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CONTROL APPARATUS FOR HIGHWAY CROSSING SIGNAL

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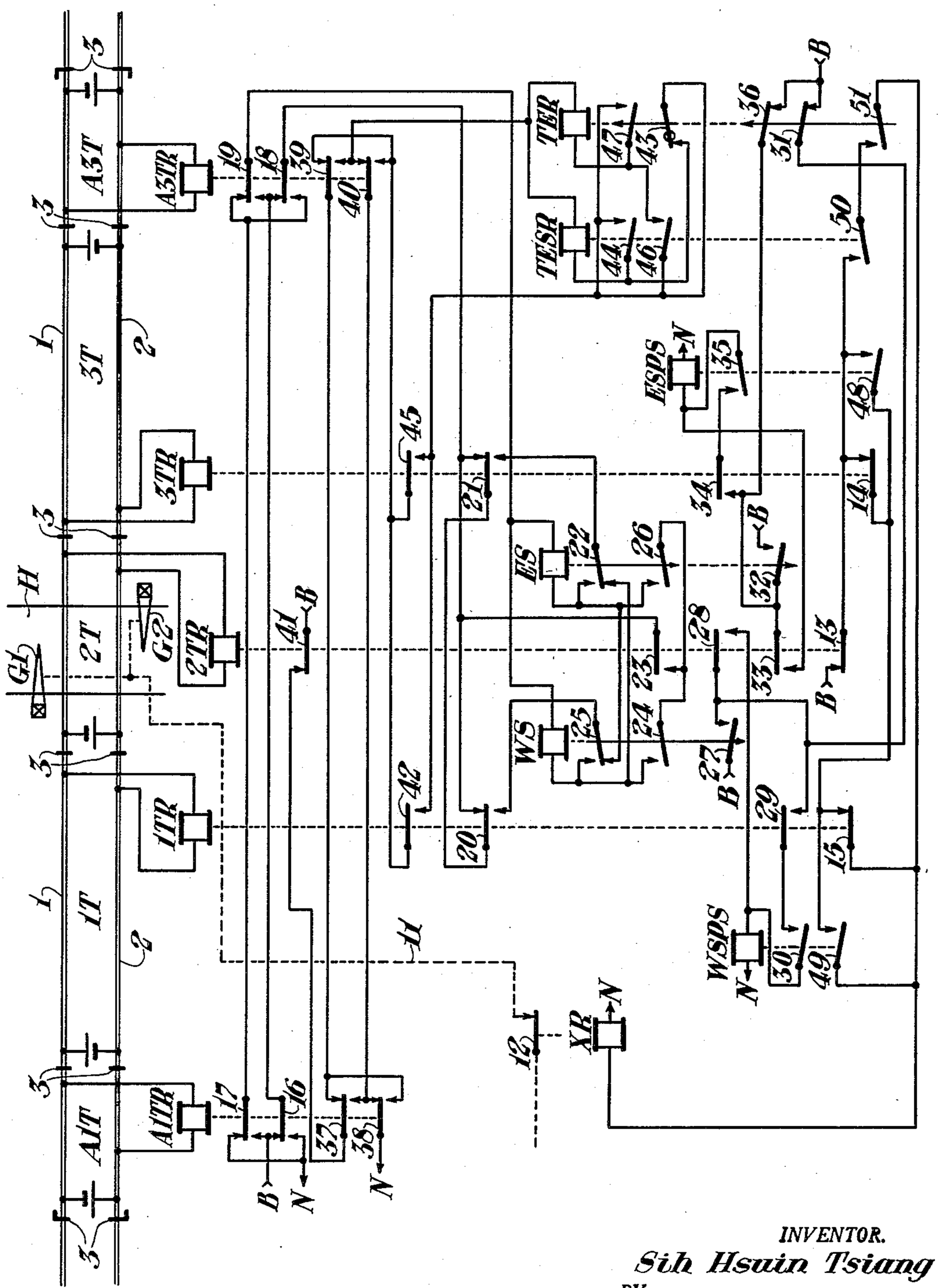

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CONTROL APPARATUS FOR HIGHWAY CROSSING SIGNAL

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My invention relates to control apparatus for highway crossing signals, and more particularly to control apparatus wherewith the warning condition of a highway crossing signal is automatically discontinued after a preselected time interval when a train stops or is switching in an approach control section, or when a track circuit condition occurs that causes the warning condition of the highway crossing signal unnecessarily.

If a highway crossing signal is operated to its warning position when no train is actually approaching the highway crossing and no dangerous condition to the highway users exist, the highway users form a habit of disregarding the warning signal with the result than an accident may occur because a highway user disregards the warning signal when a train is approaching. In order to avoid this unsatisfactory condition at highway crossings protected by automatic signals, there are in use control arrangements for restoring a highway crossing signal to its clear condition automatically a preselected time interval after it has been set to warn highway users. This action may occur either if a train has stopped in an approach control section to the highway crossing, or if a broken rail or other track circuit failure occurs in one of the control track sections for the highway crossing signal.

These control arrangements heretofore used are usually designed for a specific track layout and are not adaptable to general use. For example, the control apparatus for highway crossing signals can be classified into those adaptable for use in signaled territory of the railway and those adaptable for use in nonsignaled territory. In signaled territory, a broken rail or any other abnormal condition in the track circuit for a control section of a highway crossing signal is reflected by a restrictive indication of a railway signal. The train is then required to reduce its speed and thereby the danger to highway traffic over the crossing is decreased. In nonsignaled territory of a railway, a broken rail and other track circuit failures in a control section are not reflected by a restrictive railway signal indication and the measure of protection obtained by reduced train speed is therefore not available. Consequently the usual control arrangement for restoring the highway crossing signal to its clear condition after a selected time interval may not be safe.

Also, in highway crossing signal installations where the railway track is normally used for traffic in both directions, it is common practice to so design the crossing signal circuits that the operation of the crossing signal is halted as a train recedes from the highway crossing. This action is obtained by the use of directional stick relays. One of these relays is energized as the train is approaching the highway crossing and is then held up as the train recedes from the crossing. Contacts of this relay are used to bypass the usual track section control of the highway signal in the receding section. By this method the so-called "back-ringing" of the highway crossing signal, which is undesirable, is avoided. In normal operation the control of the highway crossing signal is returned to the usual track relays after the train has left the control

sections for the highway crossing signal. If an abnormal track circuit condition such as a broken rail occurs while the train is passing through the highway crossing signal control sections, that is, the approach or the receding sections, a condition may occur in which the directional stick relay is held up indefinitely. In this case the signal may not function properly upon the approach of a second train from the opposite direction.

In view of the foregoing circumstances pertaining to control of highway crossing signals, an object of my invention is the provision of novel control apparatus for highway crossing signals which incorporates means for returning a highway crossing signal to its clear condition, providing no condition exists which is unsafe for the highway users, a predetermined time interval after it has been set to give a warning indication.

A feature of my invention in accomplishing the preceding object is the provision of control apparatus for highway crossing signals incorporating improved means wherewith a highway crossing signal is returned automatically to its clear condition, if no danger to highway users exists, after a predetermined time interval regardless of whether the original danger indication was caused by a train occupying a control section or by a broken rail or some other track circuit failure.

Again, an object of my invention is the provision of highway crossing signal control apparatus of the type described incorporating improved means for reestablishing a danger or warning condition of a signal, which has been returned automatically to its clear condition after a predetermined time interval, when a train subsequently approaches the crossing.

Another object of my invention is to provide highway crossing signal control apparatus incorporating novel and improved means wherewith the undesirable "back-ringing" action is avoided.

Still another object of my invention is the provision of improved control apparatus for automatic highway crossing signals wherewith the warning operation of the signal is immediately effected when a train enters the controlling stretch of track, notwithstanding a broken rail having occurred in a control section as a preceding train traversed the stretch while approaching or receding from the crossing, and the signal having been cleared after passage of the train by time element control means.

A further feature of my invention is the provision of improved control apparatus for highway crossing signals requiring the use of only one time measuring means for both directions of traffic on the railway.

Other features, objects, and advantages of my invention will appear as the specification progresses.

I accomplish the foregoing features, objects, and advantages of my invention by the provision of a novel and improved circuit network which includes the track relays of a main approach control track section and an auxiliary or preliminary approach track section on each side of the highway crossing, and a positive operating track section at the crossing which extends a selected distance on each side of the highway. Each of these track sections is provided with a track circuit which includes a track relay. The track relay for each of the main control sections and the positive operating section have contacts which are arranged to control the operation of the highway crossing signal upon deenergization of the relay. The track relays for the auxiliary track sections have only pole-changing contacts, the use of which will appear shortly. In other words, only the track relays for the main control sections and the positive operating track section directly control the highway crossing signal.

The circuit network includes, in addition, directional stick relays controlled by the track relays of the main approach control sections. The energizing circuits for

the directional stick relays also include pole-changing contacts of the auxiliary track section relays so that the directional stick relays will be released when a train enters either of the auxiliary track sections when approaching or receding from the highway crossing. Each of the directional stick relays has a repeater stick relay which becomes energized only when the train enters the positive operating track section at the highway crossing. Contacts of these repeater stick relays are used to bridge the contacts of the opposite main control section track relay in the circuit network directly controlling the highway crossing signal so that the undesirable operation commonly called "back-ringing" is avoided. The stick circuits for these repeater relays are so arranged that the relays will be positively held up while the train is receding from the highway crossing, but that the relays will be released when the receding train clears the auxiliary track section regardless of the condition of the track circuits in the main control sections.

The circuit network also includes an adjustable time measuring means which operates, a preselected time interval after energization, to close front contacts and open back contacts. The time measuring means is energized over circuits including back contacts of the track relays for the main approach control sections and pole-changing contacts of the relays of the auxiliary track sections. Thus, the time measuring means is released when a train enters either of the auxiliary track sections while receding or approaching the highway crossing. Contacts of the time measuring means which are closed after the predetermined time interval are used to bridge the usual operating circuit for the highway crossing signal to cause the signal to operate to its clear condition if a train stops while approaching the highway crossing or if a track circuit failure occurs in either of the main control track sections. However, the release of the time measuring means due to the pole-changing action of the auxiliary track relays assures that the highway crossing signal will operate to its danger condition upon the approach of any train regardless of the condition of the various track circuits.

It is to be understood that a highway crossing signal as considered in this application may be any one of several known forms of highway crossing protection devices such as, an electric bell, stationary and flashing red lights, wigwag, gates, and barriers. The apparatus of my invention is effective to control the operation of any one or any combination of these several forms of highway crossing protection devices to a clear condition, that is, a position where highway traffic is free to cross the railway, and to a danger or warning condition which warns and/or obstructs the highway traffic.

I shall describe one form of apparatus embodying my invention and shall then point out the novel features thereof in claims.

The accompanying drawing is a schematic view showing a preferred form of apparatus embodying my invention when used at the crossing of a highway and a stretch of nonsignaled railway track. It is to be understood, however, that my invention is not limited to this one arrangement and that this disclosure is by way of illustration, the apparatus being useful for other intersections of highways and railway tracks.

Referring to the drawing, the reference characters 1 and 2 designate the track rails of a stretch of railway track which is intersected by a highway H. This track may be that of a single track railway or it may be one track of a multiple track railway, but it is here considered as a single track railway over which traffic moves in either direction.

Highway crossing signals are provided at the intersection of the highway H with the railway, the signals being shown as crossing gates G1 and G2. However, as pointed out hereinbefore, other forms of highway crossing protection devices can be used. It is sufficient for the present application to point out that each of the gates G1 and G2 includes an arm which is operable to a clear position where it does not interfere with highway traffic and to a danger or warning position where it extends across at least a portion of the highway as a warning to highway users that a train is approaching.

The rails 1 and 2 are divided, by the usual insulated rail joints 3, into a group of track sections A1T, 1T, 2T, 3T, and A3T. The sections A1T and 1T are formed to the left of the intersection, the section 2T is formed at the intersection, and the sections 3T and A3T are formed to the right of the intersection. As will appear hereinafter, the sections 1T and 3T are main approach control sections and are preferably of a length such that a train traveling at the maximum permissible speed for all trains in this stretch of railway will consume a selected time interval in passing therethrough, a time interval of the order of 20 to 25 seconds being generally considered satisfactory. The sections A1T and A3T are auxiliary or preliminary approach sections and each is relatively short. The minimum length of either of these auxiliary track sections is limited to that length which cannot be spanned by any railway car in use in the particular territory. In other words, once a train has entered either of these auxiliary track sections approaching or receding from the highway crossing, the track section must remain occupied by at least one pair of car wheels until the entire train has cleared that particular track section. The section 2T at the intersection of the highway crossing is a positive operating section and is of a length such that it extends a selected distance in each direction from the intersection.

Thus, the two sections A1T and 1T are auxiliary and main approach control sections, respectively, which an eastbound train traverses, in the order named, in approaching the highway crossing. The sections A3T and 3T are auxiliary and main approach control sections, respectively, which a westbound train traverses, in the order named, in approaching the crossing. The section 2T is a positive operating section which provides satisfactory warning operation of the highway crossing signal when a train is traveling in either direction at a relatively low speed.

Each of these track sections is provided with a track circuit which as here shown is of the direct current type although other types of track circuits can be used. As shown then, the track circuit for each of the track sections is of the commonly used type which includes a battery connected across the rails at one end of the section and a track relay, designated by the reference character R plus a prefix corresponding to the reference character for the track section, connected across the rails at the other end of the section. These track circuits are apparent from an inspection of the drawing, and need not be described in detail.

A suitable source of power is provided for supplying current to the control apparatus. This source of power is preferably a direct current source such as a battery, which is not shown. However, the positive and negative terminals of the battery are indicated in the drawing by the reference characters B and N, respectively.

Control of the highway crossing gates G1 and G2 is accomplished through a signal control relay XR, a control network for operating the gates G1 and G2 being indicated conventionally by a dotted line 11. Since this control network can be any one of several known arrangements, and since the specific control provided for the gates forms no part of my present invention, it is sufficient to point out that when relay XR is energized closing front contact 12, the gates are raised to a clear position and when the relay is deenergized opening front contact 12 the gates are lowered to a warning or danger position.

Signal control relay XR is in turn provided with a circuit network including several different circuit paths.

Normally, that is, when no train occupies any of the control sections, a circuit path is completed by which current flows from terminal B of the source through front contact 13 of relay 2TR, front contact 14 of relay 3TR, front contact 15 of relay 1TR, and the winding of relay XR to terminal N of the source. The remaining circuit paths for relay XR which are closed under different operating conditions of the apparatus will be pointed out hereinafter when the operation of the apparatus is described.

Directional control is obtained for the apparatus by two directional stick relays ES and WS, these relays being of the direct current, neutral type. Each of the directional stick relays ES and WS is provided with a pickup circuit and two stick circuits. Each pickup and stick circuit includes pole-changing contacts of the track relays A1TR and A3TR. The utility of this reversal of the direction of flow of current through the windings of the directional stick relays ES and WS will be pointed out when the operation of the apparatus is described. In the immediately following description, only front contacts 16, 17, 18, and 19 will be considered when tracing the various circuits. In other words, the circuits will be traced for one direction of current flow only, the track relays A1TR and A3TR being assumed to remain energized.

The relay WS, for example, is provided with a pickup circuit extending from terminal B through front contacts 16 and 18 of relays A1TR and A3TR, respectively, front contact 20 of relay 1TR, back contact 21 of relay 3TR, back contact 22 of relay ES, the winding of relay WS, and front contacts 19 and 17 of relays A3TR and A1TR, respectively, to terminal N. The first stick circuit for relay WS passes from terminal B and the previously mentioned front contacts 16 and 18 of relays A1TR and A3TR, respectively, through back contact 23 of relay 2TR, front contact 24 of relay WS, the winding of relay WS, and front contacts 19 and 17 of relays A3TR and A1TR, respectively, to terminal N. The second stick circuit for relay WS may be traced from terminal B over the same front contacts 16 and 18 of relays A1TR and A3TR, respectively, thence through front contact 21 of relay 3TR, back contact 20 of relay 1TR, front contact 25 of relay WS, the winding of relay WS, and front contacts 19 and 17 of relays A3TR and A1TR, respectively, to terminal N.

Referring next to the directional stick relay ES, this relay is provided with a pickup circuit which may be traced from terminal B of the source over front contacts 16 and 18 of relays A1TR and A3TR, respectively, front contact 21 of relay 3TR, back contact 20 of relay 1TR, back contact 25 of relay WS, the winding of relay ES, and front contacts 19 and 17 of relays A3TR and A1TR, respectively, to terminal N of the source. The first stick circuit for relay ES passes from terminal B over the previously mentioned front contacts 16 and 18 of relays A1TR and A3TR, thence through back contact 23 of relay 2TR, front contact 26 of relay ES, the winding of relay ES, and front contacts 19 and 17 of relay A3TR and A1TR, respectively, to terminal N. In a similar manner, the second stick circuit for relay ES may be traced from terminal B over front contacts 16 and 18 of relays A1TR and A3TR, respectively, front contact 20 of relay 1TR, back contact 21 of relay 3TR, front contact 22 of relay ES, the winding of relay ES, and front contacts 19 and 17 of relays A3TR and A1TR, respectively, to terminal N. It should be particularly noted that each of the circuits traced above for relays WS and ES includes a portion which is common to all of the circuits. This common portion to all these circuits consists of front contacts 16 and 17 of relay A1TR and front contacts 18 and 19 of relay A3TR. It is obvious that if either auxiliary track relay is released, its corresponding back contacts would replace the front contacts in a

manner to reverse the direction of current flow in these circuits.

Each directional stick relay has an associated repeater stick relay. For example, relay WS has associated with it the repeater stick relay WSPS, while relay ES has associated with it the repeater stick relay ESPS. These repeater stick relays function to prevent "back-ringing" of the highway crossing signals, or as specifically shown, allow the crossing gates to be raised after a train has cleared the highway crossing. Each of these relays is provided with a pickup circuit and two stick circuits. Referring first to the relay WSPS, the pickup circuit for this relay may be traced from terminal B through front contact 27 of relay WS, back contact 28 of relay 2TR, and the winding of relay WSPS to terminal N. From an examination of this pickup circuit, it will be obvious, that relay WSPS will not become energized until the train enters the track section 2T at the highway crossing. The first stick circuit for relay WSPS may be traced from terminal B over front contact 27 of the relay WS, back contact 29 of relay 1TR, front contact 30 of relay WSPS and the relay winding to terminal N. The second stick circuit for relay WSPS passes from terminal B through back contact 31 of relay TER, back contact 29 of relay 1TR, front contact 30 of relay WSPS and the winding of this relay to terminal N. Similarly, the pickup circuit for relay ESPS may be traced from terminal B over front contact 32 of relay ES and back contact 33 of relay 2TR through the winding of relay ESPS to terminal N. The first stick circuit for relay ESPS may be traced from terminal B over front contact 32 of relay ES, back contact 34 of relay 3TR, front contact 35 of relay ESPS and the relay winding to terminal N. The second stick circuit may be traced from terminal B through back contact 36 of relay TER, back contact 34 of relay 3TR, front contact 35 of relay ESPS, and the winding of relay ESPS to terminal N. The action of these two repeater stick relays in preventing "back-ringing" of the highway crossing signal will be described later in connection with the description of the operation of the entire apparatus.

Timing for the preselected time interval which must expire before the highway crossing gates G1 and G2 may be restored to a clear position is effected by time element relay TER and an associated stick relay TESR. The time element relay TER may be any one of several known forms for such time element relays. It is sufficient for the present application to point out that upon becoming deenergized the contact carrying member of relay TER is returned quickly to its initial biased position, a checking contact being closed only when this condition is fulfilled. This contact carrying member of relay TER is actuated away from its initial position to a position where front contacts are closed only after the relay has been energized for a time interval preselected by adjustment of the relay, that is, the front contacts of the time element relay are closed only after current has been supplied to the relay for a predetermined time interval. The adjustment of the relay is such that a range of time intervals from a few seconds up to a minute or more may be obtained. Similarly, ordinary back contacts of such a relay are opened only after the same predetermined time interval. However, the checking contact opens a very short time interval after the relay is initially energized.

The relay TER and its stick relay TESR are provided with alternate energizing circuits, one controlled by eastbound traffic approaching the highway crossing and the other controlled by westbound traffic approaching the highway crossing. These circuits include other pole-changing contacts of auxiliary track relays A1TR and A3TR. As stated before, the purpose of these pole-changing contacts will be shown later and for the present description of the energizing circuits these track relays will be considered to remain in their energized position with their front contacts closed, that is, only front contacts 37, 38, 39, and 40 will be considered for simplicity

in tracing the circuits. The circuit for energizing relay TESR in response to an eastbound train entering the track section 1T passes from terminal B of the source over front contact 41 of relay 2TR, front contact 37 of relay A1TR, front contact 39 of relay A3TR, back contact 42 of relay 1TR, checking contact 43 of relay TER, the winding of relay TESR, and front contacts 40 and 38 of relays A3TR and A1TR, respectively, to terminal N of the source. Similarly, a circuit is completed for energizing relay TESR in response to a westbound train entering section 3T, this circuit being identical to that just described with the exception that it includes back contact 45 of relay 3TR in place of back contact 42 of relay 1TR. In either case, when relay TESR picks up to close its front contact 44, a stick circuit is completed around the checking contact 43 of relay TER. The inclusion of checking contact 43 of relay TER in the initial energizing circuit for relay TESR assures that relay TER has returned to its biased position before any portion of the time element means can be energized.

Current is supplied to time element relay TER through front contact 46 of relay TESR and either of the two circuits traced above for relay TESR as will be apparent from an inspection of the drawing. When relay TER has been energized for a sufficient time interval to cause the front contacts to be closed, a stick circuit is completed over front contact 47 of relay TER around front contact 46 of relay TESR. Hence, it is to be seen that when an eastbound train enters the track section 1T, relay TESR picks up and current is then supplied to time element relay TER. Relay TER operates to close front contacts 47 and 51 and open back contacts 31 and 36 after the predetermined time interval for which it is adjusted has elapsed, providing the train remains in the track section 1T for a period greater than this time interval. Also, it is apparent that if the current supplied to time element relay TER is interrupted at any time before its contacts have been closed, the contact carrying member of the relay is at once released and restored to its initial biased position due to the characteristics of the relay. Similarly, when a westbound train enters the track section 3T, current is also supplied to time element relay TER to cause it to operate at the end of its adjusted time interval. It should be pointed out that relay TER is ordinarily adjusted for a time interval greater than that consumed by a train traveling at a reasonable speed through track section 1T or 3T so that the relay is energized for a sufficient period to close its front contacts only when the train is unduly delayed in either approach section or when there is a failure of a track circuit.

Normally, that is, when no train occupies any of the control sections, the apparatus occupies the position illustrated in the drawing and the gates G1 and G2 are held in their clear position. I shall now assume that with the apparatus in the normal position an eastbound train approaches the highway crossing. As this train passes through auxiliary approach section A1T, relay A1TR is shunted and releases. Upon release of relay A1TR, its contacts 16 and 17 pole-change the battery supply to the directional stick relays and also to the time element means. However, since contacts of the track relays of the control track sections actually control the supply of energy in these circuits, this pole-changing action at this time serves no useful purpose.

When the head end of the train enters control track section 1T, track relay 1TR is shunted and releases. The opening of front contact 15 of track relay 1TR opens the normal circuit path for signal control relay XR and this relay is deenergized since at this time none of its other energizing circuits is closed. With relay XR released, the gates G1 and G2 are operated to their warning condition, that is, they are lowered across the highway. Closing of back contact 20 of relay 1TR completes the previously traced pickup circuit for directional stick relay ES which then picks up. It is to be noted, however, that at this time the pickup circuit is over the back contacts 16 and 17 of relay A1TR so that the supply of energy is pole-changed with respect to the circuit as originally traced. The closing of back contact 42 of track relay 1TR, if checking contact 43 of relay TER is properly closed, completes the circuit previously traced for energizing relay TESR, with the exception that now back contacts 37 and 38 of relay A1TR are in the circuit so that the energy supply is pole-changed. Relay TESR picks up and the closing of its front contact 46 completes the similar circuit for energizing time element relay TER. Time element relay TER, thus energized, is set into operation to measure its preselected time interval.

It is to be noted at this point that when the rear end of the train clears the short track section A1T, track relay A1TR is then energized and picks up. This pole-changes the energizing circuits for relay ES and timing relays TESR and TER. This pole-changing of the circuit for relay ES causes the current to reverse its direction thru the winding of the relay, thereby causing the relay armature to be released since this relay is of the direct current, neutral type. It is well known that a reversal of the direction of the current flowing in a neutral relay winding causes the magnetic flux of the relay to die down, pass through zero, and build up in the opposite direction. As the magnetic flux passes through zero the armature of the relay is released. For the same reason, pole-changing the supply circuit for relays TESR and TER causes these relays to also release. However, since the pickup circuit for relay ES is still closed at back contact 20 of relay 1TR, relay ES immediately picks up again after the pole-changing action has occurred. Similarly, as soon as the checking contact 43 is closed, relay TESR picks up again since its energizing circuit is still closed at back contact 42 of relay 1TR. As soon as relay TESR picks up again and closes its front contact 46, relay TER is also reenergized and again set into operation to measure its selected time interval.

This condition of the apparatus just described will remain in effect while the train advances through the approach control section 1T. I shall assume that this train is traveling at a reasonable speed and that the time consumed for the head end of the train to reach and pass over the crossing is something less than the selected time interval for which time element relay TER is adjusted to operate its contacts.

When the head end of this eastbound train enters track section 2T, relay 2TR is shunted and releases. The opening of front contact 13 of relay 2TR opens the circuit for relay XR at a second point. Also, the closing of back contact 23 of relay 2TR completes the first stick circuit for directional stick relay ES and that relay is retained picked up. The closing of back contact 33 of relay 2TR completes the pickup circuit for the relay ESPS and this relay, thus energized, picks up. Opening of front contact 41 of relay 2TR interrupts the energizing circuits for relays TESR and TER and these two relays release.

When the head end of the train enters track section 3T, track relay 3TR is shunted and releases. Then, when the rear of the train vacates the section 1T and relay 1TR is reenergized and closes front contact 20, the second stick circuit for directional relay ES is completed and that relay is retained energized as the train is receding from the crossing through section 3T. The release of relay 3TR closing its back contact 34 completes both of the stick circuits for relay ESPS. In other words, since the back contacts of relay TER are still closed at this time, both stick circuits for relay ESPS are completed with energy being supplied from terminal B of the source over front contact 32 of relay ES and also over back contact 36 of relay TER.

Under this condition of the apparatus, as soon as the train clears the track section 2T so that relay 2TR is again energized and picks up, signal control relay XR is

energized by a circuit path which extends from terminal B over front contact 13 of relay 2TR, front contact 48 of relay ESPS, front contact 15 of relay 1TR, and the winding of relay XR to terminal N. Hence, as the train moves away from the crossing through track section 3T, relay XR is energized and the gates are raised to their clear position to permit highway traffic to move over the crossing. With relay 2TR having picked up to again close front contact 41 and back contact 45 of relay 3TR now closed, relays TESR and TER are again energized, although this action performs no useful function at this time. It is to be noted that if this train were to halt in the track section 3T so that relay TER completes its timing operation and opens back contact 36, the first stick circuit for relay ESPS over the front contact 32 of the relay ES will still be complete. Thus, the signal control relay XR will remain energized over the previously traced circuit and the crossing gates will remain in their clear position.

When the receding train enters the track section A3T, track relay A3TR is shunted and releases. Release of this relay pole-changes the circuits for relays ES, TESR, and TER. As previously described, this pole-changing action causes these relays to immediately release. Since, at this time, front contact 20 of relay 1TR and back contact 21 of relay 3TR are closed, the pickup circuit for relay ES is open and it remains released. Under these conditions, the pickup circuit for relay WS is completed upon the release of relay ES which closes its back contact 22. Relay WS thus picks up after the pole-changing action. Since relay 2TR has picked up prior to this time so that its back contact 28 is open, relay WSPS cannot be energized. Thus the pickup of relay WS serves no useful function.

Even though the train stops in track section 3T so that relay TER picks up, opening its back contact 36, relay ESPS remains energized when the train enters section A3T since relay ES is slower to release than relay TER. That is, relay TER releases to close its back contact 36 and complete the second stick circuit for relay ESPS before relay ES has released to open its front contact 32 to interrupt the first stick circuit for relay ESPS. Thus, the "back-ringing" of the highway crossing signal is still prevented since signal control relay XR remains energized over front contact 48 of relay ESPS.

If this train, while occupying the track sections A3T and 3T, stops for a period sufficient to allow time element relay TER to pick up, the stick circuit for relay ESPS would then be interrupted at back contact 36 of relay TER. However, when relay TER picks up, it completes another energizing circuit for relay XR. This circuit may be traced from terminal B through front contact 13 of relay 2TR, front contact 50 of relay TESR, front contact 51 of relay TER, and the winding of relay XR to terminal N. Since the length of track section A3T is such that it cannot be spanned by any car in use on the railway, when the eastbound train again starts up relay TER will remain energized until the entire train clears track section A3T. In this manner, prevention of "back-ringing" of the highway crossing signal is continued while the train is receding from the crossing. It is particularly pointed out here that, as has been described, during the entire time that the train is receding from the crossing, regardless of whether or not it halts in track section 3T or overlapping the two sections 3T and A3T, "back-ringing" does not occur because of the novel circuit arrangement using the repeater stick relay ESPS.

Since the circuits for this installation are symmetrical, the operation of the apparatus for a westbound train moving through the respective track sections at a reasonable speed is similar to that described in connection with the eastbound train. It is believed that the operation of the apparatus for a westbound train will be apparent from an inspection of the drawing taken in connection

with the previous description of the operation of the apparatus for the eastbound train. It is to be observed that when a westbound train has cleared the crossing, vacating track section 2T, and is receding from the crossing through track section 1T, signal control relay XR is provided with an energizing circuit extending from terminal B over front contact 13 of relay 2TR, front contact 14 of relay 3TR, front contact 49 of relay WSPS, and the winding of relay XR to terminal N. This circuit keeps relay XR energized during the entire time that the train is receding from the crossing in the westward direction and prevents "back-ringing" of the highway crossing signal. Again, if the train should halt after a portion of it occupies the track section A1T, the energizing circuit for relay XR would be transferred to the contacts 50 and 51 of relays TESR and TER, respectively, as was previously described for the eastbound train.

I shall next assume that with the apparatus in its normal position an eastbound train enters the section 1T and stops in that section for a period greater than the time required for time element relay TER to operate its contacts. As this train enters section 1T and shunts track relay 1TR, signal control relay XR is deenergized and releases due to the opening of front contact 15 of relay 1TR. Thus the gates G1 and G2 are operated to their warning position in response to approach of a train in section 1T. With the train stopping in section 1T for a period greater than the selected time interval for the operation of relay TER, that relay is supplied with current over the circuit including back contact 42 of track relay 1TR for sufficient time to close its front contacts. With the front contacts of relays TER and TESR closed, a previously traced circuit for energizing signal control relay XR is completed over front contact 50 of relay TESR and front contact 51 of relay TER. Relay XR, thus energized, picks up so that the gates are raised to their clear position while the train is standing in the section 1T. It is to be here noted that if the train has stopped while occupying both sections 1T and A1T, the time interval before relay TER closes its front contacts is measured from the instant that the head end of the train entered track section 1T. However, if the train stops with the entire train in section 1T, the time interval is then measured from the instant that the rear end of the train clears section A1T. In other words, as previously described, when the rear end of the train clears track section A1T, a pole-changing action occurs in the energizing circuit for relays TESR and TER and the measurement of the time interval begins again. However, the additional period of time before the gates are raised is in the interest of safety and the increased period of operation of the crossing signal is not considered objectionable. When this train again advances to approach the crossing, it will do so at a relatively slow speed. The train upon entering the positive operating section 2T shunts track relay 2TR which releases and opens its front contact 13 interposed in the control circuit for relay XR, with the result that relay XR releases and the gates are operated to the danger position. It will be recalled that the section 2T extends a selected distance each side of the crossing and satisfactory operation of the highway crossing gate is effected for a train approaching the intersection at a relatively low speed. Also, the opening of front contact 41 of relay 2TR deenergizes relays TESR and TER which release.

The directional relay ES is energized and picked up in response to this eastbound train in the manner previously explained. When the train proceeds after the halt and occupies section 2T, the previously described circuit including front contact 32 of relay ES and back contact 33 of relay 2TR is completed for energizing relay ESPS. Thus the gates are cleared, as previously explained, when the train has passed over the intersection and recedes therefrom through the section 3T.

It will be assumed next that a westbound train approaches the crossing and stops in section 3T. Track relay 3TR releases and opens front contact 14, thus causing signal control relay XR to be deenergized so that the gates are operated to their danger position. Also, relays TESR and TER are supplied with current over the circuit path through the back contact 45 of relay 3TR. With the train standing in section 3T for a period greater than the selected time interval for the operation of time element relay TER, that relay picks up at the end of this time interval to close its front contacts. Again, the energizing circuit for signal control relay XR that includes front contacts 50 and 51 of relays TESR and TER is completed so that relay XR picks up. This results in the gates being operated to their clear position while the train is standing in the section 3T. In a manner similar to that previously described, the time interval may be measured from the instant the head end of the train entered section 3T or from the time the rear end of the train cleared the section A3T depending upon whether or not the train is occupying one or both of these sections when it halts.

When this westbound train again advances towards the intersection, it will do so at a relatively low speed. Upon entering the section 2T, the shunting of track relay 2TR which releases to open front contact 13 causes relay XR to release so that the gates are again operated to their warning position. This time the directional relay WS is picked up due to the train occupying the section 3T so that when the train enters section 2T, the closing of back contact 28 of relay 2TR completes the energizing circuit for relay WSPS which then picks up. The closing of front contact 49 of relay WSPS completes an energizing circuit for the relay XR and the gates are operated to their clear position as soon as the westbound train clears the intersection and vacates the track section 2T. Thus, it is to be seen from the foregoing description that with a train stopping in either section 1T or 3T as it approaches the intersection, the gates are cleared at the end of a preselected time interval and then restored to their warning position when the train again approaches the intersection and occupies the positive operating track section 2T.

I shall next assume that with the apparatus in its normal position, the track circuit of section 1T fails due to a broken rail, a loose bond wire, or some other similar condition so that track relay 1TR is released. When track relay 1TR releases opening front contact 15, the normal energizing circuit for signal control relay XR is opened and this relay releases causing the gates to be operated to their lowered or danger position. The closing of back contact 42 of track relay 1TR completes one of the circuits for supplying current to relay TESR and in turn to time element relay TER. This results in time element relay TER being operated at the end of its selected time interval to close front contact 51. Since the front contact 50 of relay TESR is already closed, this completes the previously traced alternate pickup circuit for relay XR. When relay XR picks up, the gates are raised to their clear position with the result that the highway users are delayed because of the broken rail or track circuit failure in the approach control section 1T no longer than the preselected time interval of operation for time element relay TER.

With relay 1TR released closing back contact 20, the energizing circuit for relay ES is completed and this relay picks up. However, although the front contact 32 of relay ES is closed, the energizing circuit for relay ESPS remains open at back contact 33 of track relay 2TR, and relay ESPS remains in its released position. It is also to be noted that none of the stick circuits for relay ES is completed at this time since back contact 23 of relay 2TR and back contact 21 of track relay 3TR are open.

Let us now assume that subsequent to this failure of the track circuit for section 1T and the clearing of the gates at the end of the preselected time interval, an eastbound train approaches the crossing and enters the sections A1T and 1T. As the train moves through section A1T, track relay A1TR is shunted and releases. Upon the release of relay A1TR, its contacts 37 and 38 pole-change the energizing circuit of relays TESR and TER with the result that these relays immediately release. The release of relays TESR and TER opens the circuit for signal control relay XR which then releases to start the operation of the crossing signal. Hence, the warning position of the highway crossing signal is reestablished when an eastbound train approaches the crossing subsequent to the failure of the track circuit of section 1T and the clearing of the gate through the time element means. Obviously, this operation of the gate in response to a train approaching the crossing subsequent to the failure of a track circuit is essential in nonsignaled territory of a railroad. Furthermore, such an operation greatly adds to the safety of the highway traffic even in the signaled territory of a railway.

It is to be seen, then, that it is the release of relay A1TR to pole-change the energizing circuit for the time element means that causes the highway crossing signal to again operate to its danger condition after a track circuit failure. While it is here shown that the pole-changing action occurs as the result of the release of a track relay in the short approach or auxiliary track section, it is to be understood that the pole-changing action could be the result of other means. For example, a track instrument of any well-known type which is responsive to the passage of a train could be installed at the remote end of the main approach control section with its contacts so arranged that when the track instrument is actuated by a train, its contacts pole-change the various circuits as required.

It should be particularly pointed out that while the eastbound train is receding from the crossing through section 3T, with a track circuit failure in section 1T causing track relay 1TR to remain released after the train vacates that section, the energizing circuit for relay XR remains open at front contact 15 of track relay 1TR. This results in relay XR not picking up in the usual manner as the train is receding from the highway crossing. This in turn results in the gates not being cleared until time element relay TER has completed its operation to close its front contact 51 and pick up relay XR in the manner previously explained. This retaining of the signal in the warning position after the eastbound train has passed over the crossing for a selected time interval serves as an indication to the maintainer that there is an abnormal condition in the circuits.

I will now assume that, after a broken rail or some other track circuit failure in section 1T has caused the gates to be lowered and then cleared due to the operation of time element relay TER, a westbound train approaches the crossing. As this train passes through the auxiliary track section A3T, track relay A3TR is shunted and releases. Contacts 39 and 40 of relay A3TR pole-change the circuit for the time element means and relays TESR and TER immediately release. This opens the circuit for signal control relay XR, the release of this relay causing the highway crossing gates to be lowered to their danger position. As the train enters track section 3T, the resulting release of track relay 3TR causes relay ES, which was picked up as a result of the failure of the track circuit of section 1T, to release due to the opening of front contact 21 of relay 3TR. However, since both relays 1TR and 3TR are released, the circuit is not completed for energizing relay WS and as a result this relay remains released. Since relay WS remains released with its front contact 27 open, relay WSPS also remains released when the train enters the track section 2T. When the train clears the track section 2T and is receding from the highway crossing through section 1T, the gates remain in their lowered position since the circuit for relay XR is

open at front contact 49 of relay WSPS, the other alternate circuits being opened in the normal manner. Consequently, the gates are retained in their lowered position until time element relay TER has again had time to close its front contact 51 and reenergize signal control relay XR. Again this retaining of the gates in their lowered position for the selected time interval as the train is receding away from the crossing is an indication of abnormal conditions in the track circuits.

A track circuit failure in the section 3T which causes track relay 3TR to release will result in operation of the apparatus similar to that explained above in connection with the track circuit failure in section 1T. The response of the apparatus to this failure will be apparent from an inspection of the drawing when taken in connection with the description of the operation resulting from the failure of the track circuit for section 1T, and it is deemed unnecessary to include a detailed description of this operation.

I shall now assume that the apparatus is in its normal condition, and that an eastbound train approaches the crossing causing the gates to be operated as explained herebefore. I shall also assume that a rail of the section 3T is broken as this eastbound train is moving away from the crossing through section 3T. Under these conditions, track relay 3TR remains released after the train vacates the section due to the failure of the track circuit. As has been previously described, while the train is receding from the highway crossing, front contact 48 of relay ESPS bridges the open front contact 14 of track relay 3TR to hold relay XR energized so that the gates are raised to their clear position and held in that position. Relay ESPS is held up over its usual stick circuits. However, the passage of the train through the track section A3T and the resulting release of track relay A3TR pole-changes the circuit for relay ES. When this relay releases and opens its second stick circuit, it cannot again pick up since track relay 1TR is now energized and track relay 3TR is released. It is to be noted that relay WS is energized under these conditions and will pick up. However, this action serves no useful purpose at this time. Although relay ES upon releasing opens the first stick circuit for relay ESPS, the second stick circuit for this relay remains closed since time element relay TER has been or is now in the released position so that its back contact 36 remains closed. Since the circuit for energizing the time element means remains closed at back contact 45 of relay 3TR, after the preselected time interval has expired, relay TER will pick up. This opens the second stick circuit for relay ESPS which then releases. However, the picking up of relay TER completes at its front contact 51 a previously described alternate circuit for relay XR so that this relay remains energized and the gates remain in their clear position.

If, after the eastbound train has departed, a westbound train approaches the highway crossing and enters the track section A3T, the release of track relay A3TR will cause the circuit for time element relay TER to be pole-changed and this relay then releases. As has been previously described, the release of time element relay TER opens the circuit for signal control relay XR. Release of this relay causes the highway crossing gates to be lowered into their danger position. If the next train is an eastbound train, the action will be similar. When the eastbound train enters track section A1T, release of relay A1TR will also pole-change the circuit for time element relay TER and it releases with results as already described.

If a track circuit failure occurs in the section 1T as a westbound train is receding from the highway crossing, the operation of the apparatus will be similar to that previously described for the eastbound train and the track circuit failure in the section 3T. The response of the apparatus under this condition is obvious from an inspection of the drawing when taken in connection with

the above-described action with the eastbound train and a detailed description of this operation is not necessary for an understanding of my invention.

Although I have herein shown and described but one form of control apparatus for highway crossing signals 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 control apparatus for a highway crossing signal operable to a clear and a warning condition and located adjacent the intersection of a highway and a stretch of railway track, the combination comprising a track circuit for a track section formed in said stretch of railway track adjacent one side of said intersection, said track circuit having a track relay provided with contacts operable to different positions according as said track section is unoccupied or occupied by a train, a first circuit means including a contact of said track relay and having connections to said signal to operate the signal to its clear or warning condition according as said track section is unoccupied or occupied by a train or as said track circuit is closed or is interrupted by a failure, an electrical time measuring means having a contact biased to an open position and operated to a closed position only when current is supplied to said time measuring means for a preselected time interval, said time measuring means being normally deenergized, a second circuit means including a current source and a contact of said track relay closed when said track section is occupied or said track circuit fails, said second circuit means being connected to said timing means for supplying current thereto, a third circuit means including said contact of said time measuring means and having connections to said signal to operate the signal to its clear condition, an auxiliary track section located outside of and adjacent to the first mentioned track section at its end remote from said intersection, said auxiliary track section being of a length greater only than the maximum distance spanned by the axles of a single railway car and having another track circuit including another track relay provided with pole-changing contacts operable to different positions according as said auxiliary track section is unoccupied or occupied by a train, said pole-changing contacts being interposed in said second circuit means to release said time measuring means when a train approaches said intersection subsequent to an operation of said time measuring means.

2. In control apparatus for a highway crossing signal operable to a clear and a warning condition and located adjacent the intersection of a highway and a stretch of railway track, the combination comprising a track circuit for a track section formed in said stretch of railway track adjacent one side of said intersection, said track circuit having a track relay provided with contacts operable to different positions according as said track section is unoccupied or occupied by a train, a first means including a contact of said track relay and having connections to said signal to operate the signal to its clear or warning condition according as said track section is unoccupied or occupied by a train or as said track circuit is closed or is interrupted by a circuit failure, an electrical time measuring means having a contact biased to an open position and operated to a closed position only when current is supplied to said time measuring means for a preselected time interval, said time measuring means being normally deenergized, a second means including a current source and a contact of said track relay closed when said track section is occupied or said track circuit fails, said second means being connected to said timing means for at times supplying current thereto, a third means including said contact of said time measuring means and having connections to said signal to operate the signal to its clear condition, other means responsive to the passage of a train and located outside of and adjacent to the first mentioned track circuit at its end remote from said inter-

section, said other means having pole-changing contacts which are interposed in said second means to release said time measuring means when a train approaches said intersection subsequent to an operation of said time measuring means.

3. In control apparatus for a highway crossing signal operable to a clear and a warning condition and located adjacent the intersection of a highway and a stretch of railway track, the combination comprising a track circuit for a track section formed in said stretch of railway track adjacent one side of said intersection, said track circuit having a track relay provided with contacts operable to a first and a second position according as said track section is unoccupied or occupied by a train, said contacts also being operated to said second position if said track circuit fails, a first circuit means including a contact of said track relay and having connections to said signal to operate the signal to its clear or warning condition according as said track relay contacts are operated to said first or said second position, an electrical time measuring means having a contact biased to an open position and operated to a closed position only when current is supplied to said time measuring means for a preselected time interval, said time measuring means being normally deenergized, a second circuit means including a current source and a second position contact of said track relay, said second circuit means being connected to said timing means for at times supplying current thereto, a third circuit means including said contact of said time measuring means and having connections to said signal to operate the signal to its clear condition, pole-changing contacts responsive to the passage of a train and located adjacent to and outside of said track section at the end remote from said intersection, said pole-changing contacts being interposed in said second circuit means to pole-change said current source and release said time measuring means when a train approaches said intersection subsequent to an operation of said time measuring means.

4. In control apparatus for a highway crossing signal operable to a clear and a warning condition and located adjacent the intersection of a highway and a railway track, the combination comprising a track circuit for a track section formed in said railway track adjacent one side of said intersection, said track circuit having a track relay which is picked up or released as said section is unoccupied or occupied by a train, means including a contact of said track relay and having connections to said signal to operate the signal to its clear or warning condition according as said track relay is picked up or released, a time element relay having a contact biased to an initial position and operated to a closed position only when said time element relay is energized for a predetermined time interval, another means including said time element relay contact in its closed position and having connections to said signal to operate the signal to its clear condition, another track circuit for an auxiliary track section formed in said railway track adjacent the end of the first mentioned track section remote from said intersection, said auxiliary track section being of a length greater only than the maximum distance spanned by the axles of a single railway car, said other track circuit having another track relay which is picked up or released according as said auxiliary track section is unoccupied or occupied by a train and which is provided with pole-changing contacts, an energizing circuit for said time element relay including a current source, a contact closed when said track relay is released, and pole-changing contacts of said other track relay whereby said time element relay is released and said signal operated to its warning condition when a train approaches said intersection subsequent to said signal having been operated to its clear condition due to an operation of said time element relay.

5. In control apparatus for a highway crossing signal operable to a clear and a warning condition and located adjacent the intersection of a railway track and a highway, the combination comprising, a first and a second control track section formed in said track adjacent opposite sides of said intersection, a positive operating section formed in said track at said intersection and extending a selected distance on each side, a first and a second auxiliary track section formed in said track outside of and adjacent to the end of said first and second control sections, respectively, remote from said intersection, each said auxiliary section being greater in length than the maximum distance spanned by the axles of a single railway car, a track circuit including a track relay for each said track section, each track relay being picked up or released according as the corresponding track section is unoccupied or occupied by a train, the track relays of said auxiliary sections each having a set of pole-changing contacts, a first directional relay energized when the track relay of said first control section is released and a second directional relay energized when the track relay of said second control section is released, said first directional relay being held up if said second control section track relay is subsequently released and said second directional relay being held up if said first control section track relay is subsequently released, said set of pole-changing contacts of each auxiliary section track relay being interposed in a common portion of the energizing and holding circuits for both said directional relays; a repeater relay of each directional relay, a pick up circuit for each repeater relay including an energized position contact of the corresponding directional relay and a contact closed when said positive operating section track relay is released, a stick circuit for each repeater relay including an energized position contact of said corresponding directional relay and a contact closed when the opposite control section track relay is released, a signal control relay, means including a contact of said signal control relay to operate said signal to its clear or warning condition according as said signal control relay is energized or deenergized, and an energizing circuit for said signal control relay including in series a contact closed when said positive operating section track relay is picked up, front contacts of said first repeater relay and said second control section track relay in multiple, and front contacts of said second repeater relay and said first control section track relay in multiple, whereby back-ringing of said signal is prevented during regular operation and operation of said signal to its danger condition is assured upon approach of a train subsequent to a track circuit having opened.

6. In control apparatus for a highway crossing signal operable to a clear and a warning condition and located adjacent the intersection of a railway track and a highway, the combination comprising, a first and a second control track section formed in said track adjacent opposite sides of said intersection, a first and a second auxiliary track section formed in said track outside of and adjacent to the end of said first and said second control sections, respectively, remote from said intersection, each said auxiliary section being greater in length than the maximum distance spanned by the axles of a single railway car, a positive operating track section formed in said track at said intersection and extending a selected distance on each side, a track circuit including a track relay for each of said track sections, each track relay being picked up or released according as the corresponding track section is unoccupied or occupied by a train, the track relay for each said auxiliary track section having a first and a second set of pole-changing contacts, a first directional relay energized when the track relay of said first control section is released and a second directional relay energized when the track relay of said second control section is released, a first holding circuit for each said directional relay including a back contact of said positive operating track relay, a second holding circuit for each said directional relay including a back contact of the opposite one of said control track relays, the first set of pole-changing contacts of each said auxiliary track relay being interposed in a circuit portion which is common to all the ener-

gizing and holding circuits for both said directional relays, a repeater relay of each directional relay, a time element relay having a first contact operable to a closed position only when that relay is energized for a predetermined time interval and normally closed back contacts operable to an open position at the end of said time interval, an energizing circuit for said time element relay including a source of current, back contacts in multiple of said control track relays, a front contact of the positive operating track relay, and the second set of pole-changing contacts of both auxiliary track relays; a pick-up circuit for each said repeater relay including a front contact of the corresponding directional relay and a back contact of said positive operating track relay, a first stick circuit for each said repeater relay including said front contact of the corresponding directional relay and a back contact of the opposite control track relay, a second stick circuit for each said repeater relay including a back contact of said time element relay and a back contact of the opposite control track relay, a signal control relay, a circuit network connected to energize said signal control relay and having a first circuit path including in series a front contact of said positive operating track relay, front contacts in multiple of said first repeater relay and said second control track relay, and front contacts in multiple of said second repeater relay and said first control track relay and a second circuit path including in series a front contact of said positive operating track relay and said first contact of said time element relay; and an operating circuit connected to said signal and including a front contact of said signal control relay.

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