G. B. GRAY.

AUTOMATIC SAFETY SIGNAL SYSTEM FOR RAILWAYS.

APPLICATION FILED MAY 11, 1907.

909,083. Patented Jan. 5, 1909.

3 SHEETS—SHEET 1.

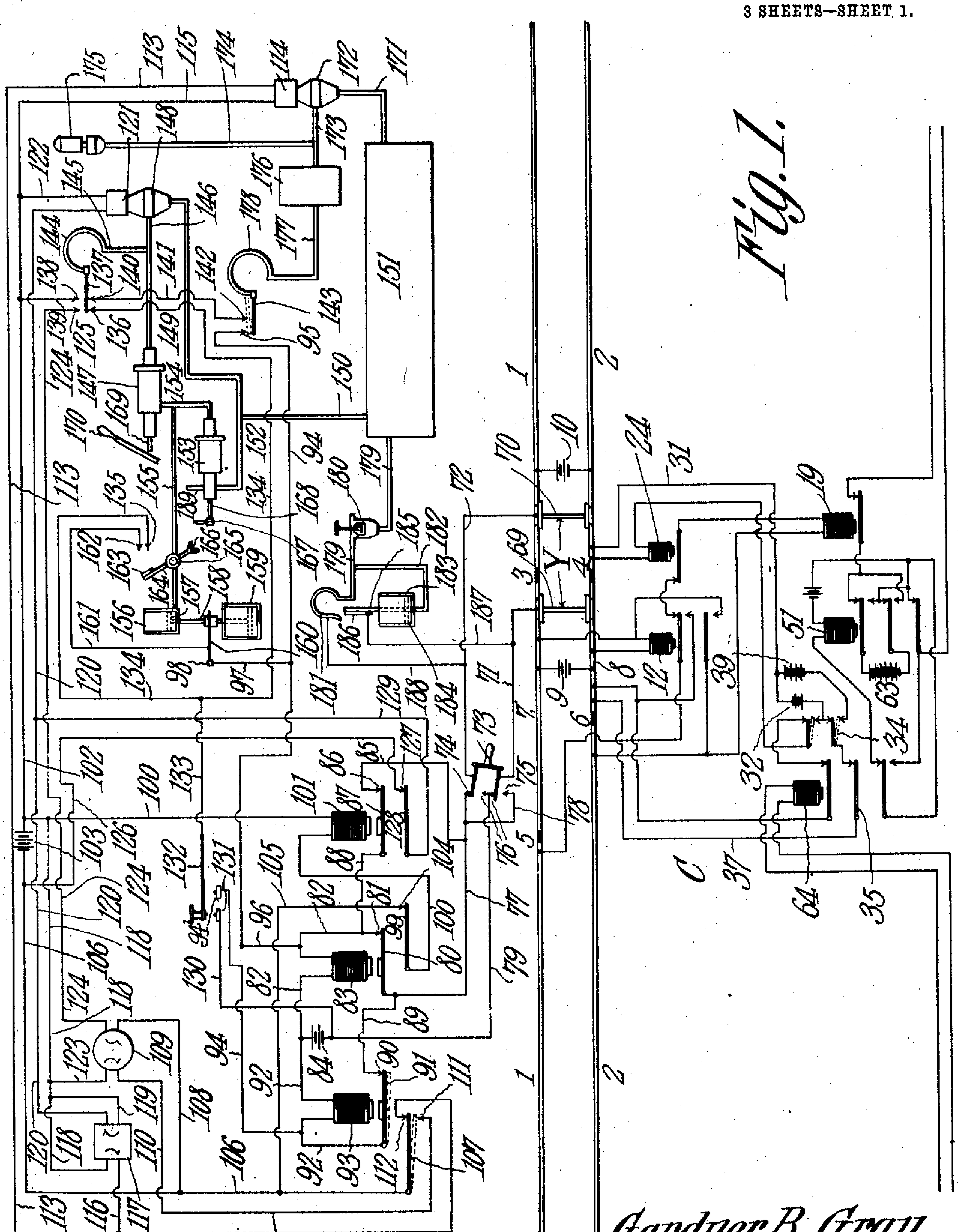

Fig. 1.

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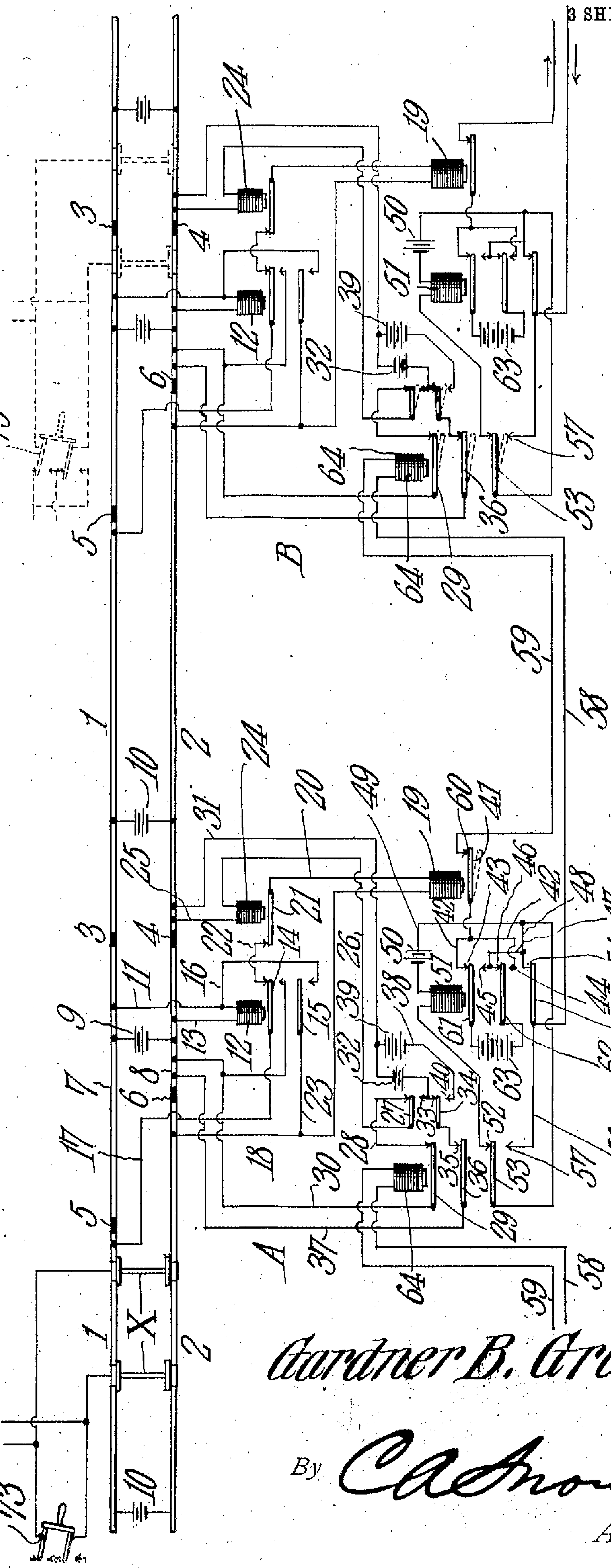
Fig. 2.



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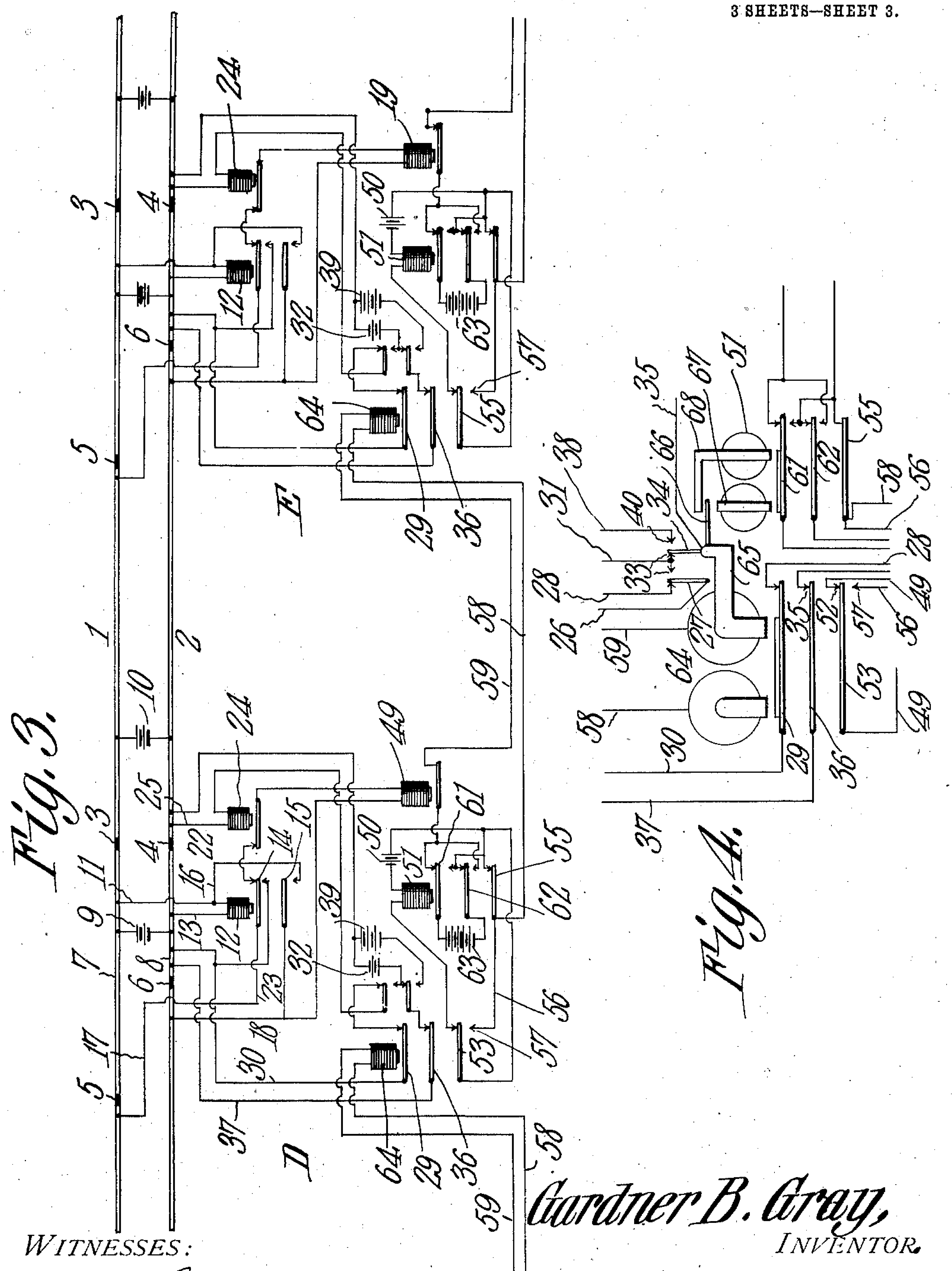

Fig. 3. Fig. 4.

WITNESSES:

[illegible]

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UNITED STATES PATENT OFFICE.

GARDNER B. GRAY, OF PITTSBURG, PENNSYLVANIA.

AUTOMATIC SAFETY SIGNAL SYSTEM FOR RAILWAYS.

No. 909,083. **Specification of Letters Patent.** **Patented Jan. 5, 1909.**

Application filed May 11, 1907. Serial No. 373,071.

To all whom it may concern:

Be it known that I, Gardner B. Gray, a citizen of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Automatic Safety Signal System for Railways, of which the following is a specification.

This invention has reference to improvements in automatic safety signal systems for railways, and its object is to provide a block system which will give both visual and audible signals to the engineman on approaching a danger zone, and will prevent the possibility of accident from collision because of the presence of such danger zone.

The improved system is entirely automatic so far as the display or sounding of signals is concerned, and the making of a permanent record of such signals, and also as to the application of the brakes should the engineman from carelessness or design or from any other cause pass into a danger zone after having been warned that the train was approaching such zone.

By this invention provision is made whereby the engineman may set the various signals to the position indicating safety after they have been moved automatically to the caution or danger position, but the arrangement is such that the restoration of the signal devices to the safety position can only be made after the signals have been moved to the caution or danger position, as the case may be, and any manipulation of the restoring means by the engineman prior to or during the setting of the signals at caution or danger will be futile, whether such manipulation be performed maliciously or thoughtlessly.

By the present system the railway line is divided up into blocks of appropriate length, and suitable indications of the presence of a danger zone, which may be represented by a moving train in the ordinary course of traffic, or a stalled train, or a wreck, or any other condition which would present an element of danger to another train, will be transmitted to the next block in advance in such manner as to indicate to the engineman of an oncoming train that a danger zone is imminent and to transmit to the second block in advance a cautionary signal to the engineman in the cab of a train entering said block.

Provision is made by the present invention whereby cautionary signals only are given to the engineman two blocks away from the danger zone, while at the block immediately preceding the danger zone not only are danger signals transmitted to the engineman but the train is automatically stopped by a suitable application of the air-brakes.

Now, these various operations are performed by means of but two main conductors along the track between the various block stations, and the system is arranged to work on a normally closed circuit. Also, provision is made whereby should the normal condition of the installation become changed, as by the breaking down of the insulation used at various points, or should other breaks occur, suitable cautionary signals will be displayed and thus give notice of the inoperative or defective condition of the system. Again, the system is so arranged that should an engineman ignore the signals given and enter upon a danger zone and so have his train stopped by the automatic application of the brakes, the latter cannot be released so that the train may proceed until the train has come to a full stop since the releasing mechanism for the brakes, when automatically set by the operation of the block system guarding the danger zone, is so timed that it can only be manipulated after an appreciable time during which the train has come to a full stop.

The construction of the system and the objects and purposes thereof will be best understood by a consideration of the manner in which the system is installed, and such installation is shown in the accompanying drawings forming part of this specification, in which,—

Figure 1 is a diagrammatic representation of the installation at one of the block stations and the installation on the cab of an engine, which, in this figure, is shown in conjunction with a particular block station; Fig. 2 is a diagram illustrating two other block stations, which may be taken as joining the left-hand end of the system shown in Fig. 1; Fig. 3 is a diagram similar to that shown in Fig. 2 and constituting a continuation of the right-hand end of the system shown in Fig. 1; and Fig. 4 is a diagram of a portion of one of the block stations, showing in greater detail a portion of the installation at the block stations.

In the following description the block stations will be referred to as A, B, C, D and E, the stations A and B being shown in Fig. 2, the station C being shown in Fig. 1, and the stations D and E being shown in Fig. 3. For convenience, these five stations shown in the three figures will be considered together, as though the diagram occupied but one sheet of drawings and was embraced under one figure designation. It will be understood, of course, that there will be as many block stations as may be desired.

At each station the rails 1 and 2 are insulated from each other at points 3—4, one directly opposite the other, and at other points 5—6, which are diagonally disposed. The insulation sections 3—4 and the other insulation sections 5—6 provide short track sections 7 and 8 at each block, the section 8 being considerably shorter than the section 7. Bridged across between the sections 7 and 8 is a battery 9, and another battery 10 is bridged across the rails 1 and 2 at or between each block station. These batteries will be hereinafter referred to. In the drawings the running gear of a locomotive is represented simply by contiguous wheels and axles, and as but two trains will be particularly considered in the following description, these pairs of wheels and axles will represent two locomotives X and Y.

Considering, first, the block stations, the circuits and apparatus located at each, as shown in the drawings, will appear from the following description. Extending from the rail section 7 there is a conductor 11 leading to an electro-magnet 12, and this magnet is connected by a conductor 13 to the other rail section 8. This places the magnet 12 normally in a closed circuit charged by the battery 9 and the magnet is therefore normally excited. This magnet 12 controls two armatures or contact levers 14 and 15. In the path of the armature 15 there is a contact point forming the terminal of a branch conductor 16 coming from the conductor 11, and the armature 15 is normally out of contact with this branch conductor 16, that is, so long as the magnet 12 is energized. The armature 14 is connected by a conductor 17 to the rail 1 to the left of the station around the insulated rail 7, and the other rail 2 to the left of the station beyond the rail 8 is connected by a conductor 18 to a magnet 19, the other terminal of which latter is connected by a conductor 20 to an armature 21 in the path of which is the termimal of a bridging conductor 22 having its other terminal in the path of the armature 14, which latter is maintained in normal contact with the adjacent terminal of the conductor 22 when the magnet 12 is energized. A branch conductor 23 connects the armature 15 with the conductor 18.

The armature 21 is controlled by a magnet 24, one terminal of which is connected to the rail 2 to the right of the station beyond the insulation 4 by a conductor 25, while the other terminal of this magnet is connected by a conductor 26 to an armature or switch lever 27, in the path of which is one terminal of a bridging conductor 28, the other terminal of which is in the path of an armature lever 29 connected by a conductor 30 to the rail section 8. Adjacent to the connection of the conductor 25 with the rail section 2 another conductor 31 is connected to said rail section 2 and leads through a battery 32 to terminals 33, one of which is in the path of a switch lever 34 connected to another terminal 35 in the path of an armature lever 36, which latter is connected by a conductor 37 to the rail section 8 adjacent to the connection therewith of the conductor 30. Branched off from the conductor 31 is another conductor 38, including a battery 39, and this conductor 38 leads to a terminal 40 in the path of the armature lever 34 on the side opposite one of the terminals 33, the other terminal 33 being in the path of the armature lever 27.

Controlled by the magnet 19 is an armature lever 41 connected by a conductor 42 to two terminals 43—44, and between these terminals 43—44 are other terminals 45—46 connected by a conductor 47 to a branch conductor 48 leading to another conductor 49, which latter includes a battery 50 and an electro-magnet 51 and leads at one end to a terminal 52 and at the other end to an armature lever 53 in the path of which is the terminal 52. The conductor 48 also leads to a terminal 54 in the path of an armature lever 55, from which latter leads a branch conductor 56 to a terminal 57 in the path of the armature lever 53, and the armature lever 55 is also connected to one of the line conductors 58, while the other line conductor 59 terminates at the station under consideration in a contact point 60 in the path of the armature lever 41.

The magnet 51 controls two armature levers 61 and 62 forming the terminals of a circuit including a battery 63 which charges the main line circuit conductors 58 and 59. The armature levers 61 and 62 have in their paths the contact terminals 43 and 45, and 44 and 46, respectively, and constitute a pole-changer for the battery 63 for a purpose which will hereinafter appear. The main line conductors 58—59 terminate at the next succeeding station in a magnet 64, shown more in detail in Fig. 4. This magnet controls the armature levers 29, 36 and 53, while one pole 65 is extended and carries a polarized armature 66 between the poles 67 and 68 of the magnet 51, which latter controls the armatures 61, 62 and 55. The armature 66 carries or controls the switch levers 27 and 34.

The circuits just described are common to all the stations along the line of the railroad, but before entering into an explanation of the operation of the system it will be necessary to trace out the cab circuits and the mechanism controlled thereby. The cab system is shown in Fig. 1 as carried by engine Y, but is the same as that carried by all the other engines. The two axles 69—70 of the engine Y are insulated one from the other but each axle and its wheels are electrically connected. The axle 69 is connected by a conductor 71 and the axle 70 is connected by a conductor 72 to the two arms of a double-arm switch 73, in the path of which arms are two contact terminals 74—75 and a double, common terminal 76, so that this switch 73 may be operated as a pole-changing switch for a purpose which will hereinafter appear. The terminal 74 is connected to a conductor 77 and the terminal 75 is also connected to the same conductor 77 through a branch conductor 78, while the two common terminals 76 are connected to a conductor 79. The conductor 77 leads to an armature lever 80 and in the path of this lever there is a terminal 81 of a conductor 82, which latter leads to a magnet 83 and from thence to a battery 84, the other side of which latter is connected to the conductor 79. The conductor 77 is also connected by a branch conductor 85 to a terminal 86 in the path of an armature lever 87 which, in turn, is connected by a conductor 88 to the conductor 82 before mentioned. Again, the conductor 77 is connected by a branch conductor 89 to a contact terminal 90 in the path of an armature lever 91, the other end of which is connected by a conductor 92 to an electro-magnet 93 and leaving the latter is connected to the battery 84 on the same side to which the conductor 82 is connected. The conductor 92, after leaving the armature lever 91 but before reaching the magnet 93, is connected to another conductor 94 leading to a contact or terminal 94′ to be hereinafter referred to. There is another terminal 95, also to be hereinafter referred to, connected by a conductor 96 to the conductor 82 before referred to, and the conductor 96 is connected by a branch conductor 97 to a terminal 98, to be hereinafter referred to.

Under the influence of the magnet 83 there is another armature lever 99 connected by a conductor 100 to an electro-magnet 101 which, in turn, is connected by a continuation of the conductor 100 to a conductor 102, including a battery 103. In the path of the armature lever 99 is a contact terminal 104 connected by a conductor 105 to another conductor 106 having one terminal connected to an armature lever 107, under the influence of the magnet 93, and the other terminal connected to the battery 103. The conductor 106, at a point between its junction with the conductor 105 and the battery 103, is connected to a branch conductor 108 in which is included a signal recorder 109, the other side of which is connected by a conductor 110 to a contact terminal 111 in the path of the armature lever 107. On the other side of the armature lever 107 is a contact terminal 112 from which leads a conductor 113 to a solenoid coil 114, to be hereinafter referred to, and from this coil 114 there leads a conductor 115 connected to the conductor 100 and thence to the battery 103. Branched off from the conductor 113 is another conductor 116 leading to a signal-indicating device 117 which, in turn, is connected by a conductor 118 to the conductor 100 and thence to the battery 103.

The signal device 117 is arranged to give visual signals both for caution and danger. The conductor 118 is connected to the other side of this signal device 117 by a branch conductor 119 and the other terminal of this other side of the signal-indicator 117 is connected by a conductor 120 to a solenoid 121, the other side of which is connected by a conductor 122 to the conductor 115 before referred to. The conductor 118 is also connected by a branch conductor 123 to the recording device 109, from which leads another conductor 124 ending in a contact terminal 125. The conductor 106, before reaching the battery 103, is connected to another conductor 126 leading to a contact terminal 127 in the path of an armature lever 128 under the influence of the magnet 101, and this armature lever 128 is connected by a conductor 129 to the conductor 120 before referred to.

Branched off from the conductor 79 before the latter reaches the battery 84 is another conductor 130 terminating in a contact 131 in the path of a manually operated key 132, and also in the path of this key, the contact 94′ is located. The key 132 is connected by a branch conductor 133 to a conductor 134 between its terminals, this conductor 134 having at one end a contact terminal 135 and at the other end a contact terminal 136, the latter being opposite the contact 125 before referred to, and between which, that is, between the contact terminals 125 and 136, there is introduced a bridging arm 137. On the same side of the arm 137 as is the contact 125 and contiguous thereto is another contact 138 connected by a conductor 139 to the conductor 115 between the battery 103 and the connection with the conductor 122. On the same side of the bridging arm 137 as is located the terminal 136 there is another terminal 140 connected by a conductor 141 to another terminal 142 contiguous to the terminal 95, and these terminals 95 and 142 are in the path of a bridging conducting arm 143.

The bridging arm 137 is carried at the end of a curved or Bourdon tube 144 connected by a branch pipe 145 to an air pipe 146 leading at one end into a cylinder 147 and at the other end connected to a valve 148 controlled by the solenoid 121. The valve 148 is connected by a pipe 149 to another pipe 150 coming from an air-supply tank 151, and from this pipe 150 extends another pipe 152 to a cylinder 153, to be controlled in a manner to be described. The cylinder 147 is connected to the cylinder 153 by a pipe 154 and from this pipe 154 there branches another pipe 155 connecting to a cylinder 156 in which is located a piston 157 on one end of a piston-rod 158, the other end of which enters a dash-pot 159, and between the cylinder 156 and the dash-pot 159 the piston-rod 158 carries a contact arm 160 to which is connected one end of a conductor 161, the other end of which is connected to a contact terminal 162 alongside the contact terminal 135 and arranged to be bridged by a conducting plate 163 on one end of a lever 164 carried by a valve 165 in the pipe 155. This lever 164 terminates at the outer end in a fork 166 in the path of a finger 167 on the end of a piston-rod 168 controlled by a piston (not shown) in the cylinder 153. The cylinder 147 before referred to is also provided with a piston (not shown) terminating in a piston-rod 169 arranged to control the throttle lever 170.

The air tank 151 is connected by another pipe 171 to a valve 172 under the control of the solenoid 114. From this valve 172 there leads a pipe 173 from which rises another pipe 174 terminating in a whistle 175. Air coming through the pipe 173 also enters a small tank 176 through an orifice of a size to prevent rapid flow, so that there is a time limit before the air in the tank 176 equals the supply pressure. This tank 176 is connected by a conductor 177 to a curved or Bourdon tube 178 carrying at its end the contact arm 143 before referred to.

The tank 151 is also connected by another pipe 179 through a manually operated valve 180 to a curved or Bourdon tube 181, and this pipe 179, through a branch pipe 182, feeds air to a cylinder 183 containing a piston 184, to the piston-rod 185 of which is connected a contact plate 186 movable into contact with the end of the Bourdon tube 181. The contact plate 186 is connected by a conductor 187 to the conductor 71, and the Bourdon tube 181 is connected by a conductor 188 to the conductor 72.

Having set forth the various circuits and instrumentalities comprised within the system, I will now proceed to describe the operation. Now, let it be supposed that there is a train drawn by the locomotive X upon a block approaching station A and which, for convenience, may be called block A. The truck of the engine short circuits the battery 10, and, therefore, shunts the current from the circuit through the conductor 18, magnet 19, conductor 20, armature lever 21, branch conductor 22, armature lever 14 and conductor 17. This so weakens the magnet 19 that its armature 41 drops and breaks the main battery circuit at the contact point 60. This deënergizes the magnet 64 at station B and the armatures 29, 36 and 53 move away from the respective contacts, which opens the circuits fed by the batteries 32 and 50. Meanwhile, the armature 53 makes contact with the terminal 57. Now, the armature 66, shown in Fig. 4, is normally polarized by the main circuit magnet 64 and the free end of this armature is normally within the influence of the strong magnetic field of the polar extensions 67 and 68 of the magnet 51 by which this armature 66 is actuated when in operation. When the magnet 64 was deenergized, the armature 66 was magnetically neutralized and meanwhile, because of the break in the circuit of the magnet 51 caused by the dropping of the armature lever 53 away from the terminal 52, the poles of this magnet also became neutralized, and the armature 66 therefore dropped by gravity or spring at the same time the armature levers 29, 36 and 53 dropped. Under normal conditions the armature levers 29 and 36 are in connection with the insulated rail sections 7 and 8 through the conductors 30 and 37, although a bridge formed by these last-named conductors and the conductors 25 and 31 normally connects these insulated rails with the main track leading to station B. Now, when the lever 53 broke the circuit of the magnet 51, the latter released its armatures 61 and 62 which have therefore moved away from the contacts 43 and 46 and made contact with 45 and 44, thus reversing the current from the main battery 63 through the main circuit conductors 58 and 59 and the magnet 64 at station C, thereby reversing the polarity of the armature 66 of this station and causing the armature levers 27 and 34 to leave the contacts with which they were in engagement and engage the contacts 33 and 40, respectively. When the switch levers 27 and 34 moved away from the terminals of the conductors 28 and 31 they broke the normal bridge between the rails 7—8 and the main track rails 1—2 beyond the station C, but another bridge was immediately formed between the conductor 31, the conductor 38, the contact point 40, the switch arm 34, the contact point 35, the armature lever 36 and conductor 37, thus including the master battery 39. Under these conditions, there is on the track at station C between the track section 8 and the succeeding track section 2 toward station D a difference of potential equal to that of the master battery 39.

The conditions are now such that an engine Y approaching station C in a direction to move toward station B will receive a caution signal. Let it be assumed that the forward trucks of the engine Y have passed the insulation 3—4 and moved on to the track sections 7—8. Now, current from the master battery 39 will flow to the contact lever 34, to and through the armature 35, thence by conductor 37 to the track section 8, and by way of the wheels and axle 69 to the conductor 71, thence by the corresponding arm of the switch 73 to conductor 79 and through the battery 84 in opposition thereto, and from thence to the magnets 83 and 93, returning by way of conductor 77, switch 73, conductor 72, axle and wheels 70, conductor 31, back to the battery 39. This passage of the current from the battery 39 through the battery 84 will neutralize the latter and cause a flow of current in the reverse direction through the magnets 83 and 93, thus instantly reversing their polarity. This will tend to repel or kick the armatures of both magnets away from their respective contact points, but the armature 91 will break the contact at the point 90, and since this armature and contact point are in series with the master battery 39 and cab battery 84 and the magnet 93, that particular circuit is broken and the magnet 93 becomes deënergized and so remains while the caution signal is being exhibited and until it is again energized in a manner which will presently appear. While the action just described has been taking place the armature lever 107, which is under the control of the magnet 93, has also dropped from contact 112 and thus broken the circuit from the contact 112 through the conductor 113, branch conductor 116, the caution end of semaphore signal 117, through conductor 118 and conductor 100 to the battery 103, thence returning by conductor 106 and armature 107 to the contact point 112. The semaphore caution or green signal is so arranged as to be displayed on the break of this circuit, and, consequently, is now visible to the engineman. The armature lever 107, however, has dropped into contact with the point 111, thus closing the circuit through conductor 110, register 109 on the caution or green side, branch conductor 123, conductor 118, conductor 100, battery 103, conductor 106 back to lever 107, this register being arranged to operate on the closing of the circuit. Moreover, when the lever 107 broke contact at 112 it also opened another circuit which may be traced as follows:—from point 112 through conductor 113 to solenoid 114, thence by conductor 115 back to the battery 103 and by conductor 106 to the lever 107. This releases the solenoid 114 and causes the opening of the valve 172 which admits air through pipes 173 and 174 to the whistle 175. This also admits air to the Bourdon tube 178, causing the latter to straighten sufficiently to move the contact arm 143 into position to bridge the contacts 95 and 142 and thereby close the gap normally open at the contact points 95 and 142 in the bridge circuit from the key lever 132 through the branch 133, conductor 134, terminals 136 and 140, normally bridged by the arm 137, thence by conductor 141, terminals 95 and 142 through the contact arm 143, thence by conductor 96 through the magnet 83, conductor 82, battery 84 and conductor 130 back to the terminal 131. Another circuit may be traced through the contact 94′, by conductor 94, through the magnet 93 and back to the battery 84. Now, the engineman by depressing the key lever 132 may close the circuit between the lever 132 and the terminals 94′ and 131, thus exciting the magnet 93 and restoring the armature levers 91 and 107 to their normal positions, thereby closing the air valve 172 and moving the arm 143 away from the contacts 95 and 142, thus opening the gap between them as before. During all this time the magnet 83 has not been affected by the opposition of the battery 39 since there is a by-path around its armature 80 through the conductor 88, armature 87 and conductor 85 back to the conductor 77.

The engineman now runs with caution until he reaches station B, where the appliances are assumed to be set for danger. At this station, however, the bridging circuit around the insulated joints 3 and 4 is broken because the magnet 64 is deënergized and the levers 29 and 36 have fallen away from the respective contact points. Therefore, the circuits fed by the battery 84 and including the magnets 83 and 93 are broken and the armatures 80 and 91 instantly drop, breaking the circuits at the points 81 and 90. The armature lever 107 also breaks the circuit at point 112, thus releasing the solenoid 114 and sounding the whistle, and bridging the contacts 95 and 142 as before. Now, however, the armature lever 80 breaks contact with the point 81, which opens the gap at this point in the circuit between the conductors 72 and 71. This gap, however, is bridged for an instant by the by-path 79, 82, 88, 87 and 85, but such by-path is quickly broken since the lever 99, dropping at the same time as the lever 80, opens the circuit at point 104, thus breaking the circuit by way of conductor 100 and magnet 101 through the battery 103, thence by conductors 106 and 105 back to the contact point 104. The magnet 101, thus becoming deënergized, breaks the bridge at the point 86, and thus gaps are opened in a circuit between the conductors 71 and 72 at the point 90 and point 111, thereby leaving the magnets 83 and 93 deenergized until again excited by the lever 132. Meanwhile, the contact lever 128 has dropped in unison with the lever 87, opening the circuit at point 127. This circuit may be traced through conductor 126, battery 103, conductor 118, branch conductor 119, danger side of the signal apparatus 117, thence by conductor 120 and conductor 129 back to the lever 128. The danger indicator operates on the break of the circuit, causing the semaphore to display the danger or red signal. Now, while this is transpiring the break at point 127 has opened another circuit which may be traced by conductor 126, battery 103, conductor 102, branch conductor 122, solenoid 121, conductor 120, branch conductor 129 back to the armature lever 128. This releases the air valve 148 and admits air to the Bourdon tube 144 through the pipe 145, thus straightening said tube and lifting the contact arm 137 from the contacts 136 and 140 into bridging relation with the contacts 125 and 138. This destroys the bridge that could be established through the conductors 96 and 134 to the key 132. Now, when the arm 137 is lifted into contact with the points 125 and 138 there is established a circuit which may be traced as follows: from the point 138 by branch conductor 139 to conductor 102, thence through the battery 103, conductor 106, conductor 108 to the danger side of the register 109, thence by conductor 124 to the terminal 125. This causes registration of the danger signal.

While the operations just described have been taking place the air valve 148 has admitted air into the cylinder 147, causing the piston-rod 169 to engage the throttle lever 170 and move it to shut off steam from the engine. This action causes the uncovering of a port leading from the cylinder 147 into the pipe 154 and through this pipe air is admitted to the cylinder 153, moving the piston controlling the piston-rod 168 and uncovering a port which admits air to the brake mechanism of the train through a main air pipe 189 receiving air from the reservoir 151 through the pipes 150 and 152. Air also passes by pipe 155 through the valve 165 into the cylinder 156 beneath the piston 157, thus lifting the arm 160 upward out of contact with the terminal 98. The arm 160 is so held until the movement of the piston-rod 168 out from the cylinder 153 brings the finger 167 into engagement with the fork 166 and causes the air valve 165 to be closed, meanwhile bringing the bridging piece 163 across the terminals 135 and 162. Since the air has been cut off from the cylinder 156 by the closure of the valve 165 the plunger in the dash-pot 159 slowly sinks and at the termination of a predetermined time period it carries the arm 160 into contact with the terminal 98. The operation just described causes the bridge from the key lever 132 through the branch conductor 133, conductor 134, terminals 135 and 162, conductor 161, arm 160, terminal 98, branch conductor 97, conductor 96, magnets 83 and 93, battery 84, conductors 94 and 130 and terminals 94′ and 131, to be completed except at the said terminals 94′ and 131 where the circuits may be completed by the depressing of the lever 132.

During the operation just described the brakes have been set and the train is brought to rest while the dash-pot plunger is traveling in a direction to bring the arm 160 into coincidence with the terminal 98. Now, when the gaps between the terminals 135 and 162 and between the arm 160 and terminal 98 have been closed, the engineman can depress the key lever 132 to close the circuits by the terminal 94′ and terminal 131. The magnets 83 and 93 are at once energized and their armatures are lifted to their normal position. At the same time the contact at point 104 is closed and the magnet 101 is energized and lifts its armatures 87 and 128 to close the contacts at 86 and 127, respectively. This causes the energization of the solenoid 121, thus releasing the throttle and brakes and permitting the engineman to start the train.

In the foregoing description reference has been made to several magnets controlling two or more armatures. This has been done largely for convenience of diagrammatic representation and the description of said diagrams. It will be understood, of course, that these armatures can in most instances be simply a single armature controlling a number of circuit terminals in such manner as to carry out the operations described with reference to the diagrams shown. It will also be understood that the magnets are wound with due regard to the office they are to perform. It will likewise be evident that the register 109 and the semaphore signal device 117 may be of any suitable structure, which need not be considered in detail in the description of the present system. Also, the several mechanical structures referred to may all be of known construction, and, therefore, will be sufficiently understood from the diagrammatic representations found in the drawings, without any further detailed description. Furthermore, the batteries will be of suitable size and construction to furnish such current as may be necessary for the operation of the system, and, if desirable, the key lever 132 may be replaced by a simple push-button.

In the foregoing description no account has been taken of the features of the system whereby careless or malicious interference with the operation of the system, on the part of the engineman, is prevented, and these features of the system will now be considered.

It will be understood, of course, that the several mechanisms and circuit connections are all securely sealed against tampering by the engineman, and the only point in the whole system which the engineman can control while the train is in motion is the key lever or push-button 132.

Let there first be considered the normal running conditions. The bridge circuit under the control of the key lever 132, although normally closed at the points 136 and 140, is normally open at the points 95 and 142; and while again there is another bridge circuit under the control of this key lever normally closed at the contact 98 through the arm 160, it is normally open at the contact points 135 and 162. Therefore, under normal conditions, no results can possibly be obtained by the closing of these circuits at the key lever or push-button 132. Now, when the magnet 93 causes the break of the circuit at the point 90 due to the deënergization of the said magnet 93 by the position of the instrumentalities when set to give a caution signal, the caution semaphore is displayed and the caution register is operated, while air is admitted to the whistle and is simultaneously admitted to the tank 176. But since the passage to the tank 176 is more or less throttled, a predetermined time period elapses before the Bourdon tube 178 operates to close the contact between the terminals 95 and 142. Thus, before the restoring bridge circuit can be made active by the manipulation of the key lever 132 the various operations incident to the conditions present when a train has reached the caution zone, have all been performed, and it is only after the completion of these various operations that the engineman can by any possibility affect the circuit conditions, and then the only result of the closing of the circuit by the key lever 132 is to restore the normal running conditions and at the same time renew the non-interference features.

When the danger zone is reached both magnets 83 and 93 are deënergized and their armatures are dropped. As before explained, this causes the solenoid 114 to open the air valve 172 and sound the whistle, and then, after a short time interval, to cause the closure of the circuit across the contacts 95 and 142. Now, the closing of these contacts would so complete the bridging circuit controlled by the key lever 132 that the engineman might interfere with the further operation of the system were it not for the fact that the deënergization of the magnet 83 had caused the magnet 101 to become deënergized and thus released the solenoid 121 and opened the air valve 148. Because of the sluggish action of the air upon the Bourdon tube 178 the Bourdon tube 144, which, because the air has free access thereto, acts quickly, has caused the rupture of the circuit at the points 136 and 140 in advance of the closure of the circuit at the points 95 and 142. The bridge circuit from the key through the conductors 94 and 134 thus remains broken. At the same time the air entering the cylinder 153 has closed the other bridge circuit through the key 132 at the points 135 and 162, but it has also broken this circuit at the point 98 by moving the arm 160 away therefrom, and it is only after a predetermined time interval that the arm 160 is again brought into contact with the terminal 98. Thus, in each case, there is an appreciable time interval before an active circuit can be closed by the manipulation of the key 132, and during this time the several operations described and due to the conditions present in the danger zone, have taken place. Now, when the key 132 is depressed and completes the bridge circuit the parts are all returned to their normal condition, when interference on the part of the engineman is out of the question.

It will be seen from the foregoing that under no conditions, whether the train be running or standing still, can the engineman by depressing the key or push-button 132, or in any other manner, either prevent, falsify or otherwise interfere with the automatic operation of the cab appliances. There is one specific condition, however, which might arise under which the engineman should possess means under his control for evading the rigid restrictions of the system.

Suppose that by some chance an engine should stop at station B with the trucks directly upon the insulating sections 3—4 and with the bridge between the section 8 and the track 2 broken, which is the condition when station B is in the danger zone. Under these conditions, the danger signal will be set and all the operations attendant to the same will be performed, but since the circuit through the conductors 71 and 72 is broken at the insulating sections 3—4, the closing of the circuit by the key 132 will have no effect and the train will be stalled since the brakes will continue in their applied condition and the engineman will be unable to either release the brakes or to again open the throttle. Provision, however, has been made to meet such an emergency. Beneath the engine, out of reach of the engineman when the engine is moving, there is located the manual valve 180 in the pipe 179 leading to the Bourdon tube 181 and, by the branch pipe 182, to the air cylinder 183. Under the conditions just described the engine is, of course at a standstill, and the engineman may then step off the engine and reach beneath the same and move the valve 180 to admit air from the reservoir 151 to the pipe 179. This air enters the tube 181 and tends to straighten the same and simultaneously enters the cylinder 183 and, acting on the piston 184, causes the piston-rod 185 and contact plate 186 to move toward the contact end of the tube 181. In the meantime, however, the straightening of the tube 181 has moved the contact end thereof out of the path of the plate 186. Now, when the piston 184 has reached the uppermost limit of its travel the engineman releases the valve 180, which may be of the self-closing type, and thus shuts off air from the tube 181 and the latter returns to its normal bent condition, bringing its end into contact with the plate 186. Since the air is also shut off from the cylinder 183 the piston 184, which, in conjunction with the cylinder 183 may be made to operate after the manner of a dash-pot, moves slowly toward its initial position, thus carrying the contact plate 186 by the contact end of the tube 181. Now, by way of the conductors 187 and 188 and the tube 181 and contact plate 186 there is established a shunt across the conductors 71 and 72. The time element entering into the operation of the devices just referred to is sufficient to enable the engineman to again mount into the cab and press the key or button 132 and thereby reëstablish the normal running conditions, and the time consumed in the return of the piston 184 to its initial position is such that the engineman may start the engine and carry the wheels from off the insulating sections 3—4.

Now, the emergency mechanism just described cannot be tampered with because so long as the valve is open the tube 181 is straightened and the circuit is broken. Hence, it is only after the valve 180 has been closed to allow the escape of the air subsequent to the introduction thereof into the tube and cylinder, that the device becomes operative.

It will be understood, of course, in relation to this emergency device, that all the structure except the valve 180 is inclosed and sealed against tampering by the engineman. Therefore, in view of the mode of operation, it will be seen that it is not within the power of the engineman to cause the closure of the shunt circuit across the conductors 71 and 72 except in the manner described, and then only after a limited period of time. Also, this can only be done when the engine is at a standstill, and need only be done under the rarely occurring conditions of an engine stopping with its truck upon the insulating sections 3 and 4.

The switch 73 is a simple pole-changing switch by means of which the cab circuit leads may have their relation to the cab circuits properly established whenever the engine is turned to run in the opposite direction from that heretofore considered.

There is still one more contingency to be considered, and that is the conditions which arise should one of the track insulations break down, for it at once becomes a menace to the safety of the system, and, therefore, due warning must be signaled to approaching trains, while the record of such signals will also give notice that an inspector's attention is required. Let it be supposed that the insulating section 4 at station B breaks down. The closed circuit, which may be traced from track section 2 through conductor 31, battery 32, armatures 34 and 36, conductor 37 to track section 8, thence returning by conductor 30, armatures 29 and 27, conductor 26 through magnet 24 and back to track section 2, is thus diverted to a circuit which may be traced from track section 2 through conductor 31, battery 32, armatures 34 and 36, conductor 37, track section 8 and across the bridge around the broken down insulation 4 to the track 2. The magnet 24 is thus shunted, causing the armature 21 to be dropped and break the circuit with the conductor 22, thus breaking the circuit from the magnet 19 through the conductor 20, armatures 21 and 14, conductor 17, track section 1, thence by battery 10, bridging the track sections 1 and 2, back through the conductor 18 to the magnet 19. The result of this is that the magnet 19 is deënergized and its armature 47 is dropped away from the contact 60, thus breaking the main line circuit 58—59 between the stations and setting the devices at station C for danger and at station D for caution, the same as though engine X had entered upon the track section controlling station B. This, of course, gives warning to any approaching train that there is trouble ahead. Again, suppose that the insulating section 3 breaks down. There is then established a circuit from battery 32, through conductor 37 to the rail section 8, thence through battery 9 to the rail section 7, around the bridge across the broken down insulation 3 to the track section 1, then across by the battery 10 to the rail 2 and by conductor 31 back to the battery; or, the return circuit from the track 1 to the track 2 may be through conductors 17 and 20 of the next station and by magnet 19 and conductor 18 back to the track 2. In either case, the battery current is diverted from the magnet 24 and the latter is so weakened as to drop its armature 21 and establish the danger conditions at station C and caution conditions at station D.

Now, let is be assumed that the insulating joint 5 breaks down. Then the first arriving engine which passes upon and spans the insulated rail sections 7—8 short circuits the battery 9 and weakens the magnet 12 and permits its armatures 14 and 15 to drop. This shunts the battery 10, which weakens the magnet 19 fed thereby, causing the opening of the main circuit 58—59 and the establishment of the usual conditions for danger and caution to the stations ahead, as before. Likewise, should the insulating section 6 break down, an arriving train shunts the magnet 12 and the magnet 19 is again weakened and drops its armature and the danger and caution conditions again prevail.

The entire electrical system is on normal closed circuit and it will be seen that should there be a break in any of the circuit connections upon the track, or should there be a broken rail, or should a switch be misplaced, the danger and warning signals would be transmitted in the manner already described. Or should a detached truck or a pair of wheels, by any chance, lodge directly upon the insulated rail sections 7 and 8 and so become a menace to traffic, these rails being shunted the magnet 12 will be weakened and the signals will be transmitted as before. Again, should the main conductors 58 and 59, or either of them, be ruptured, the deënergization of the magnet 64 will cause the establishment of the danger and cautionary conditions in the succeeding stations. Or should a circuit in the cab break down, the danger conditions are immediately established and the train is automatically stopped.

The system requires but one complete main circuit, that is, there are but two main circuit conductors extending from station to station instead of four or more, as heretofore, while at each station the combination relay, illustrated separately in Fig. 4, acts as the intermediary which virtually links adjacent mains and forms of them a complete interchain through which the varied signals find their proper destinations. It is by reason of this polarized pole-changer, shown in Fig. 4, that when caused to operate through the break of a main circuit connecting the station to the preceding station and so setting the devices at the station under consideration that danger signals will be transmitted to the cab of an oncoming train, that the circuit connections to the succeeding station are not broken but the current simply diverted through a path which will maintain the circuit connections intact, but by reversing the direction of current will cause the polarized relay at the said succeeding station to establish conditions which will cause cautionary signals to be displayed and sounded on an engine entering the caution zone.

I claim:—

1. In an electric safety signal system for railways, normally closed, charged electric circuits on moving trains, signal devices on the trains held inactive by said closed circuits, other electric circuits disposed along the line of way and each adapted to be coupled into the normally closed charged train circuits, a normally inactive source of current for each of said circuits along the line of way sufficient to overpower the charging source of the closed, charged train circuits, and means for including said normally inactive current source in the respective circuits along the line of way.

2. In an electric safety signal system for railways, normally closed, charged circuits on the train, signal devices on the trains held inactive by the said train circuits, normally closed electric circuits along the line of way coacting with the train circuits, and means for including in any one of the circuits along the line of way a normally inactive source of current sufficient to overpower the charging source of the train circuit on a change in the normal condition of the closed circuit along the line of way to cause the operation of an appropriate signal.

3. In an electric safety signal system for railways, block stations along the line of way; continuous rail sections between the blocks; insulated rail sections interposed between the continuous rail sections at the block stations; charged electric circuits at each station including the rails approaching the station; an electrically operated switch mechanism controlled by said circuit; another charged circuit leading to the next station and including the aforesaid switch and controlling a polarized, switch-operating mechanism, and normally closed, charged electric circuits at each station controlled by the polarized mechanism which, in turn, is controlled by the switch mechanism at the preceding station.

4. In an electric safety signal system for railways, block stations disposed along the line of way; a normally closed, charged electric circuit at each station including the traffic rails approaching said station; a magnet in said charged circuit; a switch under the control of said magnet; another normally closed, charged electric circuit including said switch and extending from one station to the next station; a polarized circuit-controlling and pole-changing mechanism at each station controlled by the charged circuit coming from the preceding station; insulated traffic rail sections at each station, and charged electric circuits including said insulated sections of the traffic rails and also controlled by the polarized switch and pole-changer.

5. In an electric safety signal system for railways, block stations disposed along the line of way; traffic rails having insulated sections at each station; a normally closed, charged electric circuit including the traffic rails approaching the station and an electromagnetic switch-operating means; another normally closed, charged circuit including one of the insulated sections of the traffic rails; switches included in said last-named circuit; another normally closed, charged electric circuit including a switch controlled by the first-named circuit and extending to the next succeeding station and there controlling the switches in the second-named circuit; and means whereby a break of circuit between two stations will cause a reversal of current through the circuit coupling the second station to the third station in order.

6. In an electric safety signal system for

railways, block stations arranged along the line of way; insulated rail sections included in the traffic rails at the stations; a normally closed, charged electric circuit at each station; a normally inactive source of current; means at each station under the control of the electric circuits coming from another station for including the normally inactive source of current; an open circuit including the traffic rails on each side of the insulating points, and normally closed, charged electric circuits on each train, arranged to close the normally open, charged, block-station circuit and responsive to the current from the normally inactive source at the block station.

7. In an electric safety signal system for railways, block stations along the line of way; a charged electric circuit at each block station; another charged electric circuit upon a train and arranged to be coupled with and overpowered by the source of current in the block-station circuit; other electric circuits upon the train, and electro-responsive means in the first-named train circuit arranged to control the other train circuits when coupled to and controlled by the source of current at the block stations.

8. In an electric safety signal system for railways, block stations along the line of way; normally closed, charged electric circuits at said block stations; means for opening the charged circuit at one block station and reversing the direction of current flowing in the corresponding circuit in the next succeeding block station, and normally closed, train carried circuits arranged to be coupled to and operatively controlled by the reversed circuit at a block station to cause the actuation of a predetermined signal or set of signals, and to be placed on open circuit by the open circuit at the other block station to cause the operation of other predetermined signals.

9. In an electric safety signal system for railways, block stations along the line of way; normally closed, charged electric circuits at said block stations; means for opening the charged circuit at one block station and reversing the direction of current flowing in the corresponding circuit in the next succeeding block station; normally closed, train carried circuits arranged to be coupled to and operatively controlled by the reversed circuit at a block station to cause the actuation of a predetermined signal or set of signals, and to be placed on open circuit by the open circuit at the other block station to cause the operation of other predetermined signals, and manually operative means on the train for restoring the normal conditions of the several circuits.

10. In an electric safety signal system for railways, a cab or train system comprising a normally closed charged circuit, another circuit normally closed by the first named circuit and including caution signals, still another circuit normally closed by the first named circuit and including danger signals, and means along the track for establishing electrical conditions causing rupture of the caution circuit and consequent actuation of said signal under predetermined traffic conditions, and of the danger circuits, and the consequent actuation of the said danger signal under other predetermined traffic conditions.

11. In an electric safety signal system for railways, a cab or train system comprising a normally closed, charged electric circuit; another normally closed, charged electric circuit under the control of the first-named circuit; air-brake and throttle-operating means under the control of the second circuit and rendered inactive so long as this circuit is maintained intact, and block stations along the line of way with normally closed electric circuits and inactive to the cab circuits under normal conditions but rendered active thereto by a change from the normal conditions.

12. In an electric safety signal system for railways, normally charged electric circuits along the line of way, closed electric circuits on the trains controlling cautionary and danger devices, and means for establishing circuits along the line of way and within a predetermined distance of a point of danger, electrical conditions causing rupture of the train circuits controlling the danger devices upon a train entering the danger zone, and thus effecting the actuation of said danger devices, said means also establishing in the circuits along the line of way and within a greater predetermined distance from the point of danger, electrical conditions causing the rupture of the train circuits controlling the caution devices upon a train entering the more distant or cautionary zone.

13. In an electric safety signal system for railways, mechanically operated means upon a train for the actuation of cautionary and safety devices upon a train; normally closed electric circuits for holding said devices in inoperative positions; block stations along the line of way, and means at the block stations rendered operative by the presence of a predetermined danger condition to control the circuits constraining the safety devices to release the latter to active operation.

14. In an electric safety signal system for railways, mechanically operated means for the actuation of cautionary and safety devices; normally closed electric circuits for holding said devices in inoperative positions; block stations along the line of way; means at the block stations rendered operative by the presence of a predetermined danger condition to control the circuits constraining the safety devices to release the latter to active

operation, and another electric circuit rendered active through a manually operated circuit-closer after a predetermined time period, sufficient to permit the full operation of the safety devices, for restoring the ruptured circuits.

15. In an electric safety signal system for railways, normally closed, charged electric circuits grouped at appropriate stations along the line of way, a closed circuit extending between each station and the next station and controlled at one station by one of the normally closed circuits at said station, and including a source of current at said station, and a polarized relay mechanism at the next succeeding station; means at one station for breaking the main circuit leading to the next station and thereby rupturing the closed circuits at the second station, means at the third station controlled by the reversed circuit at the second station, for reversing the circuits at said third station, and train carried circuits and signal devices responsive to the reversed and broken circuits to cause the operation of an appropriate signal in accordance with the electric conditions at the particular block station at which the train is located.

16. In an electric safety signal system for railways, mechanically operated, air-brake controlling means upon each train; closed electric circuits holding said air-brake means normally inactive; means for opening the electric circuits to cause the application of the brakes; a normally inactive, manually operative, circuit-closing means for restoring the continuity of the electric circuits, and other manually operated means, operative after a predetermined time limit, to cause the closure of the restoring circuit under the control of the first-named manual circuit-closing means.

In testimony that I claim the foregoing as my own, I have hereto affixed my signature in the presence of two witnesses.

GARDNER B. GRAY.

Witnesses:
George C. Buell,
Madge Kerns.