May 18, 1937. E. M. ALLEN ET AL 2,080,801

RAILWAY SIGNALING APPARATUS

Filed June 19, 1935 2 Sheets-Sheet 1

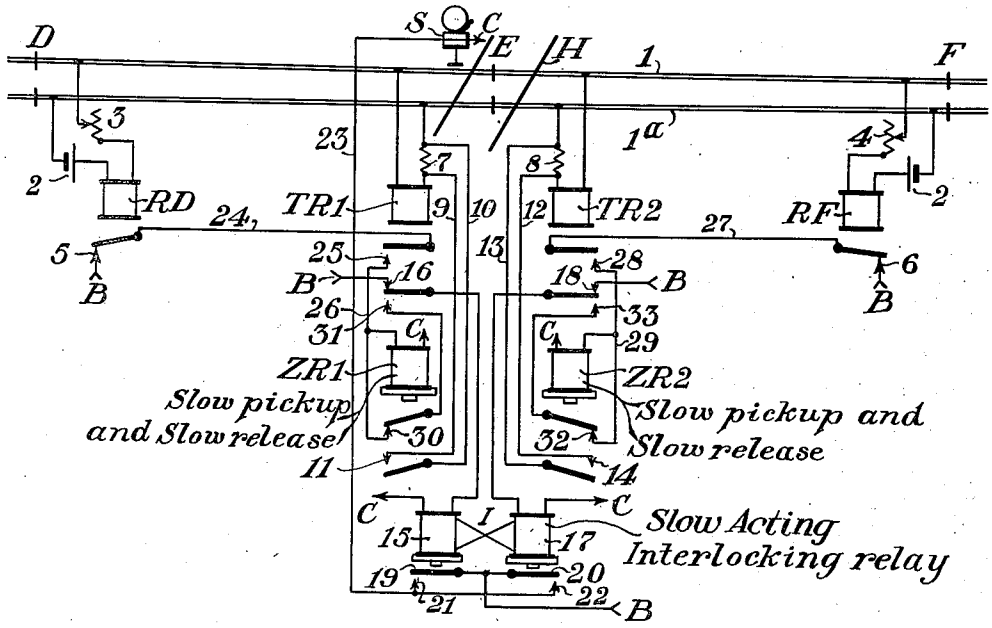


Fig. 1.

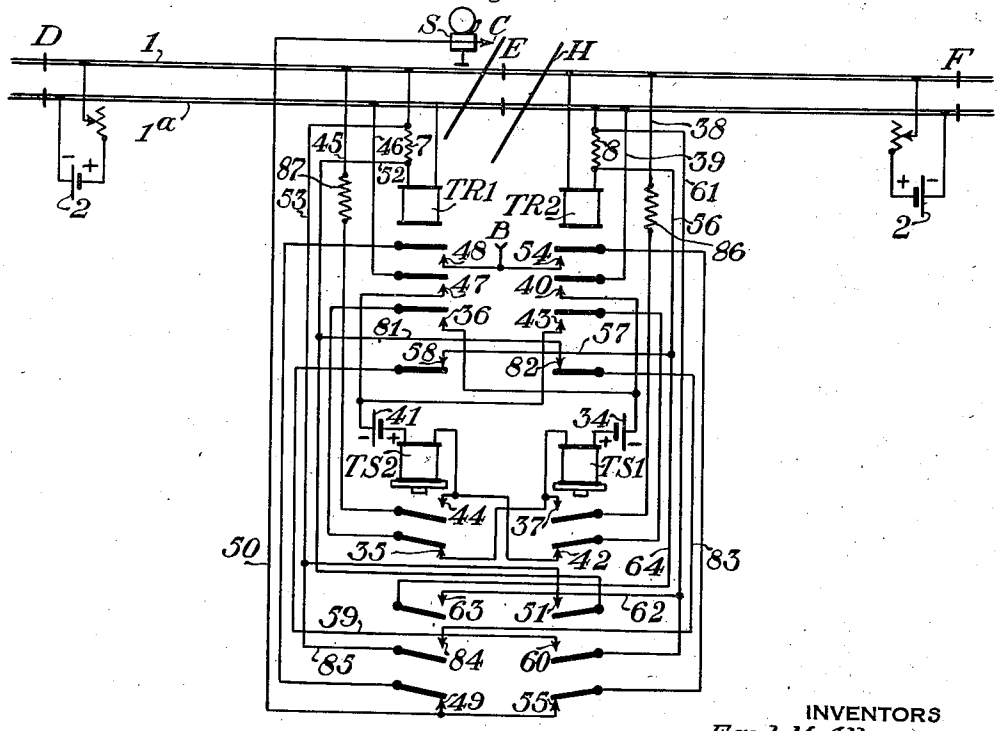


Fig. 2.

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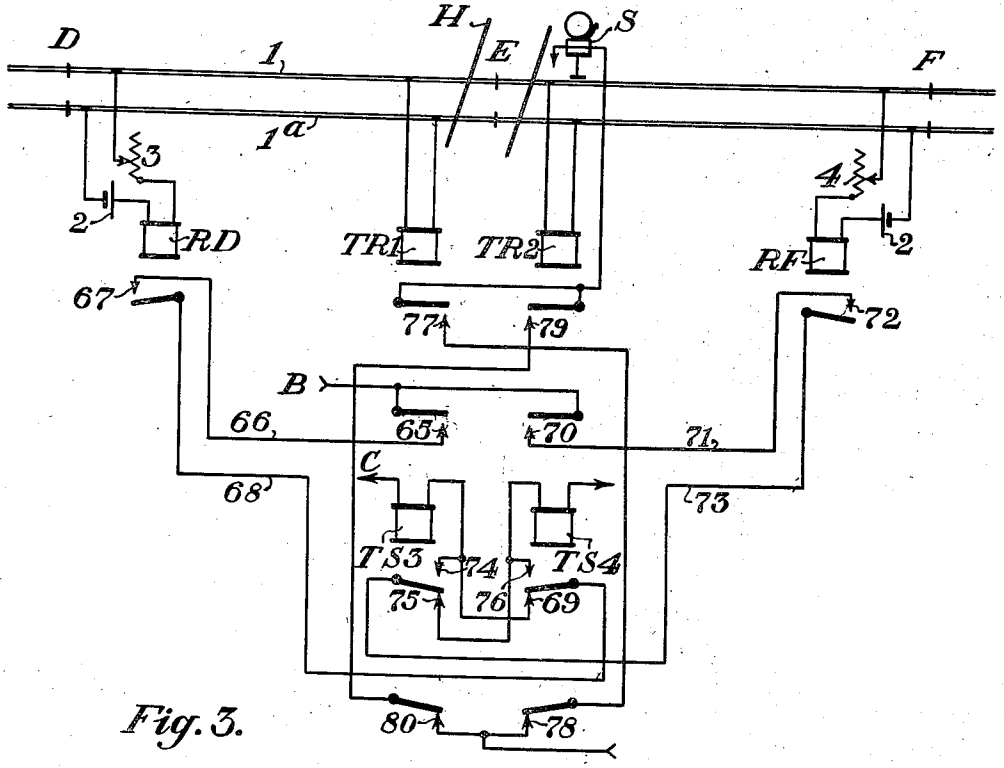


Fig. 3.

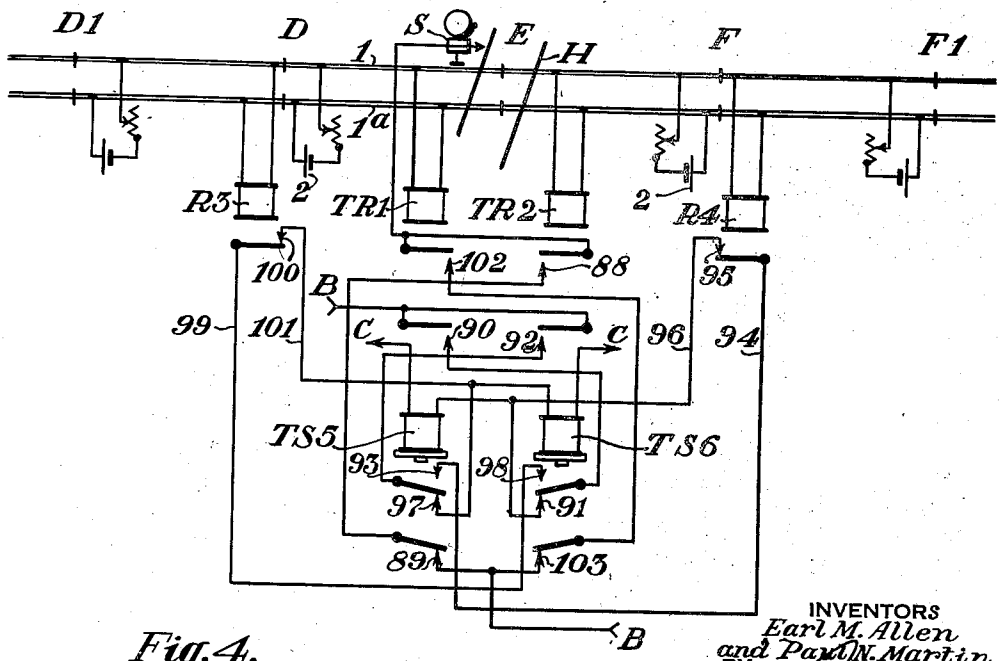


Fig. 4.

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Patented May 18, 1937 2,080,801

UNITED STATES PATENT OFFICE

2,080,801

RAILWAY SIGNALING APPARATUS

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Application June 19, 1935, Serial No. 27,400

17 Claims. (Cl. 246—130)

Our invention relates to railway signaling apparatus, and particularly to apparatus of the type comprising a highway crossing signal located at the intersection of a railway and a highway and controlled by traffic conditions in the adjacent stretch of railway track.

A feature of our invention is the provision of apparatus for establishing a directional control in response to a train travelling over a stretch of railway track, and wherewith release of such directional control is accomplished by two independent means. Another feature of our invention is the provision of novel and improved apparatus of the type here involved wherewith increased sensitivity of the track circuit is effected and loss of directional control due to a relatively high train shunt resistance is avoided.

We will describe four forms of apparatus embodying our invention, and will then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a diagrammatic view illustrating one form of apparatus embodying our invention, and wherewith directional control is effected through the medium of an interlocking relay. Fig. 2 is a diagrammatic view illustrating a second form of apparatus embodying our invention, and wherewith directional control is effected through the medium of stick relays. Figs. 3 and 4 are diagrammatic views of modified forms of the apparatus of Fig. 2, and which forms of apparatus also embody our invention.

Similar reference characters refer to similar parts in each of the views.

Referring first to Fig. 1, the reference characters 1 and 1a designate the traffic rails of a stretch of railway track which is intersected at grade by a highway H. By means of the usual insulated rail joints, the traffic rails 1 and 1a are divided into two track sections D—E and E—F, the junction E of these two track sections being at or near the intersection with the highway H. Each of these track sections is provided with a track circuit comprising a source of current connected across the traffic rails at one end of the section and a track relay connected across the traffic rails at the opposite end of the section. As here shown, the source of current for each of these track circuits is a battery designated by the reference character 2, the battery 2 for the track circuit for the section D—E being connected across the traffic rails at the left-hand end of the section in series with a relay RD and a resistor 3, and the battery 2 for the track circuit for the section E—F being connected across the rails at the right-hand end of the section in series with a relay RF and a resistor 4. The relays RD and RF are each of the low resistance type which is so adjusted that the normal flow of current supplied by the track battery 2 when the section is unoccupied is not sufficient to energize the winding of the relay to a degree where its armature is picked up, but that the increased flow of current caused by a train occupying the section and shunting the traffic rails is sufficient to energize the relay to a degree where its armature is lifted out of engagement with its back contact. Consequently, the back contacts 5 and 6 of the relays RD and RF, respectively, are normally closed and are opened in response to a train occupying the respective track section. The track relays TR1 and TR2 of the track circuits for the sections D—E and E—F, respectively, are located at the junction of the two sections and the operating winding of each relay is connected with the rails of the section in series with a resistor, a resistor 7 being interposed in the connection of the relay TR1 and a resistor 8 being interposed in the connection of the relay TR2. As will be explained more fully hereinafter, the resistors 7 and 8 are each at times short-circuited, the short-circuit connection for the resistor 7 comprising wires 9 and 10 and a front contact 11 of a relay ZR1, and the short-circuit connection for the resistor 8 comprising wires 12 and 13 and a front contact 14 of a relay ZR2.

Directional control is established through the medium of an interlocking relay designated by the reference character I. The operating windings of the relay I are supplied with current from any convenient source such as a battery not shown and whose opposite terminals are designated by the reference characters B and C. The left-hand operating winding 15 of relay I is normally supplied with current over a simple circuit which includes a front contact 16 of the track relay TR1, and the right-hand operating winding 17 of relay I is normally supplied with current over a simple circuit which includes a front contact 18 of the track relay TR2. Interlocking relay I may be one of several different types for such relay. Many arrangements for interlocking the armatures of the two electromagnets of such relay being well known in the art, it is deemed sufficient for the present application to point out that in accordance with usual practice, the armatures 19 and 20 of relay I are operated by the operating windings 15 and 17, respectively, the arrangement being such that with the operating windings 15 and 17 both energized both

armatures 19 and 20 are lifted out of engagement with the respective back contacts 21 and 22. When the winding 15 is deenergized and winding 17 remains energized, the armature 19 falls due to its own weight into engagement with its back contact 21 and in falling it actuates the interlocking feature between the two armatures so that subsequent deenergizing of the winding 17 to release its armature 20, the armature 20 is mechanically held from falling into engagement with its back contact 22. Should the winding 15 be reenergized while the winding 17 is still deenergized, the interlocking feature still retains the armature 20 out of engagement with its back contact 22 but that reenergizing of the winding 17 subsequent to such reenergizing of the winding 15, lifts the armature 20 and releases the interlocking. Should the winding 17 be deenergized and winding 15 remain energized, the armature 20 is free to fall into engagement with the back contact 22 and in so doing it actuates the interlocking feature and the armature 19 is held from falling into engagement with its back contact 21 in the event the winding 15 should subsequently be deenergized. Release of the armature 19 is accomplished in a manner similar to that just explained for releasing the armature 20. The relay I is preferably slightly slow acting, that is, both sides of the relay are provided with short slow release and slow pick-up periods and which periods are substantially equal. The directional control effected by the relay I and the manner of releasing such directional control will be explained when the operation of the apparatus of Fig. 1 is described.

As here shown, the relay I controls the operation of a highway crossing signal S located at the intersection of the highway H with the railway track. Signal S may be of any standard type for such highway crossing signals and is here shown as an audible signal in the form of an electric bell. The signal S is provided with two operating circuits one of which extends from the B terminal of the source of current over the armature 19 operated by winding 15, back contact 21, wire 23, magnet of signal S, and to the opposite terminal C of the same source of current. The second operating circuit extends from the B terminal of the current source over the armature 20 operated by winding 17, back contact 22, wire 23, magnet of signal S, and to the C battery terminal. It follows that the signal S is normally silent and is set into operation when either one of the operating windings 15 or 17 of the interlocking relay I is deenergized and its respective back contact is closed.

The relay ZR1 is associated with the track circuit of the track section D—E, and the relay ZR2 is associated with the track circuit for the section E—F, and each of these relays ZR1 and ZR2 is provided with slow pick-up and slow release characteristics. Both relays ZR1 and ZR2 are normally deenergized, and are energized by virtue of a circuit governed by the associated track circuit. Looking at relay ZR1, an energizing circuit may be traced from the B terminal of the current source over back contact 5 of relay RD, line wire 24, back contact 25 of track relay TR1, wire 26, winding of relay ZR1 and to the opposite terminal C of the same source of current. A similar circuit is provided for the relay ZR2 and which is traced from the B terminal of the source of current over back contact 6 of relay RF, line wire 27, back contact 28 of track relay TR2, wire 29, winding of relay ZR2 and to the battery terminal C. The function of these two slow pick-up slow release relays ZR1 and ZR2 will shortly appear.

In describing the operation of the apparatus of Fig. 1, we shall first assume that both track sections D—E and E—F are unoccupied, the apparatus is in the position illustrated, and an eastbound train, that is, a train moving from left to right, enters the stretch of track shown in the the drawings. When the train enters the section D—E and shunts the traffic rails, the track relay TR1 is deenergized and its armature is released. The fact that the resistor 7 is normally interposed in the connection of the winding of relay TR1 establishes a relatively low working value of current for that relay with the result that the current flowing in the winding of the relay is quickly reduced to the drop-away value of current and the relay is released even in the case of a relatively high train shunt resistance. The current supplied by the battery 2 to the rails of the section D—E is increased due to the train shunt and the relay RD is picked up. The release of the track relay TR1 opens the front contact 16 in the circuit for the operating winding 15 of relay I and that winding is deenergized and its armature 19 is released at the end of its release period to fall into engagement with the back contact 21 and to actuate the interlocking feature of the relay in the manner explained hereinbefore. The signal S is now set into operation to warn the highway users since its operating circuit which includes the contact 19—21 of relay I is closed. Thus, operation of the signal S is effected and the directional control is established upon the eastbound train entering the section D—E. When the eastbound train advances and enters the section E—F, the track relay TR2 is quickly released since the resistor 8 is normally interposed in the connection with the winding of that relay and the working value of current supplied thereto is relatively low. The current supplied to the rails of the section E—F is now increased due to the train shunt and relay RF is picked up. The release of the track relay TR2 opens the energizing circuit for the winding 17 of relay I and that winding is deenergized, but the armature 20 controlled by the winding 17 is restrained from falling into engagement with its back contact 22 by virtue of the interlocking feature of the relay. When the rear of the train passes out of section D—E, the current supplied by the battery 2 to the rails of that section is reduced and the relay RD releases its armature and closes the back contact 5. The parts are so proportioned and adjusted that ordinarily the current supplied to the winding of the track relay TR1 through the resistor 7 is less than the pick-up value of current and hence its armature remains in engagement with the back contacts after the train vacates the section D—E. Under this condition, current is supplied to the relay ZR1 over the circuit including the back contact 5 of relay RD and the back contact 25 of relay TR1 and relay ZR1 is picked up at the end of its slow pick-up period. Current is also supplied to the winding 15 of relay I in parallel with the winding of relay ZR1 over a circuit traced from battery terminal B, back contact 5 of relay RD, line wire 24, back contact 25 of relay TR1, wire 26, back contact 30 of relay ZR1, a second back contact 31 of relay TR1, winding 15 and to the opposite battery terminal C, and winding 15 is energized and the armature 19 is lifted at the end of its slow pick-up period out of engagement with the back contact 21 with

the result that operation of the signal S is stopped since the interlocking feature of the relay I restrains armature 20 from making engagement with the back contact 22. The relay ZR1 on picking up and closing its front contact 14 completes the short-circuiting path around the resistor 7, and the track relay TR1 is picked up due to the increased flow of current supplied to its winding. Relay TR1, on picking up, opens the circuit to the relay ZR1 and that relay is deenergized and its armature is released at the end of its slow release period. Winding 15 of relay I is now retained energized over its normal circuit which includes the front contact 16 of relay TR1. It is clear that even for a light weight high speed train whose train shunt resistance may be relatively high, the release of the track relay TR2 and deenergizing of winding 17 and release of its armature 20 prior to the picking up of armature 19 are assured due to the high sensitivity of relay TR2 and due to the fact the pick-up period of armature 19 is equal to the release period of armature 20 with the result that a loss of directional control is avoided. In other words, a loss of directional control for such light weight high speed train is avoided and operation of the signal S while such a train recedes from the crossing is prevented.

When the eastbound train recedes from the highway crossing and vacates the section E—F, the relay RF is released but the relay TR2 ordinarily remains down due to the fact that the current supplied to its operating winding through the resistor 8 is less than the pick-up value of current for that relay. The relay ZR2 is now supplied with current over the back contact 6 of relay RF and the back contact 28 of relay TR2 and relay ZR2 is picked up at the end of its slow pick-up period. The winding 17 of relay I is supplied with current in parallel with the winding of relay ZR2, the circuit being traced from the B battery terminal over back contact 6, line wire 27, back contact 28 of relay TR2, wire 29, back contact 32 of relay ZR2, a second back contact 33 of relay TR2, operating winding 17 and to the opposite battery terminal C. The winding 17 on being energized, raises its armature 20 and releases the interlocking feature of the relay I. The relay ZR2 on picking up, closes at its front contact 14 the short-circuiting path around the resistor 8 and the relay TR2 is picked up due to the increased flow of current supplied to its winding. Relay TR2 on picking up deenergizes the relay ZR2 by opening the back contact 28 and relay ZR2 is released at the end of its slow release period. Winding 17 is now retained energized over its normal circuit which includes front contact 18 of track relay TR2. Hence, the apparatus is restored to its normal position subsequent to the eastbound train vacating the section E—F.

It is to be noted that in the event the track circuit for the section E—F should fail while the eastbound train is passing therethrough due to a broken rail, loss of energy from battery 2 or a broken coil wire for the relay TR2, the winding 17 is supplied with current over the circuit including the back contact 32 of relay ZR2 and armature 20 is picked up and the directional control is released prior to the picking up of the relay ZR2. In the event of such failure, relay ZR2 is picked up at the end of its slow pick-up period and is retained energized, and the circuit for the winding 17 is opened at the back contact 32 and the armature 20 is again released. Since the interlocking feature of relay I was released when the winding 17 was reenergized and the armature 20 picked up, the armature 20 is now free to drop into engagement with the back contact 22 and operation of the signal S is effected to indicate such failure of the track circuit for the section E—F. In addition to the above release of the directional control through the medium of the circuit including the back contact 32 of relay ZR2, the winding 17 is energized and the directional control is released by the circuit including the front contact 18 of track relay TR2. In other words, two independent circuits either one of which is effective to release the directional control are provided. It follows, therefore, that two separate circuits for releasing the directional control are provided, one of which circuits is effective notwithstanding a failure of the usual track circuit, and the signal S is operated to both indicate such failure and to warn highway users. Hence, the highway users are not without warning in the event a westbound train, that is, a train moving from the right to the left, should later approach the highway, whereas, if release of the directional control is made dependent upon the track circuit alone as has been the custom heretofore, a failure of the track circuit such as recited above leaves the directional control set up and the signal S would not be operated if a westbound train approaches the highway. Again, a normal condition of relative high sensitivity for the track circuits is provided, and an increased current flow for picking up the track relay is available but which increased flow of current is not effected until the track section is vacated.

It is clear the apparatus of Fig. 1 will function for a westbound train, that is, a train moving from the right to the left, in a manner similar to that just described for an eastbound train.

In Fig. 2, the stretch of railway track is intersected by the highway H and is arranged into track sections D—E and E—F the same as in Fig. 1. The track circuits for each of the two track sections is the same as in Fig. 1 except for the fact that the relays RD and RF are omitted, and the resistors 7 and 8 are each provided with two short-circuiting paths to be described hereinafter.

The directional control of the operation of the highway crossing signal S of Fig. 2 is accomplished through the medium of two directional stick relays TS1 and TS2, the relay TS1 being effective for eastbound traffic and the relay TS2 being effective for westbound traffic. Looking at the eastbound directional relay TS1, this relay is controlled by virtue of a pick-up circuit and a stick circuit both of which are supplied with current from a battery 34. The pick-up circuit may be traced from the battery 34 through winding of the relay TS1, back contact 35 of the westbound directional relay TS2, back contact 36 of track relay TR1 and thence back to the battery 34. The stick circuit includes the battery 34, winding of relay TS1, its own front contact 37, resistor 38, wire 39 to the rail 1 of section E—F, thence through the wheels and axles of a train occupying that section to the rail 1a, wire 39, back contact 40 of relay TR2 and to the battery 34. It is to be seen, therefore, that the eastbound directional relay TS1 is picked up in response to an eastbound train first occupying the section D—E and is then held energized when this train subsequently occupies the section E—F over its stick circuit which is completed through the train shunt. Furthermore, it is to be noted that the

holding current is less than the pick-up value of current due to the resistor 86 being interposed in the stick circuit. The westbound directional relay TS2 is likewise provided with a pick-up circuit and a stick circuit, the pick-up circuit including battery 41, operating winding of the relay, back contact 42 of the eastbound directional relay TS1, back contact 43 of the track relay TR2 and thence to the battery 41; and the stick circuit including battery 41, winding of relay TS2, its own front contact 44, resistor 87, wire 45 to the rail 1 of section D—E, thence through the wheels and axles of a train occupying that section to the rail 1a, wire 46, back contact 47 of relay TR1 and to the opposite terminal of battery 41. Hence the westbound directional relay TS2 is picked up in response to a westbound train first occupying the section E—F and is then held energized when that train subsequently occupies the section D—E by virtue of its stick circuit which includes the train shunt, the current supplied over the stick circuit being less however than the pick-up value of current due to the resistor 87 being interposed in the stick circuit.

As will appear when the operation of the apparatus in Fig. 2 is described, the directional relays TS1 and TS2 cooperate with the track relays TR1 and TR2 for governing the operation of the highway crossing signal S, and the short-circuiting connections around the resistors 7 and 8.

In describing the operation of the apparatus in Fig. 2, we should first assume that both track sections are unoccupied, the apparatus occupies the position illustrated in the drawings and an eastbound train approaches the highway crossing. When the eastbound train enters the section D—E and shunts the track relay TR1 that relay is quickly released, the release being expedited due to the fact that the resistor 7 is normally in circuit with the operating winding of the relay. The track relay TR1 upon being released closes its back contact 48 and completes an operating circuit for the signal S which circuit also includes a back contact 49 of the westbound directional relay TS2, wire 50, and magnet of the signal S. Thus the signal S is set into operation to warn the highway users immediately following the eastbound train entering the section D—E. The track relay TR1 upon being shunted also closes its back contact 36, and the eastbound directional relay TS1 is picked up over the pick-up circuit previously traced. When the eastbound train advances through the track section D—E and enters the track section E—F, the track relay TR2 is shunted and is released, its release being expedited due to the fact the resistor 8 is normally interposed in the connection with the operating winding of that relay. The shunting of the traffic rails of the section E—F by the train also completes the stick circuit for the directional relay TS1 and hence that relay is retained energized even after the rear of the train passes the crossing and vacates the track section D—E. Since the relay TS1 is thus retained energized and its front contact 51 is closed, the resistor 7 is short-circuited by a connection which includes wire 52, front contact 51 of relay TS1 and wire 53 with the result that full rail voltage for the section D—E is applied to the operating winding of the relay TR1 to pick up that relay when the train vacates the section D—E. When the relay TR1 is picked up and its back contact 48 is opened, operation of the signal S is stopped since the operating circuit for signal S which includes the back contact 54 of track relay TR2, and the back contact 55 of relay TS1 is now ineffective due to the back contact 55 being held open. It is to be noted that should a second train enter the section D—E and shunt the track relay TR1, the signal S is again set into operation. Also should the battery 34 fail and the directional relay TS1 is not energized, the signal S would be operated.

When the eastbound train recedes from the highway crossing and vacates the section E—F, the full rail voltage of that section is applied to the operating winding of relay TR2 to pick up that relay since the resistor 8 is now short-circuited by a path which includes wires 56 and 57, front contact 58 of track relay TR1, wire 59, front contact 60 of relay TS1, and wire 61. When the train vacates the section E—F, the current supplied to the directional relay TS1 over its stick circuit is materially reduced due to the removal of the train shunt from the section E—F and that relay is released at the expiration of its slow release period. The relay TS1 upon releasing opens the short-circuiting connection for the resistor 8 at its front contact 60, and also opens the short-circuit connection for the resistor 7 at its front contact 51. It is to be seen, therefore, that signal S is operated until the rear of the train passes the highway crossing, the directional relay TS1 is effective to stop the operation of the signal S while the train recedes from the crossing and is effective to short-circuit the resistors 7 and 8 so that the track relays TR1 and TR2 are picked up by full rail voltage of their respective track circuits. It is to be noted that should the track circuit for the section E—F fail during the time the eastbound train is passing through that section, the directional stick relay TS1 is released when the train vacates the section E—F notwithstanding the fact that the track TR2 may fail to pick up. With the track relay TR2 down following the release of the directional relay TS1, the operating circuit for the signal S which includes the back contact 54 of relay TR2 and the back contact 55 of relay TS1 is closed and the signal is operated and the failure of the track circuit is detected. It is to be further noted that the polarity of the track battery 2 for the section E—F and that of the battery 34 are as indicated by the plus and minus signs on the drawings, and energization of the relay TS1 over the stick circuit with these two batteries in series is avoided. Again, since the track relay TR2 controls at its back contact 40 the stick circuit for the relay TS1, release of the directional control in response to the picking up of the relay TR2 is assured. A westbound train approaching the highway H and entering the section E—F shunts the track relay TR2 and that relay is released, the releasing of the relay being expedited due to the resistor 8. The release of relay TR2 closes its back contact 54 and completes the operating circuit for the signal S which includes the back contact 55 of relay TS1, and the signal S is set into operation immediately following the westbound train entering the section E—F. This time the westbound directional relay TS2 is picked up while the train approaches the highway crossing. When the head end of this westbound train passes beyond the highway and enters the track section D—E, the track relay TR1 is released, the releasing of the relay being expedited due to the resistor 7, and the westbound directional relay TS2 is retained energized over its stick circuit which includes the train shunt in section D—E. When the train vacates the section E—F

full rail voltage for the section E—F is applied to the winding of the relay TR2 to pick up that relay since a short-circuit path is now completed around the resistor 8 and which path includes wires 56 and 64, front contact 63 of relay TS2, and wires 62 and 61. When the relay TR2 is picked up, operation of the signal S is stopped since the other operating circuit which includes the back contact 48 of track relay TR1 is now ineffective due to the fact that the back contact 49 of relay TS2 is open. When this westbound train vacates the section D—E, full rail voltage is available for picking up the track relay TR1 due to the resistor 7 being now short-circuited by a path which includes wires 52 and 81, front contact 82 of relay TR2, wire 83, front contact 84 of relay TS2 and wires 85 and 53. Since the stick circuit for retaining the relay TS2 energized includes the train shunt of the train in the section D—E, the energizing current from this relay is materially reduced when the train vacates the section and the relay is released. Again, it is to be noted that the directional control is released notwithstanding the fact that the track circuit last occupied by the train may fail and its track relay may remain deenergized. Consequently, with the apparatus constructed as shown in Fig. 2, two circuits for releasing the directional control are provided for each direction of traffic, and in each case one of the circuits is effective even in the event a failure of the usual track circuit occurs. Also a normal condition of relatively high sensitivity for the track circuits is established and the full rail voltage for picking up a track relay is made available through the medium of the adjacent track circuit and the directional control.

In the form of invention disclosed in Fig. 3, the stretch of railway track is intersected by the highway H and is divided into two track sections D—E and E—F the same as in Fig. 1, and these track sections are provided each with a track circuit the same as in Fig. 1 except for the fact that the resistor interposed in the connection with the track relay is omitted. Directional control of the operation of the highway crossing signal S is accomplished by virtue of directional stick relays TS3 and TS4, the relay TS3 being effective for eastbound traffic and the relay TS4 being effective for westbound traffic. These directional relays are each controlled by a pick-up circuit and a stick circuit, the pick-up circuit for each relay being rendered effective to energize its relay in respose to a train approaching the intersection in the corresponding direction, and the stick circuit of each relay being effective to retain its relay energized while the train moving in the corresponding direction travels away from the intersection. The pick-up circuit for the directional relay TS3 consists of the B terminal of the current source, back contact 65 of the track relay TR1, line wire 66, front contact 67 of relay RD, line wire 68, back contact 69 of the opposing directional relay TS4, winding of relay TS3 and to the opposite terminal C of the current source. The stick circuit for the relay TS3 consists of the B terminal of the current source, back contact 70 of track relay TR2, line wire 71, front contact 72 of relay RF, line wire 73, front contact 74 of relay TS3, operating winding of the relay and to the terminal C of the current source. The pick-up and stick circuits for the directional relay TS4 are of a similar nature, the pick-up circuit consisting of the battery terminal B, back contact 70 of relay TR2, line wire 71, front contact 72 of relay RF, line wire 73, back contact 75 of relay TS3, winding of the relay TS4, and to the opposite terminal C of the current source; and the stick circuit consisting of the B terminal of the current source, back contact 65 of relay TR1, line wire 66, front contact 67 of relay RD, line wire 68, front contact 76 of relay TS4, operating winding of the relay and to the opposite terminal C of the current source.

The highway crossing signal S of Fig. 3 is provided with two operating circuits one of which includes the back contact 77 of track relay TR1 and the back contact 78 of the westbound directional relay TS4, and the other of which includes the back contact 79 of track relay TR2 and the back contact 80 of the eastbound directional relay TS3.

The operation of the apparatus of Fig. 3 is as follows: With the apparatus in the normal position, that is, in the position illustrated in the drawings, when an eastbound train approaches the highway crossing and enters the track section D—E, the track relay TR1 is released to close its back contacts, and the current supplied to the relay RD is increased causing that relay to pick up and close its front contact 67. The closing of the back contact 65 of relay TR1 and the front contact 67 of relay RD causes current to be supplied to the eastbound directional relay TS3 and that relay is picked up. The closing of the back contact 77 of relay TR1 completes an operating circuit for the signal S, and the signal S is set into operation. When this eastbound train passes over the highway crossing and enters the track section E—F, the track relay TR2 is released to close its back contacts and the current supplied to the relay RF is increased causing that relay to close its front contact 72. The directional relay TS3 is now retained energized over the stick circuit which includes the back contact 70 of relay TR2 and the front contact 72 of relay RF. It is to be noted that the westbound directional relay TS4 is not at this time picked up due to the fact that its pick-up circuit is held open at the back contact 75 of the eastbound directional relay TS3. When the train passes to the right of the highway crossing and vacates the section D—E and the track relay TR1 is picked up, the operation of the signal S is stopped since one of the operating circuits is held open at the back contact 77 of relay TR1 and the other operating circuit is held open at the back contact 80 of the directional relay TS3. When this train moves to the right and passes out of the section E—F, the track relay TR2 is picked up and the current supplied to the relay RF is so reduced that that relay releases its armature to open the front contact 72. Since the stick circuit for the directional relay TS3 includes both the back contact 70 of relay TR2 and the front contact 72 of relay RF, the relay TS3 is released and the apparatus is restored to its normal position. It follows that with the apparatus of Fig. 3, a failure of the track circuit for the section E—F while an eastbound train is passing therethrough does not leave the directional control set up, since the relay RF is released and the directional control is released thereby. In the event of such failure of the track circuit for the section E—F and the track relay TR2 remains deenergized, release of the directional relay TS3 is effective to close an operating circuit for the signal S calling attention to such failure. Furthermore, should a westbound train subsequently approach the cross-

ing, the highway users would not be without warning. It is clear that operation of the apparatus of Fig. 3 for a westbound train is similar to that just described for the eastbound train, the relay RD in this instance functioning to check the release of the directional control as the westbound train moves away from the highway crossing.

In the form of the invention disclosed in Fig. 4, means for checking the release of the directional control is accomplished by auxiliary track circuits located beyond the operating track circuits. As here shown, the stretch of railway track intersected by the highway H is divided into two track sections D—E and E—F adjacent the highway the same as in the former cases and each of these sections is provided with a track circuit. An auxiliary track section D1—D is located to the left of the section D—E and is equipped with a track circuit which includes a track relay R3. In a like manner an auxiliary track section F—F1 is located at the right of the section E—F and is equipped with a track circuit which includes a track relay R4.

The directional control of the operation of the signal S of Fig. 4 is accomplished by two directional stick relays TS5 and TS6 which are preferably slow releasing in character. These directional relays are each controlled by a pick-up and a stick circuit, which circuits are governed by traffic approaching toward and moving away from the highway intersection in a manner similar to the control of the directional stick relays of Fig. 3 except the stick circuits include contacts controlled by the relay of the auxiliary track sections. To be explicit, the eastbound directional relay TS5 is governed by a pick-up circuit consisting of the terminal B of the current source, back contact 90 of track relay TR1, back contact 91 of the westbound directional relay TS6, winding of relay TS5, and to the opposite terminal C of the current source; and is provided with a stick circuit which may be traced from the terminal B of the current source over back contact 92 of track relay TR2, front contact 93 of relay TS5, line wire 94, front contact 95 of track relay R4, line wire 96, and winding of the relay TS5 to the opposite terminal C of the current source. The pick-up circuit for the westbound directional relay TS6 consists of terminal B of the current source, back contact 92 of relay TR2, back contact 97 of relay TS5, winding of relay TS6 and to the opposite terminal C of the current source; and its stick circuit extends from the B terminal of the current source over back contact 90 of relay TR1, front contact 98 of relay TS6, line wire 99, front contact 100 of track relay R3, line wire 101, and winding of the relay TS6 to the opposite battery terminal C.

Assuming the apparatus of Fig. 4 is in the position illustrated and an eastbound train approaches the highway crossing and enters the track section D—E, the track relay TR1 is released and that relay upon releasing and closing its back contact 102 completes an operating circuit for the signal S and the signal is set into operation, this circuit also including a back contact 103 of the westbound directional relay TS6. The closing of the back contact 90 of track relay TR1 causes current to be supplied to the eastbound directional relay TS5 and that relay is picked up. When this train passes beyond the highway crossing and enters the section E—F and shunts the track relay TR2, the closing of the back contact 92 of track relay TR2 completes the stick circuit for the directional relay TS5 with the result that this relay is retained energized subsequent to the rear of the train passing to the right of the highway and vacating the track section D—E. Operation of the signal S is stopped when the rear of the train vacates the section D—E and the track relay TR1 is picked up, since the other operating circuit for signal S which includes the back contact 88 of track relay TR2 is now rendered ineffective by the back contact 89 of directional relay TS5 being held open. When this eastbound train vacates the section E—F, the track relay TR2 is reenergized and the stick circuit for the directional relay TS5 is opened at the back contact 92 of that relay to release the directional control. Furthermore, the stick circuit for the directional relay TS5 is opened to release the relay when the eastbound train enters the auxiliary section F—F1 and shunts the track relay R4. It is to be seen, therefore, that the track relay R4 of the auxiliary track section checks the release of the directional control and is effective to release such control notwithstanding the track circuit for the section E—F may fail while the eastbound train is passing therethrough and the track relay TR2 may remain deenergized.

When a westbound train approaches the highway H of Fig. 4 and enters the section E—F, the relay TR2 is shunted and the signal S is set into operation by the operating circuit including the back contact 88 of relay TR2 and the back contact 89 of relay TS5. This time the westbound directional relay TS6 is picked up since its pick-up circuit is closed at the back contact 92 of relay TR2. With the relay TS6 thus picked up, it is retained energized when this westbound train passes to the left of the highway and occupies the section D—E. Then when the westbound train vacates the section D—E and the relay TR1 is picked up, the directional relay TS6 is released and the apparatus is restored to its normal position. Furthermore, when the westbound train enters the auxiliary section D1—D and shunts the track relay R3, the stick circuit for the directional relay TS6 is opened at the front contact 100 of relay R3 and hence this auxiliary section serves to check the release of the directional control.

In practicing the form of our invention disclosed in Fig. 4, the length of the track sections adjacent the highway, and the location of the auxiliary track sections will be selected to assure that the auxiliary section is not occupied by the head end of a train moving away from the crossing prior to the rear of the train passing beyond the crossing and vacating the section preceding it. In other words, these two auxiliary track sections may not be located adjacent the operating sections but may be located at some more remote point should it seem desirable to do so.

Although we have herein shown and described only four forms of apparatus embodying our invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. In combination, two adjacent track sections each provided with a track circuit including a normally energized track relay, a signal, an operating circuit for said signal and including a

contact controlled by one of said relays and said contact closed in response to a train shunting said one relay, a directional control device operative to render said operating circuit ineffective but normally in an inactive position, circuit means controlled by the other track relay when shunted prior to the shunting of said one relay to render the directional device active, and two independent release means controlled by the train to restore the directional device to its inactive position and each effective subsequent to the train vacating the track section associated with said one relay.

2. In combination, a stretch of railway track including an insulated track section, a track circuit for said section including the traffic rails and a normally energized track relay, a signal, an operating circuit for operating said signal and including a contact controlled by said relay and said contact closed in response to a train shunting the rails of said section, a directional control device operative to render said operating circuit ineffective but normally in an inactive position, circuit means including the traffic rails on one side of the section operative to render the directional device active in response to a train approaching said section from said one side, and two independent release means controlled by the train to restore the directional means to its inactive position and each effective when the train moves away from the section on the side opposite said one side.

3. In combination, a stretch of railway track provided with an insulated track section, a track circuit for said section including a normally energized track relay, a signal, an operating circuit for said signal including a contact controlled by said relay and closed in response to a train shunting the relay, directional control means operative to render the operating circuit ineffective but normally in an inactive position, circuit means controlled by a train approaching the section from one side to render the directional means active, a first release means controlled by said relay subsequent to the train moving through the section to restore the directional device to its inactive position, and a second release means controlled by the train moving away from the section on the side of the section opposite said one side to restore the directional device if the first means fails.

4. In combination, a stretch of railway track intersected by a highway and provided with an insulated track section on one side of the highway, a track circuit for said section including a normally energized track relay, a highway signal located at the intersection, an operating circuit for said signal including a contact controlled by said relay and closed in response to a train shunting the relay, a directional device including a magnet which when energized is effective to render said operating circuit ineffective, an energizing circuit controlled by a train approaching the highway from the side opposite said section for energizing said magnet, a stick circuit for said magnet including a back contact of said track relay for energizing said magnet as the train is moving away from the highway crossing and for deenergizing the magnet subsequent to the train vacating the section, and other means controlled by the train moving away from the highway through said section and effective to deenergize said magnet subsequent to the train vacating the section.

5. In combination, a stretch of railway track intersected by a highway and provided with an insulated track section on one side of the highway, a track circuit for said section including a normally energized track relay, a highway signal located at the intersection, an operating circuit for said signal including a contact controlled by said relay and closed in response to a train shunting the relay, a directional device including a magnet which when energized is effective to render said operating circuit ineffective, an energizing circuit controlled by a train approaching the highway from the side opposite said section for energizing said magnet, and a stick circuit for said magnet including the traffic rails of the section and the train shunt of a train occupying said section.

6. In combination, a stretch of railway track intersected by a highway and provided with an insulated track section on one side of the highway, a track circuit for said section including a normally energized track relay, a highway signal located at the intersection, an operating circuit for said signal including a contact controlled by said relay and closed in response to a train shunting the relay, a directional device including a magnet which when energized is effective to render said operating circuit ineffective, an energizing circuit controlled by a train approaching the highway from the side opposite said section for energizing said magnet; and a stick circuit for said magnet including a back contact of said track relay, the traffic rails of said section and the train shunt of a train occupying said section.

7. In combination, a stretch of railway track intersected by a highway and provided with an insulated track section on one side of the highway, a track circuit for said section including a normally energized track relay, a highway signal located at the intersection, an operating circuit for said signal including a contact controlled by said relay and closed in response to a train shunting the relay, a directional device including a magnet which when energized is effective to render said operating circuit ineffective, an energizing circuit controlled by a train approaching the highway from the side opposite said section for energizing said magnet, another contact, a stick circuit for said magnet including a back contact of said track relay and the closed position of said other contact, and means controlled by the train in moving away from the highway crossing through said section and effective for operating said other contact to an open position subsequent to the train vacating the section.

8. In combination, a stretch of railway track intersected by a highway and provided with an insulated track section on one side of the highway, a track circuit for said section including a first relay connected across the traffic rails at one end of the section and a current source and a second relay serially connected across the traffic rails at the other end of the section, a highway crossing signal located at the intersection, an operating circuit for said signal including a back contact of said first relay, directional control means including a magnet which when energized is effective to render said operating circuit ineffective, an energizing circuit controlled by a train approaching the highway from the side opposite said section for energizing said magnet, and a stick circuit for said magnet including a back contact of said first relay and a front contact of said second relay.

9. In combination, a stretch of railway track intersected by a highway and provided with an

insulated track section on one side of the highway, a track circuit for said section including a first relay connected across the traffic rails at one end of the section and a current source and a second relay serially connected across the traffic rails at the other end of the section, a highway crossing signal located at the intersection, an interlocking relay, circuit means for energizing one winding of the interlocking relay and including a front contact of said first relay, an operating circuit for said signal including a back contact of said one winding, other circuit means including a track circuit located on the side of the highway opposite said sections for energizing the other winding of said interlocking relay, a slow acting relay, an energizing circuit for said slow acting relay including a back contact of said one relay and a back contact of said second relay, and a pick-up circuit for at times energizing said one winding of the interlocking relay and including a back contact of the slow acting relay.

10. In combination, a stretch of railway track intersected by a highway and provided with an insulated track section on one side of the highway, a track circuit for said section including a first relay connected across the traffic rails at one end of the section and a current source and a second relay serially connected across the traffic rails at the other end of the section, a highway crossing signal located at the intersection, an interlocking relay, circuit means for energizing one winding of the interlocking relay and including a front contact of said first relay, and operating circuit for said signal including a back contact of said one winding, other circuit means including a track circuit located on the side of the highway opposite said section for energizing the other winding of said interlocking relay, and release means for at times energizing said one winding of the interlocking relay and including a back contact of said second relay.

11. In combination, a stretch of railway track intersected by a highway and provided with two track sections one on each side of the highway, a track relay and a stick relay for each track section, a highway crossing signal located at the intersection, a pick-up circuit for each stick relay including a back contact of the associated track relay, a stick circuit for each stick relay including the traffic rails of the section other than that with which the relay is associated and the train shunt of a train occupying such other section, and two operating circuits for said signal one of which includes a back contact of the track relay for one section and a back contact of the stick relay for the other section and the other of which circuits includes a back contact of the track relay for said other section and a back contact of the stick relay for said one section.

12. In combination, a stretch of railway track intersected by a highway and provided with two track sections one on each side of the highway, a track circuit for each section including a first relay connected across the traffic rails at one end of the section and a current source and a second relay serially connected across the traffic rails at the other end of the section, a stick relay for each section, a highway crossing signal located at the intersection, a pick-up circuit for each stick relay including a back contact of the first relay for the associated section, a stick circuit for each stick relay including a front contact of the second relay of the section other than the associated section, and two operating circuits for said signal one of which includes a back contact of the first relay for one section and a back contact of the stick relay for the other section and the other of which circuits includes a back contact of the first relay for said other section and a back contact of the stick relay for said one section.

13. In combination with a section of railway track and a source of current connected across the rails of the section, a track relay and a slow acting relay, a resistor, means for serially connecting the operating winding of the track relay and the resistor across the rails of the section, means for short-circuiting said resistor including a front contact of the slow acting relay, another relay having a winding connected with said source and responsive to a train occupying the section, and circuit means for energizing the slow acting relay controlled by said other relay.

14. In combination, two adjacent track sections each provided with a track circuit which includes a track relay having an operating winding connected across the traffic rails of its section, a resistor interposed in the connection between a rail and the winding of one of the relays, and circuit means controlled by the other track relay for at times short-circuiting said resistor.

15. In a track circuit for an insulated track section the combination comprising, a first relay, a resistor, means for serially connecting a winding of said relay and the resistor across the traffic rails at one end of the section, a second relay, a source of current, means for serially connecting a winding of said second relay and the current source across the traffic rails at the other end of the section, and circuit means including a contact of the second relay for at times short-circuiting said resistor.

16. In a track circuit for an insulated track section the combination comprising, a first relay, a resistor, means for serially connecting a winding of said relay and the resistor across the traffic rails at one end of the section, a second relay, a source of current, means for serially connecting a winding of said second relay and the current source across the traffic rails at the other end of the section, a normally deenergized slow acting relay, circuit means including a back contact of each of said first and second relays for energizing the slow acting relay, and other circuit means including a front contact of the slow acting relay for short-circuiting said resistor.

17. In combination, two adjacent track sections each provided with a track circuit which includes a track relay having an operating winding connected across the traffic rails of its section, two resistors one interposed in the connection of the winding of each of the track relays, directional means controlled by said track relays and selectively responsive to the direction of traffic through said sections, and circuit means controlled by said directional means for at times short-circuiting both of said resistors.

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