(No Model.) 3 Sheets—Sheet 1.

J. PERRY & W. E. AYRTON.

ELECTRICAL CONDUCTOR FOR RAILWAYS, &c.

No. 326,237. Patented Sept. 15, 1885.

Fig. 2.

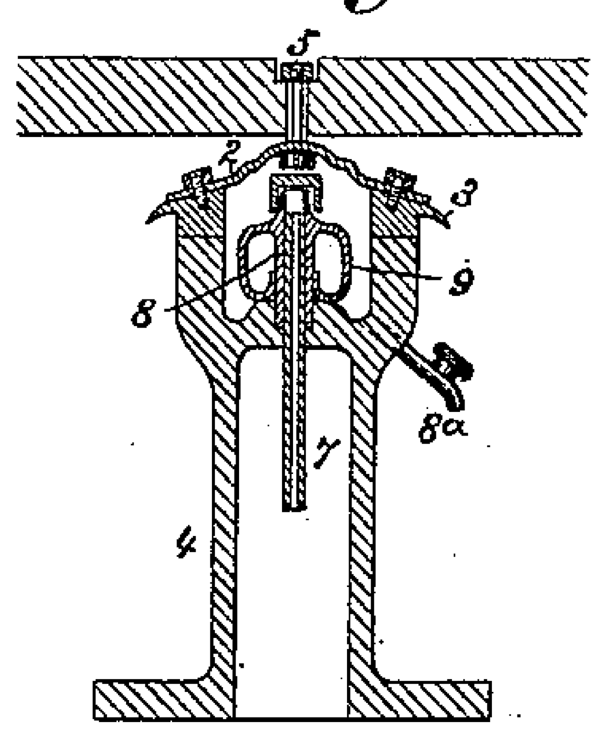


Fig. 1.

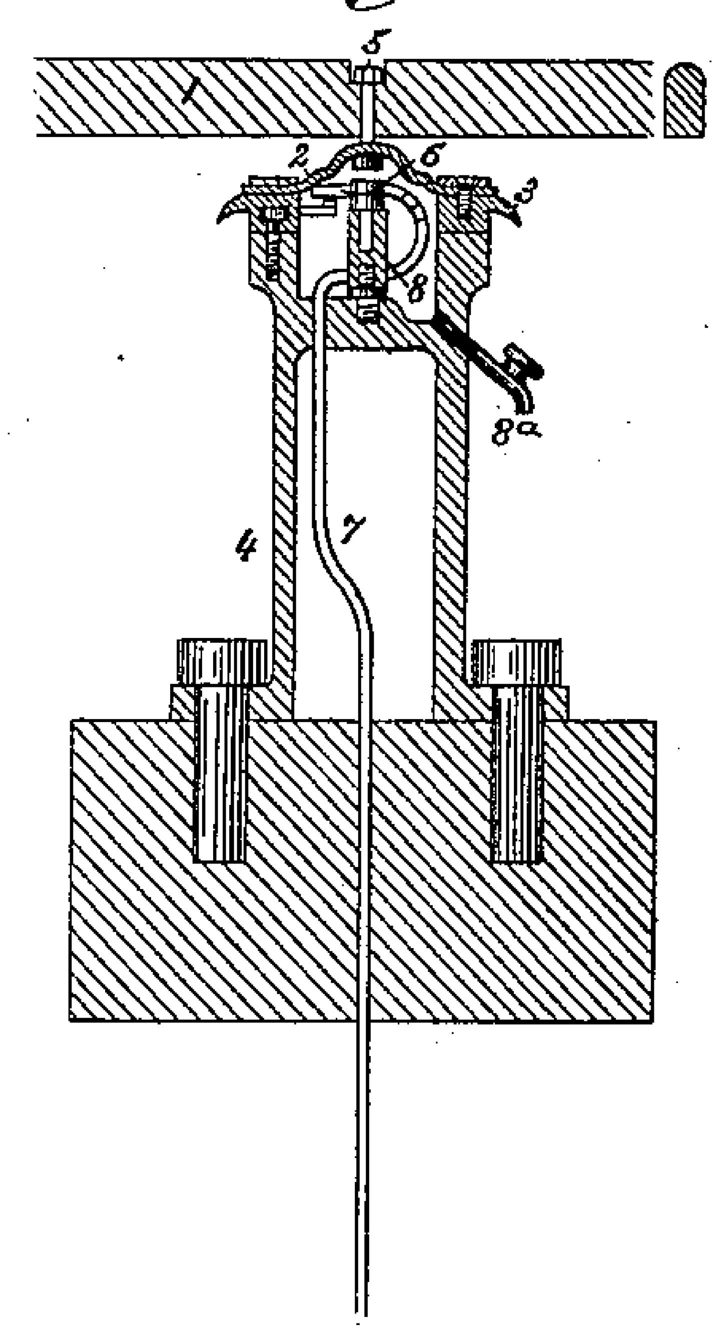


Fig. 5.

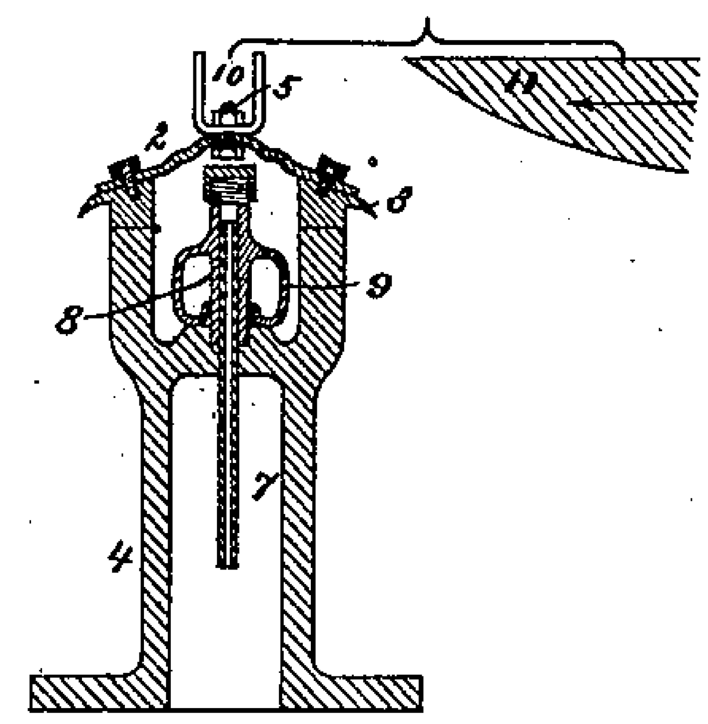


Fig. 3.

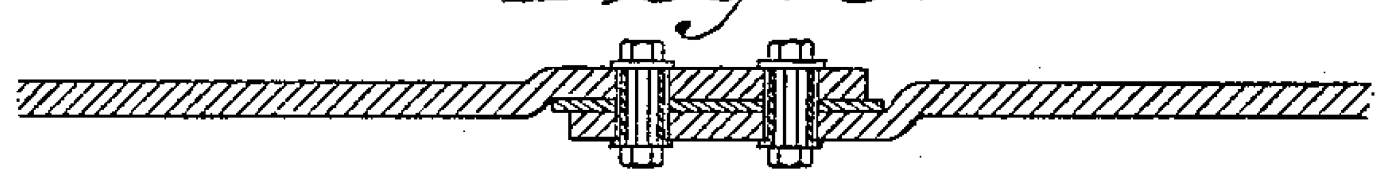


Fig. 4.

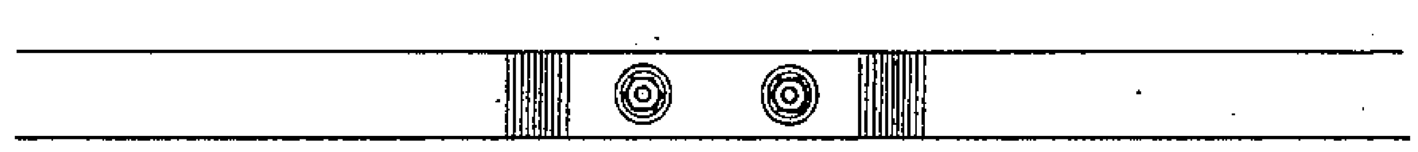


Fig. 14.

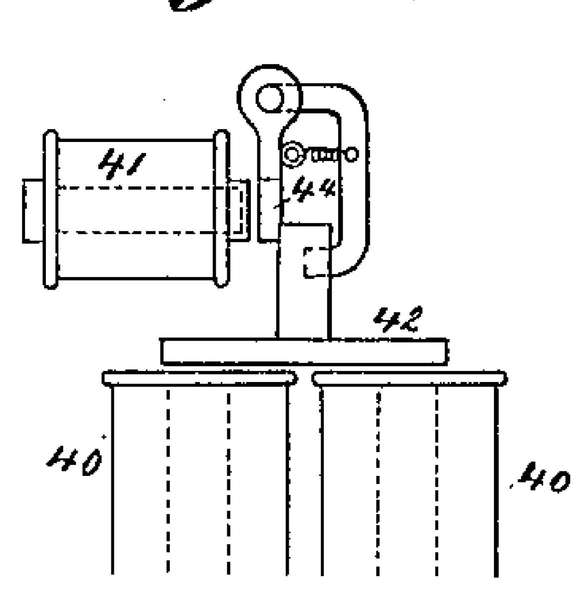
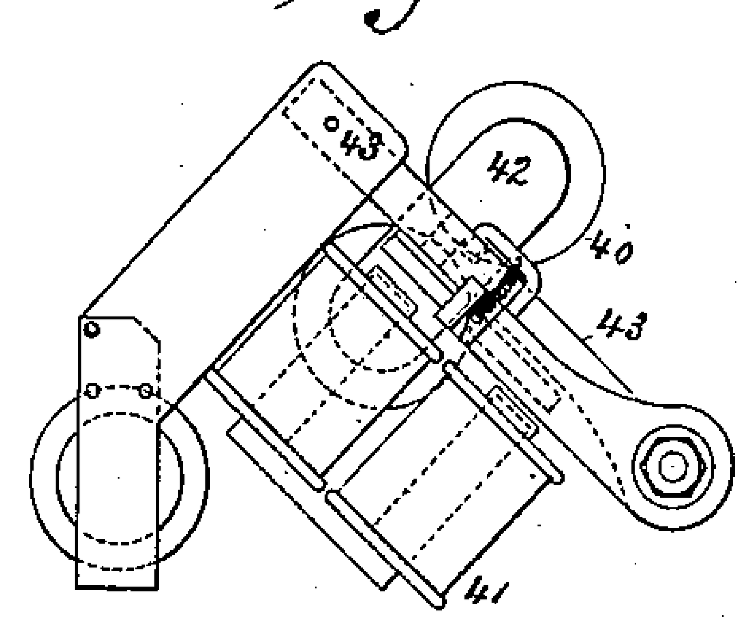


Fig. 15.



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(No Model.)

3 Sheets—Sheet 2.

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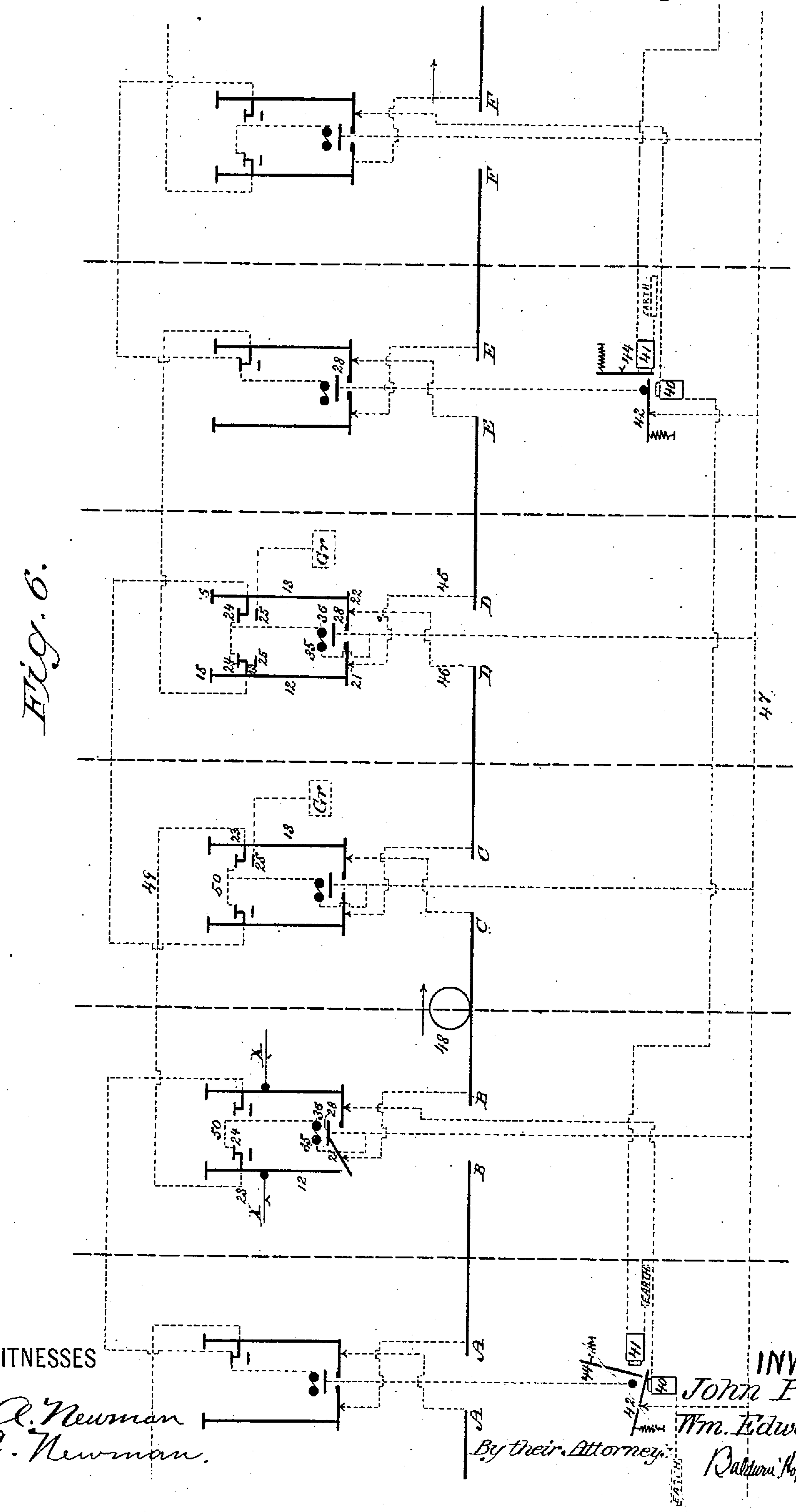
ELECTRICAL CONDUCTOR FOR RAILWAYS, &c.

No. 326,237. Patented Sept. 15, 1885.



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(No Model.) 3 Sheets—Sheet 3.

J. PERRY & W. E. AYRTON.

ELECTRICAL CONDUCTOR FOR RAILWAYS, &c.

No. 326,237. Patented Sept. 15, 1885.

Fig. 7.

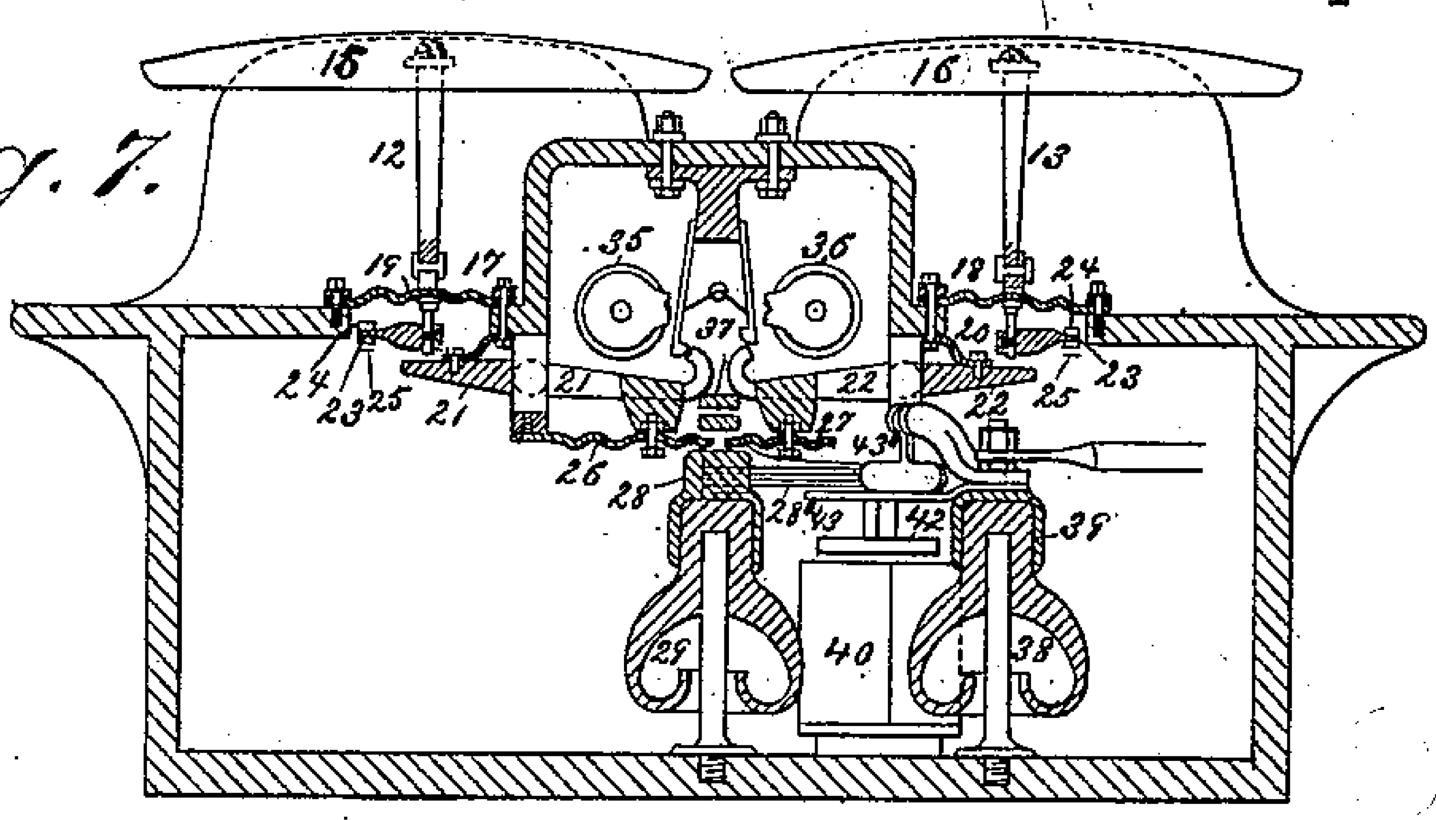


Fig. 8.

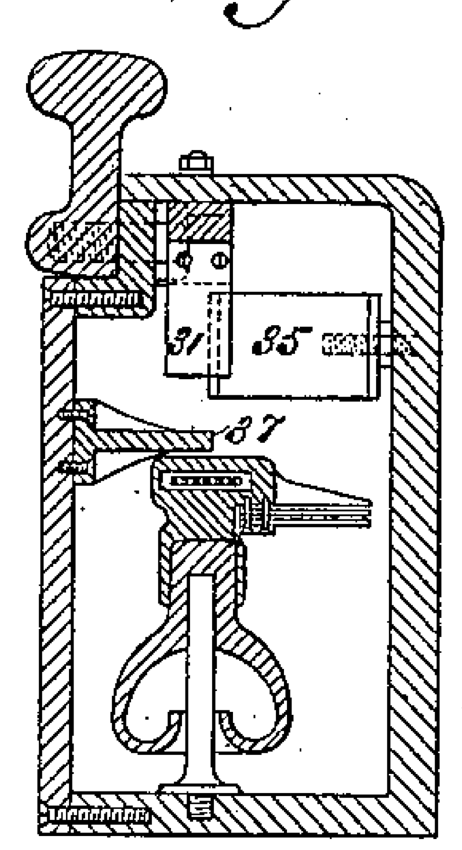


Fig. 9.

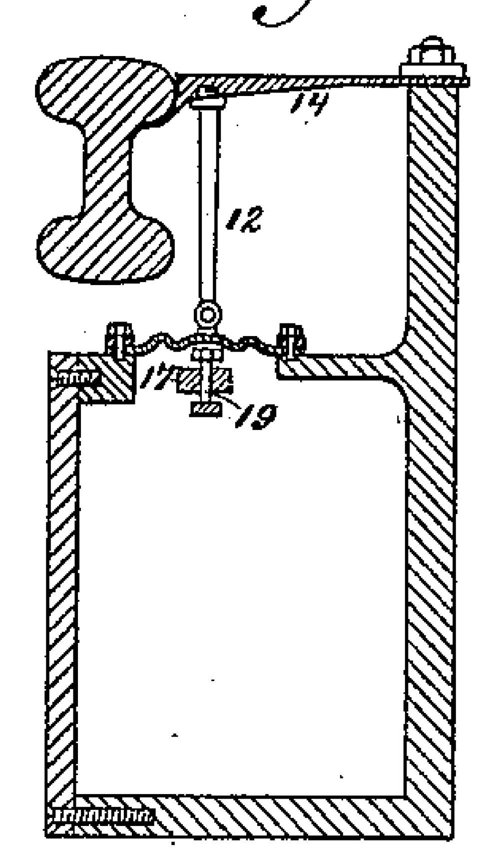


Fig. 10.

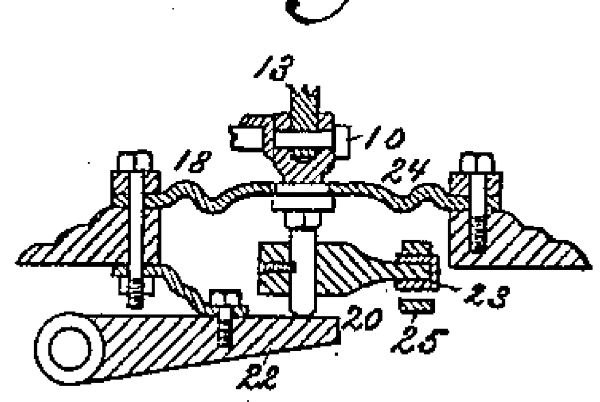


Fig. 11.

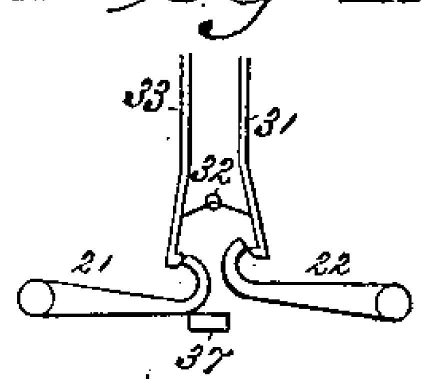


Fig. 12.

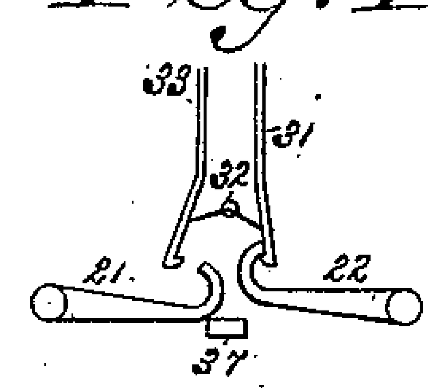
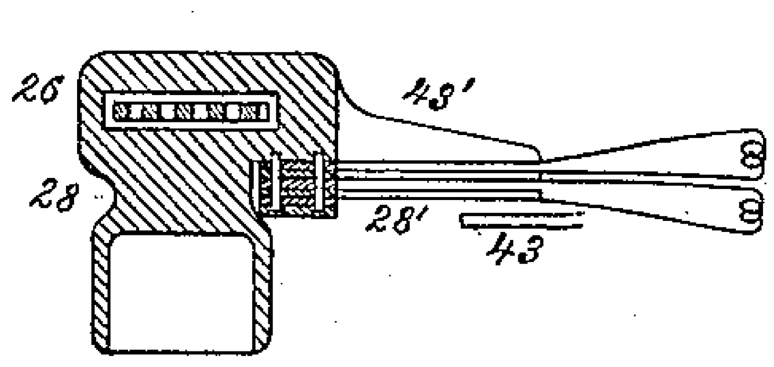


Fig. 13.



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UNITED STATES PATENT OFFICE.

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ELECTRICAL CONDUCTOR FOR RAILWAYS, &c.

SPECIFICATION forming part of Letters Patent No. 326,237, dated September 15, 1885.

Application filed June 25, 1883. (No model.) Patented in England February 24, 1881, No. 783, and May 11, 1883, No. 2,395.

To all whom it may concern:

Be it known that we, JOHN PERRY, of Falgarth Road, in the county of Middlesex, England, electrician, and WILLIAM EDWARD AYRTON, of Cowper Street, in the county of Middlesex, England, professor of technical physics, subjects of the Queen of Great Britain, have invented certain new and useful improvements in electrical conductors applicable to electric railways and to electric signaling, and in apparatus connected therewith, (for which we have received Letters Patent in Great Britain, No. 783, dated February 24, 1881,) of which the following is a specification.

Our invention is designed for the better and more convenient insulation of the electric conductor for the transmission of power in electric railways and for furnishing an automatic block system without the use of signalmen.

In electric railways it is usual to attempt to insulate either one of the two rails on which the carriage or carriages rest, or a third rail, and to collect electricity for the motive power from this so-called "insulated rail" by rollers or brushes of wire fixed to the carriage. It is extremely difficult to properly insulate a rail of this kind, as it must have many supports, and at each support there is a leakage; hence such a rail as at present in use cannot be satisfactorily employed for long distances. Another plan recently adopted is to insulate, by means of posts and telegraph insulators, the wire conveying the current for propelling the train, and to maintain a continuous sliding connection between this wire and the moving train by means of a secondary wire, one end of which is attached to the train or carriage and the other to a small jockey running on the wire insulated on the posts and pulled on by the moving train; but in summer, when the main wire is slack, it will be difficult to carry out this system for trains moving at high speeds.

Our improved apparatus consists of an insulated wire cable or other conductor or conductors placed either alongside, above, or underneath the railway, or in any other suitable position, and the insulation of which is maintained by gutta-percha, or by its being supported on insulators or otherwise. This main conductor or conductors is automatically or at will by a signalman or other person, as indicated at X, Fig. 6, electrically connected successively to one or more sections of a service-conductor in the neighborhood of the moving train. The service-conductor is a rail which may or may not be that on which the train runs, and may be rigid or somewhat elastic. It is divided into sections fairly well insulated from one another and from the earth. Since, then, leakage to the earth of the current which propels the train can only take place from that section or sections of the rail which are at any moment electrically connected with the continuous insulated conductor, the loss of power by leakage of electricity to the ground will be very much less than in the case of a single imperfectly-insulated rail—such as has been hitherto employed for electric railways, and which, if of considerable length, with its corresponding large number of points of support, would possess a very large number of points at which leakage of the motive electric current would continually take place.

Our method will be best understood from the following examples of its application:

Figure 1 is a section of an insulator to support a rail by which electricity is supplied to a vehicle or train. It is also a contact-maker, putting the rail into communication with the main conductor at the proper times. Fig. 2 is another form. Figs. 3 and 4 show the way of connecting sections of the rail. Fig. 5 shows another form, where contact is made with a bar carried by the vehicle or train. Fig. 6 is a diagram of an automatic arrangement for establishing at the proper times contact between the main conductor and the rubbed or service conductor or that from which the train directly takes the current. Figs. 7, 8, and 9 are vertical sections of the contact-boxes. Figs. 10, 11, 12, 13, 14, 15 are details of the same.

In Figs. 1 and 2, 1 is a copper or other metallic rod resting on the top of and fastened to a corrugated tempered steel disk, 2, (of the nature of but much stronger than the corrugated top of the vacuum-box in an aneroid barometer,) and which is carried by and fastened to a thick ring, 3, made of ebonite or other insulating material, either by a metal ring or by six screws and washers. The ebonite ring is itself screwed to the top of the circular cast-iron box 4, which latter is fastened to the ordinary sleepers by wooden or iron pins or screws. In these and in all the other figures sections of insulating material are indicated by the shading lines being closer together than in the case of the metallic sections. The rail 1 and the corrugated steel disks 2 have sufficient flexibility so that two or more of the latter are simultaneously depressed by an insulated collecting brush or roller carried on one or all of the carriages composing the train, or on the single carriage, if there be not more than one. Depressing any one of the corrugated steel disks brings the stud 5, which is mechanically and electrically connected with the rod or rail 1, into contact with the stud 6, which is electrically connected with the main insulated cable or conductor previously referred to, or with one of them, if there be more than one. This connection is made either by means of a gutta-percha or other insulated wire, 7. To prolong the contact the stud 6 is supported by a spiral spring, as shown in the drawings, so as to be depressed somewhat by the stud 5. In the neighborhood of a train the rail 1 or the service-conductor is then electrically connected with the well-insulated cable or main conductor at two or more points or contact-boxes, and the train receives electric power through the ordinary collecting brushes or rollers under the carriages, or under some of them, and the current, after passing through a suitable electro-motor on one or all of the carriages, returns by means of one or both of the ordinary uninsulated rails of the line, good electric contact between the successive pieces of rail forming the ordinary permanent way, and used as the return-wire, being insured by pieces of flexible wire being attached, if necessary, in addition to the ordinary fish-plates.

The mode of connecting the sections of our auxiliary rail or conductor is shown in Figs. 3 and 4. Vulcanite is interposed to prevent metallic contact from section to section. It will be seen that as only a short piece of the auxiliary rail 1 is at any moment in connection with the main cable, the insulation of the ring 3 will be quite sufficient, even in very wet weather, especially if the ring be made with a circular lip, as shown in the figures; but the insulation of the stud 6, which is always connected with the main cable, must be much more perfect, and hence the arrangements shown in the figures have been adopted by us.

In Fig. 1 a rod, 8, composed of rigid insulating material—such as ebonite, porcelain, or earthenware—and of comparatively small section, supports the stud 6, and as the inside of the cast-iron box is always fairly dry and clean, the surface-insulation of such a rod will be very considerable. Surface leakage down the outside of the gutta-percha or other insulated wire 7 is prevented by cutting the end portion of the insulating coating in the form of a pointed pencil according to the manner well known to and used by electricians; or the surface of the insulating-rod and of the end of the wire may be smeared over with paraffine or other oil, as employed by Mr. Cromwell Varley; or the cast-iron boxes themselves may be filled with paraffine or other suitable oil to prevent the possibility of moisture entering from outside, and this may be done without impairing the efficiency of the contact between 3 and 6 when the rail 1 is depressed by a neighboring train or carriage, for we have experimentally proved that although two pieces of metal separated by a very small visible distance in paraffine-oil are very well insulated from one another, there is but a very small resistance between them if they are pressed together in the oil even with a comparatively small force.

Another plan we employ for securing very high insulation, and which does not necessitate the steel disk 2 or the insulating-ring 3 fitting perfectly water-tight into the top of the cast-iron box, is shown in Fig. 2, and consists in bringing up the insulated wire 7, connecting 6 with the main cable through the center of an insulator, 9, shaped somewhat like an ordinary telegraph-insulator, and causing the outer surface of the insulated wire 7 to adhere to the inside of the tube of the insulator by the employment of a proper adherent. There will be then no surface leakage along 7, but only along the outside of the insulator 9. Small taps 8^a, which may be closed with an ordinary stop-cock, as shown in the figures, or by means of a key, may be fixed to the cast-iron boxes to allow any water being run out of them, should by chance any get in from the line, being flooded for a lengthened period, during which time, however, our system of electric railway will not, like the system hitherto employed of using one continuous badly-insulated rail, cease to work efficiently.

When using either our form of contact-box shown in Fig. 1 or that shown in Fig. 2, we place them at distances from one another varying with circumstances; but usually twenty to fifty feet is an average distance between the neighboring ones.

Another application of our method is shown in Fig. 5, and differs only from that shown in Fig. 2 in that the auxiliary insulated rail, instead of extending all along the line and being carried by the boxes, is merely an insulated bar the length of each carriage, and carried under the carriage. All the bars under the carriages comprising any one train are electrically connected together and with one terminal of the electro-motors and one or more of the carriages. On the top of the corrugated tempered steel disk 2, Fig. 5, is fixed an elastic fork, 10, which is bent slightly sidewise by the rod 11, carried by the moving carriage, but which is sufficiently rigid to depress the steel disk and make contact between 5 and 6, and therefore between the rod 11 and the main cable.

In all our arrangements previously described the distance between each contact-box and the next varies from twenty to fifty feet, so that there are several contact-boxes in each section of our insulated rail, and several sections of an insulated rail in one section of the line blocked; but the following illustrates one of our methods for making each section of our insulated rail or conductor, which is rubbed by passing train a mile or more in length—in fact, as long as the goodness of the particular system employed to insulate the rubbed conductor will allow. In this case we arrange that the electric connection between the main cable or conductor and the rubbed or service conductor of any section shall be automatically, or by a signalman at will, as indicated at X, Fig. 6, made when the train enters the section, and automatically or at will by a signalman broken as the train leaves the section.

The automatic method of contact we employ when the sections of our rubbed insulated conductor are long will be best understood from the following examples of its application:

A B B C C D D E E F in Fig. 6 are several long sections of our insulated service conductor, each half a mile or a mile or more in length, and which are passed over successively by a moving train, the ordinary direction of motion of which is shown by the arrows. The insulated conductor, of which the insulated points separating the sections are at A B C D E F, may be the rail bearing the weight of the train.

As the dimensions of the drawings are limited, thick vertical dotted lines are introduced to indicate long-space intervals.

At the intervals C and D in Fig. 6 is represented our normal contact box, one of which may be placed at each of the distant insulated junctions of our rubbed rail; or, if it be desired to add our automatic absolute block system, hereinafter described, then at certain of the insulated junctions of the rubbed rail we employ our block-contact box, represented symbolically at A and at E; and at the insulated junction next passed over by the carriage or train moving in its ordinary direction, indicated in the figure by the arrows, we place a form of contact-box represented symbolically at B and at F.

The mechanical and electrical details of all these different forms of contact-box are shown in Figs. 7, 8, and 9.

We will first describe the mechanical structure of the contact-boxes, and afterward we will explain their electrical connections and mode of action.

The contact-boxes employed along the line are all substantially alike, with the exception that some of them can be simplified by the omission of some of the parts which are necessary in others.

The figures of the drawings represent the more complex of the contact-boxes—that is to say, one in which the whole of the parts are to be found.

12 and 13 are two plungers, which are successively depressed by the wheels of the train passing along the line of railway. They instantly fly up again after the passage of the wheel, as they are attached to very stiff spring-plates, one of which is shown in section in Fig. 9, where it is marked 14. This spring is fastened by means of nuts to the top of the cast-iron box containing the apparatus, which box is let into a hole dug in the ballast of the permanent way. The rapidity of the movement is diminished by the curvature or rounded form of the parts 15 and 16, with which the wheels come into actual contact. The lower ends of the plungers 12 and 13 are attached by pivots to the tops of two corrugated tempered steel disks, 17 and 18, closing two holes in the top of the cast-iron box, and below these disks are fastened short plungers 19 20, one of which is shown to a larger scale in Fig. 10.

The plungers, when operated upon, give motion to levers 21 and 22, and after the plungers have acted these levers are caused to return by springs unless retained by means hereinafter described. The short plungers 19 20 move simultaneously with the exterior plungers, 12 13, and they carry an insulated arm, at the end of which there is a metal contact-piece, 23. The downward movement of the plunger carries this contact-piece from contact with the stationary metal stop 24 into contact with another stationary metal stop, 25.

26 and 27 are two springs supported on their ends on blocks of vulcanite, and also attached to similar blocks upon the extremities of the levers 21 22. When the outer end of the lever is pressed down by the plunger, its inner end, rising, draws up the corresponding spring, 26 or 27, into contact with a metal cap, 28, mounted upon the top of a porcelain insulator, 29.

It is required in the working of the apparatus that the lever 21 or 22 which is first caused to move (and this will depend on whether the train is running forward or backward along the line) shall become locked in the position to which it is brought by the plunger, while the lever, which is afterward operated on shall return again to its original position immediately the train is passed and the plunger rises. This is effected by forming hook-like ends to the levers 21 and 22, and providing spring-catches 31 and 33 to engage with them. Between the two catches there is an elbow-piece, 32, which is able to turn upon a pivot, and which operates with the catches in the following manner: Supposing the plunger 13 to be first depressed, then as the inner end of the lever 22 rises it is caught by the spring-catch 31, which tends to fly inward, and is locked thereby, as shown in Fig. 11. The end of the catch 31, as here seen, is not yet quite home under the hook of the lever 22. The catch would enter further were it not for the elbowed piece of metal 32 between the springs. The piece 32 is held in position partly by the action of a small spring, (not shown in the figure,) tending to keep it in its normal symmetrical position, as here shown, but mainly by the pressure of the spring-catch 33. The parts, however, only momentarily remain as here seen, for immediately the plunger 12 is pressed down by the wheels of the train the lever 21 rises at its inner end, pressing the catch 33 outward. This allows the piece 32 to move to the position in which it is shown in Fig. 12, the catch 31 entering completely beneath the hook of the lever 22 and the catch 33 being held off out of the way, so that it will permit the immediate return of the lever 21 as soon as the wheels of the train have passed beyond the plunger 12. If the train be running in the other direction, so that the plunger 12 is first depressed, and after it the plunger 13, then the lever 21 will be retained by the catch 33, and the piece 32 will assume a position such as to prevent the catch 31 from engaging with the lever 22. The lever, which is retained by the catch 31 or 33, is liberated at a subsequent period by the attraction of an electro-magnet, the two poles of which, 35 36, have the catches 31 33 between them. When this magnet is excited by a current passing in its coils, it attracts the steel of which the catches are composed, drawing them apart and liberating the lever which they held. The lever so liberated falls down onto a stop, 37, where it remains until it is again lifted by its plunger on the passage of another train.

38 is another porcelain insulator within the contact-box. It supports a metal cap, 39, upon which are mounted the armatures of two electro-magnets, 40 and 41. These are seen more clearly in Figs. 14 and 15. When the magnet 40 is excited, it draws down toward its poles the armature 42. A metal blade, 43, is connected with this armature. When the armature is released by the magnet, a spring tends to raise it, bringing the blade 43 into electrical connection with a metal arm, 43′, projecting from the cap 28, as is seen in Fig. 13. The armature 42, however, is not free to rise immediately. The current ceases in the coils of the maget 40, for the armature 44, which serves as a locking-catch, drops in, as is seen in Fig. 14. The armature 42, therefore, remains down until it is released by a current passing in the coils of the magnet 41. This magnet then attracts the armature 44 and draws it back out of the way.

For the purpose of preventing sparking there are several metal blade-springs, 28′, fixed upon the cap 28, and the bar 43, as it rises, acts upon these springs, one after the other, until it presses all of them together between its own surface and that of the metal arm 43′ upon the cap 28. These springs are insulated at the ends attached to the cap 28; but each spring is connected to the cap by a wire, as shown in Fig. 13, which offers a considerable resistance to the passage of the current; or, in other ways, the springs on the cap may be connected electrically with the cap through sufficient resistance. In this manner we avoid sudden and injurious make and break of electrical connection, which would otherwise take place.

We will now proceed to describe, by reference to Fig. 6, the electrical connections of the contact-boxes. There are six contact-boxes here shown, one at each of the intervals A, B, C, D, E, and F. Of each box the parts numbered 12, 13, 15, 16, 21, 22, 23, 24, 25, 28, 35, and 36 are diagrammatically indicated; but to avoid confusion reference-numbers are not repeated throughout. The contact-boxes C and D are what we term "normal contact-boxes." These may be repeated indefinitely along the length of line, and, if it is not intended to apply the block system of working, all the contact-boxes will be of the normal type represented at C and D. Pairs of contact-boxes, like A B and E F, are used only at the ends of each block-section. The connections of the levers 21 and 22 are the same at each contact-box, with the exception of the levers 22 in the contact-boxes B and F. By means of an insulated wire, 45, the lever 21 is in each case connected permanently with the section of rubbed conductor in advance of the contact-box. The lever 22 is in contact-boxes A, C, D, and E connected by a wire, 46, with the section of rubbed conductor in rear of the contact-box.

47 is an electric main from which the electric energy to propel the trains is drawn. In the case of the normal contact-box the cap 28 is in permanent connection with the electric main, and so it is in contact-boxes B and F; but in the case of the contact-boxes A and E this connection is in some cases severed, as hereinafter described, for the purpose of stopping a following train.

A train in passing any contact-box from left to right operates in the manner already explained to bring the lever 21 (or, more correctly, the spring 26, attached to this lever) into electrical connection with the cap 28, and the electrical current then flows by the wire 45 to the section of service-conductor on which the train is then entering. Thus 48 represents a train which has just passed the contact-box B. It has raised the lever 21 into contact with the cap 28, and there is now electrical communication between the electric main 47 and the section B C of the service-conductor. The lever 21 of the contact-box B remains in this position until the train passes the contact-box C. If the movement of the train 48 had been in the reverse direction it would, in passing the contact-box C, have raised the lever 22 therein, and this lever would be retained in the position so given to it until the train had passed the contact-box B. The release of the lever 21, which is shown to be raised in the contact-box B, will be effected when the train 48 presses down the plunger 13 of the contact-box C. It then brings the piece 23, which moves with this plunger, into contact with the stop 25, and the stops 25, in this as in all the other contact-boxes, are always in electrical connection with the earth. A wire, 49, connects the contact-piece 23 on plunger 13 of box C with the corresponding contact-piece on the plunger 12 of the contact-box B. This contact-piece is now resting against its stop 24, and the stop is connected by a wire, 50, with the limb 36 of the liberating electro-magnet. The coils of the magnet are continuous through the two limbs 36 and 35, and the terminal 35 of the magnet is always electrically connected with the electric main 47. This is so in all the contact-boxes. Consequently, on the depression of the plunger 13 in the contact-box C an electrical current will flow from the main 47 through the liberating-magnet 35 36 in the contact-box B to earth by the stop 25 in the contact-box C, with which, on the passage of a train, the contact-piece 23 on the plunger 13 is brought into momentary contact. In a precisely similar manner the train, as it passes each contact-box and depresses the second plunger of this box, completes the circuit of the electro-magnet 35 36 in the contact-box last passed, and this whether the train be running forward or backward; but as the train is never to back past the contact-boxes B and F, these being the extremities of a block-section of the line, the plungers 12 in these boxes are not connected. At the contact-boxes B and F the stop 24, belonging to the plunger 13, is not connected with the electro-magnet, as a current arriving at the box B by the wire 49 should be without influence on the magnet 35 36 in the box A. In the contact-boxes D and E the lever 22 is not required to connect the section of the service-conductor in rear of the box with the electric main, for trains never back past these boxes; consequently these levers 22 may be employed for another purpose. The lever 22 in the box F is connected with the electro-magnet 40 in the box E, and through this with the electro-magnet 41 in the box A, and this magnet is also connected permanently to earth. Now, in the box E the cap 28 is only connected with the electric main 47 through the armature 42 and parts connected therewith, and the momentary depression by the train of the lever 22 in the box F causes this armature 42 to be attracted and the connection with the box with the main to be severed. The change of position of the armature 42 is permanent, for immediately it is attracted it is blocked by the armature 44 moving in behind it. A train now passing the box E onto the section E F of the service-conductor will receive no current, and will quickly come to rest, more especially as the brakes may be automatically applied immediately the current ceases to be supplied to the train.

At the contact-box A the parts are shown in such position that a train passing the box onto the section A B will receive no current. The passage of the train 48 by the contact A has caused the armature 42 to be drawn down, and so it will remain until the train passes the contact-box F. Then the same current which causes the armature 42 in the box E to be attracted excites the magnet 41 in the box A and causes it to attract its armature 44. The movement of the armature 44 liberates the armature 42, which, rising to its stop, again connects the electric main with the cap 28 in the box A.

The form of the instruments herein described may be varied; but

What we claim is—

1. The combination, in an electric railway, of (*a*) a main insulated conductor or electric main conveying the propelling-current; (*b*) a number of comparatively short service-conductors fairly well insulated from one another and from the earth; (*c*) metallic brushes or equivalent connections coupling a motor on the train with the service-conductors; (*d*) contact-makers connecting the main conductor with the section of the service-conductor in the vicinity of the train and disconnecting the same when the train has passed.

2. The combination of the electric main, a number of comparatively short service-conductors that are moved successively into electric connection with the electric main by the passing train, and the conductors that connect the electric main with the service-conductors when thus moved.

3. The combination, in an electric railway, of (*a*) a main insulated conductor or electric main; (*b*) a number of comparatively short service-conductors fairly well insulated; (*c*) contact-boxes or instruments controlling the connections between the main and the service-conductors, and operating to electrically connect with the main conductor the section of the service-conductors in which the train is entering and to separate from it the section which the train has left, substantially as described.

4. The combination, in an electric railway, of (*a*) a main conductor or electric-main; (*b*) a number of comparatively short service-conductors fairly well insulated; (*c*) contact-boxes or instruments which put the current on from the main to a service conductor when a train passes, and (*d*) electro-magnetic appliances in connection with the said contact-boxes with circuits successively closed and reopened by a train in its progress, and which operate in the contact-boxes within a prearranged distance behind a train to prevent connection being established between the main conductor and the service-conductor, substantially as described.

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