(No Model.)

2 Sheets—Sheet 1.

R. M. HUNTER.

DYNAMO ELECTRIC REGULATOR FOR AN ENGINE DRIVING A GENERATOR.

No. 510,602. Patented Dec. 12, 1893.

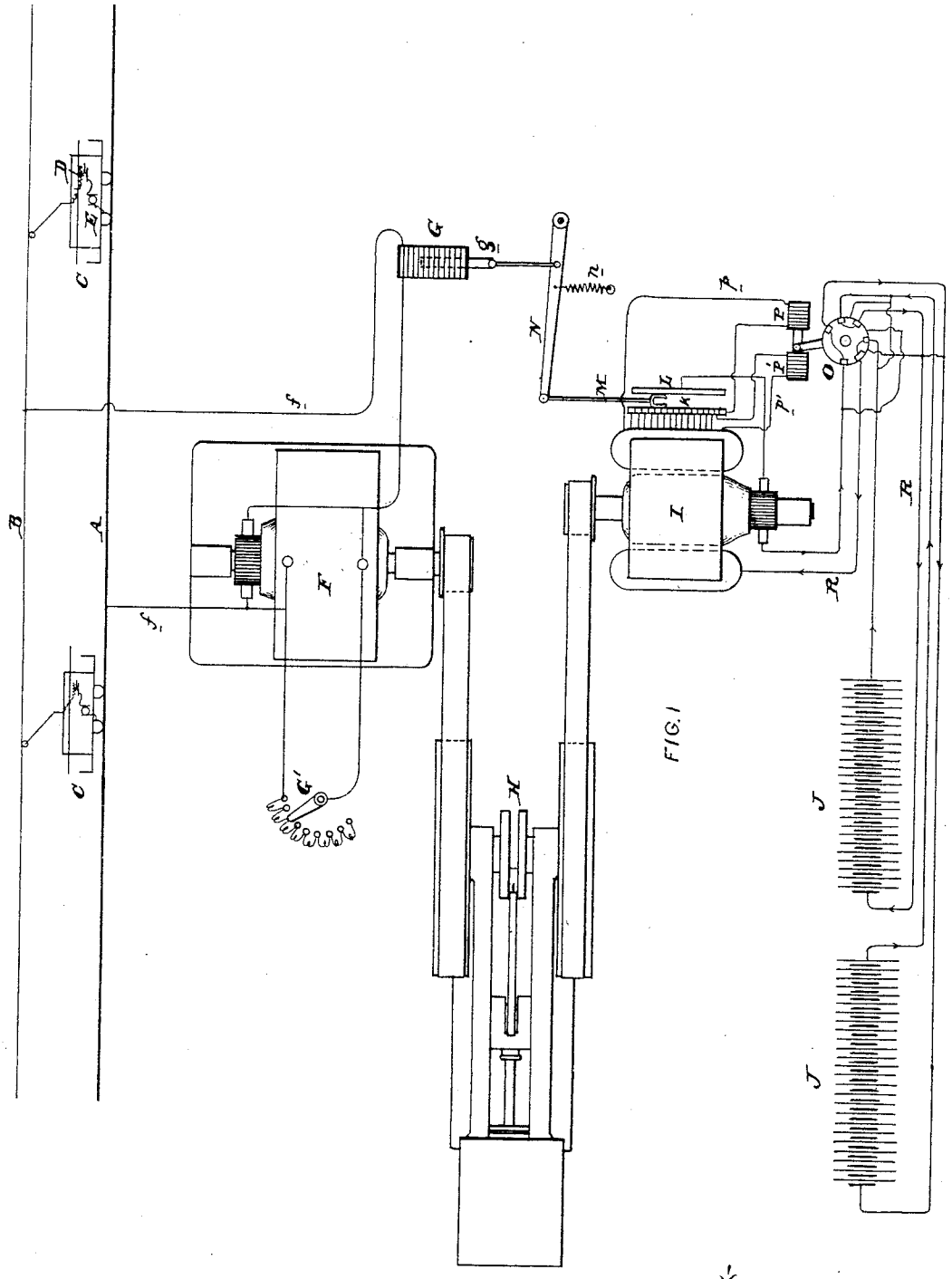

FIG. 1

Attest
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(No Model.) 2 Sheets—Sheet 2.

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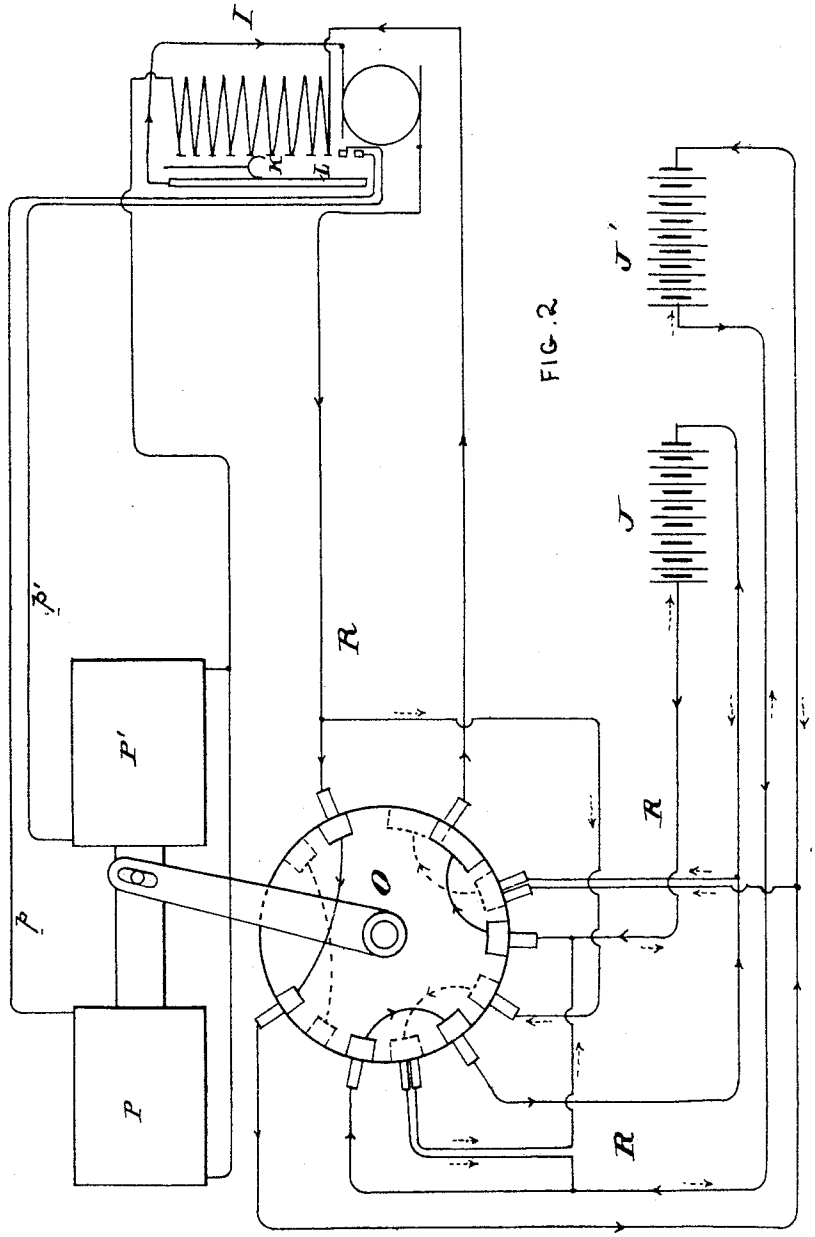

FIG. 2

Attest
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UNITED STATES PATENT OFFICE.

RUDOLPH M. HUNTER, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO THE THOMSON-HOUSTON ELECTRIC COMPANY, OF CONNECTICUT.

DYNAMO-ELECTRIC REGULATOR FOR AN ENGINE DRIVING A GENERATOR.

SPECIFICATION forming part of Letters Patent No. 510,602, dated December 12, 1893.

Application filed October 29, 1892. Serial No. 450,329. (No model.)

To all whom it may concern:

Be it known that I, RUDOLPH M. HUNTER, of the city and county of Philadelphia and State of Pennsylvania, have invented an Improvement in Electric Railways, of which the following is a specification.

My invention has reference to electric railways, and consists of certain improvements which are fully set forth in the following specification and shown in the accompanying drawings, which form a part thereof.

This application, Case No. 232, has particular reference to governing mechanism for the central station of an electric railway, whereby the output of the generator may be maintained in exact accordance with the demand, both as to potential and current.

In operating railways from a central station, considerable difficulty frequently arises from the fact that great variation in the current required for the electric cars occurs, and this variation is frequently so sudden in its action, that it is impossible to make an engine sufficiently quick in responsive action and automatic to compensate for the great variation in duty required of it. It will be readily understood, that if a number of cars were standing still and the engine was operating the dynamo or electric machine or generator at a speed necessary to maintain the potential, and with a power sufficient for the necessary output in watts to suit the requirements of the remaining cars in motion, and if the numerous cars standing still suddenly be put into motion, the output of the generator would instantly be taxed to such an extent and with such sudden rapidity, that the engine could not govern itself quickly enough to compensate for the increase of demand in power, and consequently its speed would be decreased by the heavy duty required of the generator. The result would be that the potential in the line would be lowered. It is desirable that the potential shall not deviate in the slightest degree, but shall under all conditions remain constant, and further that the central station plant shall be such that the greatest duty which could positively be put upon the generator shall not in the least cause the engine to vary its speed, because any variation in speed means an equivalent variation in electro motive force since shunt or compound machines used as generators in electric railway systems are designed to produce a varying current of fixed potential for a constant speed. As the speed is proportional to the potential it is evident that any variation in the speed will change the potential and thus render the operation defective.

The object of my invention is to overcome this defect in central station plants of electric railways as heretofore constructed, by so operating the engine that its speed is uniform under all conditions of working and all variations of load.

In carrying out my invention, I employ an engine of any of the well known types commonly used in electric central station work, provided with the necessary automatic regulator for varying the power while maintaining a fixed speed (such as variable cut-off gear), belted or mechanically connected to the dynamo electric machine or generator for supplying current to the railway, and a second dynamo electric machine which at one time acts as a generator for charging secondary batteries, and at another time as a motor for assisting the engine; and combining therewith, suitable automatic devices for coupling the motor with the batteries so that it shall run as a motor when the demand in the line circuits is such that the machine needs assistance to maintain its speed, and also to couple the motor in such relation with the batteries that it may be driven by the engine for the purpose of charging the batteries when the demand in the line is light and less than can easily be supplied by the engine.

It frequently happens in electric railway plants that most of the time an engine of very small power is amply sufficient for the duty demanded of the engine, and in fact all the time except at certain times under special conditions of working in the line. My improvement enables me to employ an engine which is amply sufficient for the normal operations of the railway but which is not large enough for any special demands, and by it

with my improvement, I am enabled to automatically increase the power transmitted through the engine to the dynamo generator to maintain a constant speed for all loads. By this means I am enabled to reduce the initial cost of the engine and the boiler capacity of the central station, while in addition I provide means to maintain a more uniform speed under all loads.

In the drawings, Figure 1 shows a diagram, partly in plan and partly in elevation, illustrating my improvements, and Fig. 2 is a diagram illustrating the switch mechanism and circuits.

A is the railway track and may be the return conductor.

B is the positive or suspended conductor extending along the railway.

C are electric cars having electric motors E to propel them, and a regulator D of any suitable construction for controlling the speed of the motor. The cars have suitable current collecting devices or trolleys for making contact with the suspended conductor B. It is immaterial what the particular construction of the cars or railway system may be, as any of the systems working on constant potential in general use may be substituted for the particular construction illustrated.

F is a dynamo electric machine or generator and is shown as shunt wound and adapted to deliver, by the conductors *f*, current of constant potential to the line circuit A, B.

A rheostat is arranged in the field coils in the usual manner for varying the output of the machine as may be required. This regulation is not automatic, and is only designed to give the machine a capacity sufficient for the number of cars which may be in circuit when working under the condition requiring the greatest output.

H is an automatic engine of any suitable construction having the usual form of governor or speed regulator, which engines are adapted to maintain a constant speed under varying loads. Any of the usual well known types of this class of engine may be employed. This machine is belted to the band pulley of the dynamo electric machine or generator F.

I is a dynamo electric machine and is also belted to the engine H so that the engine may run the machine I as a generator, or it may be driven by the machine I when acting as a motor.

J, J are two sets of storage batteries or electrical accumulators, and have preferably an equal number of cells so that the potential of one set is equal to that of the other.

R are motor circuits connecting the machine I with the storage batteries J J, through a switch O adapted to couple the batteries J J in series or parallel with the dynamo electric machine generator I. The object of this is to couple the batteries in series when they are operating the machine I as a motor, and to couple them in parallel when the machine I is acting as a generator and charging the batteries, so that the electro motive force of the dynamo may overcome the counter electro motive force of the batteries. The switch O is operated by an electrical device consisting of a core acting upon a lever connected with the switch and moved by two solenoids P, P′. When the core is drawn into the solenoid P′ the batteries are coupled in series and the machine I is acting as a motor to assist the engine H, but when the core is drawn into the solenoid P, the batteries are coupled in parallel and the machine I is acting as a generator to charge them.

The energizing of the solenoids P and P′ is controlled by automatic devices actuated by the variation of the current in the line, and this will now be described. G is a solenoid in the circuit *f* leading from the generator F to the positive conductor B of the line. This solenoid G operates a core *g* connected to a lever N in opposition to a spring *n*. The lever N moves a slide M between a series of contacts K and a straight conductor L. The various contacts K are connected to different coils of the field magnets of the dynamo electric machine I. As the slide M is moved down it cuts out more or less of the coils of the field magnets, so as to vary the power of the motor proportionally to the increase of current required in the line circuit. The full lines and solid arrows in Fig. 2 indicate the course of the electric current under this operation of the machine I as a motor in series with the batteries. When the current in the line decreases so that the engine has more power than sufficient to operate the generator F, the slide M descends to the lowermost contact K which closes the motor circuit through all of the coils of the field magnets and the solenoid P which is included in a circuit *p*. This would instantly throw the switch to the dotted position to couple the batteries in parallel, the dotted arrows indicating the course of the current with the batteries in parallel and in position for charging. The machine I which has been acting as a motor would then as a motor be cut out of circuit. The engine after the switch was thrown would then operate the machine I as a generator to charge the batteries, and this could be maintained until some large demand for current in the line was made upon the generator F. Under this demand, the solenoid G would raise the core *g*, and as the slide M rose to the contact K next but one to the bottom, the current would pass through the circuit *p′* and solenoid P′ and throw the batteries in series, and as the slide continued to raise, more of the coils of the motor could be thrown into circuit, and the machine I would act as a powerful motor and quickly assist the engine H which would otherwise be overburdened and lose its speed. The switch thus acts to throw the dynamo electric machine as a motor into or out of circuit

as required. As the dynamo electric machine I is always running at what should be an absolutely uniform speed, the counter electro motive force in the machine always acts to prevent any possibility of short circuiting sufficient to cause injury due to the burning of insulation, and also prevents excessive sparking in the commutating switch O.

The construction of the apparatus should best be such that the duty of the engine H is constant, that is to say, the engine should either be running both the generator F and generator I where the duty of the generator is small, or the engine H should be assisted by the dynamo electric machine I when the demand or output of the generator F is greater than that which could be supplied by the engine alone. The apparatus should be automatic so that the dynamo electric machine I acts, in a certain sense as a governor to the engine, performing the dual function of maintaining its speed and increasing the power transmitted by its belt to the generator F.

It is quite evident that the details of construction for converting machine I into a generator or motor, for coupling the batteries in series or parallel, or for varying power in the motor may be greatly modified without departing from the principles of my invention, which comprehends broadly the employment of a motor controlled by the varying current in the line to assist the engine under extraordinary fluctuation in the current or excessive demands made upon the generator of the central station.

What I claim, and desire to secure by Letters Patent, is—

1. The combination of an electric railway system employing a series of electrically propelled cars having independent means for controlling the speed of the several cars, with a central station plant consisting of a generator for supplying current of constant potential to the line, an engine adapted to operate the generator, an electric motor adapted to assist the engine, and an electrically actuated switch controlled by the current in the line circuit for throwing the electric motor into or out of operation.

2. The combination of an electric railway system employing a series of electrically propelled cars having independent means for controlling the speed of the several cars, with a central station plant consisting of a generator for supplying current of constant potential to the line, an engine adapted to operate the generator, an electric motor adapted to assist the engine, and an electrically actuated switch controlled by the current in the line circuit for varying the power of the motor automatically in accordance with the variations in the line current.

3. The combination of an electric railway system employing a series of electrically propelled cars having independent means for controlling the speed of the several cars, with a central station plant consisting of a generator for supplying current of constant potential to the line, an engine adapted to operate the generator, an electric motor adapted to assist the engine, an electrically actuated switch controlled by the current in the line circuit for varying the power of the motor automatically in accordance with the variations in the line current, two sets of secondary batteries, and an automatic electrically controlled switch for coupling the two sets of secondary batteries in series or parallel with the motor whereby the batteries may operate the motor when it is required to assist the engine or the batteries may be charged by the motor acting as a generator when the engine has more power than sufficient for the generator due to the demand of the line circuit.

4. The combination of an electric railway system having a series of electric cars in circuit, a constant potential generator connected with the line, an automatic engine adapted to operate the generator, a dynamo electric machine connected with the engine so as to be driven by it, storage batteries; a switch for varying the electro motive force of the batteries, circuits connecting the batteries with the dynamo electric machine, and electrically actuated devices controlled by the current in the line circuit for controlling the switch whereby the dynamo electric machine may be operated either as a motor or generator to assist the engine or charge the batteries.

5. The herein described method of operating an electric railway which consists in supplying current of constant potential to the line circuit in accordance with the requirements of the several electrically propelled vehicles, supplying the demand for current by operating a constant potential generator at uniform speed, maintaining the operation of the generator by means of a steam engine, and controlling the speed of the steam engine by means of an electric motor whose power is varied automatically and proportionally with the increase of current required in the line, whereby a steam engine of minimum capacity may be utilized in a central station plant under conditions of exceptional fluctuation in the demand for current.

6. The herein described method of operating an electric railway which consists in supplying current of constant potential to the line circuit for supplying a series of electric cars, maintaining a constant potential generator at uniform speed for delivering current to the railway circuit, operating the said generator by means of a steam engine, operating the armature of a dynamo electric machine by means of a steam engine or vice versa, charging storage batteries by means of the motor-generator when the duty of the en-

gine is less than that required to operate the generator to supply the demands of the line, and operating the dynamo electric machine as a motor to assist the engine when the demands of the line are greater than the capacity of the engine, and controlling the operations of the dynamo electric machine either as a motor or generator automatically by the variations in the current in the line circuit.

In testimony of which invention I have hereunto set my hand.

R. M. HUNTER.

Witnesses:
ERNEST HOWARD HUNTER,
HELEN L. MOTHERWELL.