Oct. 11, 1938. C. H. LAY 2,133,171

CONTROLLING APPARATUS FOR HIGHWAY CROSSING SIGNALS

Original Filed July 2, 1935 2 Sheets-Sheet 1

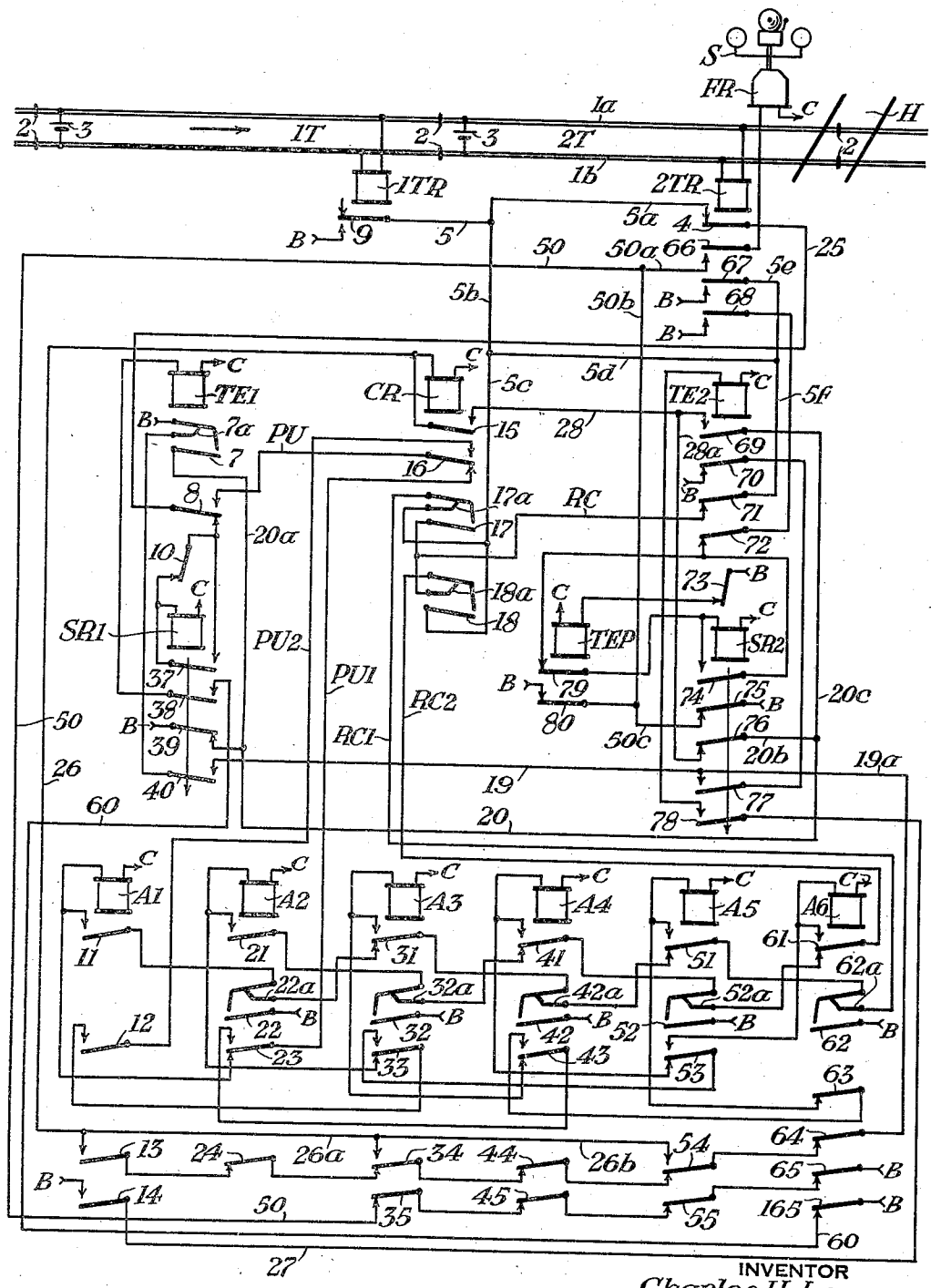



Fig. 1.

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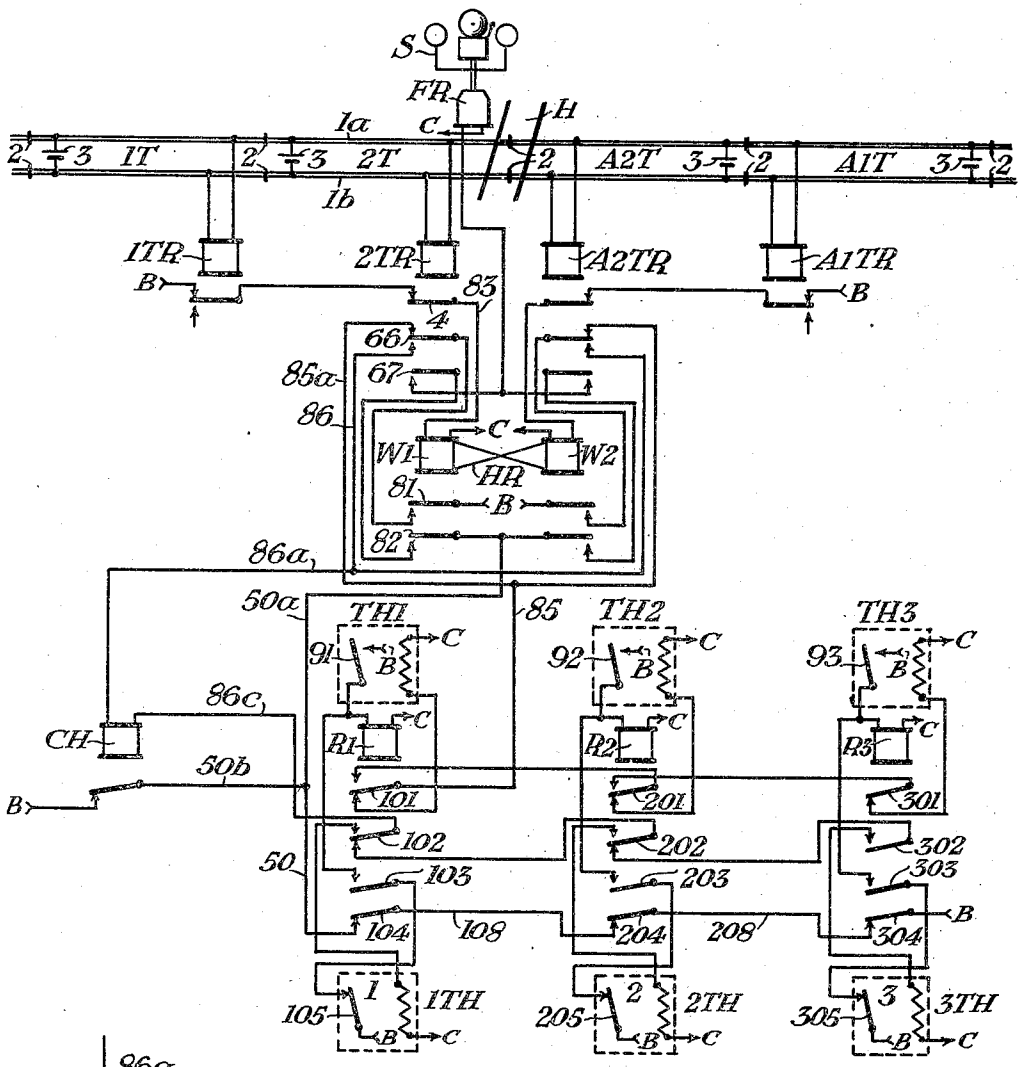



Fig. 2.

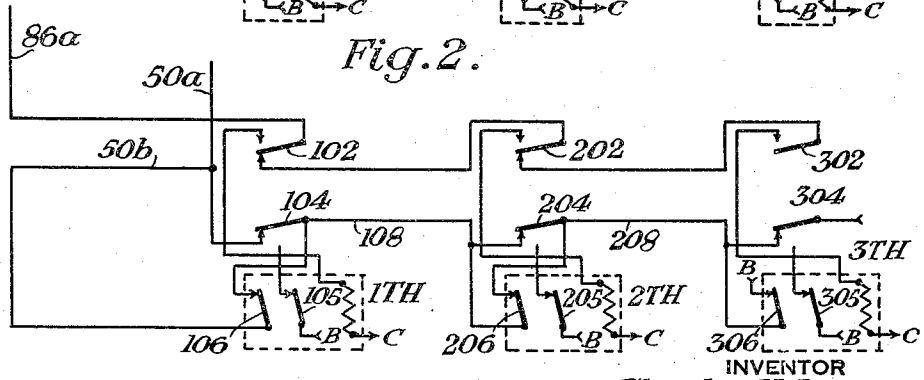



Fig. 2a.

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# UNITED STATES PATENT OFFICE

2,133,171

## CONTROLLING APPARATUS FOR HIGHWAY CROSSING SIGNALS

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Continuation of abandoned application Serial No. 29,487, July 2, 1935. This application February 8, 1936, Serial No. 62,968

24 Claims. (Cl. 246—130)

My invention relates to controlling apparatus for highway crossing signals, and particularly to apparatus controlled by a train approaching the crossing for starting the operation of the crossing signal in accordance with the speed of the train.

This present application is a continuation of my copending application Serial No. 29,487, filed July 2, 1935, now abandoned, for Controlling apparatus for highway crossing signals.

A feature of my invention is the provision of novel and improved apparatus controlled by a train approaching a highway crossing for registering the speed of the train and then governing the starting of the operation of the highway crossing signal in accordance with such registered speed.

I will describe three 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 circuits and apparatus embodying my invention. Fig. 2 is a diagrammatic view of a second form of circuits and apparatus which also embody the invention, and Fig. 2*a* is a fragmental view showing a modified form of the circuits for checking the timing devices of Fig. 2.

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

Referring first to Fig. 1, the reference characters 1*a* and 1*b* designate the rails of a stretch of railway track over which traffic normally moves in the direction indicated by the arrow, which rails are divided by insulated joints 2 to form time measuring and signal operating track sections designated 1T and 2T, respectively. Each of these sections is provided with a track circuit including a track battery 3 and with a track relay designated R with a prefix corresponding to its location. The exit end of section 2T is intersected by a highway H protected by a signal S of any preferred type. The signal S as here shown conventionally illustrates a combined audible and flashing light highway crossing signal. It will be understood, however, that my invention is not limited to this specific type of signal as any of the standard types may be used. The signal S is normally inactive and is rendered active to give a warning whenever a train approaches the intersection. The immediate control of the signal S is in a mechanism designated FR, which mechanism is effective to cause signal S to give a warning in response to current supplied thereto.

The signal control apparatus embodies a chain of counting relays A1—A6 arranged for successive energization during the cyclic operation or interaction of a time element relay TE1 and a slow release relay SR1, in cooperation with a controlling relay CR, while a train or vehicle is occupying the measuring section 1T and until it enters the operating section 2T. The time required to pick up relays A1 and A2 corresponds to that required for a maximum speed train to pass through the measuring section 1T, while the additional time required to pick up the relays A3—A6 of the chain corresponds to the additional time consumed by lower speed trains in passing through the measuring section. These latter relays are employed to correspondingly delay the starting time of the highway signal, as will subsequently more clearly appear.

The signal control apparatus also includes a second time element relay TE2 and a second slow release relay SR2, which interact while a train occupies the operating section in cooperative relation with the relay CR to successively effect the release of the energized A relays of the chain. The operation of signal S is started only when counting relays A3—A6 are all in their released position. The particular type of time element relay employed is immaterial, however, for the purpose of this disclosure it may be assumed that the time element relays TE1 and TE2 are of the general type covered by the Lazich and Ashworth Patent No. 1,966,965, issued July 17, 1934. In this type of relay, circuit changing contacts are actuated after any desired pre-set period of time and a checking or off-normal contact is provided to check that the relay contacts have properly returned to normal when the relay is released. In the present arrangement, a checking relay TEP is normally energized over a circuit including the checking contact 13 of the time element relay TE2 to check the proper return of that relay to its initial position and to effect operation of the signal S when a train enters the operating section 2T, should the relay TE2 have failed to return to its normal position following its last operation.

In order to describe the invention in detail, I will first describe the operations which take place when a train moving toward the crossing in the direction indicated by the arrow is traveling at a speed so low that the counting relays all function to delay the operation of signal S.

When a train enters section 1T, the track relay 1TR releases and completes a circuit for the slow release relay SR1. This circuit extends from ter-

minal B of a suitable current source, through the back contact 9 of track relay 1TR, over conductor 5 and its branch 5a, front contact 4 of relay 2TR, conductor 25, back contact 8 and checking contact 10 of time element relay TE1, winding of relay SR1, and to terminal C of the same current source. Relay SR1 now picks up and completes a circuit for the time element relay TE1. This circuit extends from terminal B at the back contact 165 of counting relay A6, over conductor 60, front contact 38 of relay SR1, winding of relay TE1, and to terminal C. The relay SR1 also completes a stick circuit for itself at its front contact 37 which circuit excludes the checking contact 10 of relay TE1.

The time element relay TE1 upon becoming energized immediately opens its checking contact 10. After the expiration of a predetermined time interval, the back contact 8 opens the stick circuit for relay SR1. After a slight delay, relay SR1 releases and at its front contact 38 reopens the operating circuit of relay TE1. When relay TE1 releases, it recloses the circuit of relay SR1. It will be apparent therefore that the above cyclic operation or interaction of relays SR1 and TE1 will repeat itself and will continue until the train enters section 2T, releasing relay 2TR and opening front contact 4 which interrupts the circuit of relay SR1, or alternately, until the circuit of relay TE1 is interrupted by the opening of back contact 165 of relay A6, as will be made clear hereinafter.

The first time that relay TE1 picks up at the expiration of its time interval as described above, it completes a circuit for the counting relay A1. This circuit extends from terminal B of the current source over back contact 9 of relay 1TR, conductors 5 and 5a, front contact 4 of relay 2TR, conductor 25, through the front contact 8 of relay TE1, the pick-up conductor PU over which all A relays are picked up, back contact 16 of relay CR, pick-up conductor PU1 over which all of the odd numbered A relays are picked up, back contact 23 of relay A2, winding of counting relay A1, and to terminal C.

When relay A1 picks up, its front contacts 12, 13, and 14 close and thereby prepare pick-up circuits for relays A2, CR, and TE2, respectively. Also, front contact 11 closes a stick circuit for relay A1 itself. This latter circuit extends from terminal B of the current source now connected with conductor 5 by back contact 9 of relay 1TR thence over branch wires 5b and 5c, back contact 17a of relay CR, release control conductor RC1 over which all odd numbered A relays are released, back contacts 62a, 51, 42a, 31, and 22a of relays A6, A5, A4, A3, and A2, respectively, its own front contact 11, winding of relay A1, and to terminal C.

A slight interval of time after relay TE1 picks up, relay SR1 releases, and at this time merely interrupts the circuit of relay TE1. When relay TE1 releases the first time, it merely recloses the pick-up circuit for relay SR1.

When relay SR1 picks up the second time, however, it completes a pick-up circuit for relay CR, due to the pick up of relay A1 in the meantime. This circuit extends from terminal B over back contact 7a of relay TE1, through front contact 40 of relay SR1, conductors 19 and 19a, back contacts 64, 54, 44, 34, and 24 of counting relays A6, A5, A4, A3, and A2, respectively, the front contact 13 of relay A1, conductor 26, winding of relay CR, and to terminal C.

The relay CR now picks up and at its front contact 16 connects the pick-up conductor PU with the pick-up conductor PU2 over which all even numbered A relays are picked up. The relay CR also at its front contact 17 closes an auxiliary stick circuit for relay A1 including the release control conductor RC, the back contact 71 of relay TE2 and branches 5f, 5d, and 5b of conductor 5. At the same time, relay CR opens the initial stick circuit of relay A1 at the back contact 17a.

When relay TE1 picks up the second time, front contact 8 completes the pick-up circuit for counting relay A2. This circuit extends over front contact 8, pick-up conductor PU, front contact 16 of relay CR, conductor PU2, front contact 12 of relay A1, back contact 33 of relay A3, winding of relay A2 and to terminal C. The relay TE1 also closes at its front contact 7 a stick circuit for relay CR and at its back contact 7a opens the pick-up circuit of relay CR. The stick circuit of relay CR extends from contact 7 of relay TE1, over conductors 20a, 20, and 20b, through back contact 76 of relay SR2, conductors 28a and 28, contact 15 and winding of relay CR, and to terminal C.

When relay A2 picks up, it transfers the stick circuit of relay A1 from its back contact 22a to its front contact 22; at front contact 23 prepares the pick-up circuit of relay A3; and at back contact 24 opens a second point in the above-traced pick-up circuit of relay CR. Relay A2 also completes a stick circuit for itself at front contact 21 which circuit extends over contactors 5, 5b, and 5c, front contact 18 of relay CR, conductor RC2, back contacts 61, 52a, 41, and 32a of relays A6, A5, A4, and A3, respectively, front contact 21 of relay A2, winding of relay A2, and to terminal C.

When relay SR1 releases the second time, its back contact 39 connects terminal B to the conductor 20 to maintain relay CR energized independently of the front contact 7 of relay TE1. When relay TE1 releases the second time, it merely recloses the previously traced pick-up circuit of relay SR1.

When relay SR1 picks up the third time, its back contact 39 opens the stick circuit of relay CR. The relay CR now releases and at its back contact 16 reconnects the pick-up conductor PU to pick up conductor PU1 which is included in the pick-up circuits of the odd numbered A relays. The relay CR also transfers the stick circuit of relay A2 from the path including its front contact 18 to the path including its back contact 18a and the branch conductor RC.

When relay TE1 picks up the third time, its front contact 8 completes the prepared pick-up circuit for relay A3. This circuit is the same as that traced for relay A1 up to conductor PU1 thence over front contact 23 of relay A2, back contact 43 of relay A4, winding of relay A3, and to terminal C.

When relay A3 picks up, it transfers the stick circuit of relay A2 from the back contact 32a to the front contact 32; at front contact 33 prepares the pick-up circuit of relay A4; and at front contact 34 prepares a new pick-up circuit for relay CR, which circuit excludes front contact 13 and back contact 24 of relays A1 and A2, respectively. The relay A3 at its back contact 35, also opens a point in the main circuit of mechanism FR which is employed to render signal S active. This circuit extends from a terminal B, through back contacts 65, 55, 45, and 35 of relays A6, A5, A4, and A3, respectively, con-

ductors 50 and 50a, back contact 66 of relay 2TR, now open, and through mechanism FR to a terminal C. Relay A3 on closing its front contact 31 completes its stick circuit which extends over conductors 5, 5b, and 5c, back contact 17a of relay CR, conductor RC1, back contacts 62a, 51, and 42a of relays A6, A5, and A4, respectively, front contact 31 and winding of relay A3, and to terminal C.

When relay SR1 releases the third time, it performs no particular function other than to open the circuit for relay TE1. When relay TE1 releases for the third time its back contact 7a again prepares the pick-up circuit for relay CR. The release of relay TE1 closes the circuit for relay SR1, and when relay SR1 picks up the fourth time, its front contact 40 completes the prepared pick-up circuit for relay CR.

Relay CR now picks up the second time and its front contact 16 again prepares the pick-up circuit of the even numbered counting relays. Relay CR also transfers the stick circuit of relay A3 from its back contact 17a and branch conductor 5c to its front contact 17 and the release control conductor RC and branch 5f of conductor 5, in the same manner that the stick circuit of relay A1 was transferred when relay CR picked up for the first time.

The subsequent cyclic operation of relays TE1, SR1, and CR, which results in the sequential energization of counting relays A4, A5, and A6 will be clear from the drawings and from the foregoing description so that a detailed description of the repeated relay operations involved in such energization of the counting relays is believed to be unnecessary. It will be sufficient to state that when the counting relays have completed a full cycle of operation, relays A1 to A6 all be energized, relays TE1 and CR will both be deenergized, and relay SR1 will be energized.

The foregoing operations are those which take place when a train or vehicle enters the measuring section 1T provided the train remains in such section for a sufficiently long period of time, that is, provided it is a slow speed train. No further operations take place thereafter until the train enters the operating section 2T.

When the train enters section 2T, the track relay 2TR releases and at its front contact 4 opens the circuit of relay SR1. The relay SR1 accordingly releases, but its release accomplishes no immediate result. When relay 2TR releases, its back contact 67 connects terminal B to branch 5e of the conductor 5 so that conductor 5 and all its branches will continue to be connected to terminal B of the current source even after the train clears section 1T and relay 1TR again picks up. The relay 2TR at its back contact 66 completes an auxiliary circuit for the mechanism FR of signal S which extends from the B terminal connected through the contacts 75 and 80 of relays SR2 and TEP to the conductors 50c, 50b, and 50a. At its back contact 68, relay 2TR completes a circuit for the slow release relay SR2, which circuit extends from terminal B over back contact 68, back contact 72 of time element relay TE2, front contact 79 of relay TEP, winding of relay SR2, and to terminal C.

When relay SR2 picks up, it opens back contact 75 to open one of the auxiliary circuits through mechanism FR of signal S; at front contact 74 completes a stick circuit around the front contact 79 of relay TEP; and at front contact 78 closes the operating circuit of the time element relay TE2. This latter circuit extends from terminal B through front contact 14 of relay A1, conductor 27, front contact 78 of relay SR2, winding of relay TE2, and to terminal C. The relay SR2 also, at back contact 76, opens a point in the stick circuit of relay CR, but without effect even should that relay be energized at the time, for the reason that front contact 77 will under such circumstances close a pick-up circuit for relay CR as will subsequently be explained. Should the relay SR2 for any reason fail to pick up, the circuit completed at its back contact 75 will become effective to actuate signal S without further delay.

When the time element relay TE2 becomes energized, it first opens the circuit of relay TEP at checking contact 73 and then some time later actuates its other contacts. The relay TEP immediately releases, opening the pick-up circuit of relay SR2 at its front contact 79 and at its front contact 80 opens the other of the auxiliary circuits traced through the mechanism FR of signal S, to prevent operation of the signal at this time. Should the relay TE2 for any reason fail to pick up, the relay TEP will not be released and the circuit traced through its front contact 80 and mechanism FR will become effective to actuate the signal S without further delay. When relay TE2 fully picks up, its back contact 72 opens the stick circuit of relay SR2.

When relay SR2 releases, its front contact 78 opens the circuit of relay TE2. The relay TE2 then releases and recloses its checking and back contacts 73 and 72. The relay TEP now picks up and at its front contact 79 again completes the pick-up circuit of relay SR2. It will be evident from the foregoing that relays SR2, TE2, and TEP interact as long as the operating section 2T remains occupied or, alternatively, until the operating circuit of relay TE2 is interrupted by the opening of front contact 14 of relay A1. During the normal interaction of these relays, front contact 80 of relay TEP and back contact 75 of relay SR2 are never closed long enough to enable mechanism FR to actuate signal S.

The first time that relay TE2 fully picks up, its back contact 71 interrupts the stick circuit including the release control conductor RC and the last picked up A relay of the chain. In the present instance, the stick circuit of relay A6 is interrupted.

When relay A6 releases, it transfers the stick circuit of relay A5 from the path including its front contact 62 to the path including its back contact 62a; and its back contact 64 prepares a pick-up circuit for relay CR; and at its back contact 65 recloses a point in the first circuit traced through mechanism FR of signal S.

A slight interval after relay TE2 picks up, relay SR2 releases, but at this time is merely effective to interrupt the circuit of relay TE2.

When relay TE2 releases the first time, its back contact 70 closes a point in a pick-up circuit for relay CR, and its back contact 71 again closes a point in a circuit including release control conductor RC, which comprises a part of a common release control circuit for all of the relays A1—A6.

When relay SR2 picks up the second time, it completes the prepared pick-up circuit of relay CR. This circuit extends from a terminal B through back contact 70 of relay TE2, front contact 77 of relay SR2, conductor 19a, back contact 64 of relay A6, front contact 54 of relay A5, over conductors 26b, 26a, and 26, winding of relay CR, and to terminal C.

The relay CR now picks up and transfers the stick circuit of relay A5 from the path including its back contact 17a and branch 5c of conductor 5 to the path including its front contact 17, the release control conductor RC and the back contact 71 of relay TE2.

When relay TE2 picks up the second time, its front contact 69 closes a stick circuit for relay CR including the conductors 20c, 20 and the back contact 39 of relay SR1, so that the opening of the pick-up circuit of relay CR at back contact 70 is without effect. The relay TE2 at its back contact 71 now opens the stick circuit of relay A5.

When relay A5 releases, it transfers the stick circuit of relay A4 from the path including its front contact 52 back to the path including its back contact 52a, release control conductor RC2, front contact 18 of relay CR and branch 5c of conductor 5. Relay A5 at its front contact 54 opens a point in the last employed pick-up circuit of relay CR and at the back contact 54 closes a point in an alternative pick-up circuit for relay CR. The relay A5 also, at back contact 55, recloses another point in the first traced circuit including mechanism FR of signal S.

A slight interval after relay TE2 picks up, relay SR2 releases for the second time, and at its back contact 76 closes a multiple branch of the stick circuit for relay CR which is independent of front contact 69 of relay TE2. When relay TE2 releases the second time, its back contact 71 again closes a point in the release control circuit of the relays A1—A6. When relay SR2 picks up the third time, its back contact 76 opens the stick circuit of relay CR.

The relay CR now releases and transfers the stick circuit of relay A4 from the path including its front contact 18 and branch 5c of conductor 5, to the path including its back contact 18a, release control conductor RC, and the back contact 71 of relay TE2.

When relay TE2 picks up the third time, its back contact 71 opens the stick circuit of relay A4, which in releasing, transfers the stick circuit of relay A3 from the path including its front contact 42 back to the path including its back contact 42a; at its back contact 44 closes a point in one of the pick-up circuits for relay CR; and at back contact 45 recloses another point in the main circuit including mechanism FR of signal S.

A slight interval of time after relay TE2 picks up, relay SR2 releases for the third time, but at this time the latter relay merely interrupts the circuit for relay TE 2. When relay TE2 releases for the third time, its back contact 70 again closes a point in the pick-up circuit of relay CR, while its back contact 71 again closes a point in the common release control circuit for relays A1—A6. When relay SR2 picks up the fourth time, its front contact 77 completes the pick-up circuit for relay CR which was prepared by the closure of back contacts 44 and 70 of relays A4 and TE2, respectively.

The relay CR now picks up and transfers the stick circuit of relay A3 from the path including its back contact 17a and branch 5c of conductor 5, to the path including its front contact 17, the release control conductor RC, and the back contact 71 of relay TE2.

When relay TE2 picks up the fourth time, its front contact 69 again closes the stick circuit for relay CR to prevent this relay from being released by the opening of its pick-up circuit at back contact 70. Relay TE2 also opens the stick circuit for relay A3 at its back contact 71 so that when relay A3 releases, its contacts 31—35 perform functions similar to those performed by the contacts 51—55 of relay A5 on its release. The back contact 35 of relay A3, it will be observed, was the last open point in the main circuit including the mechanism FR of signal S. The operation of signal S will accordingly begin as soon as contact 35 closes and this operation will continue until relay 2TR picks up following the exit of the train from section 2T.

During the next two cycles of interaction of relays SR2 and TE2, the relays CR, A2, and A1 are released in a manner which will be apparent in the light of the foregoing description.

When relay A1 releases, its front contact 14 disconnects terminal B from the circuit of relay TE2, thus preventing the latter relay from again picking up. With relay TE2 in its released position, the checking relay TEP remains picked up, thereby checking that the relay TE2 has fully released. With relay TE2 released, relay SR2 again picks up and remains picked up until its circuit is interrupted by the picking up of the track relay 2TR.

When relay 2TR picks up, it opens at its back contact 66 a common point in the main and auxiliary circuits of the signal control mechanism FR, thereby stopping operation of signal S. Relay 2TR also opens the pick-up and stick circuits of relay SR2 at back contact 68 so that relay SR2 will release, thus again placing the circuits in their normal condition.

If a vehicle or train traveling at or near its maximum speed, assumed as being 90 miles per hour, for example, enters section 1T, it will pass on into section 2T before the relay A3 has been picked up whereby the main control circuit through mechanism FR of signal S will be closed at back contact 66 of relay 2TR as soon as the train enters section 2T and will remain closed until the train clears this section. The length of section 2T obviously determines the time of operation of the signal S for maximum speed trains, and this length will ordinarily be such as to allow the signal S to be operated for a 20 second period.

If a train approaching the crossing is traveling at a speed slightly below maximum, 75 miles per hour, for example, relays A1—A3 will have been picked up prior to the entry of the train into section 2T. Under these circumstances, the main circuit through mechanism FR of signal S will be open at the back contact 35 of relay A3 when the train enters section 2T. The commencement of operation of the signal will therefore be delayed until relays SR2, TE2, and CR have completed the cycle of operations necessary to effect the release of relay A3.

More specifically, when the train enters section 2T, relay SR2 picks up and at its front contact 77 completes one of the pick-up circuits of relay CR. The relay CR now picks up and transfers the stick circuit of relay A3 from the path including its back contact 17a and branch 5c of conductor 5 to the path including its front contact 17, the release control conductor RC and the back contact 71 of relay TE2.

When relay TE2 picks up, its back contact 71 opens the stick circuit of relay A3, which accordingly releases and closes the main circuit through mechanism FR of signal S to start operation of the signal substantially 20 seconds before the train reaches the crossing.

If a train approaching the highway is traveling at a speed of 60 miles per hour, for example,

relays A1—A4 will have been picked up prior to the entry of the train into section 2T. Under these circumstances, the main circuit of mechanism FR of signal S will be open at back contacts 35 and 45 of relays A3 and A4 when the train enters section 2T. The commencement of operation of signal S will therefore be delayed until relays SR2, TE2, and CR have completed the cycles of operation necessary to effect the release of both relays A4 and A3.

In this instance, when relay SR2 picks up, it does not close a pick-up circuit for relay CR, such circuit being open at back contact 44 of relay A4. When relay TE2 picks up, its back contact 71 opens the stick circuit of relay A4, which relay releases, and at its back contact 45 closes one point in the main circuit of mechanism FR, and prepares a pick-up circuit for relay CR at its back contact 44. Relays SR2 and TE2 now release, in sequence.

The cycle of operations which follows is the same as previously described and need not be repeated, it being understood that the operation of signal S will start, as before, when relay A3 releases.

If the train approaching the highway is traveling at a speed of 45 miles per hour, for example, the relays A1—A5 will have been picked up prior to the entry of the train into section 2T. Under these circumstances the main circuit of mechanism FR will be open at contacts 35, 45, and 55 of relays A4, A5, and A6, respectively, and the commencement of operation of signal S will accordingly be delayed until relays SR2, TE2, and CR have completed the cycles of operation necessary to effect the release of relays A3—A5.

In the foregoing description, it will be observed that the pick-up and stick circuits of relay SR1 include the back contact 9 of relay 1TR, and that the circuit of the last operated counting relay in all instances also includes this back contact. Therefore, if a train enters the measuring section 1T and then backs out of the section, relay SR1 and the operated counting relays will all release and will be ready for operation when a train again enters the measuring section.

Referring now to Fig. 2, rails 1*a* and 1*b* comprise a single track stretch over which traffic may approach the highway H from either direction. The track sections A2T and A1T, respectively, correspond to sections 2T and 1T of Fig. 1 and these sections are equipped with like track circuits including track relays A2TR and A1TR, respectively.

In this form of my invention, I employ separate timing devices TH1, TH2, and TH3 of the thermal type to successively pick up the signal control relays R1, R2, and R3, while a train approaching the highway occupies one or the other measuring section 1T or A1T, respectively. Separate thermal timing devices 1TH, 2TH, and 3TH are used for successively releasing the signal control relays after a train approaching the highway has entered the operating section 2T or A2T. A relay CH is used for checking the integrity of the timing devices 1TH, 2TH, and 3TH. The selective control of the signal S by the previously mentioned timing devices and relays is obtained by means of an interlocking relay HR, the two windings W1 and W2 of which are controlled by traffic to the left and right of the highway, respectively, as described hereinbelow.

When a train approaching the highway from the left enters section 1T, the track relay 1TR releases and at its front contact interrupts a normally closed circuit including the front contact 4 of relay 2TR, and the winding W1 of relay HR. When relay HR releases, its back contact 81 closes a circuit through the winding of thermal timing device TH1 to initiate the operations required to determine in accordance with the speed of the train through the measuring section, when operation of signal S will be started. This circuit extends from terminal B through back contact 81, front contact 66 of relay 2TR, conductors 85*a* and 85, back contact 101 of relay R1, winding of timing device TH1, and to terminal C. The timing device TH1 is adjusted to close its contact 91 only if the train entering the measuring section consumes more than a minimum predetermined time interval in such section prior to its entry into the adjacent operating section. Therefore, if the train is moving at the maximum speed, it will enter section 2T before contact 91 has had time to close.

Under such circumstances, when the train enters section 2T and track relay 2TR releases, the circuit through the winding of TH1 is interrupted at the front contact 66 of relay 2TR, thereby preventing the closure of contact 91. At the same time, the relay 2TR at its back contact 67 completes the main operating circuit through mechanism FR of signal S. This circuit extends from terminal B, through back contact 304 of relay R3, conductor 208, the back contact 204 of relay R2, conductor 108, the back contact 104 of relay R1, conductors 50 and 50*a*, the back contact 82 of relay HR, back contact 67 of relay 2TR, and through the mechanism FR, to terminal C. From the foregoing, it will be apparent that when a maximum speed train approaches the highway, the signal S will start operating when the operating section is entered and will continue to operate until the train clears such operating section.

I will now assume that the train advances through section 1T at a somewhat lower speed, so that contact 91 of the timing device TH1 has had time to close before the train entered section 2T.

When contact 91 closes, relay R1 picks up and at its back contact 101 opens the circuit through the winding of the timing device TH1. The front contact 101 substitutes a circuit including the back contact 201 of relay R2 and the winding of timing device TH2, for the winding of TH1, so that the closing movement of contact 92 of the timing device TH2 is immediately started. The relay R1, at its front contact 102, prepares a series circuit including the winding of the timing device 1TH and relay CH; at its back contact 104 opens a point in the operating circuit through mechanism FR; and at its front contact 103 closes a stick circuit for itself through the normally closed contact 105 of timing device 1TH.

If the speed of the train is only slightly below the maximum, the train as it enters section 2T will release relay 2TR and consequently interrupt the operating circuit of timing device TH2 before this device has had time to close its contact 92. When this occurs, the back contact 66 of relay 2TR will complete the previously prepared circuit including the windings of relay CH and of timing device 1TH. This circuit extends from terminal B, through the back contact 81 of relay HR, back contact 66 of relay 2TR, conductors 86 and 86*a*, the winding of relay CH, conductor 86*c*, front point of contact 102 of relay R1, and the winding of the timing device 1TH, to terminal C. If this circuit is intact, the

checking relay CH immediately picks up and opens its back contact to remove connection of terminal B from conductor **50***b*, thereby preventing the mechanism FR of the signal S from actuating the signal on closure of the back contact **67** of relay **2**TR at such time as the formerly traced main circuit through mechanism FR is open. After the expiration of a time interval determined with respect to the time required for the train to come within 20 seconds running time of the crossing, contact **105** of the timing device **1**TH opens the stick circuit of relay R**1**, releasing this relay and at its back contact **104** completing the circuit through mechanism FR of signal S, to start operation of the signal.

It will be apparent that if the speed of the train through section **1**T is materially less than last assumed, the circuit through the winding of the timing device TH**2** will remain closed for a sufficient time period to effect the closure of contact **92**. In such a case, relay R**2** will pick up and at its contacts **201**—**204** will perform circuit changes similar to those brought about by the closure of contacts **101**—**104** of relay R**1**. A slow train entering section **2**T, by causing the release of relay **2**TR, prevents the timing device TH**3** from closing its contact **93**, and closes the series circuit through the windings of relay CH and timing device **1**TH. The relay CH immediately picks up, thus preventing operation of the signal, as before. When the contact **105** of the timing device **1**TH opens, relay R**1** releases but although its back contact **104** closes, the signal control circuit is inoperative because this circuit is still open at back contact **204** of relay R**2**. With relay R**2** picked up, when relay R**1** releases, its back contact **102** connects the winding of timing device **2**TH to conductor **86***c* by way of the front contact **202** of relay R**2**. When contact **205** of the timing device **2**TH opens, relay R**2** releases and at its back contact **204** completes the circuit through mechanism FR to start operation of the signal S. The added delay in operation of the signal introduced by the timing device **2**TH is such as to allow the lower speed train to approach within approximately 20 seconds running time of the crossing before operation of the signal is started.

In case a still lower speed train enters section **1**T, the winding of the timing device **TH3** will be included in circuit with conductor **85** over the obvious path including the front contacts **101** and **201** of relays R**1** and R**2**, and the back contact **301** of relay R**3**, a sufficient period to close front contact **93** of timing device **TH3**. After the expiration of a period of time sufficient to close contact **93**, relay R**3** will pick up. When relay R**3** picks up, its back contact **304** opens a further point in the main operating circuit of mechanism FR; its front contact **302** prepares a circuit for the winding of the associated timing device **3**TH; and its front contact **303** completes a stick circuit for the relay itself.

When the train finally enters section **2**T, operations fully described hereinbefore take place preparatory to closing of the main circuit through mechanism FR. When the back contact **204** of relay R**2** closes, operation of the signal will not take place immediately because of the open back contact **304** of relay R**3**. After the added delay introduced by the operation of the timing device **3**TH in opening contact **305** and effecting the release of relay R**3**, back contact **304** closes and completes the circuit through mechanism FR to start the operation of signal S at least 20 seconds before the train can reach the intersection.

When the train clears section **1**T, the relay **1**TR will again pick up. When the train enters section A**2**T, relay A**2**TR will release and at its front contact corresponding to contact **4** of relay **2**TR, will open the circuit for winding W**2** of relay HR. Owing to the mechanical interlocking incorporated in relay HR, the contacts associated with winding W**2** cannot now close and therefore the release of relay A**2**TR, when released by a train moving to the right, can exercise no control over the signal control apparatus.

When the train clears section **2**T, relay **2**TR again picks up; its back contact **67** opens the circuit of signal mechanism FR to stop operation of the signal; and front contact **4** recloses the circuit including winding W**1** of relay HR which relay accordingly closes its contacts **81** and **82**. When the train finally clears section A**1**T, the circuit through winding W**2** of relay HR is again completed and this relay is now in condition to fully release the proper contacts, depending upon the direction from which the train is approaching the intersection.

The signal control apparatus functions in the same manner whether a train approaches the intersection from one or the other direction and it will therefore be unnecessary to describe the operations which occur when a train approaches the intersection from the right.

As previously brought out, relay CH functions to check the integrity of the operating circuits of the timing devices **1**TH, **2**TH, and **3**TH. If one of these devices should fail to respond, due to an open circuit, for example, relay CH will not pick up so that operation of the signal S will be started without further delay.

In Fig. 2*a*, I have shown sufficient of the apparatus of Fig. 2 to illustrate an alternative way in which the failure of operation of signal S due to failure of a timing device may be guarded against. In this form of the invention, the relay CH is omitted and conductor **86***a* terminates in contact **102** of relay R**1** and therefore forms a part of the energizing circuits of the timing devices **1**TH, **2**TH, and **3**TH, exactly as in Fig. 2.

These timing devices as employed in Fig. 2*a* each have an additional normally closed contact, designated **106**, **206**, and **306**, respectively, each of which is adjusted to open an instant after its associated winding becomes energized. The branch conductor **50***b*, which in Fig. 2 receives current through the back contact of relay CH to complete an auxiliary circuit for mechanism FR receives current over a series path including contact **106**, conductor **108**, contact **206**, conductor **208** and contact **306** to likewise operate the signal S independently of the main operating circuit whenever a train enters an operating section and any one of the timing devices **1**TH, **2**TH, or **3**TH fails to operate. This condition always exists when a maximum speed train enters one of the operating sections **2**T or A**2**T. In the case of a lower speed train, however, relay R**1** will have been picked up before such train entered an operating section, and if the timing device **1**TH should fail to respond, its contact **106** will fail to interrupt the auxiliary operating path and the signal S will accordingly start operating immediately.

In case both relays R**1** and R**2** have been picked up and timing device **1**TH has functioned properly by opening its contact **106** to prevent actuation of the signal immediately when the train entered the operating section, then if the timing device

2TH fails to respond following the release of relay R1, an auxiliary path for operating the signal S will be provided which path includes conductor 50a, back contact 104 of relay R1, conductor 108, and the remaining portions of this series path.

It will be apparent that if after relay R3 has been picked up and timing devices 1TH and 2TH have functioned properly following the entry of the train into an operating section, then if the device 3TH fails to respond the auxiliary operating path for signal S including conductor 108, back contact 204 of relay R2, conductor 208, and contact 306 of device 3TH will not be interrupted and operation of the signal S will therefore be started at once.

If single direction control of the signal S is all that is required, the relay HR may be omitted and a track relay contact arrangement similar to that shown in Fig. 1 employed. On the other hand, the form of the invention illustrated in Fig. 1 may also be employed to control the signal S by trains approaching the intersection from either direction. In such a case, an HR relay and a track relay contact arrangement similar to that shown in Fig. 2 will be required.

Although I have herein shown and described only three 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 including a measuring section and an operating section each equipped with a track circuit including a normally energized track relay, said operating section having a highway intersecting the exit end thereof, a warning device at the intersection operative to warn traffic on the highway of the approach of trains; a chain of relays for registering, by the number of them which become operated, the time consumed by a train after its entry into the measuring section prior to its entry into the operating section of the stretch, means under control of the track relay of the measuring section when a train enters it for initiating the successive operation of the relays of said chain, means controlled by the track relay of the operating section when the train enters it for preventing any non-operated relays of the chain from being thereafter operated, a second timing device placed under control of the track relay of the operating section when the train enters it to successively effect the release of the operated relays of the chain, and an operating circuit for said warning device including back contacts of relays of said chain and of the track relay of said operating section.

2. In combination, a stretch of railway track intersected by a highway, a normally inactive highway signal control circuit, a first contact included in said circuit, train controlled means for actuating said contact to render said circuit active when a train approaching the intersection reaches a predetermined location in such stretch, time measuring means including a chain of relays arranged for consecutive operation, train controlled means for starting the operation of said time measuring means when a train approaching the intersection enters the stretch, other contacts governed by relays of said chain and effective at predetermined periods after said time measuring means has been started to prevent said highway signal control circuit from becoming active when said first contact is actuated, and means controlled by a train reaching said predetermined location prior to the time said other contacts become effective for rendering said other contacts ineffective thereafter.

3. In combination, two successive sections of railway track, a highway intersecting said track adjacent the exit end of the second section, a highway signal, a track circuit for each section including a track relay, a chain of relays, means controlled by the track relay of the first section for initiating the sequential operation of the relays of said chain, means controlled by the track relay of the second section for stopping the operation initiated by the track relay of the first section and for starting the sequential release of the operated relays of the chain, means also controlled by the track relay of the second section for starting the operation of said signal, and means for delaying the operation of said signal for a time period determined by the number of relays of the chain which have been operated and the time required to effect their release.

4. In combination, a stretch of railway track intersected by a highway, a highway signal located at the intersection, means for setting said signal into operation as a train approaching the highway from either direction reaches a point a fixed distance from the intersection, a group of relays, timing means set into operation by the entry of a train into the stretch from either direction and arranged to successively energize relays of said group until the train reaches said fixed distance from the highway, other timing means arranged when operating to successively effect the release of the energized relays of said group, means for disabling said first mentioned timing means and starting the operation of said other timing means when the fixed distance from the highway is reached by the train, and means controlled jointly by the energized relays of said group and by said other timing means to delay the starting of the operation of said signal until the energized relays of said group have all been released.

5. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, a chain of stick relays each having a contact for effecting control of said signal, means controlled by a train approaching said intersection for successively picking up one or more of said relays according as the speed of the train is at its maximum or at some lower value, means controlled by the approaching train for effecting the sequential release of the operated relay or relays of said chain, and means for initiating the operation of said signal when the relays of said chain have all been released.

6. In combination, a stretch of railway track intersected by a highway, a highway signal located at the intersection, means for setting said signal into operation when a train reaches a fixed point in said stretch, a group of relays, timing means set into operation by the entry of a train into the stretch and arranged to successively energize relays of said group until the train reaches said fixed point, other timing means arranged when operating to successively release the energized relays of said group, means for disabling said first-mentioned timing means and for starting the operation of said other timing means when the fixed point is reached, and means controlled jointly by the energized relays of said

group and by said other timing means to delay the starting of the operation of said signal for a time depending on the number of relays of said group which were picked up and then released.

7. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, a chain of stick relays, timing means responsive to the entry of a train into a first portion of the stretch, means including said time measuring means for picking up a variable number of the relays of said chain in accordance with the time consumed by a train while occupying said first portion of the stretch prior to its entry into a second portion of the stretch, other timing means for effecting the successive release of the operated stick relays of said chain, means for stopping the operation of said first mentioned timing means and for starting the operation of said other timing means when the train enters said second portion of the stretch, and means for setting said signal into operation when certain of the picked up relays of said chain have been released.

8. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, control means for starting the operation of said signal when a train reaches a fixed point in said stretch, a chain of relays, certain relays of said chain acting when energized to prevent said signal from being operated by said control means, a first time measuring device responsive to the entry of a train into the stretch for successively energizing the relays of said chain, a second time measuring device for successively effecting the release of the energized relays of said chain, and means operated by said control means for stopping the operation of said first time measuring device and starting the operation of said second time measuring device.

9. In combination, a stretch of railway track divided into two track relay equipped sections one of which is intersected by a highway, a highway crossing signal located at the intersection, a stick relay, a timing device for picking up said stick relay and set into operation by the track relay of the section which is first entered by a train approaching the highway, a second timing device having normally closed contacts, a stick circuit for maintaining said stick relay energized including said normally closed contacts of the second timing device, a circuit for said signal including back contacts of said stick relay and of the track relay associated with the section intersected by the highway, and an operating circuit for said second timing device also including a back contact of the track relay associated with the section intersected by the highway.

10. In combination, a stretch of railway track divided into two track relay equipped sections one of which is intersected by a highway, a highway crossing signal located at the intersection, a stick relay, a timing device for picking up said stick relay and set into operation by the track relay of the section first entered by a train approaching the intersection, a second timing device including a normally closed contact, a stick circuit for maintaining said stick relay energized following pick up thereof by said first timing device and including said normally closed contact of the second timing device, a circuit for said signal including back contacts of said stick relay and of the track relay of the section intersected by the highway, and an operating circuit for said second timing device including a front contact of said stick relay.

11. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located adjacent the intersection, a first time measuring device comprising a plurality of individual timing units each of which includes a thermal relay and a stick relay, circuit means controlled by a train in traveling a fixed distance in approaching the intersection for successively operating said timing units, means for maintaining the stick relays of said units energized, a second time measuring device comprising a plurality of individual timing units one for each unit of said first time measuring device, means controlled jointly by a train when it has traveled said fixed distance and by the energized stick relays for successively operating the timing units of said second device to effect the successive release of said stick relays, and a control circuit for said signal including back contacts of said stick relays.

12. In combination, two adjoining sections of railway track, a series of timing relays, means for successively operating relays of said series while a vehicle occupies the first of said two sections, a chain of normally deenergized stick relays successively energized over circuits closed by the energized timing relays of said series, a stick circuit for each relay of the chain adapted to retain its relay energized when once picked up, a second series of timing relays, control circuits for the relays of said second series prepared by the successive pick up of said stick relays, control means rendered effective as the vehicle enters the second of said two sections to successively operate the timing relays of said second series to successively effect the release of the energized stick relays, and a signal circuit completed jointly by said stick relays in their released position and by said control means.

13. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, control means for starting the operation of said signal as a train reaches a fixed point in said stretch, a stick relay adapted when energized to prevent the control of said signal by said control means, a timing device arranged to complete an energizing circuit for said stick relay a predetermined time after a train enters said stretch, a second timing device including normally closed contacts and placed under control of said control means by said stick relay, and a stick circuit for said stick relay including said normally closed contacts of the second timing device.

14. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, control means for starting the operation of said signal as a train reaches a fixed point in said stretch, a first stick relay adapted when energized to prevent operation of said signal by said control means, a timing device arranged to complete an energizing circuit for said first stick relay a predetermined time after a train enters the stretch, a second stick relay adapted when energized to prevent the control of said signal by said control means and by said first stick relay, a second timing device set into operation in response to the energization of said first stick relay and arranged to complete an energizing circuit for said second stick relay a predetermined time after the operation of said first stick relay, a third timing device including a normally closed contact and placed under control

of said control means by said first stick relay, a stick circuit for said first stick relay including said normally closed contact of the third timing device, a fourth timing device including a normally closed contact and placed under control of said control means by the release of said first stick relay, and a stick circuit for said second stick relay including said normally closed contact of the fourth timing device.

15. In combination, a stretch of railway track divided into a measuring and an operating section each equipped with a track relay, said operating section being intersected by a highway, a highway crossing signal at the intersection, a chain of relays, a pair of inter-controlled relays set into operation by the track relay of the measuring section when a train approaching the intersection enters the measuring section, an auxiliary relay cooperating with said pair to sequentially energize the relays of said chain; circuits for sticking up the energized relays of said chain, said circuits excluding contacts of said pair of relays; a second pair of inter-controlled relays cooperating with said auxiliary relay and set into operation by the track relay of said operating section, means controlled by the track relay of said operating section for at the same time stopping the operation of said first pair of relays, means controlled by said second pair of relays and by said auxiliary relay to successively interrupt the stick circuits of the energized relays of said chain, and an operating circuit for said signal closed when the track relay of said operating section and all relays of said chain are in their released position.

16. In combination, a stretch of railway track divided into a measuring and an operating section each equipped with a track circuit including a track relay, the operating section being intersected by a highway, a highway crossing signal at the intersection, a control circuit for said signal open at a given point, means controlled by the track relay of said measuring section for measuring the time consumed by a train while in said measuring section and prior to its entry into said operating section and for opening a second point in said control circuit if a predetermined minimum time expires before the train enters the operating section, means controlled by the track relay of the operating section for closing said given point in said control circuit, other means set into operation by the entry of the train into the operating section for closing said second point in said control circuit to start operation of the signal, and other operating circuits for said signal closed by the track relay of the operating section and opened by said means to prevent the immediate operation of said signal if the time consumed in said measuring section exceeds said predetermined minimum.

17. In combination, a stretch of railway track divided into a measuring and an operating section each equipped with a track circuit including a track relay, the operating section being intersected by a highway, a highway crossing signal at the intersection, a control circuit for said signal open at a given point, means controlled by the track relay of the measuring section for measuring the time consumed by a train while in said measuring section and prior to its entry into said operating section and for opening a second point in said control circuit if a predetermined minimum time expires before the train enters the operating section, means controlled by the track relay of the operating section for closing said given point in said control circuit, other means set into operation by the entry of the train into the operating section for closing said second point in said control circuit to start operation of the signal after the expiration of a time period, a second operating circuit for said signal closed by the track relay of the operating section, and means included in circuit with the means set into operation by the entry of the train into the operating section for rendering said second operating circuit ineffective.

18. In combination, a stretch of railway track divided into a measuring and an operating section, each equipped with a track circuit including a track relay, the operating section being intersected by a highway, a highway crossing signal at the intersection, a control circuit for said signal open at a given point, means controlled by the track relay of a measuring section for measuring the time consumed by a train while in said measuring section and prior to its entry into said operating section and for opening a second point in said control circuit if a predetermined minimum time expires before the train enters the operating section, means controlled by the track relay of the operating section for closing said given point in said control circuit, other means set into operation by the entry of the train into the operating section for closing said second point in said control circuit to start operation of the signal after the expiration of a time period, an emergency circuit for operating said signal controlled by the track relay of the operating section and including a contact immediately opened by the means set into operation by the entry of the train into the operating section, whereby if said last-named means fails to respond when the train enters said operating section said last-named contact will render said emergency circuit effective for operating said signal.

19. In combination, a stretch of railway track divided into track relay equipped measuring and operating sections, the latter of which is intersected by a highway, a highway signal at the intersection, a chain of relays, means set into operation by the track relay of the measuring section for energizing a variable number of the relays of said chain depending on the time such measuring section is occupied prior to the entry of the train into the operating section, means controlled by the track relay of the operating section to prevent any relays of said chain which remain deenergized from being picked up, means also set into operation by the track relay of the operating section to effect the release of the energized relays of the chain one at a time, and means for starting the operation of said signal effective when a given one of the relays of said chain becomes released.

20. In combination, a stretch of railway track divided into track relay equipped measuring and operating sections, the latter of which is intersected by a highway, a highway signal at the intersection, a chain of relays, means set into operation by the track relay of the measuring section for energizing a variable number of the relays of said chain depending on the time such measuring section is occupied prior to the entry of the train into the operating section, means controlled by the track relay of the operating section to prevent any relays of said chain which remain deenergized from being picked up, means also set into operation by the track relay of the operating section to effect the release of the energized relays of the chain one at a time, and means effective for starting the operation of said

signal when and only when the track relay of the operating section and certain relays of said chain are in their released position.

21. In combination, two successive sections of railway track, a highway intersecting said track adjacent the exit end of the second section, a highway signal, a track circuit for each section including a track relay, a chain of relays, means controlled by the track relay of the first section for initiating the sequential operation of the relays of said chain, means controlled by the track relay of the second section for stopping the operation initiated by the track relay of the first section and for starting the sequential release of the operated relays of the chain, means also controlled by the track relay of the second section for starting the operation of said signal, and means for delaying the operation of said signal for a period determined by the extent to which the chain of relays is operated and the time required to effect their release.

22. In combination, a stretch of railway track intersected by a highway, a highway crossing signal located at the intersection, a chain of relays, timing means, means controlled by a train approaching the intersection to initiate operation of said timing means in response to the entry of the train into a first portion of the stretch, means controlled by said timing means for energizing a variable number of the relays of said chain in accordance with the time consumed by the train while occupying said first portion of the stretch prior to its entry into a second portion of the stretch, other timing means associated with said chain of relays and effective when set into operation to release the relays one at a time at definite intervals apart, means for stopping the operation of said first mentioned timing means and for starting the operation of said other timing means when the train enters said second portion of the stretch, and means for setting the signal into operation when all of the relays of said chain have been released.

23. In combination, a stretch of railway track divided into measuring and operating sections, the latter of which is intersected by a highway, a track circuit for each of said sections including a track relay, a highway crossing signal at the intersection, a chain of relays, means set into operation by the track relay of the measuring section for energizing one at a time a variable number of the relays of said chain depending on the time such measuring section is occupied by a train prior to the entry of the train into the operating section, means set into operation by the track relay of the operating section to effect the release of the energized relays of the chain one at a time at stated intervals apart, and means effective to start the operation of said signal when the track relay of the operating section and the relays of said chain are all in their released position.

24. In combination, a forward section and a rear section of railway track, a highway intersecting said track adjacent the exit end of said forward section, a chain of relays provided with means for causing the relays if energized to release sequentially at predetermined time intervals after a train enters said forward section, timing means set into operation by the entry of a train into said rear section to energize the relays in said chain successively, a highway crossing signal for said intersection, and means for actuating said signal when said forward section is occupied provided only said relays are all released.

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