April 16, 1935. H. A. THOMPSON 1,998,175

CONTROLLING APPARATUS FOR HIGHWAY CROSSING SIGNALS

Filed June 16, 1931 2 Sheets-Sheet 1

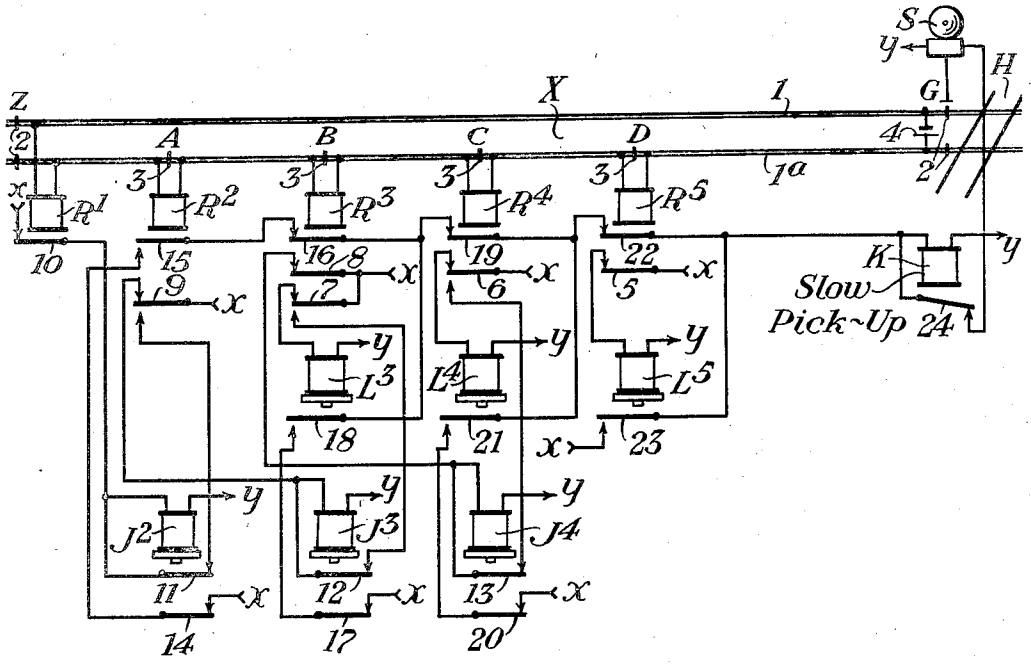


Fig. 1.

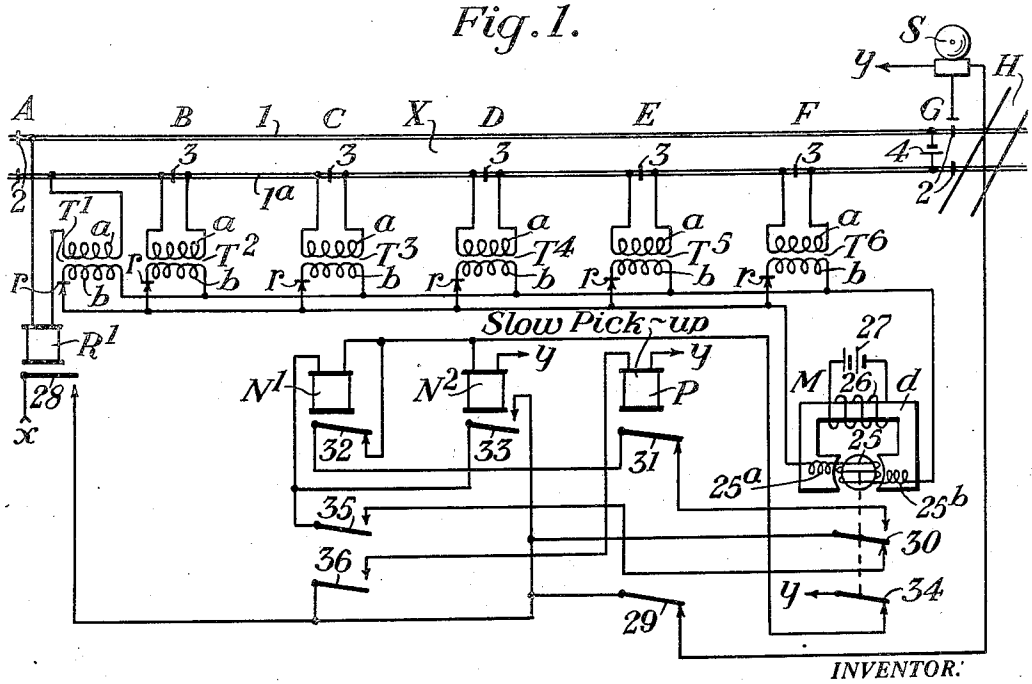


Fig. 2.

INVENTOR.

H. A. Thompson,

By A. R. Vincill

His ATTORNEY.

April 16, 1935. H. A. THOMPSON 1,998,175

CONTROLLING APPARATUS FOR HIGHWAY CROSSING SIGNALS

Filed June 16, 1931 2 Sheets-Sheet 2

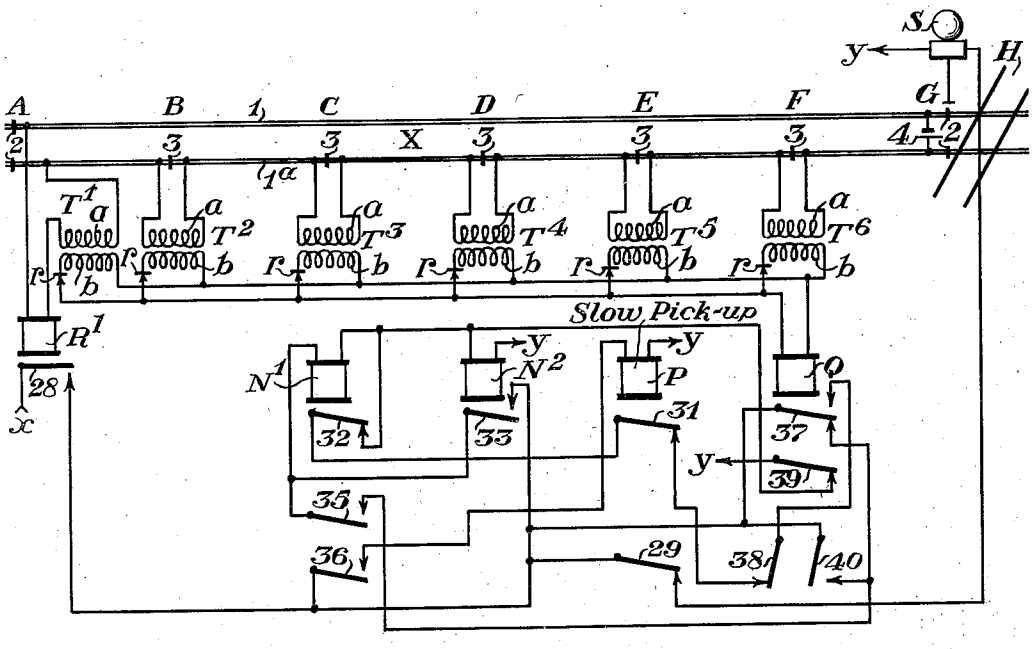


Fig. 3.

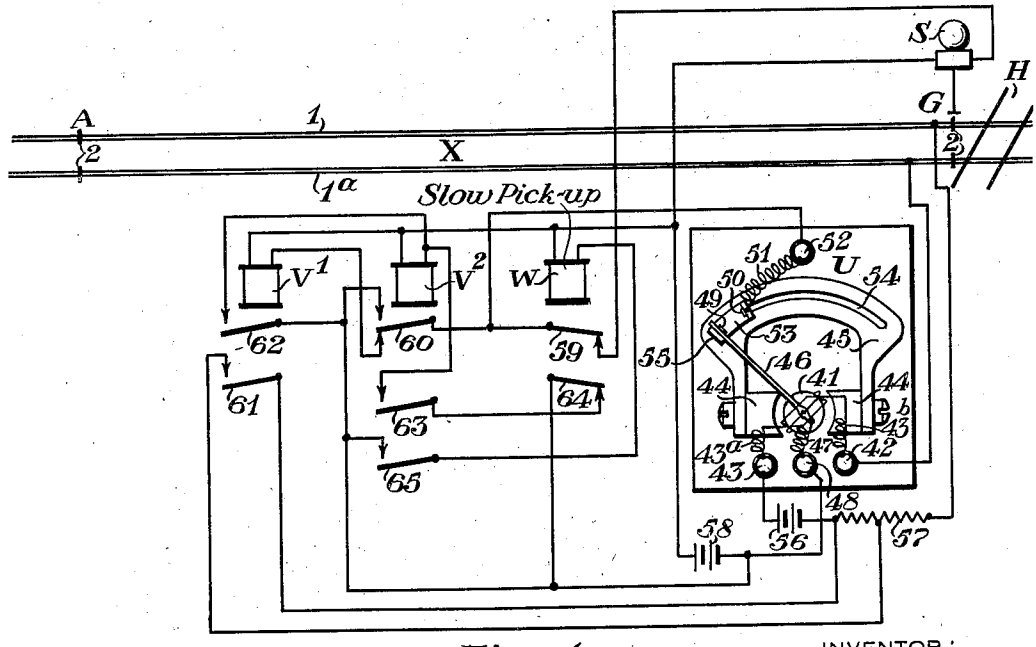


Fig. 4.

INVENTOR:
H. A. Thompson,
BY A. R. Terrill
His ATTORNEY

Patented Apr. 16, 1935 1,998,175

UNITED STATES PATENT OFFICE

1,998,175

CONTROLLING APPARATUS FOR HIGHWAY CROSSING SIGNALS

Howard A. Thompson, Edgewood, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application June 16, 1931, Serial No. 544,729

32 Claims. (Cl. 246—130)

My invention relates to controlling apparatus for highway crossing signals, that is, to apparatus for the control of signals which are placed at intersections of railways and highways for the purpose of warning users of the highway when a train is approaching a crossing.

One of the features of my invention is the provision of apparatus for preventing a continued operation of a highway crossing signal in the event that a train should stop within a control section for such signal before it reaches the crossing or in the event that a train having once set the signal in operation by entering the signal control section should back out of such section. Another feature of my invention is the provision of apparatus for causing a signal to be operated for approximately the same length of time when a high speed train is approaching the crossing as when a low speed train is approaching the crossing.

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

In the accompanying drawings, Fig. 1 is a diagrammatic view of one form of apparatus embodying my invention. Fig. 2 is a similar view of another form of apparatus embodying my invention. Fig. 3 is a similar view of still another form of apparatus constructed in accordance with the present invention. Fig. 4 is a similar view of a fourth form of apparatus constructed in accordance with the present invention.

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

Referring to the drawings, and with particular reference to Fig. 1 thereof, apparatus constructed in accordance with my invention is shown in combination with a stretch of railway track X which comprises rails 1 and 1a and which is intersected by a highway H protected by a signal S of any preferred type. The rails 1 and 1a are divided by insulated joints 2 to form a main section Z—G and the rail 1a is subdivided by similar joints 3 into a series of relatively short intermediate sections Z—A, A—B, B—C, C—D and D—G. A track battery 4 is connected across the rails 1 and 1a adjacent the right-hand end of the section Z—G, as viewed in the drawings, and a track relay R^1 is connected across the rails 1 and 1a adjacent the left-hand end of this section. Track relays R^2, R^3, R^4 and R^5 are connected in series with the relay R^1 by having the terminals of their windings connected with the rail 1a on opposite sides of the joints 3. The apparatus also embodies a plurality of slow-releasing relays L^3, L^4 and L^5 and a second plurality of slow-releasing relays J^2, J^3 and J^4, each of which is associated with a track relay R having a corresponding exponent, and each of which controls a time element relay K which, in turn, controls the operation of the signal S.

Normally, that is to say when the section Z—G is unoccupied, the track relays R are all energized by virtue of the track circuit in which they are connected in series. The slow-releasing relays L are also all energized by virtue of circuits which receive energy from a source having terminals x and y and which include front contacts 5, 6 and 7 of the track relays R^5, R^4 and R^3, respectively. The slow-releasing relays J are also all energized by circuits which include front contacts 8, 9 and 10 of the track relays R^3, R^2 and R^1, respectively. Under these conditions the signal S is ineffective.

I will assume that an eastbound train proceeding toward the crossing H passes the point Z and shunts the track relay R^1, contact 10 of which will then open the pick-up circuit for relay J^2. I will also assume that relay J^2 is so constructed that if an eastbound train moves through section Z—A at a speed of, for example, not less than sixty miles per hour, the completion of a stick circuit for this relay by back contact 9 of track relay R^2 when the train enters section A—B will be just in time to prevent contacts 11 and 14 of relay J^2 from opening.

Therefore, if the train moves through section Z—A at a speed of not less than sixty miles per hour, the deenergization of relay R^2 when the train reaches point A will complete an operating circuit for signal S passing from terminal x, through contact 14 of relay J^2, contact 15 of relay R^2, contact 16 of relay R^3, contact 19 of relay R^4, contact 22 of relay R^5, back contact 24 of time element relay K, and the mechanism of signal S to terminal y. Signal S, which is here indicated as a highway crossing bell, would, therefore, start ringing.

At the same time that the operating circuit is completed for signal S, time element relay K becomes energized by a circuit which follows the circuit just traced for signal S as far as contact 22 of relay R^5, and thence passing through the winding of relay K to terminal y. Relay K is of a type which picks up slowly but releases quickly, and is designed to respond, when energized, only at the expiration of a time interval which is of sufficient duration to permit a train proceeding at a predetermined minimum rate of speed to traverse the length of any one of the sections between points A and G. The energization of relay K, as just described, will not there-

fore cause the back contact 24 of this relay to open and interrupt the signal circuit previously traced therethrough, if the train continues, without stopping, through section A—B at a rate of speed not less than the minimum rate.

The opening of front contact 9 of relay R^2, when the train enters section A—B, breaks the pick-up circuit for relay J^3 which passes from terminal *x*, through front contact 9, and the winding of relay J^3 to terminal *y*. I will assume that relay J^3 is so constructed that if an eastbound train moves through section A—B at a speed of, for example, not less than fifty miles per hour, the completion of a stick circuit for this relay by back contact 7 of track relay R^3 when the train enters section B—C will be just in time to prevent contacts 12 and 17 of relay J^3 from opening.

When the train enters section B—C, the deenergization of track relay R^3 will open its front contact 16, thus interrupting the circuit previously traced through this contact for signal S and time element relay K. The deenergization of relay R^3 also causes its front contact 7 to open the circuit for the associated slow-releasing relay L^3 controlled by this contact. At the expiration of a predetermined interval of time, which is sufficient for relay K to become fully deenergized, relay L^3 closes its back contact 18.

Therefore, if the train has moved through section A—B at a speed of not less than fifty miles per hour, the deenergization of relay R^3, when the train reaches point B, will complete a second operating circuit for signal S passing from terminal *x*, through contact 17 of relay J^3, contact 18 of relay L^3, contact 19 of relay R^4, contact 22 of relay R^5, back contact 24 of relay K, and the mechanism of signal S to terminal *y*. This will cause the signal S to continue its operation. The signal S may be so designed that the relatively short interval, during which its operating circuit is open after the opening of contact 16 of relay R^3 and before the closing of contact 18 of relay L^3, will not cause a noticeable interruption in its operation. A second circuit for relay K is also thus established, which causes this relay to start over again its operation for opening its contact 24.

The opening of front contact 8 of relay R^3, when the train enters section B—C, breaks the pick-up circuit for J^4, which is similar to the pick-up circuit previously traced for relay J^3. I will assume that relay J^4 is so constructed that if an eastbound train moves through section B—C at a speed of, for example, not less than forty miles per hour, the completion of a stick circuit for this relay by back contact 6 of track relay R^4, when the train enters section C—D, will be just in time to prevent contacts 13 and 20 of relay J^4 from opening. When the train enters section C—D, the deenergization of track relay R^4 will open its front contact 19, thus interrupting the circuit previously traced through this contact for signal S and time element relay K. The deenergization of relay R^4 also causes its front contact 6 to open the circuit for the associated slow-releasing relay L^4 controlled by this contact. At the expiration of a predetermined interval of time which is sufficient for relay K to become fully deenergized, relay L^4 will close its back contact 21.

Therefore, if the train has moved through section B—C at a speed of not less than forty miles per hour, the deenergization of relay R^4, when the train reaches point C, will complete a third operating circuit for signal S passing from terminal *x*, through contact 20 of relay J^4, contact 21 of relay L^4, contact 22 of relay R^5, contact 24 of relay K, and the mechanism of signal S to terminal *y*. This will cause signal S to continue its operation. A third circuit for relay K is also thus completed which causes this relay to start over again its operation for opening its contact 24.

When the train enters section D—G, the deenergization of track relay R^5 will open its front contact 22, thus interrupting the circuits for signal S and time element relay K. The deenergization of relay R^5 also causes its front contact 5 to open the circuit for the associated slow-releasing relay L^5 controlled by this contact. At the expiration of a predetermined interval of time which is sufficient for relay K to become fully deenergized, relay L^5 will close its back contact 23, thereby completing a fourth circuit for signal S passing from terminal *x*, through back contact 23 of relay L^5, contact 24 of relay K and the mechanism of signal S to terminal *y*. A fourth circuit is thereby also completed for relay K.

When the train departs from section Z—G, the track relays all become reenergized, and thereupon restore the apparatus to its initial condition.

It follows that if the train proceeds uninterruptedly toward the crossing H at speeds not less than those specified for the various sections, the signal will operate except for the periodic interruptions between the deenergization of the relays R and the response of the associated relays L.

If the train should stop in any of the sections, the time element relay K will respond, at the termination of the predetermined time interval for which it is adjusted, and open its back contact 24, thereby interrupting the signal circuit previously traced through this contact. If the train, after stopping, should go ahead and enter the next section in advance, it will deenergize the track relay R associated with such section and interrupt the circuit for the relay K controlled by the front contact of such track relay. The deenergization of relay K will again cause the signal S to function as hereinbefore described.

If, instead of going ahead, the train should back out of section Z—G, such of the relays R as may have been deenergized will successively be reenergized in a reverse order and restore the apparatus to its normal condition without again causing the signal S to function. This is because the front contacts of each relay R close before the back contact of the associated relay L opens, and consequently the relay K is maintained energized.

If, instead of proceeding through section Z—A at a speed of sixty miles per hour or higher, an eastbound train should move through this section at some lower speed, contact 11 of relay J^2 would open before back contact 9 of relay R^2 would become closed. Hence, although contact 15 of relay R^2 would become closed in the circuits first traced for signal S and relay K, these circuits would still be open at contact 14 of relay J^2. Hence signal S would not be operated before the train arrived at point B.

If the train should proceed through section A—B at a speed of fifty miles per hour or higher, signal S and relay K would become energized by the second circuit which was traced through contact 17 of relay J^3 and contact 18 of relay L^3. If, however, the train proceeded through section A—B at a speed of less than fifty miles per hour, contact 12 of relay J^3 would open before back contact 7 of relay R^3 would close. Hence contact

17 of relay J^3 would also open, and would therefore prevent operation of signal S and energization of relay K, although back contact 18 of relay L^3 were closed.

If the train should now proceed through section B—C at a speed of forty miles per hour or higher, signal S and relay K would become operated by the third circuit traced through contact 20 of relay J^4 and contact 21 of relay L^4. If, however, the train proceeded through section B—C at a speed of less than forty miles per hour, contact 13 of relay J^4 would open before back contact 6 of relay R^4 would become closed. Contact 20 of relay J^4 would therefore also be opened and prevent operation of signal S and relay K, although back contact 21 of relay L^4 were closed.

Signal S will, however, be operated for a given period every time relay L^5 becomes deenergized on account of the presence of a train in section D—G, or when relay L^5 becomes deenergized for any other reason.

Sections Z—A, A—B and B—C may be of equal lengths, while relays J^2, J^3 and J^4 may be constructed to have different periods of release according to the minimum train speeds of sixty, fifty and forty miles per hour, respectively. A modification of this arrangement could provide relays J^2, J^3 and J^4 with equal periods of release, but with the lengths of sections Z—A, A—B and B—C varied according to the minimum train speeds of sixty, fifty and forty miles per hour, respectively.

The speed of a train moving through sections Z—A, A—B and B—C determines whether or not bell S shall ring when the train reaches points A, B and C, respectively. The speed of a train moving through section C—D does not, however, determine whether or not bell S shall ring when the train reaches point D. Bell S will ring whenever an eastbound train enters section D—G.

In the forms of apparatus shown in Figs. 2, 3 and 4, there is no means controlled by the speed of a train in one section for determining whether or not the bell will ring when the train enters the next section in advance as in Fig. 1. In the forms of apparatus shown in Figs. 2, 3 and 4, the bell will ring when a train enters each section, and will continue to ring while the train is in each section unless the train stops or is moving at less than a given minimum speed which, for example, might be fifteen miles per hour. The train speed at which the bell will stop ringing is determined by the time required for slow pick-up relays P of Figs. 2 and 3 and relay W of Fig. 4 to open their back contacts.

With the forms of apparatus shown in Figs. 2 and 3, sections A—B, B—C, C—D, D—E and E—F may be of equal lengths. Section F—G should preferably be short.

With each of the four forms of apparatus shown, the bell will stop ringing if a train remains in a section long enough for a slow pick-up relay, such as relay K of Fig. 1, relay P of Figs. 2 and 3, and relay W of Fig. 4, to open its back contact.

In Fig. 2, I have shown another form of apparatus constructed in accordance with my invention. In this particular construction, I employ a series of transformers T designated by appropriate exponents, and having primary and secondary windings *a* and *b*, respectively. The primary *a* of transformer T^1 is connected in series with the track relay R^1, and the secondary *b* of transformer T^1 is connected with the movable control winding 25 of a galvanometer relay M through flexible connections 25^a and 25^b. This relay comprises a core *d* provided with a stationary winding 26 which is constantly energized by a battery 27. The terminals of the primary winding of each of the transformers T^2, T^3, T^4, T^5 and T^6 are connected with the rail 1^a on opposite sides of the insulated joints 3, and the secondaries of these transformers are connected in parallel with each other and with winding *b* of transformer T^1. The apparatus also includes two neutral relays N^1 and N^2 and a slow acting relay P which, as here shown, is of the type which releases quickly and picks up slowly. Under normal conditions, the track relay R^1 is energized by its track circuit but winding 25 of the galvanometer relay M, the neutral relays N^1 and N^2 and the time element relay P are all deenergized.

With the apparatus in this condition, I will assume that an eastbound train, approaching the crossing H, enters section A—G at A and causes the deenergization of track relay R^1. This will complete a circuit passing from terminal *x* of a source of electric energy not shown in the drawings, through back contact 28 of track relay R^1, back contact 29 of time element relay P, and operating mechanism of signal S to terminal *y* of the same source. This will cause the signal to operate and warn traffic on the highway H of the approach of the train. The train, as well as shunting track relay R^1, also shunts the primary *a* of transformer T^1. The dying down of the current in this primary *a* causes a momentary surge of current to be induced in the secondary *b* of the same transformer, flowing from left to right as shown in the drawings and of sufficient magnitude to energize the movable control winding 25 of the galvanometer relay M momentarily. This completes a pick-up circuit for relay N^2 passing from terminal *x*, through back contact 28 of track relay R^1, front contact 30 of relay M, back contact 31 of slow pick-up relay P, back contact 32 of neutral relay N^1, and winding of neutral relay N^2 to terminal *y*. This causes relay N^2 to close its front contact 33.

As soon as the surge of current in the winding 25 of the galvanometer relay M dies out, front contact 30 of this relay opens and interrupts the pick-up circuit just traced for relay N^2. However, immediately upon the opening of front contact 30 of relay M and before back contact 34 of this relay has had time to close, a pick-up circuit for relay N^1 and a holding circuit for relay N^2 is established passing from terminal *x*, through back contact 28 of track relay R^1, front contact 33 of relay N^2, and the windings of relays N^1 and N^2 in series to terminal *y*. As soon as back contact 34 of relay M closes, a second pick-up circuit is established for relay N^1 passing from terminal *x*, through back contact 28 of relay R^1, front contact 33 of relay N^2, winding of relay N^1, and back contact 34 of relay M to terminal *y*. Both terminals of the winding of relay N^2 are now connected with terminal *y* with the result that relay N^2 is shunted and so rendered slow-releasing. This delays the opening of front contact 33 of relay N^2 for a time interval of sufficient duration to permit front contact 35 of relay N^1 to close. The closing of front contact 35 of relay N^1 completes a stick circuit for this relay passing from terminal *x*, through back contact 28 of relay R^1, back contact 30 of relay M, front contact 35 of relay N^1, winding of relay N^1, and back contact

34 of relay M to terminal *y*. The energization of relay N^1 establishes a circuit for the time element relay P passing from terminal *x*, through back contact 28 of track relay R^1, front contact 36 of relay N^1, and winding of relay P to terminal *y*, but relay P being slow acting, does not respond until a predetermined time interval has elapsed of a duration sufficient to allow a train, moving at a certain minimum speed, fifteen miles per hour for example, to enter section B—C.

When the train enters section B—C, the transformer T^2 is shunted which causes the galvanometer relay M to become energized again momentarily, as hereinabove described, and to open its back contact 30. This interrupts the stick circuit for relay N^1, previously traced through this contact, thereby causing the deenergization of this relay. The deenergization of relay N^1 causes its front contact 36 to open, thus interrupting the circuit for relay P long enough to permit this relay, which is of the type that releases quickly, to become fully deenergized. The deenergization of relay N^1 also causes back contact 32 thereof to close and consequently when relay M closes its front contact 30, the circuit for relay N^2, previously traced through these contacts, is completed. From this point on, the cycle of operations hereinbefore described is repeated.

I will now assume that a train has entered one of the sections between the points A and G and also that the relay N^1 is energized by its stick circuit previously traced and that the time element relay P is energized by virtue of its pick-up circuit but has not yet responded. Under these conditions, if the train should stop, the time element relay P will, at the expiration of the time interval for which it is adjusted, respond and open its back contact 29. This will interrupt the circuit previously traced through this contact for the signal S and cause it to discontinue its operation. If the train should now proceed into the next section toward G, it will shunt the transformer T for such section and will thus cause the energization of the galvanometer relay M which will open its back contact 30 and interrupt the stick circuit for relay N^1. This will cause relay N^1 to open its front contact 36 and interrupt the circuit for time element relay P which will again close its back contact 29 and reestablish the circuit for the signal S.

On the other hand, if the train, instead of proceeding, should back out of the main section A—G, it will successively permit the reenergization of such of the transformers T as may have been shunted thereby. The reenergization of any of the transformers, however, will tend to cause a surge of current in the circuit for the galvanometer relay M of an opposite polarity such as will tend to maintain the back contacts of relay M closed. As a result, the stick circuit for relay N^1 is not opened and the circuit for the time element relay P previously traced through front contact 36 of relay N^1 is maintained intact. The signal circuit through back contact 29 of relay P therefore remains open. It may be desirable to connect an asymmetric unit *r* in series with the secondary of each of the transformers T so as to prevent the surge of current produced in the secondary *b* of any one of the transformers, caused by the shunting of its primary by a train, from dissipating itself in the secondary of another of the transformers, the primary of which has been and still is shunted by the same train.

Asymmetric units *r*, arranged as shown, will also prevent surges of current in the reverse direction, from right to left, from forcing the contacts of relay M against their back points when a train backs away from crossing H.

It will be apparent from the foregoing that as long as a train proceeds uninterruptedly through the several sections at a speed not less than a predetermined minimum, the signal S will operate without interruption, but that if the train should stop or back out of signal control territory the operation of the signal will discontinue. In this respect the apparatus functions as an indication of the progress of a train approaching the crossing H.

In Fig. 3, I have shown another form of apparatus constructed in accordance with my invention in which I employ a polarized relay Q instead of the galvanometer relay M shown in Fig. 2. In this embodiment of my invention, if a train enters section A—B, it will deenergize the track relay R^1 and cause it to close its back contact 28, thus establishing the signal circuit previously traced. The train upon entering section A—B also shunts the primary of the transformer T^1 and causes a momentary energization of the polar relay Q. This causes front neutral contact 37 of relay Q to close and establish a pick-up circuit for relay N^2 passing from terminal *x*, through back contact 28 of track relay R^1, front neutral contact 37 and normal polar contact 38 of relay Q, back contact 31 of time element relay P, back contact 32 of relay N^1, and winding of relay N^2 to terminal *y*. The energization of relay N^2 causes it to close its front contact 33. As soon as the surge of current in the circuit for relay Q dies out, front contact 37 of relay Q opens and interrupts the circuit just traced through this contact for relay N^2, but a pick-up circiut for relay N^1 is established, in series with relay N^2, passing from terminal *x*, through back contact 28 of track relay R^1, front contact 33 of relay N^2, and windings of relays N^1 and N^2 to terminal *y*.

As soon as relay Q closes its back contact 39, a second pick-up circuit is established for relay N^1 passing from terminal *x*, through back contact 28 of relay R^1, front contact 33 of relay N^2, winding of relay N^1, and back contact 39 of relay Q to terminal *y*. Both terminals of the winding of relay N^2 are now connected with terminal *y* with the result that relay N^2 is shunted and rendered slow-releasing. This delays the opening of front contact 33 of relay N^2 for a time interval of sufficient duration to permit front contact 35 of relay N^1 to close. The closing of this contact establishes a stick circuit for relay N^1 passing from terminal *x*, through back contact 28 of track relay R^1, back neutral contact 37 of polar relay Q, front contact 35 of relay N^1, and back neutral contact 39 of polar relay Q to terminal *y*. The energization of relay N^1 also causes front contact 36 of this relay to close and establish a circuit for time element relay P passing from terminal *x*, through back contact 28 of track relay R^1, front contact 36 of relay N^1, and winding of relay P to terminal *y*. If the train proceeds at a speed not less than the predetermined minimum, previously referred to, it will enter section B—C before the time element relay P opens its back contact 29 in the circuit for signal S controlled thereby.

When the train enters section B—C, the transformer T^2 is shunted which causes the polar relay Q to become energized again momentarily, as hereinabove described, and open its back contact 37. This interrupts the stick circuit for relay N^1, previously traced through this contact, thereby causing the deenergization of this relay.

The deenergization of relay N^1 causes its front contact **36** to open, thus interrupting the circuit for relay P long enough to permit this relay, which is also of the type that releases quickly, to become fully deenergized. The deenergization of relay N^1 also causes back contact **32** thereof to close and consequently when relay Q closes its front contact **37** the circuit for relay N^2, previously traced through these contacts, is completed. From this point on, the cycle of operations hereinbefore described in connection with this particular form of my invention is repeated.

If the train should back out of any one of the sections, it will permit the reenergization of the transformer for that section and will so tend to cause a surge of current in the circuit for the polar relay Q. The surge of current in such case, however, will be of opposite polarity to that caused by the shunting of the transformer and therefore this relay will open its normal polar contact **38** and close its reverse polar contact **40**. This establishes a branch path for the stick circuit for relay N^1 through reverse polar contact **40** of relay Q and thus maintains relay N^1 energized and the circuit for relay P through front contact **36** of relay N^1 intact, notwithstanding that back normal contact **37** which controls the main path for the stick circuit for relay N^1 is subsequently opened. The time element relay P is thus maintained energized and the signal circuit through its back contact **29** held open during the backing movement of the train.

It may be desirable to connect an asymmetric unit *r* in series with the secondary winding of each of the transformers T in order to prevent the current generated in any one of these secondaries from being dissipated in the other secondaries. Asymmetric units *r*, if used, will also prevent surges of current in the reverse direction from energizing relay Q.

In Fig. 4, I have shown apparatus constructed in accordance with a still further embodiment of my invention in which I employ an ammeter relay U, two neutral relays V^1 and V^2 and a time element relay W, which as here shown has a slow pick-up and a quick release, for controlling the signal S, and in which the track X is divided by insulated joints **2** to form a single unbroken section A—G extending the entire length of the signal control territory. The relay U comprises the usual movable coil **41** the opposite terminals of which are connected with terminal posts **42** and **43** by means of flexible connections 43^b and 43^a, respectively, and which is mounted for oscillatory movement between the pole pieces **44** of a permanent magnet **45**. The coil **41** actuates an arm **46** one end of which is connected by a flexible connection **47** with a terminal post **48** and the other end of which carries a contact **49** for engagement with a contact **50** which is connected by a flexible connection **51** with a terminal post **52**. The contact **50** is carried by a slide **53** mounted in a guideway **54** so that when the coil **41** is energized, the arm **46** will first carry the contact **49** into engagement with the contact **50** and then as the current increases, will move the contact and slide bodily in a clockwise direction, as viewed in the drawings. When the current in the coil **41** is interrupted, the arm **46** first carries the contact **49** out of engagement with the contact **50** and then engages a shoulder **55** on the slide **53** and returns the slide and contact **50** to their initial positions. The terminal post **42** of the coil **41** is connected directly with the rail 1^a of the track X adjacent the point G, and the other terminal **43** of this coil is connected with one terminal of a battery **56**, the other terminal of which is connected through a resistor **57** with the rail **1** of the track X adjacent the point G.

In this apparatus, if an eastbound train enters section A—G, a circuit for coil **41** will be completed, passing from one terminal of battery **56**, through resistor **57**, rail **1**, wheels and axles of the train, rail 1^a, terminal post **42**, coil **41**, and terminal post **43** to the other terminal of battery **56**. This will cause the arm **46** to swing in a clockwise direction and move the contact **49** carried thereby into engagement with the contact **50**. This will cause the signal S to operate by virtue of a circuit passing from a battery **58**, through terminal post **48**, flexible connection **47**, arm **46**, contacts **49—50**, flexible connection **51**, terminal post **52**, back contact **59** of time element relay W, and operating mechanism of signal S to battery **58**. A circuit is also established, passing from battery **58**, through arm **46** and contacts **49—50** of relay U, back contact **60** of relay V^2, and winding of relay V^1 to battery **58**. The energization of relay V^1 shunts the left-hand portion of the resistor **57** by establishing a circuit passing from battery **56**, through front contact **61** of relay V^1, right-hand portion of resistor **57**, rail **1**, wheels and axles of the train, rail 1^a and coil **41** of ammeter relay U to battery **56**. This increases the current flowing in coil **41** and causes the arm **46** and contacts **49—50** to move forward a certain distance. The energization of relay V^1 also causes the energization of relay V^2 by virtue of a pick-up circuit passing from battery **58**, through front contact **62** of relay V^1, and winding of relay V^2 to battery **58**. This causes relay V^2 to close its front contact **63** which establishes a stick circuit for this relay, passing from battery **58**, through back contact **64** of time element relay W, front contact **63** of relay V^2 and winding of this relay to battery **58**. The energization of relay V^2 causes it to open its back contact **60** and interrupt the circuit previously traced through this contact for relay V^1. This causes relay V^1 to open its front contact **61** and to interrupt the circuit previously traced through this contact which shunted the left-hand position of the resistor **57**, thereby increasing the resistance to the current flow in the coil **41** and causing the arm **46** to move to the left and open contacts **49—50**. This does not, however, interfere with the operation of the signal S for the reason that a circuit is now established for the signal passing from battery **58**, through front contact **60** of relay V^2, back contact **59** of time element relay W, and operating mechanism for signal S to battery **58**. The energization of relay V^2 also causes it to close its front contact **65** which establishes a pick-up circuit for time element relay W, but this relay, being adjusted to operate only after a predetermined time interval has elapsed, does not immediately respond.

Now if the train proceeds at a speed not less than a predetermined minimum, it will decrease the resistance of the circuit including rails **1** and 1^a for the coil **41** so that the arm **46** will again move to the right and close the signal circuit through contacts **49—50** before the time element relay W functions. The time element relay W afterward responds and opens its back contacts **59** and **64**, thereby interrupting the circuit for signal S and the stick circuit for relay V^2, respectively, previously traced through these contacts. The denergization of relay V^2 immediate-

ly opens its front contact **65**, thus interrupting the circuit for the time element relay W and causing this relay to close its back contact **59** which again causes the operation of signal S. The interval of time during which the circuit for signal S is thus interrupted is only that required for the front contact **65** of relay V^2 to open and the back contact **59** of relay W to close. The deenergization of relay V^2 also closes its back contact **60**, thereby reestablishing the circuit for relay V^1 previously traced. The apparatus is thus restored to its initial condition and the cycle of operations above described is repeated.

It will be noticed that if the train proceeds at not less than a given minimum speed, the operation of signal S is not interrupted when the signal circuit through the contacts **49—50** is opened on account of the opening of contact **61** of relay V^1, a second circuit for the signal being then established through back contact **59** of time element relay W and front contact **60** of relay V^2. The design of the signal S may be such that its operation will be continuous notwithstanding the periodic brief interruptions in its operating circuits by relay W. If, however, the train should stop anywhere within section A—B, the contacts **49—50** will not close, and therefore when the time element relay W responds and opens its back contact **59**, the branch path controlled by front contact **60** remains open and the signal S will cease operation. If the train should proceed after stopping, the decreased resistance in the circuit for coil **41** will again cause the contacts **49—50** to close and reestablish the circuit for signal S.

Although I have herein shown and described only four forms of apparatus embodying my 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 my invention.

Having thus described my invention, what I claim is:

1. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic on said highway at such intersection, a time element relay for controlling said signal, and means controlled by a train proceeding uninterruptedly over said stretch for successively forestalling operation of said time element relay.

2. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay for controlling the operation of said signal, a track relay for controlling the operation of said slow-acting relay, and means operable by a train at varying distances from such intersection for periodically controlling the operation of said slow-acting relay independently of said track relay.

3. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay for controlling the operation of said signal, a track relay operable by a train upon entering said stretch for starting the operation of said slow-acting relay, and means operable by a train at predetermined time intervals for stopping and restarting the operation of said slow-acting relay.

4. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic on said highway at such intersection, a slow-acting relay for controlling said signal, means operable by a train at different locations in said stretch for energizing said slow-acting relay, and means controlled by said train operable means for causing the deenergization of said slow-acting relay.

5. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic on said highway at such intersection, a time element relay for controlling said signal, and means operable by a train at different points along said stretch for alternately rendering said time element relay effective and ineffective.

6. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic on said highway at such intersection, a time element relay for controlling said signal, and means operable by a train at time intervals of predetermined duration for alternately causing the energization and deenergization of said time element relay.

7. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic on said highway at such intersection, a time element relay for controlling said signal, means operable by a train upon entering said stretch for causing the energization of said time element relay, and means operable by such train at predetermined distances from said intersection for successively causing the deenergization of said time element relay momentarily.

8. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic on said highway at such intersection, a time element relay for controlling said signal, a circuit for said time element relay, and means operable by a train at different points in said stretch for successively interrupting said circuit.

9. In combination, a stretch of railway track divided into a plurality of sections, a signal, a time element relay for controlling said signal, a circuit for said time element relay, and means associated with each of said sections for interrupting said circuit momentarily.

10. In combination, a stretch of railway track divided into a plurality of sections, a signal, a time element relay for controlling said signal, and means associated with each of said sections for periodically delaying the operation of said relay.

11. In combination, a stretch of railway track divided into a plurality of sections, a signal, a time element relay for controlling said signal, a contact device associated with each of said sections, a plurality of control relays controlled by said contact devices, a main circuit for said time element relay controlled by each of said contact devices, and a plurality of auxiliary circuits for said time element relay, each controlled by one of said control relays.

12. In combination, a stretch of railway track divided into a plurality of sections, a plurality of track relays connected in series and adapted to be successively deenergized by a train proceeding through said sections, a plurality of auxiliary relays each controlled by one of said track relays, a signal, a time element relay, a circuit for said time element relay controlled by each of said track relays, a circuit for said signal controlled by each of said track relays and by said time element relay, and a plurality of additional circuits for said signal each controlled by said time element relay and by one of said auxiliary relays.

13. In combination, a stretch of railway track divided into a plurality of sections, a signal, a time element relay for controlling said signal, a track relay associated with each of said sections,

a circuit for said time element relay including a front contact of each of said track relays, an auxiliary relay associated with each of said track relays, a circuit for each of said auxiliary relays including a front contact of the associated track relay, and a plurality of auxiliary circuits for said time element relay each controlled by a back contact of one of said auxiliary relays.

14. In combination, a stretch of railway track divided into a plurality of sections, a signal, a time element relay for controlling said signal, a circuit for said time element relay, a track relay associated with each of said sections for controlling said circuit, and a relay controlled by each of said track relays for controlling said circuit jointly with the associated track relay.

15. In combination, a stretch of railway track divided into a plurality of sections, a signal, a time element relay for controlling said signal, a track relay associated with each of said sections for controlling said time element relay, and a plurality of slow-releasing relays each controlled by one of said track relays for controlling said signal jointly with said track relays.

16. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic over said highway at such intersection, a plurality of track relays arranged at intervals along said track, a slow pick-up relay, a circuit for said signal including a front contact of each of said track relays and a back contact of said slow pick-up relay, and a circuit for said slow pick-up relay including said front contacts of said track relays.

17. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic over said highway at such intersection, a plurality of track relays arranged at intervals along said track, a slow pick-up relay, a plurality of slow-releasing relays, a first circuit for said signal controlled by said track relays and by said slow pick-up relay, and a plurality of additional circuits for said signal each controlled by certain of said track relays and by one of said slow-releasing relays.

18. In combination, a stretch of railway track intersected by a highway, a signal for controlling traffic over said highway at such intersection, a plurality of track relays arranged at intervals along said track, an auxiliary relay associated with certain of said track relays, and a slow-acting relay controlled by said track relays and by said auxiliary relays for controlling said signal.

19. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay for controlling said signal, an auxiliary relay for controlling said slow-acting relay, a control relay, a pick-up circuit for said auxiliary relay controlled by said control relay, a stick circuit for said auxiliary relay controlled by said control relay, and means controlled by a train at varying distances from said intersection for successively energizing said control relay.

20. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay and a track relay for jointly controlling said signal, an auxiliary relay for controlling said slow-acting relay, a control relay, a pick-up circuit for said auxiliary relay controlled by said control relay, a stick circuit for said auxiliary relay controlled by said control relay, and means controlled by a train at varying distances from said intersection for successively energizing said control relay.

21. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay and a track relay for jointly controlling said signal, an auxiliary relay for controlling said slow-acting relay, a control relay, a pick-up circuit for said auxiliary relay controlled by said control relay, a stick circuit for said auxiliary relay controlled by said control relay, and a plurality of track transformers arranged at varying distances from said intersection for successively energizing said control relay.

22. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay for controlling said signal, an auxiliary relay for controlling said slow-acting relay, a polar relay, a pick-up circuit for said auxiliary relay controlled by said polar relay, a stick circuit for said auxiliary relay controlled by said polar relay, and means controlled by a train at varying distances from said intersection for successively energizing said polar relay.

23. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay for controlling said signal, a first auxiliary relay for controlling said slow-acting relay, a second auxiliary relay, a control relay, a pick-up circuit for said second auxiliary relay controlled by said control relay, a pick-up circuit for said first auxiliary relay controlled by said second auxiliary relay, a stick circuit for said first auxiliary relay controlled by said control relay, and means controlled by a train at varying distances from said intersection for successively energizing said control relay.

24. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a slow-acting relay for controlling said signal, a first auxiliary relay, a second auxiliary relay for controlling said slow-acting relay, a polar relay, a pick-up circuit for said second auxiliary relay controlled by a front neutral contact and a normal polar contact of said polar relay, a pick-up circuit for said first auxiliary relay controlled by a front contact of said second auxiliary relay, a first stick circuit for said first auxiliary relay controlled by a back neutral contact of said polar relay, a second stick circuit for said first auxiliary relay controlled by a reverse polar contact of said polar relay, and means controlled by a train at varying distances from said intersection for successively energizing said polar relay in a normal direction when said train is approaching said intersection and for successively energizing said polar relay in a reverse direction when said train is backing away from said intersection.

25. In combination, a stretch of railway track intersected by a highway, a signal for governing traffic over said highway at such intersection, a control relay controlled by a train in said stretch for controlling said signal, a slow-acting relay for controlling said signal jointly with said control relay, a first auxiliary relay for controlling said slow-acting relay, a second auxiliary relay, a pick-up circuit for said second auxiliary relay controlled by said control relay and by said first auxiliary relay, a pick-up circuit for said first auxiliary relay controlled by said second auxiliary relay, a stick circuit for said first auxiliary relay controlled by said slow-acting relay, and means

controlled by said second auxiliary relay for controlling said control relay jointly with said train.

26. In combination, an electrical conductor, an indication device, means for supplying current to said conductor, means for energizing said indication device when the current in said conductor increases, and means for alternately energizing and deenergizing said indication device when said current ceases to increase faster than a given rate and for again energizing said device constantly when said current again increases.

27. In combination, a stretch of railway track intersected by a highway, a highway crossing signal for said intersection, a slow-release relay responsive to the speed of a train approaching said intersection so that it remains closed if a train approaches at high speed but becomes open if a train approaches at a lower speed, means controlled by said relay for operating said signal when a train moving at high speed arrives at a given point, and means for starting operation of said signal when a train moving at a lower speed arrives at a point nearer said intersection.

28. In combination, a stretch of railway track intersected by a highway, a highway crossing signal for said intersection, a plurality of slow-release relays responsive to the speed of a train approaching said intersection, and means controlled by each of said relays for operating said signal when a train arrives at a corresponding distance from said intersection.

29. In combination, a stretch of railway track intersected by a highway, a highway crossing signal for said intersection, a stick relay having a pick-up circuit which becomes opened when a train arrives at a given point and having a stick circuit which becomes closed if a train approaching said intersection arrives at a second point within a given period of time after arriving at said first point, and means controlled by said relay for controlling said signal.

30. In combination, a section of railway track including an insulated joint in one rail, a signal adjacent one end of said section, a track circuit for said section including a battery connected across the rails at one end of the section and a relay connected across the rails at the opposite end of said section as well as a second relay connected to the one rail around said insulated joint, a slow-release stick relay, a pick-up circuit for said stick relay including a front contact of said first relay, a stick circuit for said stick relay including a back contact of said second relay, and a circuit including a front contact of said stick relay for controlling said signal.

31. In combination, a stretch of railway track one rail of which is divided by insulated joints into a plurality of successive sections, a plurality of transformers the primary winding of each of which is connected to said rail around a corresponding one of said insulated joints, a track circuit for said stretch including a track battery connected across the rails adjacent one end of said stretch and a track relay connected across the rails adjacent the other end of said stretch, an electrical device, a circuit comprising a plurality of branch paths each of which includes a secondary winding of one of said transformers and which are in multiple with each other but in series with said electrical device, and a plurality of asymmetric units each of which is connected in a corresponding one of said branch paths to prevent current generated in each of said secondary windings from being dissipated in any of the other secondary windings.

32. In combination, a section of railway track, a source of current connected across the rails of the track adjacent one end of said section, a highway crossing signal, and means for causing operation of said signal when the magnitude of the current drawn from said source is increasing due to the shunting action of a train approaching the said end of the section and for stopping the operation of said signal when the the magnitude of such current ceases to increase due to the stopping of such train in the section.

HOWARD A. THOMPSON.