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METHOD OF AND APPARATUS FOR OPERATING ELECTRIC RAILWAYS BY DYNAMIC INDUCTION.

No. 458,859. Patented Sept. 1, 1891.

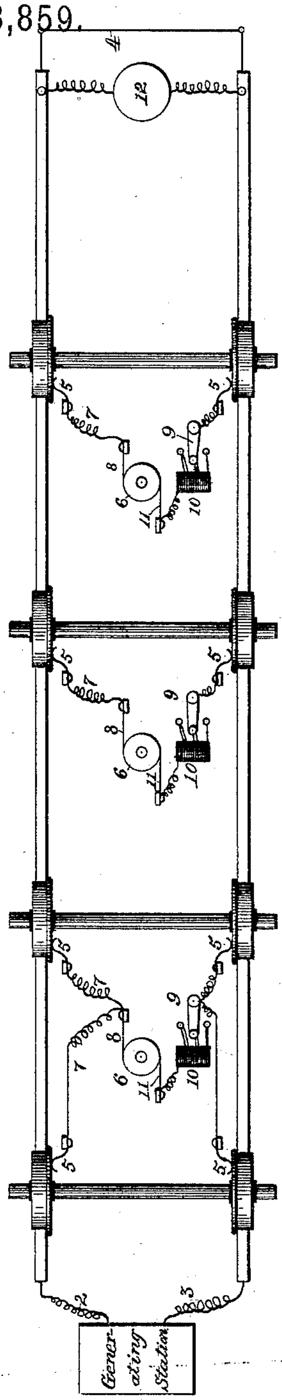

Fig. 1.

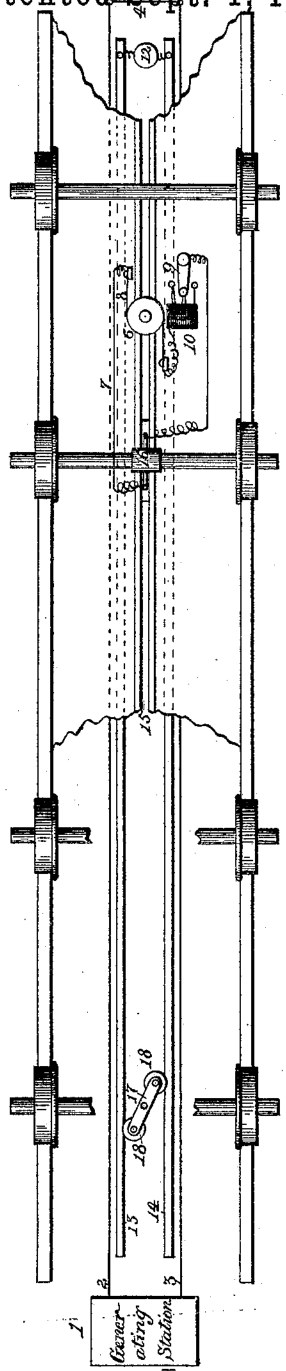

Fig. 2.

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Fig. 7.

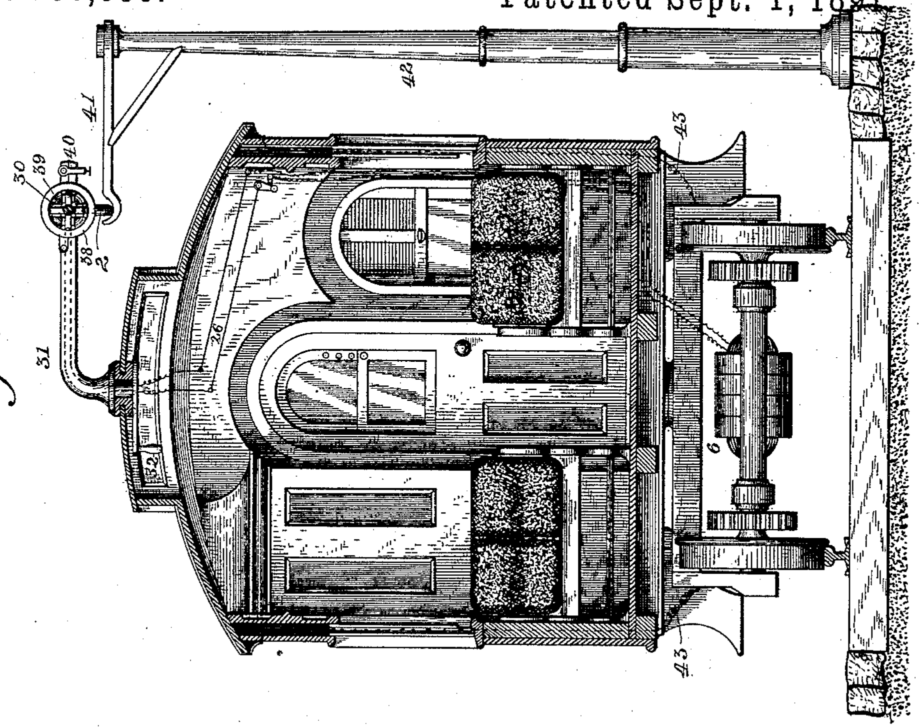

Fig. 3.

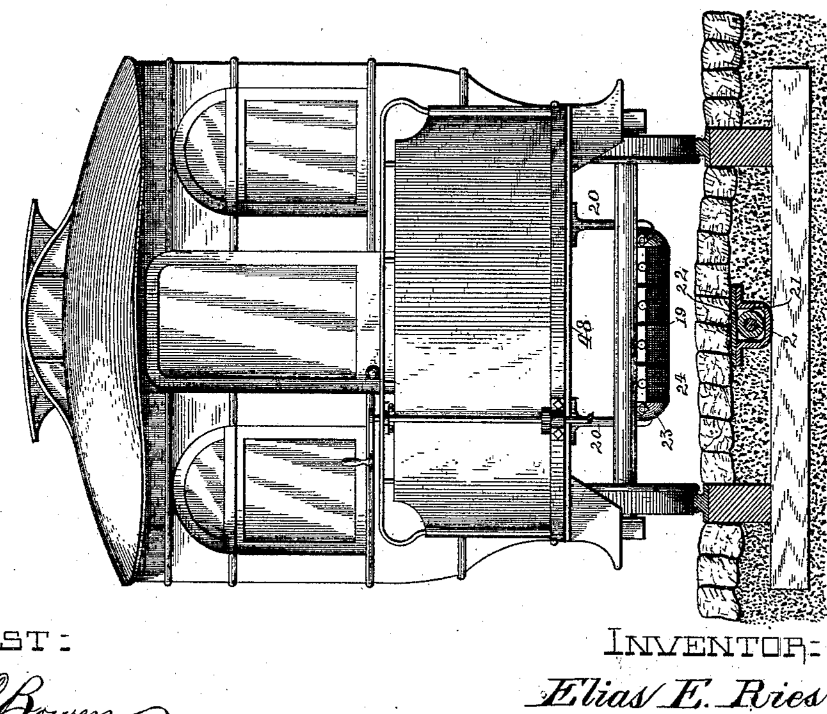

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Fig. 5.

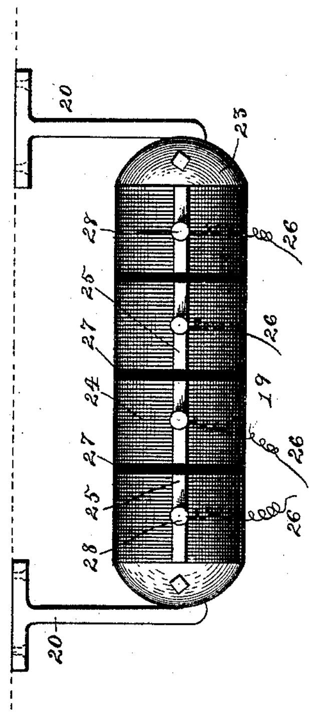


Fig. 6.

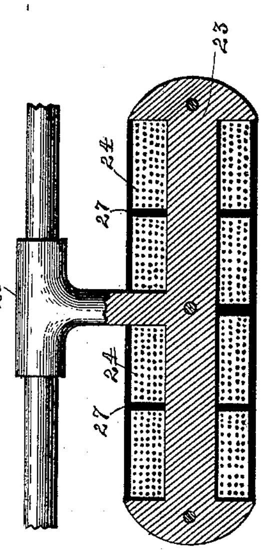
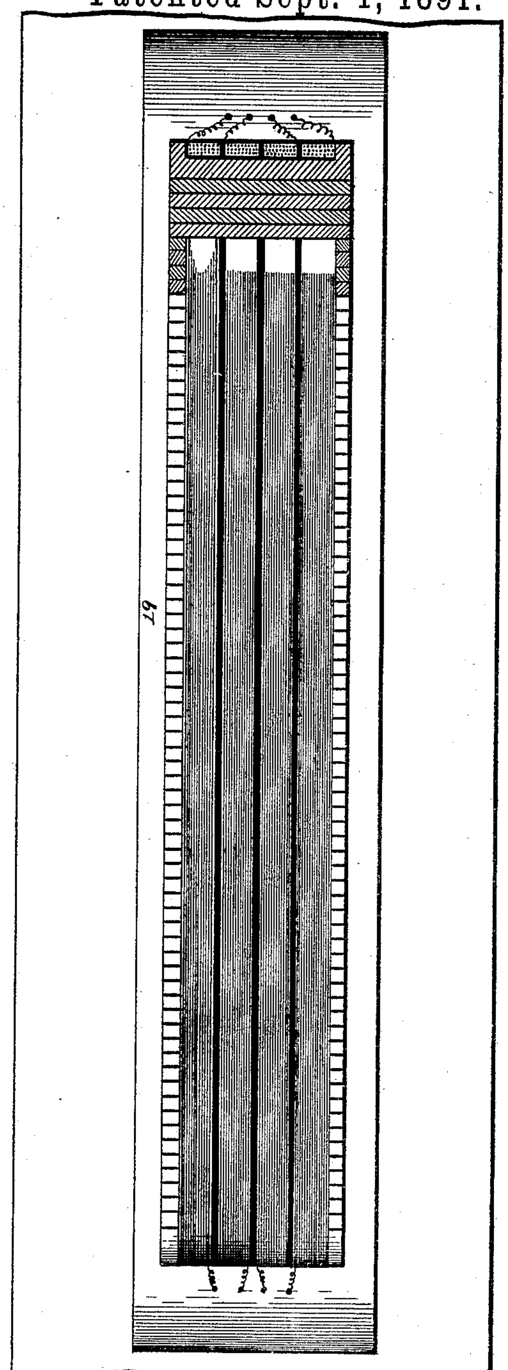


Fig. 4.



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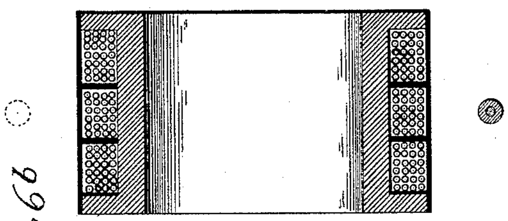

Fig 6b

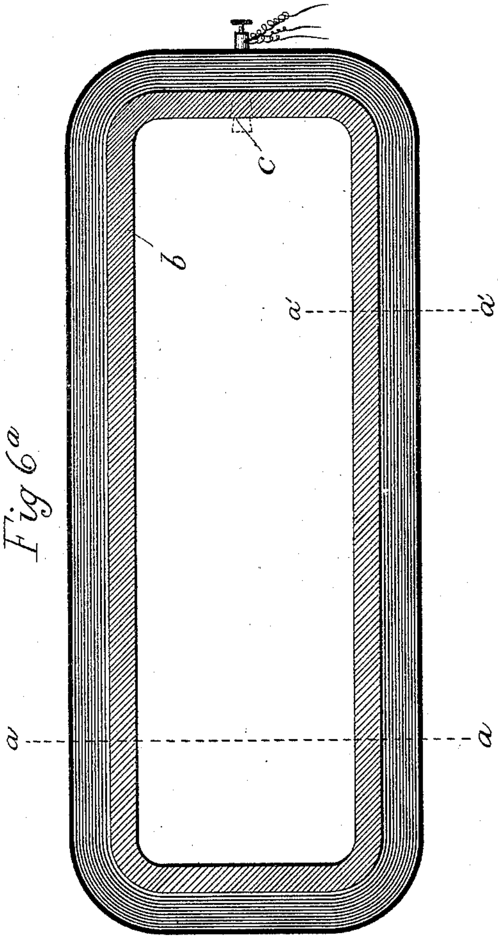

Fig 6a

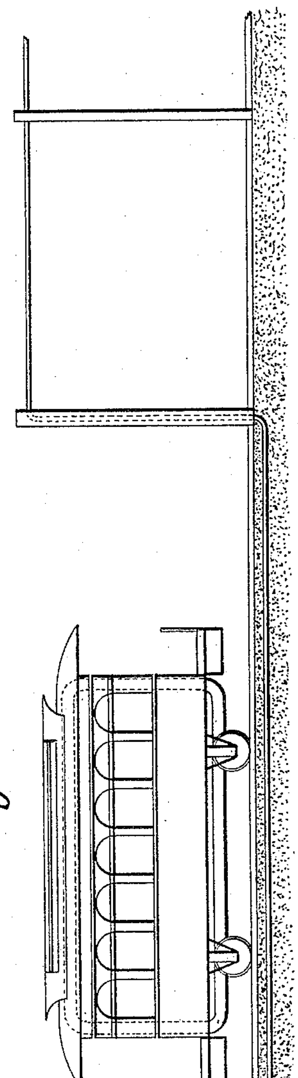

Fig 6c

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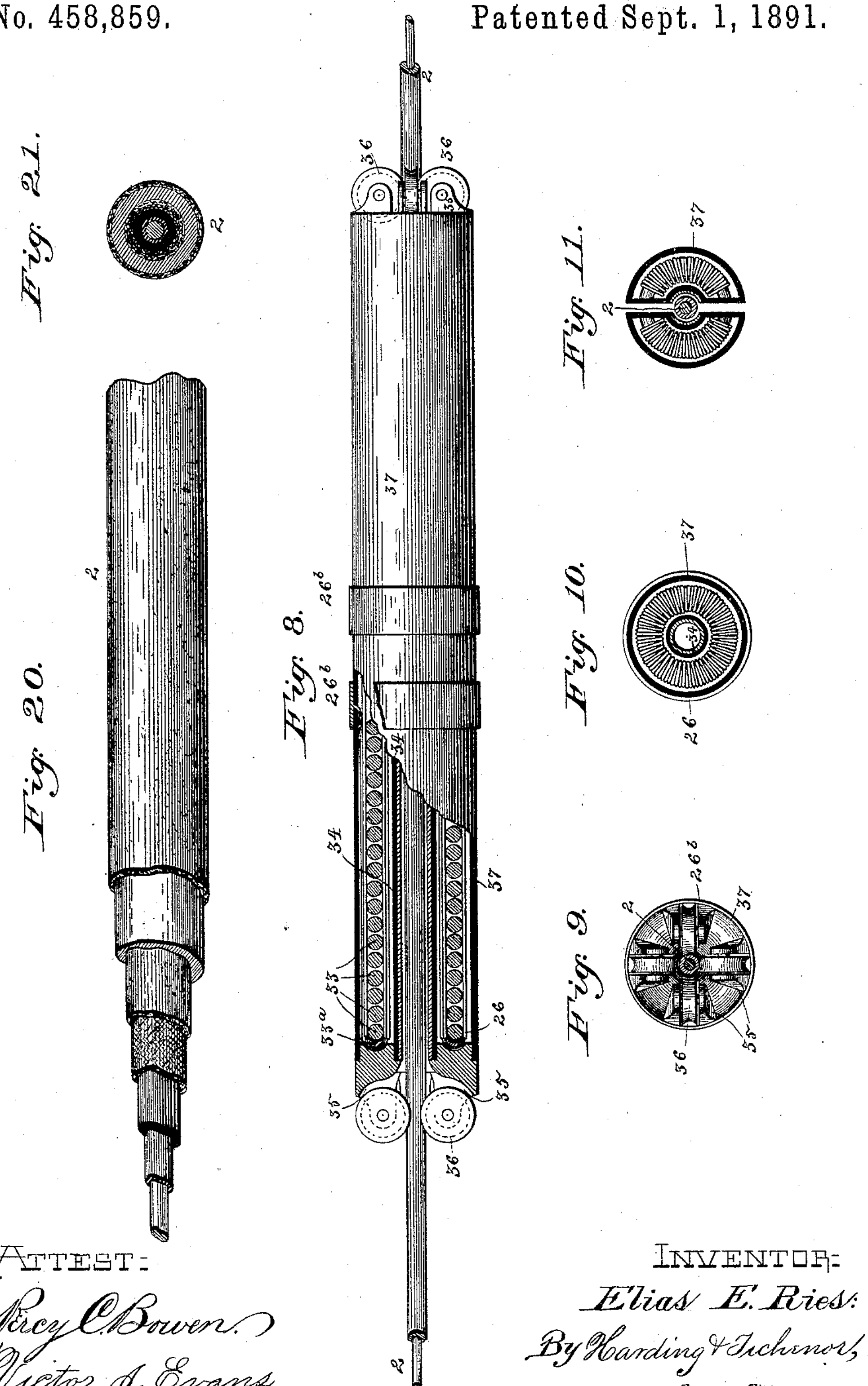

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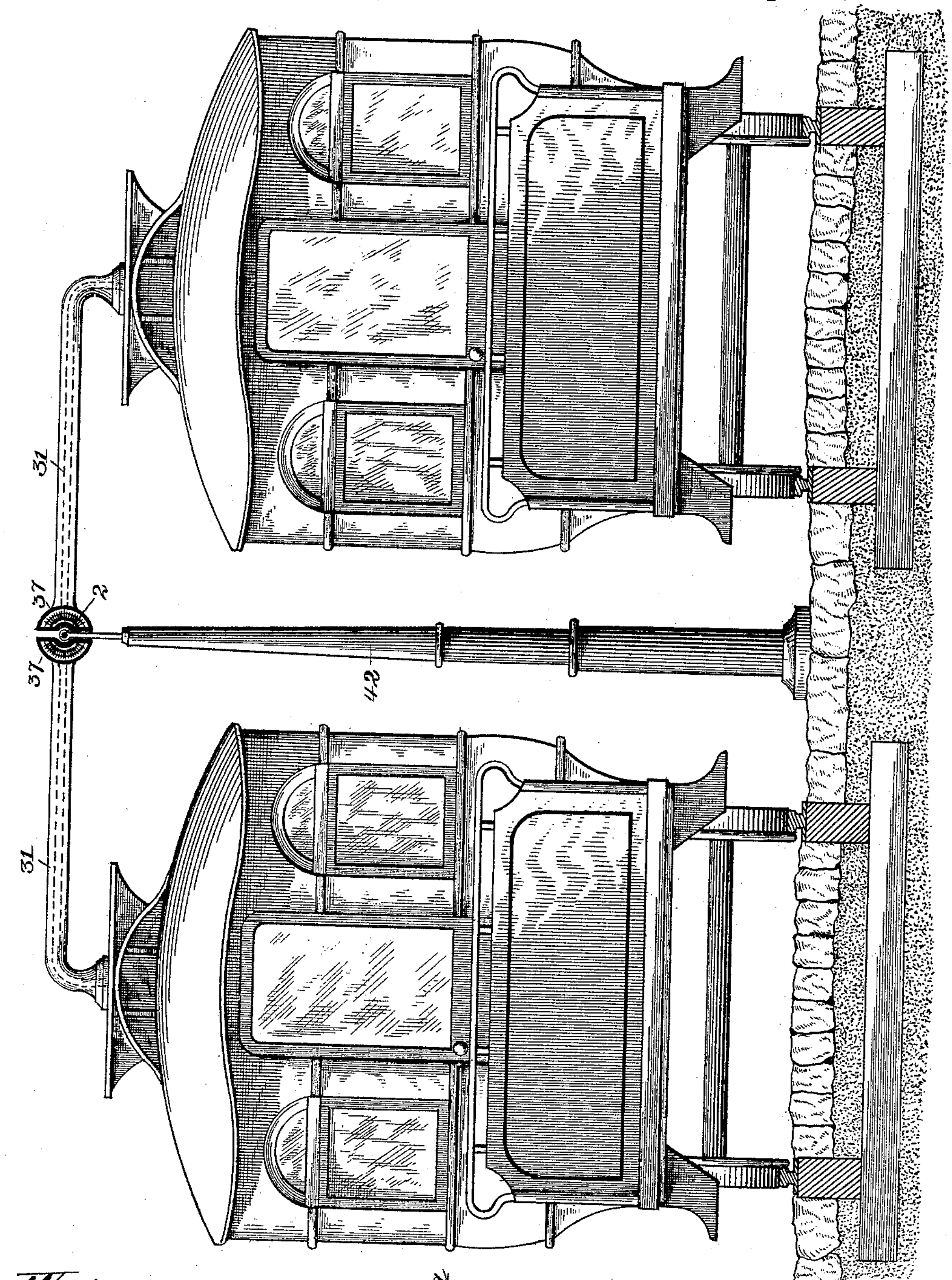

Fig. 11a

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METHOD OF AND APPARATUS FOR OPERATING ELECTRIC RAILWAYS BY DYNAMIC INDUCTION.

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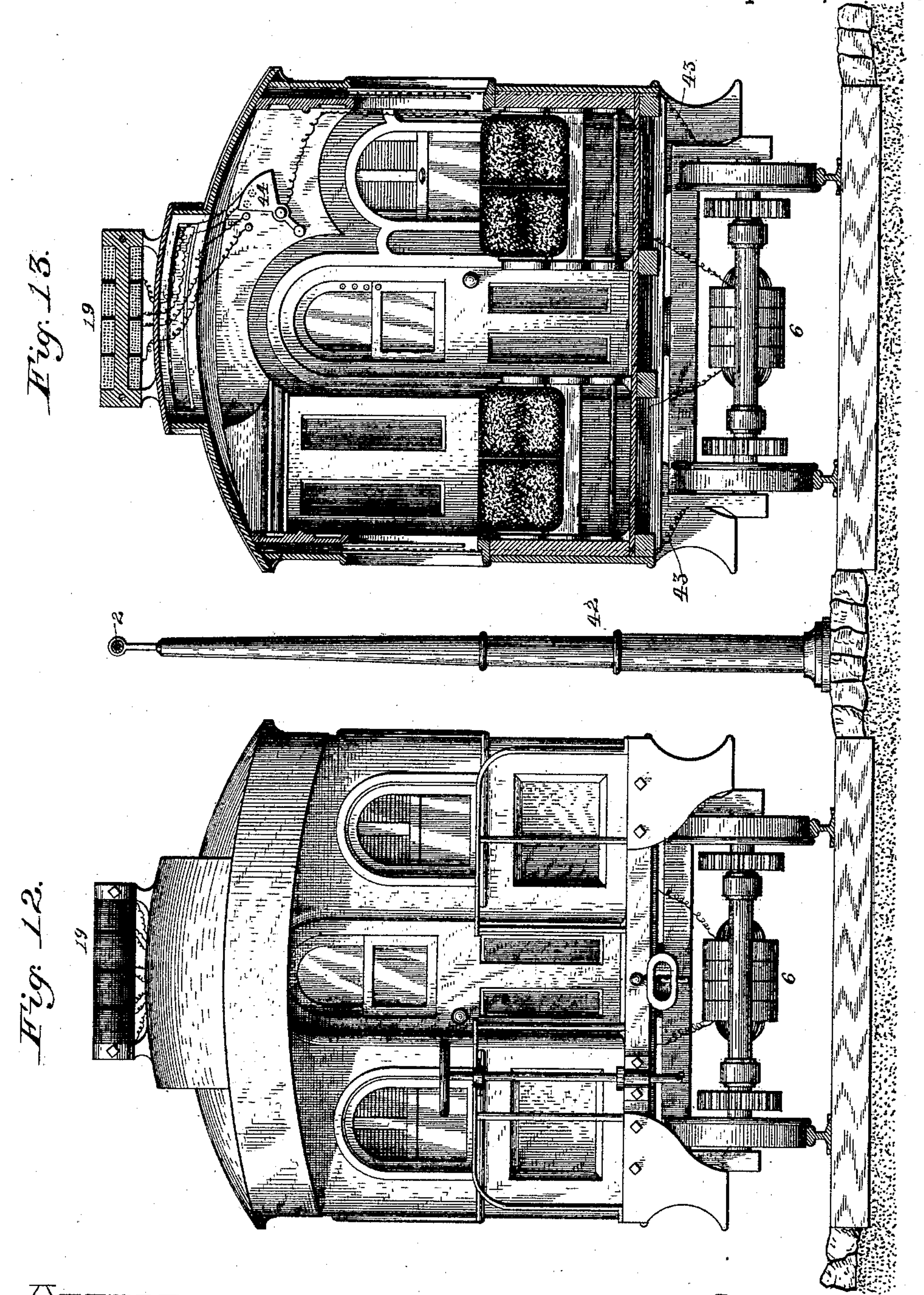

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METHOD OF AND APPARATUS FOR OPERATING ELECTRIC RAILWAYS BY DYNAMIC INDUCTION.

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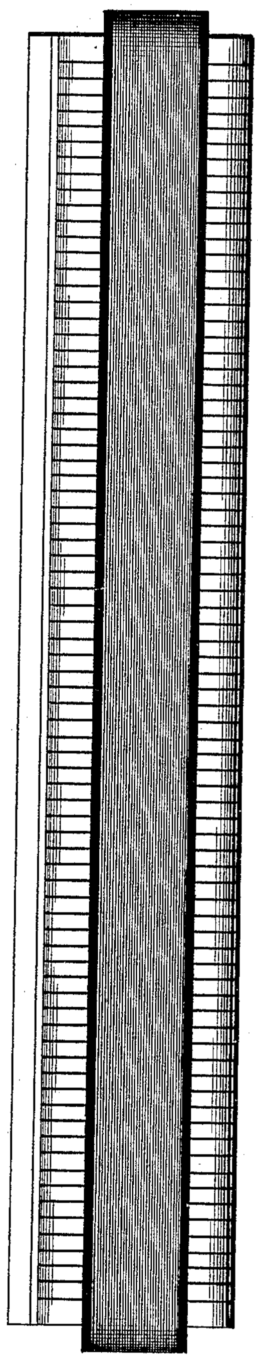

Fig. 14.

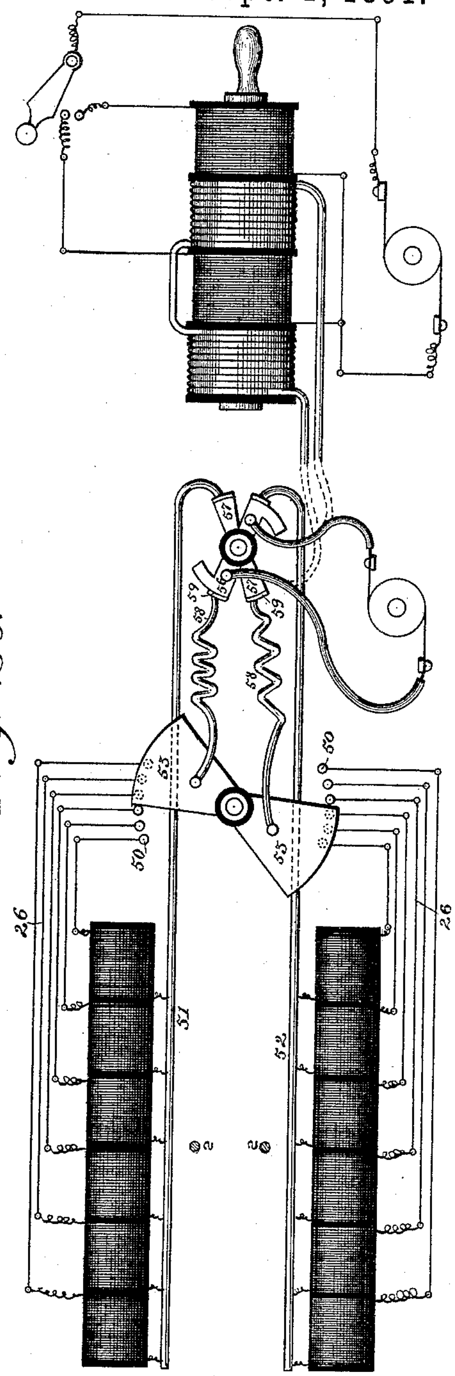

Fig. 26.

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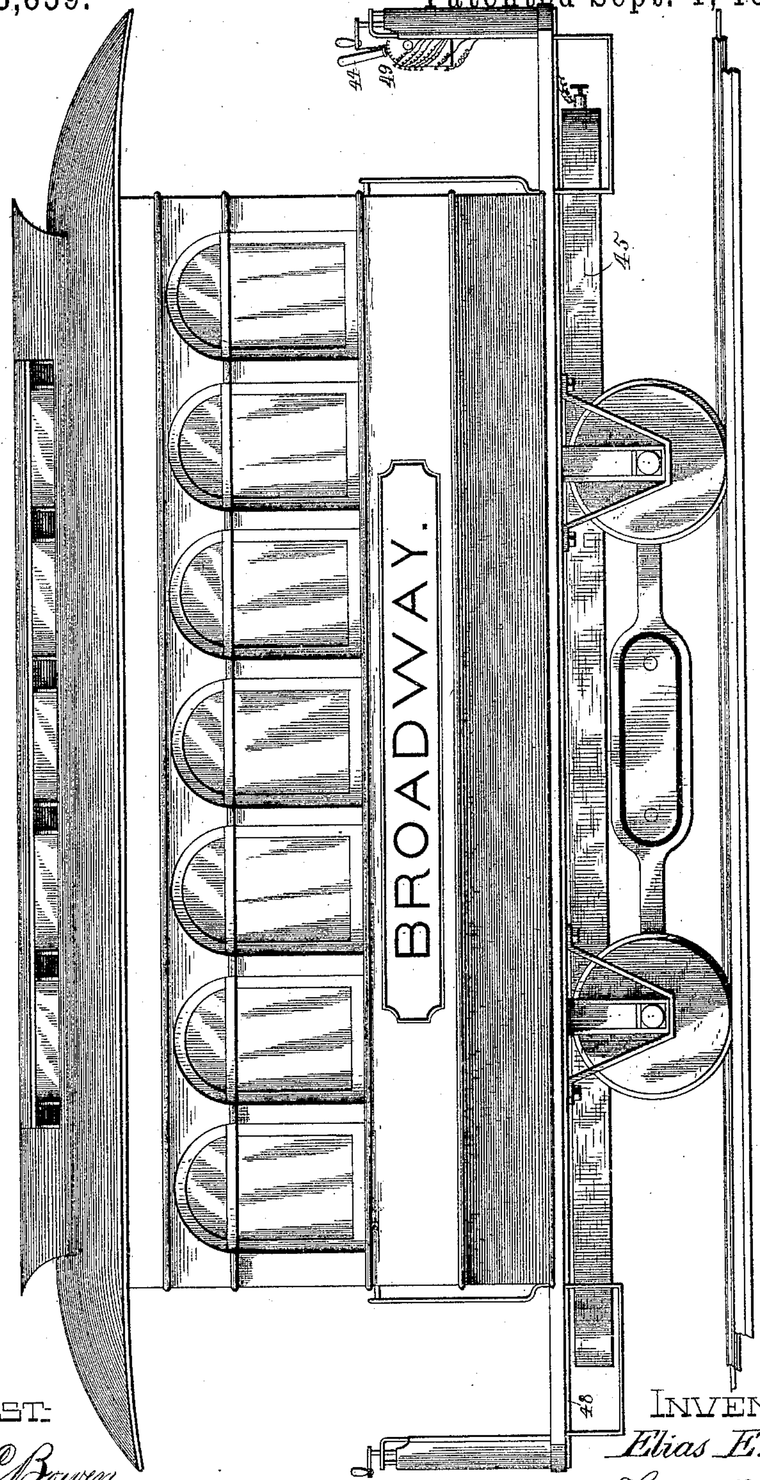

Fig. 15.

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METHOD OF AND APPARATUS FOR OPERATING ELECTRIC RAILWAYS BY DYNAMIC INDUCTION.

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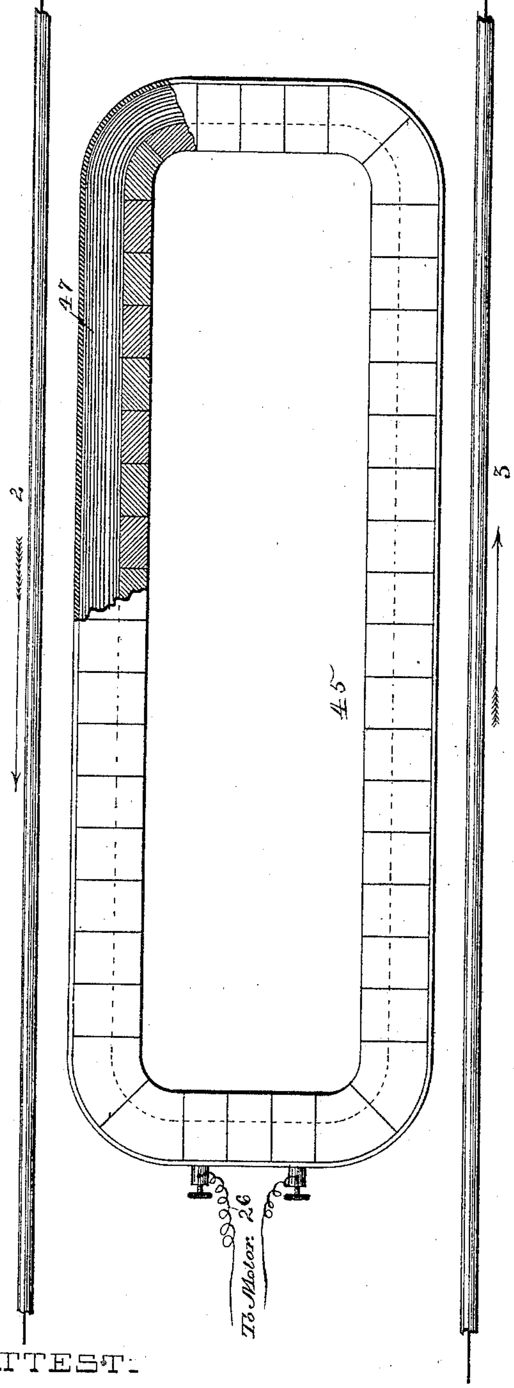

Fig. 16.

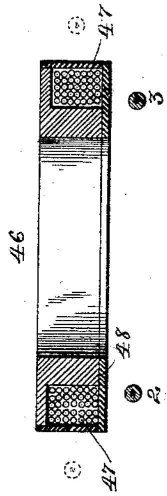

Fig. 17.

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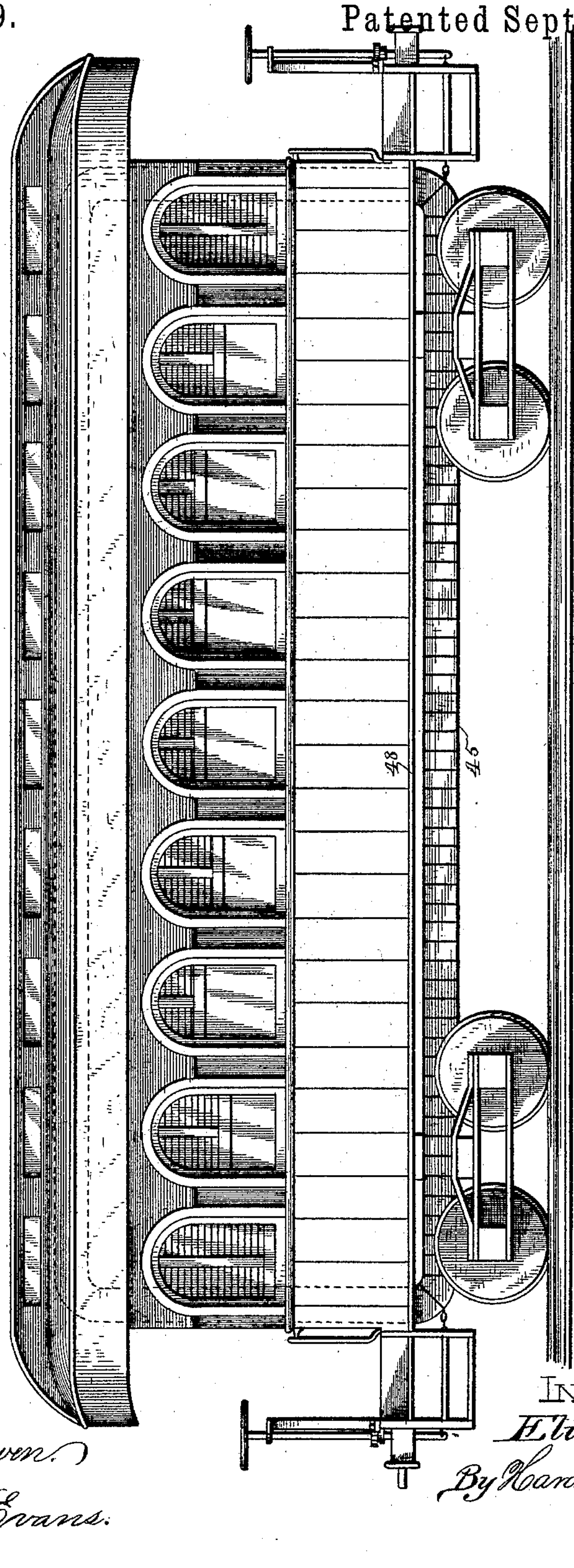

Fig. 18.

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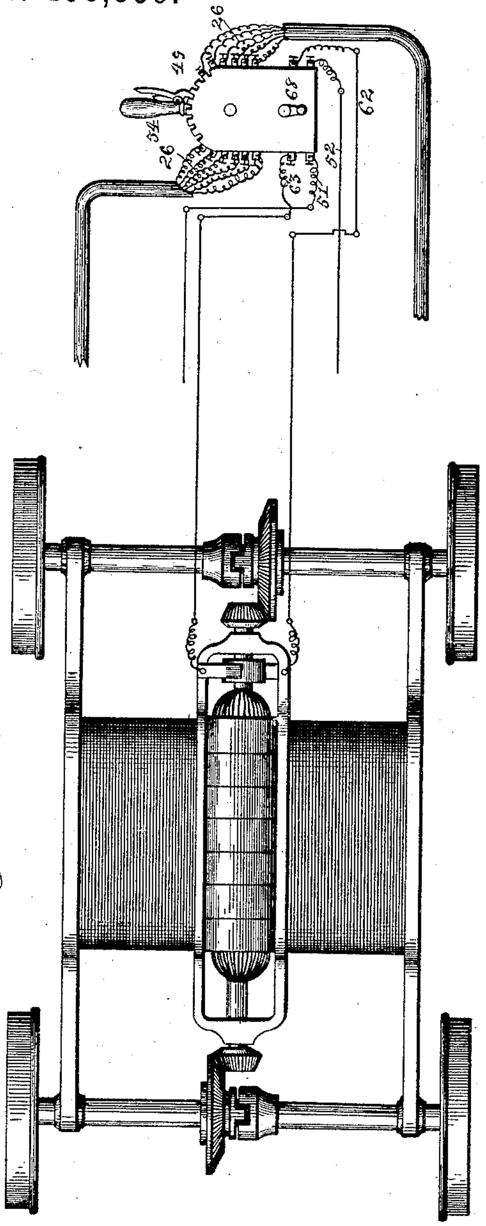

Fig. 24.

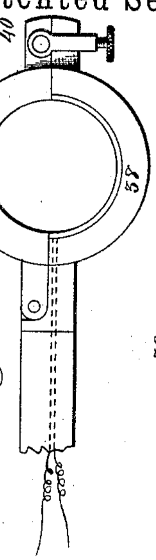

Fig. 22.

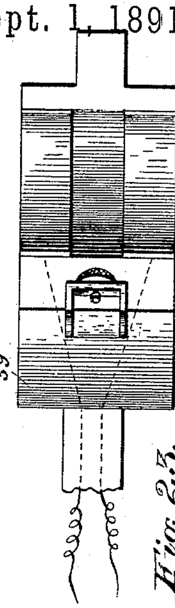

Fig. 23.

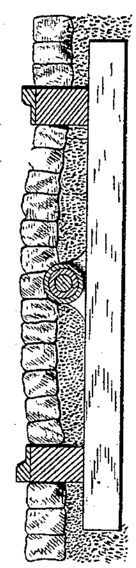

Fig. 19.

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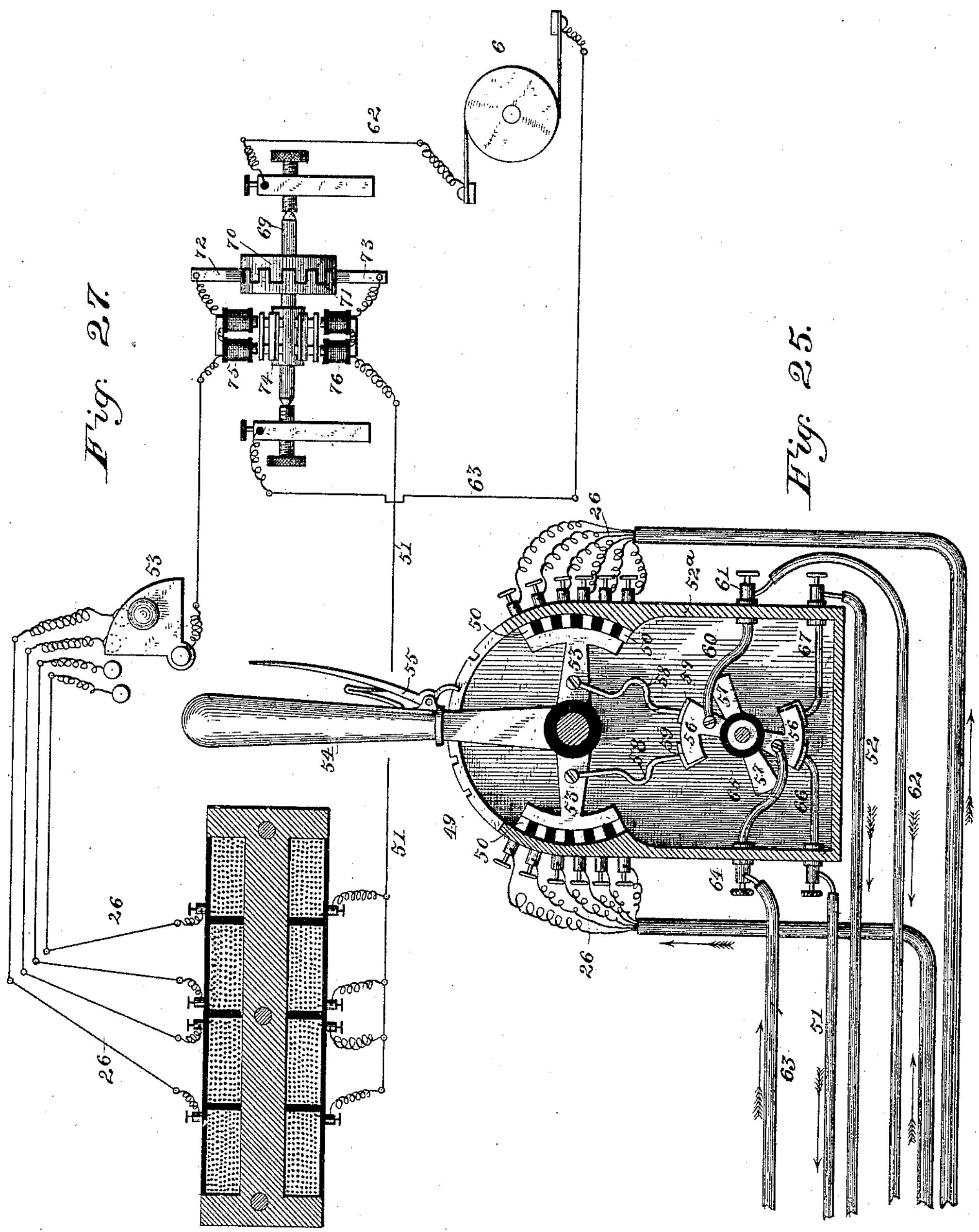

Fig. 27.

Fig. 25.

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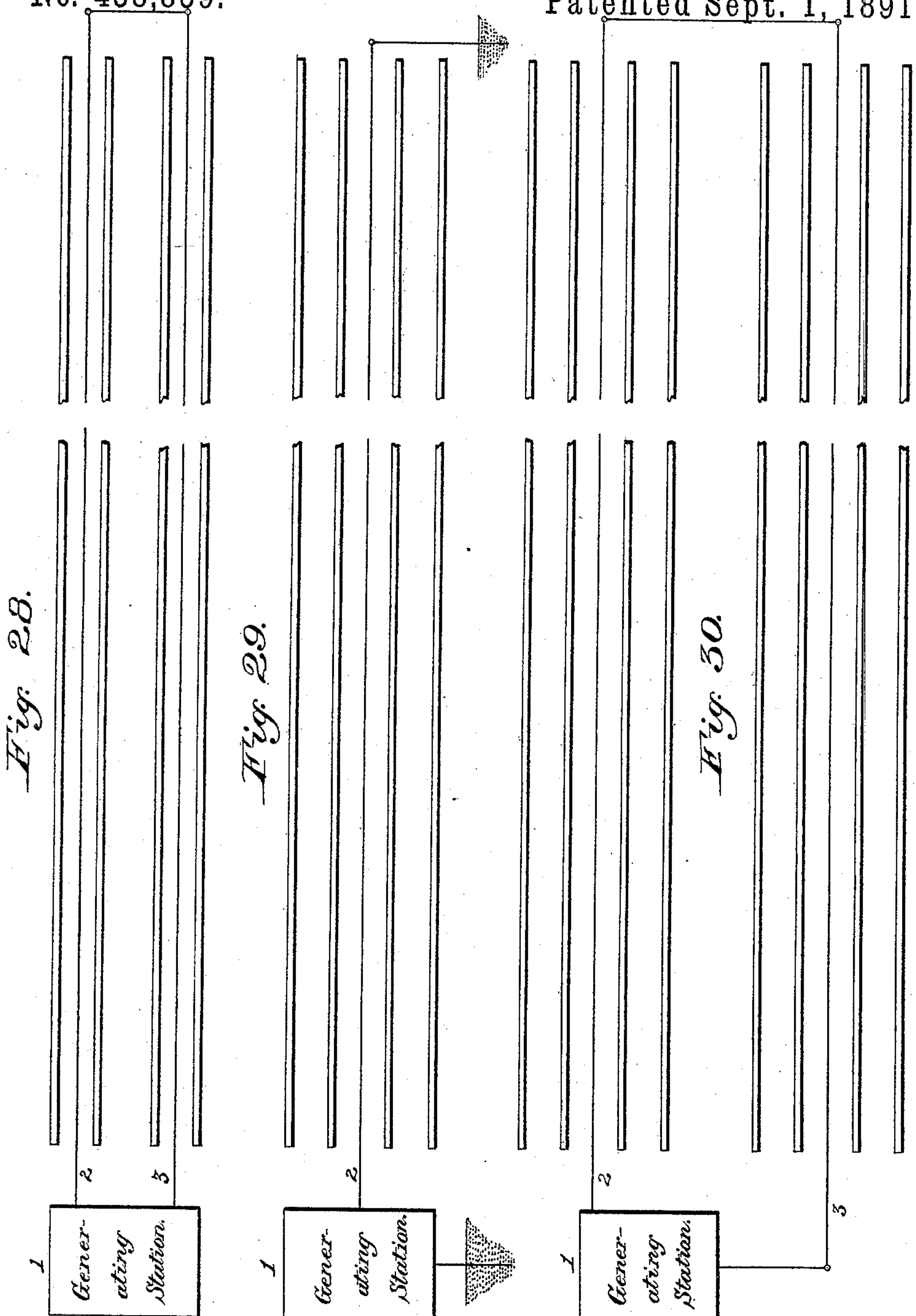

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METHOD OF AND APPARATUS FOR OPERATING ELECTRIC RAILWAYS BY DYNAMIC INDUCTION.

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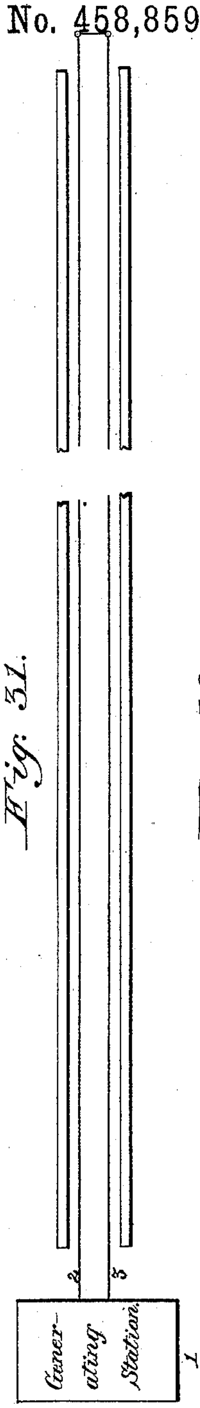

Fig. 31.

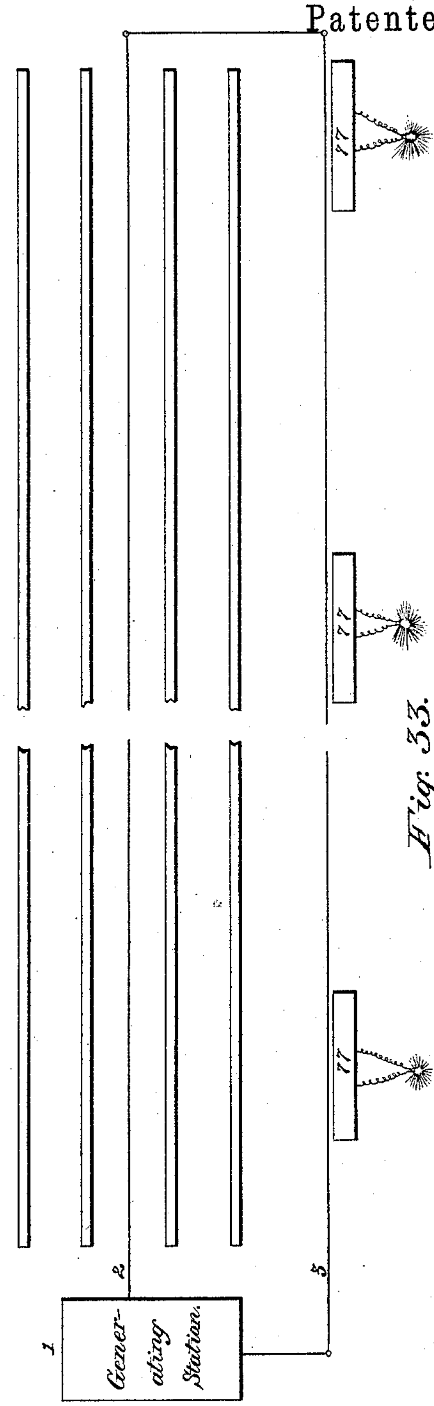

Fig. 32.

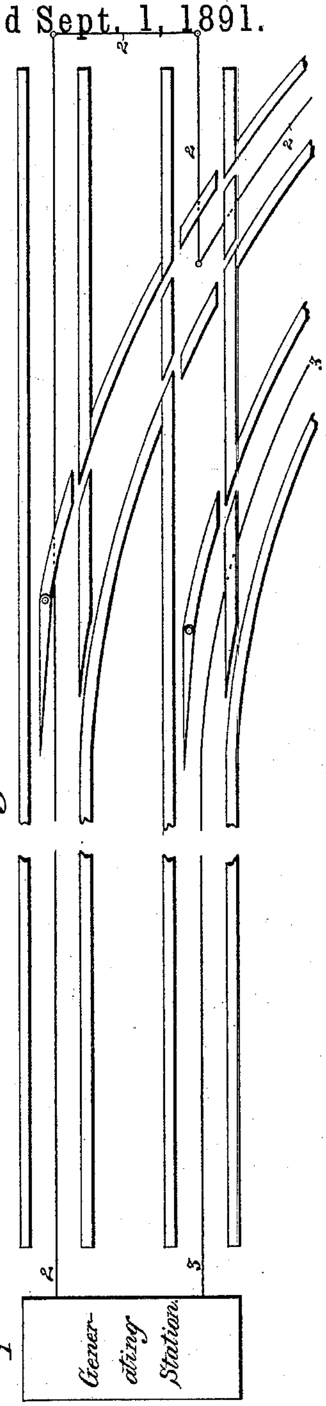

Fig. 33.

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UNITED STATES PATENT OFFICE.

ELIAS E. RIES, OF BALTIMORE, MARYLAND, ASSIGNOR TO RIES & HENDERSON, OF SAME PLACE.

METHOD OF AND APPARATUS FOR OPERATING ELECTRIC RAILWAYS BY DYNAMIC INDUCTION.

SPECIFICATION forming part of Letters Patent No. 458,859, dated September 1, 1891.

Application filed May 17, 1887. Serial No. 238,509. (No model.)

To all whom it may concern:

Be it known that I, ELIAS E. RIES, a citizen of the United States, residing at Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Methods of and Apparatus for Operating Electric Railways by Dynamic Induction; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In the ordinary systems of electric locomotion the actuating-current derived from a stationary source is conducted either by the rails or by separate conductors arranged parallel and in close proximity to the track directly to the motor or motors mounted upon the wheeled vehicle. These separate conductors or rails thus used for conducting the current directly to the motor upon the wheeled vehicle must necessarily be exposed for contact with collecting brushes or wheels. They cannot for this reason be insulated with such care as the advanced state of the art would permit if electrical contact with the same were not required, and considerable loss of current by leakage is experienced in consequence thereof. The necessarily imperfect insulation of the line conductors necessitates the employment of currents of comparatively low tension and considerable quantity, and for the transmission of such currents expensive conductors of good conducting material and of considerable cross-section are required.

It is the object of my invention to overcome the difficulties of electric locomotion due to the direct communication of the source of electrical energy with the traveling motor by substituting for the system involving such direct communication one in which the actuating-current is generated by electro-dynamic induction, whereby I am enabled to insulate the conductors proceeding from the generator or generators in the most perfect manner which the art affords, to utilize currents of very high tension and comparatively small quantity, and to employ line conductors of inferior conducting capacity in surface overhead and underground electric-railway systems.

Other advantages not here enumerated result from the employment of my novel system, which embraces not only a new apparatus, but also a new mode of operation, as will clearly appear from a detailed description of the same. In my system I arrange one or more stationary generators along the track or line of way and carry the intermittent or alternating currents of high tension generated by the same through a thoroughly-insulated conductor into inductive proximity to another conductor or conductors, which may be either stationary and arranged along the track for contact with brushes connected with the motor upon the vehicle or may be mounted upon the traveling vehicle and suitably connected in circuit with the motor. There are, therefore, two independent circuits in inductive proximity to each other, one for carrying the primary currents generated by the stationary generators and the other for carrying the currents generated by dynamic induction to the motor. The two circuits have the relation of a primary and a secondary coil of an inductorium, with this difference, however, that while in the ordinary inductorium the relations of the resistances of the two circuits is such that the induced currents have greater tension than the inducing-currents in the circuits employed in my system this relation is directly reversed. Again, another difference is that in the ordinary inductorium the coils are invariably fixed, while in accordance with my invention they may be movable with relation to each other. The system of conductors which carries the induced current I have called the "translator-conductor" or the "secondary of the transformer," and the system of conductors which carries the inducing-currents will be spoken of in this specification as the "inducing or line conductors." The currents generated in the translator are necessarily alternating, and they may be utilized as such in a motor constructed to be operated by such currents, or these currents may be first commutated to flow in the same direction and then utilized in an electric motor of ordinary construction. All this will more fully appear from the following detailed description, with reference to the accompanying drawings, which form a part hereof, and in which I have illustrated several of the very numerous forms which my invention may assume; but it will be understood that I do not propose to limit myself to the particular embodiments of the principle of my invention herein shown and described, nor to the details of construction pointed out, since these are only a few specimens of a great number which may be employed without departing from the spirit of my said invention.

Figure 1 represents a diagram of my improved system of electric locomotion in its simplest form, in which the rails constitute the translator or secondary of the transformer. Fig. 2 is a similar view of a modification, in which separate conductors located between the rails are used as the secondary of the transformer. Fig. 3 shows an end view of a vehicle with the secondary of the transformer secured to the bottom of the same and the road-bed and line conductors in section. Fig. 4 is a plan view of the secondary of the transformer used in the construction shown in Figs. 12 and 13, the same being partly in section. Fig. 5 is an end view of the transformer used in the system shown in Fig. 3. Fig. 6 is a cross-section of the same when suspended from the car-axle instead of secured to the bottom of the car. Fig. 6^a is a vertical longitudinal section of a modified and improved form of translator which might be substituted for the one shown in Fig. 6. Fig. 6^b is a transverse section on line a a, Fig. 6^a. Fig. 6^c is a diagram showing a car provided with the transformer shown in Fig. 6^a and showing its use in connection with underground and overhead line conductors where both forms are used on the same line of railway. Fig. 7 is a cross-section of the vehicle with the translator carried by a swinging arm upon the roof, with the line conductor mounted upon poles or standards along the road. Fig. 8 is a side view, partly in section, of the translator carried by the swinging arm. Fig. 9 is an end view of the same, showing the guiding-trolleys; Fig. 10, a cross-section of the translator, and Fig. 11 a cross-section of a modified form of such translator. Fig. 11^a is an end view of a double-track road, showing the use of the translator represented in Fig. 11. Figs. 12 and 13 are an end view and cross-section, respectively, of a vehicle with the translator placed upon the roof and the line conductor between the two vehicles carried upon posts. Fig. 14 is a side elevation of a modified form of translator. Fig. 15 is a side elevation of a street-car having the translator arranged underneath on the bottom of the car and preferably rectangular in form. Fig. 16 is a plan view of the translator preferably used in such street-car, the line conductors being indicated diagrammatically. Fig. 17 is a cross-section of such translator with the line conductor in proper relation thereto. Fig. 18 is an elevation of a railway-car with a rectangular translator placed vertically one on each side thereof. Fig. 19 is a cross-section of the road-bed of the street-railway. Figs. 20 and 21 are a side view and cross-section, respectively, of the line conductor when the same is placed under ground. Figs. 22 and 23 are an end and plan view, respectively, of the clamp in which the translator used in the construction shown in Fig. 7 is placed. Fig. 24 shows the general arrangement of the motor and a switch for controlling the currents from two translators, one on each side of the car. Fig. 25 is a transverse sectional view of the switch. Fig. 26 is a diagram of said switch in proper relation to the translator-circuits, showing also how an ordinary transformer may be interposed for reconverting low tension to high tension. Fig. 27 is a view illustrating conventionally or theoretically a commutator for straightening the alternating currents from the transformer, and Figs. 28 to 33 are diagrams showing the relative locations of the line conductors and rails which I contemplate using in my system.

Like numbers and letters of reference indicate corresponding parts in all the views.

In the systems indicated in Figs. 1 and 2 the generator or generators are preferably placed at one end of the line of railway, as indicated at 1. 2 and 3 are line conductors proceeding from the generators and extending along the track parallel to the same. A cross-connection 4 closes the circuit from said conductors.

In Fig. 1 the line conductors are shown directly under the rails, and in this instance these rails constitute the secondary of the transformer or the translator, and provision is made for contact of the same with the wheels of the vehicle, which in turn are suitably insulated from their axles, as clearly indicated in the drawings. Contact-brushes 5 5 bear upon the wheels and are connected with the motor 6, as will be presently described. Such contact-brushes 5 5 may be used in connection with either two or four wheels of the vehicle; but in each case the brushes on one side of the car are connected by suitable conductors 7 with the brushes 8 of the motors, while the contact-brushes on the other side of the car are connected with the switch-arm 9, which when swung to the right or the left makes contact with different termini of the rheostat 10, which, in turn is connected with the other brushes 11 of the motors on the line. At the end of the track farthest from the generating-station the translator-rails are connected with a resistance 12, included in the said connection. This resistance, however, may be omitted. The operation of this arrangement will now be easily understood. The alternating or intermittent currents passing over the line conductors will induce alternating currents in the translator-circuit, which is closed at one end by the motor on the traveling vehicle and at the other end, when but one traveling motor is in use, by the artificial resistance 12 or by a simple cross-connection, and this cross-connection may be dispensed with when more than one motor is on the line. The engineer, having control of the switch-arm 9, can close the circuit to the motor at will, and by changing the contact to different termini of the rheostat 10 can regulate and determine the flow of current to the motor, according to the length of active translator from moment to moment. The motor must be of a kind to be operated by alternating currents, and it will be evident that this motor may be of any description—as, for instance, of the character shown in Fig. 27, although I do not here limit myself to the same. If more than one car provided with a motor should happen to be on the same line of rails, as shown in Fig. 1, each motor will receive its proportion of currents, since all the motors are then arranged in multiple arc to each other.

In Fig. 2 the line conductors are depressed below the surface of the road-bed, and between the same and parallel thereto are two conductors 13 14, which at the farthest end may be bridged by resistance 12, as in Fig. 1. These conductors 13 14 here constitute the secondary of the transformer, and the same, as well as the line conductors 2 3, are placed in an excavation or conduit in the center of the road-bed. The slot 15 in the center of said road-bed permits the entrance of an arm 16, which projects downwardly from the car and is arranged to be under control of the engineer or motor-man. Secured to the lower end of said arm is an insulating carrier or yoke 17, having a contact-wheel 18 at each extremity. By means of the arm 16 the carrier 17 may be swung around the arc of a circle, so as to effect the contact of the wheels 18, respectively, with the translator-conductors 13 14. If such contact is established, the current will proceed from the translator to one of the contact-wheels, and by suitable connections up through arm 16, and by conductor 7 to the brush 8 of the alternating-current motor 6, then through the armature of said motor by the other brush, rheostat, switch-arm 9, and by wires, as indicated, through arm 16, to the other contact-wheel 18 back to the transformer. It will thus be understood that more than one motor may at the same time proceed along the tracks and all receive their requisite amount of current in the same manner as shown in the arrangement of Fig. 1. It will also be seen that in this case the rails form no part of the transformer, and in fact are not at all in the circuit; but in order to prevent wasteful induction from the line-conductors into the track the wheels of the vehicle should be thoroughly insulated from their axles, so that no current can pass up into the car through the metallic portions of the same, except such as is admitted by the arm 16; or the traffic-rail sections may be insulated from one another, and thereby divide up the length exposed to the inductive action, which of course will then be open-circuited and not affected by the induced currents, as indicated in Fig. 2. In the operation of this system line currents will naturally be of comparatively very high tension, and it is therefore not necessary that the translator-conductors should be arranged in close proximity to the former. On the contrary, it is advisable to separate the translator-conductors a reasonable distance from the line conductors. It will be noticed that as the motor proceeds from the generating-station toward the farther end of the road the inductive effect upon the secondary of the transformer decreases, and for this reason, mainly, the rheostat 10 is provided, by means of which the resistance of the motor as the car approaches the end of its travel may be automatically regulated and reduced.

In Fig. 3 the translator 19 is secured by brackets 20, depending from the floor of the car in proximity to the road-bed under which the line conductor 2, properly insulated, is placed between the track-rails. Said conductor is incased in an iron trough 21, provided with a cap 22, of non-magnetic insulating material. The iron trough serves as a shield against lateral induction, which would injuriously affect neighboring telegraphic or telephonic cables, and the cap 22 is purposely made of non-magnetic material, so that the inductive effect upon the translator may not be intercepted, as would be the case if said shield were of magnetic material. The iron trough serves also as a path for the magnetic lines of force from the laminated iron core 23 of the translator 19, (shown in detail in Figs. 5 and 6,) whereby the inductive effect is materially increased.

In Fig. 6 the translator itself is shown in cross-section, and in Fig. 5 in end elevation. It will be seen that it is composed of a laminated core 23, of soft iron, and loops of wires 24, wound transversely over the same. These loops are collected at each end by metal strips 25, from each of which a wire 26 proceeds to the motor; but, as will be seen from what follows, a suitable switch, and in some cases a commutator, is interposed between the translator and the motor. The translator extends throughout the whole length of the car, and the currents induced in the same are, by reason of its peculiar construction, of comparatively very low tension and great quantity. The reason for this is that the sum total of the cross-sections of the wires in the translator is much greater than the cross-section of the line conductor, while the effective length of the translator-conductor is much shorter than the line. With this construction it will be understand that while the difference of potential at the terminals of the line conductor or the electro-motive force of the generator may be very great the difference of potential between the ends of the effective lengths of the line conductor is moderate, and the current induced by that effective portion of the line conductor in the translator can never rise above that moderate difference of potential. Thus I am enabled to use at the distant station a generator of very high electromotive force and still obtain from the translator in the motor-circuit a current of comparatively low tension. The collection-strips 25 on each side of the transformer are interposed between the insulating-partitions 27, and each pair of such strips is in communication with the binding-post 28, from which the wires 26 proceed, all of which is clearly indicated in Fig. 5.

In Fig. 6 the transformer is shown as hung by sleeves 29 from the car-axles; but in all other respects the construction is the same as that in Fig. 5. Inasmuch as the loops of the transformer (shown in Figs. 5 and 6) are united at their ends in the manner illustrated and described, practically these several loops or coils are single conductors of very low resistance, the same as a single plate of copper would be. The same connection of the sections of coils into loops will be used in the translator shown in Fig. 4 when the same is used on the top of a car, in the manner represented in Figs. 12 and 13.

Figs. 6^a and 6^b illustrate a translator constructed upon the same principle as that represented in Figs. 4, 5, and 6. In this case, however, the translator has the shape of a rectangular frame, more especially adapted for use when placed vertically in a car, as indicated in dotted lines in Fig. 6^c. There is a rectangular iron frame-core *b*, U-shaped in cross-section, and insulated wires are wound upon the core in insulated groups, as indicated in Fig. 6^b, and these groups may be united by binding-posts, as indicated in Fig. 6^a. By preference the iron core is not continuous, but has a portion of it cut away, which is replaced by some non-conducting material, as indicated in dotted lines at *c*. The purpose of this is to prevent the generation of currents in the magnetic core. As shown in Fig. 6^c, this translator is made as large as the frame of the car on which it is used, and it may act in conjunction with an underground line conductor or in conjunction with an overhead line conductor. In the first instance only the lower branch of the translator will be acted upon inductively by the line conductor, and in the second instance only the upper branch of the translator will be acted upon, the magnetic core forming an anti-inductive shield for the other branch in each instance. In electric railways proceeding from the populated portion of a city to suburban places the line conductor in the populated portion of the city will be laid, preferably, under the track, while in the suburbs the cheaper overhead line conductor may be used. With a car equipped as indicated the transit from the city to the suburbs may be made without a moment's interruption of the effective working of the motor, as will be readily understood.

In Fig. 6^b the underground line conductor is indicated in solid lines, while the overhead line conductor is indicated in dotted lines.

In Fig. 7 the translator 30 is carried by a laterally-projecting arm 31, mounted upon the roof of the car and arranged to be swung from one side of the car over to the other side by a crank-handle 32.

The translator itself (shown more clearly in Fig. 8) consists of wire loops wound over a series of iron rings 33, which are arranged side by side, so as to constitute in effect a laminated core in the form of a tube or pipe extending the whole length of the car. The insulated wire loops are wound upon these rings as a core in the same manner as the armature of a Gramme machine and at each end are connected with the conductors 26 for connection with the motor. An interior lining 34, of insulating material, protects the inner wires against contact with the insulated line conductor 2, which passes axially through the said translator. At each end the transformer is provided with four brackets 35, in each of which is mounted a grooved roller 36, these four rollers embracing and centering the line conductor. An exterior covering 37, of any desired material, protects the translator against injurious effects of the weather. This translator is carried upon the swinging arm 31, as stated before, which arm is provided at its free end with a bearing 38, semicircular in shape, and a cap 39, pivoted at one end to the arm and provided with means for clamping it down upon the translator at the other end, as indicated at 40. All this is clearly shown in Figs. 22 and 23. A modified form of translator of this character is shown in Fig. 11, where the same is represented as divided into two halves, each half in the shape of two arcs of concentric circles bounded by radial lines. Each half is bound by itself, and the two parts when joined together leave room for a line conductor passing between and in inductive proximity to them.

As shown in Fig. 11^a, each semicircular translator may be carried upon a swinging arm on a separate car upon adjoining tracks, so that two lines of railway can be operated by a single line conductor, similar in this respect to the arrangement shown in Fig. 7, except that the line conductor may in this case be fixed securely in place, as in Figs. 12 and 13. In Fig. 7 the line conductor is mounted upon arms 41, projecting from posts 42, planted all along the road, like telegraph-poles, as will be clearly seen by reference to said Fig. 7. The line conductor 2 rests loosely in a depression or hook at the end of arm 41, and as the car proceeds it is lifted from its support at each post until the car has passed, when by its own gravity it will again settle upon the arm 41. In Fig. 7 are also shown the circuit connections 26 to the motor 6, which is geared to the wheels of the car, as indicated in the drawings, or in any other convenient manner. The roof of the car is preferably made of iron to serve as an inductive shield to protect the watches of the passengers against magnetization. The electric charges induced in said roof are carried to ground by conductors 43, suitably connected with the wheels.

In Figs. 12 and 13 are shown two cars on adjoining tracks, with the line conductor 2 fixed upon poles 42, planted between the adjacent parallel tracks. There is a translator 19 fixed upon the roof of each car, each translator being constructed substantially like those described with reference to Figs. 4, 5, and 6. In Fig. 13 an ordinary switch 44, interposed between the translator and the motor, is shown, and in this case also the metal roof is connected with the ground by wires 43.

In Fig. 15 the street-car is shown provided with a translator having the shape of a rectangle, as indicated in Fig. 16. A rectangular frame 45, of magnetic material, preferably laminated, as shown in Fig. 16, and having the cross-section indicated at 46 in Fig. 17, is wound all around with wire like the frame of a galvanometer. The wire wrapping 47 is held in place at its lower side by a plate 48, of insulating material, and two line conductors 2 3, one on each side of the car, one carrying the current in one direction and the other returning it in the other, act inductively upon wires 47, the termini 26 of which are connected with the motor. The line conductors 2 3 may be arranged either to the right or left beyond the translator or to the right and left under the same, as indicated in Fig. 17.

In Fig. 18 the translator is constructed substantially like that shown in Fig. 6ª. Two such translators are used in this instance, both placed vertically. One of these translators is on each side of the car, preferably within the same, and an anti-inductive shield 48, of iron, extending horizontally above the lower branches of the translators, prevents inductive action within the car and upon the upper branches. The line conductors in this latter instance are arranged like those in Figs. 16 and 17, as is more particularly exhibited in Fig. 31. A single conductor in this case may serve for both translators, the upper coils of which are not affected and serve simply as conductors, except when in addition to the lower line conductor an upper one is also used. (See Fig. 6ᶜ.)

In Fig. 24 the general arrangement of the motor upon the car, the manner of gearing the same to the car-axle, and the circuit connections to a translator on each side of the car are indicated in a general way. There is a switch 49 interposed between the motor and the translators, and the details of construction of said switch and its mode of operation are shown in detail in Figs. 25 and 26.

In Fig. 26 there are two translators shown diagrammatically, one on each side of the line conductors 2 3, which latter, it will be understood, extend parallel to the active wires of the translators. The particular construction of those translators is of no consequence to the operation of the switch, but may be such as shown in Figs. 6, 6ª, and 6ᵇ. It is sufficient to know that a series of wires 26 26 proceeds from each translator and terminates in a circular row of contact-points 50. Each of these wires proceeds from one section of the translator, while the other terminals of the section of each translator are collected upon a conductor 51 and 52, respectively. With the two sets of coils in series the potential would in some cases be too high and the quantity too small; but by connecting the two sets in parallel the electro-motive force may be reduced to the desired point and the current strength at the same time increased.

In Fig. 25 the mechanical construction of the switch is shown in detail, as follows: There is a frame 52ª, of insulating-material, the upper part of which is shaped upon the arc of a circle and having distinct contact-points 50, separated from each other by blocks of insulating material and each connected with a binding-post, as shown, from which binding-posts the conductors 26 return to the translator. The switch-lever 53 is pivoted in the center of the circle, upon the arc of which the upper part of frame 52 is shaped, and the switch-handle 54, provided with suitable locking devices 55, is adapted to turn the switch down to cause the same to make contact with one or more of the contact-points 50. Two other switch-arms 56 57 are pivoted below the switch-arm 53. They are individually insulated, but turn upon the same axis and cross each other at an acute angle. The spring-arms 58 58 connect switch-arm 53 with contact-plates 59, the arrangement being such that when switch-arm 53 is moved about its pivot the flexible conductor-arms 58 will yield to that motion. As indicated in Fig. 26, two branches of the switch-arm 53 are insulated from each other, as are also the two branches of switch-arm 56, while the two branches of switch-arm 57 are metallically connected, the same being in fact made of one piece of metal. In the position of the switch shown in Fig. 25 the currents from the two translators traverse the wires 26 26, and from thence proceed by the contact-points 50 over switch-arm 53, the flexible conductor 58 to contact-plates 59. If now switch-arm 56 is in the position shown in Fig 25—that is to say, if it bridges both the contact-plates 59 59—the two branches of current from the two translators unite upon switch-arm 56, and the united current passes by conductor 60 to binding-post 61 in frame 52, and then by conductor 62 to the motor. From the motor the current returns by conductor 63, binding-post 64, conductor 65 to the second branch of switch-arm 56. Here the current divides again, one branch passing by conductor 66 and 51 to one translator and the other branch by conductor 67 and 52 to the other translator. Thus it will be seen that in the position of switch-arms 56 and 57 shown in Fig. 25 the currents from the two translators pass in multiple arc to the motor, and it will be understood that by proper manipulation of switch-handle 54 the currents from any number of sections of the translator may be brought into play. On the other hand, if the two switch-arms 56 57 are turned into the position indicated in Fig. 26 the two translators are coupled in series as follows: from the translator actuated by line conductor 51, by wires 26, to conductors 50, one branch of switch-arm 53, spring-arm 58, and one of the contact-plates 59, one branch of switch-arm 56, by conductor 60 62, to the motor, from the motor, by conductor 63, to the second branch of switch-arm 56, and conductor 52 to the second translator, and by wires 26, proceeding from said translator, to the second series of contact-points 50, and by the second branch of switch-arm 53 and spring-arm 58 and switch-arm 57 to conductor 51, back to the first translator. As has been stated above, the two switch-arms 56 57 rotate in unison, and they are moved by handle 68, which is indicated in Fig. 24.

In the operation so far described I have assumed that the currents generated in the translator are utilized in the motor just as generated. Since these currents are necessarily alternating, a peculiarly-constructed motor is obviously required for this purpose. It is, however, important that provision should be made which will allow the use of any ordinary electric motor. The commutator shown in Fig. 27 is intended to accomplish this result, and it will be understood that this commutator must be interposed between a direct or continuous current motor, in cases where such a motor is desired to be used, and the translator-circuit.

Upon a metallic shaft 69, formed of two parts insulated from each other, are mounted two circular disks 70 71, one being connected to one insulated part of the shaft and the other to the other insulated section and each provided with teeth upon their inner faces, which teeth mesh like the teeth of crown-wheels, but are insulated from each other, as indicated. The construction is such that when the said disks are placed face to face, as shown in the drawings, their edges present a series of contact-plates, which alternately belong to one and the other disk and which are insulated from each other, as stated above. The contact-brushes 72 73 bear upon diametrically-opposite sides of the common edge of the said disks in such manner that if one of the brushes is in contact with a tooth belonging to one of the disks the other brush bears upon a tooth belonging to the other disk. Upon the same shaft 69 are mounted a series of armatures 74 74, arranged radially about and secured upon the shaft, and are equal in number to the number of teeth upon both disks, and in operative relation to those armatures are arranged two electro-magnets 75 75, which are connected, respectively, with brushes 72 and 73, with one of their terminals, and with switch-arm 53 and conductor 51, with their other terminals, respectively. The shaft 69 is mounted in bearings, as indicated, and said bearings are connected by conductors 62 63 with the commutator-brushes on the ordinary or straight-current electric motor 6.

The operation of this apparatus will now be easily understood. An electric impulse proceeding from the translator by wires 26 reaches the electro-magnet 75 by way of switch-arm 53. It then passes by a brush 72 to disk 70 and by shaft 69 and conductor 62 to the motor, from which it proceeds over conductor 63 to the other half of shaft 69 and to disk 71. From there the current continues by brush 73 over the magnet 76 and returns by the conductor 51 to the translator. By the electric current thus passing through the magnets 75 and 76 these magnets are energized and each of them attracts one of the radial armatures 74, mounted upon the shaft 69, whereby a partial rotation is given to such shaft, sufficient in extent to bring one tooth of disk 71 in contact with brush 72 and one tooth of disk 70 in contact with brush 73. The next impulse from the translator will be in the reversed direction. It will therefore proceed over conductor 51 to magnet 76, brush 73, disk 70, shaft 69, conductor 62, to the straight-current motor 6, and from said motor by conductor 63 to the section of shaft 69 to which disk 71 is secured, then to brush 72, electro-magnet 75, and by switch-arm 53 and conductor 26 back to the translator. It will be noticed that this second impulse, although proceeding from the translator in an inverse direction, still passes in the same direction as the first through the straight-current motor 6. It will also be clear that this second impulse, energizing the two electro-magnets, will cause the latter to again rotate the shaft 69 to the extent of one tooth of the compound disk 70 71, whereby the brushes 72 73 will be restored to their original relation to said compound disk, so that the next impulse will traverse the apparatus in precisely the same path as the first. The electro-magnets 75 76 and the system of radial armatures 74 have here the function of an electromotor timed to the spaces occupied by the teeth of the compound disk 70 71. This apparatus therefore is an alternating-electric-current motor, which is here shown as applied for the purpose of straightening out the alternating currents furnished by the translator, but which may be used, if made of proper size, as the propelling-motor, as hereinbefore stated.

It will be understood that any other apparatus adapted to perform the function here assigned to the alternating-current motor may be substituted for the one here shown, and I do not propose to limit my invention either to the alternating motor here illustrated for operating the commutator or to the particular construction of the commutator itself. This part of my invention, however, I do not claim herein, since the same has been made the subject of a separate divisional application, Serial No. 368,195, filed October 15, 1890.

In the remaining figures of drawings, Figs. 28 to 33, the general arrangement of the line conductor or conductors in relation to the track or tracks is diagrammatically indicated.

In Fig. 28 the line conductors 2 3 form a round metallic circuit, one of the wires being between the rails of one track and the other wire between the rails of another track parallel to the first, or, if so desired, at any angle to the first and at any distance from the same. The line conductors are here supposed to be under ground, in the manner indicated in Fig. 19 or in Fig. 3, the transformer being in this case attached to the bottom of the car.

Fig. 29 shows a single conductor placed between two parallel tracks, the conductor being grounded at each end, and is supposed to be carried overhead in the manner shown in Figs. 12 and 13, the translator being in this case carried on the roof of the car. Thus a single line conductor is made to act inductively upon two translators or two series of translators, each series being upon a car or cars on one of the tracks. This same arrangement may also be used in connection with the semi-tubular translator shown in Fig. 11, or also with the tubular translator shown in Figs. 8, 9, and 10, as will be readily understood.

In Fig. 30 two line conductors are shown in a round metallic circuit, each being between two lines of tracks. It will be apparent that this arrangement is adapted to the same use for which the arrangement in Fig. 29 is particularly designed, and it will be used in all cases where the grounding of currents of such high tension as are used in my system is objectionable.

In Fig. 31 the two line conductors in a round metallic circuit are placed between the rails of one track and are intended to operate upon cars provided with two translators each, one on each side of the car, as described with reference to Fig. 18; but it may also and will be used in the system described with reference to Fig. 2, and also in the system described with reference to Figs. 15, 16, and 17.

In Fig. 32 two line conductors in a round metallic circuit are shown. One of them, the conductor 2, is placed between two parallel tracks and is designed to operate upon translators in the same manner as the line conductors in Fig. 29. The second line-conductor 3, serving as the return, is placed at some considerable distance from the tracks, so as not to act inductively upon the translators on the cars, but to act upon a series of translators 77, arranged along the line of said conductor and in inductive proximity thereto. These translators may furnish current for electric lights, as indicated, or for other purposes.

In Fig. 33 I have indicated two line conductors in a round metallic circuit applied to two lines of track, with branch tracks proceeding therefrom. It seems unnecessary to particularly describe the arrangement of the line conductors since the drawings speak for themselves.

In my system of electric locomotion which I have thus described numerous modifications may be made both in the general arrangement of circuits and in the specific construction of the devices without departing from the spirit of my invention, and I wish it to be understood that so long as the fundamental principle upon which this invention is based is adhered to a system of locomotion involving said principle will come within the scope of my invention.

I make no claim herein to the system of electric railway comprising two sectional translators mounted on a car in inductive proximity to a line conductor carrying alternating current, with a motor for propelling the car, fed by the translators, and switches for varying the number of active sections of each translator and for variously connecting the two translators; nor do I claim herein the combination of an electric locomotor, a current-rectifier upon said locomotor, a source of alternating electric currents, and means for connecting said source with said rectifier; nor do I herein claim the combination of an electric motor, a vehicle carrying the same, a source of alternating electric currents, and a rectifying - commutator through which currents are delivered from said source to said motor, since all these features, although shown and described herein, have been made the subject of a divisional application, Serial No. 368,195, filed October 15, 1890. Neither do I claim herein a system of electrical conversion and distribution comprising a rectilinear inducing conductor or conductors charged with maintained and practically uniform alternating currents, and one or more elongated translator-coils in inductive relation thereto and electrical translating devices requiring for their operation maintained and practically uniform currents in the external circuit of the translators; nor do I herein claim any of the modifications of which such system is capable, since all this, although shown and described herein, has been made by me the subject of a divisional application, Serial No. 368,194, filed October 15, 1890. Neither do I claim herein the method of propelling vehicles by the agency of electricity by feeding one or more electric motors mounted upon the vehicle or vehicles and arranged to propel the same with electric currents of alternating polarity; nor do I claim herein the various modifications of which this method is capable, since all this, although shown and described herein, has been made by me the subject of a separate divisional application, Serial No. 359,231, filed June 5, 1891.

Having now fully described my invention, I claim and desire to secure by Letters Patent—

1. The method of propelling vehicles by the agency of electricity by causing alternating or intermittent currents on a line or lines of conductors extending along a railway to induce alternating currents in a circuit or circuits feeding one or more propelling electric motors.

2. The method of propelling vehicles by the agency of electricity by causing alternating or intermittent currents on a line or lines of conductors extending along a railway to induce alternating currents in a circuit or circuits carried upon the vehicle or vehicles and feeding one or more propelling electric motors, substantially as described.

3. The method of propelling vehicles by the agency of electricity, which consists in charging the circuits of alternating-current electric motors mounted upon and geared to vehicles with alternating currents by dynamo-electric induction, substantially as described.

4. The art of electric locomotion, which consists in generating in the circuit or circuits of traveling electric motors by induction from one or more stationary conductors carrying alternating or intermittent current of a given tension an induced current or currents having a different tension and operating the said motors by means of the currents so induced or a portion thereof, substantially as described.

5. The art of electric locomotion, which consists in charging the circuits of traveling electric motors with low-tension electric currents by induction from one or more stationary line conductors carrying alternating or intermittent currents of higher tension and in causing the induced currents to propel the motors, substantially as described.

6. The improvement in the art of electric locomotion, which consists in establishing in one or more closed coils carried by a moving vehicle by induction from one or more stationary conductors along the line of way induced currents differing in electro-motive force from that of the current or currents carried by the stationary conductors and in feeding said induced currents to the motor or motors, substantially as described.

7. The improvement in the art of electric locomotion, which consists in establishing in one or more closed coils carried by a moving vehicle by induction from one or more stationary conductors along the line of way induced currents differing in electro-motive force from that of the current or currents carried by the stationary conductors and in operating the vehicle by means of such induced currents, substantially as described.

8. The art of electric locomotion, consisting in charging the circuits of electric motors traveling upon adjacent parallel tracks with electric currents by dynamo-electric induction from a single line, substantially as described.

9. An electric railway consisting of one or more lines of insulated conductors extending along the track of railways and charged with alternating or intermittent currents from a stationary source, and electric motors mounted upon vehicles upon the track or tracks and having their external circuits or other portions thereof in inductive proximity to the line or lines of insulated conductors, substantially as described.

10. An electric railway consisting of one or more lines of insulated conductors extending along the track or tracks of railways and charged with alternating or intermittent currents from a stationary source, and electric motors mounted upon vehicles upon the track and having their external circuits entirely carried upon the vehicles and in inductive proximity to the line conductors, substantially as described.

11. An electric railway consisting of a line conductor or conductors charged with alternating currents and extending along a railway track or tracks, and alternating-current motors mounted upon vehicles upon the track and fed with acutating-currents by electrodynamic induction from the charged line conductor or conductors, substantially as described.

12. In a system of electric locomotion, the combination of a line or lines of conductors extending along a railway-track in alternate underground and overhead sections electrically connected together and charged with intermittent or alternating currents with a translator coil or coils mounted upon the vehicle, with one side in inductive proximity to the line of the underground sections and with the other side in inductive proximity to the line of the overhead sections of the line conductor, and an electric motor fed by the translator-coils and geared to the vehicle, whereby the latter is propelled from section to section without interruption, substantially as described.

13. An underground line conductor constituting the primary or inducing circuit of a transformer, having a magnetic shield toward the earth and a free inductive field toward the translator or induced circuit of the transformer, substantially as described.

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

ELIAS E. RIES.

Witnesses:
GEO. H. TICHENOR,
E. L. WHITE.