(No Model.) 3 Sheets—Sheet 1.

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

APPARATUS FOR OPERATING AUTOMATIC BLOCK SIGNALS.

No. 384,811. Patented June 19, 1888.

Fig. 1.

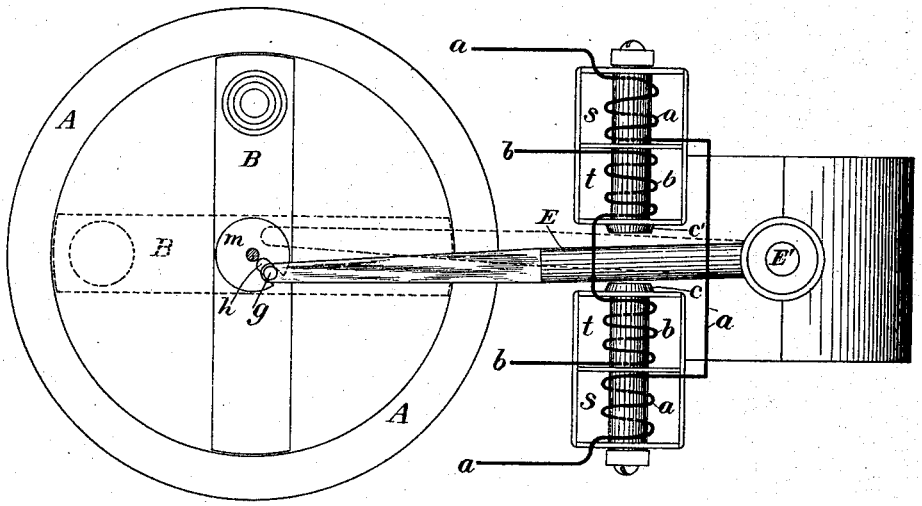
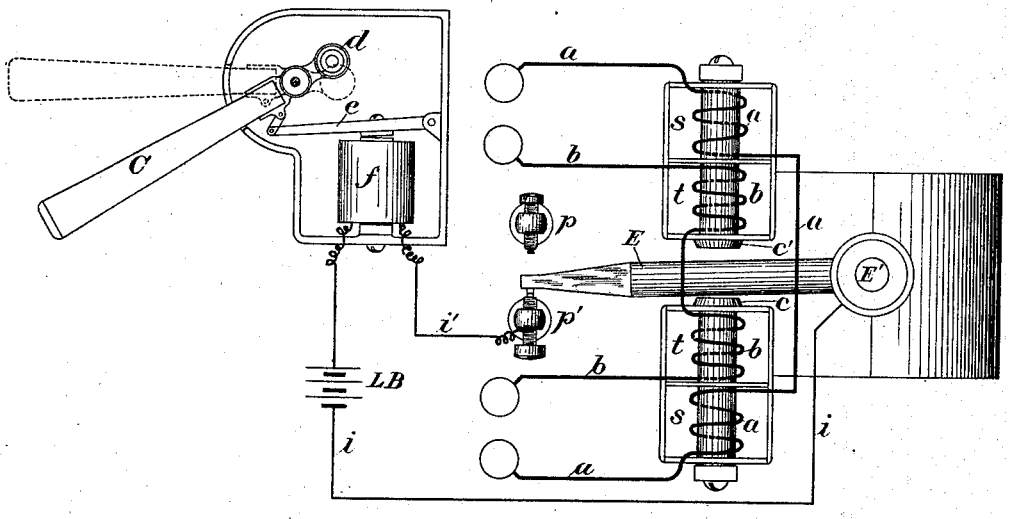


Fig. 2.



WITNESSES.

H. L. Gill.

W. B. Corwin

INVENTOR.

Thomas D. Williams.

John S. Lucock.

by M. Baldwin & Sons their attorneys.

(No Model.) 3 Sheets—Sheet 2.

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

APPARATUS FOR OPERATING AUTOMATIC BLOCK SIGNALS.

No. 384,811. Patented June 19, 1888.

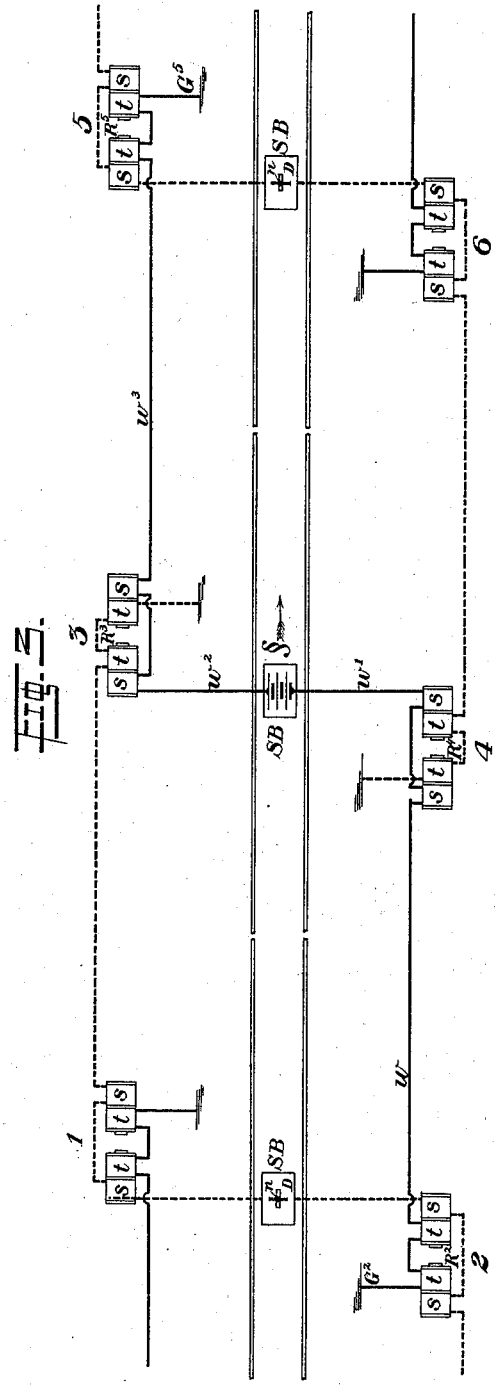


Fig. 3.

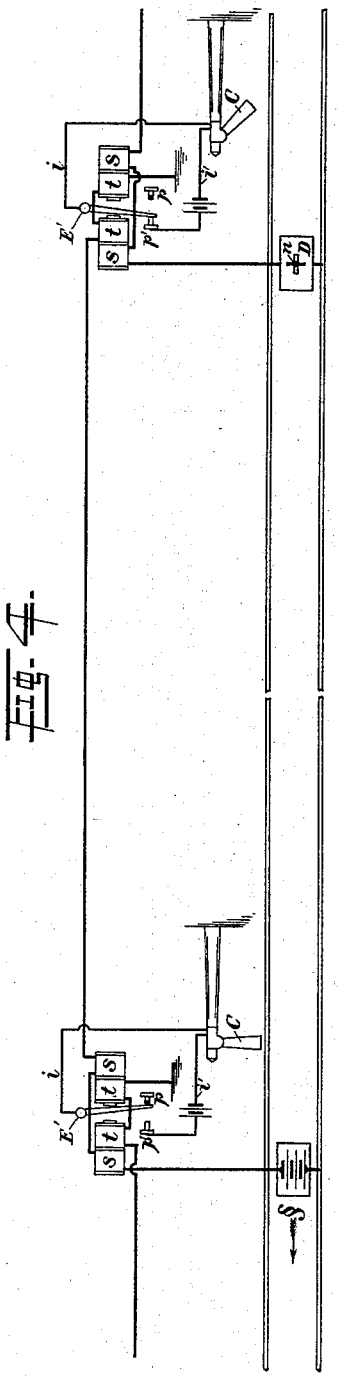


Fig. 4.

WITNESSES.

H. L. Gill.

W. B. Corwin

INVENTOR.

Thomas D. Williams.
John S. Lucock.
by W. Baxwell & Sons.
their Attorneys.

(No Model.) 3 Sheets—Sheet 3.

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

APPARATUS FOR OPERATING AUTOMATIC BLOCK SIGNALS.

No. 384,811. Patented June 19, 1888.

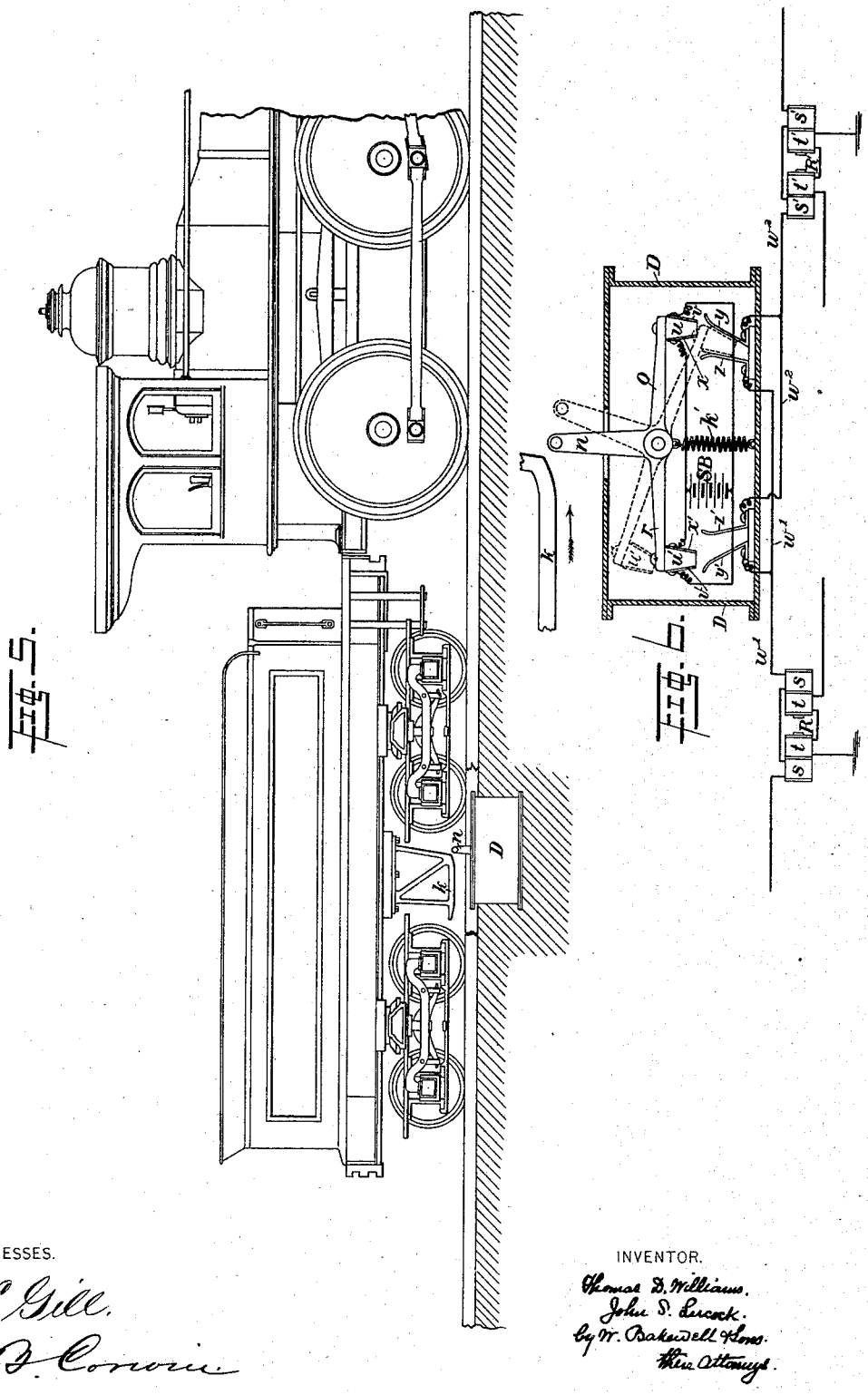


FIG. 5.

FIG. 6.

WITNESSES.

R. L. Gill.

W. B. Connor.

INVENTOR.

Thomas D. Williams.
John S. Lucock.
by W. Bakewell & Sons.
their Attorneys.

UNITED STATES PATENT OFFICE.

THOMAS D. WILLIAMS, OF ALLEGHENY CITY, AND JOHN S. LUCOCK, OF BELLEVUE, ASSIGNORS OF THREE-FIFTHS TO JAMES W. CLARK, GEORGE M. EITEMILLER, AND GEORGE MORRIS, ALL OF ALLEGHENY COUNTY, PENNSYLVANIA.

APPARATUS FOR OPERATING AUTOMATIC BLOCK-SIGNALS.

SPECIFICATION forming part of Letters Patent No. 384,811, dated June 19, 1888.

Application filed April 30, 1888. Serial No. 272,284. (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, both in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Apparatus for Operating Automatic Block-Signals; and we do hereby declare the following to be a full, clear, and exact description thereof, reference being had to the accompanying drawings, in which—

Figure 1 is a plan view of a differentially-wound polarized relay, showing its connection and that of a sectional line-circuit with a semaphore-signal. Fig. 2 illustrates the devices shown in Fig. 1 when the signals are operated by a local battery. Fig. 3 represents the arrangement of sectional circuits and differentially-wound polarized relays in relation to each other and to a single-track railway, the signals being omitted for clearness of illustration. Fig. 4 shows the arrangement of an automatic signal system as applied to one track of a double-track railway, and when the signal is operated by a local battery. Figs. 5 and 6 represent our device for throwing the signal-operating device in and out of circuit with the battery and for reversing the current, illustrating its operation by a passing train, Fig. 6 being an enlarged sectional view of the current-reversing device.

In the several figures like letters refer to the same devices.

Our invention has relation to automatic electric block-signals for railways, in which semaphore or other signals arranged at various points along the railway-track are operated by the passing trains, so as to warn other trains running on the same track in either direction from entering on the block or section of the road on which the operating-train has entered.

The present invention is a modification of that described in another specification prepared and filed by us, in which we have described an improved system of automatic block railway-signals, the important feature of that invention being the use in connection with a source of electrical energy and an electrically-operated signal of a differentially-wound polarized relay. This improvement as described in said specification is equally applicable to the use of a battery, dynamo, or other electrical generator, whether located on some part of the moving train, or, when a stationary generator is used, located at each signal-station, and whether the signal is operated directly by the armature of the differentially-wound polarized relay placed in the line-circuit or by a local-battery circuit opened and closed by the armature of the polarized relay.

In the specification above referred to, we have described our improvements as applied by means of a local circuit at each station, and with the use of an electrical generator located on each train of cars, and our present invention has reference to and is designed to cover the modifications above referred to.

Our present invention therefore consists in the use of differentially-wound polarized relays in connection with a source of electrical energy and electrically-operating signal device, first, when the battery or other source of electrical energy is stationary and not connected with the train of cars, whether the signal is operated either directly by the armature of the differentially-wound polarized relay—that is to say, without the intervention of a local-battery circuit—or by means of such local battery; and, second, when a local-battery circuit is used to operate the signal at each station, such circuit being opened and closed by the armature of a differentially-wound polarized relay, whether the main battery or source of electrical energy for each station is stationary or whether it is transitory, being located on some part of a train of cars.

In order that our invention may be understood by those skilled in the art, we will briefly describe so much of the construction and operation of our improved system as is necessary for that purpose.

The distinguishing characteristic of our automatic block-signal system is the use of differentially-wound polarized relays in connection with a battery, (and we use the term "battery" in this specification to mean a gal-

vanic battery, a dynamo, or any other suitable generator of electric current,) and with a semaphore or other electrically-operated signal, and with suitable line-circuit wires, by means of which the operation of the signal so as to indicate either "safety" or "danger" may be effected and the signal changed by changing the polarity of the current sent from the battery. From this it also results that when the batteries are carried on the trains, and when two trains on the same track are running in opposite directions, (as when meeting each other,) the signals operated by one train will be operated in the reverse direction from those operated by the other train, simply because the relative position of the poles of the battery to the signals is changed by the reversal of position of the locomotive or car carrying the battery. If, however, the batteries are stationary, the reversal of position of the locomotive or battery-car will not accomplish this object, and it becomes necessary to provide some device which shall make the requisite reversal of polarity when trains run in opposite directions on the same track, and this is one of the purposes of the present invention.

Fig. 1 represents a differentially-wound polarized relay, such as we use in our system, which, for sake of brevity, we shall hereinafter designate as a "differential" relay. It consists of an electro-magnet, the two legs *c c'* of which (forming the core of the electro-magnet) are wound with two wires, *a b*, in opposite directions. The wire *a* is wound around the legs *c* and *c'* in one and the same direction, while the other wire, *b*, is wound around the legs *c* and *c'* in the reverse direction. These windings or coils we designate, for convenience, the "upper" (*s*) and the "lower" (*t*) coils. These coils are insulated from each other and wound in any convenient relative position, but always in opposite directions. The armature E of the differential relay is pivoted at E' and extends between the pole-pieces of the relay *c c'*, and at its free end is a pin, *g*, which enters a slot, *h*, in a circular disk, *m*, affixed to the center of motion of the revolving arm B of an electric signal. The arm B is set in a box or frame, A, and turns freely on its center of motion, which is also its center of gravity, in order that in moving the signal-arm the armature E may have only to overcome the friction of the pivot, the arm being balanced on its center. When the armature E is attracted toward the pole-piece *c* of the polarized relay, the signal-arm B will occupy a vertical position, and in moving from pole-piece *c* to pole-piece *c'* the armature will cause the signal-arm to perform a quarter-revolution and assume the position shown by dotted lines in Fig. 1. By this arrangement the arm of the signal is operated directly by means of the polarized relay.

In another application, before referred to, we make use of a local battery and circuit at each station to operate the signal, as shown in Fig. 2, in which the differentially-wound relay and the semaphore-signal are the same as described in Fig. 1. At the free end of the armature E (pivoted at E', as before described) are two adjustable contact-screws, *p p'*, one of which is placed on each side near the free end of the armature E. One of these contacts, *p'*, is connected by wire *i'* with one pole of the local battery LB, and the armature E of the relay is connected by wire *i* with the other pole of LB. In this local circuit is placed a local electro magnet, *f*, the armature *e* of which, when attracted by the magnet, depresses the semaphore-arm C; but when the local magnet is demagnetized and the armature *e* is released the counter-weight *d* raises the arm C to a horizontal position. When the differential relay attracts its armature E toward the contact *p'*, the local circuit *i i'* is made and the semaphore is depressed; but when the differential relay draws the armature E in the opposite direction toward the contact *p* the local circuit is broken and the arm C is free to act by gravity. The result, therefore, on the action of the semaphore is the same whether the arm C is operated mediately or immediately by the differential relay and whether a local battery and circuit are used or not. The core of the differential relay being a permanent magnet, the position of the armature E, whether in contact with *p* or *p'*, remains unchanged when the differential relay is demagnetized and until a current is sent through its coils of opposite polarity or reverse direction from that by which it was last actuated.

The advantage which we obtain from the use of a differentially-wound polarized relay is due to the fact that a current of either sign (+ or —) passed over the wire *a* and upper coil, *s*, of the differential relay will have an opposite magnetizing effect on the polarized cores from a current of the same sign passed over wire *b* and lower coil, *t*, and also that a current of a given sign passed through the upper coil, *s*, will have the same magnetizing effect as a current of opposite sign passed over in the same direction through the lower coil, *t*. Now, as the setting of each semaphore either to signal "safety" or "danger" depends solely on the direction in which the armature E is attracted, and as the direction in which the armature E is operated depends on the sign of the current used, or the direction in which it passes over the coil of the differential relay, it results that semaphore-signals may be set in either position, as may be desired, simply by passing a positive or negative current over the upper or lower coil of the differential relay from the battery on a passing train or from a stationary battery thrown into circuit by a passing train, and so as to give either a positive or negative current, according to the direction in which such train is traveling.

Our automatic electric block-signal system is composed of a number of sectional line-circuits arranged in series, and in case of a single-track arrangement each section is composed

of two half-sections, one being on each side of the track, the half-section on one side being immediately in advance of the half-section on the other side.

Fig. 3 illustrates the position and arrangement of the differential relays and line-wires for one complete section, in which the line-wire of the sectional circuit is an unbroken line, $w\ w'\ w^2\ w^3$, while the dotted lines represent the line-wires of two other half-sections.

Numerals 1, 3, and 5 indicate signal-stations on one side of the track, and 2, 4, and 6 signal-stations on the other side. At each signal-station is located an electric signal and a differential relay, *s t*, which may be used either with a local battery, LB, and a local circuit, *i i'*, as shown in enlarged detail in Fig. 2, or without the local battery and circuit, as shown in Fig. 1. In Fig. 3 the signals and local batteries and circuits are omitted in order to prevent confusion, as they are clearly illustrated in Figs. 1 and 2. There is also located between two opposite signal-stations a battery, SB, with a device for making the electrical connection between the stations and reversing the current by the action of the passing train, which device will be more particularly described further on.

The arrangement used at one station, as described, is repeated at every signal-station along the railroad, the local battery and circuit being employed at any station, if desired. It will be noticed by reference to Fig. 3 that the differential relay at each station forms in every instance the connection in series between two adjacent stations, that each complete sectional circuit has (in a single track arrangement) four differential relays, one at each station—as, for example, at signal station 2, another at the next signal-station, 4, on same side of the track, another at signal-station 3 on the opposite side of the track, and another at station 5, also on the opposite side of the track—and that the line-wire at station 2 is connected with the lower coil, *t*, of the relay, runs to the upper coil, *s*, of the next relay at station 4, thence to the upper winding of the next relay at station 3, and thence to the lower winding of the next relay at station 5, and also that in each differential relay the upper winding is connected with the line-wire of one section and the lower winding with the line-wire of the adjoining section. The direction of the electric current in a single sectional circuit is illustrated by Fig. 3. The ground-wire of the circuit, commencing at G^2, (station 2,) runs to the lower winding, *t*, of the differential relay R^2. Thence the line-wire *w* passes to the next station, 4, on same side of the road, connecting with the upper winding, *s*, of the differential relay R^4. Thence the line-wire *w'* connects with the battery SB and current-reversing device connected therewith, crossing the railroad-track either before or after connection with the battery SB. The line-wire w^2 thence passes to the differential relay R^3 at station 3, connecting with the upper coil, and thence by wire w^3 to the lower winding of the differential relay R^5 at station 5, and thence to ground at G^5. The arrangement of the line-wires of the adjoining sections is the same. (See Fig. 3.)

The operation is as follows, it being observed that the signals located on the right-hand side of a moving train are those by which it is to be guided, the signals on its left-hand side being those which guide a train moving in the reverse direction: Supposing a train to arrive at the point § on the track between stations 3 and 4, the train moving in the direction of the arrow in Fig. 3, by the operation of devices hereinafter described, connected with battery SB, the circuit is closed, connecting stations 3 and 4 on the line-wire $w'\ w^2$, through the battery SB, and the effect is as follows: The negative current from G^2 at station 2 traverses the lower coil, *t*, of differential relay R^2, closing the contacts *p'* of the local circuit, and the semaphore-arm C at that station is depressed to indicate "safety," because the section covered by signal at 2 is then clear. The current then passes to the upper coil, *s*, of the differential relay R^4, (at station 4,) when the armature of this relay opens the contact *p'* and breaks the local circuit at that station, which permits the semaphore-arm C at that station to be raised by gravity to indicate "danger," thus cautioning trains following the train at § not to enter on that section of the track. The current then crosses the railroad-track through the stationary sectional battery SB, and the positive current passes by wire w^2 to the differential relay R^3, (at station 3,) traversing its upper coil, *s*, and causing the armature E (either with or without the aid of the local battery) to set the signal C at station 3 to "safety." The current then traverses the wire w^3 to the lower winding, *t*, of the differential relay R^5 at station 5, operating the armature of the differential relay, and thus setting the signal C at station 5 to "danger." Thus whenever a train is on any section of the railroad the signal on its right at its rear is set to "danger" to warn any train following it not to enter on that block-section, while the signal on its left and in front of it is also set to "danger," so as to warn any train meeting it not to enter on that section; and, further, that as soon as a train has passed a station at which a "danger" signal had been set on its left-hand side, such signal is immediately reversed and set to indicate that the section is clear. In like manner a train running in the opposite direction to meet the first-mentioned train causes the signals to be set in the reverse direction, so that each train is warned by the signals on its right hand of the approach of the other train, and is prevented from entering upon the same section.

It will be apparent from the description already given 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 signal 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, because, the stationary section-battery SB being located between the signals on opposite sides of the road, one is actuated by a positive current and the other by a negative current; also, that all the signals connected with the lower winding of the differential relays 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. In speaking of the upper and lower windings or coils of the differential relays we must be understood to mean only to distinguish the two coils which are wound in opposite directions on the same core, the relative positions of the coils, which might seem to be indicated by the words "upper" and "lower," having no effect on the operation.

It is also true and essential to the successful operation of our system that the connection of the line-wire of each sectional circuit with the upper or lower coil of the differential relays should cause the signals to be operated so as to indicate in one case "danger" and in the other case "safety" when a train is moving in one direction, but that when the direction of the same train is reversed, or when another train runs in the opposite direction on the same track, the action of the signals should also be reversed, so that a signal operated by a current traversing a coil wound in one direction, which sets a signal to "danger," should set the same signal to "safety" when the electric current is set in motion by a train running in the reverse direction. This we accomplish by means of the device shown in Figs. 5 and 6, which is placed between every two opposite stations in a single-track road and at every station in a double-track road.

The apparatus we are about to describe may be placed in a box, D, as shown in Fig. 5, and must be located near to one side of the track or between the rails, as may be most convenient, excepting the battery, which may be placed in any convenient position.

Referring to Fig. 6, SB is the section-battery or other source of electrical energy. R is a differential relay situate at a station on one side of the track, with its upper and lower coils, *s t*, and R′ is the differential relay at the opposite station on the other side of the track, with its upper and lower coils, *s′ t′*. A lever composed of three arms, *n o r*, is pivoted to a post or in any convenient manner so near to the railroad-track that the vertical arm *n* may be slightly above the level of the rails and within reach of a rod, *k*, attached to the bottom of one car of the train or to the locomotive or tender, so that as a train of cars passes the station the rod *k*, engaging the lever-arm *n*, will move it to one side or the other, according to the direction in which the train is moving. The vertical lever-arm *n* is rigidly attached to the horizontal arms *r o*, so that the movement of the arm *n* depresses one of the arms *r o* and elevates the other, as shown by dotted lines in Fig. 6. A coiled spring, *k′*, or other device attached to the lever directly under the vertical arm *n* serves to keep it normally in a vertical and the arms *r o* in a horizontal position. At the outer extremity of the horizontal arm *o* is a small block, *u*, of ebonite or other insulating material, projecting downward, so that when that end of the lever is depressed, as before described, the block *u*, which is covered on each side with metallic plates *v* and *x*, will enter between two metallic leaf-springs, *y z*, as shown by dotted lines in Fig. 6. A similar ebonite block, *u′*, with metallic plates *v′* and *x′*, is attached to the outer extremity of the lever-arm *r*, and similar short metallic leaf-springs, *y′ z′*, are similarly placed to receive the block *u′* when the arm *r* is depressed. When the lever-arms *r o* are in their normal horizontal position, neither of the blocks *u u′* is in contact with the leaf-springs *y z y′ z′*, and the battery SB is not in circuit. The poles of the sectional battery SB are permanently connected with the plates *v x* and *v′ x′*—one pole to the plates *v* and *v′* and the other to the plates *x* and *x′*. The leaf-springs *y z* and *y′ z′* are insulated from ground and from each other and are connected with the line-wires—the springs *y′* and *z* with the line-wire *w′*, and the springs *z′* and *y* with the line-wire *w²*. (See Fig. 6.) When so arranged, if the train moves in the direction indicated by the arrow in Fig. 6, it pushes the lever-arm *n* over to the right, causing the ebonite block *u* to enter between the leaf-springs *y* and *z*. This at once connects the battery SB with the sectional line-wires. The positive current from the battery would then flow through the plate *x* and spring *z* to the station differential relay R on one side of the track, while the negative current would flow through the plate *v* and spring *y* to the differential relay R′ on the other side of the track. This would instantly operate all the signals in the sectional circuit, as before described. The arm *n* would resume its vertical position and the arms *r o* their horizontal position as soon as the car which engaged the lever-arm *n* had passed; but the relays being polarized their armatures will retain their positions and hold the signals in place until they are similarly actuated in the opposite direction, either by a reverse movement of the lever or by a change of current.

Fig. 4 illustrates the operation of our system connected with one track of a double-track railway and with a local battery and circuit, such as shown in Fig. 2, the operation being similar in kind, but there being only half the number of signals and differential relays in each sectional circuit.

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, the combination

of a source of electrical energy and a differentially-wound polarized relay in circuit therewith, and a railroad-signal connected with the armature of the relay and operated thereby, substantially as described.

2. The combination of a stationary source of electrical energy, two or more differentially-wound polarized relays, each connected with the line-wires of two adjacent line-circuits or block-sections, and a signal operated mediately or immediately by the armature of a differentially-wound polarized relay, substantially as described.

3. The combination of a stationary source of electrical energy normally disconnected from the line-circuit, mechanism, substantially as described, for connecting and disconnecting the generator to or from the circuit and for reversing the polarity, arranged to be operated by a passing train, and two or more differentially-wound polarized relays in the battery-circuit, and two or more railroad-signals, each arranged in relation to the armature of a differentially-wound polarized relay, so as to be operated thereby, substantially as described.

4. In an automatic electric block-signal system, the combination of a stationary battery or source of electrical energy with a lever placed on or near the line of the railway-track, such lever having an arm extending so as to come in contact and be turned backward or forward by a passing train, and two horizontal vibrating arms, each furnished with two insulated plates, connected, respectively, with opposite poles of the battery, two pairs of contacts electrically connected with the line-wires of the battery-circuit, and so arranged relatively to each other and to the insulated plates of the lever-arm that when one arm is depressed a current of one sign and when the other arm is depressed a current of the opposite sign is sent over the line-wires to differentially-wound polarized relays to operate the block-signals, substantially in the manner hereinbefore described.

In testimony whereof we have hereunto set our hands this 13th day of April, A. D. 1888.

THOMAS D. WILLIAMS.
JOHN S. LUCOCK.

Witnesses:
W. B. CORWIN,
H. L. GILL.