(No Model.)

5 Sheets—Sheet 1.

J. H. HOLMES.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 445,448. Patented Jan. 27, 1891.

Fig. 1.

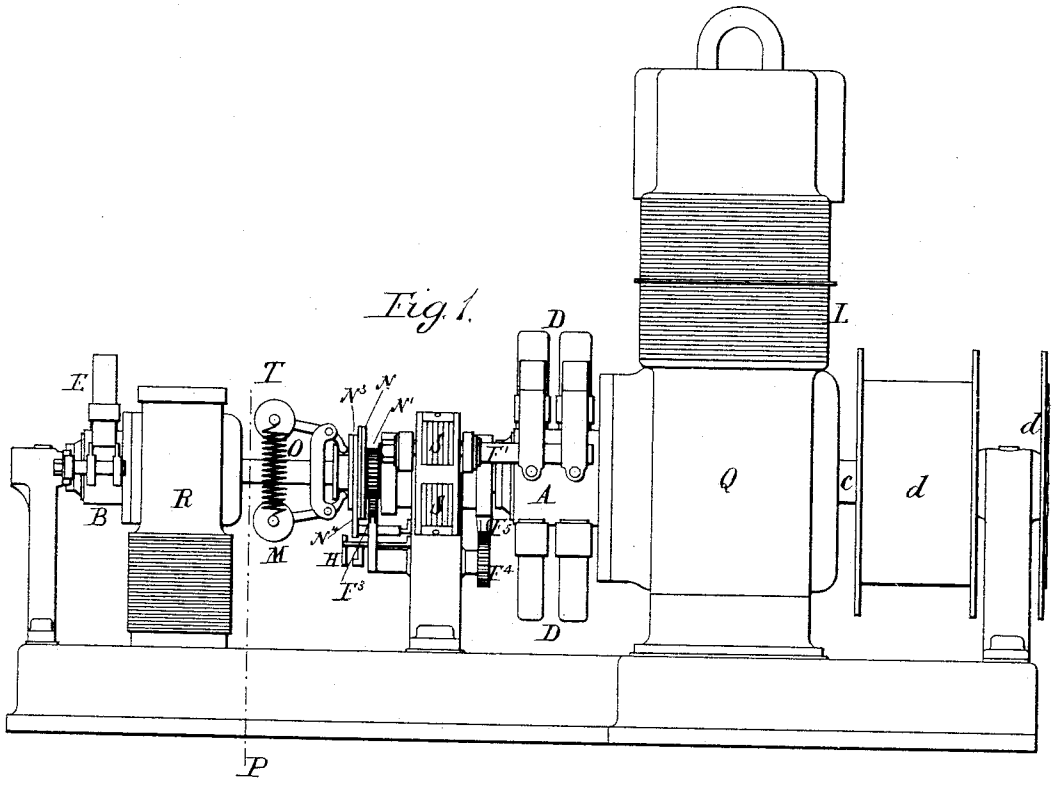
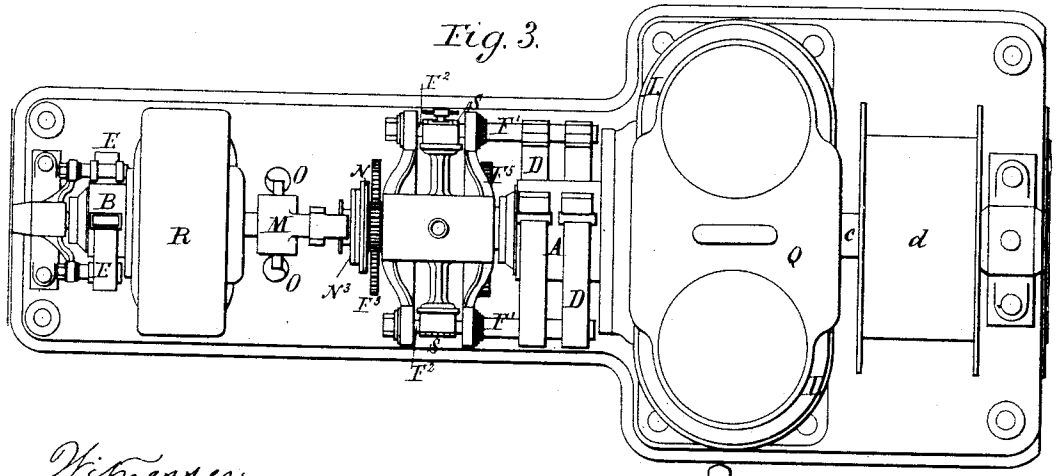


Fig. 3.



Witnesses:
J. A. Rutherford.
Percy B. Hill.

Inventor:
John H. Holmes
By James L. Norris.
Attorney.

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Fig. 2.

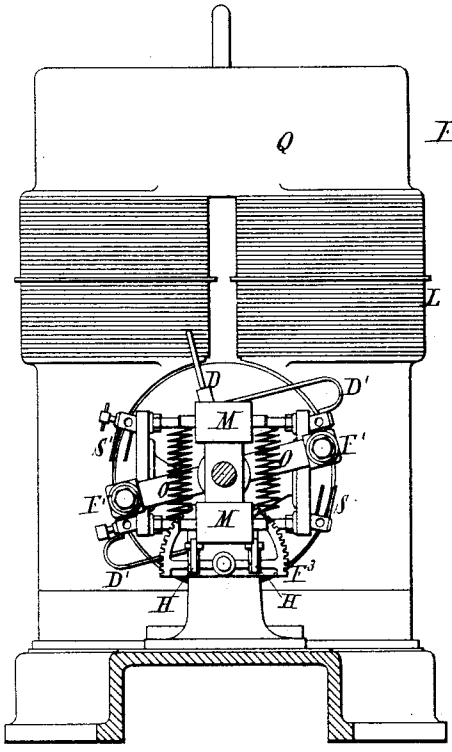
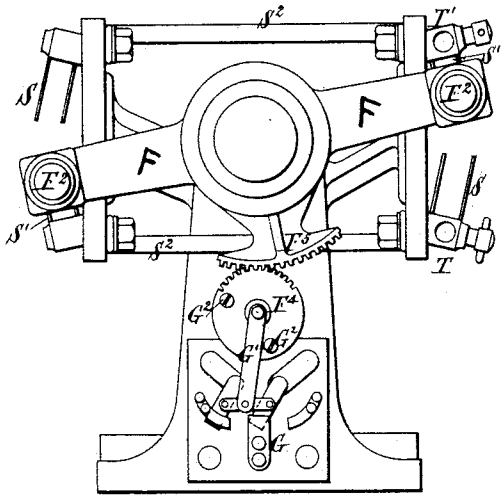


Fig. 4.



Witnesses:
J. A. Rutherford.
Percy B. Hills.

Inventor:
John H. Holmes.
By James L. Norris.
Attorney.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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J. H. HOLMES.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 445,448. Patented Jan. 27, 1891.

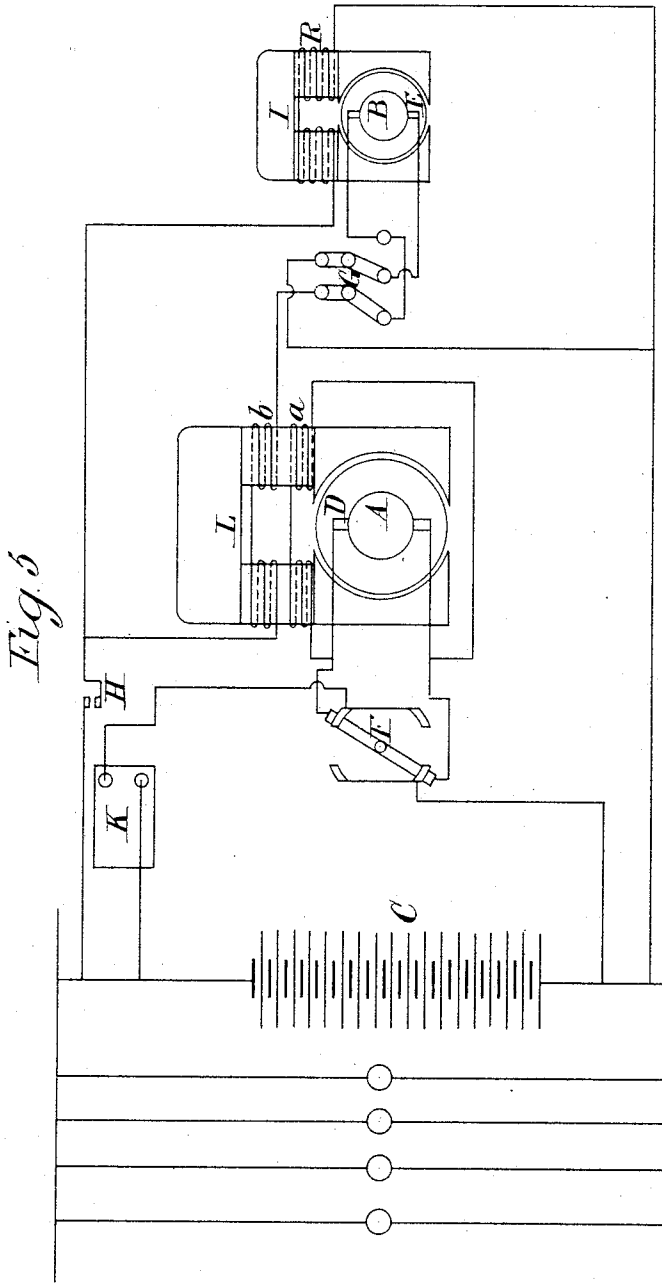


Fig. 5

Witnesses:
J. A. Rutherford.
A. H. Norris.

Inventor.
John H. Holmes.
By James L. Norris.
Attorney.

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J. H. HOLMES.

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Fig. 6.

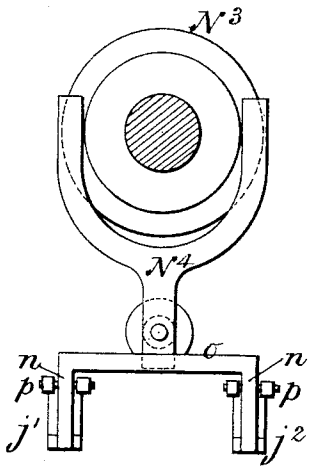
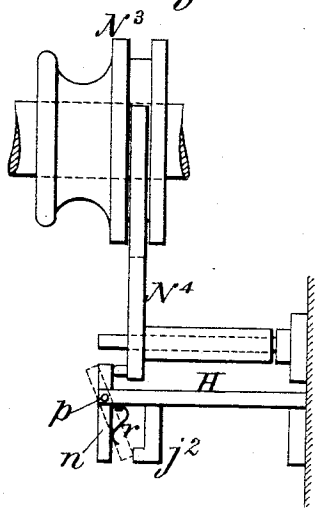


Fig. 7.



Witnesses:
J. A. Rutherford
Robert Everett.

Inventor:
John Henry Holmes.
By James L. Norris.
Attorney

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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J. H. HOLMES.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

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Fig. 8.

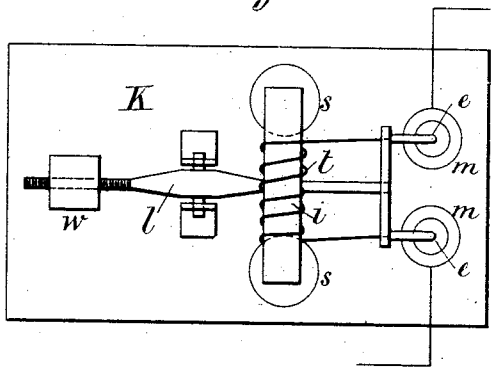
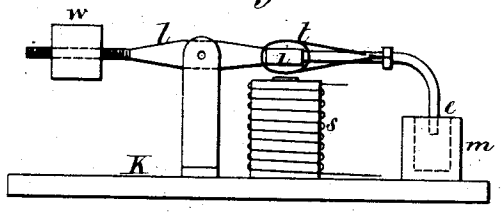


Fig. 9.



Witnesses:-
J. A. Rutherford.
A. H. Norris.

Inventor:
John H. Holmes.
By James L. Norris.
Attorney

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

JOHN H. HOLMES, OF NEWCASTLE-ON-TYNE, ENGLAND.

REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 445,448, dated January 27, 1891.

Application filed May 14, 1890. Serial No. 351,771. (No model.) Patented in England December 17, 1889, No. 20,244, and in France March 31, 1890, No. 204,702.

To all whom it may concern.

Be it known that I, JOHN HENRY HOLMES, electrical engineer, a citizen of England, residing at Portland Road, Newcastle-on-Tyne, in the county of Northumberland, England, have invented certain new and useful Improvements in Electric Generating Machinery for Use in Connection with the Electric Lighting of Railway-Trains, (for which I have received Letters Patent in England dated December 17, 1889, No. 20,244, and in France dated March 31, 1890, No. 204,702,) of which the following is a specification.

This invention relates to improvements in electric generating machinery for use in connection with the electric lighting of railway-trains, and has for its object to construct an apparatus which will maintain a constant difference of potential at the terminals of the dynamo-electric generator under a considerable variation in speed and when driven in either direction. Practically speaking, the electro-motive force of an ordinary separately-excited dynamo varies directly as the speed at which the armature revolves. So therefore, if the speed be increased, say, from five hundred revolutions per minute to one thousand revolutions per minute, the electro-motive force will be doubled. The electro-motive force, however, varies also directly as the strength of the magnetic field, so that if the strength of field of the separately-excited dynamo be reduced in the same proportion as the speed at which its armature revolves be increased, then the electro-motive force of the armature will remain practically constant.

To this end, according to my invention, I construct a dynamo-electric machine with two armatures arranged to revolve together, but in separate magnetic fields. The one is the main generating-armature, the other being for regulating the strength of the magnetic field of the generating-armature.

I separately excite the magnets of the machine from some external source, such as a set of accumulators, and provide the magnets of the generating-armature with two distinct exciting-circuits. One circuit is a high-resistance shunt-circuit and the other is of less resistance and is coupled up to the source of current, so as to have the small regulating-armature in series with it. The regulating-armature is so coupled up that its own electro-motive force opposes the electro-motive force of the source of supply. The high-resistance shunt-circuit is preferably so proportioned that at the highest speed at which the generating-armature is intended to be run it (without the aid of the second exciting-circuit) will give a magnetic field of an intensity proper for the required electro-motive force in the generating-armature. When thus arranged, the second exciting-circuit ought to have no current passing through it—a result which is brought about by the electro-motive force of the regulating-armature being at the highest speed equal and opposite to the external source of electro-motive force by means of which the exciting of the magnets is accomplished. If, however, the speed falls, the electro-motive force of the regulating-armature is lessened in the same proportion, and, being no longer equal to the external electro-motive force, a current will be permitted to flow through the second exciting-circuit of the magnets of the generating-armature, thus increasing the intensity of the magnetic field to make up for reduction of speed, with the result of maintaining a practically uniform electro-motive force in the generating-armature.

When the speed falls to the lowest limit, which I will assume to be half the highest rate of speed, then the electro-motive force of the regulating-armature in the case I am considering will be half the electro-motive force of the external source of supply, so that it will be seen that it is necessary to calculate the proportions of the second exciting-circuit of the generating-armature magnets upon the basis of only half the electric pressure of the external source of electro-motive force being available, and the resistance of the regulating-armature forming part of the circuit-resistance. At the lowest speed, therefore, half the exciting-power upon the generating-armature magnets will be produced by one coil having the full difference of potential of the external source of electro-motive force at its terminals and by a second coil having half the difference of potential of the external source of electro-motive force at its terminals,

less of course by the drop of potential due to the resistance of the regulating-armature, which forms a portion of this circuit.

In speaking of the proportioning of the parts I assume that the magnets of the generating-armature are used with a low magnetic density well below the saturation-point for the iron of which they are composed. I prefer to use them thus; but by careful allowances a sufficiently near result might be obtained with the iron in a condition more nearly saturated when the full exciting-power is on.

When I use an electric machine of the nature described for generating electric currents for the lighting of railway-trains in conjunction with the storage-batteries, I use the latter for the external source of electro-motive force, by which I excite the magnets, and drive the armature by means of gearing, which transmits the power from the axle of the van or vehicle in which the machinery is placed. I also arrange a centrifugal governor driven from the same source, which is made to switch on the circuit from the storage-batteries to the magnet-coils as soon as the speed rises to about the minimum speed at which the electric generating apparatus is intended to come into action, and which also switches off the current when the speed falls below the minimum speed.

As it is desirable that when the railway-train runs backward the dynamo would still be able to do its work properly, I prefer to make the brushes which collect current from the two armatures of copper-wire gauze and placed in positions radial to the commutators, being held in brush-holders attached to flat springs lying parallel to a tangent drawn to the surface of the commutator at the points at which the brushes bear. I also reverse the lead of the brushes of the generating-armature when the direction of rotation changes by means of mechanism of the following description: The brush-holders are carried by arms which, in the usual manner, can be rotated together around the axis of the armature, the motion in either direction being limited by stops. The motion is transmitted from the axle of the machine through gearing coupled to the axle and by means of a friction-clutch which slips round as soon as the brush-carrying arms are hard up against their stops.

To prevent any wear of the friction-clutch faces occurring excepting when the speed of the axle is very low, I arrange on the axle a centrifugal governor, the balls of which at a slow rate of revolution fly out and separate the faces of the friction-clutch, so that they do not touch excepting at speeds below this slow rate of revolution. When the direction of rotation of the armatures is changed the polarity of the brushes is also changed. I therefore utilize the motion which reverses the "lead" to work reversing switches of a kind well understood, so as to alter the connections and keep the polarity at the terminals of the machine the same.

I do not find it necessary to make provision for reversing the lead of the brushes of the regulating-armature, because the current running through this armature is usually small, and at maximum speed is, in fact, *nil*. I therefore place these brushes in fixed positions at the neutral points.

In order that my invention may be thoroughly understood, I will now proceed to describe an apparatus constructed in accordance therewith, for which purpose I will refer to the accompanying drawings, in which—

Figure 1 shows a side elevation of the combined generating and regulating dynamo-machines; Fig. 2, a cross-section on line T P; Fig. 3, a plan; Fig. 4, a view of the brush-reversing gear on an enlarged scale; Fig. 5, a diagram plan of the circuit and connections. Figs. 6 and 7 are enlarged detail views of the switch for coupling the exciting-circuits of both dynamos with the accumulators. Figs. 8 and 9 are respectively a plan and an elevation of the automatic switch hereinafter referred to.

The generating-dynamo Q has its field-magnets L excited first by an ordinary high-resistance shunt-circuit *a*, and secondly by a circuit *b*, of less resistance, coupled up to the accumulator C, which is charged by the dynamo, and having the armature of the regulating-dynamo R in series with it, the regulating-dynamo being so coupled up that its own electro-motive force opposes the electro-motive force of the accumulator. The armature of the generating-dynamo and that of the regulating-dynamo are both fixed on the same shaft *c*, driven by pulleys *d* from an axle of the vehicle. This shaft carries the commutator A of the generating-dynamo, and the commutator B of the regulating-dynamo. The brushes D of the commutator A are mounted in spring-holders D′, carried by bars F′, projecting from shiftable arms F F, mounted loose on the armature-shaft *c*, so that, according as these arms are brought from one inclined position—such as that shown at Fig. 4—to an opposite one, the brushes which are held in a radial position on the commutator have the requisite lead imparted to them on the one or the other side of the vertical center line, according as the armature-shaft is rotating in the one direction or the other.

The arms F F are connected together by pins F^2, and these pins are made to enter between the one or other pair of contact-jaws S S or S′ S′, connected, respectively, to the screw-terminals T T′ for the circuit-wires, so that as the polarities of the brushes are reversed, on the reversal of the motion of the armature-shaft their connection with the circuit is at the same time reversed by the movement of the arms F. The jaws S S′ on the right-hand side are coupled, respectively, with the jaws S S′ on the left-hand side by means of copper bars S^2 S^2.

The reversal of the position of the arms and brushes on the reversal of the motion of the shaft is effected as follows: Loose upon the shaft is a friction-disk N, to which is fixed a pinion N′, gearing with a toothed sector F^3, fixed on a spindle passing through the standard carrying the rocking arms F, which spindle has fixed on its other end a pinion F^4, gearing with a toothed sector F^5 on the boss of the arms F.

A second friction-disk N^3 is carried round by the shaft, but can slide longitudinally upon it. This disk has a neck, into which take the ends of the arms of the governor M, fixed on the shaft, the weights of which are drawn together by springs O, so as, when at rest or moving very slowly, to cause the arms to press the disk N^3 against the disk N with a certain amount of frictional contact. From this arrangement it will be seen that if, after having revolved in one direction, the armature-shaft is made to revolve in the contrary direction by the reversal of the motion of the carriage the disk N^3 will carry round with it the disk N, and in thus turning the pinion N′, the sector F^3, and pinion F^4 will cause the arms F to be brought into the opposite inclined position, thereby reversing the position of the brushes and contacts, as above described. As soon as the arms F have passed as far as they can into the jaws S or S′, so as to be arrested in that position, the disk N^3 will slip upon the disk N until the speed of the shaft *c* has increased sufficiently to cause the governor M to draw the disk N^3 backward out of contact with the disk N, in which position it will continue as long as the machine is running.

The disk N^3 has a groove which is embraced by the fork of an arm N^4, which, when the disk is slid backward to a certain extent by the governor, will act upon the switch H, Figs. 6 and 7, that couples up the exciting-circuits of both dynamos with the accumulators, the resistance of the governor-springs O being so arranged that these contacts are not made until the armature-shaft has attained a certain speed slightly under the minimum speed at which the dynamo is intended to generate current. The switch H may be a double-break bridge-over switch, made of two bars *n n*, rigidly connected by a cross-bar *o* and turning on insulated pivots *p p*. As the governor-arms diverge the arm of the fork N^4 is drawn back and forces the bars *n n* into the jaws j' j^2, and the circuit is then complete through j', *n*, *o*, *n*, and j^2. When the governors converge, the arm N^4 returns and frees the switch, which is thrown off by the spring *r*.

The spindle carrying the sector F and pinion F^4 also carries loose upon it an arm G′, which acts upon a switch G, so as to reverse the connection of the armature B with the coils *b* of the field-magnets L at the same time that the polarity of the brushes D is reversed on the reversal of the motion of the train, the motion of the arm G′ being effected by pins G^2 on the pinion F^4.

As before stated, the brushes E of the regulating-dynamo are held stationary on the commutator B.

As before explained, I prefer to arrange the shunt-circuit *a* of the field-magnets L so that when the generating-armature is running at its highest speed this circuit will unaided give a magnetic field of the intensity proper for the required electro-motive force in the generating-armature. In the circuit *b* the electro-motive force of the accumulators should be entirely balanced by the opposing electro-motive force of the regulating-armature when running at the same maximum speed. On a reduction of the speed the resulting reduction of electro-motive force in the armature A will be entirely compensated for by an increase of magnetic intensity produced by the circuit *b*, as the opposing electro-motive force of the regulating-armature will now be decreased to such an extent as to allow a sufficient current from the accumulators to pass through the circuit to effect such increase of intensity.

For switching the armatures of the generating-machine onto the lamp or charging circuit, I prefer to use an automatic switch K, Figs. 8 and 9, which couples up the circuit as soon as the electro-motive force rises to the proper amount, and which breaks the circuit again when the electro-motive force falls below the proper amount. The switch K consists of a rocking lever *l*, having an adjustably-weighted tail *w* and carrying an iron armature *i*, wound with a thick wire coil *t*, below which is an electro-magnet, the fine-wire coils S S of which is connected as a shunt to the dynamo circuit, so that on the production of a current of a certain strength in the latter the armature is attracted in opposition to the weight *w*, causing the ends *e e* of the coil *t* to dip into the mercury-cups *m m*, which are connected to the leads of the main circuit, so that this circuit is now closed. The current which now flows through the coil *t* in increasing the polarity of the armature assists the coils S S in holding the lever down; but when the electro-motive force of the dynamo falls below a certain minimum the main current in *t* and the shunt-current in S S will not have sufficient force to cause the lever to be held against the weight *w*, (or it might be a spring,) and this consequently in overcoming the attraction will tilt the lever and cause the main circuit to be broken.

It will be obvious that any other known construction of automatic switch having similar action might be used in place of the above, and I make no claim to the said construction as part of my present invention.

Having thus described the nature of my invention and the best means I know for carrying the same into practical effect, I claim—

1. In electric machinery for lighting railway-trains, a generating-dynamo the field-

magnets of which have, in addition to the ordinary shunt-wound exciting-circuit, a supplemental circuit connected to an independent source of current, and having in series with it the armature-circuit of a regulating-dynamo driven at the same speed or subject to the same degree of speed variation as the generating-dynamo, the electro-motive force of the regulating-armature being made to oppose the electro-motive force of the independent source of current, so that its variation in proportion to the variation of speed will practically maintain constant the electro-motive force of the dynamo, substantially as described.

2. In a generating-dynamo for lighting railway-trains, the combination, with the ordinary shunt exciting-circuit for the field-magnets, of a supplemental exciting-circuit connected to an external independent source of electric current and to the armature-circuit of a regulating-dynamo subject to the same variations of speed as the generating-dynamo, the electro-motive force of the armature-circuit being opposed to that of the independent source of current, so as in counteracting it to a greater or less degree, according to the speed of the regulating-armature, to maintain the electro-motive force of the generating-dynamo practically uniform.

3. In a generating-dynamo for lighting railway-trains, the combination, with the ordinary shunt exciting-circuit for the field-magnets, of a supplemental exciting-circuit which is subject to two opposing electro-motive forces, the one proceeding from a constant independent source of current and the other from the armature-circuit of a regulating-dynamo whose armature revolves at the same speed or is subject to the same speed variation as that of the generating-dynamo, so that as the electro-motive force of the regulating-armature increases with an increase of speed it will tend to neutralize the electro-motive force of the constant source of current, substantially as and for the purpose described.

4. In electric generating machinery for lighting railway-trains, the combination of a generating-dynamo L, having a shunt exciting-circuit *a* and a supplemental exciting-circuit *b* connected to an external source of current C and in series with the armature of a regulating-dynamo I, driven at the same speed or subject to the same speed variation as the generating-dynamo, the last-named armature being so connected to the exciting-circuit *b* that its electro-motive force acts in opposition to the electro-motive force of the independent source of current, substantially as and for the purposes described.

5. In dynamo-electric generating machinery wherein the armature is required to operate when revolving in either direction for effecting the reversal of the lead of the commutator-brushes when the direction of rotation is reversed, a friction-clutch, part of which revolves with the armature-shaft, while the other part is attached to the brush-gear, and which operates in combination with a governor so as to be kept in gear when the shaft is stationary or revolving at a very slow speed, but which is moved out of contact by means of the governor as soon as a certain slow speed is exceeded, substantially as herein described.

6. The combination, with a governor, of a friction-clutch for actuating the commutator-brushes, which is moved out of gear by the governor when a certain rate of speed is exceeded, a contact device acted upon by the governor when the speed requisite for producing a certain electro-motive force is attained, so as to couple up the exciting-circuits, the governor being made to act upon the said contact device so as to uncouple the exciting-circuits when the speed falls below the said rate, substantially as described.

7. The combination of a generating-dynamo, a regulating-dynamo whose circuit includes a regulating-coil on the generating-dynamo, mechanism for reversing the position of the commutator-brushes on the reversal of the motion of the armature-shaft, and a switch connected to said mechanism, so that when this reverses the position of the brushes it also reverses the connections of armature of the regulating-dynamo with the regulating-coil on the field-magnets of the generating-dynamo, substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 1st day of May, A. D. 1890.

JOHN H. HOLMES.

Witnesses:

PERCY CORDER,
Solicitor and Notary Public, Newcastle-upon-Tyne.

HARRY BENSON,
Solicitor, 41 Moslen St., Newcastle-upon-Tyne.