No. 780,885. PATENTED JAN. 24, 1905.

S. W. HUFF.

RAILWAY ELECTRIC SIGNAL.

APPLICATION FILED JAN. 17, 1898.

6 SHEETS—SHEET 1.

Fig. 8.

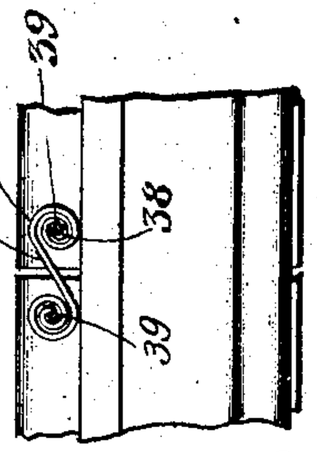


Fig. 7.

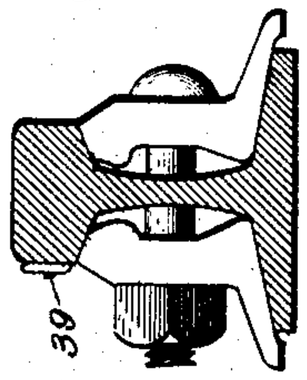


Fig. 6.

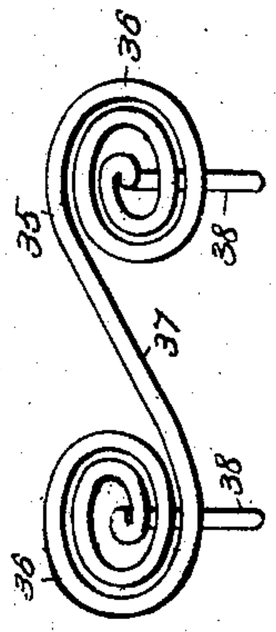
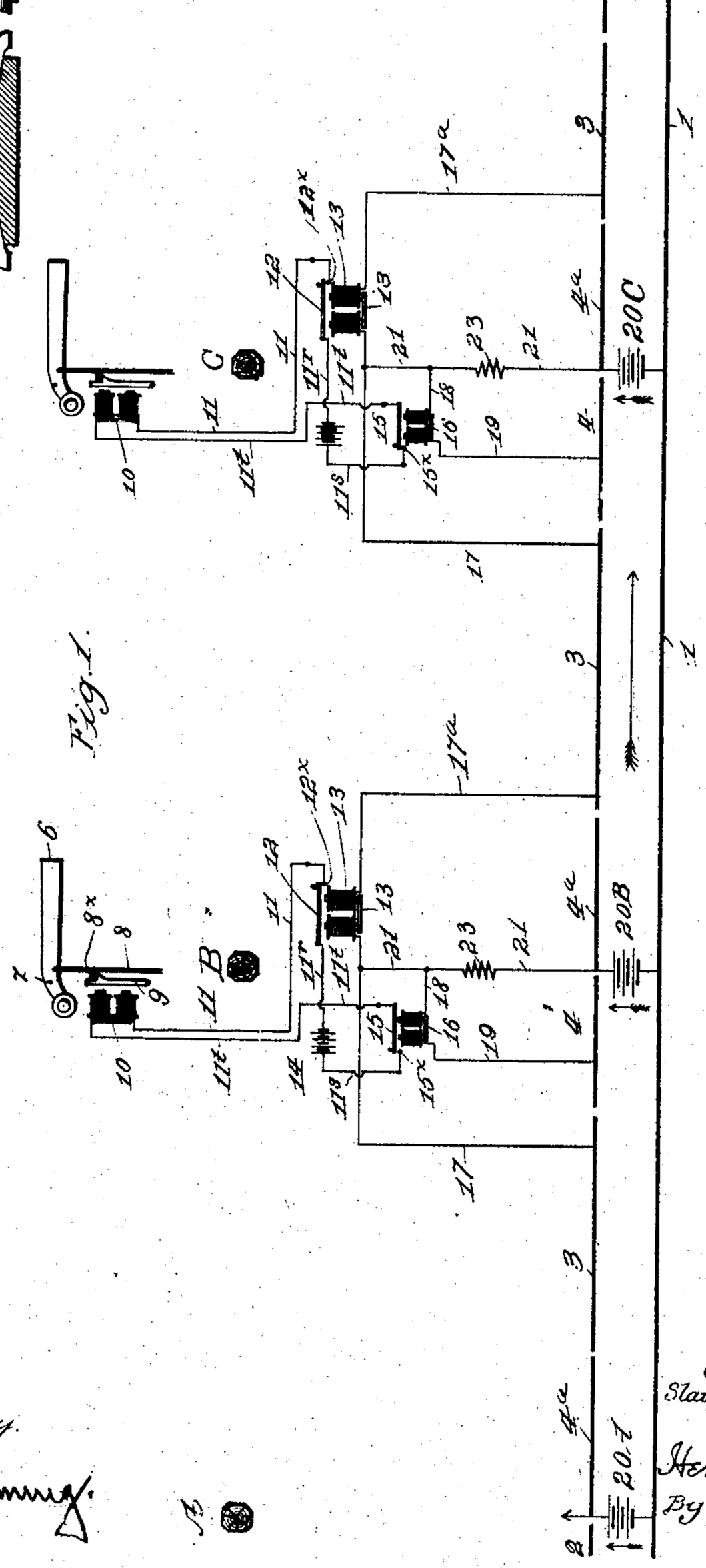


Fig. 1.



Witnesses
Herbert Bradley.
Katherine E. Manning.

Inventor
Slaughter W. Huff.
By Harvey C. Knight
Attorney

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S. W. HUFF.

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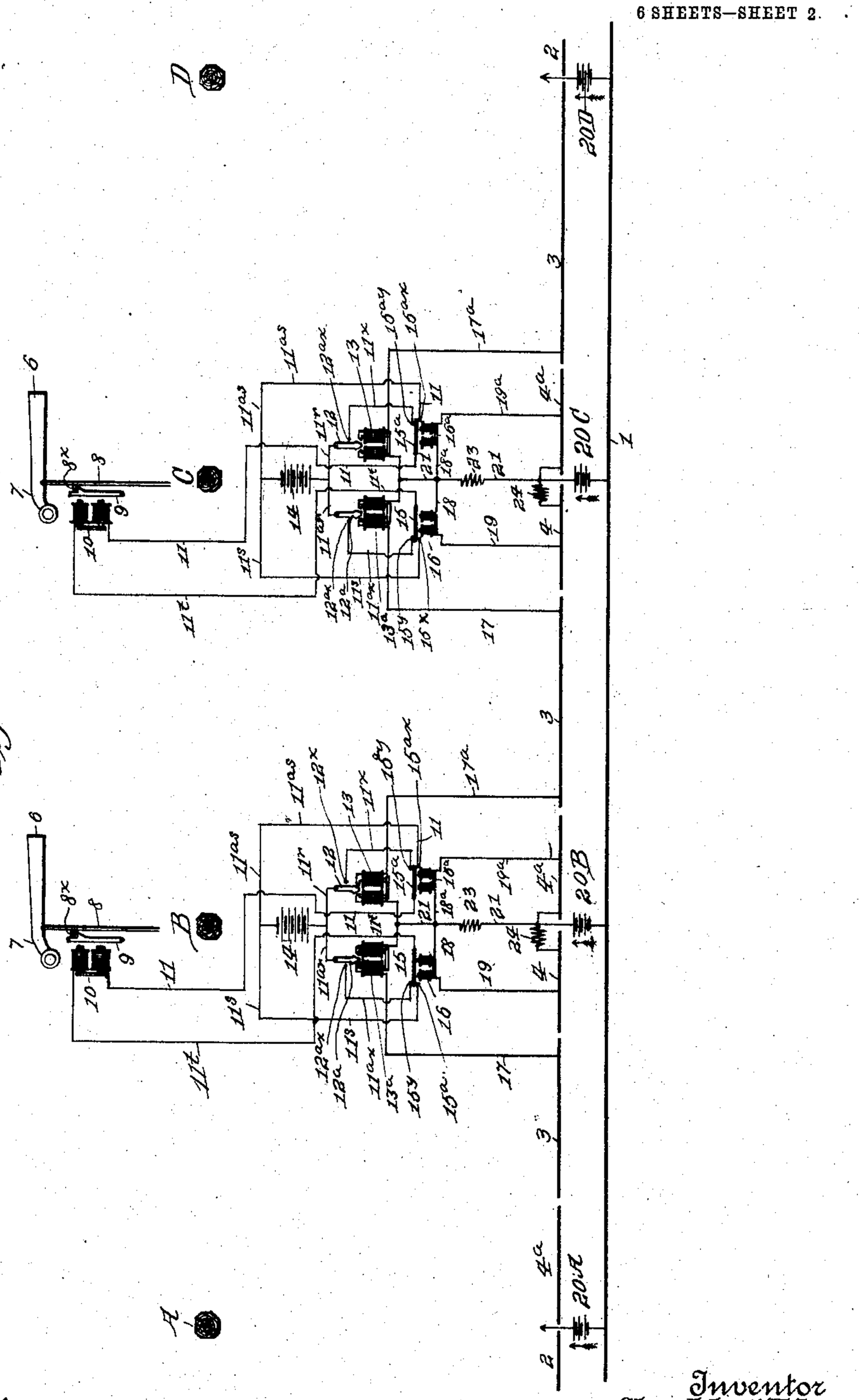
6 SHEETS—SHEET 2.

Fig. 2.



Witnesses
Herbert Bradley.
Katherine E. Cummings.

Inventor
Slaughter W. Huff.
By Harvey C. Knight
Attorney

No. 780,885. PATENTED JAN. 24, 1905.

S. W. HUFF.

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6 SHEETS—SHEET 3.

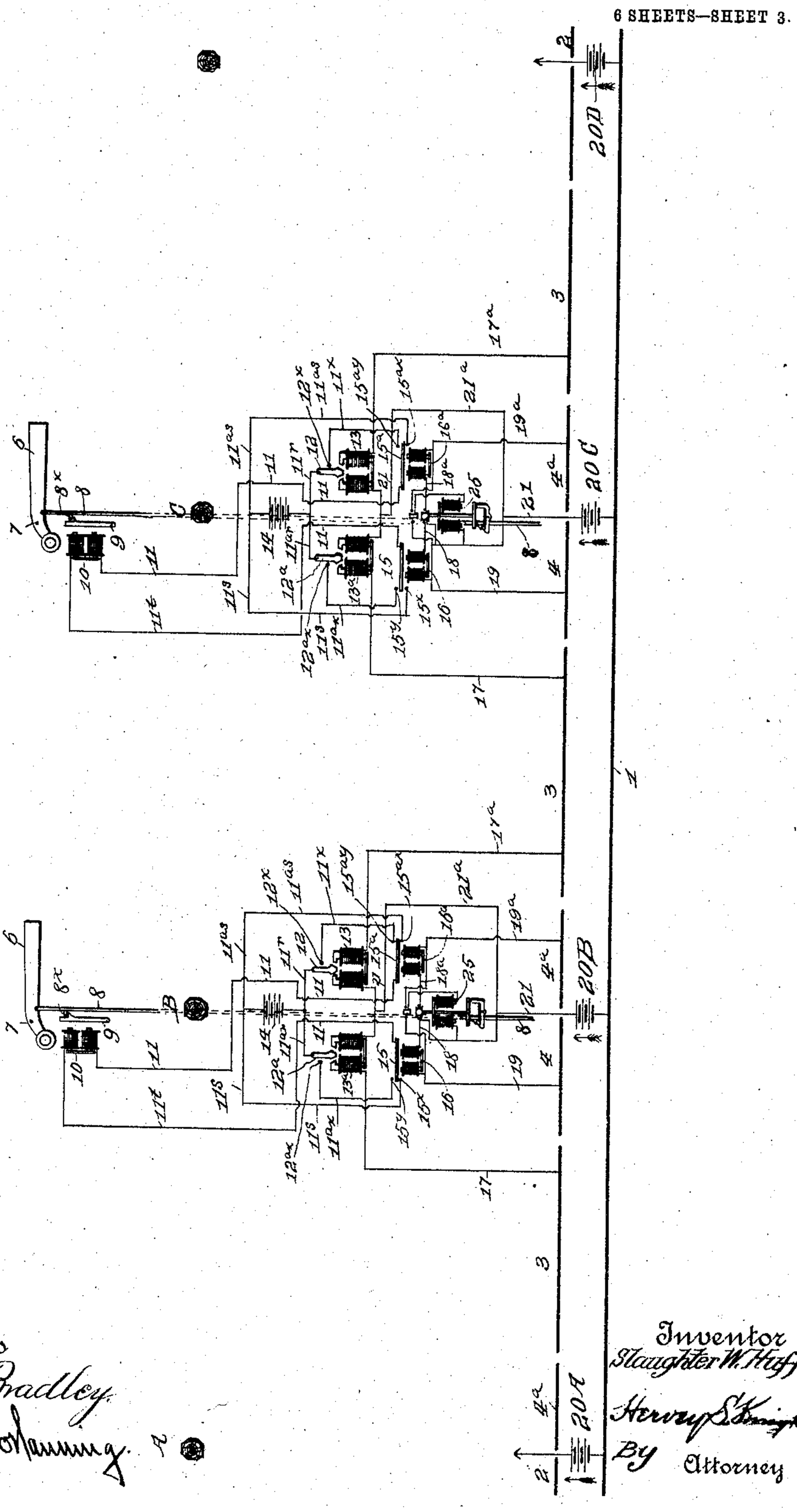

Fig. 3.

Witnesses
Herbert Bradley.
Walter E. Manning.

Inventor
Slaughter W. Huff.
Henry S. Knight
By Attorney

No. 780,885. PATENTED JAN. 24, 1905.

S. W. HUFF.

RAILWAY ELECTRIC SIGNAL.

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6 SHEETS—SHEET 4.

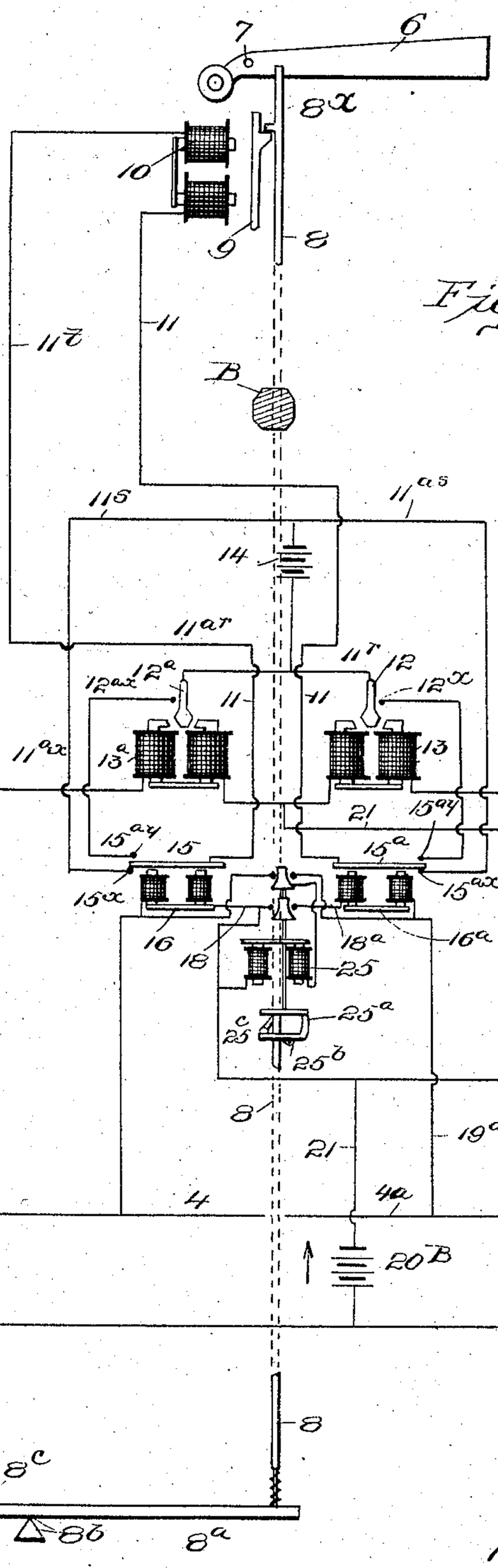

Fig. 3a

Witnesses

Harry A. Knight

Harold Lewis.

Inventor

S. W. Huff

By Hervey B. Knight

Attorney

No. 780,885. PATENTED JAN. 24, 1905.

S. W. HUFF.

RAILWAY ELECTRIC SIGNAL.

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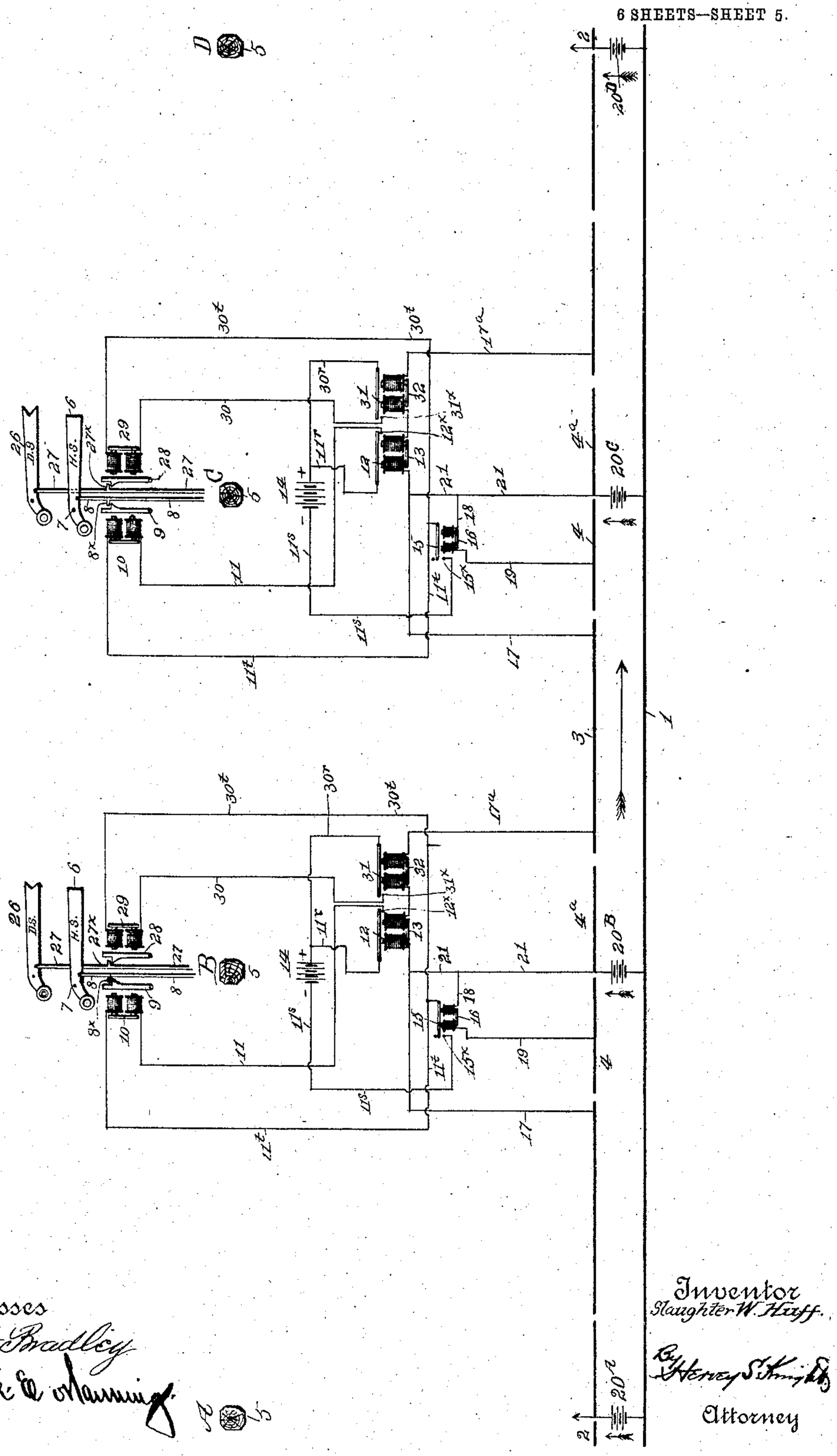
6 SHEETS—SHEET 5.

Fig. 4.



Witnesses
Herbert Bradley
Kalkmann & Manning

Inventor
Slaughter W. Huff.
By Henry Sternfels
Attorney

No. 780,885. PATENTED JAN. 24, 1905.

S. W. HUFF.

RAILWAY ELECTRIC SIGNAL.

APPLICATION FILED JAN. 17, 1898.

6 SHEETS—SHEET 6.

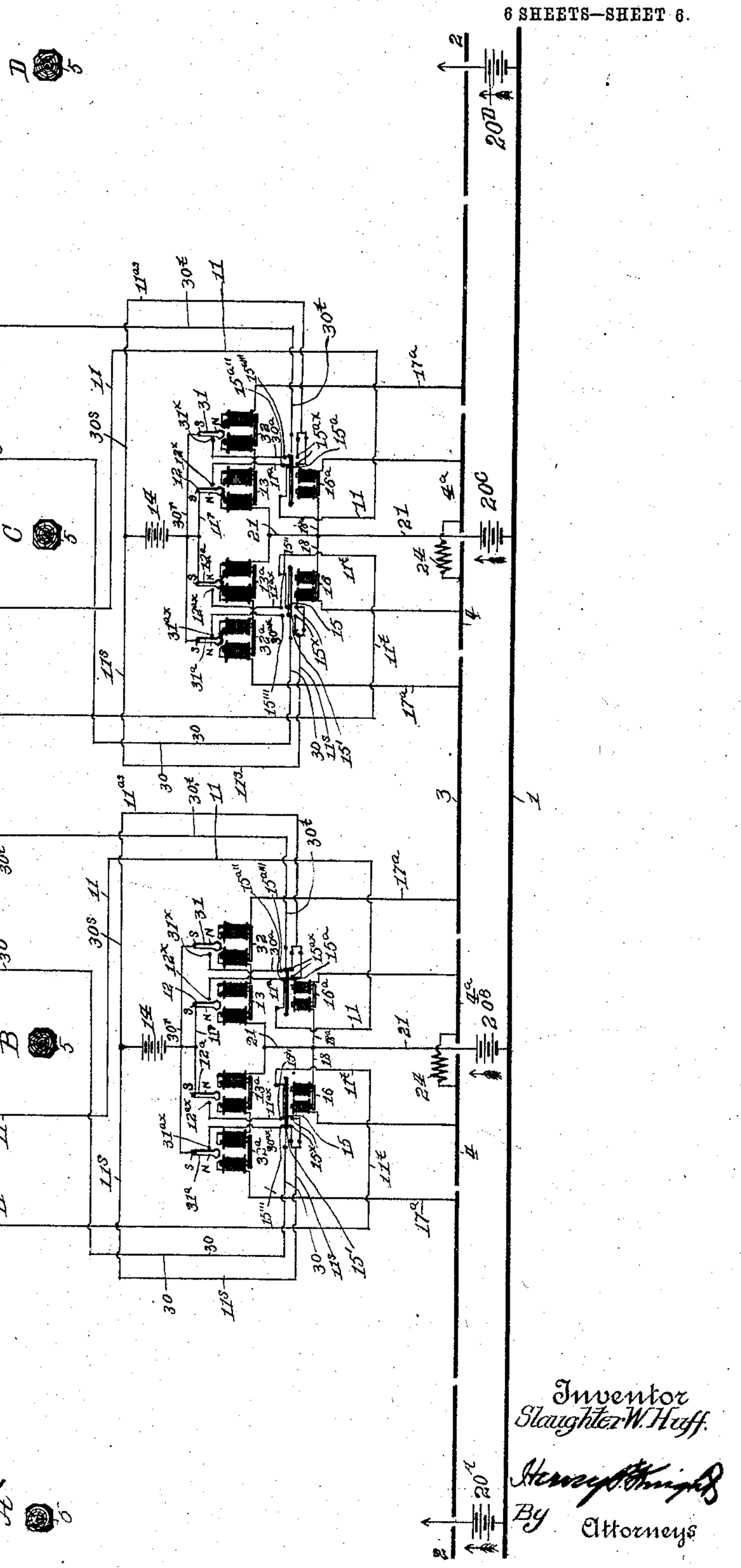


Fig. 5.

Witnesses
Herbert Bradley.
Katherine E. Mannix

Inventor
Slaughter W. Huff.
Attorneys
By

No. 780,885. Patented January 24, 1905.

UNITED STATES PATENT OFFICE.

SLAUGHTER W. HUFF, OF BALTIMORE, MARYLAND.

RAILWAY ELECTRIC SIGNAL.

SPECIFICATION forming part of Letters Patent No. 780,885, dated January 24, 1905.

Application filed January 17, 1898. Serial No. 666,991.

To all whom it may concern:

Be it known that I, SLAUGHTER W. HUFF, a citizen of the United States, and a resident of Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Railway Electric Signals, of which the following is a specification.

This invention relates to means through the medium of which a signal will be actuated electrically by the presence of a train as it successively passes certain points along the railway and will signify to the engineer the condition of the track ahead.

While the novel features are applicable to signals working upon various principles, I prefer to use it, and for the purposes of illustration I shall herein describe it in connection with a system wherein all the signals are normally set to "danger" and each signal drops to safety position as the train approaches it, provided the section of track ahead is clear, but in which each signal will remain standing at danger position should the section ahead be blocked. It is immaterial to the system what construction or arrangement of signal be employed, as the ultimate object of my invention is simply to close or leave open, according to circumstances, a local circuit which is employed for actuating the signal. Obviously, therefore, any arrangement of signal may be employed whose operation depends upon the opening and closing of an electric circuit; but while the above is true I prefer to employ the conventional semaphore, which is moved to a horizontal position to indicate that the section ahead is not clear and is dropped to indicate that the track-section ahead is clear. Any suitable means may be employed for moving this semaphore normally to danger position; but I prefer to employ automatic mechanism for this purpose, whereby each signal will be set to danger position by the train itself as it passes a given point—such, for instance, as one of the appliances described and claimed in my applications serially numbered 666,989 and 666,990 and filed of even date herewith.

In a signal system operating along the lines which I have mentioned the following conditions have to be met:

First, it is necessary to arrange circuits in such a manner that a train approaching a signal-post will show a safety signal. This of course can be arranged by simply having the presence of the wheels upon the adjacent track close a local track-circuit, which will result in the proper signal being given; but, second, it is necessary that the closing of the circuit should be rendered of no effect if a train be immediately on the opposite side of the same post. To accomplish this, it is necessary to employ an additional track-circuit having a relay which coöperates with the circuit first named to control the signal, so that in the event of the presence of two trains in adjacent sections of the road the circuit first named will be rendered ineffective to move the signal to "safety." Therefore one feature of my invention consists in what I shall for convenience term a "home" track-circuit controlled by the presence of a train on one side of the post and adapted to actuate the signal either directly or (preferably) through the medium of a signal-circuit, and an additional distance track-circuit controlled by the presence of a train within a predetermined distance on the other side of the post and including a relay that controls the track-circuit first named; but, third, if the signal is to be applied to single-track roads, where trains are moving in opposite directions on the same track, it becomes necessary to have each track-circuit arranged with the same controlling relation to the other. The second feature of my invention therefore consists in arranging two similar local track-circuits individually controlled by the presence of trains on the respective sides of the signal-post, each having control over the signal (preferably through the medium of a local signal-circuit) and each including a relay, which relay under the influence of a train on the corresponding side of the post renders ineffective the control of the other track-circuit over the signal. For convenience the relays included in the respective track-circuits are also made the means whereby said circuits respectively control the signal-circuit, their armatures being so arranged that the operation of either will close the signal-circuit, while the simultaneous operation of both will open it.

Fourth. If we employ an automatic setting device of any well-known construction, provision must be made to avoid the tripping of the signal after it has been set by a train when the train reaches the same position on the opposite side of the post at which a train coming in the opposite direction must trip the signal. A further feature therefore consists in making the coöperating track-circuits ineffective under the influence of a train leaving the post. This is accomplished by utilizing one conductor (preferably the continuous track-rail) in common for both circuits and introducing a means for bridging the break in the other conductors of said circuits, (preferably the insulated sections of track,) whereby the appropriate relay will alone be actuated by the approach of a train to either side of the post and will be held in effective position as the train departs, at which time the other relay will also have been called into use; hence no effect on the signal. This means for bridging the break may be in the nature of a circuit-closer actuated mechanically by the approach of a train from either direction and thereafter holding the break closed electrically till after the departure of the train, or it may be a high resistance, so that the resistance of either circuit when closed through the high-resistance conductor will be great enough to prevent attracting the relay's armature, but will not prevent holding the armature after it has once been attracted by a full current. When, therefore, a train closes a track-circuit on the side of approach, it will close the relay on that side but will not close the relay ahead; but as the train passes the break in the track the track-circuit ahead is also closed before the preceding one is opened, at which time the circuit-closer, if used, will be called into play. Then the train passes beyond the effective point of the first circuit; but a sufficient current will continue to flow through the circuit-closer or the high resistance, whichever is used, and retain the closure of the first relay. As we have seen that the simultaneous closure of both relays prevents tripping the signal, it follows that the signal dropped on the approach of the train, then set as the train passes the post, will not be dropped again by the departure of the same train from the other side of the post, notwithstanding the same circuit will have been closed that is depended upon for actuating the signal when a train approaches on that side of the post.

A fifth condition to be met is the avoidance of the operation of the signal-circuit in the event of a train being present at a distant point, but within the danger limit. A further feature therefore consists in arranging an additional (preferably high-resistance) relay to control the signal-circuit and which is itself under control of what I shall term a "distance-circuit," the parts being so arranged that both the distance-relay and the local relay will operate if the track is clear to close the signal-circuit. Likewise in the application of the system to a single-track road the distance-relay must be duplicated upon opposite sides of the post, whereby it enters in as a controlling element in whichever direction the train may be moving. In order that the signal be actuated by the proper one of these relays, they are both normally open and each is under the influence of a battery located at the end of the section on its side of the post, which battery is included in the distance-circuit and which distance-circuit has a part in common which results in both the local and distance relays being energized and the signal actuated unless the section ahead is blocked by the presence of a train. If a train should be present in the section ahead or if other danger conditions exist which would short-circuit or cut out the battery ahead, the local track-circuit relay alone would operate and the signal could not be dropped to "safety." In order not to require too fine adjustment of the distance circuit-relays, which operate under the flow of current in one direction only, I employ polarized relays.

Further conditions which I desire to provide for and which are very essential are to simplify the connections, reduce the cost of equipment, and save much in running expenses. Further features accordingly consist in employing in a common continuous circuit in which are introduced in a condition of normal equilibrium a common battery at each post for actuating both the local track-relays and a distance-relay in each direction from the post and introducing each of these batteries by divided conductors into four circuits, and in order that only the proper relay may act at the proper time introducing these batteries in multiple relation in the distance-circuits, so that they normally oppose one another and are not in action until short-circuited by presence of danger condition between them. Since each battery will be short-circuited by the presence of a train on the approach side of a post, the distance-relay will be operated by the battery from the distant end of the section and its armature will be attracted and the signal operated; but if there is a train at any point in that section beyond the post being approached the distant battery will be short-circuited and the local distance-relay will not be actuated and no safety-signal will be received. The local battery, which has to be short-circuited to permit operation of a local distance-relay by the distant battery, is short-circuited through the local track-relay, which must be operated simultaneously with the corresponding distance-relay to get a signal. These conditions render it possible to employ a single battery with a conductor divided so as to supply two local track-circuits

and two distant circuits running in opposite directions from the post. If a gravity-battery or other source of high internal resistance is employed, each distance-relay which is of high resistance will have the local battery effectively short-circuited from it by simply closing the circuit through the corresponding local track-relay; but if a battery of small internal resistance is employed I find it necessary to introduce a high-resistance conductor between the battery and the distance-relay in order that the latter may be effectively short-circuited by closing the corresponding local track-circuit, which is of very much lower resistance. My arrangement involves all the advantages of a constantly-complete circuit, so that it is not dependent upon mechanical operation to render it effective, and at the same time it involves the advantages of open-circuit batteries, for the batteries being normally opposed there is no flow of current, and consequently no waste.

The arrangement as above outlined practically comprises the following: Four relays and one battery are located at each signal-station. Two of these relays are acted upon by the battery connected between the rails of the track at that signal and through a circuit closed by the presence of a train within a predetermined distance of the signal-station. One or the other relay acting on the train may be on one or the other side of the signal-station. The other two relays are acted upon by the batteries at the next signal-stations when either local relay is acted upon by the battery next on its side of the station, the circuit being completed by the presence of a train within a predetermined distance from the signal-station. Since the current which actuates these last two relays must come from the next station and through the track-rails, a train between the relay and the next station, its wheels connecting between the rails, would short-circuit the battery and prevent any action upon the relay. Likewise an open switch or a break in the track would prevent flow from the battery with the same result. These four relays through their armatures form the local circuit through the local battery and trip and are so connected to the two terminals of the battery and the two terminals of the trip that the action of both the local relays would effect a short-circuit of the magnet of the trip also; hence no action. The action of a local actuated relay and a distant actuated relay on the same side of signal-post would leave the circuits open; hence no effect, while the acaction of a local actuated relay and a distant actuated relay on different sides of the signal-post (the condition existing when a train approaches the signal-station from one side closing the circuit through the local actuated relay on that particular side and the track is clear to the next station on the opposite side, allowing the current to come from the battery at that station and actuate the relay) would effect a circuit through the local battery and trip, causing the trip to act and a clear signal to be given.

An additional feature to be noticed in connection with the arrangement above described is that the home-signal relay is not prevented from closing by the presence of a train in the second section ahead even though the circuit next to the battery ahead be closed by said train through the next high-resistance relay. This is because the battery is of sufficient strength to send the current in both directions through said relay. Danger will therefore not be indicated on the home signal unless a train be within the next succeeding block. Expanding this principle and employing signal-relays of different resistances, I am enabled to provide a system whereby a distance-signal may be employed in addition to the home signal in order to indicate whether a train be in the second section ahead and without requiring a multiplication of distance-circuits. This is done by introducing in the distance-circuit a relay requiring a much stronger current than the home-signal relay which will operate along with the home-signal relay when all the current flows from the next battery ahead, but which when a portion of such current is led off in the other direction by the presence of a train in the second section ahead will not operate, notwithstanding sufficient current does pass rearward to energize the home-signal relay.

By the foregoing arrangement I am enabled to establish a system embodying two characters of signals, relays of differential resistance controlling the respective signals, a common circuit embracing all the relays of which one conductor is divided into insulated sections in the usual way, and a single battery at each station. The distance-signals described may be placed at any points between the home signals or on the same posts with said home signals. The latter arrangement is preferred, as it results in considerable saving of apparatus, the post, setting device, and some of the instruments being then used in common for both signals. I shall accordingly illustrate the distance-signals as being associated with the home signals and employing a number of parts in common therewith. When so associated, the distance-signals are brought under control of the local circuits, and therefore subject to the train receiving the signal precisely in the same manner as described with reference to the home signals. When the distance-signal system is to be adapted to single-track railways, it is desirable to employ polarized distance-signal relays as well as polarized home-signal relays, so that they operate only with respect to the distant train whose presence they are intended to indicate ahead of the train receiving the signal. In duplicating the system for thus operating in

both directions of travel I find it desirable to have at each station a distinct local signal-circuit for signal—to wit, a distance-signal circuit under control of both the distance-relays and both of the track-relays and the home-signal circuit, also under control of said track-relays, together with the home-signal relays, and to provide the two track-relays with distinct sets of contacts for the respective signal-circuits. In this way each signal will be tripped to "safety" only under the conditions which it is intended to indicate—that is to say, the home signal will always be tripped to "safety" unless there is a train in the block immediately ahead of the train receiving the signal, while the distance-signal will always be tripped by the presence of a train in the second block ahead of the train receiving the signal.

My invention will be fully understood upon reference to the accompanying drawings, in which—

Figure 1 is a diagrammatic view illustrative of the simplest embodiment of my invention for a double-track railway—that is, for a track used in one direction only. Fig. 2 illustrates the application of the same principle to a single-track road or one in which the track is employed for travel in both directions. Fig. 3 is a view similar to Fig. 2, but illustrating a modification—namely, the use of a make and break instead of a resistance interposed between the respective track-circuits at each post. Fig. 3[a] is a view similar to Fig. 3, showing mechanism for setting signal and showing more in detail the make and break of Fig. 3. Fig. 4 is a view illustrating the embodiment of both home and distance signals in connection with a track traveled in one direction only. Fig. 5 illustrates the application of the home and distance signals and controlling-circuits to a track traveled in both directions. Figs. 6, 7, and 8 represent by perspective view, by a transverse section of rail-joint, and by side elevation of the rail-joint the construction of a bond employed for reducing the resistance at the rail-joints sufficient to adapt the tracks to serve as conductors in making up the circuits employed in my invention.

Referring to Fig. 1, 1 represents the continuous rail of a railway-track, and 2 the companion rail thereof, which is divided up into insulated sections for the purposes of my invention. These sections are of two kinds—namely, long sections 3, extending the greater part of the distance between signal-stations, and short sections 4 or 4[a], adjacent to the signal stations or posts and extending on opposite sides thereof distances sufficient to afford the desired leads or offsets from the signal-post at which the presence of the train will trip the signal. These leads are for the purpose of insuring the operation of the signal a long enough time beforehand to enable the engineer to stop the train before reaching the post and for other effects hereinafter referred to. 5 represents the posts, which are here employed simply for the purpose of indicating the location of the signal-stations. Each post is assumed to be provided with a signal 6, pivoted at 7 and having a controlling-rod 8, which is so arranged in practice that it will tend to draw the signal down to safety position whenever the armature 9 is withdrawn by an electromagnet 10 from engagement with a projection 8[x] on said controlling-rod 8. The semaphore may be set automatically by any approved device—such, for instance, as the track device shown in Fig. 3, wherein 8[a] is a lever connected at one end with the rod 8 and fulcrumed at 8[b] and connected at its opposite end with a tread 8[c], which is in such relation to the railway-rail as to be depressed by the wheels of the rolling-stock. These mechanical details are utilized for the sole purpose of illustration, and in further consideration of my invention it will simply be necessary to bear in mind that the energizing of the electromagnet 10 (or the deënergizing of said magnet if it should be used in a normally closed circuit) will actuate the signal, whatever its character may be. The control of this magnet under certain varying conditions is therefore the ultimate object to be attained by the arrangement of circuits, relays, &c., now to be described. To accomplish the above object, I introduce the magnet 10 in what I term a "signal-circuit," which, commencing and ending at the magnet, is represented by wire 11, contact-point 12[x], armature 12, wire 11[r], battery 14, wire 11[s], contact 15[x], armature 15, and wire 11[t]. The signal-relay 13 at station B is energized by the battery 20[c] at the next station ahead, being included in a circuit with said battery, (represented by wires 21 and 17 at said distant station,) a track-section 3 between stations, and wire 17[a], relay 13, upper end of wire 21, wire 18, relay 16, wire 19, and lead-section 4 at the home station. This leaves a break in the circuit, which is closed by the presence of a train on the lead-section 4 and continuous rail 1. The track-relay 16 is included in what is called the "home" track-circuit, energized by the home battery 20, and represented by wire 21, relay 16, wire 19, lead-section 4, and continuous rail 1, said circuit being also normally open, and closed simultaneously with the distance track-circuit by the presence of a train on the lead-section 4 and continuous rail 1. When the relays 13 and 16 are both energized, the signal-circuit heretofore described as including their respective armatures 12 and 15 will be completed, magnet 10 will be energized, and the signal dropped to safety position, thus indicating a clear track ahead. The batteries 20, of which one is located at each signal-station, are connected in parallel between the continuous rail 1 and the distance-circuits and

track-circuits which they charge, and they are such that they normally flow in the same direction, so that no action upon the parts results. If, however, a train bridges the space between lead-section 4 and continuous rail 1, a circuit will be completed through the home battery 20, which will then no longer oppose the distant battery at the next station ahead, and said distant battery having the circuit closed at the same time through wires 21 17, track-section 3, wires 17ª, 21, 18 and 19, and track-section 4 it follows that both the relays 13 and 16 are energized and the safety signal given as explained. If, however, a train should be present in the block ahead, and thereby close the circuit between the long section 3 and continuous rail 1, the battery 20 at distant station will be short-circuited and magnet 13 not energized. Hence no safety signal will be given and the train approaching the home signal will come to a stop. It is true that the presence of a train in the block ahead will likewise close the circuit from section 3 to rail 1 through battery 20, wires 21, relay 13, and wire 17ª back to the section 3; but at this time the presence of the train on lead-section 4 will short-circuit the battery 20, because relay 16 is of very much lower resistance than the relay 13. Hence relay 13 will remain open, as explained, and the signal remain at "danger." If the difference of resistance is not sufficient to insure operation only under the proper conditions, the desired operation may be insured by employing polarized relays. In the event that the signal drops to "safety" as the train approaches a post the train proceeds without slacking speed past the post and comes upon the lead-section on the opposite side. In tracks traveled in one direction only the lead-section on the side of departure (numbered 4ª) is in electrical contact with the wire 21. As soon as the front of the train strikes this section the battery 20 is short-circuited, relay 16 opened, and backflow toward the second station behind prevented. If at this time a train should be approaching the station A behind, it can get no safety signal, as there will be no flow of current to actuate the relay 13 at said station A. It will therefore be seen that a train can never get a safety signal so long as there is a train at any point ahead nearer than the second block. Should it happen that a train in any block should back onto the next lead 4ª behind, this would likewise prevent a safety signal being given to a train coming onto the lead 4 of the same station, because the battery 20 at said station would be short-circuited and the signal-circuit could, therefore, not be closed through the armature 15 at that station. To further provide for complete short-circuiting of battery 20 at any station under these conditions and of the relay 13 when the circuit is closed by a train on the section 4 1, I may introduce a resistance 23 in the conductor 21 unless the batteries 20 are of very high internal resistance, when the resistance 23 will not be necessary. The explanation of this is that when two circuits of relatively high and low resistance are connected in parallel with a source having high internal or artificial external resistance the high-resistance circuit is effectively short-circuited by closing the low-resistance circuit, so that no current will flow over the former. A further advantage arising from the connection of the conductor 21 to the lead-section 4ª is that I am thus enabled to employ the automatic setting mechanism for the signal hereinbefore referred to as being embodied in co-pending applications. This setting mechanism is actuated by the train as it passes the signal-station, and it moves the controlling-rod 8 up until its projection 8^x is engaged by the armature 9. By short-circuiting the battery 20 the signal-circuit is opened and the armature allowed to engage the controlling-rod as soon as the forward end of the train passes the station. The signal therefore remains set behind the train.

The principles described with reference to Fig. 1 are applied to a track traveled in both directions by duplicating the parts which control the signal-circuit, as shown in Figs. 2 and 4. Here the relays 13 and 16, together with their connecting-conductors, are duplicated, as shown, and the armatures of said relays are so introduced as parts of the signal-circuit that said circuit may be completed either by closing the relays 13 and 16 or the relays 13ª and 16ª, while the closing of any less than two of the relays paired as stated or any more than two of them will break the signal-circuit, and thus prevent giving a signal. This will be understood by following the circuits of these parts. The circuit of the signal-relay 13 is unchanged from that described with reference to Fig. 1. The circuit-relay 16, which is ample for signaling the condition of the track ahead of trains passing from left to right in Fig. 2 is unchanged from that described with reference to Fig. 1. The circuits of the signal-relay 13ª and the local track-relay 16ª, which are ample for indicating the condition of track ahead of trains passing from right to left, in Fig. 2 are precise counterparts with the circuits of relays 13 and 16. It thus remains only to follow the signal-circuit for energizing the magnet 10 either by magnets 13ª or 16ª. If a train approaches the station B from the left, relays 13 and 16 are energized, respectively, by the distant battery 20^C and by the home battery 20^B through circuits already explained with reference to Fig. 1. This then closes the signal-circuit over the following conductors: commencing with magnet 10, through wire 11 to armature 15ª, which not being energized rests against contact 15^{ay}, thence over wire 11^x to contact 12^x, thence through armature 12 and wire 11^r to

battery 14, thence through wire 11^s, contact 15^a, armature 15, which has been drawn down upon said contact, and wire 11^t back to magnet 10. If a train should approach station B from the right, relays 13^a and 16^a will be energized and the signal-circuit will then be as follows: wire 11, armature 15^a, contact 15^{ax}, wire 11^{as}, battery 14, wire 11^{ar}, armature 12^a, contact 12^{ax}, wire 11^{ax}, contact 15^y, armature 15, and wire 11^t to magnet 10. In either case precisely the same control is had over the signal and the same effect upon either pair of relays which control the signal will result from the presence of a train at either of the four danger-points heretofore referred to. For instance, if a train should be on section 3 battery 20 at station C would be short-circuited and relay 13 could not close, or if a train should be on the lead-section 4^a relay 16^a would be closed as well as 16 and the circuit would be broken, and hence no signal. In order to prevent a signal being tripped again as the train leaves a station, (assuming that the signal has been automatically reset in passing the station,)—in other words, to prevent a train closing the same circuit when departing from the station on either side that it would close on approaching from that side—I provide for closing both the relays 16 and 16^a as the train departs, which we have seen will break the signal-circuit. To accomplish this, I introduce either a circuit make and break or else a very high resistance between the two track-circuits of relays 16 and 16^a, so that as a train passes a station it will continue to hold down the track-relay on the side of approach, together with that one on the side of departure, and hold the signal-circuit open. In Fig. 2 I accomplish this by inserting a resistance 24 between the lead-sections 4 and 4^a, which resistance is so graduated that it will not permit the passage of sufficient current to attract the armature of the track-magnet on the side opposite approach; but when a track-magnet on the side of approach is once closed the resistance 24 permits the passage of sufficient current to hold said relay closed even after the train passes a station and gets onto the lead-section on the side of departure. The same result is accomplished by the arrangement shown in Fig. 3, according to which a mechanically-operated make and break 25 is introduced in the wire 21 in such relation that upon the dropping of the signal-setting arm 8 the rod of the make and break will be moved up through the medium of lever 25^a, pivoted at 25^b and engaged by projection 25^c on said rod 8. The setting-rod 8 is raised for setting the signal to "danger," preferably automatically, by means of lever 8^a, connected at one end with rod 8, pivoted at 8^b and having on its other end a tread 8^c in position to receive and may be depressed by the car-wheels as they pass the signal-post. These parts are shown on an enlarged scale in Fig. 3^a. The effect of this mechanically-operated make and break is to cut out the local track-relays and throw the magnet of the mechanical make and break into the local track-circuit, in which position the parts are then held by the armature of the rod being attracted and neither of the local track-relays can be energized and the signal cannot be again dropped by the departure of the train.

Fig. 4 represents the application of the principles of my invention to the use of the home and distance signals to one of the tracks of a double-track road, in which case each track is traveled in one direction only. In a system employing both home signal 6 and distance-signal 26 for tracks traveled in one direction only the apparatus and connections heretofore described with reference to Fig. 1 may be substantially embodied as a whole, and to this it is simply necessary to add a signal of a distinguishing character which will represent the distant block to be guarded against, to provide an independent signal-operating circuit for said signal, and to introduce into the distance track-circuit an additional signal-relay which will control the distance-signal circuit. A home track-circuit and relay are brought into controlling relation with the distance-signal circuit in precisely the same manner as described with reference to the various embodiments of the home-signal system, as will be understood upon reference to Fig. 4. If the distance-signal is mounted, as shown, upon the same post as the home signal or at any other point within convenient reach, a common home track-circuit and relay 16 may be employed for both the home and distance signal circuits, and likewise the common local battery 14 may be employed for said circuits. The circuit of the home signal being identical with that described with reference to Fig. 1 it is simply necessary to here describe the additional circuit and parts included by it for operating the distant signal under the influence of a train in the second block ahead. This will be understood upon reference to Fig. 4, wherein the distance-signal 26 is controlled by setting rod 27, having projection 27^x engaged by armature 28, under control of distance-signal magnet 29. The magnet 29 is brought under control of the distance-signal relay 32 and the home track-relay 16, which bears the same relation to the distance-signal as it does to the home signal, through the following circuit: commencing with the magnet 29, wire 30, contact 31^x, armature 31, wire 30^r, battery 14, wire 11^s, contact 15^x, armature 15, and wire 30^t. Of these parts the battery 14, wire 11^s, contact 15^x, and armature 15, as well as the relay 16 for controlling said armature, are common to both home and distance signals. If, therefore, a train is standing in the position 4 1, both the home and distance signal circuits are placed between the armature 15

and contact 15^x, so that it only remains to close either or both of said circuits by its individual relay 13 or 32 in order to show "safety" with respect to the portions of the track represented by the home and distance signals. If no train is standing in the block between stations B and C, then the relay 13 will be energized upon the arrival of a train at 4 1 for reasons heretofore explained and the home signal will drop. At the same time, if there be no train in the second block ahead, the relay 32 will also be energized by the same current passing through the relay 13 and the distance-signal will drop, so that the track ahead is clear and the train may proceed at full speed. If, however, a train is standing in the block B C, all the current from battery 20^c will be cut out and neither signal will show "safety," or if the block B C is clear and a train is standing in the block C D then such a portion of current from battery 20^c will flow around through the wheels of the train in the block C D that there will not be sufficient current passing rearward to close the relay 32, which requires a strong current; but the relay 13, which only requires a very low current, will be energized, and the result will be that the block B C will be shown not "clear," and while the engineer may pass the station B he is warned to proceed cautiously and keep his train well under control, inasmuch as he might gain sufficient upon the train ahead to reach the next station to receive a danger home signal at that station and necessitate his coming to a stop. The distance-signal magnet 29 is connected by wire 30 with the distance-signal relay 32 and through said relay with the battery 14, the remainder of the circuit between the opposite end of the battery and the relay 16 being made of the wire 11^s, which forms a part of the circuit 11, 12, 11^r, 14, 11^s, 15, and 11^t of the home-signal magnet 10, while the connection between the relay-armature 31 and relay 16 is effected by wire 30^r, battery 14, and wire 11^s, which last-named is one of the wires 11 of said home-signal circuit. It will thus be seen that by locating the two signals at adjacent points much mechanism is saved. It is likewise to be noted that if an automatic signal-setting device is employed this may be used in common for both signals. In order to insure the operation of the distance-signal independently of the home signal when a train is in the second block ahead and without entailing the instalment of an independent distance track-circuit, the distance-signal relay 32 is of very much lower resistance than the home-signal relay 13. It therefore follows that while both the relays 13 and 32 operate alike to trip their respective signals when a train bridges the opening 4 to 1 at station B in Fig. 4, provided there is no train in either the first or second blocks ahead, thus showing the track clear, when a train is in the second block ahead between stations C and D a circuit will be closed through battery 20 at station C and the relays 13 and 32 at said station. This will prevent the backflow of current from battery 20 to station B sufficient to actuate the relay 13, but will permit ample flow of current to actuate the relay 32. If, therefore, at this time a train comes upon the lead-section 4 at station B, short-circuiting the battery 20 at station B and closing a circuit through said station of the next battery 20 ahead, relay 13 will drop the home signal to safety position, while the distance-signal will fail to act because such a large proportion of the current from battery 20^c will be short-circuited by the presence of a train in block C D that there will not be enough backflow to actuate the relay 32 at station B. I thereby am enabled to provide on a single circuit two distinct relays controlling two distinct signals and operating so as to indicate different conditions ahead of the train being signaled.

To apply the home and distance signal system to a track traveled in both directions, it is simply necessary to bring each of the signal-circuits 11 and 30 under control of two signal-magnets polarized so that each magnet will operate with respect to a flow of current induced by a train traveling in the appropriate direction and to further introduce as controlling elements in said signal-circuits the home track-relays, each of which bears the same relation to the home signal-circuit upon its own side of the station as heretofore described with reference to Fig. 2, and at the same time serves in dual capacity for the home and distance signal operated from its own side of the station as described with reference to Fig. 4. The only material change required to be introduced over and above the combination of parts of the system heretofore separately described is to provide independent sets of contacts for the respective home track-relays, through which they close home and distance signal-circuits independently.

The embodiment of the features of signaling in opposite directions and transmitting two different characters of signals all over a common distance track-circuit will be readily understood upon reference to Fig. 5. Here the home and distance signals and their controlling circuits and relays are the same as described with reference to Fig. 4, with the exception that the relays 13 and 32 are duplicated on the opposite side of the station in relays 13^a and 32^a and the circuits are sufficiently modified to render the control of each signal subject to either of its corresponding relays, together with the appropriate home track-relay. Also the armatures 12, 31, 12^a, and 31^a are polarized, so that each will operate to close the circuit controlled by it only when the current flows through its field toward the station. The circuits employed for operating the signals under various conditions are as

follows: If a train approach station B from the left and no train is standing in the block ahead, relays 16 and 13 are both energized, and the following circuit will be closed through the home signal—to wit, from magnet 10 through wire 11 to the armature-terminal 15^{a}, contact 15^{a2}, wire 11^{a}, contact 12^{x}, polarized armature 12, wire 11^{r}, battery 14, wire 11^{s}, contact 15^{x}, terminal 15, and wire 11^{t} to magnet 10. If at the same time there is no train standing in the second block ahead, sufficient current will flow from the battery 20^{c} rearward to energize the relay 32, and the distance-signal circuit will thereby likewise be closed, as follows: commencing with magnet 29, through wire 30 to terminal 15′, through contact 15^{x}, wire 11^{s}, battery 14, wire 30^{r}, armature 31, contact 31^{x}, wire 30^{a}, contact $15^{a'''}$, terminal $15^{a'}$, and wire 30^{t} to magnet 29. When a train approaches a station from the right, then the relays 16^{a} and 13^{a} are energized to show a safety home signal if the track was clear in the block ahead, and the relays 16^{a} and 32^{a} coöperate to show a safety distance signal if the second block ahead is clear. The circuits employed for moving these two signals to "safety" correspond precisely to the two circuits just described for moving said signals under similar conditions when a train approaches the station from the left.

One of the essentials to a successful automatic signal system is the use of the tracks as conductors and dividing up said tracks into insulated blocks and rendering the track between insulations continuous in conductivity and of low resistance. To bridge the rail-joints and render the track electrically continuous, I have devised a special form of bond for railway signal systems, which are shown in Figs. 6, 7, and 8. This bond consists of a single wire or rod 35 of small diameter, having its ends curled into spiral form to provide flat resilient portions 36, preferably curled in the opposite direction and lying in the same plane and having the extreme ends 37 of said rod or bar bent perpendicular to the plane of the resilient portions and forming attaching ends. I then drill two small holes in the head of the rail on the outside and sufficiently below the tread, suitably spaced apart, to receive the attaching ends 38, introduce said ends into the holes, and drive in alongside of them wedging drift-pins 39, which securely bind the attaching ends in the sockets. A bond constructed after this manner answers all the purposes desired for electric signal systems, is cheaply made, and readily attached without disturbing the existing conditions of the rails.

Having thus described my invention, the following is what I claim and desire to secure by Letters Patent:

1. In a railway electric signal system, a main continuous circuit extending throughout the system and formed in part by the track-rails, signals arranged to be controlled by said circuit at the respective signal-stations, batteries having like poles connected to corresponding wires in said circuit in multiple, whereby they are normally balanced; insulated lead-sections in the track at the approach of the respective signal-stations, and a short-circuiting connection extending from a point between each battery and the main circuit to the corresponding lead-section through which said battery is short-circuited by the presence of car-wheels on the lead-section whereby the signal approached is subject to action by the battery at a distant station, acting through the main continuous circuit and the short-circuiting connection at the station being approached.

2. In a railway electric signal system, the combination of a continuous main circuit throughout the system, formed in part by the track-rails and embodying one continuous or return conductor embodied in one rail of the track, while the other rail of the track is divided into insulated sections providing main sections between stations and lead-sections at the approach of each signal-station, batteries inserted in multiple in the main circuit, conductors connecting the main insulated sections, making the main circuit continuous past the insulated lead-sections of the track at the signal-stations, a conductor connecting each lead-section to an intermediate point in the main circuit, batteries at the stations introduced into the main circuit in multiple, and signal-actuating devices connected with and controlled by the main circuit at the respective stations.

3. In a railway electric signal system, the combination of a series of signal-stations, the railway-track divided into two lead-sections at each station and a main section between each two stations, a continuous main circuit throughout the system including all of the main track-sections, together with conductors connecting the main track-sections end to end for maintaining the continuity of the main circuit past the lead-sections, signal-controlling devices introduced in the main circuit at the respective stations, batteries located at the respective signal-stations, conductors which connect the batteries in multiple with the main circuit, whereby they balance one another, and conductors connecting the lead-sections at the respective stations in shunt with the main circuit, and short-circuiting the battery at the station, by the entrance of a train upon the lead-section, and leaving the signal-controlling device at such station subject to a distant battery.

4. In a railway electric signal system, the combination of a series of signal-stations, the railway-track divided into two lead-sections adjacent to each signal-station and a main section between each two signal-stations, a continuous main circuit throughout the system including all of the main track-sections, to-

gether with conductors connecting said main track-sections end to end for maintaining the continuity of the circuit past the lead-sections, signal-controlling devices introduced into the main circuit at the respective stations, a battery located at each station, and conductors which connect the batteries in multiple and lead-sections in shunt with the main circuit; each of said shunt-conductors including a relay which controls the signal at that station.

5. In a railway electric signal system, the combination of a series of signal-stations, the railway-track divided into two lead-sections adjacent to each station and a main section between each two stations, a continuous main circuit throughout the system including all of the main track-sections together with conductors for maintaining the continuity of the main circuit past the lead-sections, signals at the respective stations, a battery located at each station, and conductors which connect the batteries in multiple with the main conductor and the lead-sections in shunt therewith; a signal-controlling relay in the main circuit at each signal-station and a signal-controlling relay in the shunt connection each including a relay at each station, both of which relays together operate the signal.

6. In a railway electric signal system, the combination of a plurality of signals each having a magnet for controlling it, a corresponding number of batteries, a common circuit including all of said signal-controlling magnets, and in which the batteries are introduced in multiple and separate short circuits independent of the main circuit controlled by rolling-stock through which each of said batteries may be separately short-circuited so as to permit a distant battery to exert its influence over the adjacent portion of the common circuit.

7. In a railway electric signal system for single-track railways, the combination of a plurality of signals and a corresponding number of controlling-magnets therefor, insulated lead-sections of track on opposite sides of each signal, a continuous main circuit including all the signal-controlling magnets, batteries for the respective signals introduced in multiple in the continuous main circuit, and a separate independent short-circuiting conductor connecting each lead-section in short-circuiting relation between the adjacent battery and main conductor.

8. In an electric signal system, the combination of a signal, a pair of signal-circuits, each having two breaks therein, two pairs of relays, one pair of which closes the two breaks of one signal-circuit upon the approach of a train to the signal from one direction and the other pair of which closes the breaks of the other signal-circuit upon an approach of a train to the signal from the other direction, said relays being positioned so that the energizing of both pair will open said signal-circuits, insulated sections of tracks, a common source of electricity for two relays, one of each pair, two circuits each connecting one of the insulated sections with a relay through the common source, a resistance between the insulated sections whereby one of the relays energized on the approach of a train is retained in such condition during the departure of the train, and an automatic mechanism actuated by the passage of the rolling-stock.

9. In combination with a signal, a pair of signal-circuits through either of which said signal may be controlled, a pair of local track-relays controlling the respective signal-circuits, lead track-sections on the respective sides of the signal in circuit with said local track-relays; a second pair of relays also controlling the respective signal-circuits, and in circuit with distant portions of the track to be guarded, and a make and break in each signal-circuit under control of the local track-relay of the other signal-circuit, so that either local track-relay and corresponding distant circuit-relay are effective as to either signal, while the action of more of the relays upon a given signal-circuit would be ineffective.

10. In combination with a signal, a pair of relays each controlling said signal through a separate signal-actuating circuit, a pair of make-and-break connections normally forming parts of different signal-actuating circuits, and each movable to form a part of the other signal-actuating circuit and controlled by one of the relays whereby the action of both simultaneously prevents the action of the signal, distance track-circuits through which the respective signal-circuits are responsive to the condition of track on opposite sides of the signal, suitable batteries introduced in multiple in said track-circuits, and local track-circuits in which said relays are positioned short-circuiting the battery at the signal-station when a train is present.

11. In combination with a signal, a pair of relays each controlling said signal through an independent circuit, contacts in each signal-circuit controlled by the relay of the other circuit, whereby the action of both relays simultaneously prevents action on the signal, track-circuits through which the presence of rolling-stock on the respective sides of the signal affects the respective relays, and a connection between said track-circuits through which a condition established by rolling-stock in the track-circuit on the side of approach is maintained through the medium of the track-circuit on the side of departure.

12. In combination with a signal, a pair of relays each controlling said signal through an independent circuit, contacts in each signal-circuit controlled by the relay of the other circuit, whereby the action of both relays simultaneously prevents action on the signal, track-circuits through which the presence of rolling-stock on the respective sides of the signal affects the respective relays, and an electrical

connection between said track-circuits through which a condition established by rolling-stock in the track-circuit on the side of approach is maintained through the medium of the track-circuit on the side of departure.

13. In combination with a signal, a pair of relays each controlling said signal through an independent circuit, contacts in each signal-circuit controlled by the relay of the other circuit, whereby the action of both relays simultaneously prevents action on the signal, track-circuits through which the presence of rolling-stock on the respective sides of the signal affects the respective relays, and a connection between said track-circuits through which a condition established by rolling-stock in the track-circuit on the side of approach is maintained through the medium of the track-circuit on the side of departure; said connection between the track-circuits consisting of the resistance graduated to prevent initiating any effect in one track-circuit from the other by an approaching train, but permitting the maintenance by a departing train of an effect established in the track-circuit on the side of approach.

14. In a railway electric signal, the combination of a signal-circuit, relays respectively controlling the signal-circuit, local track-circuits including the respective relays, and a connection between said track-circuits for retaining the flow of current through a relay on the side of approach after the train passes the station.

15. In a railway electric signal, the combination of a signal-circuit, two relays, connections between the relays and the signal-circuit arranged to close the latter when either relay is open and the other closed, insulated track-sections on opposite sides of the signal-station, and local track-circuits including the respective track-sections and corresponding relays, and a connection between the said track-sections operating to hold closed the relay on the side of approach through the circuit of the relay on the side of departure and thus prevent retripping of the signal after being reset.

16. In a railway electric signal, the combination of a signal-circuit, two relays, electrical connections including the armatures of said relays through which said signal-circuit is closed when either relay is closed and the other is open, insulated rail-sections on opposite sides of the signal-station and a continuous rail extending past the same, conductors between the respective rail-sections and corresponding relays, a conductor between said relays and the continuous rail, a battery inserted in the last-named conductor, and a resistance of substantially the character described between the insulated rail-sections.

17. In a railway electric signal, the combination of a signal-circuit, two relays in controlling relation to said signal-circuit, a local track-circuit controlling one of said relays, and a distance track-circuit controlling the other of said relays, local and distant batteries for the respective circuits, and lead-sections of track adjacent to said signal, having short-circuiting connections with said relays and controlling the supply of current from the batteries; substantially as and for the purpose set forth.

18. In a railway electric signal system, the combination of signals at a plurality of points, electric batteries for actuating said signals, and a single circuit through which the batteries control the signals and an independent short-circuiting connection at each signal; parts of the track between the batteries being introduced as parts of the conductors of the said circuit, and other parts of the track being insulated and connected with the main circuit through the short-circuiting connections as a means for controlling said circuit, and the batteries having like poles connected with the respective conductors of the circuit.

19. In a railway electric signal system, the combination of signals at a plurality of points, electric batteries, a single continuous main circuit in which said batteries are introduced in multiple, an independent means for controlling each of the signals included in said circuit, circuit-controlling relays 16 located at the respective stations, likewise controlling the signals; insulated parts of the track between the stations introduced into the single continuous main circuit, insulated parts of the track at the station connected with and conductors which include the relays 16 and the parts of the track adjacent to the signal thereby controlling the signal-circuit by the approach of a train to the signal.

20. In a railway electric signal, the combination of two signals at each station for indicating the condition of track in separate sections ahead, relays controlling the respective signals, a circuit extending to distant sections ahead, and batteries located in the separate sections and feeding into said circuit; the relays being of such oppositions that one is affected by the battery-power from one section ahead while the other is affected only by the battery-power of a plurality of sections ahead, so that the signals will respectively indicate the condition of track in different sections.

21. In a railway electric signal system, the combination of home and distance signals at each station, circuits controlling said signals and extending from the station, and batteries located in the several sections ahead; the home signal being under control of the nearer battery alone, while the distance-signal is actuated only by the combined strength of both batteries.

22. In a railway electric signal, the combination of a signal-circuit, two relays simultaneously controlling said signal-circuit, a local track-circuit controlling one of said relays, and a distance track-circuit controlling the

other of said relays, both said circuits being simultaneously controlled by the approach of a train to the signal, a local battery for said signal-circuit, a home battery for the home track-circuit, and a distance-battery for the distance track-circuit.

23. In a railway electric signal, the combination of a signal-circuit, two relays operating simultaneously controlling said signal-circuit, a local track-circuit controlling one of said relays, and a distance track-circuit controlling the other of said relays, a local battery for said signal-circuit, a home battery for said local track-circuit, and a distance-battery for the distance track-circuit; the local and distance track-circuits being simultaneously controlled by a train approaching the signal, and the batteries in said circuits being normally opposed and being short-circuited by the presence of a train on the track at a point between the stations.

24. In a railway electric block-signal system, the combination of a signal-circuit at each station, two relays controlling each signal-circuit, a normally open home track-circuit at each station including one of said relays, a normally open distance track-circuit including the other relay at each station, insulated track-sections at the respective stations forming parts of the local track-circuits, and a battery at each station.

25. In a railway block-signal system, the combination of home and distant circuit-blocks, batteries introduced therein, signals for the home and distant blocks, located at a station and respectively responsive only to the home and distant block-batteries, an independent controlling relay for the home signal in circuit with and responsive only to the battery of the home circuit-blocks, an independent controlling-relay for the distant signal in circuit with and responsive only to the battery of the distant circuit-block, and a relay cooperating with each of said signal-relays to control its signal, upon the approach of a train to the station.

26. In a railway electric signal, the combination of a home track-relay controlled by the presence of a train, the signals for indicating the condition of blocks in the signal system, signal-relays of differential form, each connected through the home track-relay with the signal which it is to control, whereby the presence of a train at the home station may actuate either signal; a circuit including the signal-relays and extending to the blocks of the system represented by said signal-relays to be guarded, and resistance in said circuit between the blocks whereby the signal-relays will be independently energized by the presence of a train in the respective blocks which they represent.

27. In a railway electric block-signal system, the combination of home track-relays at the respective stations connected in circuits through which they may be controlled by the presence of a train; home and distance signals for representing the condition of blocks in the system, differential signal-relays for each block, each controlling its corresponding signal-circuit in connection with a home track-relay, circuits including the signal-relays of the system, and a battery for each block introduced into the distance-circuits so as to supply current in either direction through said circuits; whereby on the approach of a train to a station, the signal refuses to act if the battery ahead is cut out by the existence of a danger condition in the next block, while the signal relay or relays in the next block acts as a resistance to divert rearward sufficient current to operate the home signal, but prevents the passage rearward of sufficient current to operate the distance signal-relay when the battery is short-circuited by a train in the second block ahead.

28. In a railway electric block-signal system, the combination of local and distance track-circuits fed by batteries located respectively at the home and distance stations and connected in multiple with the said circuits, local track-relays in the local track-circuits, signal-circuit-controlling relays in the distance track-circuits and independent local signal-circuits, each including a signal, the armature of a local track-relay, and the armature of a signal-circuit-controlling relay at a station.

29. In a railway electric circuit, the combination of a local track-circuit controlled by the presence of a train, a relay actuated by said local track-circuit, a local signal-circuit controlled by said local track-circuit relay, a continuous distance track-circuit extending without break through a plurality of distant blocks, controlled by a train within either of said distant blocks, and supplied with current from a plurality of batteries located at stations in the respective distant blocks, and a distant track-circuit relay at the local station, but in said continuous distant track-circuit, responsive only to the said distant batteries, and also controlling the aforesaid local signal-circuit.

30. In a railway electric signal, the combination of a signal, a circuit controlling said signal, two home track-relays, independent connections through which said home track-relays may individually control the signal-circuit, said independent connections for each home track-relay being broken by the actuation of the other home track-relay, and home track-circuits controlling the respective home track-relays and in turn subject to control by the presence of a train on opposite sides of the signal; substantially as set forth.

31. In a railway-circuit electric signal, the combination of two similar home track-circuits individually controlled by the presence of trains on the respective sides of the signal-

stations, relays included in said home track-circuits, a signal, a signal-circuit including the armatures of the home track-circuit relays and distance track-circuits also controlled by said home track-circuit relays; the armatures of the relays being arranged so that the closing of either will close the signal-circuit, while the simultaneous closing of both will open said signal-circuit.

32. In a railway electric signal, the combination of a signal, a signal-circuit, low and high resistance relays normally rendering said signal-circuit ineffective, a local track-circuit controlling the low-resistance relay, a distance track-circuit including a distant battery controlling the high-resistance relay, and connections whereby both of said track-circuits are closed by the presence of a train, the connections of said relays being such that the closing of both is necessary to the actuating of the signal-circuit.

33. In a railway electric block-signal system, the combination of home and distance signals, independent signal-circuits including said signals, relays of low and high resistance controlling said signal-circuits, a plurality of sources of electricity at different distant points, a distance-circuit including both relays and all the sources of electricity, and a local track-circuit common to and controlling both signal-circuits.

34. In a railway electric signal system, the combination of a signal at a station, a local signal-circuit, circuits extending in opposite directions from said station, two relays included in each of the respective circuits and each having control over the signal-circuit; said relays having independent armatures polarized, and responsive only to a current from one direction, to wit, from the direction of the track the condition of which it is intended to disclose through the signal, and said armatures each separately controlling the signal-circuit.

35. In a railway electric signal system, the combination of a plurality of stations, two signals located at each station, local signal-circuits for the respective signals, a continuous conductor and a suitable return-path extending through all the stations, batteries located at points along the route in proper relation to exert their influence over the continuous conductor subject to the approach of a train to any station, and two relays at each station, having independent polarized armatures which separately control the respective signals and responsive only to currents passing over the continuous conductor in opposite directions, whereby they are affected by the condition of the continuous conductor on the respective sides of the station and local track-circuits short-circuiting the battery at the station by the approach of a train in either direction.

SLAUGHTER W. HUFF.

Witnesses:
M. M. CORBIN,
FRED L. WITTIG.