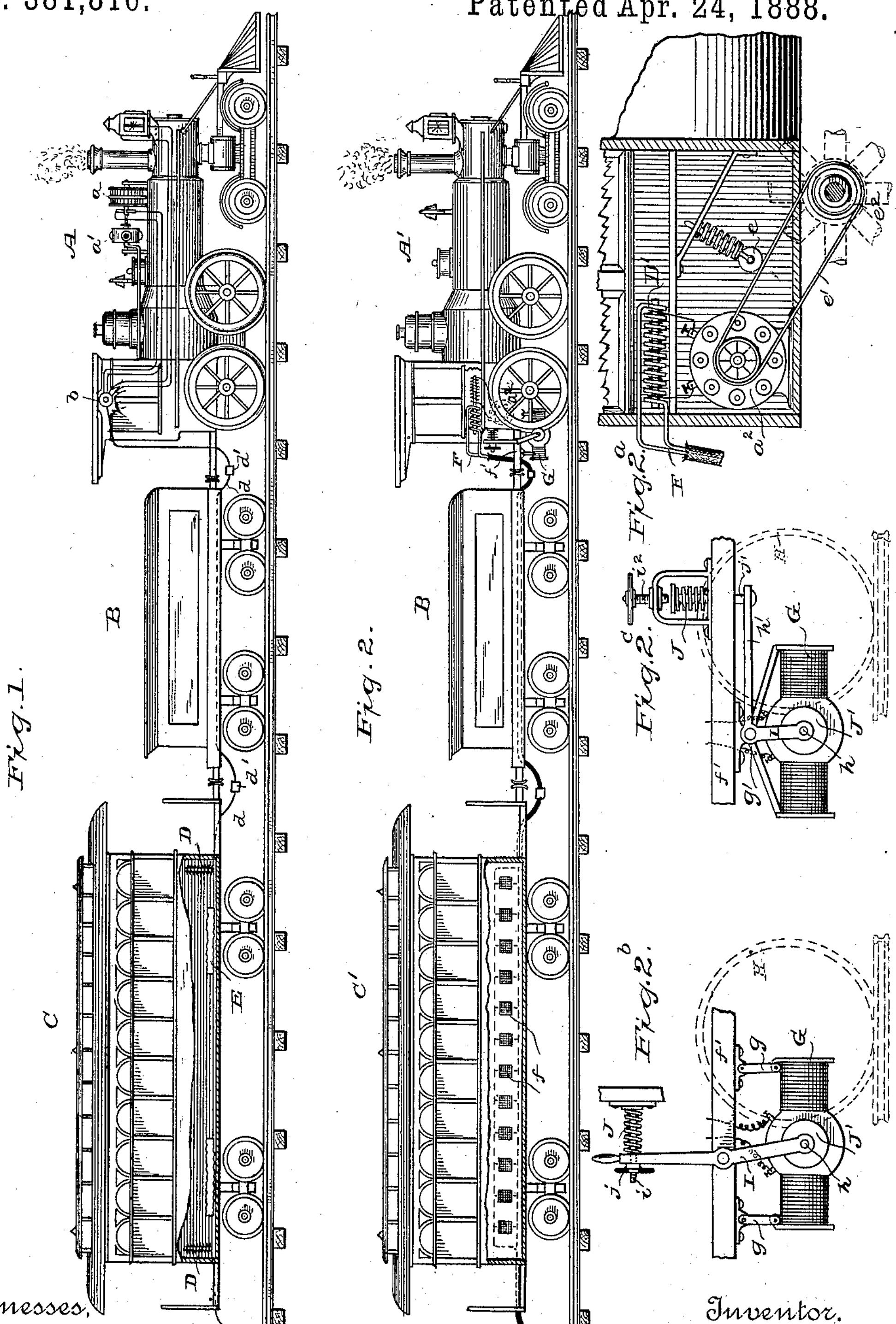
(No Model.) 5 Sheets—Sheet 1.

E. E. RIES.

ELECTRIC HEATING APPARATUS FOR RAILWAY CARS.

No. 381,816. Patented Apr. 24, 1888.



Witnesses.

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A. S. Henderson.

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By his Attorney

Frankland Jannus.

(No Model.)

5 Sheets—Sheet 2.

E. E. RIES.

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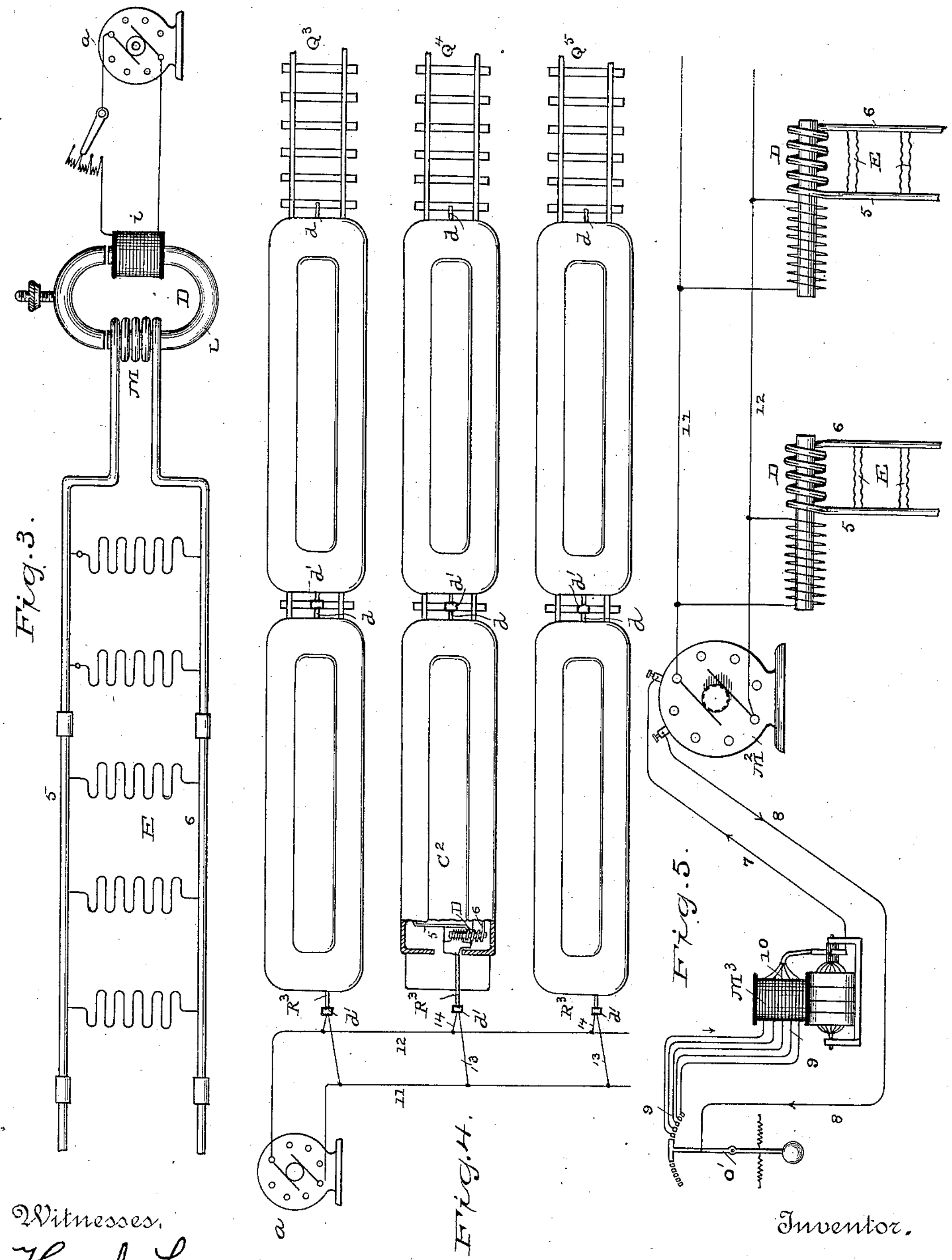

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(No Model.)

5 Sheets—Sheet 3.

E. E. RIES.

ELECTRIC HEATING APPARATUS FOR RAILWAY CARS.

No. 381,816. Patented Apr. 24, 1888.

Fig. 6.

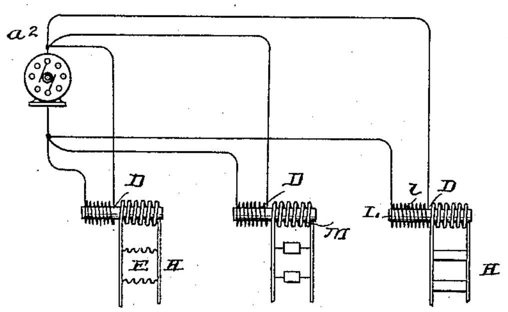


Fig. 7.

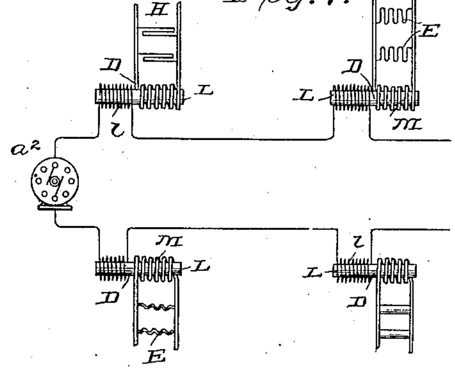


Fig. 8.

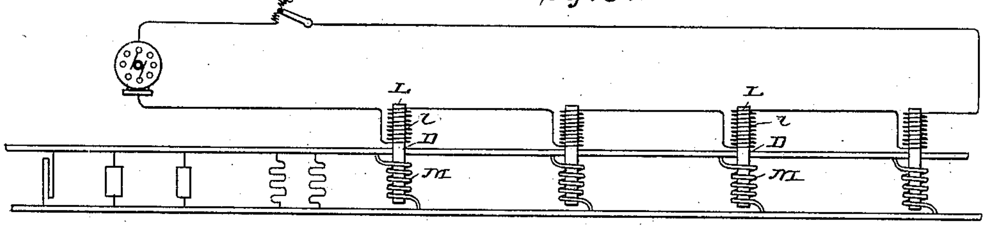
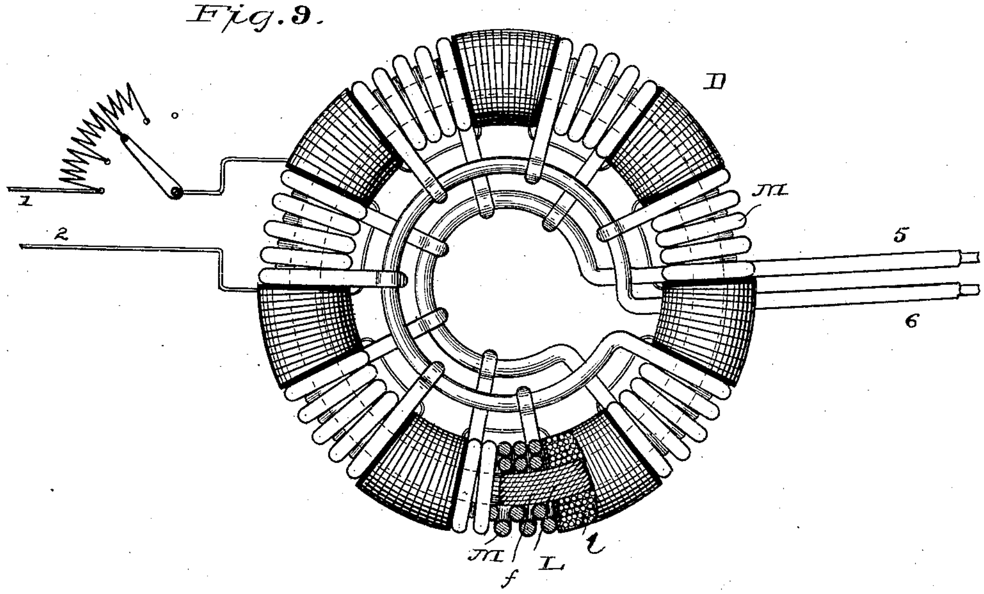


Fig. 9.



Witnesses,
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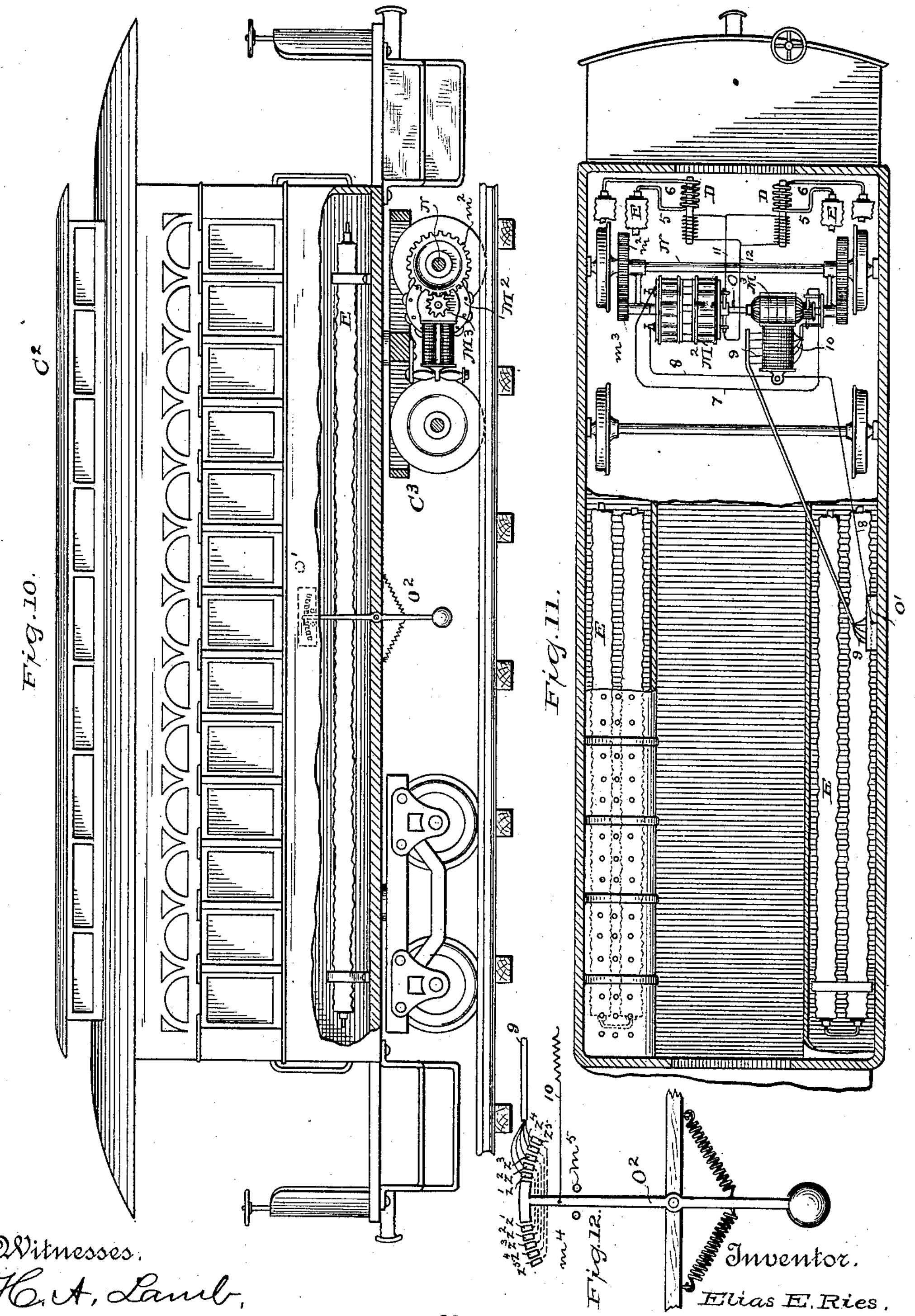
(No Model.) 5 Sheets—Sheet 4.

E. E. RIES.

ELECTRIC HEATING APPARATUS FOR RAILWAY CARS.

No. 381,816. Patented Apr. 24, 1888.



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(No Model.)

5 Sheets—Sheet 5.

E. E. RIES.

ELECTRIC HEATING APPARATUS FOR RAILWAY CARS.

No. 381,816. Patented Apr. 24, 1888.

Fig. 13.

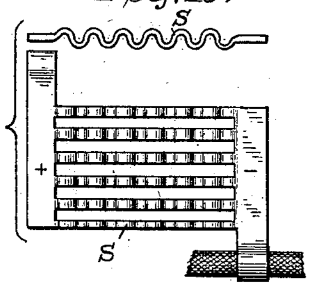


Fig. 14.

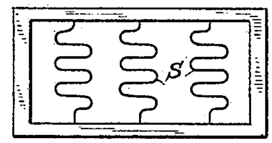


Fig. 15.

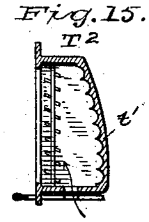


Fig. 16.

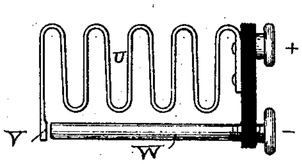


Fig. 17.

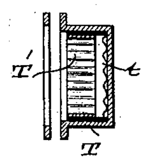


Fig. 17a

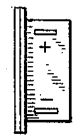


Fig. 18.

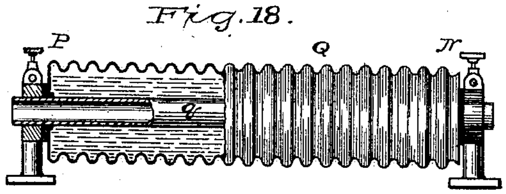


Fig. 19.

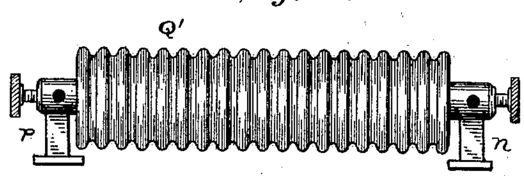


Fig. 20.

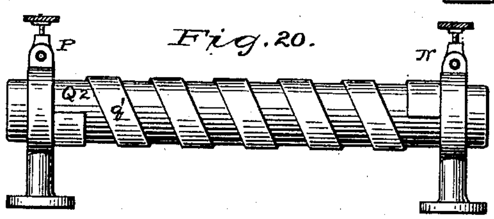


Fig. 21

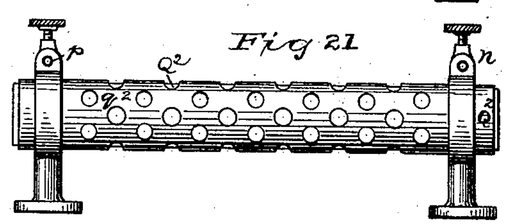


Fig. 22.

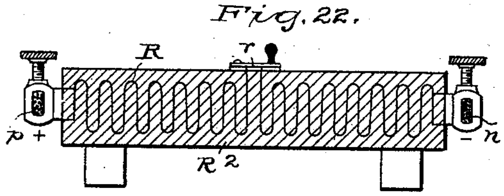
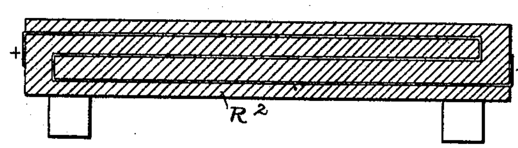


Fig. 23.



Witnesses.
H. A. Lamb.
A. H. Henderson.

Inventor.
Elias E. Ries.
By his Attorney
Frankland Jannus.

N. PETERS. Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

ELIAS E. RIES, OF BALTIMORE, MARYLAND, ASSIGNOR OF ONE-HALF TO ALBERT H. HENDERSON, OF SAME PLACE.

ELECTRIC HEATING APPARATUS FOR RAILWAY-CARS.

SPECIFICATION forming part of Letters Patent No. 381,816, dated April 24, 1888.

Application filed February 9, 1887. Serial No. 227,045. (No model.)

To all whom it may concern:

Be it known that I, ELIAS E. RIES, a citizen of the United States, residing at the city of Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Electric Heating Apparatus for Railway-Cars, of which the following is a description.

My present invention relates to a system of heating cars by means of the electric current; and it consists, broadly, in a new and improved method of producing electricity of such quality as to be available for the purpose, and in improved methods of utilizing the currents produced, which methods include heat absorbing and radiating devices, means for regulating the flow of current thereto, means for cutting the heating devices out of circuit when the desired limit of temperature has been reached, methods of arranging said heating devices, and means for connecting the generators with the source of power at the desired times either automatically or manually.

The invention is applicable as well to long heavy trains of numerous cars as to shorter and lighter trains, and it is also applicable to individual cars—as, for instance, where they are electrically propelled or otherwise.

The numerous accidents in which wrecked trains have been set on fire by their heating devices, many lives lost, and much property destroyed show the necessity for the adoption of new methods, and by my present discoveries it is proposed to eliminate all elements of danger from car-heating in the future. With that in view I have devised heating apparatus, to be located in each car and operated by currents of electricity, generated, preferably, at such times as will not add to the work required of the locomotive drawing the train, which is supposed, for the purposes of the following description, to be steam-driven except when otherwise specified.

The moving energy of a train cannot economically be spared when ascending grades, or even when traveling upon a level, unless the speed of the train be reduced or the force of the prime motor increased, either of which methods would add to the expense of operating a railway; but when the train is running on a downgrade or is preparing to stop at stations there is an enormous amount of power available for my purpose, which power is otherwise completely wasted and gotten rid of by friction between the brake-shoes and the wheels. During these times, for periods of one, five, or ten minutes, or thereabout, the whole power of the momentum of the train is available without adding one cent to the cost of operating or increasing the motive power during these intervals of time.

The amount of force generated by a heavy train of cars running rapidly on a downgrade is very large, amounting in many instances to several hundred horse-power, which force, otherwise wasted, can be saved and transformed into electricity by means of generators mounted upon the locomotive and driven from the axle or periphery of one or other of the driving-wheels, or in case the train is so heavy that the power developed under such circumstances would be too great to handle at a single point then a generating-dynamo can be attached to the axle of each car, suitable automatic devices being provided whereby said generators are brought into action only at such times as the train is running on its momentum. During these intervals of time my generators are automatically put into motion and transform the force of the train into currents of electricity, which are then converted into heat, and in most instances conveyed through suitable regulating and controlling devices directly to heating apparatus capable of quickly receiving a large amount of heat, and then gradually giving off the same by radiation, so that a constant temperature may be maintained and the heating continued after the generator has gone out of action. In this connection advantange is also taken of the great capacity of water for storing heat and gradually, instead of rapidly, giving out the stored heat for warming the car. Instead of water, however, I have selected, as being preferable on account of its very low freezing capacity, a solution of water saturated with sodium chloride. In very cold climates still more resistant solutions may be employed made with magnesium or calcium chloride. This solution is contained within and partly fills a heat-radiating tube, which should be coated outside and inside with a thin coating of asphaltum or other insulating heat-conducting material, which, when charged, will last indefinitely and require no further attention after being placed in position and a proper electrical connection is made. For some purposes it may be more convenient to use a steam-driven dynamo located upon the engine, and when that is the case I shall use it either exclusively or in connection with the momentum-driven generators just referred to. The generators produce current of high tension and small quantity, which current, it is well known, has only small heating power, and in order to carry out my system I carry the current from the generators through the primary coils of a sufficient number of converters. The secondary coils of each are of very large wire, arranged to produce current of greater quantity and at the same time lower potential than has as yet been commercially produced for any purpose, which current has great heating capacity, and is carried from the transformers direct to the points of consumption, where are located the heat-radiating or heat storing and radiating devices by means of which the cars are heated.

In order to most economically utilize and convert the electric current generated, as heretofore described, from the agency of force otherwise wasted, the heat-radiating surfaces are made sufficiently large for the purpose required, and of course of sufficiently low electrical resistance, so that a current of low electro-motive force, but of large volume or quantity, may be readily sent through them. It is well known that an electrical current of high tension or electro-motive force does not appreciably heat an electrical conductor except it also has large volume, and that it is the volume or intensity of the current flowing per second, (coulombs or ampères,) and not its electro-motive force or electrical pressure, (volts,) that produces heat in a conductor. It is also known that the amount of electrical energy represented in a conductor that is carrying a current having an electro-motive force of, say, five hundred volts and an intensity of one ampère is equal to that represented by a current of five hundred ampères having an electro-motive force or pressure of one volt. Consequently, in order to obtain the greatest heating effect of the current, I provide an apparatus whereby the comparatively high-tension current generated by the dynamo is converted into a current of low electro-motive force, but of very large volume, and, inasmuch as by this method of heating by electricity it is desirable that the heating-current be diffused over a large surface rather than concentrated at a single point, the heating devices in cases where a continuous supply of current is to be supplied are preferably composed of one or more thin corrugated bands or strips of copper or other metal, so formed as to expose a large radiating-surface, although the construction may be varied, as heretofore specified. In either case the electrical resistance of the circuit containing the heating devices is preferably sufficiently small to enable the low-tension current used to readily overcome it. In practice the heating effect of the current may, in some cases, be considerably increased by arranging the converter or transformer in such a manner that the secondary or induced current flowing through the circuit will be perceptibly an alternating or intermittent one, and under this method of operating the "extra current" impulses, due to the successive breaks in the circuit, can be made to overcome any undue resistance in the circuit, even though the original potential is very small. This method, however, I do not recommend where inconvenience would result from the use of perceptible alternating currents of large volume.

From what has already been said it will be apparent that, owing to the absence of all fires from the cars, especially when the illuminating and signal lamps are also lighted by electricity, as contemplated in connection with the system, it would be difficult to conceive a safer heating medium than the currents employed. There is absolutely no danger of receiving a shock in case of accidental contact with exposed portions of the heating-circuit—as, for instance, the radiating-plates—even though they may be uncomfortably hot to touch, due to the passage through them of the heating-current. For the same reason the current is not likely to leave its conductors as readily as would currents of higher potential, and as all the line-conductors forming the circuit proper are amply large (preferably stranded copper cable) and covered with a non-conducting covering, and inasmuch as all the radiating and heating devices are fully protected from contact with the wood-work or other inflammable material of the cars, to guard against damage in case of any accidental overheating, absolute safety to train and passengers is insured. In case of collision or other accident the generation of the heating current is instantly and automatically stopped, and thereby all danger from fire that might otherwise result from the continuance of the heating or accidental short-circuiting, as well as all danger from shock due to the current itself, is entirely removed.

The question of economy involves not only the production and translation of electric current, but, since my apparatus occupies very little otherwise valuable space, the room now occupied by the stoves and other appurtenances, which if removed would accommodate at least four additional passengers, would be entirely saved.

In order to warm the cars before the train is ready to start from the terminal station, I propose to erect a special plant for that purpose, using primary current from any available source, the secondary conductors from which lead to the various station-tracks and are provided with suitable couplings whereby they can be connected to one or more cars of the train, according to the particular arrangement of apparatus thereof. Instead of a separate stationary plant, however, I may equip the engine used for making up trains with a steam-driven dynamo mounted on top of the boiler, similar, for example, to that indicated in Figure 1 of the drawings, this engine to remain connected to the heating system on the train for a sufficient time after the train is made up and before it is ready to start.

The various details of construction and arrangement embraced in a system embodying my invention will be hereinafter fully described, and are illustrated in the accompanying drawings, in which—

Fig. 1 is a view in elevation showing a locomotive and short train embodying a general organization of the system. Fig. 2 is also an elevation showing a locomotive and short train embodying a different arrangement of my system. Fig. 2^a shows a different mode of connecting the generator with its motive power. In this view is also shown a transformer in its theoretical position. Figs. 2^b 2^c are enlarged details showing the manner of establishing a friction-gear connection between the generator and one of the driving-wheels of the locomotive. Fig. 3 is a theoretical diagram showing the generator, transformer, and train-heating circuit leading therefrom, being substantially what is shown in Fig. 2. Fig. 4 is a diagram of a station-plant for heating the cars before starting. Fig. 5 is a diagram of the connections shown in Fig. 11. Figs. 6 and 7 are theoretical diagrams of different modes of connecting and operating local transformers. Fig. 8 shows a number of transformers, the primary coils being all in series and the secondary coils all in parallel. Fig. 9 is a plan view of a transformer apparatus, such as I prefer to use. Fig. 10 is an elevation, partly in section, showing a regular passenger-coach equipped with a completely self-contained generating and heating apparatus. Fig. 11 is a plan view of the devices shown in Fig. 10. Fig. 12 is an enlarged detail of the automatic switch for controlling the operation of the apparatus. Figs. 13, 14, 15, 17, and 17^a show heat-radiating devices for use with my system. Fig. 16 is a thermostatic cut-out combined with a heater. Fig. 18 is an elevation, partly in section and partly broken away, showing a heat storing and radiating device. Figs. 19, 20, 21, 22, 23 are detail views of different forms of similar apparatus.

Similar letters denote like parts throughout.

In Fig. 1 is shown a short train, consisting of a locomotive, A, tender B, and car C. Upon the locomotive is an electric generator, *a*, of the alternating type, driven by a special engine, *a'*, suitably connected thereto, the working-conductors from the generator being led to a switch-board, *b*, which should be placed in some position where it will be readily accessible to the person having charge of it. The heating-circuit extends by suitable conductors, *d*, provided with couplings *d'*, between the separate portions of the train, and includes transformers D, two of which are shown in position in the interior of the car C. The primary coils of these transformers are preferably connected in series, and the secondary circuits include one or more heaters, E, connected in multiple arc, substantially as shown in the diagram Fig. 8.

The heating equipment of the train shown in Fig. 2 is somewhat differently arranged from that in Fig. 1, the generator being in this instance arranged to be driven by the momentum of the locomotive and train instead of by a separate engine. The generating-dynamo is placed under the engineer's seat, and connected by a belt with driving-pulleys e^2 on the axle of the rear driver of the locomotive, as shown in detail in Fig. 2^a, in which figure is also shown an automatic belt-tightener, *e*, by which the driving-belt *e'* is maintained at a proper tension. This generator is to be used, preferably, at times when it is desired to check the speed of the train—as when approaching a station—or to utilize its surplus energy—as when running down grades; and in order that it may be readily disconnected from the motive power and cease to exert a retarding influence thereon, I provide a loose pulley as well as a fast pulley upon the axle of the driving-wheel, the belt *e'* being shifted from one to the other to start or stop the generator whenever desired. In very cold weather the generator can of course be kept in operation the entire time; but this is not the preferable mode of operation. The transformer D' is also mounted upon the locomotive and shown in proximity to the generator a^2, and from this generator lead large conductors F, which extend throughout the train, being suitably coupled between connected portions thereof, and include any desired number of radiating devices, *f*, which are connected in multiple arc and shown in position in the car C', the current being thus transformed at a single point and transmitted from there by sufficiently large conductors throughout the train.

A modified form of connection between the generator and its motive power is shown in Figs. 2^b and 2^c, where a generator, G, is shown suspended by suitable links from the foot-board *f'* of the locomotive A'. The links may be attached to each end of the generator, as at *g*, or be rigidly secured thereto and brought to a central point above the axis, as at *g'*. With either construction the generator G is suspended in such a manner as to allow of its being moved toward and away from the driving-wheel H, which is shown in dotted lines. The armature-shaft *h* is mounted in suitable bearings secured to the outer ends of a pair of levers, I, pivoted to the foot-board *f'*. As shown in Fig. 2^b, the levers I are continued upward and brought to some convenient point within reach of the engineer, and at their upper ends are slotted and pass over fixed screw-threaded stems *i*, around which are coiled springs J, against which the lever-arms rest or are forced by the nut *j* on the stem *i*. When the nut *j* is unscrewed the force of the spring will press the lever-arm outward and its lower portion inward toward the driving-wheels, thereby forcing the friction-pulleys J′, secured to the extremities of the armature-shafts h, forcibly against the peripheries of the driving-wheels H and holding them there with a practically-constant pressure adapted to yield somewhat in case of any serious jar or vibration. The frictional connection is unmade by turning the nuts j until the levers are forced against the springs, the spring compressed, and the friction-pulleys thus carried out of contact with the driving-wheels H. In Fig. 2^c the levers I, instead of being continued upward, are provided with an extension, h', to the extremity of which is secured a rod, j', extending upward through the foot-board f' and terminating in a head, a spiral spring, J, being coiled around the said rod, acting to force it upward and hold the friction-pulley J′ in operative relation to the periphery of the driving-wheel H with a firm but yielding pressure. A screw-stem, i^2, is mounted above the rod j', and when screwed down against the end thereof compresses the spring, as in the former instance, and releases the friction-pulley from its contact with the driving-wheel and stops the generator. The suspended generator (shown in Fig. 2^b) is also shown in position upon the locomotive A′, and it will be understood that this mechanism is to be properly inclosed by a protective casing. (Not shown.) In addition to the generator G the generator a^2 (shown in detail in Fig. 2^a) is also indicated in dotted lines. The circuit from the generator G will, however, extend to the transformer D′, as already described with reference to the generator a^2, which may be of the alternating or magneto type, and I may use either a continuous or an alternating current machine, as generator G, as desired.

The transformer D, or device by means of which I convert an alternating current of high tension into a heating-current of very low tension, is shown in a conventional form in several of the figures of the drawings, and consists, preferably, as is more fully shown in Fig. 9, of a magnetic body or core, L, of layers of iron plates, f, upon which is wound a series of primary coils, l, of comparatively fine wire, and interposed between the said primary coils, in suitable relation thereto, are secondary coils M, of very large wire of low resistance, calculated to emit a current of very large volume but low potential. In said Fig. 9 I have shown the primary coils all connected in series and the secondary coils in multiple arc, thereby materially reducing the resistance of the secondary circuit, while at the same time the greatest inductive effects are obtained from the high-tension small quantity primary current.

The primary coils of the transformers D may be connected with their respective generators in a variety of ways, each specially adapted to some particular circumstance—as, for instance, independently, as shown in Fig. 6; in series independently, as shown in Fig. 7; in series as a group, as shown in Fig. 8; in parallel, as shown in Fig. 11.

In the heating, storing, and radiating devices, Figs. 18 to 23, advantage is taken of the well-known property of many bodies of quickly absorbing a large amount of heat and gradually emitting the same. This heat-absorbing material may be either a liquid or a solid, and may be disposed or arranged in any desirable and practical manner, whereby it will best serve the purpose required. For the purpose of this invention, and owing to its well-known capacity for storing heat, I have selected as one means of attaining this result a solution composed of water saturated with sodium chloride, this solution resisting frost at very low temperatures. In very cold climates still more resistant solutions may be employed made with magnesium or calcium chloride, as before stated. This solution is contained within and partially fills a hermetically-sealed radiating-tube, which should be coated outside and inside with a thin coating of asphaltum or other insulating heat-conducting material, and which, when once charged and sealed, will last indefinitely, and will require no further attention after being placed in position and the proper electrical connection made. As already stated, space enough is left unfilled in the hermetically-sealed tube to permit of free expansion and contraction of the contained liquid without straining, and as the interior is not exposed to the oxygen of the air, the oxidation is very slight and soon ceases.

In Fig. 18 is shown a tube of corrugated metal, Q, through the center of which, and insulated therefrom, passes the large (preferably tubular) conductor q, the passage of the current through which heats the liquid within the tube, which latter in turn gives forth heat from the radiation of the exterior surface of the tube Q. In Fig. 19 is also shown a corrugated tube, Q′, but in this case the interior conductor, q, is omitted, and the current passes along the tube Q′ itself, thereby storing heat in its fluid contents, and at the same time giving off a portion of it by direct radiation.

In Fig. 20 is shown a block of lime, terra-cotta, soapstone, porcelain, or other similar substance, Q^2, upon the exterior of which is spirally wound a thin broad strip of copper or other good conducting material, q', which, being properly connected to the main conductors P N, is heated by the passage of the current, and while heating the block Q^2 for future use emits a considerable portion of its heat.

In Fig. 21 the block Q^2 is shown as being placed within a thin tube of iron or copper, q^2, which said tube is formed with a large number of holes, made in order to reduce the conducting-surface to the proper amount and to permit of a certain amount of direct radiation from the inclosed cylinder.

In Figs. 22 and 23 are shown strips of thin copper or other metal, R R′, which are embedded in a suitable plaster or cement, R^2, and in that position they will heat the material so surrounding them, which will in turn gradually give out by radiation the heat so imparted. As shown in Fig. 22, the main conductors *p* and *n* are built up of a number of small wires in order to obtain increased flexibility and to avoid self-induction, and the conductor R as consisting of two short strips extending toward each other and provided at their extremities with a cut-out, *r*, by which the said strips are disconnected, practically cutting the entire heating-coil R out of circuit.

In Fig. 13 is shown a radiator that consists of a number of thin strips of copper or other metal, S, electrically connected at their ends and preferably punched and formed from a single sheet, and so arranged that when placed in circuit they may be heated by the passage of a proper current.

The device shown in Fig. 14 is similar to that shown in the preceding figure, the radiating-strips S being placed farther apart and made of increased size.

In Figs. 17, 17^a are shown a sort of wall-pocket consisting of a box or frame, T, provided with a corrugated reflecting-plate, *t*, on its rear wall and vertical corrugated radiating-strips T′ along its front, as seen in Fig. 14.

A slightly-different form is shown in Fig. 15, it being intended to pass a current of air therethrough in the direction of the arrow, said air to be heated in passing between the metallic plates *t*′ of the box T^2.

A thermostatic radiator is shown in Fig. 16, consisting of a number of folds, U, of metal, the outer one of which carries a contact, V, which, when the temperature becomes too high, is lifted off its seat on the return conductor W, thereby breaking the circuit, and is to be used whenever it is desired to prevent the heat from rising above some particular point. The return conductor or seat W may be adjustable in length by the screw-threads on seat W, extending through the outer wall or casing, and the amount of expansion necessary to cut out thereby regulated, and the device can be utilized either as a self-regulating radiator or as an adjustable safety cut-out in connection with other heating devices.

In the selection of the particular form of heat-developing devices from among those just described or others that may readily be constructed in accordance with the principles laid down, judgment will be exercised and the conditions carefully considered. The simplest form embodying my construction is that shown in Fig. 1 of the drawings, where an alternating current is generated by a separate engine mounted on the locomotive at such times as steam can be most economically spared—as, for example, when the train is running downgrade or preparing to stop. The transformers D are located upon the cars to be heated, and near them the heat-developing devices, which, as there shown, are corrugated liquid-containing tubes, such as shown in Figs. 18 and 19.

The other method of operation hereinbefore referred to, and exemplified in Fig. 2, is to locate the generator upon the locomotive, where it is arranged to be driven by the momentum of the train, the transformers being also located near the generator, low-resistance circuit-wires carrying the heating-current, preferably formed of copper strands, being led throughout the train, the heating devices being connected between said conductors in parallel, as shown in the car C′, in which figure the heating devices *f* are represented as sunk in the sides of the car, they being substantially such devices as are shown in Figs. 14, 15, and 17. They may also be arranged down the middle aisle of the car, in which position they are particularly convenient. Their number will depend altogether upon circumstances, and when placed, as indicated in Fig. 2, between the seats of the cars they should be furnished with a suitable switch-knob, whereby a passenger may open the circuit or close it at will. When placed in the floor of the car the heaters may receive air from the exterior thereof, and by suitably regulating the air passing through them they may serve to ventilate as well as warm the car.

In the case of railways on which the trains are comparatively short and light, and on which it is desired to utilize the surplus mechanical energy of the train for generating the heating-current, the arrangement just described, and shown in Fig. 2, is preferred. Where, however, the trains are long and heavy, and hence the combined force and momentum of its cars very great when under rapid headway, the total energy available for conversion on descending grades, or when coming to a stop, would amount in many instances to several hundred horse-power, which would be too great to be conveniently and effectively handled at any one point. I therefore prefer and propose in such cases to equip each separate car with its own generator, which is automatically operated, as hereinafter described, when the car or train is descending a grade, to generate a current that can be utilized not only for heating the car, but, if desired, for various other purposes. In this modification of my invention the operation does not materially differ from that already described; but the circuits and apparatus on each car are complete and self-contained, requiring no circuit-connections between the cars, and the entire operation of the apparatus is automatically controlled. It will also be apparent that not only is the gross available energy of the train subdivided and used to better advantage, but this arrangement permits the coupling into the train of cars not provided with electric heating apparatus without in any manner interfering with the operation of cars that are so equipped. Such an arrangement is shown in Figs. 10, 11, and

12, C^3 being the truck of an ordinary passenger-coach, upon one of the axles, N, of which are mounted gear-wheels m^2. A counter shaft, O, is secured in suitable bearings and connected by gears m^3 with the gears upon the axle N. An electric generator, M^2, is firmly mounted upon the frame of the truck C^3 of the car C^2, its armature being supported upon the counter-shaft O in such position that movement of the car in either direction will cause rotation thereof. The generator M^2 is of the alternating type, and is preferably operated by means of an exciter, M^3, which is also firmly secured to the body of the truck C^3 and has its armature upon the counter-shaft O. I do not, however, propose to confine myself to a separately-excited alternating-current generator, since the generator employed may be a magneto or may be self-exciting; or I may use one of continuous-current type in connection with the pole changing interrupter hereinbefore described. I have, however, illustrated the arrangement just described.

The working conductors 7 8 from the exciter M^3 extend to and include the field-magnet coils of the generator M^2, and the terminals 9 10 of the field-magnet circuit of the exciter M^3 extend to a switch-box, O′, placed at some convenient point on the car where it will be at all times readily accessible. The working-conductors 11 12 from the generator M^2 extend to a pair of transformers, D, the working-conductors 5 6 of which lead to heaters E, the ends of which will be seen in proximity thereto in Fig. 11. The transformers and the generators will in practice be effectually protected by suitable casings, (not shown,) and the heaters used in the present instance are of the indirect radiator type shown in Figs. 18 and 19, and extend longitudinally under the sides of the car.

In order to most effectually utilize the surplus energy of a train, and thereby operate upon the most economical basis, I provide each car when equipped, as just described, or the generating apparatus wherever located, with an automatic switch, O^2, the function of which is to throw the generator into operation at such times, and, further, to throw in more or fewer of the field-magnet coils thereof, and so to cause it to generate more or less current according to the pitch of the grade being traversed.

In a previous application, Serial No. 205,541, June 22, 1886, is more fully described a pendulum-switch of the kind here used. In the present instance the contacts $z' z^2 z^3 z^4 z^5$ represent the terminals of the field-magnet coils of the exciter M^3, those on either side of the central position representing the same coil, so that the same result may be produced whichever end of the car happens to be in front. A pair of holes, $m^4 m^5$, are formed one on each side of the pendulum-lever O^2, and the plug (a removable stop pin or plug) is placed in the one in front of the pendulum, so that it can only move away from its central (neutral) position when the car is on a downgrade, when, by moving onto the contiguous contacts $z' z^2 z^3 z^4 z^5$, &c., it will throw in successively more and more of the field-magnet coils of the exciter M^3, and thereby increase the magnetizing-current in accordance with the pitch of the grade the car is descending, thus utilizing the increased power developed by the momentum of the car and storing the same in the form of heat in the corrugated heating-tubes. A further modification may consist of a single automatic or manual switch on the locomotive, which is connected by circuit-wires with the generators under each car, so as to enable the operation of the entire series to be simultaneously controlled from a single point.

The various conductors extending from the switch-board b (shown upon the locomotive A) are for convenience concentrated into a single properly protected and insulated cable, which is provided with suitable couplings between cars and in that manner carried throughout the train. As shown in Fig. 1, the circuit includes simply the high-tension conductors from an alternating-current generator, the heaters being located in proximity to the transformers on each car. In Fig. 2, however, the work of transformation is accomplished on the engine in close proximity to the generator, and the heating-conductors are carried throughout the train. With them, of course, may be combined various other circuits, and all carried in one cable.

In order to provide means for heating the cars at terminal stations where trains are made up, I provide a stationary plant, the organization of which is shown in the diagram Fig. 4. a is a generator of alternating currents of high tension, the working-circuit of which is represented by the conductors 11 12. Q^3 Q^4 Q^5 are three separate station-tracks adapted to receive entire trains, and upon each of which are shown two connected cars, C^2, the electrical connections between which are shown in cable form at d, the end connections, R^3, being connected to branch wires 13 14, extending from the mains 11 12, respectively, and uniting in any convenient form of coupling, d', which is then connected to the extremity R^3 of the working-circuits of the respective trains, substantially in the manner hereinbefore described.

In another application filed by me in the United States Patent Office simultaneously herewith (February 9, 1887) I have described and claimed my invention as applied to heating in general by the use of a low-tension heating-current, and therefore I do not herein claim the same, broadly, except so far as it is applicable to the heating of railway-cars and other vehicles.

The herein-described automatic gravity-switch seen in Figs. 5, 10, 11, 12, and claimed in combination with the electric generating apparatus, is claimed generically in a separate application for Letters Patent filed April 11, 1888, Serial No. 270,247.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a system of heating cars by electricity, the combination of the moving vehicle, a generator of electricity arranged to be driven by the momentum thereof, one or more inductional transformers for converting the current from said generator into one of much greater intensity, heating devices in the secondary circuit of the transformer, and means, substantially such as described, for completing the generator-circuit and bringing the transformer into action under predetermined conditions.

2. In a system of heating cars by electricity, the combination of the moving vehicle, an electric generator arranged to be driven when the vehicle is in motion, an inductional transformer or transformers in the generator-circuit, heat-radiating devices in the transformer-circuit, and means, substantially as described, for automatically closing the generator-circuit when the vehicle is moving on a descending grade and for opening said circuit on an ascending grade.

3. In a system of heating cars by electricity, the combination, with a car, a generator of high-tension currents, and transforming apparatus for converting said currents or a portion thereof into one of lower tension but larger volume, of automatic switching devices arranged to close the generator-circuit when the car is descending a grade, substantially as described.

4. In a system of heating cars by electricity, the combination of a car, a generating and transforming apparatus, and automatic switching devices, said switching devices being mounted on said car and operated by the force of gravity and controlling the operative condition of the generator to cause the generator to produce more or less current according to the pitch of the grade being traversed by the car, as described.

5. In a system of heating cars by electricity, the combination, with a car or cars, of a generator on each car arranged to be driven by one of the axles thereof, one or more inductional transformers in the circuit of said generator, heating devices in said car located in the secondary or working circuit of the transformer, and means for automatically closing the generating-circuit under predetermined conditions.

6. In a system of heating cars by electricity, the combination, with a car or cars, of a dynamo electric machine upon each car, a generating-circuit, inductional transformers in said generating-circuit, heating devices located on said car and connected in parallel in the secondary circuit thereof and arranged to receive the secondary currents from the transformer or transformers, and means, as described, whereby the dynamo-electric machine is arranged to generate the main supply-current and act as a braking-generator when on descending grades.

7. In a system of heating cars by electricity, the combination, with a separate generator for each car, said generator being operated by connection with one of the axles thereof, of one or more inductional transformers included in said generator-circuit and a series of exposed conductors of relatively large area and arranged as translating devices in the secondary circuits of the aforesaid transformers, as described.

8. In a system of heating cars by electricity, the combination, with the axle of one of the supporting-wheels, a counter-shaft in continuous mechanical connection with said axle, an alternating-current generator, the armature of which is mounted on said counter-shaft, suitable inductional transformers arranged to receive the current from the generator and to convert it into one of lower potential and increased intensity, and heat-radiating devices upon the car adapted to receive said low-tension current, substantially as shown and described.

9. In a system of heating cars by electricity, the combination, with one of the axles of a car, of a main generator of alternating electric currents and an exciter therefor, separate field-magnet coils for the exciter, the terminals of all of which are brought to a suitable switch-box, and a gravity-switch arranged to operate only when the car is descending a grade and to cut in more or fewer of the coils of the field-magnet of the said exciter according to the pitch of the grade upon which the car is traveling, as described.

10. In a system of heating cars by electricity, the combination, with a car and one of the axles thereof, of a counter-shaft in continuous mechanical connection with said axle, an alternating-current generator and a separate continuous-current exciter therefor, the armatures of both machines being mounted upon said counter-shaft, inductional transformers arranged to receive the current from the generator and to transform the same into one of lower potential but increased intensity, heating devices upon the car arranged to develop heat from said current, and a pendulum or gravity switch arranged to operate when the car is traversing a grade and to cut out more or fewer of the coils of the field-magnet of the exciting-generator as the grade is of greater or lesser steepness, as set forth.

11. In a system of heating cars by electricity, the combination of the alternating-current generator and continuous exciter, means, substantially as described, for continuously rotating the armatures thereof, the gravity-switch O^2, having duplicate sets of points, and a movable stop whereby the action of said switch is limited to one or other of the set of points according to the direction in which the car is moving, as shown and described.

12. In a system of heating cars by electricity, the combination, with an electric conductor of large area, of a tube of corrugated metal within which said conductor is arranged, substantially as described.

13. In a system of heating cars by electricity, the combination, with the main supply-conductors, of a heating device consisting in whole or in part of a corrugated metallic tube supported between fixed standards and adapted to absorb the expansions and contractions due to its changes of temperature produced by the passage therethrough of the electric current, substantially as described.

14. In a system of heating cars by electricity, a combined heat-developing device and thermostatic cut-out consisting of a corrugated plate of metal provided with a movable contact and included in the heating-circuit in such a manner that undue heating and consequent excessive expansion of said plate will move the contact and open the heater-circuit, substantially as set forth.

15. In a system of heating by electricity, a combined heat-developing device and thermostatic cut-out consisting of a strip of metal adapted to expand beyond a predetermined point under the influence of heat due to the passage therethrough of an abnormal electric current, and an adjustable stop or contact against which the strip normally rests and through which its circuit is normally completed, substantially as described.

16. The method herein described of converting the surplus energy or momentum of a moving car or train into heat, which consists in causing said surplus energy of the car or train to generate a current of electricity, transforming said current into one of lower electro-motive force and larger volume, and sending said transformed currents through heat developing, radiating, or translating devices of low electrical resistance and large surface, substantially as described.

17. The herein-described method of heating railway cars or trains by electricity, which consists in generating an electric current or currents through the agency of the surplus mechanical energy of the car or train when said car or train is descending a grade or coming to a stop, transforming the current so generated into one of larger volume but lower electro-motive force, and in then sending the said transformed current or a portion thereof into one or more heat developing and absorbing devices on said car or train, substantially as described.

In testimony whereof I hereto affix my signature in presence of two witnesses.

ELIAS E. RIES.

Witnesses:

FRANKLAND JANNUS,

W. C. DUVALL.