(No Model.) 4 Sheets—Sheet 1.

T. D. WILLIAMS & J. S. LUCOCK.

AUTOMATIC ELECTRIC BLOCK SIGNAL SYSTEM.

No. 384,810. Patented June 19, 1888.

FIG. 2.

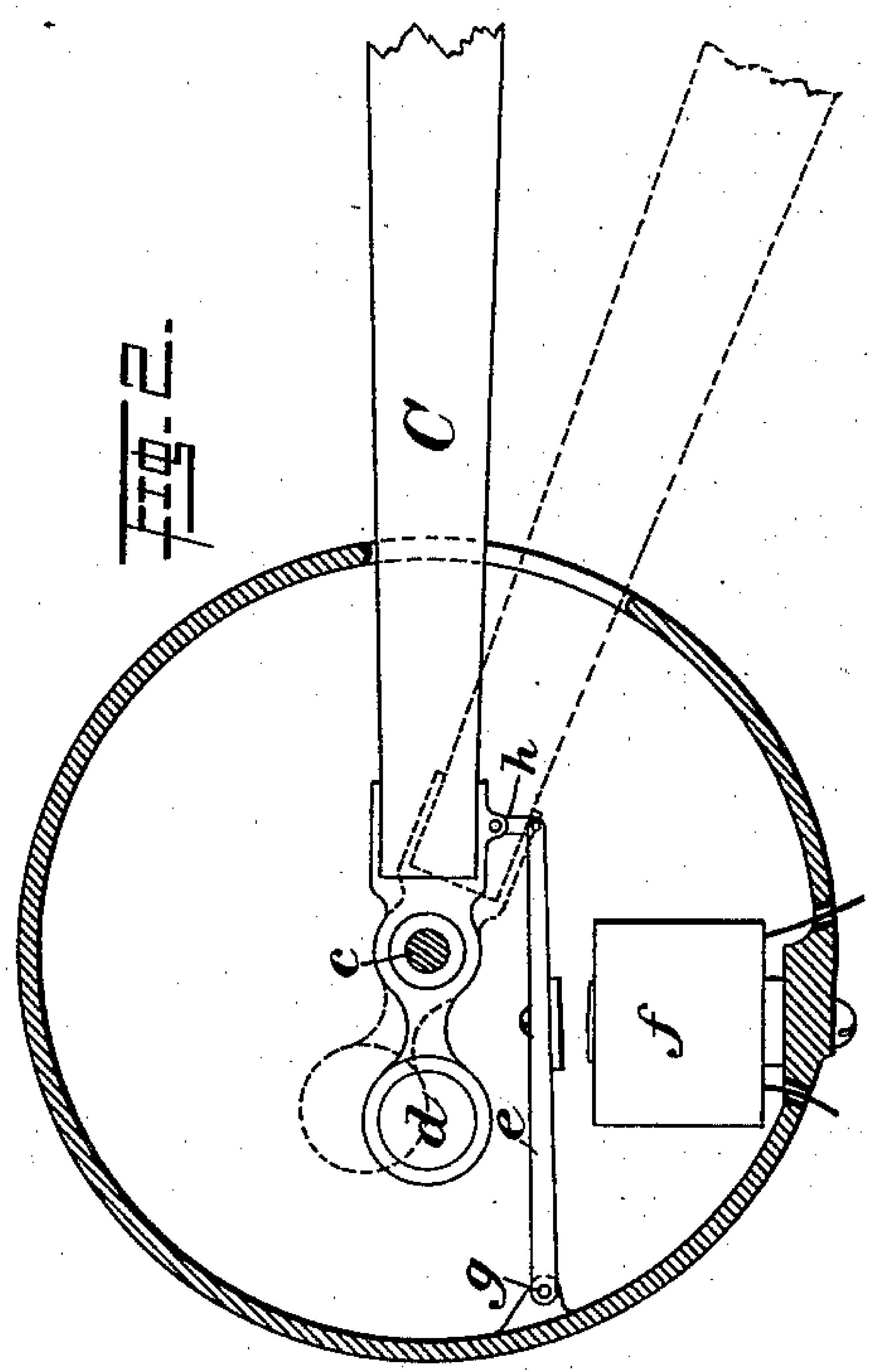

FIG. 1.

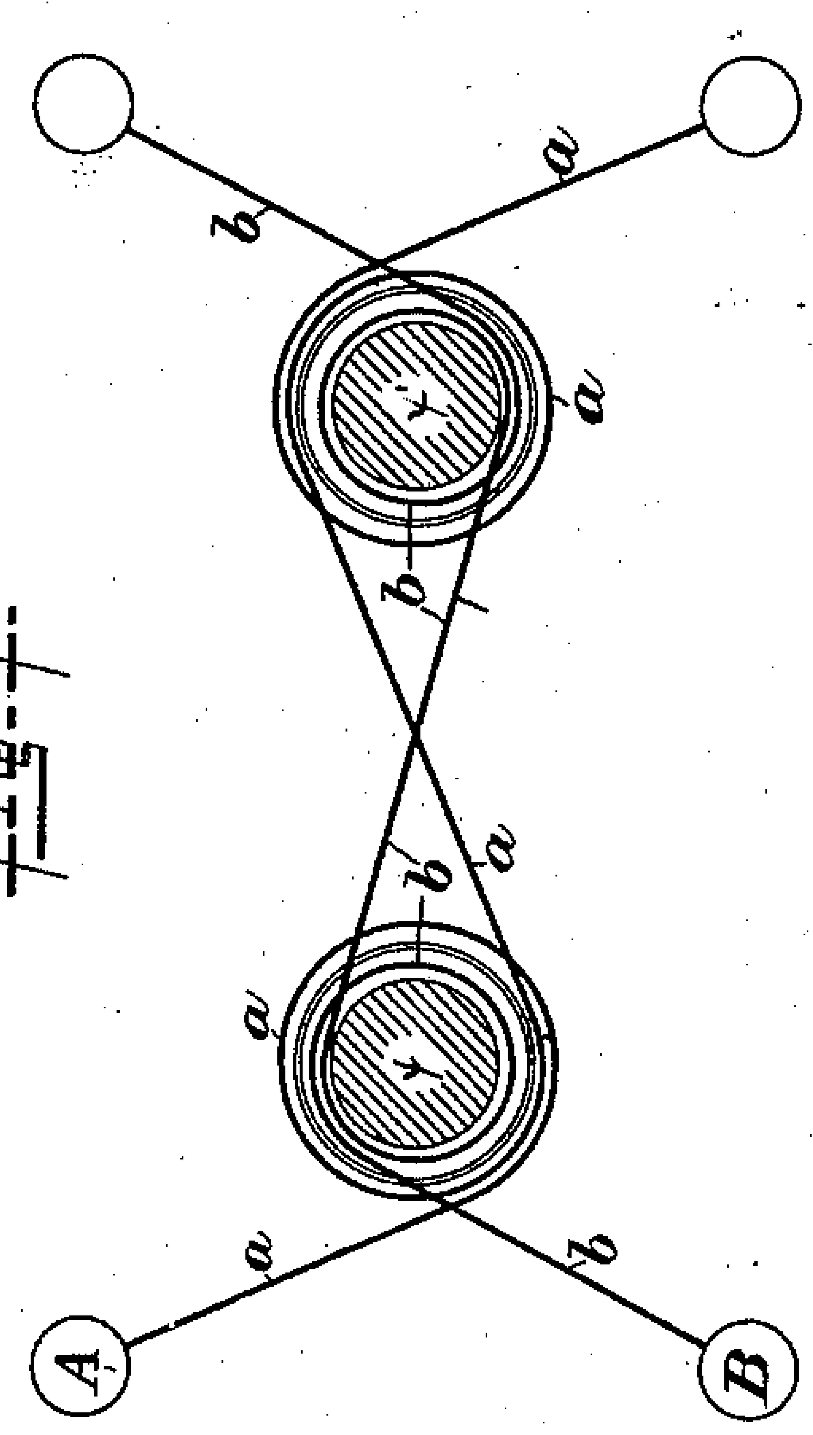

FIG. 3.

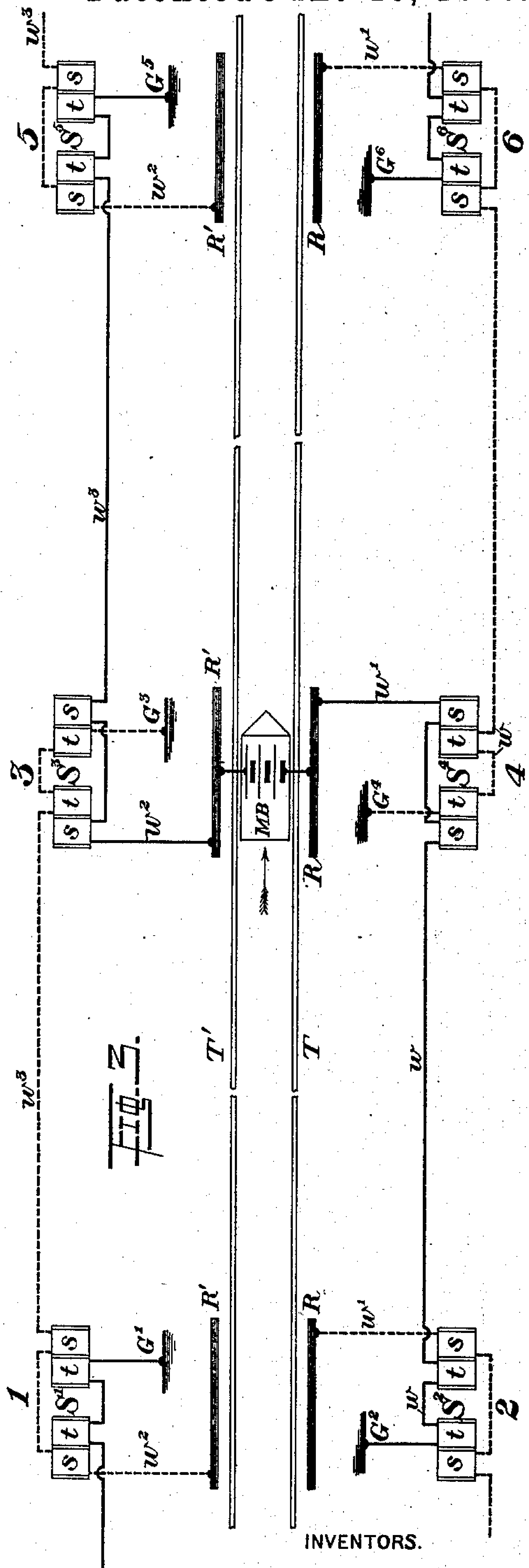

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FIG. 4.

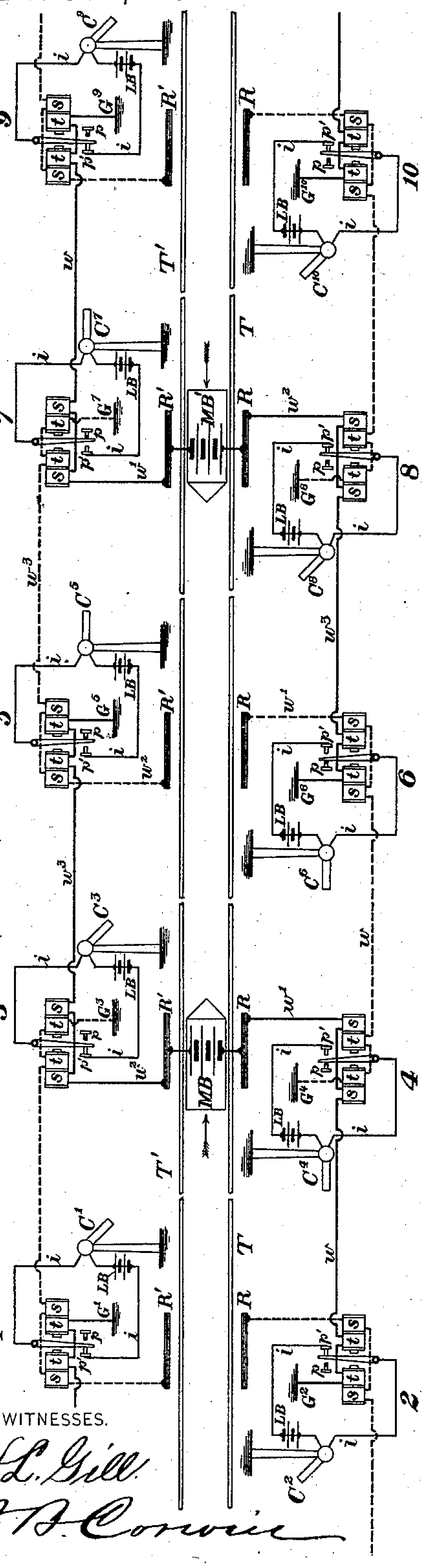
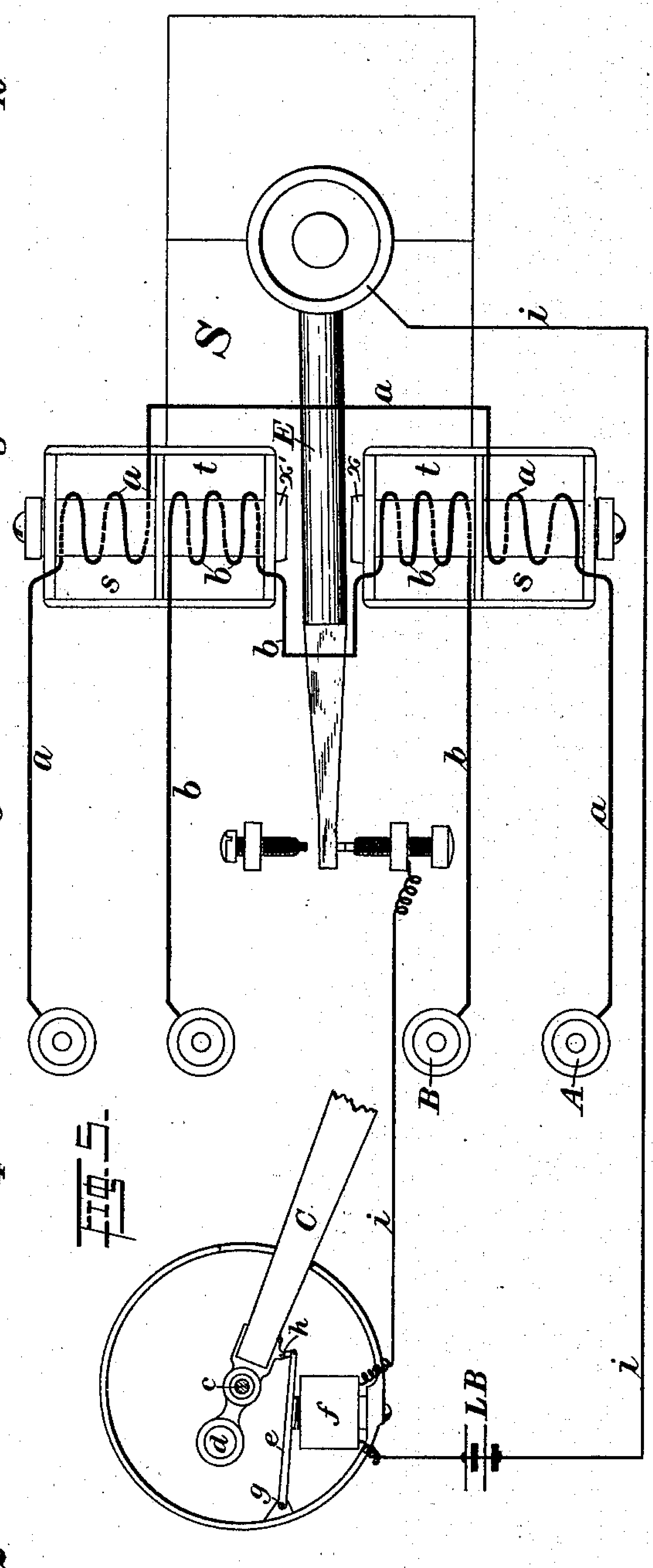


FIG. 5.



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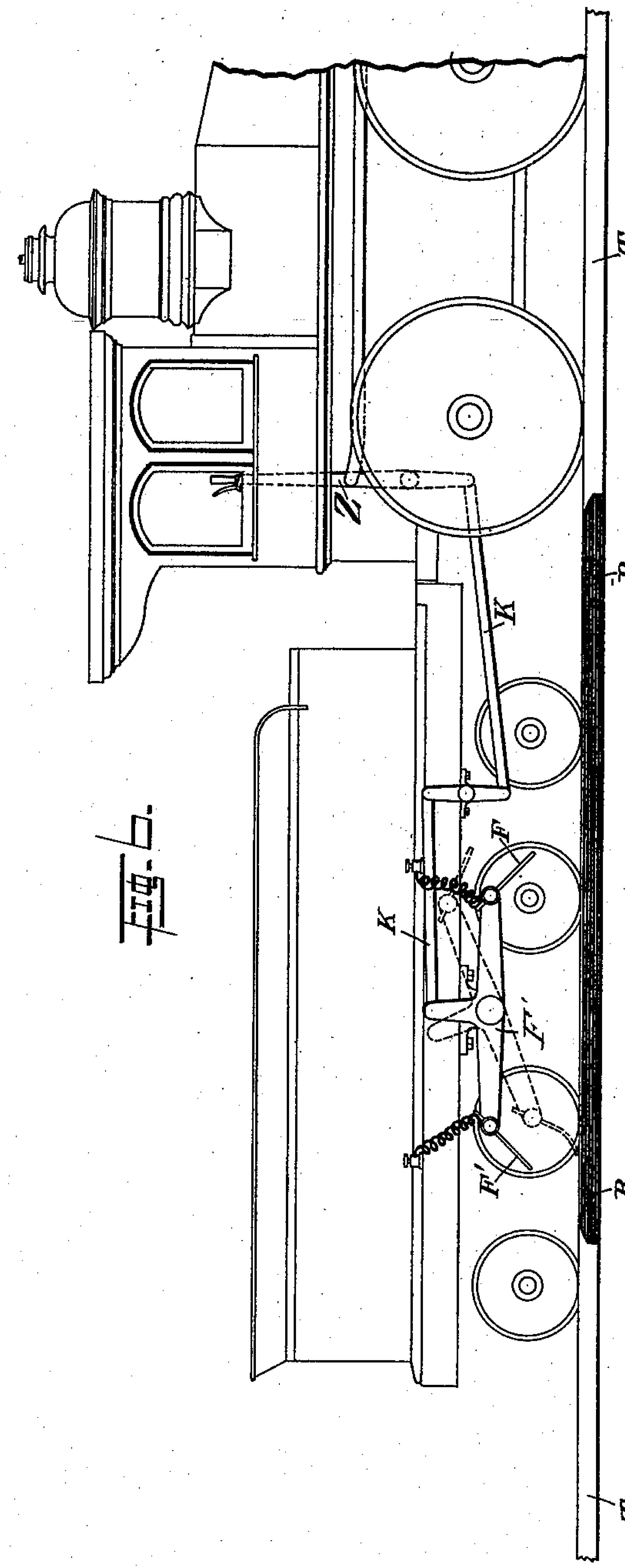

Fig. 6.

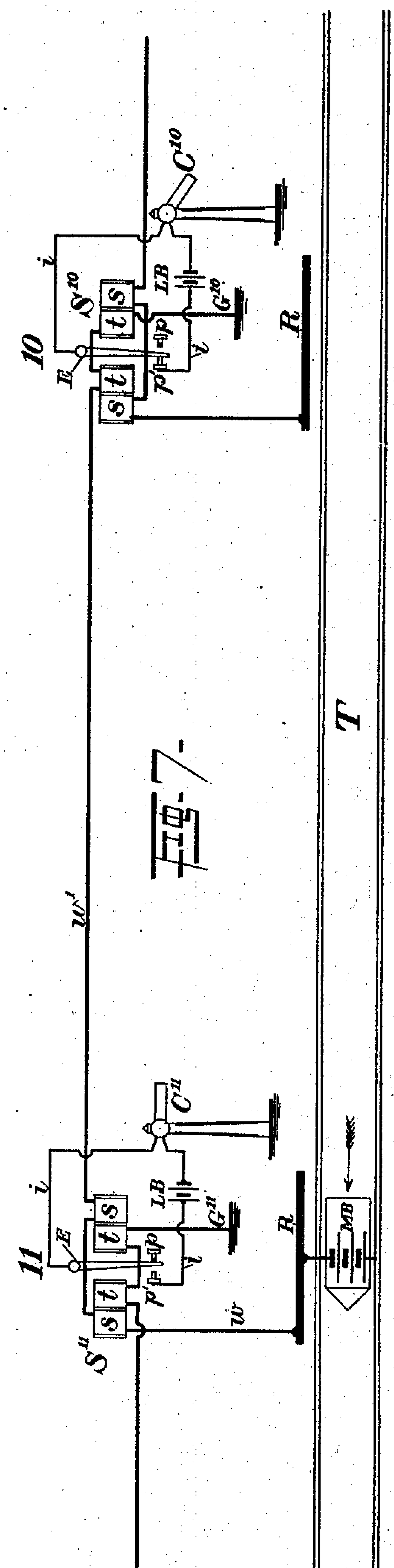

Fig. 7.

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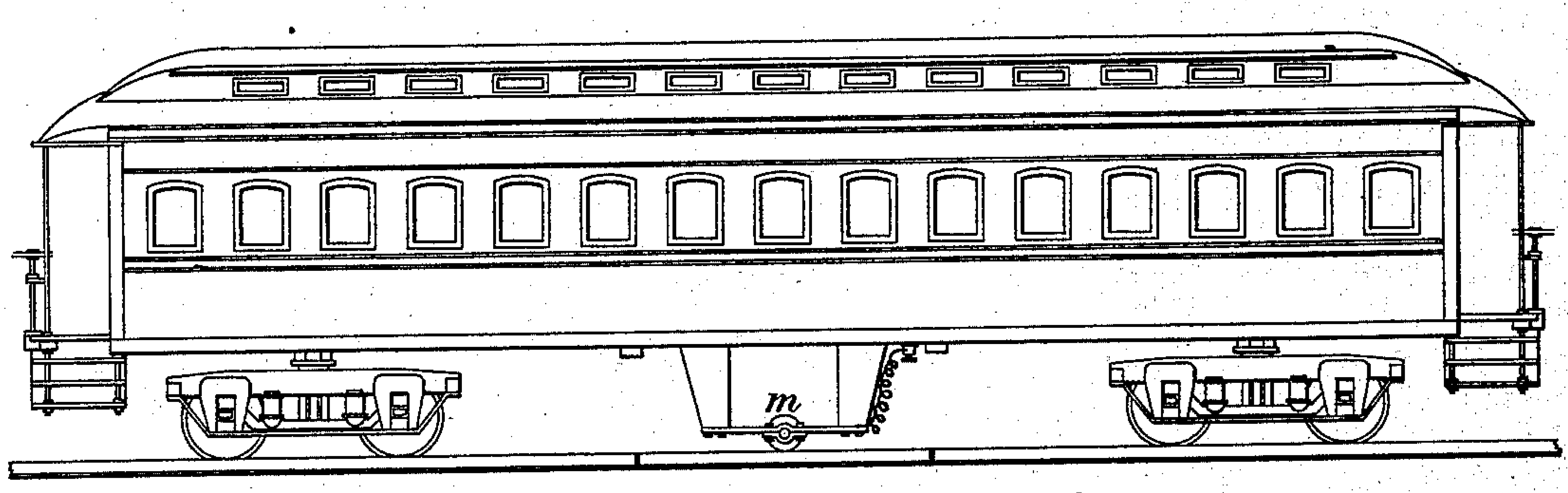
Fig. 8.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC ELECTRIC BLOCK-SIGNAL SYSTEM.

SPECIFICATION forming part of Letters Patent No. 384,810, dated June 19, 1888.

Application filed February 9, 1888. Serial No. 263,539. (No model.)

To all whom it may concern:

Be it known that we, THOMAS D. WILLIAMS, of Allegheny City, and JOHN S. LUCOCK, of Bellevue borough, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Automatic Electric Block-Signal Systems; and we do hereby declare the following to be a full, clear, and exact description thereof, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a sketch illustrating the arrangement of the coils of a differentially-wound polarized relay. Fig. 2 represents the operative parts of the signal. Fig. 3 represents the arrangement of the sectional line-circuits and differentially-wound polarized relays in relation to each other and to a single-track railway, the signals being omitted. Fig. 4 represents the arrangement of line-wires, differentially-wound polarized relays, local circuits, and signals composing our block-signal system of a continued series of sectional line-circuits. Fig. 5 is a plan view of a differentially-wound polarized relay with the local battery and circuit and the operative parts of the signal. Fig. 6 shows an arrangement for changing the connections of the terminals of the battery by means of the reversing-lever of the locomotive. Fig. 7 illustrates the application of our improvement to one of the tracks of a double-track railway. Fig. 8 shows a modified device for securing connection between the terminals of a moving battery and the line-circuit wires.

Like symbols of reference indicate like parts in each.

Our improvement is applicable to railways having one or more main tracks, but is specially useful in its application to a single main track, because it operates automatically from the train, and as the train enters each separate section of the railroad it can operate simultaneously four semaphores or other signals, two on the right-hand side and two on the left-hand side of the track, as will be hereinafter more fully explained.

The operation of our improvement is based chiefly on the employment at each block or signal station of a differentially-wound polarized stationary relay in connection with a battery or source of electrical energy, either moving or stationary, placed either on the train or at the block-stations, so that by putting the positive pole of the battery or dynamo in electrical connection with any electro-magnetically-operated signal the action of the signal will be precisely the reverse of what it is when such connection is with the negative pole of the battery or dynamo. From this it is obvious not only that any such signal can be operated in either direction (to indicate either "safety" or "danger") from the passing train by merely bringing one or other pole of the battery or dynamo in electrical connection with the signal, but that also in case of trains moving on the same track in opposite directions and both having the positive pole of the battery or dynamo on the left-hand side of the train (for example) or on opposite sides of the track the signals will be operated in reverse directions by the two trains. From this it also follows that the amount of connecting-wire used is greatly reduced and the entire apparatus is very much simplified. As we purpose to secure a separate patent for the modified construction and arrangement involved in the use of stationary batteries or dynamos, we shall in this specification confine our description to the use of a battery or other source of electrical energy located on some part of the train and moving therewith.

By the term "differentially wound" as applied to a relay we mean that each leg of the core of the electro-magnet has two separate wires wound in opposite directions, as illustrated in Figs. 1 and 5 of the drawings, in which x and x' are the two legs of the relay, (shown in cross-section in Fig. 1,) and a and b the two wires. One, a, starting at the binding-post A, is wound around x and x' in one and the same direction, while the wire b, starting at binding-post B, is wound around both legs in the opposite direction. The well-known effect of this arrangement is that a positive current passed through the coil a, connected with the battery at A, will have an opposite magnetizing effect on the polarized cores x x' from a positive current passed through the coil b, connected with the battery at B, and also that a current passed from A over the coil a will have the same magnetizing effect as an opposite current passed from B over the coil b.

In our system the railway is divided into any number of sections, not by any actual division or separation of the roadway or track, but by the location at different points along the road of electrically-operated signals, the distance between them being a matter of convenience. In a single-track road, which we shall first describe, one such signal is placed on each side of the track T, the two signals being substantially opposite to each other. For convenience we designate one side T, the east side, and the other side T', the west side of the track. The signal-stations are numbered 1 2 3, &c., the even-numbered stations being on the east side and the odd numbered stations on the west side of the track.

The signal used may be of any description operated by electro-magnetism. That which we have shown in Fig. 2 is one in which a semaphore-arm, C, is pivoted at c and has a counterbalancing-weight, d, which tends to raise the arm to a horizontal position, as shown in Fig. 2. A lever, e, which is also the armature of an electro-magnet, f, is pivoted at g to the frame or case of the signal, and its free end is connected at h to the under side of the semaphore-arm, so that when the core of the electro-magnet f is magnetized it draws down its armature e, causing the semaphore-arm C to be depressed, as shown in dotted lines in Fig. 2, which indicates "safety," while the elevated position which the semaphore arm assumes by gravity when the electro-magnet ceases to act indicates "danger."

As stated, the track of the railway may be continuous, or as much so as is usual. On each side of the track, and preferably outside of the rails, are short bars or rails R R', which are insulated in any convenient manner from any ground-connection.

On the track between the rails T T' in Fig. 3 is represented by the usual sign a battery, MB, which is supposed to be located on a locomotive or on the tender or any of the cars of a train, the arrow adjacent to MB indicating the direction in which the train carrying the battery MB is moving. In Fig. 4 two such batteries are shown, with arrows pointing toward each other, indicating two similarly-equipped trains traveling toward each other on the same track. The electric generator used may be a battery or dynamo, as may be preferred; but by the term "battery" as used in this specification we mean either.

Our system is composed of a number of sectional line-circuits, there being one complete line-circuit for two half-sections which are on opposite sides of the road, and one half-section being immediately in advance of the other. In Fig. 3 two complete sectional line-circuits (without the signals) are shown, the line-wire of one being shown in unbroken and the other in broken lines. Each of these sectional line-circuits is divided into two normally-disconnected halves, one half being on one side of the railroad-track and the other or corresponding half-section on the other side, as shown in Figs. 3 and 4, and each half terminating at the short rails or insulated bars R R'. These two half-sections are electrically connected and the electric circuit established in each sectional line-circuit whenever a locomotive or car properly equipped with a battery reaches the point of the track situate between the two insulated bars R R'. This is accomplished by means of two metallic brushes, F F', or equivalent device, (see Fig. 6,) connected one with each pole of the locomotive-battery and forming contact with the insulated bars R R', respectively, as they pass over them. This condition of things is shown in Fig. 3, in which the locomotive-battery MB, traveling in the direction indicated by the arrow, forms contact at its positive pole with the bar R' on the west side of the track and at its negative pole with the bar R on the east side of the track. This sectional circuit is now complete, beginning at ground G^2 (station 2) and following the wire w to station 4, thence by wire w' to insulated bar R and to negative pole of battery, thence to positive pole of battery, thence to insulated bar R' on west side of track, thence by wire w^2 to station 3, thence by wire w^3 to station 5, and to ground at G^5. This arrangement is repeated on every section on both sides of the track, as shown in Fig. 3.

Connected with each signal C at every station is a local battery, LB, and circuit i i, (see Fig. 4,) with a local electro-magnet, f, (shown in Fig. 2,) by which, when the magnet is energized by closing the local circuit, the semaphore-arm C is drawn down, as before described, to indicate "safety." When, on the other hand, the local circuit is opened by the circuit-breaker, the local electro magnet releases its armature, and the semaphore-arm C is set by gravity to "danger."

Each local circuit is closed and opened at the contact-points p p', the armature of the relay S of the sectional line-circuit operating to open and close the local circuit by the attraction of the armature E of the relay in one direction or the other, which brings it in contact with one or other of the two contact-points p p', and the armature being retained in that position by the polarized cores until a change takes place in the current. There is a polarized relay S at each station, which is differentially wound, which is an important factor in the operation of our improved circuit.

Around the legs of the core of the relay-magnet are wound two coils, s t, one of which, s, for convenience, we shall designate as the "upper" and the other, t, as the "lower" coil. These coils are insulated from each other and wound in any convenient relative position, one coil being wound in one direction and the other coil in the opposite direction around the legs of the magnet, as shown in Fig. 5, this arrangement of coils being the same in each relay. In each sectional line-circuit there are four such differentially-wound polarized relays, (which, for convenience, we shall hereinafter describe as differential relays,) each of which is also electrically connected with another sectional line-circuit. This will be best understood by reference to Fig. 3, in which the ground-wire of the circuit, commencing at G^2, (station 2,) is connected with the lower winding, *t*, of the relay S^2. The wire *w* connects the said lower winding, *t*, with the upper winding, *s*, of the relay S^4, and wire *w'* connects the upper winding, *s*, with the insulated bar R.

The wire w^2 (on the opposite side of the railroad-track) connects the insulated bar R' with the upper winding, *s*, of relay S^3, and the wire w^3 connects the upper winding of relay S^3 with the lower winding, *t*, of relay S^5, and the ground-wire is connected with the lower winding, *t*, of relay S^5. It will be noticed that at each station the connection of the line-wire to the upper or lower coils of the differential relay determines the setting of the signal to "safety" or "danger," and that on one side of the track, if the connection with the upper coil of the differential relay sets the signals to "safety," the connection with the upper coil on the opposite side of the track sets the signal to "danger" when operated by a train moving in the same direction, while in a train moving in the opposite direction the operation of the signals is reversed, and, also, that all the signals connected with the lower winding of the coils are operated, under otherwise similar circumstances, in the opposite direction to those connected with the upper winding when the current is of the same sign, it being understood, also, that all the upper coils are wound in one direction and the lower coils in the opposite direction, as it is the direction of the winding and not the relative position of the coils (as upper or lower) that determines the action of the current on the circuit-closers of the local circuit, and thereby on the signals, the terms "upper" and "lower" winding being used merely for convenience.

In describing the connection of the sectional circuits with the relays, as shown in Fig. 3, we have followed only the circuit indicated by unbroken lines, which, it will be noticed, connects only with one winding of each relay. The other winding in such case is, however, connected with the line-wire of an adjoining sectional circuit, as indicated by dotted lines. For example, in one sectional circuit the line-wires (marked *w w'*, &c.) connect at station 4 with the upper winding, *s*, of the relay S^4, while the lower winding, *t*, of that relay is connected with the wire *w* of an adjoining circuit, and so in each of the relays one winding or coil is connected with one sectional circuit and the other winding or coil with a separate and adjoining circuit. This will be better understood by reference to Fig. 3 and tracing the connections formed by the unbroken and by the dotted lines, respectively.

The operation of our system is shown in Fig. 4, which illustrates the action of the signals as effected by two trains running in opposite directions toward each other on the same track. In this figure the signals are so disposed that those on the right-hand side of each train are those by which each train is to be regulated. In this figure the train indicated by MB, traveling in the direction of the arrow, arrives at stations 3 and 4 between the insulated bars R R'. The brushes on the locomotive (or battery-car) complete the circuit, and the effect is as follows: The negative current from G^2 at station 2 passes over the lower coil of relay S^2, closes the contact *p'* of the local circuit, and the semaphore-arm C^2 is drawn down to indicate "safety," because the section which the signal No. 2 covers is then clear. The current then passes to the upper coil of the relay S^4, when the armature of this relay opens the contact *p'* and breaks the local circuit at station 4, which permits the semaphore-arm C^4 at this station to be raised by gravity to indicate "danger," thus cautioning trains following MB not to enter upon that section. The current then crosses the railroad-track by the battery, and the positive current passes by wire w^2 to the relay S^3, the upper coil of which it traverses, causing the contacts *p'* of the local circuit at that point to close, setting the signal C^3 at station 3 so as to indicate "safety." The current then passes along wire w^3 to the lower winding of the relay S^5, causing the contact *p'* of the local circuit at that point to open and causing the semaphore-signal C^5 on the left-hand side at station 5 to be set to "danger." By this means whenever a train is on any section of the road between two block-signals the signal to its right at its rear is set to "danger" and the signal to its left in front of it is set to "danger," so as to serve as a warning to any trains coming to meet it, and, besides this, as soon as a train has passed a station at which a danger-signal has been set on its left-hand side that signal is immediately reversed and set to indicate "safety;" but suppose that another train (marked in Fig. 4 by MB') is traveling, as indicated by the arrow, to meet the first train, MB. Then the connection of the poles of the battery MB' in relation to the circuits is the reverse of that before described in relation to MB, and the train MB' having reached the signal-station 7, next but one to that on which the train MB had entered, the effect is as follows: The negative current, starting at G^9, (station 9,) traverses the lower winding of the relay S^9, closing the contact of that local circuit and setting the signal at station 9 to "safety." The current then traverses the upper coil of relay S^7 at station 7, opening the contacts of that local circuit and setting the semaphore-arm at station 7 (to the right of train MB') to "danger." The current then crosses the track by the battery, and the positive current traverses the upper winding of the relay S^8 at station 8, closes the local circuit at the point, setting the signal to "safety," and thence to the lower winding of the relay S^6, at station 6, opening the contact of the local circuit and setting the signal C^6 to "danger." This signal at station No. 6, being located to the right of the first train, MB, serves as a warning to it of an approaching train on the section immediately ahead of it.

It is sometimes necessary or convenient to run a train backward, and when this is the case the right-hand side of the locomotive, on which we have supposed the negative pole of the battery to be placed, becomes for the time the left-hand side, and in order to accommodate the apparatus to this change it is only necessary to place a switch or other pole-changing arrangement in connection with the battery, by which the connections of the positive and negative poles of the battery will be reversed by merely moving a switch or key, and when this is done the operation of the apparatus when the train is running backward will be the same as before described.

In Fig. 6 an arrangement is shown by which, when the battery is placed on the locomotive or adjacent tender or car, the change of terminals may be effected by the reversing-lever of the engine. This figure represents one rail, R, of a track and a locomotive and tender. The battery is supposed to be located on the tender, although it may be placed on the locomotive or on any car in the train. On each side of the tender (or car carrying the battery) is a lever, F^2, pivoted at its center to a shaft or stationary bearing. At each extremity of each lever is a metallic brush, F and F', which, when the lever is in a horizontal position, are both raised clear of the track or rail R; but whenever the horizontal arm of the lever is depressed in either direction one of the brushes, F or F', is moved into contact with the rail R, as shown in dotted lines in Fig. 6. One brush, F, of each pair is electrically connected with the positive and the other, F', with the negative pole of the battery. The two levers, one on each side of the tender, are connected together by being attached to a common shaft or otherwise, so that they are moved simultaneously by the operation of the reversing-arm Z of the locomotive through the medium of interposed levers K K, &c., so that whenever the engine of the locomotive is reversed to change the direction of running of the train the polarity of the terminals of the battery is changed.

The brushes F F' on both sides of the track are so connected with the poles of the battery that when the positive brush on one side is in contact with one rail the negative brush on the other side is brought into contact with the other rail, and so that when the brushes are reversed on one side and in relation to one track they are also reversed on the other side and in relation to the other track. By the term "rail" in this connection we mean either the insulated rail which forms a part of the railroad-track or the insulated rail-section placed alongside of the track, as before described. The effect of this arrangement is such that when the locomotive is running forward the connection of the terminals of the battery with the rails is the reverse of that which exists when the locomotive is run backward, and that this change of terminals is effected at the same time and by the same lever as that which effects the reversal of the engine. Instead of connecting this pole-changing apparatus with the reversing-arm of the locomotive, the arm Z may be a separate lever, extending to or into any carriage of the train. Such arrangement may be readily modified to suit the requirements of the particular block-signal system to which it is applied.

We will now proceed to explain the arrangement of our system when applied to a railroad having more than one track and on which trains run only in one direction. On such a track the only function required of the block-signal system is that as a train passes any block-station the signal at that station shall be set to "danger," and the signal immediately in the rear, which before had been set to "danger," should now be set to "safety." The arrangement of the circuits and signals for this purpose is shown in Fig. 7, in which the same letters are used as in the figure representing the system applied to a single track. The arrangement of the circuits in the figure will be readily understood from that which has gone before. S^{10} and S^{11} are differentially-wound polarized relays, each of which is placed at the end of one section and at the beginning of another. Thus the line-wire of section 10 connects at its forward end with one coil, (say the upper winding) of the relay S^{10}, while the rear end of the line-wire in section 11 connects with the lower winding of the same relay, S^{10}, and at its forward end connects with the upper winding of relay S^{11}, and the line-wire of section 12 connects with the lower winding of relay S^{11}. Connected with the relay at each station is a local battery, LB, and circuit *i i*, &c., the contact-points of which are opened and closed by the armature E of the relay, as before described. The semaphore-signal may also be constructed and operated as before mentioned in reference to the single-track system. The short insulated bar R needs only to be placed on one side of the track when the track is used only for trains running in one direction.

The battery or dynamo placed on the locomotive or some part of the train is represented in Fig. 7 by the usual symbol for a battery and marked MB. The negative pole of the battery is brought in contact with the insulated bar R, and the positive pole is connected with the axle or some other point of the locomotive or car and through the rails of the track to the ground.

This being the arrangement and construction, the operation is as follows: On the locomotive-battery reaching, for example, station 11, as shown in Fig. 7, the negative current follows the wire *w* and connects with the upper coil, *s*, of the polarized relay S^{11}, which attracts its armature to the right, opens the contacts *p p′*, and, breaking the local circuit, demagnetizes the semaphore-magnet, and, releasing its armature, allows the signal C^{11} to rise by gravity to a position indicating "danger," thus protecting the rear of the section 12, in which the train has just entered, and at the same time the current from the negative pole of the battery, following the line-wire *w′*, connects with the lower winding of the polarized relay S^{10}, and passes thence to ground at G^{10}. The passage of the current through the lower coils attracts the relay-armature to the left, closes the contacts *p p′* of the local circuit at station 10, and draws down the armature of the semaphore-magnet, setting the signal C^{10} for "safety." In the double-track system, as well as in the single-track system before described, the relays, being polarized, retain the armature in the position to which it is drawn by the passage of the main-line current over the upper or lower coil of the relay, as the case may be, until the attraction is changed by the reversal of the character of attraction of the current, as before described.

In place of using insulated rails R R′, as shown in Figs. 3 and 4, it may be preferred to insulate a short portion of the track in a manner well known and heretofore practiced, the insulated portion of the track being short enough to be contained within the space between the forward and rear trucks of a car. In this case, instead of a brush, a small wheel, *m*, in circuit with a battery, (see Fig. 8,) may be located midway between the trucks and low enough to come in contact with the insulated rail, the operation being otherwise precisely the same as before described in connection with the insulated bars placed parallel to and either inside or outside of the railroad-track.

In our improved apparatus, where a battery is used, a dynamo or other source of electric energy may be substituted therefor as an equivalent, and we desire to cover such substitution in the claims. Other substitutions of equivalents may be made. For example, suitable links or levers may be substituted for gearing, and vice versa.

Having thus described our improvement, what we claim as our invention, and desire to secure by Letters Patent, is—

1. In a block-signal system for railways, the combination, with a source of electrical energy, of two or more differentially-wound polarized relays, each connected with the line-wires of two adjoining circuits or sections and each arranged in connection with a local battery and circuit to open and close the same for the purpose of operating an electric signal at each end of such circuit or section in the same or opposite directions, according to the windings or coils with which such line-wires are connected, substantially as described.

2. The combination, in a block-signal system for railways, of a battery of line-wires and four or more differentially-wound relays placed on opposite sides of a railway-track, each such relay being connected with and operating an electrically-operated signal, said relays and wires being arranged to run from ground at one station through the lower coil of the first such relay, thence to the next station and through the upper coil of the second such relay, and thence to an insulated portion of the railroad-track and on the opposite side of said track from an insulated portion thereof to a third differentially-wound polarized relay at the station opposite to that last named and through the upper coil thereof, and thence to a fourth such relay at the next station and through the lower coil thereof to ground, the circuit between the two sides of the track, which is normally broken, being made or completed by the arrival of a train at the point between the second and third stations, substantially as described.

3. The arrangement of two or more line-circuits consisting of line-wires and differentially-wound polarized relays connected together in series by connecting one coil of each such polarized relay at each station with the line-wire of one circuit and the other coil of the same relay with the line-wire of the next adjoining circuit, substantially as and for the purposes described.

4. In a block-signal system for railways, the combination, with a source of electrical energy, of insulated rails forming part of or placed near to the railroad-track, four differentially-wound polarized relays, two at adjoining stations on one side of the track and two at adjoining stations at the other side, connected together, excepting between the rails of the track, by a line wire or wires connected with one or other of the coils of such relays, according to the relative direction in which the signal at each station is to be operated, a local battery and circuit at each station, the circuit of which is made or broken by the armature of the polarized relay, and an electrically-operated signal at each station, the same being arranged and operated substantially as described.

5. The combination, with the line-wires of the circuits of a railroad-block-signal system, and with a battery or batteries, of differentially-wound polarized relays arranged in connection with the electrically-operated block-signals and the local battery and circuit thereof, substantially as described, and so that each signal may be automatically operated in different directions, according as the line-wire is connected with one or other of the coils of the relay and according to the name of the current (whether positive or negative) that is passed over the circuit, substantially as described.

6. The combination of a differentially-wound polarized relay having an armature pivoted at one end and extending between the poles

of the relay, and having the other end located between contact-points to make and break the local battery-circuit, a local electro-magnet, and block-signal operated mediately or immediately by the armature thereof, substantially as and for the purposes described.

7. The combination, with a battery located on the locomotive, tender, or other car of a train, of two pairs of metallic brushes or contacts mechanically connected with such car, so as to be movable to and from contact with the rails of the track, one brush of each pair being electrically connected with the positive and the other with the negative pole of the battery, and furnished with intermediate gearing for bringing one brush of each pair, having opposite signs, into contact with the opposite rails of the railroad-track, respectively, and for reversing them at pleasure by moving the lever in one direction or the other, and thus changing the direction of the electric current, substantially as described.

8. The combination, with a battery located on the locomotive, tender, or car, of metallic brushes or contacts connected, respectively, with the positive and negative poles of the battery, the lever for reversing the engine of the locomotive, and levers interposed between and connected with said brushes and reversing-lever and capable of operating the brushes to bring alternately the positive and negative pole brushes in contact with the rails of the track, substantially as described, so that the engineer, when reversing his engine, shall also reverse the direction of the electric current to operate the electric block-signals in the manner hereinbefore set forth.

In testimony whereof we have hereunto set our hands this 1st day of February, A. D. 1888.

THOMAS D. WILLIAMS.
JOHN S. LUCOCK.

Witnesses:
THOMAS W. BAKEWELL,
JNO. K. SMITH.