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6 Sheets—Sheet 1.

P. W. LEFFLER.

ELECTRIC RAILWAY.

No. 561,898. Patented June 9, 1896.

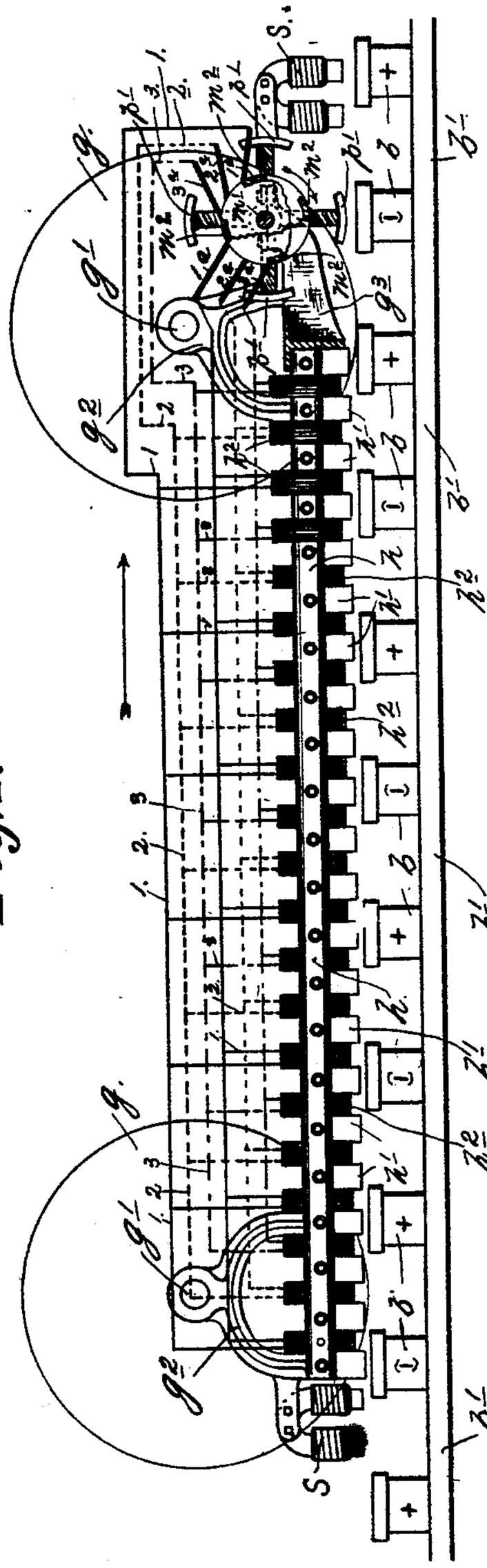

Fig. 1.

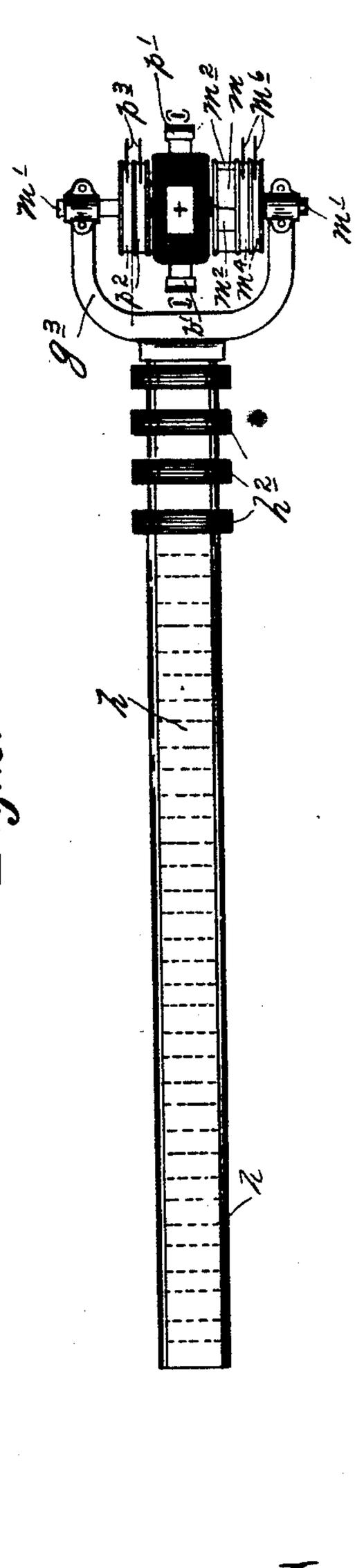

Fig. 2.

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A. D. Merchant.

Inventor:
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By his Attorney.
Jas. F. Williamson

...WER.

...EFFLER.

ELECTRIC RAILWAY.

6 Sheets—Sheet 2.

No. 561,898. Patented June 9, 1896.

Fig. 9.

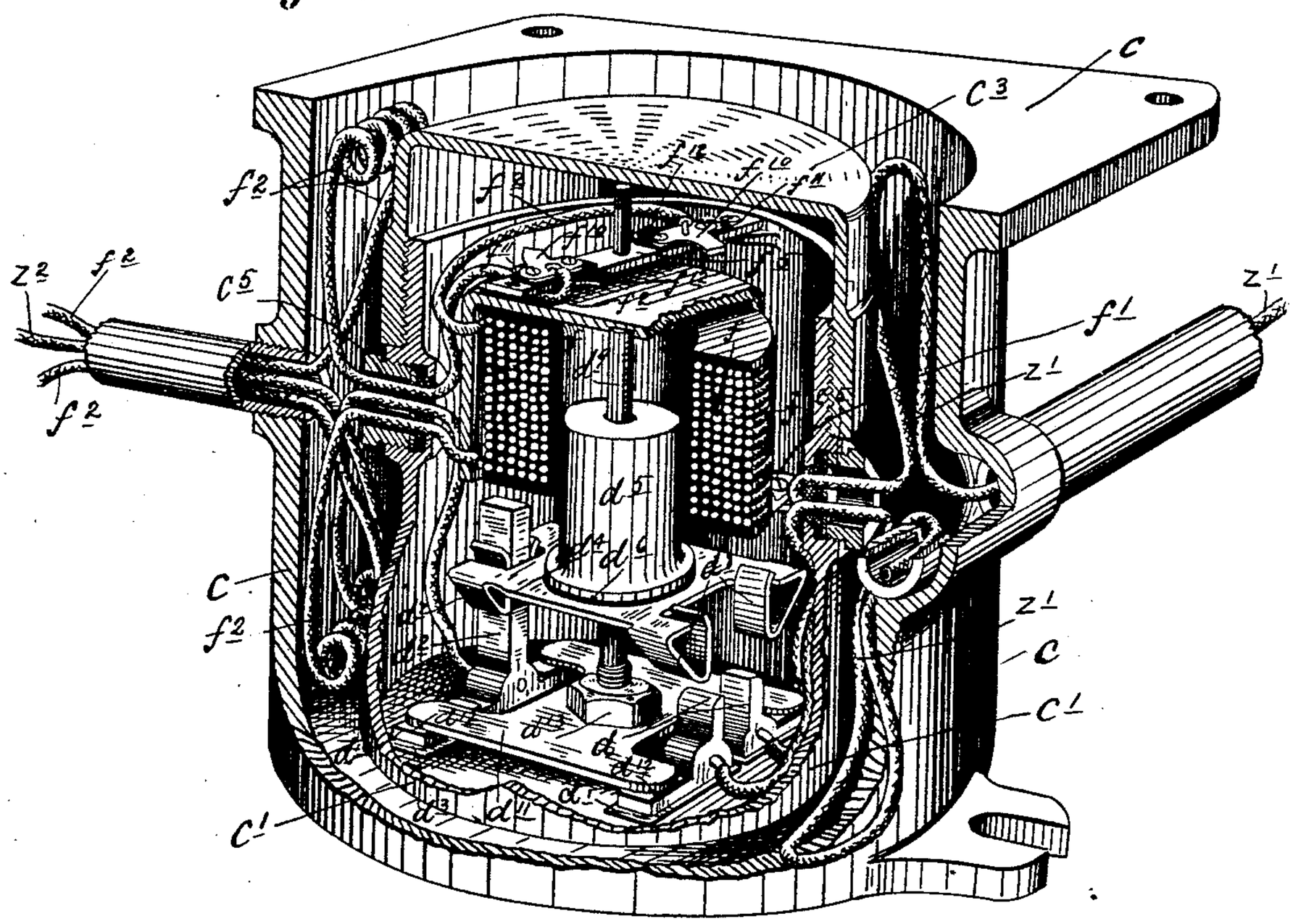
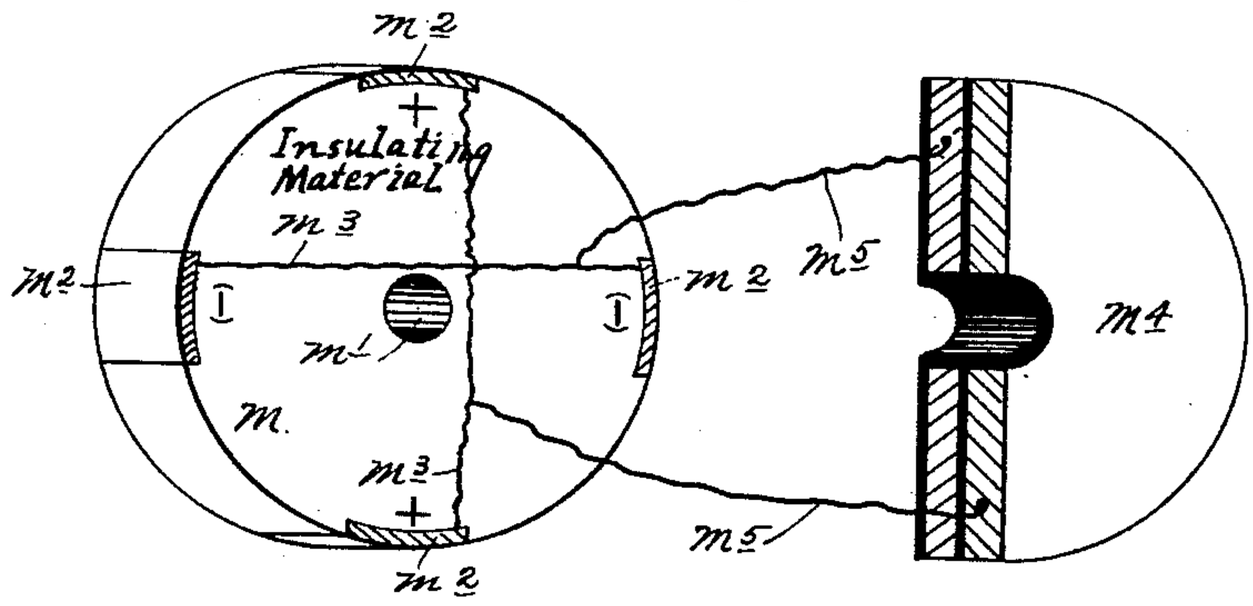


Fig. 3.



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6 Sheets—Sheet 3.

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ELECTRIC RAILWAY.

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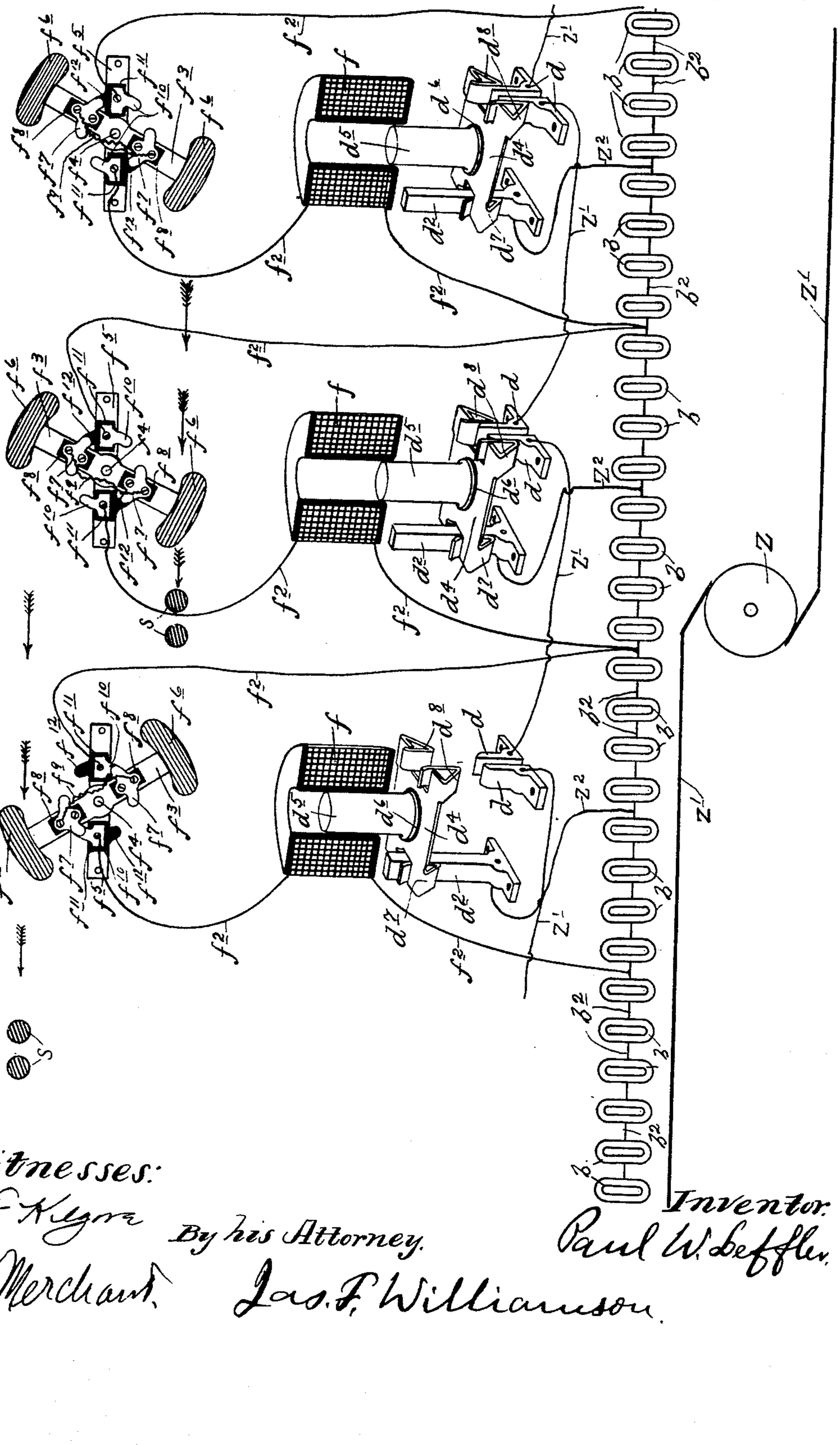

Fig. 4.

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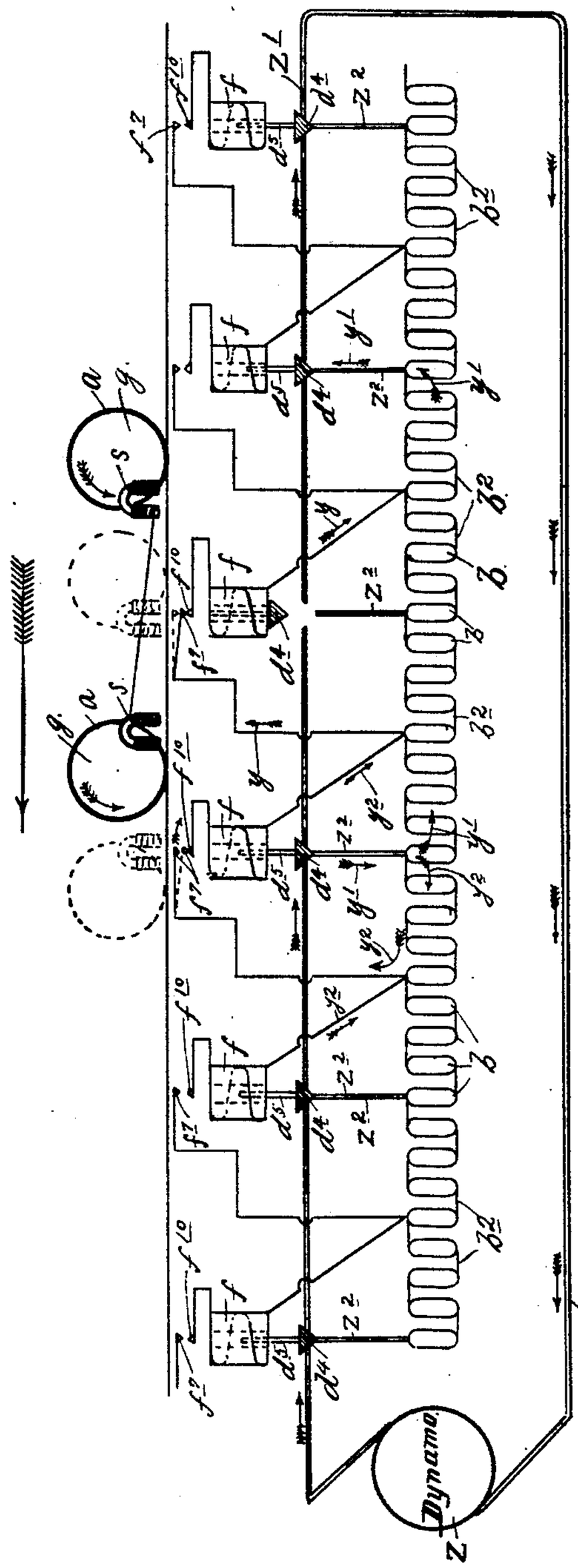
No. 561,898. Patented June 9, 1896.

Fig. 5.



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6 Sheets—Sheet 5.

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ELECTRIC RAILWAY.

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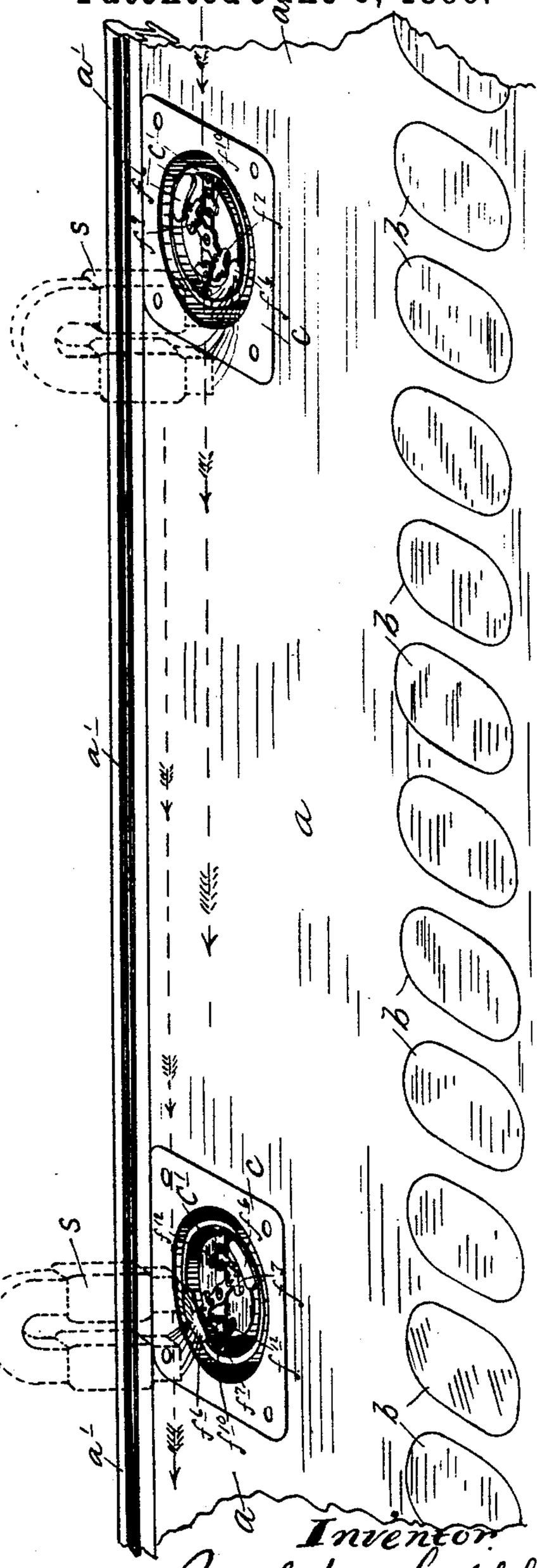

Fig. 6.

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No. 561,898. Patented June 9, 1896.

Fig. 7.

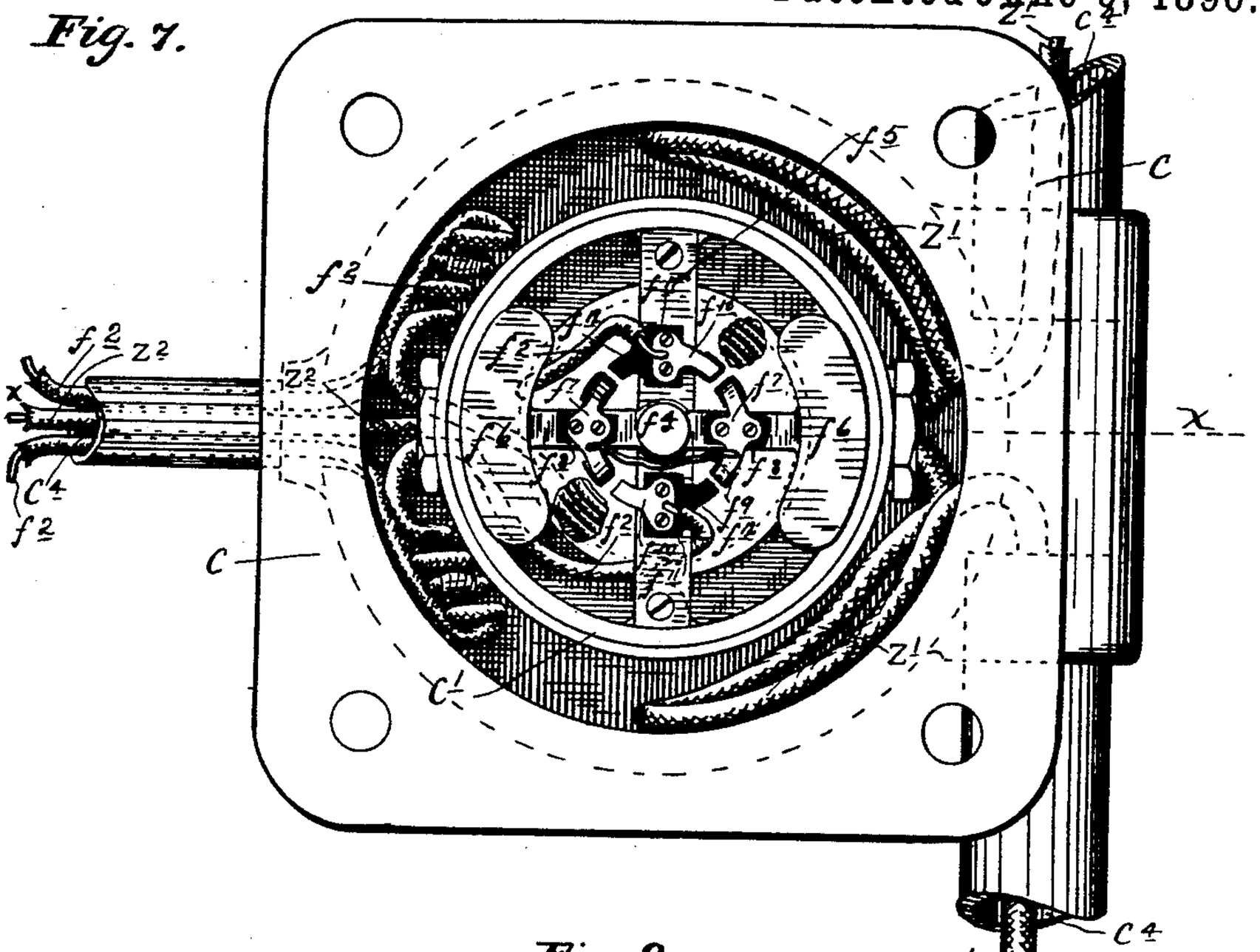
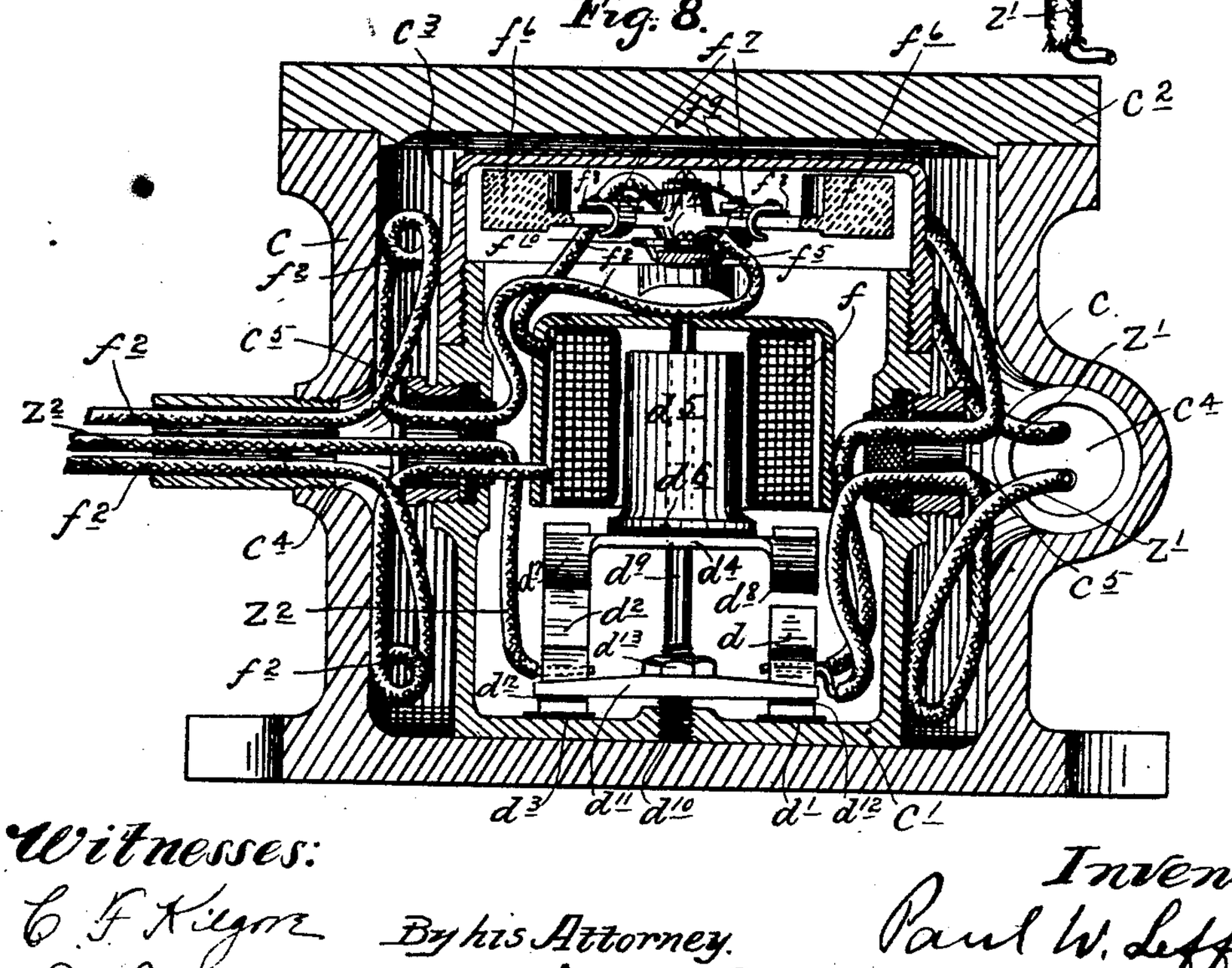


Fig. 8.



Witnesses:
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W. D. Merchant.

By his Attorney.

Inventor:
Paul W. Leffler
Lan. F. Williamson

UNITED STATES PATENT OFFICE.

PAUL WILLIAM LEFFLER, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE LEFFLER ELECTRO MAGNETIC RAILWAY COMPANY, OF SAME PLACE.

ELECTRIC RAILWAY.

SPECIFICATION forming part of Letters Patent No. 561,898, dated June 9, 1896.

Application filed August 12, 1895. Serial No. 558,993. (No model.)

To all whom it may concern:

Be it known that I, PAUL WILLIAM LEFFLER, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electric Railways, &c.; 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.

My invention relates to electric railways of the class shown and described in my prior patents, bearing Nos. 514,561 and 514,718, of date February 13, 1894, entitled "Electric Railways," and has for its object to provide certain improvements in said systems, with a view of simplification and increased efficiency.

To these ends my invention comprises the novel devices and combinations of devices hereinafter described, and defined in the claims.

The preferred form of my invention is illustrated in the accompanying drawings, wherein, like letters and figures referring to like parts throughout the several views—

Figure 1 is a view partly in side elevation and partly in diagram, showing one of the car-trucks and a portion of the field. Fig. 2 is a plan view of the car-armature and pole-changing mechanism removed from the car. Fig. 3 is a diagram view showing the wiring of the commutator. Fig. 4 is a diagram view showing the field-magnets, the wiring, and the switches for controlling the sections of said field. Fig. 5 is a diagram view showing the wiring of field-magnets, the switches, and the relations of the same to the switch-magnets carried by the car. Fig. 6 is a perspective view of a portion of the road-bed and magnetic field, some parts being removed, and the switch-operating magnets carried by the car being shown by dotted lines. Fig. 7 is a plan view of one of the switch-boxes, the cover to the same being removed. Fig. 8 is a vertical transverse section through the switch-box, taken on the line $x\ x$ of Fig. 7; and Fig. 9 is a sectional perspective view of the switch-box shown in Figs. 6 and 7.

$a\ a'$ represent, respectively, the pavement and the rails of an ordinary surface street-railway.

b represents the field-magnets rising from the common soft-metal base plate or core b', resting on the bottom of the electroduct or electric conduit. The adjacent members of the field-magnets b are so wound that they will be of opposite polarity. As shown, these field-magnets are connected up in series by means of wires b^2. The field thus formed is energized from a dynamo z at the central station or elsewhere through a main feed or supply conductor-wire z', which is connected to said series of field-magnets at different points along the line by means of branch wires z^2. Thus the field is divided into sections, the wiring of which field-sections offer a very high electrical resistance as compared with the corresponding sections of the feed-wire or supply-conductor z'. In other words, the field is divided into sections, forming each a part of a shunt-circuit or by-path from the supply-conductor z', which shunt-circuit offers a relatively high resistance, as compared with the section of said conductor z', which is spanned by said shunt-circuit. Hence so long as the said supply-conductor z remains unbroken the current will follow the lesser resistance and flow through said conductor z' without energizing the magnets of the field; but whenever the circuit through the supply-conductor z' is broken intermediate of any of the branch wires z^2 the current will be forced to take the only available path and pass through the sections of the field which are included between the nearest unbroken branch wires z^2.

To open and close the circuit through said main conductor z', I provide the following switch mechanism: The switches are inclosed within switch-boxes $c\ c'$, composed of the outer box c and the inner box c', which boxes are provided, respectively, with removable covers $c^2\ c^3$ and wire-passages $c^4\ c^5$.

The switch-boxes $c\ c'$ are located in the roadway, one at the side of and adjacent to each section of the field. Within each of these switch-boxes the sections of the feed-wire z' terminate in contact-pieces d, which are in-

sulated from each other and the switch-box c' by means of insulations d', and the branch feed-wires z^2 terminate within said switch-box c' in a contact-post d^2, insulated from the box by an insulating-strip d^3.

d^4 d^5 is a vertically-movable main-circuit closer, comprising the conducting-plate d^4 and the soft-iron cylindrical core d^5, secured thereto but insulated therefrom by an insulating-disk d^6. The portion d^4 has one pair of frictional contact-jaws d^7, which slide on and remain constantly in contact with the post d^2, and another pair of spring-contact jaws d^8, which, when said closer d^4 d^5 is in its lowermost position, engage one with each of the fixed contact-pieces d. This circuit-closer d^4 d^5 is guided to a true-line movement by a guide-rod d^9, provided at its lower end with screw-threads d^{10}, screwed into the bottom of the box c' and having its body portion working centrally through the cylindrical core d^5.

d^{11} is a clamping-plate surrounding the rod d^9 and engaging insulations d^{12} on the feet portions of the contact-pieces d d d^2. This plate d^{11} is tightly clamped in working position, and the said contact-pieces d d d^2 thereby held to place by means of a nut d^{13} on the rod d^9.

The circuit-closer d^4 d^5 normally closes the circuits through the feed-wire z' and the branch wire z^2 and is raised to break said circuits by means of a solenoid f, surrounding the core d^5 and held in position, centrally of the box c', partly by the upper end of the guide-rod d^9 and partly by feet f', projecting from the case of said solenoid and secured to the walls of the box c'. As shown, these solenoids f are located in shunt-circuits f^2 running from the field, and these shunt-circuits are closed and opened at the proper times by a shunt-circuit closer, which, as will later appear, is operated from devices carried by the car. The shunt-circuits f^2 correspond in number to the sections of the field-magnets, and it may be here noted that these shunt-circuits, instead of connecting with the supply-conductor z' indirectly through the field-sections, might be connected to said supply-circuit z' directly. In the shunt-circuit closer for said shunt-circuits f^2 f^3 is an oscillating lever, pivoted at its center on a pivot-pin f^4, projecting from the center of a cross-bar f^5, supported from the box c', immediately over the coil f. This lever f^3 is provided at its opposite ends with enlarged soft-iron heads f^6 and carries a pair of contacts f^7, which are insulated from said lever f^3 by insulations f^8, but are electrically connected with each other by a short wire f^9. When thrown into the position shown at the extreme left of Fig. 4, these contacts f^7 engage with a corresponding pair of contacts f^{10}, secured to the cross-bar f^5, but insulated therefrom by insulations f^{11}. The contacts f^{10} are secured to the broken ends of the shunt-circuit f^2, and the contacts f^7 and connecting-wire f^9, when connected therewith, complete or close the said shunt-circuit f^2. When the lever f^3 is thrown into its opened position, (shown at the extreme right of Fig. 4,) the contacts f^7 engage with friction-lugs f^{12}, which, as shown in the drawings, are formed integral with the insulations f^{11} on the bar f^5 and serve to hold the lever f^3 in its set position under a light friction.

In the accompanying drawings the car-truck is indicated by dotted lines g g'. The car-armature is formed by a continuous core h, preferably of laminated bars, having a series of downwardly-projecting pole-pieces h' and a series of magnetic coils h^2, which, instead of being wound around the said pole-pieces in the manner shown in my said prior patents, are wound around the core h, between said pole-pieces h'. The pole-pieces h' of the armature are, as shown, spaced apart one-third the distance between the field-magnets b, and the coils h^2 are connected up in three series or sets by means of circuit-wires 1, 2, and 3, represented, respectively, by full, dotted, and broken lines. As shown, the armature-core h is supported from the axles g' of the truck g g' by hanger-brackets g^2.

The pole-changer herein employed is, with the exception of the commutator, substantially the same as that set forth and claimed in my said prior patent, No. 514,561.

Attention being first given to the commutator, Figs. 1, 2, and 3, m is a cylinder of insulating material, secured on a shaft m', mounted in the prongs of a bracket g^3, projecting forward from the end of the armature-core h. This cylinder m is provided with peripheral metallic contacts m^2, the diametrically opposite members of which are electrically connected by wires m^3 to form pairs.

m^4 are a pair of insulated feed-rings, which are secured on the shaft m' by the side of the cylinder m. These feed-rings m^4 are connected, one to each of the cross-wires m^3, which connect the pairs of contacts m^2, by means of a pair of wires m^5. (Best shown in Fig. 3.) As shown, there are four of these contacts m^2, or two pairs, located on quarters of the cylinder m, and the said contacts each occupy one-third of a quadrant, or one-twelfth of the circumference of the cylinder.

1^a, 2^a, and 3^a represent three pairs of brushes connecting, respectively, the three armature-circuits 1, 2, and 3 with the commutator-contacts m^2. By reference to Fig. 1 it will be noted that the brushes which constitute pairs are located on quarters of the cylinder m, and that the proportions and relations of said parts are such that the commutator being in the position shown and running in the direction indicated by the arrow in Fig. 1 the brushes 1^a will be just leaving the contacts m^2, the brushes 2^a will be midway between said contacts, while the brushes 3^a will have just made contact with said contacts m^2.

The feed-rings m^4 receive current from and deliver to a pair of brushes m^6, engaging one with each of said rings m^4, and forming part

of a supply-circuit leading from a storage battery carried by the car or other suitable source of supply. (Not shown.)

p' represents a magnetic commutator-controller fixed on the shaft m', insulated therefrom and from the commutator and having radial pole-pieces, which are so wound that the adjacent members are of opposite polarity, as indicated in Fig. 2. Current is supplied to the controller from insulated rings p^2 on the shaft m, which rings in turn are in contact with a pair of contact-brushes p^3, forming part of a supply-circuit extending from a storage battery carried by the car or other source of supply. (Not shown.)

Coming now to the devices carried by the car for operating the switches in the sections of the supply-conductor, s s is a pair of magnets carried one at each end of the car-truck g g' in position to operate, under the movement of the car, one on each end or head f^6 of the shunt-circuit-closing lever f^3. These magnets s are shown as of the horseshoe form and may be either permanent magnets or electromagnets, energized from a storage battery carried by the car or other suitable source. (Not shown.)

It will be noted by reference to the diagram Figs. 4 and 6 that the magnets s are offset sidewise from each other to cause the engagement of the same with the opposite heads f^6 of the lever f^3, as above set forth.

Operation: Normally the main-circuit closers d^4 d^5 are all in their lower or closed positions, as shown at the right in Figs. 4, 5, and 6. In this position of said circuit-closers d^4 d^5 the main conductor z' is closed throughout its entire length; but when the cars are in operation upon the track the switch-controlling magnets s s will at all times cause the main circuit to be broken adjacent to the car and the immediate field-sections to be thereby thrown into action. For example, referring to Fig. 5, suppose the car to be running in the direction indicated by the arrows and to have arrived at the position shown by full diagram lines. (For action of magnets s s see also Figs. 4 and 6.) In this position the forward magnet s has just passed the outer end or head f^6 of the shunt-circuit-closing lever f^3 of one of the switches and by its magnetic attraction turned said lever f^3 into its closed position, as shown at the extreme left in Figs. 4 and 6. In this position, as already pointed out, the contacts f^7 and connecting-wire f^9 close the corresponding shunt-circuit f^2, causing the shunted current to flow as indicated by the arrows y. This energizes the solenoid f, which, acting on the core d^5 of the main-circuit closer d^4 d^5, raises said circuit-closer into the position shown at the extreme left of Fig. 4 or in Fig. 9. In this raised position of main-circuit closer (see particularly Fig. 5) the circuit through the main wire z' and the adjacent branch wires z^2 are broken, thus causing the main current to take a path through two adjacent field-sections, as indicated by the arrows y'. Next, suppose the car to have arrived at the position shown by dotted lines in Fig. 5. In this position the forward switch-magnet s is just passing the next adjacent switch and is turning the shunt-circuit-closing lever f^3 thereof from its opened into its closed position. At the next instant the shunt-circuit of this switch will be closed, the solenoids f energized, and the main-circuit closer d^4 d^5 thereof raised to break the main circuit at this point and cause the next adjacent forward field-section to be energized. In this action the shunted current will flow through the shunt-wire f^2, as indicated by the arrows y^2. Again, in this dotted-line position of the car the rear car switch-magnet s is just passing the particular switch, which in the position of the car (shown by full lines in said Fig. 5) was held in its opened position. In this instance said rear switch-magnet s is acting upon the inner end or head f^6 of the shunt-circuit-closing lever f^3 and is turning said lever f^3 backward from its closed into its opened or normal position. (Shown at the right in Figs. 4 and 6.) At the next instant the shunt-circuit of the switch will be broken, the solenoid f deënergized, and the main-circuit closer d^4 d^5 dropped to close the main circuit, thus throwing out of action or back into its normal condition the section of the field which has just been passed over by the car. In this manner the field-section which the car is immediately approaching is always kept energized, while the sections immediately passed are, as just stated, rendered inactive. Further, the above switching of the supply-circuit from the feed-wire sections through the field-sections, and vice versa, is accomplished without breaking or stopping the flow of said current. This is important, as it avoids sparking in said circuits.

The operation of the pole-changer and armature-magnets carried by the car would probably be understood from the foregoing description, but may be briefly summarized as follows: When the car is in motion, the pole-changer will be given one revolution for every four field-magnets passed under the magnetic attraction between the field-magnets and the magnetic controller p' of said pole-changer. Under this action, it will be noted by reference to Fig. 1, at the instant of time therein illustrated both the circuits 1 and 3 are in circuit in parallel with each other, while a little farther on circuit 3 alone will be closed. Then only one-third or one set of the armature-coils h^2 are in circuit; but by the way they are placed on the armature-body instead of the poles I get the effect of polarizing all three sets of the pole-pieces from one series of coils.

The changes in the polarities of the sets of armature-magnets are made just as the poles of the particular set pass the poles of the field-magnets. When the centers of the poles of the armatures cross the centers of the field-magnets, one member of the pair of commu-

tator-brushes controlling the same is just making contact with one positive plate m^2, while the other member of said brushes is just making contact with one negative plate m^2, and both brushes of course leave said plates at the same instant. At this point, as already stated, there are two circuits and corresponding sets of armature-coils energized for an instant. This of course permits a greater flow from the batteries, which gives extra power to the armature-magnets, and this at a time when the greatest magnetic efficiency can be obtained.

In virtue of the above improved arrangement and timing of the armature-magnets and pole-changer I am enabled to control the magnetic forces in such manner that with a given amount of current flow the maximum pulling force is obtained on the car.

What I claim, and desire to secure by Letters Patent of the United States, is as follows:

1. The combination with the car or other traveling body, of magnetic devices for producing a magnetic field along the line of travel, a supply-conductor electrically connected to said field at intervals along the line for dividing said field into sections having a relatively high electrical resistance as compared with the corresponding sections of said supply-conductor, and switches, in said supply-conductor, operated from said traveling body, for breaking the circuit through said supply-conductor and causing the current to take a by-path through the adjacent field section, or sections, substantially as described.

2. The combination with the car, or other traveling body, provided with a magnetic switch-operating device, of the series of field-magnets, the supply-conductor in constant connection with said series of field-magnets at intervals along the line for dividing the said series of magnets into sections having a relatively high resistance as compared with the corresponding sections of the supply-conductor, and magnetic switches in said supply-conductor operated from said switch-operating device, for breaking the supply-circuit and causing the current to take a by-path through the adjacent field section or sections, substantially as described.

3. The combination with the car, or other traveling body, provided with a switch-operating device, of the series of field-magnets, the supply-conductor in constant connection with said series of field-magnets at intervals along the line, corresponding shunt-circuits connected to a suitable source of supply, and switches comprising circuit-closers, in said shunt-circuits operated by the switch-operating device of said traveling body and corresponding supply-circuit closers in said supply-conductor controlled by said shunt-circuits, said parts operating, substantially as described.

4. The combination with the car, or other traveling body, provided with switch-operating magnets, of the series of field-magnets, the supply-circuit in constant connection with said series of field-magnets at intervals along the line, corresponding shunt-circuits from said field-magnets, and coöperating switches comprising shunt-circuit closers in said shunt-circuits, operated by said switch-operating magnets on the car and corresponding supply-circuit closers in said supply-circuit controlled by said shunt-circuits, substantially as described.

5. The combination with the car, or other traveling body, provided with a pair of laterally-offset switch-operating magnets, of the series of field-magnets, the supply-circuit in connection with said series of magnets at intervals along the line, corresponding shunt-circuits, and coöperating switches comprising each the pivoted shunt-circuit-closing lever with heads subject to the alternate vibrating action of said switch-operating magnets, the solenoid or equivalent magnet in said shunt-circuit, and the main-circuit closer subject to the action of said solenoid, substantially as described.

6. The combination with the car, or other traveling body, provided with the pair of laterally-offset switch-operating magnets, of the series of field-magnets, the supply-circuit in connection with said series of field-magnets at intervals along the line, corresponding shunt-circuits, and coöperating switches comprising each the pivoted shunt-circuit-closing lever with headed ends subject to the vibrating action of said switch-operating magnets, the solenoid in said shunt-circuit, and the main-circuit closer comprising the three insulated contacts in the main circuit and the movable contact-piece engageable with said three contacts and having the extended core subject to the action of said magnetic coil, substantially as described.

7. The combination with the car provided with the switch-magnets $s\,s$, of the series of field-magnets b, the supply-conductor z', with branch wires z^2, leading to said field-magnets, the contacts $d\ d^2$, at the broken ends of said wires z' and z^2 respectively, the shunt-circuits f^2 from said field-magnets, the solenoid f in said shunt-circuits f^2, the shunt-circuit-closing lever f^3 with electrically-connected contacts f^7 and the end heads f^6, and the main-circuit closer $d^4\ d^5$ with contact-jaws d^7 and d^8, said parts operating substantially as described.

8. The combination with a car, or other traveling body, of the armature on the traveling body, formed by the extended core with laterally-projecting pole-pieces and coils wound around said core between said pole-pieces, electric connections to said coils, and automatic pole-changing mechanism applied to said electric connections, substantially as and for the purpose set forth.

9. The combination with the car, or other traveling body of the armature carried by said

traveling body, formed by an extended core with laterally-projecting pole-pieces and coils wound around said core between said pole-pieces, electric connections, connecting said coils in interpositioned sets, and automatic pole-changing mechanism applied to said electric connections, substantially as and for the purpose set forth.

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

PAUL WILLIAM LEFFLER.

Witnesses:
HARRIETT M. SMITH,
FRANK F. PRATT.