No. 898,216. PATENTED SEPT. 8, 1908.

E. E. GRANGER.

ELECTRIC RAILWAY CONDUIT.

APPLICATION FILED AUG. 4, 1906.

4 SHEETS—SHEET 1.

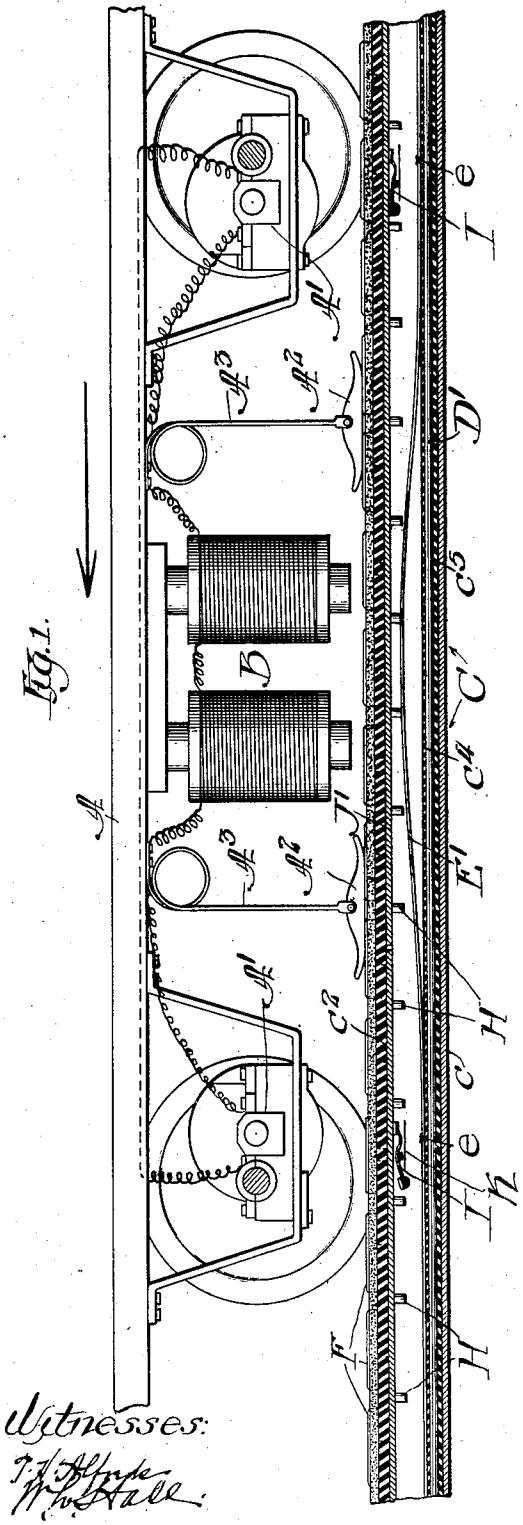

Fig. 1.

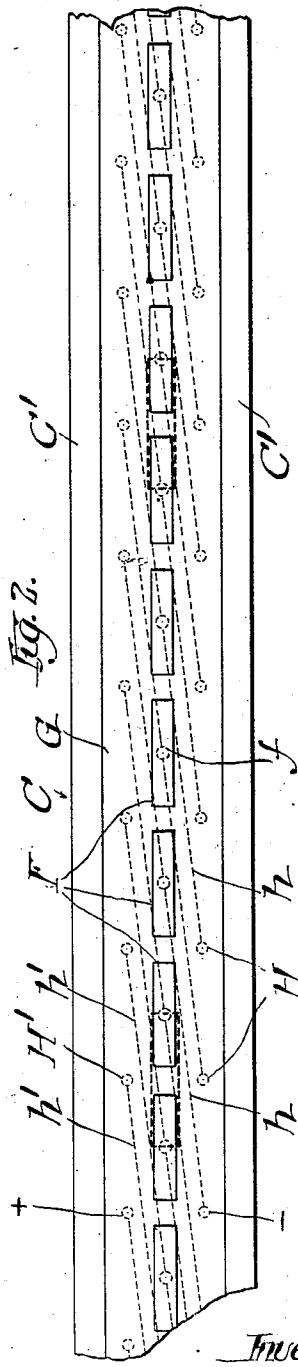

Fig. 2.

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4 SHEETS—SHEET 2.

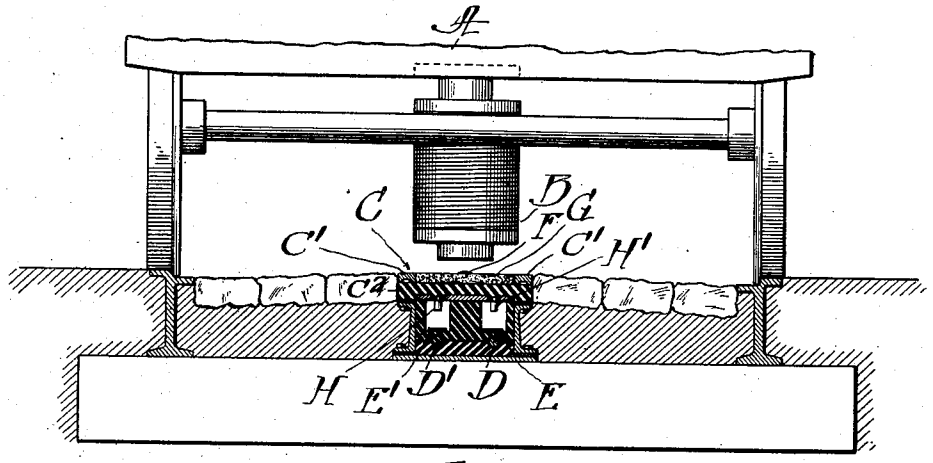

Fig. 3.

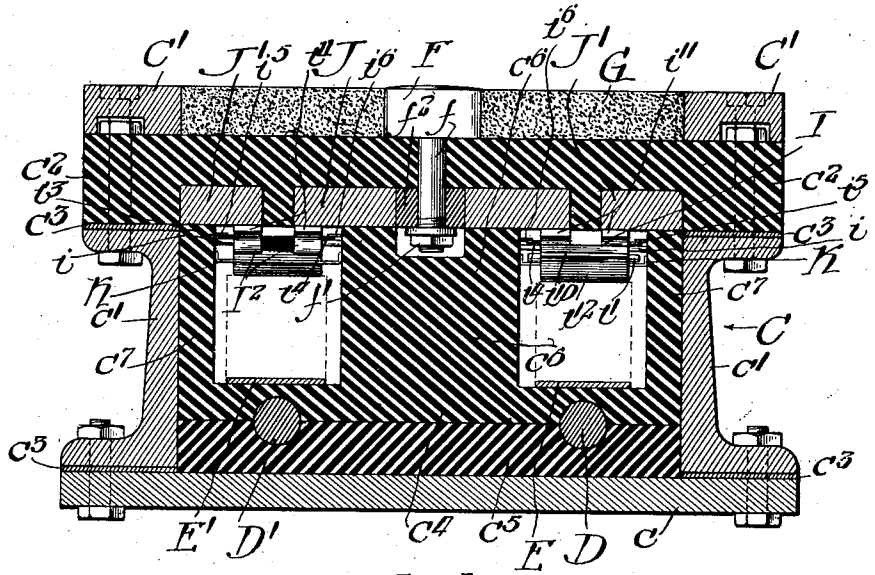

Fig. 4.

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4 SHEETS—SHEET 3.

Fig. 5.

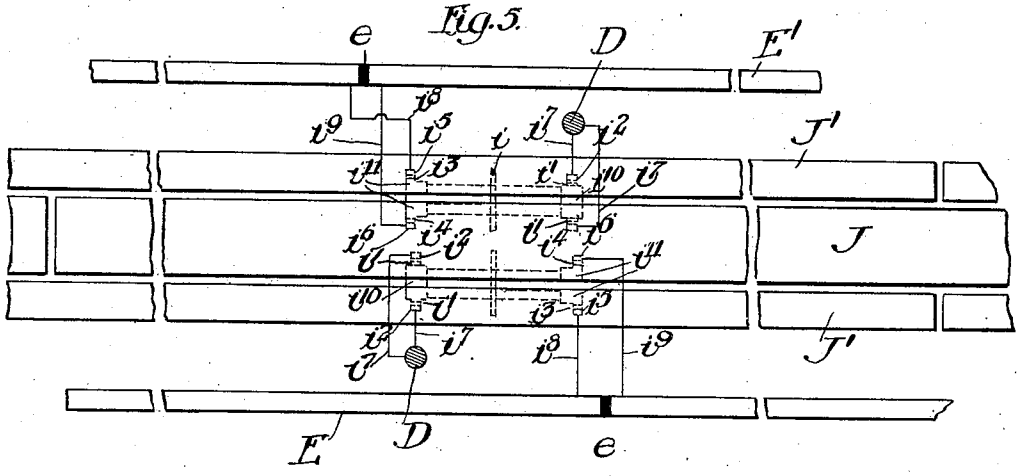


Fig. 6.

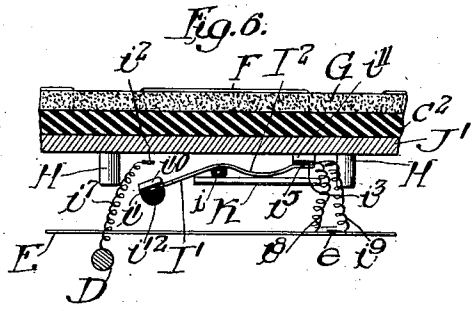


Fig. 7.

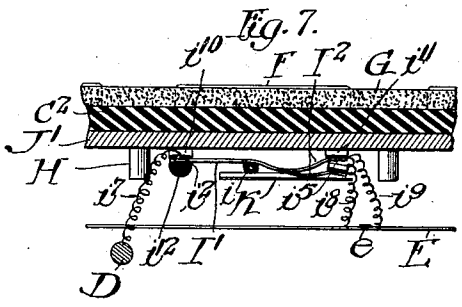


Fig. 8.

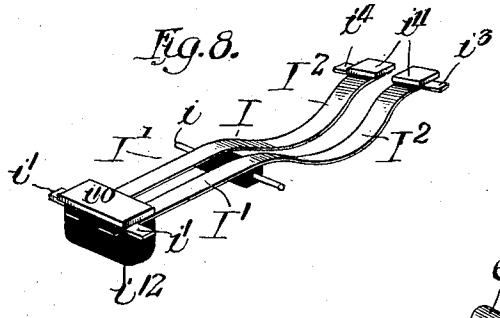
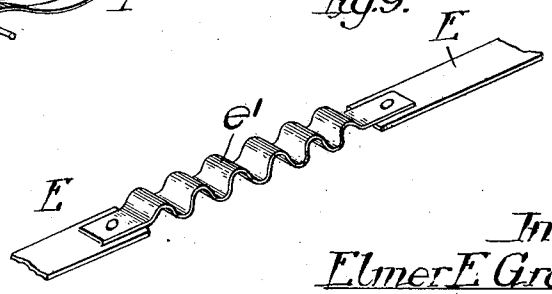


Fig. 9.



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No. 898,216. PATENTED SEPT. 8, 1908.

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ELECTRIC RAILWAY CONDUIT.

APPLICATION FILED AUG. 4, 1906.

4 SHEETS—SHEET 4.

Fig. 10.

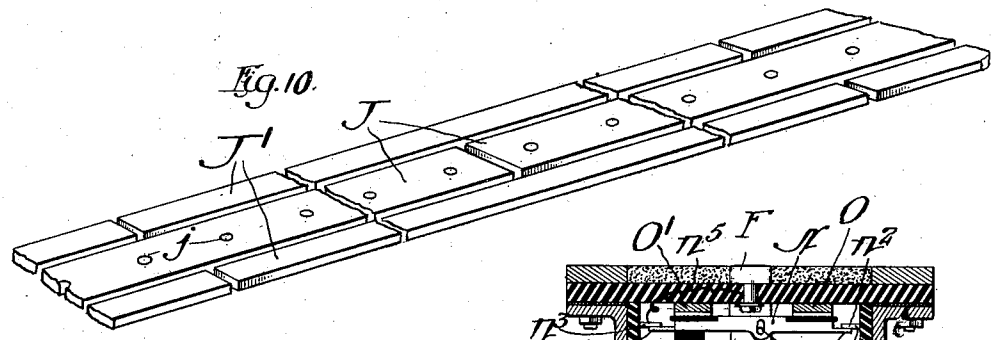


Fig. 11.

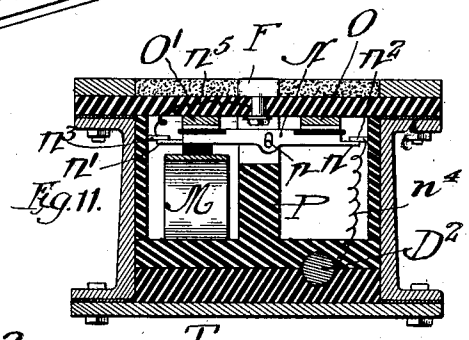


Fig. 12.

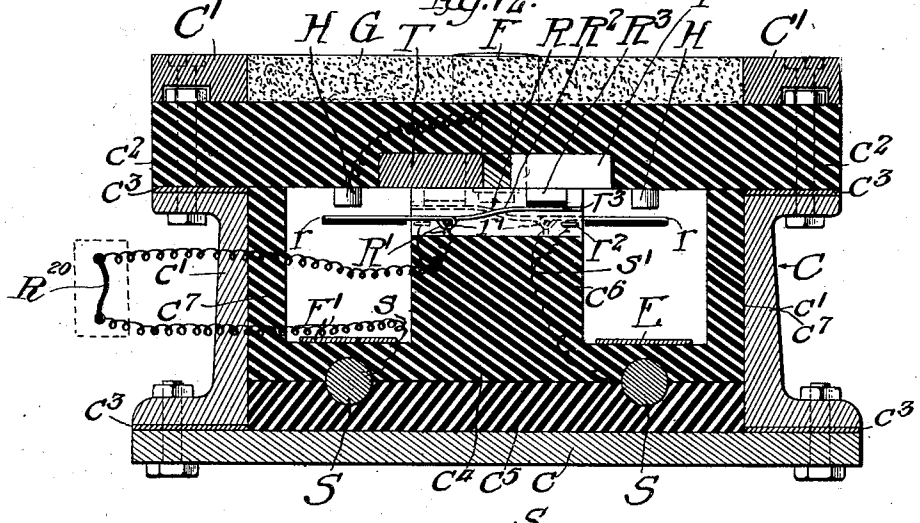


Fig. 13.

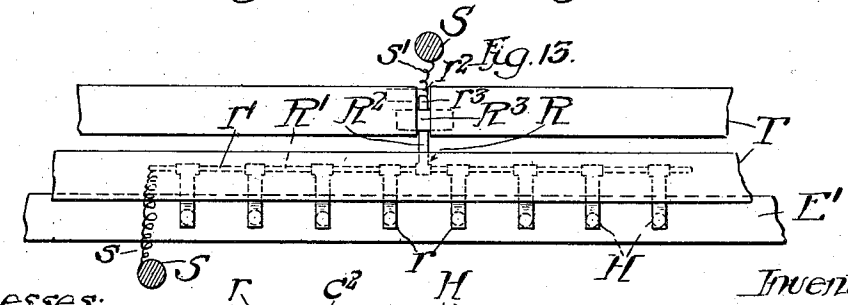
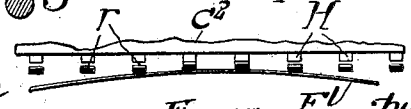


Fig. 14.



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UNITED STATES PATENT OFFICE.

ELMER E. GRANGER, OF CHICAGO, ILLINOIS.

ELECTRIC-RAILWAY CONDUIT.

No. 898,216. Specification of Letters Patent. Patented Sept. 8, 1908.

Application filed August 4, 1906. Serial No. 329,244.

To all whom it may concern:

Be it known that I, ELMER E. GRANGER, a citizen of the United States, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electric-Railway Conduits; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to improvements in electric railways and refers more specifically to an improved conduit for electric railways and electrical transmission devices therefor of that class in which the conduit is preferably sealed and the working circuit is closed from the conductor or conductors in the conduit to the motor of an overhead car through suitable contacts in the wall of the conduit which coöperate with collecting devices or shoes carried by the car to close the motor circuit.

The invention consists in the matters hereinafter set forth and more particularly pointed out in the appended claims.

Among the objects of my invention is to provide a conduit of this type and the electrical equipment therefor which shall produce a certain and reliable electrical connection between the conductor or conductors within the conduit and the motor on the car, and operating in such manner that only the electrical transmitting devices in that part of the conduit immediately beneath the car are included in the closed working circuit and thereby avoiding danger of exposed street contacts tending to endanger life; and to provide an improved construction for closing the working circuit so arranged as to insure a positive and prompt closing and breaking of the several sections of the transmitting devices.

Other objects of the invention will appear from the following description and the claims appended hereto.

I have shown in the drawings herein a practical embodiment of my invention, but it will be understood that the construction may be widely varied within the limits of the invention.

In said drawings:—Figure 1 is a longitudinal sectional view embodying my invention, showing an overhead car. Fig. 2 is a plan view of the exposed surface of the conduit through which the working circuit is closed to the motor, showing in dotted lines certain of the electrical connections. Fig. 3 is a transverse, vertical section of a portion of the railway tracks and the relation of my improved conduit to the rails thereof. Fig. 4 is an enlarged, transverse, vertical section of the closed conduit. Fig. 5 is a view, diagrammatic in its nature, illustrating the relation of the safety switches to the circuits in the conduit through which the working circuit is closed. Fig. 6 is a fragmentary longitudinal view of the conduit illustrating the normal or inoperative position of one of the safety switches. Fig. 7 is a similar view illustrating the switch in position to close the circuit. Fig. 8 is a perspective view of said switch. Fig. 9 is a perspective view of a portion of one of the connectors, showing means for maintaining proper tension on said connectors. Fig. 10 is a perspective view illustrating magnetic bars located in the top of the conduit and constituting pole extensions of the magnet on the car. Fig. 11 is a transverse vertical section of the conduit, showing a slightly modified form of the safety switch. Fig. 12 is a transverse section of a connector illustrating a still further modified form of the safety switch. Fig. 13 is a fragmentary plan view, diagrammatic in its nature, of the form of switch shown in Fig. 12, together with the part which coöperates therewith. Fig. 14 is a diagrammatic view illustrating the manner in which the switch terminals engage the contact studs in the conduit wall.

As shown in said drawings, A designates a portion of the car or vehicle, which carries a magnet B which in this instance, operates the electrical transmitting mechanism within the conduit, and provided with suitable electric motors A^1. The car is also provided with collectors or shoes A^2 A^2 supported from the car by spring rods A^3 which transmit the current from the conduit contacts to the motor. C designates, as a whole, the closed conduit located between the rails of the car and track, and D D^1 the feed and return conductors, respectively, contained within the conduit. E E^1 designate magnetic, undulatory connectors adapted to be raised in an undulatory motion by the magnet on the car, or magnets otherwise suitably placed, when the car passes thereover, both to operate the safety switches hereinafter described, and to constitute a portion of the conductor of the working circuit. F F designate a plurality

of separated contact pieces which extend through the upper wall of the conduit, as herein shown, and are exposed outside of the conduit for contact with said collectors A^2 on the car, and through which the current is transmitted from the electrical devices in the conduit through to the motor on the car.

The conduit consists, as herein shown, of a bottom wall c, side walls c^1 c^1 made of channel cross-section, as herein shown, and a top wall c^2; said top and bottom walls being suitably secured to the flanges of the side walls by bolts. Packing strips c^3 are interposed between said side, top and bottom walls for the purpose of sealing the conduits against the entrance of water. The top wall of the conduit may be, and preferably is, made of wood or other insulating material. Metallic protecting strips C^1 extend longitudinally, at each side of the top wall of the conduit and are secured thereto by bolts. Said top wall is suitably perforated for the extension therethrough of the shanks f of the contacts F, which latter are shown as elongated on the street in the direction of the length of the conduit. The said contact pieces are fastened in place by nuts f^1 and are surrounded at their lower ends by insulating bushings or washers f^2. The space between the side rails or strips C^1 may be filled with a layer of asphalt or other insulating material G and the outer ends of the contact pieces F, which are embedded in said insulating layer, will preferably project slightly above the surface thereof to afford proper engagement thereby of the shoes or brushes A^2. The feed and return conductors D D^1 are shown as located in elongated passages formed partially in upper and partially in lower strips c^4 c^5, made of wood or other insulating material, whereby said conductors are insulated from each other and from the transmitting mechanism within the conduit. The conduit is divided into laterally separated chambers by a central partition c^6, and the side walls of the conduit are lined with insulating strips or boards c^7. The arrangement herein shown is provided for a system wherein both the feed and return wires are located within the conduit. The invention is, however, applicable to systems wherein the current is returned through a conductor outside the conduit, as one of the track rails.

In the construction under consideration, but a single row of contact piecec F are employed and the flexible, undulatory connectors E E^1 do not contact directly with said contact-pieces F. The working circuit is closed through said single row of contacts F by the following devices: The conduit is provided in its top wall, on each side of the central line of the contact pieces F, with two rows of contact pieces H H^1 having the form of studs located vertically above and adapted for contact with said connectors E E^1 when said connectors are raised by the action of the magnet. One set or row of studs, the studs H, are connected with the central set of contact pieces F by connecting wires h, while the other set of studs H^1 are likewise connected with the central contact pieces by other connecting wires h^1. Each contact piece F is, therefore, connected with a positive and a negative stud H H^1, respectively. The studs H H^1 connected with each of the contact pieces F are located in front and rear of the latter, respectively, as shown in Fig. 2, and the magnet B and the shoes A^2 on the car are so arranged that as the connectors E E^1 are moved into contact with two laterally opposite studs H H^1 under the influence of the magnet B, one of the shoes A^2 will engage one of the contact pieces F of the central row connected with and in front of one of said studs, while the other shoe will engage a contact F connected with and in rear of the other stud. It will thus be seen that the motor circuit is closed at any given time, for instance, through one of the connectors, as the connector E, the stud H engaged thereby, one of the contact pieces F, one of the shoes A^2, the motor, the other shoe A^2, the contact F engaged by said latter shoe, the stud h^1 and the connector E^1. The circuit just traced begins and terminates with said connectors. The said connectors are connected with the supply and return conductors through suitable switches, now to be described. The connectors, while mechanically continuous, are made of sections of suitable length which are insulated from each other, as shown at e, so that but a short section of each connector is charged at a time. The length of said sections of the connectors is such that no parts of the connectors ahead or behind the car are energized, thereby avoiding danger of charging an exposed part of the conduit and its transmitting equipment.

Referring now to the construction and operation of the safety-switches illustrated in Figs. 1 to 8, inclusive, by which the sections of the undulatory connectors are connected with the supply and return conductors as the car passes over the same, and through which the working circuit is closed to the motor, these parts are made as follows: One convenient form of switch I is shown in detail in Figs. 6, 7 and 8, and in position in the conduit in Fig. 1. The switch shown in said figures has the form of a lever, it consisting of two like parts or members located side by side, each composed of an arm I^1 and an arm I^2 on opposite sides of a centrally disposed, horizontal pivot pin i. The said switch members are connected by an insulating block through which extends the pivot pin i. Said switches are located just below the top wall of the conduit and the pivot pins i thereof extend between and are supported

on the central partition c^6 and the side linings c^7, as most clearly shown in Fig. 4. The said two member switches are located in pairs either side by side or one in advance of the other, when both feed and return conductors are within the conduit. One end or arm I^1 of each switch is provided with terminals i^1 adapted for contact with contact pieces i^2 fixed to the adjacent lining c^7 of the side wall of the conduit and partition c^6 (Fig. 4). The other end of the two member switch is provided with terminals i^3 i^4 adapted for contact with other contact pieces i^5 i^6 projecting inwardly from said insulated partitions and linings c^6 c^7, respectively. The contact pieces i^2 on the two sides of the circuit are connected with the adjacent conductors D or D^1 by means of wires i^7 i^7 (Fig. 5). The contact pieces i^5 i^6 at each side of the conduit are connected with the adjacent sections of the appropriate connectors E E^1 by means of wires i^8 i^9. When the switches are closed, the working circuit is closed from one of the main conductors through the adjacent switch and thence to two sections of the adjacent connector, from whence it is transmitted through the contacts F and shoes A^2 to the motor, and the return current is transmitted through the other shoe A^2, the contacts F and other undulatory connector, through the terminals i^5 i^6 of the other switch and said switch, the contact i^2 and wire i^7 to the other main conductor.

An important feature of the present invention embraces the manner of closing and opening the safety switches combined with the manner of mounting the switches, whereby is avoided danger of short circuiting the current from one conductor to another through the contacts F at a time when the car is not over a given length of the conduit. The switches normally occupy the position shown in Fig. 6 with the arms I^1 of the switch swung downwardly and the switch terminals i^3 i^4 in engagement with their appropriate stationary contacts i^5 i^6. Normally also, the connectors lie flat on the floors of the lateral chambers of the conduit, as shown in Fig. 4. As the car moves along the track, the magnet carried thereby, or other magnets energized by the presence of the car, raises the connectors in a wave-like or undulatory movement for the purpose of raising the same into contact with the contact studs H, H^1 as before stated, and also for the purpose of mechanically raising the depressed ends of the switches I and to bring their terminals i^1 into contact with their co-acting stationary terminals i^2. Inasmuch as the mechanical lifting of the normally depressed ends of the switches tends to lower the normally raised ends of the switches, it is necessary to provide some means for holding the said latter ends of the switches up against their contacts when the connectors raise the other ends thereof. This result may be effected by magnetically holding the ends I^2 of the switches in their elevated positions when the other ends thereof are raised and so constructing the switches, either by making them of spring-metal, or providing lost motion at their pivots, whereby both ends may be held up to their contacts at the same time. Moreover, it is necessary to provide means for holding both ends of the switches against their contacts for a time after the connectors drop to their lower positions. Such holding of the switches is magnetically effected by means permitting the switches to open before the car passes off the part of the conduit in which they are located. I have herein shown one practical form of mechanism for magnetically effecting these results, that cooperate with the magnet on the car, and which will now be described; located in the top wall of the conduit are a number of downwardly facing bars which are energized by the magnet on the car and constitute, in effect, pole extensions of the said magnet. The switches are provided at their ends with magnetic pole pieces designed for contact with said pole extensions, the end I^1 of each switch being provided with a single magnetic pole piece i^{10}, and the other or forked end of the switch being provided with like magnetic pole pieces i^{11} i^{11}. The said magnetic pole pieces i^{10} and i^{11} are insulated from the switches by insulating blocks, as shown in Figs. 6, 7 and 8. The said magnetic bars or pole extensions are shown more clearly in Figs. 4, 5 and 10. In the construction under consideration, three of such magnetic bars are employed, J and J^1 J^1, the bar J being located between the bars J^1 and separated therefrom by air gaps or otherwise. Each of said bars are longitudinally divided into sections of appropriate length corresponding to the length of the sections of the undulatory magnetic connectors, and said sections are separated at their ends by air gaps or otherwise. The central bar J is provided with openings j through which may extend the shanks f of the contact pieces F. The longitudinal spaces between said bars J J^1 may be filled by ribs depending from the non-conducting top wall of the conduit, and the studs H, H^1 may be attached to said ribs, or otherwise attached to said wall. The central sections J of the multi-pole extensions meet end to end at points intermediate the meeting ends of the outer sections J^1 of said pole extensions, as more clearly shown in Fig. 10, for a purpose hereinafter described.

The principal parts of the safety switches I, as herein shown, are made of spring metal, or at least the arms of said switches are made of spring metal, in order to permit both ends of the switches to be raised at the same time. The same general result may be secured in a straight switch by providing a slotted piv-

otal connection therefor, as shown in Fig. 11, hereinafter described. In Fig. 5 is illustrated the position of said switches relatively to the sections of the pole extensions. As herein shown, each switch is so arranged that the magnetic pole piece of the end I^1 thereof bridges the space between the central part of the pole extension and one of the side parts thereof, and may, therefore, be held in its upper or closed position when either of the members of the pole extension is energized, while the magnetic pole piece of one member of the arm I^2 is adapted for contact with the central member of the pole extension and the magnetic pole piece of the other member of the arm I^2 is likewise adapted for contact with the adjacent outer or side member of the pole extension. The terminal of one of the members of the arm I^2 of each switch may, therefore, be held engaged with its associated contact piece while the terminal of the other member of said arm is depressed from its contact piece, as shown in Fig. 7. The construction therein shown consists, in effect, of two switches mounted on a single pivot and insulated from each other. The two members of each switch may, however, be separately mounted, or the switch may be otherwise constructed. The normally depressed end I^1 of the switch is provided on its under face with an insulating extension i^{12} adapted for engagement by the undulatory connector to raise the switch to its closing position.

The operation of the mechanism thus far described is as follows: As the car moves along the track the undulatory connectors E E^1 are lifted by the magnet on the car, or other suitably placed magnets, in a wave-like or undulatory motion into contact with the studs H H^1, as shown in Fig. 1. The raising of said connectors operate ahead of the magnets on the car, relatively to the direction of movement of the car, to raise the normally depressed ends of the safety switches and thereby close the motor circuit through said switches. The tendency of raising the depressed ends of said switches in the manner stated is to lower the opposite ends thereof, but this tendency is overcome by the magnetic action of the pole extensions J J^1 which act on the pole pieces i^{11} of the normally raised ends of the switches to hold the terminals i^3 i^4 against their contact pieces in the manner stated. When the switch is thus raised, the circuit is closed through said switch to both sections of the associated connector with which the two arms of the switch are connected. That is, the section of said connector which extends forwardly and that which extends rearwardly from the insulation e dividing said sections.

It is assumed that the car shown in Fig. 1 is traveling to the left. It will be seen from said Fig. 1 that the switch I at the right hand side of the figure has been closed by mechanical action, and is being held in its closed position by the magnetic action of said pole extensions. In the continued progress of the car, when the magnet passes beyond the section of the central member J of the pole extension with which the switches, shown in Fig. 5, coöperate, said section will be demagnetized and the members of the switches which carry the contact pieces i^3 drop away from their contacts i^5, as indicated in Fig. 7, so that the sections of the connectors in rear of said switches are cut out of the circuit. The contact pieces of the ends I^1 of the switches are, however, held up to their contacts by the magnetic attraction of the adjacent sections of the outer members of the pole extension, which sections of said outer members extend beyond the sections of the inner or central member, as clearly shown in Figs. 5 and 10. The other members I^2 of the switches, whose terminals engage the contacts i^5, are likewise held up to their contacts until the magnet on the car passes beyond said sections of the outer members of the pole extension, thereby insuring a closed circuit through the connectors as long as the car is over the part of the conduit containing the same. Likewise, when the car reaches the part of the conduit including the next forward pair of switches, the magnet on the car operates through the pole extension to hold the arms I^2 of said next adjacent switches to their contacts during the time the normally depressed ends of said switches are raised, and said switches are held in their closed positions until the magnet on the car passes beyond the magnetic influence of the sections of the pole extensions associated therewith. This operation continues throughout the length of the conduit so long as the car is in motion. It will, of course, be understood that the sections of the connectors and the sections of the pole extensions are of such length that said sections of the connectors are cut out of the working circuit before the same are exposed in rear of the moving car, so that there is no danger of the conduit, in rear or advance of a passing car, being charged in a manner to endanger the lives of persons passing thereover. As soon as a car has passed over and away from a part of the conduit containing a given pair of switches I, and the sections of the pole extensions coöperating therewith are deënergized, the ends I^1 of said switches drop by gravity and assume the position indicated in Fig. 6. When the switches are in this position there is no danger of short-circuiting the current from one side of the conduit to the other through the exposed contact pieces F of the conduit and an intervening conductor in the event that said undulatory connectors be accidentally raised, through breakage or part-

ing thereof, or in the event the switches be held raised by accidental sticking of the connector caused by arcing due to imperfect contact for the reason that the raising of such weighted ends of the switches at this time serves through the lever action of the switches to depress the ends I^2 thereof and prevents the closing of the switches.

In order to prevent both ends of a switch being thrown upwardly to its closed position by raising of the connector along such a length as to engage both ends of the switch, I may provide a shield K, located below the end I^2 of the switch and extending between and attached at its ends to the sides of the conduit chamber, as shown in Fig. 4. Such shield prevents the connector being brought into contact with the end I^2 of the switch and, therefore, avoids the contingency referred to. In practice the parts are so arranged that the switches and connector sections are raised into and lowered from their contacts at a time when the circuit is open, thus avoiding arcing at the contact points which might tend to overheat or melt and cause the same to stick.

In Fig. 11 is shown a construction wherein only the feed or supply wire is contained in the conduit, the return conductor being located outside the conduit, as, for instance, the track rail. In this construction but a single undulatory strip M is employed. The said strip acts mechanically to operate a switch N through which the working circuit is closed from the supply conductor D^2 in the conduit and through the contact pieces F to the motor. The switch is provided with terminals n n^1 which are adapted for contact with stationary contact pieces n^2 n^3, respectively, in the conduit. The said contacts n^2 are connected with the main conductor by wires n^4, while the several contacts n^3 are connected with the externally exposed contact pieces F by means of wires n^5. The switch N is weighted at its end which carries the contact piece n^1 and is normally depressed at said end, but is adapted to be raised by the strip M in the same manner as before set forth. The pole extension, comprising the members or bars O and O^1, operate in a manner like the pole extensions before described, to assist in closing the switches and maintaining them closed for the desired length of time. In this instance, the switch is made rigid and is pivoted to the central partition P of the conduit by means of a pivot pin p extending through a slot of the lever. Such slotted connection permits both ends of the switch to bring the contact pieces thereof in contact with their associated contacts at the same time, as is obvious. When the switch is out of operation the end carrying the contact piece n^1 is depressed or swung downwardly while the other end engages the member O of the pole extension. As in the construction previously described, the pole extension serves to hold the normally elevated end of the switch from falling when the other end thereof is raised and also operates to hold both ends of the switch uppermost to maintain the circuit closed for the proper period. It will be observed that the strip M of this construction serves merely as a mechanical means for operating the switch and does not constitute part of the circuit through which current is carried from the supply conductor to the motor. If desired, however, current from the supply wire in the conduit may be transmitted to said contacts F in the same general manner as in the construction previously described.

The switches described constitute safety devices by which is avoided liability of the transmitting mechanism of the conduit being dangerously charged at times other than when a car is located thereover, and may operate otherwise than herein shown for this purpose. They are herein shown as adapted to close the working circuit. The same principle may, however, be applied to such a safety switch which is not normally in the working circuit but employed to short circuit the current in case the strip or connector should rise in a part of the conduit over which a car is not then passing, thereby avoiding the closing of the circuit through the exteriorly exposed conduit contacts at such time. For instance, the switches may be permanently connected with the conductor and the normally raised ends of the switches may be swung downwardly, when the normally depressed ends thereof are swung upwardly by the accidental raising of the connector against contacts through which the current is short-circuited, with a result that a portion of such short circuit may be burned out. Similarly, the connectors, or one of them, may be permanently connected with the conductors or one of them, and the switches employed to short circuit the current in the same manner. The latter construction is shown in Figs. 12 to 14, both inclusive. In this construction the switches R are designed to be permanently connected with one of the main conductors S, as by a conductor s, and the normally depressed end of the switch, when raised, is adapted for engagement directly with the contact studs H, as shown in Fig. 14. The switch has a plurality of terminals r adapted for contact with said contact studs H. The terminals extend from one side of a rod r^1 which is pivotally mounted at R^1 on the central partition c^6 of the conduit; and the switch is provided with a tail-piece R^2 having a magnetic pole piece R^3, insulated therefrom. Magnetic bars or pole extensions T T are located in the top wall of the conduit and operate in the manner heretofore described to hold the normally elevated

end or tail-piece of the switch in its uppermost position at a time when the other end of said switch is raised and held up by the undulatory strip associated therewith. Located beneath the single end or tail-piece of each switch is a contact piece r^2 that is adapted to be engaged by a terminal r^3 carried by said tail-piece and is connected by a wire s^1 with the conductor S opposite to the conductor permanently connected with the associated switch. When the terminals or ends r of the switches are raised into contact with the studs H the working circuit is closed from one of the main conductors S, the wire or conductor s, the switch R, the studs H, the street contacts F, thence back through the studs H in the opposite sides of the conduit and associated switch R to the other conductor S. When the switch is in its inoperative position, as shown in Fig. 12, the superior weight of the multi-terminal end of the switch acts by gravity to hold the tail-piece in its elevated position. During the time the switch is closed the tail-piece and its terminal is held up to its associated magnetic bar or pole extension by the action of the magnet on the car or other suitably placed magnets.

The terminal r^3 on the tail-piece of the switch and the contact piece r^2 arranged as described are provided to short-circuit the current in case of accidental raising of the undulatory connector, such as to raise the multi-terminal end of the switch into contact with the associated contact studs H. When this occurs, there being no magnetic force to hold the tail-piece elevated, the lever action of the switch operates to swing the terminal of the tail-piece into contact with the contact piece r^2 and thereby short-circuit the current. The conductor s through which the current is short-circuited may be led to a suitable point outside of the conduit to a fuse-box R^{20} and arranged to burn out a fuse constituting part of the path of the short-circuited current, and thereby render the closing of the switch harmless at this time. Only a portion of one switch is shown in Fig. 13, but it will be understood that the corresponding switch at the other side of the conduit is oppositely disposed relatively to the switch shown. In practice the multi-terminal end of the switch may be so disposed that said terminals are not raised by the lever action into actual contact with the contact studs H, indicated in Fig. 14, but it is only those terminals engaged by the undulatory strip at any given time that engage their associated contact studs. In this manner the working circuit is closed through not more than two street contacts at a time, thereby minimizing leakage of current on the street.

The connectors may include or embody tension devices such as the spring connections e^1, (Fig. 9) which operate to maintain proper tension upon the connectors to prevent the same from buckling when expanded, and from becoming unduly taut when contracted.

While the switches herein illustrated are raised to their closing positions directly by the mechanical action of the magnetically operated connector or strip, it will be observed that said switches may be properly said to be magnetically operated and, in some instances, may be so operated when in circuit with an undulatory connector without the interposition of a mechanical element, as the connector or strip.

While it may be ordinarily unnecessary to disconnect but one of said main conductors when properly insulated to avoid danger in the above contingency to persons and traffic on surface of the street, the employment of said safety devices for both positive and negative sides as shown furnishes an absolute safe-guard against possible defective insulation within the conduit and effectually prevents all possibility of the system under any condition being short circuited on surface of the street.

I claim as my invention:—

1. The combination with a conduit, the exteriorly exposed contacts thereof and a conductor in the conduit, of a flexible strip or connector in the conduit capable of an undulatory movement throughout its length under the action of a magnet, and switches arranged along the length of the conduit through which the working circuit is closed and controlled by said strip or connector.

2. The combination with a conduit, the exteriorly exposed contacts thereof and a conductor in the conduit, of a flexible strip or connector in the conduit capable of an undulatory movement under the action of a magnet, and magnetically controlled switches in the conduit controlled by said strip or connector.

3. The combination with a conduit, the exteriorly exposed contacts thereof, and a conductor in the conduit, of a continuous flexible strip or connector in the conduit extending from end to end thereof and capable of an undulatory movement under the action of a magnet, said strip or connector being divided into a plurality of sections insulated from each other, and switches in the conduit arranged to be controlled by the strip or connector.

4. The combination with a conduit, the exteriorly exposed contacts thereof and a conductor in the conduit, of a strip or connector in the conduit capable of an undulatory movement under the action of a magnet, and switches within the conduit, spaced at distances apart not greater than the length of a car, controlled by said strip or connector.

5. The combination with a conduit, the exteriorly exposed contacts thereof and a

conductor in the car, of a mechanically continuous strip or connector in the conduit extending from end to end thereof and capable of an undulatory movement under the action of a magnet and designed to constitute part of the circuit over which current is passed to the motor of an overhead car, and switches in the conduit controlled by said strip or connector, said strip or connector being divided into a plurality of sections electrically insulated from each other.

6. The combination with a supply conductor, a conduit and the exteriorly exposed contacts of the conduit, of magnetically operated means in the conduit for closing the circuit between said conductor and contacts, including automatic devices coöperating with said circuit closing means operating to prevent establishment of said circuit at a time when the normally open parts of said circuit closing means are moved towards their closing positions by other than magnetic means.

7. The combination with a conductor in a conduit and the exteriorly exposed contacts of said conduit, of magnetically operated switches in the conduit through which the circuit is closed between the conductor and said contacts, and means whereby establishment of said circuit is prevented at a time when the switches are moved toward their closing positions by other than magnetic means.

8. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts embracing a strip in the conduit capable of undulatory movement under the action of a magnet, and automatic means for preventing the establishment of a circuit between said conductor and contacts when said strip is raised by other than magnetic means.

9. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts comprising a strip in the conduit capable of an undulatory movement under the action of a magnet, switches in the conduit mechanically controlled by the said strip and means for controlling said switches to prevent the establishment of a circuit between the conductor of the conduit and the exposed contacts when the strip is raised by other than magnetic means.

10. In an electric railway system, a conduit provided in its wall with exteriorly exposed contact pieces, a supply conductor therefor, and transmission devices for establishing electric connection between the conductor and said contact pieces embracing switches in the conduit, a strip in the conduit in circuit with said conductor and capable of an undulatory motion under the action of a magnet, and means for controlling said switches to prevent the establishment of a circuit between the conductor and contact pieces when the strip is raised by other than magnetic means.

11. In an electric railway system, a closed conduit provided in its wall with exteriorly exposed contact pieces, a supply conductor therefor, and transmission devices for establishing electric connection between the conductor and said contact pieces embracing switches in the conduit, a strip in said conduit capable of an undulatory motion under the action of a magnet, said strip mechanically operating said switches and the switches constituting parts of the transmitting circuit between the conductor and contacts, and means for controlling said switches to prevent the establishment of a circuit between the conductor and contact pieces when the strip is raised by other than magnetic means.

12. The combination with a conductor in a conduit and the exteriorly exposed contacts of the conduit, of a flexible strip or connector in the conduit through which the circuit is closed between the conductor and said contacts, and automatic devices located in the conduit for preventing the establishment of a circuit between the connector and said contacts when the connector is raised by other than magnetic means.

13. The combination with a conductor in a conduit and the exteriorly exposed contacts of the conduit, of a flexible strip or connector in the conduit composed of sections insulated from each other through which the circuit is closed between the conductor and said contacts, and automatic devices located in the conduit for preventing the establishment of a circuit between the connector to said contacts when the connector is raised by other than magnetic means.

14. The combination with a conductor in a conduit and the exteriorly exposed contacts of the conduit, of a flexible strip or connector in the conduit through which the circuit is closed between the conductor and said contacts, magnetically controlled switches in the conduit constituting also parts of said circuit, and means for controlling said switches to prevent the establishment of a circuit between said conductor and contacts when the connector is raised by other than magnetic means.

15. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a strip in the conduit capable of an undulatory movement under the

action of a magnet, and a switch in the conduit mechanically controlled by said strip.

16. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a strip in the conduit in circuit with said conductor and contact pieces, and capable of a vertical undulatory movement under the action of a magnet, and a switch in the conduit in circuit with the conductor and arranged to be mechanically moved in position to close the circuit between the conductor and said contacts when said strip is raised.

17. In an electric railway system, a closed conduit provided in its wall with exteriorly exposed contact pieces, a supply conductor therein and transmission devices for establishing electrical connection between the conductor and contact pieces, comprising switches in the conduit and combined mechanical and magnetic means for operating said switches including a magnetically controlled, undulatory strip in the conduit.

18. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor in a conduit and the exteriorly exposed contacts in the wall of the conduit comprising a switch in the conduit and a strip capable of undulatory movement under the action of a magnet which is moved into contact with the switch to close the same.

19. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a flexible connector composed of insulated sections and capable of an undulatory movement under the action of a magnet and magnetically controlled switches for closing the circuit between the sections of said connector and said conductor.

20. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a switch in circuit with the conductor, and a strip in the conduit capable of undulatory movement under the action of a magnet for closing said switch, said switch being normally open at one end and normally closed at its other end, said strip acting on the normally open end of the switch to close the same.

21. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a switch in circuit with the conductor, a strip in the conduit capable of undulatory movement under the action of a magnet for closing said switch, one end of said switch being normally open and the other end normally closed, said strip acting on the normally open end of the switch to close the same, and magnetic means acting on the normally closed end of the switch to hold said end closed while the other end thereof is being moved to its closed position.

22. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a flexible connector composed of insulated sections and capable of an undulatory movement under the action of a magnet and magnetically controlled switches for closing the circuit between the sections of said connector and said conductor, said switches being constructed and arranged to complete the operative closing of the working circuit only when the switch is magnetically controlled.

23. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a flexible strip capable of an undulatory movement under the influence of a magnet, a switch one end of which is normally open and the other normally closed, said strip acting on the normally open end of the switch to close the same, means for holding the normally closed end of the switch closed while the other end is being closed, and operating when the strip is raised by other than magnetic means to prevent the operative closing of the working circuit through said switch.

24. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a flexible connector composed of insulated sections and capable of an undulatory movement under the action of a magnet, magnetically controlled switches for closing the circuit between the sections of said connector and said conductor, and means for controlling said switches to complete the operative closing of the working circuit only when the switches are magnetically controlled, said switches having the form of a lever and being so arranged that the normally closed end thereof is open when the other end is closed at a time when the switch is demagnetized.

25. In an electric railway system, the com-

bination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts, comprising a switch in circuit with the conductor, and a strip in the conduit capable of undulatory movement under the action of a magnet for closing said switch, one end of said switch being normally open and the other end normally closed, said strip acting on the normally open end of the switch to close the same, and magnetic means acting on the normally closed end of the switch to hold said end closed while the other end thereof is being moved to its closed position, and operating thereafter to hold the switch closed after said strip is moved out of contact therewith.

26. In an electric railway system, a conduit provided in its wall with exteriorly exposed contact pieces, a supply conductor therein, and transmission devices for establishing electric connection between said conductor and contact pieces embracing switches in the conduit, consisting of pivoted levers provided at their ends with terminals, stationary contacts in the conduit adapted for engagement with said terminals, each of said switches being so arranged that one of the terminals thereof is normally engaged with its associated stationary contact, while the other terminal is out of engagement with its stationary contact, means for mechanically closing said switches to bring the latter terminals in engagement with their stationary contacts, and magnetic means for holding the normally engaged terminals in engagement with their stationary contacts during the closing movement of the switches.

27. In an electric railway system, a conduit provided with exteriorly exposed contact pieces, a supply conductor in the conduit and means for establishing electrical connection between said conductor and contact pieces embracing switches in the conduit consisting of levers pivoted between their ends and provided at their ends with terminals, stationary contacts in the conduit adapted for engagement with said terminals, each of said switches being so mounted that one end thereof is normally retracted from its associated contact, while the terminal of the other end is normally engaged with its contact, mechanical means for moving the retracted ends of the switches to close the same, and magnetic means for holding the terminals of the other ends of the switches with their contacts during the closing movement of the switches.

28. In an electric railway system, a conduit provided with exteriorly exposed contact pieces, a supply conductor in the conduit, and means for establishing electrical connection between said conductor and contact pieces, embracing switches in the conduit consisting of levers pivoted between their ends and provided at their ends with terminals, stationary contacts in the conduit adapted for engagement with said terminals, each of said switches being so mounted that one terminal thereof is normally retracted from its associated contact while the other terminal is in normal engagement with its associated contact, a strip in the conduit capable of undulatory motion under the influence of a magnet and adapted to move the retracted ends of the switches to close the same, and means operating to hold the terminals at the other ends of the switches engaged with their contacts only when the strip is raised under the action of a magnet.

29. In an electric railway system, a conduit provided with exteriorly, exposed contact pieces, a supply conductor in the conduit, and means for establishing electrical connection between said conductor and contact pieces, embracing switches in the conduit consisting of levers pivoted between their ends and provided at their ends with terminals, stationary contacts in the conduit adapted for engagement with said terminals, each of said switches being so mounted that one end thereof is normally retracted from its contact while the terminal at the other end thereof is normally engaged with its associated contact, a strip in the conduit capable of undulatory motion under the influence of the magnet and adapted to engage the retracted ends of the switches to close the same, and a magnetic bar in the conduit with which said normally elevated ends of the switches are engaged.

30. In an electric railway system, a conduit provided in its wall with exteriorly exposed contact pieces, interiorly exposed contact studs in the conduit electrically connected with said contact pieces, a supply conductor within the conduit and transmission devices for establishing electrical connection between said conductor and studs embracing switches in the conduit and a flexible connector capable of undulatory movement under the action of a magnet to bring the connector into contact with said studs and to also operate said switches.

31. In an electric railway system, the combination with a conduit, the exteriorly exposed contacts thereof, and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts comprising switches in the conduit, contacts in the conduit adapted for engagement by the terminals of said switches, and a flexible connector in the conduit capable of undulatory movement under the action of a magnet for closing the switches, said connector being composed of sections insulated from each other, and in circuit with said lat-

ter contacts, each switch having at one end thereof two terminals for contact with two associated contacts, one of which latter contacts is in circuit with one and the other with another of two adjacent sections of the connector.

32. In an electric railway system, a conduit provided in its wall with exteriorly exposed contact pieces, interiorly exposed contact studs in the conduit electrically connected with said contact pieces, a supply conductor within the conduit, and transmission devices for establishing electrical connection between said conductor and studs embracing switches in the conduit, and a flexible connector capable of undulatory movement under the action of a magnet to bring the same into contact with said studs and to also operate the said switches, said connectors being composed of sections insulated from each other, each switch having at one end thereof, two terminals each adapted for electrical connection with one of the two adjacent sections of the connector.

33. In an electrical railway system, a conduit provided in its wall with exteriorly exposed contact pieces, feed and return conductors therein, and flexible conductive connectors in the conduit capable of undulatory motion under the action of a magnet, combined with switches mechanically operated by said connectors and magnet for establishing a circuit between said conductors and through the contact pieces to a translating device outside of a conduit, and means cooperating with said switches operating to prevent the establishment of a circuit between the conductors when the said connectors are raised by other than magnetic means.

34. In an electric railway system, a conduit provided in its wall with exteriorly exposed contact pieces, a feed and return conductor in the conduit and transmitting devices for establishing a circuit from the feed to the return conductor through the contact pieces and an external translating device comprising switches in the conduit, flexible connectors also in said conduit capable of undulatory motion under the action of a magnet and operating to mechanically raise said switches and arranged to constitute, together with said switches, parts of said circuit between the conductors, and means for controlling said switches to prevent establishment of a circuit between the conductors when the connector is raised by other than magnetic means.

35. In an electrical railway system, the combination with a closed conduit, a row of contact pieces in the wall of said conduit which are exposed to the exterior thereof, and two rows of contact studs exposed to the interior of the conduit and of opposite polarity and electrically connected with the outwardly exposed contact pieces, of supply and return conductors in said conduit, and means for electrically connecting said conductors with their corresponding interiorly exposed contact pieces.

36. In an electric railway system, the combination with a closed conduit, a supply and return conductor therein, a row of contact pieces in the wall of said conduit which are exposed to the exterior thereof, and two rows of contact studs of opposite polarity which are exposed to the interior of the conduit and electrically connected with said exteriorly exposed contact pieces, of means for establishing connection between said conductors and said interiorly exposed contact studs embracing flexible magnetic strips or connectors.

37. In an electric railway system, the combination with a closed conduit, supply and return conductors therein, a central line of exteriorly exposed contact pieces in the wall of the conduit, and contact studs projecting into the interior of the conduit and arranged on opposite sides of said central line of contact pieces and electrically connected with the latter, of undulatory magnetic connectors adapted to be moved into engagement with said inwardly projecting contact studs and comprising longitudinal sections insulated from each other, and means for establishing electrical connections between the sections of said connectors and said conductors.

38. The combination with the conductor in a conduit and the exteriorly exposed contacts thereof, of a flexible strip capable of an undulatory motion under the action of a magnet and constituting means for controlling the working circuit between said conductor and contacts, and means controlled by said strip when raised by a magnet, whereby the working circuit is closed and arranged to prevent establishment of the circuit at a time when the strip is raised by other than magnetic means.

39. The combination with the conductor in a conduit and the exteriorly exposed contacts thereof, of a flexible strip capable of an undulatory motion under the action of a magnet and constituting means for controlling the working circuit between said conductor and contacts and constituting also part of said circuit, and means controlled by said strip when raised by a magnet, whereby the working circuit is closed, and arranged to prevent establishment of the circuit at a time when the strip is raised by other than magnetic means.

40. In an electric railway system, the combination with a conduit, its exteriorly exposed contacts and a conductor, of means for closing the circuit between the conductor and said exteriorly exposed contacts com-

prising a flexible, mechanically continuous connector composed of sections insulated from each other and capable of an undulatory movement under the action of a magnet, and switches for closing the circuit between the sections of the connector and said conductor.

In testimony, that I claim the foregoing as my invention I affix my signature in presence of two witnesses, this 6th day of July A. D. 1906.

ELMER E. GRANGER.

Witnesses:

W. L. HALL,

GEORGE R. WILKINS.