The connection of the dynamo to the lamp and battery circuit is accomplished when the dynamo has attained such speed (be it greater or less) as will give the proper potential. This I have also indicated above. In shunt with the dynamo I place the governor B, which is composed of an electromagnet C, which is connected to the wires a and b, the shunt-circuit from the dynamo passing through the magnet C. Within the magnet I place a bar c, which will tend to be drawn into the magnet in proportion to the strength of the current passing therethrough. I arrange a spring d in the manner shown in Fig. 1, against the tension of which said bar acts when magnetized and which tends to force the bar c to its normal position when the strength of the current in the magnet C permits such adjustment. Operated by the bar c I arrange a current-director D, which is composed, preferably, of a series of carbon blocks E F G and E', F', and G'. The carbons E E and E' E', I arrange upon the pivoted lever D' and upon each end thereof and connect said lever to one end of the bar c. Between the carbons E and E', preferably adjacent to the pivot e, I insulate the lever D', so that the current will not pass from one end of the lever to the other. The carbons F and G are suitably connected with the plates F^2 and G^2 adjacent to the carbons E E, while the carbons F' and G' are carried upon the same plates F^2 and G^2 adjacent to the carbons E' E', so arranged that diagonal connections will be made between the carbons on the current-director when the bar c is drawn out of its equilibrium, which is arranged to be maintained when the current from the dynamo through the magnet is of a given intensity. The purpose of the director just described as controlled by the shunt-magnet C (whose action depends upon the potential or pressure between the main lines a and b) is to send the current in one direction or the other through the armature of an electric motor or to interrupt such current entirely, and the motor in turn acts to decrease or increase the amount of resistance in the shunt-circuit passing through the field-magnet of the dynamo or to maintain it constant. The motor is also in a shunt-circuit between the main wires a and b, and its current is interrupted entirely so long as the potential on the main circuit is normal and the potential magnet C is in equilibrium. Upon any departure from such normal pressure the director is brought into action and maintained in action until its rotation in one direction or the other corrects the aforesaid departure by strengthening or weakening the field-magnet of the dynamo to increase or decrease the dynamo-potential, according as the departure from normal pressure is below or above the normal point. Between the field of the dynamo A and the main circuit I arrange a shunt-circuit consisting of the wire J, connected with a rheostat K by means of the arms j, said rheostat being connected with the field of the dynamo A by means of the wire J'. The object of my electromagnet and switch apparatus is to throw in or out the resistance of the rheostat, determined by whether the dynamo is furnishing too large or too small an electromotive force. I then arrange the motor M, preferably provided with a gear m, meshing with the wheel W, to which the arm j is attached. Thus the movement of the motor will throw in or out the resistance of the rheostat, depending upon its direction. I connect the brush m' of the motor by the wire m^2 to the lever D' and connect the brush m^3 by the wire m^4 to said lever D' on the other side of the pivot e from that to which the wire m^2 is connected. The field of the motor is connected to the carbon F F' of the current-director by the wire h and with each other by the wire h' and also to the main line a by the wire h^2. The carbons G and G' are connected by the wire g to the main line b. When the electromagnet C becomes charged to the extent of drawing the bar c against the tension of the spring d, upper contact will be made between the carbons E and F at one end of the current-director and between the carbons E' and G' at the other end. The current will then pass from the main line a by wire h^2, field, wire h', opposite field, wire h, carbon F, carbon E, wire m^2, brush m', the motor, brush m^3, wire m^4, carbon E', carbon G', wire g, to main-line wire b. This will cause the motor to revolve, throwing the arm j of the rheostat into such a position as to bring additional resistance into the main-line circuit, which will tend to demagnetize the fields of the dynamo A, and therefore decrease the electromotive force supplied to the main line. When the magnetism in the electromagnet is insufficient to hold the bar c against the tension of the spring d, contact is made between the carbon E and the carbon G on one end of the current-director and between the carbon E' and the carbon F' on the other. The current then passes in just the opposite direction through the motor-armature and then through the fields to the main line, and therefore revolves the wheel W in the opposite direction, carrying the arm j and throwing out resistance and in this manner bringing up the magnetism of the field of the dynamo until the current through the electromagnet C is sufficient to raise the current-director lever until it occupies the position shown in Fig. 2 when the carbons are out of contact with each other. I do not limit myself to this arrangement for the current-director nor to its details. (The current-director illustrated here forms the subject of an application filed simultaneously herewith in which claims are set up thereon, and the same is true of the current-directors shown in Figs. 2 and 3.) Instead of using carbon contacts I may use any other suitable material, although carbon is in many respects superior, because of the fact that it does not blister and peel with large currents and prevents sparking, nor do I limit myself to the use of a motor for the purpose of operating the rheostat-arm j, as this may be accomplished by other well-known means.

I will now next describe the automatic means for reversing the connection of the armature of the dynamo to the main line for a change in the direction of the car. I accomplish this result by means of the device illustrated in Figs. 4, 5, 6, and 7. Attached to one end of the dynamo-shaft 17 is a wheel 18, provided with a rim 19. To the face of the wheel 18 I arrange two curved levers 20 and 21, Fig. 6, each pivoted near one end to the wheel and each lever provided with a projection 20' and 21', respectively. A spring 22 connects said levers and tends to draw them toward each other. As thus arranged, it is apparent that with the rapid motion of the dynamo-shaft the levers 20 and 21 will tend to separate against the tension of said spring. Mounted in a suitable frame 23, Fig. 4, which is secured to the frame in which the dynamo-shaft 17 is mounted, I arrange a wheel 24, provided with a rim 25, adapted to come in contact with the projections 20' and 21' on the levers 20 and 21, so arranged that when the wheels are quiet or moving slowly the projections 20' and 21' will make close contact with the rim 25 on the wheel 24, and the movement of the wheel 18 on the dynamo-shaft when the dynamo is starting will move the wheel 24. The wheel 24, however, is limited in its motion, preferably to one-quarter of one turn as the limit, being stopped by the projection 25 on the wheel 24 coming in contact with the stationary portion 27 of the frame 23. The wheel 24 is provided with a face 28, Fig. 5, on the side of the wheel opposite that upon which is placed the rim 25, in which face 28 are countersunk four contacts 29, 30, 31, and 32, equally spaced, and preferably at equal distances from the center. Four corresponding brushes 29', 30', 31', and 32' are mounted in insulated blocks in the frame 23. The contacts 29, 30, 31, and 32 are joined in pairs within the stationary wheel by means of the insulated contacts 33 and 34, respectively. Connected with the brushes 29', 30', 31', and 32' are wires leading to the armature and to the mains. When the dynamo starts and is revolving slowly, the pressure of the projections 20' and 21' on the wheel 18 will cause the wheel 24 to make a partial revolution, which will operate the contacts 29, 30, 31, and 32 and will cause them to assume in reference to the brushes either the position shown in Fig. 5, in which the current passes from the brush 29' to brush 30', from brush 32' to brush 31', or on the wheel being revolved in the opposite direction, caused by the movement of the dynamo-shaft in that direction, from brush 29' to brush 32', from brush 30' to brush 31', the insulated connecting-pieces 33 34 occupying a position at right angles to that which they occupy in Fig. 5. It is understood that the direction of current in the fields of the dynamo and the field polarity remains the same, this being provided for by locating the reversing-switch just described between the brushes of the dynamo and the main line, as appears in the circuits already traced, and by deriving the shunt-circuit for energizing the fields from the main lines themselves, as shown in Fig. 1, and by thus changing the direction of the current from the armature to the mains the direction of current is maintained the same, regardless of the direction in which the car is moving. If the dynamo is speeded up, the centrifugal force will remove the pressure of the projection 20′ and 21′ on the levers 20 and 21 from the rim 25. The wheel 24, which carries the contacts as aforesaid, will remain stationary and unaffected by said levers. It is only when the dynamo slows down that there is any friction between the projections on the levers and the rim of the wheel. There is just sufficient motion given to the wheel to make the change of connections, and this change is only made when the direction of movement of the car is reversed.

Between the cars of the train I arrange suitable electric connectors, as indicated in Fig. 3.

I will now describe the means for automatically bringing the dynamo into action at the proper instant by connecting its armature-circuit to the main line when the conditions are such that the electromotive force of the dynamo, whatever its speed, will when connected in be adequate to meet without danger the opposing electromotive force from the battery.

In Fig. 2 I show a car equipment in which the main-line wires *a* and *b* are suitably connected up with the local circuit, preferably in the following manner: To the wire *a* I connect the wire 1, which is provided with a switch S in series between the main line on the one hand and the storage battery T and the lamp-circuit on the other hand, the object being to provide automatically for cutting out or bringing in the current from the main line to the storage battery and the lamp-circuit. This switch S is preferably composed of two bars pivoted together, each of which is wound by a wire, one terminal of said wire being connected to the wire 1, the other to the contact-plate *s*. One of the bars is stationary. The other is movable and connected to a spring *p*, tending to hold the switch-bars apart, and the other end of said switch-bar is provided with a contact-plate P, adapted to engage with contact-plates P′ and P^2, to one of which the wire 1 makes contact and to the other the wire 3, connected with the electromagnet L. The operation of this switch is to provide for the making of contacts between the plate P and the contact-plates P′ and P^2 whenever the current from the wire 1 magnetizes and tends to draw the two bars of the switch together against the tension of the spring *p*. The current will then flow through the wire 1, contact-plates P′ P P^2, which connects with the electromagnet L and from which the current will pass by wire 4 and 5 to the storage battery T, also by wire 6 and wire *v* to the lamp-circuit O after passing through the regulator device Q. One coil of the electromagnet L is placed in the described series circuit, (while at the same time having its second coil in a permanently-closed shunt-circuit between the main lines *a* and *b*.) The shunt-coil is connected with the main wire 1 by the wire *l*, as above described, and with the wire 7, which connects with the wire *b*. The contact-plate *s*′, similar to *s*, is connected by the wire s^2 to the wire 7. The pivoted lever N, provided with carbon contact *n* on one side of the lever and carbon contact *n*′ on the opposite side of the lever, is arranged to make contact, respectively, with the carbon *r* on the plate *s* and the carbon *r*′ on the plate *s*′. Said pivoted lever N is connected with the iron bar N′ in the magnet L and the spring N^2, counterbalancing the pull of the magnet to a certain extent for the purpose of holding the pivoted lever N out of contact until current due to a specified voltage is sent through the magnet. When the current is passing through the shunt-circuit, it enters the wire *l* and the shunt-coil l^2 on the magnet L, which becoming charged draws the bar N′ downward, making contact between the carbons *r* and *n* and *r*′ and *n*′, which will make a current from the wire 1 through the wire on the switch-bars, tending to draw them together against the tension of the spring *p* and make contact between the plates P, P′, and P^2. Current will then pass through the wire 3 to the large series coil 4′ on the magnet L and strengthen the pull of the bar N′, tending to hold securely in position the switch-bars S. Current then passes to the wire 4, wire 5, to the storage battery T, and also by wire 6, arm U to the rheostat *u*, wire *v*, to the lamp-circuit O. The magnet L, it will be noticed, has its shunt-coil l^2 permanently in circuit, that coil being the only one except the shunt-coil of the field-magnet and coil C of the governor B which is in circuit with the dynamo when it begins to rotate and throws the reversing-switch to one side or the other, and no other apparatus is in circuit until the generator reaches a speed which will produce the normal voltage with no resistance in its field-magnet circuit. When this point is reached or when any other desired voltage is attained, the magnet L is energized by the shunt-coil l^2 and closes the circuit of the coil on the main switch S. This switch will be held firmly closed so long as the voltage is above the lower limit, and current will flow from the generator to the battery and lamps through a circuit containing series magnet 4′. This will strongly energize the magnet L, but will leave the magnet S free to respond to an abnormally low voltage. In the event, however, of the pressure of the generator falling below that of the storage battery or the pressure of the battery rising above that of the generator the current in coil 4′ will fall to zero, and upon the subsequent passage of a slight reverse current therein the coil 4′ will overcome the shunt-coil l^2, and thereby release the core N′, which in turn will open the circuit of the main switch S. This provides that after the battery is fully charged it will not be disconnected so long as the train is running at a sufficient speed to give the dynamo the normal voltage, and the main switch will not be opened till there is an excess of battery-voltage above the dynamo-voltage. In the wire 7 there is a switch 8, which should be closed when the lamp-circuit is used.

I also provide for the lamp-circuit an automatic regulator in which a shunt-magnet responding to differences in potential on the lamp-circuit is employed, like the magnet C, heretofore described, to control a director, such as I have explained in connection with the governor B. This director, like the one just mentioned, controls an electric motor, which in turn serves to introduce more or less resistance into the lamp-circuit to compensate for any variations from an adjusted and predetermined potential due either to a reduced number of lamps or to a variation in the normal potential of the system or of the storage battery when it alone is operating the lamps. This is particularly designed for sleeping-cars, since it enables the porter to turn down all of the lamps simultaneously to any desired degree, and they will then remain in that condition without disturbance by a change of pressure due to turning a portion of the lamps completely off or to any other cause. It is also of advantage in such a situation, because it enables individual lamps to be turned on and off without affecting the remaining lamps. This is required by the necessity of having separate lamps in the individual berths or compartments which must be capable of separate control without regard to one another. If the lamp-resistance were not thus varied with respect to the potential applied to the lamps, but were left as a lump resistance in series with all the lamps in a bunch, the turning out of a portion of the lamps would cause the potential applied to the remaining lamps to rise until with but one or two lamps in circuit the resistance would have but little or no practical effect in reducing the lamp-potential below that applied to the batteries, which is greater than the lamps could endure. The advantage of employing a motor as the controlling, connecting, or operating device between the shunt-magnet measuring the lamp-potential and the resistance in the lamp branch lies in the fact that if the lamp-potential is to remain constant the measuring-magnet must also receive a constant current and its core be held in a constant position, except as it may temporarily move in or out upon any departure from the normal desired potential to set in action mechanism that will correct the departure and allow the core to resume its normal position. If the said controlling, connecting, or operating device took the form of a direct attachment of the magnet-core to the rheostat-arm, the magnet could only correct the said departure by a movement of its armature in or out to a new position, which position could only be secured by a change in the pressure of the system, which is the very feature which it is desired to keep unchanged. It should also be noticed that the magnet C is connected to that part of the circuit which supplies the battery outside of the resistances Q in series with the lamps, and hence measures the battery conditions, while the magnets X in the lamp branches measure the lamp conditions, which are different from those of the battery.

In connection with the lamp-circuit I arrange a magnet X, which is also connected with the wire 7 and a current-director Z. This current-director is similar in construction to the current-director used with the dynamo-regulator, the middle bar or plates z^2 being pivoted at z^3, at which point it is also provided with insulation to prevent current passing from one end to the other. When the current passing through the lamp-circuit, and therefore through the magnet X in multiple with the lamps, is greater than that required or advised in the lamp-circuit, the magnet becoming charged draws the bar x against the tension of the spring X′, thus operating the pivoted plate z^2 of the current-director Z and making diagonal contacts between the carbons z and z' at one end of the current-director and between the carbons y and y' at the other end. Current will then pass from the wire 4 to contact z', contact z, wire 9, to armature 10, to wire 11, to contacts y y', to wire 15, to field 13, to wire 12, to wire 16, and to wire 7 beyond the switch 8. The passage of the current in this direction through the armature 10 and the field 13 will move the armature within said field in such a direction as to throw in a greater amount of the resistance of the rheostat Q by means of the rack 14, connected with the armature 10 and adapted to mesh with teeth on the rheostat-arm U. On the other hand, when the intensity of the lights is less than that required the magnet X will be weakened, the spring X′ will withdraw the bar x, and opposite contacts will be made within the current-director Z. The current through the armature 10 will thus flow in the opposite direction, while that through the field 13 still retains its former direction, and the armature, rack, and rheostat-arm will be moved in such a way as to throw out a portion of the resistance u, and thus add to the intensity of the lights. I preferably secure the spring X′ to an indicator-arm X^2, which points to figures or other marks to show the intensity of the lamp-circuit when the arm points to them, respectively, and so arrange the connection of the spring to said arm that when the arm is drawn toward the lesser number the spring is correspondingly released and will cause the regulator to throw in more resistance in the manner described, and thus reduce the light, and when operated in the opposite direction will cause the regulator to throw out resistance, and thus increase the light. I describe this apparatus in an application on current-director, as before stated, and do not here limit myself to any particular indicating device. In case the storage battery becomes overcharged the current is pushed backward toward the main line, tending to cause a reversal in the magnet L, the bar N′ will, as I have already described, be released from the pull of the magnet, and the spring N^2 will draw it up and break contacts between r' and n' and r and n. The switch S will then immediately break contacts with the plates P′ and P^2, and no current will pass from the dynamo to the local circuit. The lamp-circuit will then be supplied by the storage battery until the current passing through the magnet L will close up the switch and draw current from the main line.

As constructed, my system will provide for supplying a train with an electric-lighting system in which the current from the dynamo shall be maintained constant in its voltage and delivered to each car in just sufficient quantities to maintain the lights at a constant degree of intensity and to keep the storage battery fully charged, the dynamo having an adequate current capacity for this purpose—to wit, a capacity sufficient for the normal lamp-load plus the battery-load. It will be noticed that the governor for the dynamo is absolutely automatic in its operation, as is also that of the regulator of the light-circuit placed between the storage battery and said circuit. Thus in reference to the regulator, regardless of the number of revolutions made by the axle of the car, the current delivered to the train will be maintained at a constant voltage, and the device that is used for regulating the supply to the lamp-circuit may be so adjusted that the lamps in circuit shall be kept at any desired degree of luminosity.

The means for operating the rheostat in the regulating device for the lamp-circuit are shown as substantially a motor; but I do not wish to limit myself to this means of controlling the rheostat. Instead of the field-magnet and armature I may use a common motor or any suitable automatic arrangement.

I do not limit myself to such an arrangement of the current-director that there shall be no contact between the carbons when the director is in equilibrium, since I can so adjust it that it shall operate as pressure is applied to the carbon contacts. It will also be noticed that in the current-director used in my system I provide for yielding contacts, so that in case one contact is made first it will give until the other contact is made, this being particularly desirable in apparatus of this kind, especially that in which the apparatus is to be automatic and where the contacts are apt to be made and broken very frequently. I also call attention to the fact that I have used, preferably, carbon contacts, which I find to be particularly serviceable in electric-lighting apparatus, the carbon being a material which makes good contact and does not blister or become injured by sparking. As stated before, however, the subject of current-directors is contained in a separate application filed simultaneously herewith and to which cross-reference is hereby made.

In Fig. 3 I show as a modification a train-lighting system arranged in substantially the same manner already described, with this difference that instead of placing the switch S and its connections, including the magnet L, carrying a shunt and series coil, pivoted lever N, and carbon contacts in the local circuit on each car, as shown in Fig. 2, I may arrange them, as shown in Fig. 3, on the car containing the dynamo, thus leaving each of the local circuits 35, 36, and 37 connected with the mains a and b and each containing a storage battery and lamp-circuit and a regulator for the lights in that circuit. As thus arranged the lights in each of the cars in the train are maintained of equal intensity, the storage batteries forming a reservoir for the train and the combination of storage batteries operating on the switch S in the manner indicated by the one storage battery and lamp-circuit in Fig. 2. By this arrangement I do away with the necessity of providing additional switches and electromagnets for each car, making the system more economical and, it is believed, equally efficient. The operation of these various elements of the system placed as indicated in Fig. 3 is substantially the same as that already described in reference to Fig. 2.

Although I have entitled my invention a "Train-lighting system" and have described the same as used in lighting several cars in a train and have mentioned a "distributing-circuit" and other features which may be pertinent to a train of several cars, I do not of course intend to limit myself to any number of cars, since it would operate equally well for lighting one car or several, and therefore wherever in the description or claims I have used the word "train" I wish it to be understood as meaning either one or more cars and the expression "distributing-circuit" as being the main circuit for one car or for more.

The operation of my device is such that it is unnecessary to provide an electrician with a train equipped therewith. There is nothing dependent upon the oversight of the conductor, engineer, or electrician. When the wires are coupled between the cars of the train, the system is ready for operation and will operate as soon as current is supplied from the dynamo. The mechanism connected therewith is simple in its construction and operation, inexpensive, and performs its results in a positive and economical manner.

In some of the following claims I describe the potential-magnet as "independent of the armature-current," which phrase is only intended to express the essential character of the potential-magnet as a device which measures the electrical potential or pressure in distinction from measuring the armature-current or volume of current generated by the armature. Just as a greater or lesser volume of water may flow under a given head or pressure so a greater or lesser electric current may flow under a given electrical potential or pressure, and in my system I employ a potential-magnet as an agent which will measure not the current-flow, but the potential, and set in action devices which will correct any departure from the potential which it is desired to maintain regardless of what the volume of current flow may be. In prior systems a magnet measuring the total current volume—not the potential—has been placed in the main circuit in series with the armature at a point between the armature and the point where the main circuit branches to the lamps and battery. Such magnet measures and maintains constant the current volume in that part of the circuit, with the result that by reason of the variable demands of the battery for current neither the lamps nor the battery receive a constant amount of current nor, for the same reason, a constant pressure or potential. In addition the varying number of lamps and the varying demands of the battery call for a variable amount of current—not a constant amount—and this is provided for by my arrangement. I have also used the same expression regarding the field-magnet and with the same meaning—viz., that the field-magnet strength does not follow or gage the armature-current. Thus for a given armature-current the field-magnet may be either weaker or stronger, dependent on whether the speed is higher or lower.

What I claim as my invention, and desire to secure by Letters Patent of the United States, is—

1. In a system of lighting railway-vehicles electrically the combination with an axle, of a dynamo-electric generator of a capacity greater than the normal lamp-load driven thereby having its field-magnet strength independent of the armature-current, electric lamps and a storage battery connected in multiple with each other to the armature of said generator, a potential-magnet also independent of the armature-current connected in multiple to the said armature and a field-magnet regulator for the generator controlled by the said magnet.

2. In a system of lighting railway-vehicles electrically the combination with an axle, of a dynamo-electric generator of a capacity greater than the normal lamp-load driven thereby having its field-magnet energized by a shunt-circuit from the armature whereby the strength of said magnet is independent of the armature-current, electric lamps and a storage battery connected to the armature of said generator in multiple with each other, a potential-magnet also independent of the armature-current connected to the said armature in multiple with the lamps and battery, and a rheostat-regulator for the field-magnet circuit controlled by the said magnet.

3. In a system for lighting railway-vehicles electrically the combination with an axle, of a generator of a capacity greater than the normal lamp-load driven thereby having its field-magnet independent of the armature-current and energized by a shunt-circuit, electric lamps and a storage battery connected in multiple with each other to the armature of the generator, a potential-magnet also independent of the armature-current connected to the armature in multiple with the said lamps and battery, a circuit-closer in the main circuit between the point of said circuit at which the magnet and the field-magnet are connected on the one hand, and the lamps and battery are connected on the other hand, and an operating connection between the said circuit-closer and the said magnet whereby the said magnet and the field-magnet will be permanently in circuit, but the lamps and battery will have their circuit connection closed by the said magnet.

4. In a system for lighting railway-vehicles electrically the combination with an axle, of a generator of a capacity greater than the normal lamp-load driven thereby having its field-magnet independent of the armature-current and energized by a shunt-circuit permanently closed, a shunt-magnet also independent of the armature-current permanently connected to the armature, lamps and a storage battery supplied with current by the said generator, but having their connection controlled by the said magnet, and circuit-breaking devices dependent upon the relative potential of the generator and the storage battery for disconnecting the battery from the charging-circuit automatically when fully charged.

5. In a system of lighting railway-vehicles electrically the combination with an axle, of a generator of a capacity greater than the normal lamp-load driven thereby having its field-magnet strength independent of the armature-current, a potential-magnet, a field-magnet also independent of the armature-current regulator controlled by the said magnet, electric lamps and a storage battery operated by the generator, a shunt-magnet controlling the connection of the generator with the lamp and battery circuits and a series magnet controlling the disconnection thereof.

6. In a system of lighting railway-vehicles electrically the combination with an axle, of a generator of a capacity greater than the normal lamp-load driven thereby, a potential-magnet independent of the armature-current, a regulator for the generator controlled by the said magnet, electric lamps and storage batteries operated by the said generator, a potential-coil permanently in circuit controlling the connection of the lamps and battery with the generator and a coil opposing the last-named magnet and connected in series

between the generator and battery for controlling the disconnection of the lamps and battery with the generator.

7. In a system of lighting railway-vehicles electrically the combination with an axle, of a generator of a capacity greater than the normal lamp-load driven thereby, a potential-magnet connected to the armature-circuit but independent of the armature-current, a field-magnet regulator controlled by the said magnet, electric lamps and a storage battery operated by the said generator, a switch in the main circuit between the generator and the lamps and battery, a potential-magnet connected to the main circuit between the said switch and the generator for controlling the closure of said switch, and a series magnet in the main circuit between the said switch and the lamps and battery for controlling the opening of the said switch.

8. In a system of lighting railway-vehicles electrically the combination with an axle, of a generator of a capacity greater than the normal lamp-load driven thereby, a potential-magnet connected to the armature-circuit but independent of the armature-current, a regulator for the field-magnet circuit controlled by the said potential-magnet, lamps and a storage battery operated by the generator, a switch in the main line between the generator and the lamps and battery, a potential-coil controlling the closure of said switch and connected to the main line between the said switch and the generator and a series coil upon the same core as the shunt-coil last mentioned and connected to the main line between the said switch and the lamps and battery.

9. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle, of a group of lamps and a storage battery connected thereto in multiple, a regulator for the dynamo, a second regulator in the lamp-circuit, and a magnet measuring the potential applied to the lamps and controlling the said second regulator.

10. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle, of a group of lamps and a storage battery connected thereto in multiple, a regulator for the generator, a resistance in the lamp branch in series with the lamps and a magnet connected to the lamp-circuit on the lamp side of said resistance, so as to measure the potential applied to the lamps and a controlling connection between said magnet and the said resistance.

11. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle of a group of electric lamps and a storage battery in multiple, a potential reducing resistance in the lamp branch in series with the lamps, a regulator for the generator, a potential-magnet measuring the potential applied to the battery, controlling devices between said magnet and the regulator, a second potential-magnet measuring the potential applied to the lamps and controlling devices between the said magnet and the said resistance.

12. In a system for lighting railway-vehicles electrically the combination with a generator driven by the vehicle, of a group of electric lamps and a storage battery, a regulator for the generator, a resistance in the lamp branch in series with the lamps, a motor, controlling devices between the said motor and the said resistance, a magnet measuring the potential applied to the lamps and controlling devices between said magnet and the resistance.

13. In a system for lighting railway-cars electrically the combination with a generator driven by the vehicle, of a group of electric lamps and a storage battery in multiple, a resistance in the lamp branch in series with the lamps, a motor for said resistance, a magnet connected to the lamp-circuit and measuring the lamp conditions, controlling devices between said magnet and said motor, a regulator for the dynamo operated by a motor and a magnet in the main line measuring the battery conditions and controlling the regulator-motor.

14. In a system for lighting railway-vehicles electrically, the combination with a dynamo driven by the vehicle, of a group of electric lamps and a storage battery in multiple, two potential-magnets, one measuring the potential applied to the battery, the other measuring the potential applied to the lamps, a regulator for the dynamo controlled by the first-named magnet and a resistance in the lamp branch in series with the lamps controlled by the second-named magnet.

15. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle, of a storage battery connected thereto, a group of lamps connected thereto through a resistance, a regulator for the dynamo controlled by the storage-battery conditions and a second supplementary regulator controlled by the lamp conditions.

16. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle of a storage battery connected thereto, a group of lamps connected thereto in multiple with the battery, a resistance in the lamp branch in series with the lamps, a regulator-magnet between said resistance and the dynamo measuring the storage-battery conditions, a regulator controlled thereby, and supplementary regulating devices controlled by a magnet in the lamp branch measuring the lamp conditions.

17. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle of a regulator therefor, a group of lamps and a storage battery in multiple, a resistance in the lamp branch in series with the lamps, a potential-magnet measuring the potential applied to the lamps independently of the armature-current and

controlling devices between said magnet and the said regulator.

18. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle, of a regulator therefor, a group of electric lamps and storage battery in multiple, a resistance in the lamp branch, a magnet controlling the said resistance and a manual adjuster therefor.

19. In a system for lighting railway-vehicles electrically, the combination with a generator driven by the vehicle of a regulator therefor, a group of electric lamps and a storage battery in multiple, a resistance in the lamp branch, a potential-magnet measuring the potential applied to the lamps, an operating connection between said magnet and the said resistance and a manual potential-adjuster for modifying at will the lamp-potential.

20. In a system of lighting railway-vehicles electrically, the combination with a generator of a capacity greater than the normal lamp-load driven by an axle, lamps and a storage battery operated thereby, a circuit-breaker in the main line between the generator and the said lamps and battery, three shunt-circuits permanently connected to the main line between the said switch and the generator, one containing the field-magnet coils of the generator, another containing a magnet independent of the armature-circuit and controlling the resistance in the field-magnet circuit, and the third controlling the closure of the said switch, and a reversing-switch in the main line between the armature-brushes and the point of connection of said field-magnet circuit.

21. In a system for lighting railway-vehicles electrically, the combination with a generator of a capacity greater than the normal lamp-load driven by an axle, of lamps and a storage battery, a switch in the main-line circuit between the said lamps and battery and the generator, three shunt-magnets all independent of the armature-current but connected to the main line between the said switch and the generator, one being the field-magnet, another controlling the said field-magnet, and the third controlling the said switch, and two magnets connected to the main line, one being a series magnet controlling the opening of the said switch, and the other being a shunt-magnet for regulating the current delivered to the lamps.

22. In a system for lighting railway-vehicles electrically, the combination with a shunt-generator of a capacity greater than the normal lamp-load driven by the car-axle, having its field-magnet strength independent of the armature-current, lamps and a storage battery, a switch in the main-line circuit between the lamps and battery and the generator, a shunt-coil on the generator side of said switch controlling the closure thereof, a reversing-switch in the main-line circuit between the armature-brushes and the point of connection of the field-magnet shunt-circuit, and means for operating the said reversing-switch by the movement of the vehicle in one direction or the other.

23. In a system for lighting railway-vehicles electrically, the combination with a car-axle, of a generator of a capacity greater than the normal lamp-load driven thereby, electric lamps and a battery receiving a variable current from the said generator, a field-magnet circuit receiving current varying in inverse ratio to the change of potential due to change of speed and independent of the variation in the current delivered to the said lamps and battery, a switch between the lamps and battery and the generator, a potential-magnet controlling the closure of said switch, and a series magnet controlling its opening.

24. In a system for lighting railway-vehicles electrically, the combination with an axle, of a generator of a capacity greater than the normal lamp-load driven thereby, having its field-magnet strength varied according to the tendency to potential variation due to changes of generator speed, but independent of variations in armature-current, constant-potential lamps connected in multiple to the generator-armature, a storage battery in multiple with the lamps, circuit-closing devices in the main circuit between the generator and the said lamps and battery controlled by the generator-potential, and circuit-breaking devices between the generator and the said lamps and battery controlled by the main-line current.

25. In a system for lighting railway-vehicles electrically, the combination with an axle, of a generator of a capacity greater than the normal-lamp load driven thereby at a variable speed, a potential-magnet permanently connected in a shunt-circuit from the armature, lamps and a storage battery having their connection with the said generator controlled by the potential of the system and their disconnection therefrom by the current of the system, a shunt-circuit containing the field-magnet of the generator, a resistance in such circuit, a motor operating the resistance and a director for the said motor controlled by the said potential-magnet so as to be set and maintained for one direction of action of said motor or another so long as the potential of the system is either above or below the point determined by the said magnet.

26. In a system for lighting railway-vehicles electrically, the combination with an axle, of a generator driven thereby, lamps and a battery having their connection with the said generator determined by the potential of the system and their disconnection therefrom by the current of the system, a field-magnet circuit, a resistance therein, a motor for operating the resistance, a director having two separated sets of contacts, an intermediate set of contacts and a potential-magnet adapted to maintain said intermediate contacts in connection with one only of the two sets of

separated contacts so long as the potential of the system is above or below the point determined by the said magnet.

27. In a system for lighting railway-vehicles electrically, the combination with an axle of a generator of a capacity greater than the normal lamp-load driven thereby, lamps and a direct-current storage battery having their connection with the said generator determined by the potential and their disconnection therefrom determined by the current of the system, a field-magnet circuit having its current always in the same direction and of a magnitude varying inversely with the tendency to potential variation due to changes in speed, an armature-circuit having the current therein changed in direction according to the direction of the vehicle, and of a magnitude varying directly with the number of lamps and inversely as the battery-potential and a reversing-switch between the said armature-circuit and the main line controlled by the direction of travel of the vehicle.

28. The combination in an electric-lighting system of a variable-speed dynamo of a capacity greater than the normal lamp-load regulated for constant potential, lamps and a storage battery operated thereby, a main circuit, a switch for connecting the armature of the dynamo to said main circuit, an electromagnetic motive device for operating the said switch, a potential-magnet permanently connected to said main circuit on the dynamo side of the said switch and contacts in the circuit of the said motive device controlled by the said potential-magnet.

29. In an electric train-lighting system the combination with a dynamo, of a train-line adapted for connection through two or more cars of the train, a storage battery and lamp-circuit on each car connected with said train-line to form a train system, and automatic disconnecting-switches between each car-circuit and the said train-line.

30. In a train-lighting system, a constant-potential dynamo, a distributing-circuit adapted to be connected through two or more cars, a local circuit on a car arranged to form part of a train system, a magnet-coil arranged on the car and connected in shunt in the distributing-circuit, a relay-circuit in which is placed an electromagnetic switch, said relay-circuit being controlled by said magnet-coil, with a storage battery and lamp-circuit, substantially as described.

31. In a train-lighting system, a constant-potential dynamo, a distributing-circuit adapted to be connected through two or more cars, a local circuit on a car arranged to form part of a train system, a magnet-coil arranged on the car and connected in shunt with the distributing-circuit, a relay-circuit in which is connected an electromagnetic switch, said relay-circuit being controlled by said magnet-coil, a series coil placed with the shunt-magnet coil and connected in the circuit between the distributing-circuit and the storage battery, and a storage battery and lamp-circuit, substantially as described.

32. In a train-lighting system, a constant-potential dynamo, a distributing-circuit adapted to be connected through two or more cars, a local circuit on a car arranged to form a part of the train system, a magnet-coil arranged on the car and connected in shunt with the distributing-circuit, a relay-circuit in which is connected an electromagnetic switch, said relay-circuit being controlled by said magnet-coil, a series coil placed with the shunt magnet-coil and connected in the circuit between the distributing-circuit and the storage battery, a lamp-circuit, and a potential-regulator between the storage battery and the lamp-circuit, substantially as described.

33. In a train-lighting system, the combination of a dynamo, a distributing-circuit extending throughout the train, an automatic potential-regulator for said dynamo, a local circuit on a car of the train containing a storage battery and a lamp-circuit, an automatic switch between said distributing-circuit and said local circuit, arranged to break the connection between said circuits when the voltage of the distributing-circuit falls below that of the storage battery and the local circuit, with an automatic potential-regulator in the local circuit through which the current from either the distributing-circuit or the storage battery must pass before it can reach the lamp-circuit, substantially as described.

34. In a train-lighting system, a local circuit, a storage battery placed therein, a lamp-circuit, a regulator placed between said storage battery and said lamp-circuit, arranged to automatically control the current flowing to the lamp-circuit, with a means for adjusting said regulator, substantially as described.

35. In a train-lighting system, a lamp-circuit, a storage battery connected with said lamp-circuit, a regulator placed between the storage battery and said lamp-circuit, an indicator connected with said regulator, and means for adjusting the regulator to maintain a predetermined voltage in the lamp-circuit.

36. In a system for lighting railway-vehicles electrically, the combination with a generator, of an automatic connection-switch set to connect the generator to the line at a given speed, a storage battery permanently connected to the line while the said switch is closed, electric lamps intermittently connected to the line while the said switch is closed, a magnet measuring the generator-potential, a current-changing regulator controlled by the said magnet and adjusting the amount of the battery-current to the counter electromotive force of the battery whenever the lamps are disconnected, and a resistance in the lamp branch determining, together with the said magnet, the potential applied to the lamps whenever both lamps and battery are connected to the generator.

37. In a system for lighting railway-vehicles electrically the combination with lamps and

a storage battery in multiple of a constant-potential dynamo driven by the vehicle at an intermittent and variable speed and having a capacity sufficient to simultaneously operate the lamps and charge the battery and a current-varying regulator for the dynamo adjusting the volume of armature-current to either the lamps alone (the battery being charged), to the battery alone, (the lamps being out of use), or to lamps and battery together.

Signed at Albany, New York, this 4th day of September, 1901.

JAMES F. McELROY.

Witnesses:
CHARLES L. WICK,
ERNEST D. JANSEN.