July 23, 1940. J. M. EVANS ET AL 2,209,225

CONTROL SYSTEM

Filed Nov. 4, 1936 3 Sheets-Sheet 1

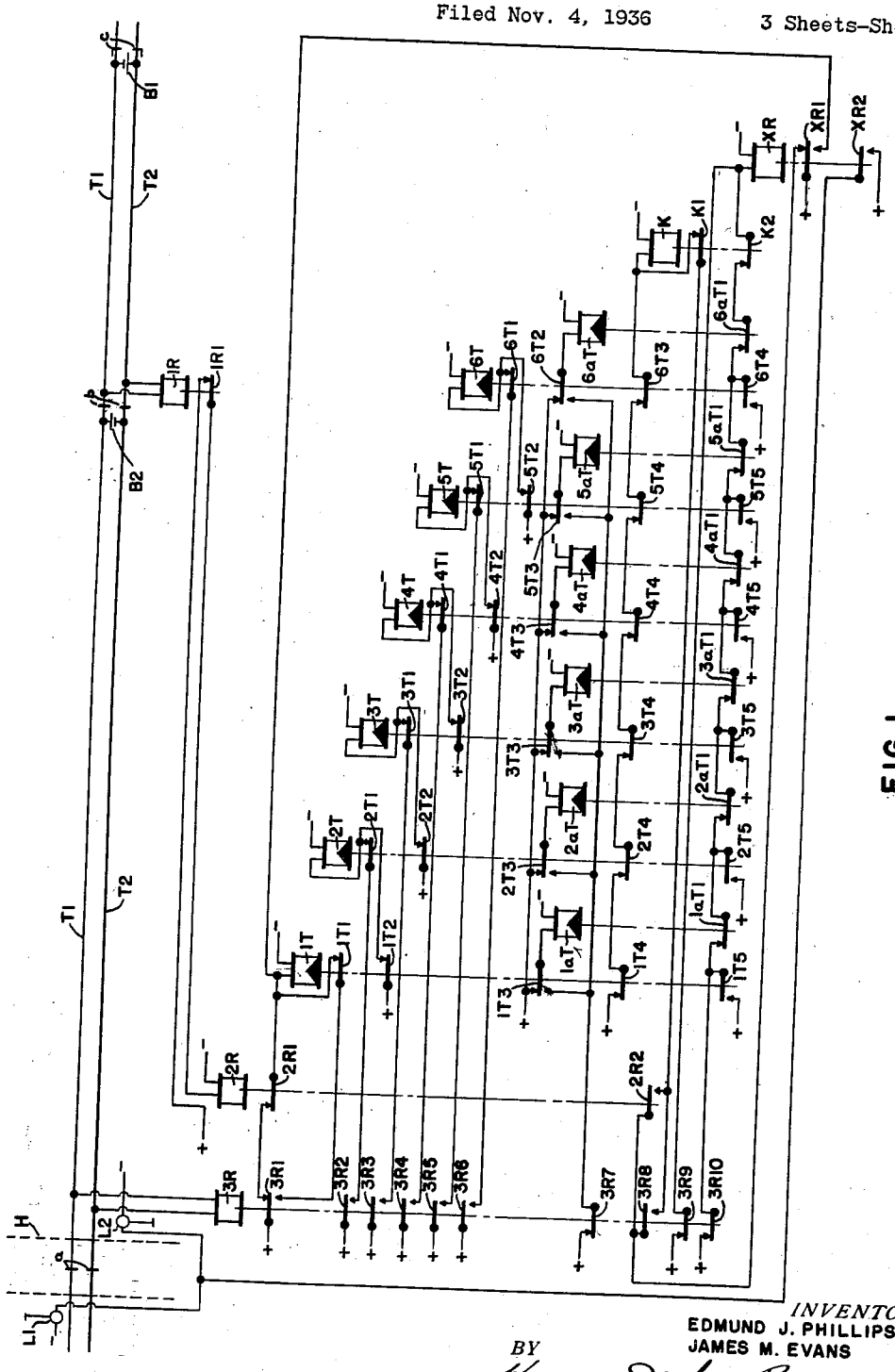


FIG. 1.

INVENTORS
EDMUND J. PHILLIPS
JAMES M. EVANS

BY Harness, Dickey, Pierce & Mann
ATTORNEYS.

July 23, 1940. J. M. EVANS ET AL 2,209,225

CONTROL SYSTEM

Filed Nov. 4, 1936 3 Sheets-Sheet 2

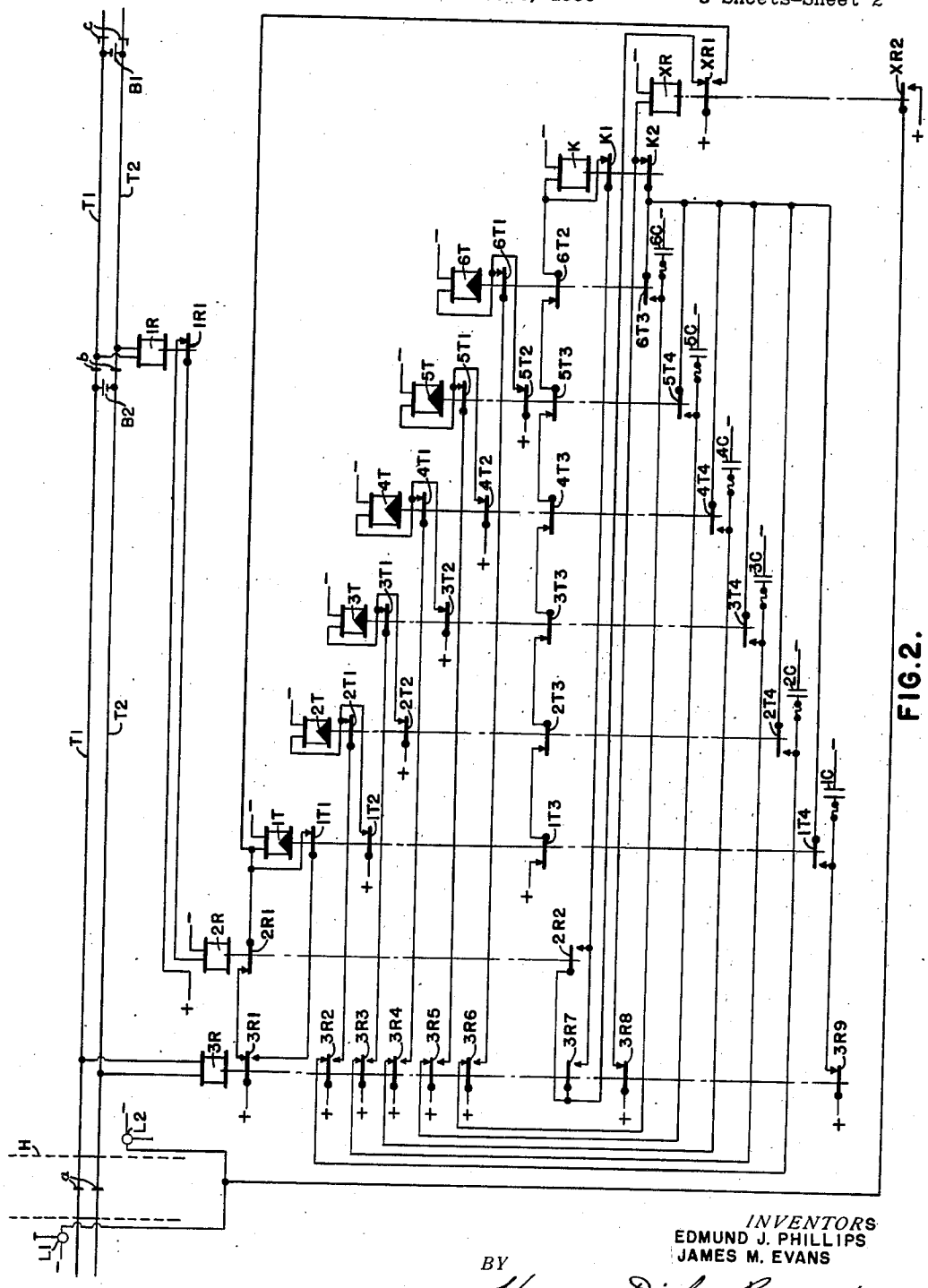


FIG. 2.

INVENTORS
EDMUND J. PHILLIPS
JAMES M. EVANS

BY

Harness, Dickey, Pierce & Mann
ATTORNEYS.

July 23, 1940. J. M. EVANS ET AL 2,209,225

CONTROL SYSTEM

Filed Nov. 4, 1936 3 Sheets-Sheet 3

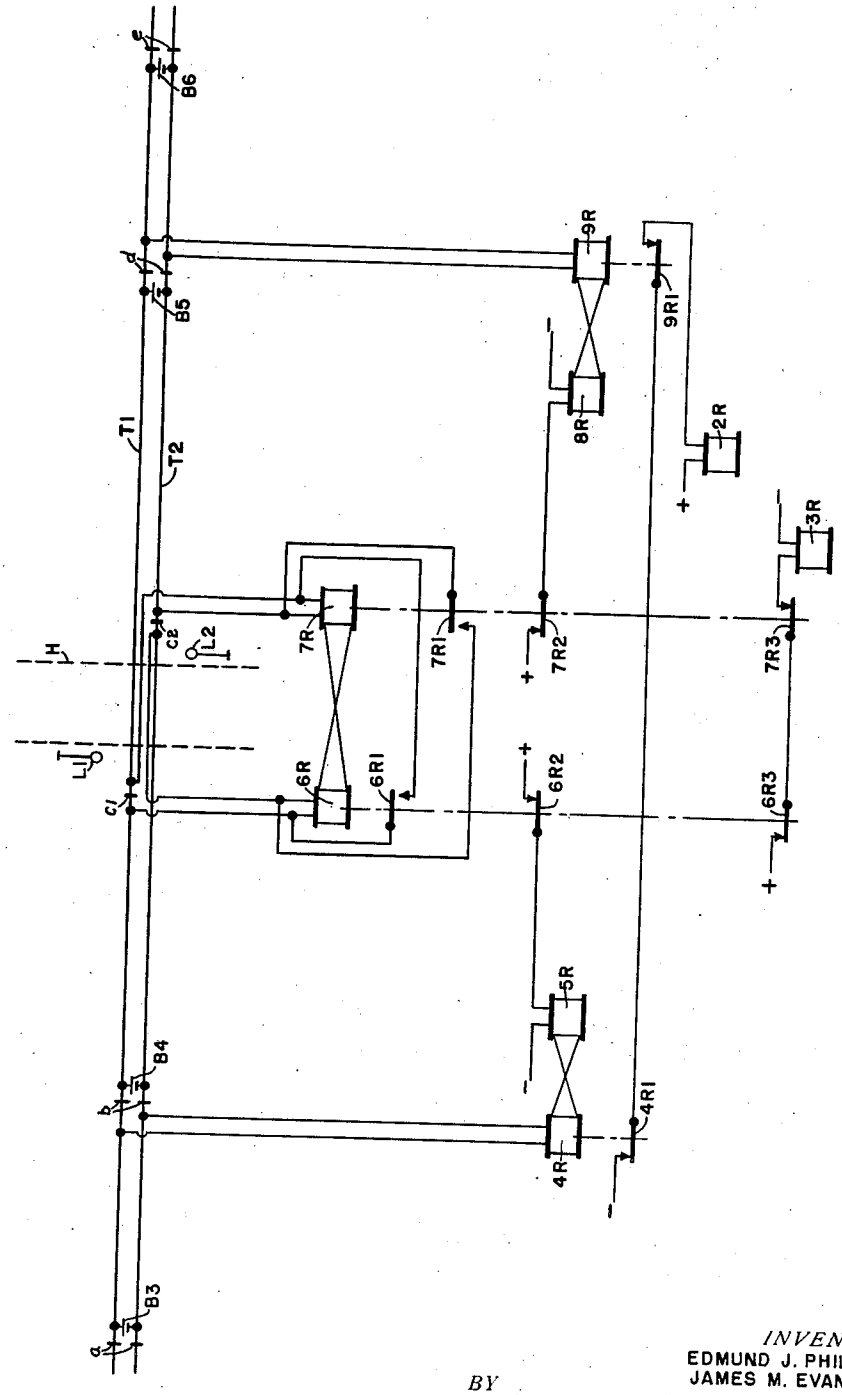


FIG. 3.

INVENTOR
EDMUND J. PHILLIPS
JAMES M. EVANS

BY Harness, Dickey, Pierce & Mann.
ATTORNEYS.

Patented July 23, 1940 2,209,225

UNITED STATES PATENT OFFICE

2,209,225

CONTROL SYSTEM

James Moore Evans, Detroit, Mich., and Edmund J. Phillips, Chicago, Ill., assignors to Evans Products Company, Detroit, Mich., a corporation of Delaware

Application November 4, 1936, Serial No. 109,110

10 Claims. (Cl. 246—130)

The present invention relates to protective systems for crossings, or the like, and in particular provides an improved system for actuating crossing signal devices, or the like, in response to the approach of a vehicle to the crossing, characterized in that the distance in advance of the crossing at which a vehicle is effective to actuate the signals is varied in accordance with the speed of approach of the vehicle.

One illustrative application of the control system of the present invention is in connection with the signal devices located at the intersection between a highway and a railway, although it is not limited to such application, but may be embodied in any of a wide variety of protective systems. The signaling devices themselves may take a wide variety of forms, such, for example, as bells, lights, gates, barriers or the like, and, to include all these as well as other and equivalent elements, the signaling elements are hereinafter referred to generically as signal devices.

In conventional rail-highway crossing protective systems, the tracks are divided into signaling sections extending at either side of the crossing, and the entrance of a train or other vehicle into either section is effective to actuate the signaling devices and to maintain them in the actuated condition until the crossing is passed. In the conventional systems, the actuation of signals occurs when the vehicle reaches a predetermined point relative to the crossing, which point is independent of the speed of approach of the vehicle. Consequently, a substantially longer period of warning is given, as to the approach of a slowly moving train than is given to the approach of a rapidly moving train, resulting in unnecessary delays in traffic; and also resulting, in many cases, in a tendency on the part of the highway traffic to disregard the signal devices.

To overcome difficulties of the just mentioned kind, as well as others, it has been proposed to arrange the control systems for the signaling devices in such a way that a rapidly moving train actuates the signals when it is a greater distance from the crossing than does a slowly moving train, the general object being to make more uniform the period of warning in cases of both rapidly and slowly moving trains.

With the foregoing considerations in mind, objects of the present invention are to provide a crossing protective system adapted to control the actuation of crossing signal devices in accordance with the speed of approach of vehicles to the crossing; to provide such a system embodying means to delay the operation of the signaling devices upon the approach of slowly moving vehicles; to provide such a system constructed and arranged to provide a substantially uniform period of operation of the signaling devices in response to the approach of vehicles operating at a relatively wide range of speeds; to provide such a system involving a series of relays interconnected together and arranged to measure the speed of approach of a vehicle, and involving additional mechanism responsive to the timing relays for actuating the signaling devices at the expiration of a period determined by the timing relays; to provide such a system embodying means to insure timely operation of the signaling devices even in the event of failure of the timing mechanism; to provide such a system constructed and arranged to insure proper operation in the event a following train approaches the signal at a time that a leading train is within the signaling zone; and to provide such a system, in which the same timing mechanism may be used for vehicles approaching the crossing from either direction.

With the above and other, as well as more specific objects in view, which appear in the following description and in the appended claims, preferred but illustrative embodiments of the present invention are shown in the accompanying drawings, throughout the three views of which corresponding reference characters are used to designate corresponding parts, and in which:

Figure 1 is a diagrammatic view of the improved crossing protective system as embodied in a rail-highway crossing;

Fig. 2 is a diagrammatic view of a modification of the systems shown in Fig. 1; and,

Fig. 3 is a diagrammatic view of a further feature of the invention which may be embodied in the systems of Fig. 1 and Fig. 2.

Referring particularly to Fig. 1, an illustrative highway H is illustrated as intersecting a rail system having the two rails T1 and T2. Illustrative signaling devices comprising the warning lights L1 and L2 are positioned adjacent the crossing and at opposite sides of the track, in positions to warn highway traffic of the approach of trains on the tracks T1 and T2. As stated hereinbefore, the signaling devices L1 and L2 are to be regarded in a representative sense, and may in practice comprise lights, bells, gates, barriers or the like, a characterizing feature being that the signals are arranged for operation in response to approach of rail traffic to the highway.

The rails T1 and T2 are divided by rail joints *a*, *b*, and *c* into two signaling sections *a*—*b*, and *b*—*c*, extending in one direction from the crossing. For purposes of description, the section *a*—*b* may be termed an operating or warning

section, and the section *b*—*c* may be termed a timing section.

The illustrated relay mechanism comprises a series of three relays 1R, 2R, and 3R; a series of timing relays 1T, 2T, 3T, 4T, 5T, and 6T; a series of auxiliary timing relays, 1*a*T, 2*a*T, 3*a*T, 4*a*T, 5*a*T, and 6*a*T; a signal operating relay XR, and a checking relay K.

Relays 1R and 2R respond to the entrance of a train or other vehicle into the timing section *b*—*c*, and the relay 3R responds to the entrance of a train or other vehicle into the operating section *a*—*b*. These relays may be connected into the associated sections in accordance with any conventional track system, but are shown as connected thereinto in accordance with the so-called continuous system. For this purpose, section *b*—*c* is provided with a battery B1, connected between the two rails T1 and T2, and the terminals of the relay 1R are also connected to the two rails T1 and T2. Similarly, section *a*—*b* is provided with a battery B2 connected between the two rails and the relay 3R is also connected between the two rails.

The timing relays 1T, 2T, 3T, 4T, 5T, and 6T are connected together as a relay chain and function in response to the de-energization of the relays 1R and 2R to measure the time required by a vehicle to traverse the timing section *b*—*c*. As described in more detail hereinafter, de-energization of the relays 1R and 2R results in the timing relays 1T, etc. being successively de-energized. The de-energization of the relay 3R, which occurs when the vehicle enters the warning section interrupts this successive de-energizing of the timing relays and initiates the timing out of the auxiliary timing relays. The number of timing relays de-energized during the passage of the vehicle through the timing section thus serves as a measure of the speed of the vehicle.

The details of connection of the timing relays can best be understood from the description of operation given below. It is noted at this time, however, that each of the timing relays 1T, 2T, 3T, 4T, 5T and 6T is provided with a series of front contacts and a series of back contacts, the front contacts being closed when the associated coil is energized and the back contact being closed when the associated coil is de-energized. Each of the timing relays is provided with timing mechanism to delay the movement of the armature from the energized to the de-energized or released position for a predetermined period, although the closing movements are not delayed, and the contact arrangement in each relay is such that the front contacts reach the open positions slightly before the back contacts reach the closed positions. The timing mechanism is diagrammatically indicated by the blacked in portion of each relay coil, and in practice may be arranged in any of a variety of well known ways.

The auxiliary timing relays 1*a*T, 2*a*T, 3*a*T, 4*a*T, 5*a*T, and 6*a*T respond to the timing relays of corresponding number and are provided with time delay mechanisms to give them progressively increasing periods of delay. That is, the time delay for relay 1*a*T is of minimum value, and the time delay periods provided for relays 2*a*T, etc. are of progressively increasing duration.

The number of timing relays 1T, etc., which are de-energized as above described determines which of the auxiliary timing relays are de-energized and consequently determines the length of the interval by which the operation of the signaling device is delayed after the entrance of the vehicle into the warning section *a*—*b*.

The circuit connections of the auxiliary time relays, as well as for the checking relay K, and the signal relay XR may best be understood in connection with the following description of operation.

Throughout the diagram, Fig. 1, all of the relay mechanisms are shown with the contacts in the positions occupied when the coils are energized, in which cases, all of the relay front contacts are in the closed position, and all of the relay back contacts are in the open position. These are the positions occupied by the relays as long as neither of the sections *b*—*c* and *a*—*b* are occupied by a vehicle effective to cause operation of the signal devices.

Throughout the following description only those relay contacts are mentioned which have an effect upon the sequence being described, in order to simplify the description.

Sequence of operation—Rapidly moving trains

Assuming, for example, that a train moving at or above the maximum rate of speed for which the control system is set; that is, a train for which the maximum signal distance is desired, approaches the crossing from the right as viewed in Fig. 1, the entry thereof into section *b*—*c* forms a short circuit between the rails, which acts to divert current away from the coil of the relay 1R. Accordingly, relay 1R falls to a de-energized position, and the opening of its contact 1R1 breaks the circuit for the repeater relay 2R. Relay 2R in turn falls to the de-energized position immediately, no time delay mechanism being provided on this relay, and in so doing opens the contact 2R1. The opening of contact 2R1 interrupts the circuit for the coil of the first time relay 1T, which circuit initially extends from the positive line through the contact 3R1, contact 2R1, and through the coil of relay 1T to the negative line.

Upon interruption of this circuit, the armature of relay 1T tends to fall to the de-energized position, which action is, however, delayed by the timing mechanism associated therewith. Until this time delay mechanism times out, accordingly, the front contacts of relay 1T remain closed and the back contacts thereof remain open.

The time delay provided for relay 1T slightly exceeds the time required for a vehicle, traveling at or above the maximum speed, to traverse the entire section *b*—*c*. In the instance being described, accordingly, the vehicle enters the section *a*—*b* before relay 1T times out. The entry of the vehicle into section *a*—*b* completes a shunt circuit around, and de-energizes, the remaining relay 3R. In response to this action, relay 3R falls to the de-energized position, bringing its movable contact 3R1 into engagement with an associated lower contact, and also opening its contacts 3R9 and 3R10.

The action of contact 3R1 completes a re-energizing circuit for the coil of the time relay 1T, which extends from the positive line through contact 3R1, the still closed front contact 1T1, and thence through the coil 1T to the negative side of the line. As long, accordingly, as contact 3R1 remains closed, or, in other words, as long as the vehicle remains within the section *b*—*c*, a continuous energizing circuit is provided for the coil of time relay 1T, and it, as well as the

other time relays, all remain in the energized position. The entrance of the vehicle into the operating section thus interrupts the previously instituted timing action.

The opening of contacts 3R9 and 3R10 interrupts both of two initial energizing circuits for the coil of the signal relay XR. One of these circuits includes the contacts of the auxiliary time relays in series, but these contacts are now closed as stated.

The interruption of the circuits for the signal relay XR, causes the contacts XR2 thereof to close. Closure of the contact XR2 completes circuits for each of the signal devices L1 and L2 located at the crossing, which circuits extend from the positive line through the contact XR2 and thence in parallel through the signal devices L1 and L2 to the negative lines.

As the trailing end of the vehicle passes out of section *b*—*c*, the relay 1R is again energized and closes its contact 1R1, re-completing the original energizing circuit for the coil of the relay 2R. Relay 2R in turn resumes the energized position, reclosing its contact 2R1. Closure of contact 2R1 has no effect other than to prepare the original energizing circuit for the time relay 1T. The passage of the vehicle out of the timing section accordingly has no effect upon the actuated condition of the signals.

As the trailing end of the vehicle passes beyond the rail joint *a*, the relay 3R resumes the energized condition, and the contacts thereof move to the original positions shown in Fig. 1. The reopening of contact 3R2 breaks the previously traced holding circuit for the time relay 1T, but this action is without effect since the original circuit for the latter relay is now complete through contact 2R1.

The reclosure of contacts 3R9 and 3R10 recompletes the original energizing circuits for the coil of the signal relay XR, the contacts of which accordingly resume the positions illustrated in Fig. 1. The opening of contact XR2 interrupts the circuits for the signal devices L1 and L2, terminating the signal operation.

Reviewing the just stated sequence, it is noted that the entrance of a train into the timing section *b*—*c* starts the timing mechanism in operation, and the departure thereof from the timing section terminates the operation of the timing mechanism. If the train is traveling at or above the maximum speed for which the system is set, the interruption of the timing action occurs before any of the timing relays become deenergized, and, therefore, the signals are placed in operation immediately upon the train's entrance into the operating or signal section *a*—*b*.

Sequence of operation—Slowly moving trains

By the term "slowly moving train" reference is herein made to a train moving at such a rate that the time required to traverse the timing section *b*—*c* exceeds the time required for one or more of the time relays 1T, 2T, etc. to time out. The timing out of these time relays, in turn, through the auxiliary time relays 1*a*T, etc., delays the actuation of the signal devices L1 and L2 for a period determined in accordance with the number of the time relays which time out.

Considering the case in which the speed of the train allows only one of the time relays, that is, time relay 1T, to time out, it will be appreciated that, as in the previous example, the entrance of the vehicle into the timing section *b*—*c* de-energizes the relays 1R and 2R, which in turn de-energize the coil of the first line relay 1T, the circuits involved beng the same as those previously traced.

At the expiration of the period for which relay 1T is set, the front contacts thereof move to the open position, and the back contacts thereof move to the closed position. The opening of contact 1T2 interrupts the circuit for the coil of the second time relay 2T, causing this relay to start timing out. The opening of the contact 1T3 interrupts one of two energizing circuits for the coil of the first auxiliary time relay 1AT. The other energizing circuit for relay 1AT is controlled by contact 3R7.

When the vehicle enters the section *a*—*b*, the relay 3R is de-energized, as previously described, and all of the contacts thereof move to the de-energized positions. In this instance, the opening of contacts 3R9 and 3R10 is without effect, since the contacts 1T5 are now closed in parallel therewith. Similarly, the closure of contact 3R1 is without effect, since the contact 1T1 in series therewith is now open.

The opening of contact 3R7 interrupts the remaining energizing circuit for the first auxiliary time relay 1AT, which accordingly starts timing out. The closure of contact 3R2 completes a re-energizing circuit for the coil of the second time relay 2T, which circuit extends from the positive line through contact 3R2, contact 2T1, and thence through the coil 2T to the negative line. Completion of this circuit, as will be appreciated, interrupts the timing out of the second time relay 2T.

The de-energization of the coil of the auxiliary time relay 1*a*T, effected by the opening of contact 3R7, as described above, causes this relay to start timing out. At the expiration of the time period provided by relay 1*a*T, the contacts 1*a*T1 thereof move to the open position, interrupting the circuit for the signal relay XR which, as described in connection with the first example, places the signal devices L1 and L2 in operation. In this instance also, closure of contact XR1 upon its lower stationary contact provides a re-energizing circuit for time relay 1T, which thereupon recloses and through contact 1T3 causes reclosure of relay 1*a*T. The signal relay XR thus acts, upon operation, to reset all operated time relays and auxiliary time relays.

As the trailing end of the vehicle passes the rail joints *b*, the relays 1R and 2R are again energized and the contacts thereof resume the illustrated energized positions. Re-energization of relay 2R prepares the original energizing circuit for the first time relay 1T, but does not affect the circuits for the signal devices.

As the trailing end of the vehicle passes out of the section *a*—*b*, the relay 3R is re-energized and the contacts thereof resume the illustrated positions. The reclosure of the contacts 3R9 re-energizes the signal relay, as described in connection with the first example, restoring the signal devices L1 and L2 to the inactive condition. Movement of the contact 3R1 of the relay 3R into engagement with its associated upper stationary contact recompletes the original energizing circuit for the coil of the timing relay 1T.

Summarizing the just described example, it is noted that the timing out of the time relay 1T before the vehicle passes entirely through the timing block *b*—*c* renders one of the auxiliary time relays, in this case 1*a*T, effective to delay the operation of the signal for a predetermined period after the passage of the vehicle into the

operating section *a*—*b*. In accordance with the present invention, the period of delay afforded by the auxiliary time relay 1*a*T is such that the signals remain actuated in response to the just described slowly moving train for a period which does not differ, more than a predetermined amount, from the period during which they would be actuated by a train traveling at the maximum speed for which the system is designed.

Considering the case of a train traveling at a still lower rate, sufficient to allow, during its passage through the section *b*—*c*, time relay 2T, as well as time relay 1T, to time out, it is believed to be evident that, as in the preceding example, the timing out of relay 1T de-energizes the coil of relay 2T, and also renders the circuit for the coil of the auxiliary time relay 1*a*T subject to contacts 3R7 of relay 3R.

Upon the timing out of the relay 2T, the contacts thereof fall to the de-energized position. The opening of contact 2T2 de-energizes the third time relay 3T and starts its timing out action. The opening of contact 2T3 renders the circuit for the coil of the second auxiliary time relay 2*a*T subject to contacts 3R7, and the closure of contact 2T5 completes a circuit to battery around the contacts 3R10, 1T5, and 1*a*T1, but is without other immediate effect.

If the train passes the rail joints *b* before the time relay 3T times out, which timing out action began with the timing out of relay 2T, as just described, it is believed to be evident that the consequent closure of the relay contact 3R3 completes a re-energizing circuit for the coil of the time relay 3T and interrupts the timing out thereof. In this event, the only time relays involved in the operating sequence are relays 1T and 2T and the auxiliary relays 1*a*T and 2*a*T, both of which are de-energized and start timing out when the vehicle enters section *a*—*b* and de-energizes relay 3R. In this case the signal devices are placed in operation when the time relay 2*a*T times out, opening the contacts 2*a*T1. This action opens the only available energizing circuit for the coil of the signal relay XR, it being noted that the time delay of relay 1*a*T is shorter than the time delay of relay 2*a*T, so that the contact 1*a*T1 opens prior to the opening of contact 2*a*T1, but without effect. The de-energization of the coil of relay XR places the signals in operation in accordance with the previous description, and also resets time relay 1T. Time relay 1T in turn resets relays 2T and 1*a*T; and relay 2T resets relay 2*a*T.

As the trailing end of the vehicle passes beyond the rail joints *b*, relays 1R and 2R are re-energized, but the system remains otherwise unaffected.

As the trailing end of the vehicle passes beyond the rail joints *a*, the operating relay 3R is re-energized and moves the contacts thereof to the illustrated positions. Reclosure of contacts 3R9 re-energizes the signal relay XR, terminating the signal operation.

It is believed to be evident that in the event the vehicle moves at a lower rate than considered in the immediately preceding examples, some or all of the remaining time relays 3T, 4T, 5T, and 6T may time out during the passage of the vehicle through the timing section *b*—*c*, in addition to the relays 1T and 2T. It is believed to be evident also that as each succeeding time relay 3T, etc. times out, it opens the circuit to the coil of the succeeding time relay, initiating the timing out thereof. Also, as each time relay times out, it renders the circuit of the associated auxiliary time relay subject to the contact 3R7, which, in turn, initiates the timing out thereof upon the entrance of the vehicle into section *a*—*b*.

The circuit for the coil of relay XR is ultimately controlled by the contacts of the last of the auxiliary time relays to be de-energized. Assuming the time relay 4T is the last one to completely time out during the passage of the vehicle through the timing section, closure of the contacts 4T5 thereof forms a shunt circuit around all of the contacts 3R10, 1T5, 1*a*T1, 2T5, 2*a*T1, 3T5, and 3*a*T1. The opening of the contacts 1*a*T1, 2*a*T1, 3*a*T1, therefore, which occurs prior to the opening of the contacts 4*a*T1 because the time delay periods thereof are progressively shorter, does not interrupt the circuit for the coil of relay XR. At the expiration of the timing period for which relay 4*a*T1 is set, however, the opening of contacts 4*a*T1 interrupts the only existing circuit for the coil of relay XR, causing it to assume the de-energized position and place the signal devices in operation.

As in the previously described examples also, independently of the number of the time relays that time out during the passage of the vehicle through the timing section, the passage of the trailing end of the vehicle past the rail joints *b* restores the relays 1R and 2R to the energized position; interrupts the timing out of the timing relays 1T, 2T, etc.; and, by de-energizing relay 3R, initiates the timing out of all auxiliary time relays corresponding to already de-energized time relays. For example, where the vehicle enters the warning section after time relay 4T has timed out, but during the timing out period of relay 5T, the de-energization of the relay 3R completes a re-energizing circuit for the coil of the time relay 5T through the contacts 3R5 and the still closed contacts 5T1; and de-energizes all of relays 1*a*T, 2*a*T, 3*a*T and 4*a*T.

In each instance also where one or more of the time relays is timed out during the passage of the vehicle through the timing section, the de-energization of relay XR causes the resetting of all operated timing relays; and the passage of the trailing end of the vehicle beyond the rail joints and immediately restores the relay 3R to the original position, which in turn re-energizes relay XR, terminating the signal operation.

The actual calculation and determination of the timing of the various timing relays 1T, etc. and the auxiliary time relays 1*a*T, etc. may be determined in various ways, depending upon the operating requirements of the associated protective system, and principally by the selection of the maximum and minimum periods of operation of the signal devices for the range of speeds at which trains may be expected to traverse the timing and warning section. For example, it may be desired to provide a minimum operating period of 25 seconds for the signal device, and to provide a maximum operating period of 35 seconds therefor. The minimum signal period of 25 seconds, in conjunction with the maximum allowable speed of the trains on the system, of course immediately determines the length of the warning section *a*—*b*. The selection of a ten second variation between the minimum period and the maximum period also determines the setting of the respective auxiliary time relays 1*a*T, etc. That is, each successive one of these auxiliary time relays to become effective in any particular operating instance, is required to impose an additional ten

seconds delay in the operation of the signal devices. Therefore, the initial auxiliary time relay 1*a*T requires a setting of ten seconds; relay 2*a*T requires a time setting of twenty seconds; relay 3*a*T a setting of thirty seconds, etc., the last illustrated auxiliary time relay 6*a*T requiring a time setting of sixty seconds.

The selection of the twenty-five seconds minimum and thirty-five seconds maximum operating times for the signal devices also determines the time intervals required for the timing relays 1T, 2T, etc. That is to say, a train traveling at the maximum allowable speed must traverse the timing section *b*—*c* in a time just slightly less than the timing afforded by the time relay 1T, since, as previously stated, for a train traveling at maximum speed, the signals are required to be placed in operation immediately upon the entrance of the train into the warning section *a*—*b*. Since the maximum warning period is thirty-five seconds, it follows that a train traveling slightly in excess of $^{25}/_{35}$ of the maximum operating speed must also traverse the timing section before the timing relay 1T times out; and, a train traveling at or below $^{25}/_{35}$ of the maximum speed must require a time to traverse the timing section which exceeds the time period for relay 1T. The time period for relay 1T is, therefore, the length of the section *b*—*c* divided by $^{25}/_{35}$ of the maximum allowable speed. Or, where:

l=length of section *b*—*c*;
t1=timing period of relay 1T;
m=maximum allowable train speed;

The value *t1* is given by the expression:

$$t1=l\div\left(\frac{25}{35}m\right)$$

To go further, it is believed to be evident that the second time relay 2T would be allowed to time out in the event of the approach of a train traveling at a speed less than $^{25}/_{35}$ of the speed of a train which allows just the one relay 1T to time out. That is to say, the total time period (*to*) allowed by timing relays 1T and 2T is:

$$to=l\div\left(\frac{25^2}{35}m\right)$$

The time period *t2* is thus *to*—*t*. Thus, the total time period required to time out any particular number of relays 1T, 2T, etc. is equal to the length of the timing section (*l*) divided by the maximum allowable speed (*m*) times the fraction $^{25}/_{35}$ raised to a power, which power is equal to the number of timed out relays. The individual time period for each timing relay, on the other hand, is the just stated total time period minus the accumulated time periods of the preceding relays in the series.

The total number of relays used determines the range of speeds below the selected maximum speed within which the signal operation may be maintained within the selected limits. Conversely, the number of relays used determines, for a particular range of speeds, the maximum and minimum periods of signal operation. For a given range of speeds, the greater the number of timing relays used, the closer may be maintained the maximum and minimum signal operating periods.

It will be noted that all signal operations, as affected by the time relays and the auxiliary time relays, are initiated by the dropping out or de-energization of these relays. The danger of any of the time relays, or other relays in the system, failing to fall to the de-energized position when the coil thereof is de-energized is negligible. It may occur from time to time, however, due to wire failure or other causes that a relay will falsely fall to the de-energized position or will fail to move to the energized position when the coil thereof is energized. In accordance with the present invention, means are provided to prevent a false operation of the signals in response to failures of the just stated character and also to assure that, in the event of such a failure a maximum period of signal operation is provided.

Referring further to Figure 1, the contact 3R9 is connected to supply a direct energizing circuit for the coil of the signal relay XR. A false opening of any of the auxiliary time relay contacts 1*a*T1, etc., therefore, is ineffective to de-energize the relay XR as long as the relay 3R is energized; that is, as long as no vehicle occupies the warning section *a*—*b*.

In order to insure that, in the event any time relay fails to reclose properly upon being re-energized or falsely falls to the de-energized position, the signals will be actuated at the time the vehicle enters the warning section *a*—*b*, the checking relay K is provided, the initial energizing circuit of which includes the contacts 1T4, 2T4, etc. of the time relays in series. As long as all time relays remain in the energized position, relay K also remains energized. Also, upon movement to the energized position, the relay K completes a self-holding circuit for itself through its own contact K—1, contacts 3R8 and 2R2 in parallel, and through the contact of the signal relay XR when the latter is in its upper position. Due to the contact XR, this self-holding circuit is broken each time the signal relay XR operates. If at this time any of the time relays 1T, etc. are in the de-energized position, relay K falls to the de-energized position, and can be re-energized only by reclosure of all of the time relay contacts. If any time relays therefor fail to restore themselves after the train passes the crossing, the relay K remains in de-energized position. On the other hand, if any of the time relays 1T, 2T, etc. drop away when no train is on either track section, the control circuit for relay K is broken, and since the self-holding circuit includes front contacts 2R2 and 3R8, which are open when the track sections are unoccupied, relay K drops out. At any time that relay K is in the de-energized position, the contact K2 thereof is in the open position, and renders the signal relay XR subject to control entirely by the relay 3R at contact 3R9.

Although no abnormal movement of any time relay to de-energized position results in a de-energization of the checking relay K, the normal operation of these relays to the de-energized position does not have this effect, since, any time a time relay is normally de-energized, one or the other of the relays 2R or 3R is also de-energized by the presence of a vehicle in the associated section. When either of these two relays is de-energized, the contacts 3R8 or 2R2 thereof, as the case may be, closes in the previously described self-holding circuit and retains the checking relay K in the energized position until the signal relay XR is deenergized.

Checking relay K thus normally remains energized, is de-energized immediately upon the false falling away of a time relay if no vehicles are in the section, is automatically deenergized at the end of each operating sequence in which any one of the time relays is properly de-energized; is re-energized only if all operated time relays prop-

erly reclose; and, when de-energized, renders the signal devices subject entirely to the relay 3R.

It may occur from time to time that during the passage of one train through the warning section *a*—*b*, a following train will enter the section *b*—*c*. In such instance, the illustrated arrangements reduce any delay which, in the absence of the leading train, would otherwise be introduced into the operation of the signals by the approach of the following train.

To accomplish this the system is so arranged that if the signals have been placed in operation by a leading train, and if, while such leading train is still occupying the warning section and thus maintaining the signals in operation, a following train enters the timing section, such entrance of a following train is ineffective to initiate the timing action. As previously described, the contact XR1 of the signal relay XR, when in the lower position, closes an energizing circuit for the coil of the first time relay 1T. As long as this energizing circuit is complete, therefore, the de-energization of the relays 1R and 2R which results from the entrance of the following train into the timing section is ineffective to de-energize the first timing relay 1T. Since timing relay 1T directly controls the succeeding time relays, such entrance is equally ineffective to cause the de-energization of any other time relays 2T, 3T, etc.

If the passage of the leading train beyond the rail joints *a* occurs after the entrance of the following train into the warning section, no interruption in the signal operation occurs during the passage of the two trains past the intersection, since in this instance relay 3R is not re-energized when the leading train passes beyond the rail joints *a*. Accordingly no re-energization of the signal relay XR occurs until the following train has passed beyond the intersection.

In the event the leading train passes beyond the rail joints *a* after the following train enters the timing section but before the following train enters the warning section, the passage of the leading train past the rail joints *a* immediately renders the following train effective to initiate the timing action. In this case, the re-energization of the relay 3R and the signal relay XR which results from the passage of the leading train past the rail joints *a* breaks (at contact XR1) the previously described energizing circuit for relay 1T. Relay 2R being now de-energized by the presence of the following train in the timing section, relay 1T becomes de-energized and initiates the usual timing action. In this case, however, since the timing is not initiated immediately upon the entrance of the following train into the timing section, any time delay which would normally be occasioned by such following train is shortened and the maximum allowable warning period is provided for such train. This is desirable since the passage of the leading train past the intersection may have occasioned an abnormal traffic congestion at the crossing making it advisable to give a substantial period of warning of the approach of the following train.

Modified embodiment—Fig. 2

Referring now to Figure 2, an embodiment of the invention is shown in which the auxiliary time relays may be omitted, and the function thereof performed by introducing selective delays in the release of the signal relay XR. In the embodiment of Fig. 2, each of the time relays, instead of starting the timing out of an auxiliary time relay, as described with reference to Fig. 1, completes a discharge circuit for the coil of XR, the discharge circuit embodying one or more condensers, which causes a flow of current through the coil of the signal relay, which flow continues for the predetermined time period.

The general arrangement and operation of the system shown in Figure 2 duplicates that shown in Figure 1. That is to say, the relays 1R, 2R, and 3R are provided in the same circuit relation to each other, to the signal relay, and to the respective sections; and a series of time relays 1T, 2T, 3T, etc. is provided, the energizing and self-holding circuits of which are arranged as described in connection with Figure 1.

So far as concerns the operation of the system, accordingly, in the instance where a train is traveling at or above the maximum speed for which the system is adjusted, the operation duplicates that of the system in Fig. 1. The sequential dropping out of the time relays 1T, 2T, etc., in the event the vehicle traversing the timing section *b*—*c* travels at a rate below the maximum speed, is also the same as described with reference to the system in Fig. 1.

In the arrangement of Fig. 2, the previously described contacts 1T4, 2T4, etc. of the respective time relays are connected in parallel branches of a circuit leading to the signal relay XR. Each contact 1T4, etc. is disposed to be open when the associated coil is energized. Closure of each contact, however, connects an associated condenser 1C, 2C, 3C, etc. in a local circuit with the coil of the signal relay XR. Each local circuit extends from the negative side of the line, or the common return conductor, through an associated time relay contact and thence through the coil of the signal relay XR to the negative or common return line. A charging circuit for each condenser is provided by a contact on the relay 3R. For example, when relay 3R is in the energized position, the contact 3R9 affords a charging circuit for condenser 1C. Similarly, upper fixed contacts associated with the moving contacts 3R2, 3R3, etc. provide corresponding charging circuits for the condensers 2C, 3C, etc. As long as no vehicle occupies the warning section *a*—*b*, accordingly, all condensers are supplied with charging current and are thus normally in a charged condition. The capacities of the respective condensers are such that they provide time delays in the dropping out of the signal relay XR which corresponds to the time delays provided by the auxiliary time relays of the system of Figure 1.

In view of the preceding description of Fig. 1 and the immediately preceding description with reference to Fig. 2, it is believed that a description of one typical operating sequence will serve to make the operation of the system of Fig. 2 entirely clear. Assuming, for example, that a vehicle enters the timing section *b*—*c*, the relays 1R and 2R are de-energized as previously described, and the de-energization of the latter starts the timing out of the first time relay 1T. If the vehicle enters the warning section *a*—*b* prior to the timing out of relay 1T, the consequent dropping out of the relay 3R immediately de-energizes the coil of the signal relay XR (at contact 3R8). Under these conditions no delay is introduced into the dropping out of the signal relay and it immediately closes the contact XR1 to place the signal devices L1 and L2 in operation.

If the speed of the train is below the just

stated value, one or more of the time relays 1T, 2T, 3T, etc. may complete their timing out before the vehicle enters the warning section *a*—*b*. Assuming, for example, that time relays 1T, 2T and 3T drop out, three parallel discharge circuits are provided for the coil of relay XR, one of which includes condenser 1C, the second of which includes condenser 2C and the third of which includes the condenser 3C. The circuit including condenser 1C is in itself sufficient to afford a predetermined time interval corresponding for example to the time provided by the previously described auxiliary time relay 1*a*T. The additional discharge circuits connected in parallel with the first are effective to supplement the effect of the first, and provide a total time delay in the discharge action which equals the total time afforded by the auxiliary time relay 3*a*T of Fig. 1. The dropping out of the three time relays 1T, 2T, and 3T in the order named and at the time intervals described with reference to Fig. 1, affords a discharge circuit for the coil of the signal relay XR which delays its release movement for an interval equal to the interval provided by relay 3*a*T in the system of Figure 1.

Modified embodiment—Fig. 3

In each of the foregoing two embodiments, sections at only one side of a crossing have been considered. In the broader aspects of the invention, arrangements for effecting proper signal operation for trains approaching the crossing from either direction, and to prevent false signal operation by trains leaving the crossing, may be effected in various ways. A preferred arrangement, however, is shown in Fig. 3.

Referring to Fig. 3, the rails T1 and T2 of an illustrative track are intersected by a highway H, and are divided by rail joints *a*, *b*, *c*1, *c*2, *d*, and *e*, into two timing sections *a*—*b*, and *d*—*e*, disposed at opposite sides of the crossing; and two warning or signal sections *b*—*c*1 and *c*2—*d* also disposed at respectively opposite sides of the crossing. The two control relays 2R and 3R are arranged for selective control by vehicles approaching the crossing from either direction, and correspond in all respects in function to the correspondingly numbered relays in the systems of Figs. 1 and 2. The various circuits controlled by the relays 2R and 3R are therefore not shown in Fig. 3, in order to simplify the drawing.

The control of the two relays 2R and 3R is effected by a series of three relays of the interlocking type, the coils of which are designated 4R through 9R. Relays 4R and 5R are mechanically connected together to form an interlocking relay structure, such, for example, as the type disclosed in the Patent No. 1,799,629 granted to Lockhart April 7, 1931; that is to say, the armatures of these two relays are connected together in such a way that if one of them is de-energized and falls to the de-energized position, it mechanically locks the other against movement beyond a mid-position, part way between the energized and the de-energized position, and the interlocking thus interposed is not released until both relays are restored to the energized condition. The relay 4R is connected directly across the timing section *a*—*b*, and normally is energized from a battery B3. Contact 4R1 of relay 4R is of the so-called "flagman" type, that is, it is closed when the associated coil is energized and moves to the open position only if the associated relay is permitted to fall to the completely de-energized position. The relay 5R is used simply to interlock the relay 4R and the coil thereof is connected in a local circuit including a contact 6R2 of the relay 6R. The contact 6R2 is not of the "flagman" type, and is closed only when the associated coil 6R is energized.

The two relays 6R and 7R are connected respectively across the sections *b*—*c*1, *c*2 and *d*—*c*1, *c*2, and normally receive power from batteries B4 and B5. The relays 6R and 7R are interlocked together in the manner described with reference to relays 4R and 5R. In addition to the previously mentioned contact 6R2, the relay 6R is provided with a contact 6R3 of the "flagman" type. The relay 7R is provided with contacts 7R2 and 7R3 which duplicate the corresponding contacts of relay 6R. Contacts 6R3 and 7R3 are disposed in series in a circuit which includes the coil of the relay 3R. In addition, relays 6R and 7R are provided with back contacts 6R1 and 7R1 to form a conventional staggered connection of relays 6R and 7R into the sections *b*—*c*1, *c*2 and *d*—*c*1, *c*2.

The remaining two relays 8R and 9R are related in the manner described with reference to relays 4R and 5R. The relay 8R is controlled by the contact 7R2 and the relay 9R is provided with a contact 9R1 of the "flagman" type which, in conjunction with the previously described contact 4R1, controls the circuit of the relay 2R.

A typical operating sequence is as follows:

Assuming that a vehicle enters the approach section *a*—*b*, the relay 4R is de-energized and the contact 4R1 thereof moves to the open position, interrupting the circuit to the relay 2R with functions as described in connection with Figs. 1 and 2. The de-energization of relay 4R also mechanically locks the armature of the relay 5R but this is of no consequence in the present instance since no contacts of relay 5R are utilized.

As the vehicle proceeds through the timing section *a*—*b* and enters the warning section *b*—*c*1, *c*2, the relay 6R is de-energized and falls to the de-energized position, opening the contacts 6R2 and 6R3. The opening of contact 6R3 de-energizes the relay 3R which functions as described in connection with Figs. 1 and 2. The opening of contact 6R2 de-energizes the coil of the relay 5R which operation is without effect in the example being considered. The de-energization of relay 6R also applies a mechanical interlock to the armature of the relay 7R. The passage of the leading end of the vehicle past the rail joint *c*1 is without immediate effect upon either of relays 6R and 7R. The passage of the leading end of the vehicle past the rail joint *c*2, however, completes a direct shunting circuit for the coil of relay 7R. Upon being de-energized, relay 7R closes its contact 7R1 and opens its contact 7R2. Contact 7R3, being of the "flagman" type as previously described, is retained closed by the mechanical interlock previously applied by relay 6R. The closure of contact 7R1 is without effect during vehicle travel in the direction now being described, but the opening of contact 7R2 de-energizes the coil of the interlocking relay 8R.

As the trailing end of the vehicle passes out of the section *a*—*b*, the relay 4R is re-energized and recloses its contact 4R1, recompleting the circuit for the relay 2R. This relay, accordingly, resumes the energized position which, as described with reference to Figs. 1 and 2, is without effect upon the signal devices located at the intersection.

When the trailing end of the vehicle passes the rail joint *c*1, the initial direct shunting circuit

for the coil of relay 6R is interrupted. A supplemental shunting circuit for coil 6R is provided, however, through the now closed back contact 6R1, which circuit extends for example from one terminal of coil 6R to the rail T2, thence through the vehicle wheels and axles to the rail T1, and through contact 6R1 to the other terminal of coil 6R. Acordingly, coil 6R remains de-energized until the trailing end of the vehicle passes the rail joint C2, at which time the just described supplemental shunting circuit is interrupted, restoring the coil 6R to the energized condition.

The re-energization of relay 6R restores all of the contacts thereof to the illustrated positions. Reclosure of contact 6R3 re-completes the energizing circuit for the relay 3R which, as described with reference to Figs. 1 and 2, restores the signal system to its original unactuated condition. The reclosure of contact 6R2 re-energizes the coil of the relay 5R, which thereupon resumes the energized position releasing the interlock between relays 4R and 5R. Reopening of contact 6R1 is without effect.

As previously stated, the re-energization of the relay 6R does not release the mechanical interlock previously applied thereby to the armature of the relay 7R. Accordingly, relay 7R remains in the interlocked position until the trailing end of the vehicle passes beyond the rail joints *d*. At this time, the relay 7R recloses its contact 7R2, re-energizing the relay 8R, and reopens its contact 7R1. The latter action is without effect.

The re-energization of relay 8R does not release the previously applied interlock to the armature relay 9R, but as the trailing end of the vehicle passes beyond the section *d*—*e*, coil 9R is re-energized and releases the lock. No change in the position of the contact 9R1 occurs, however.

From the foregoing description, it is seen that the passage past the intersection of the vehicle traveling in the direction stated, first de-energizes the relay 2R upon the entrance of the vehicle into the approach timing section; and de-energizes the relay 3R upon the entrance of the vehicle into the approach operating section. Relays 2R and 3R remain de-energized until the trailing end of the vehicle passes beyond the rail joint *c2* at the far side of the intersection. The re-energization of relays 3R and 2R, which occurs when the trailing end of the vehicle passes the rail joint *c2*, restores the signal system to its original unactuated condition. During the passage of the vehicle through the operating and timing sections *c1*, *c2*—*d* and *d*—*e*, the mechanical interlocks applied to relay 7R by relay 6R and applied to relay 9R by relay 8R remain effective. No signal operation accordingly results from the passage of the vehicle through the just identified sections. When, however, the trailing end of the vehicle passes beyond the rail joint *d*, relay 7R is re-energized, restoring itself to its original condition and releasing the lock applied thereto. Similarly, when the trailing end of the vehicle passes beyond the joints *e*, relay 9R is re-energized and releases the lock previously applied thereto.

It is believed to be evident that in the event of vehicle travel in the reverse direction, a signal timing action is initiated by the entrance of the vehicle into the section *d*—*e*, at which time the relay 2R is de-energized. Similarly, the passage of the vehicle past the rail joints *d* de-energizes the relay 3R to either immediately place the signal devices in operation or to initiate a sequence which places the signal devices in operation after a suitable time delay, as described with reference to Figures 1 and 2. Also, relays 2R and 3R remain energized until the trailing end of the vehicle passes the rail joint *c1*, at which time the signal system is restored to its initial condition. Also, the relays 6R and 4R remain in the interlocked condition until the trailing end of the vehicle passes beyond the rail joints *b* and *a*, respectively. The interlocking relation of the system is such, accordingly, that only the relays associated with the approach sections are effective to control the signal relays 2R and 3R, and the relays associated with the outgoing sections are ineffective to control relays 2R and 3R.

Although specific embodiments of the present invention have been described and explained, it will be appreciated that various changes in the form, number and arrangement of parts may be made in the illustrated arrangement within the spirit and scope of the present invention.

What is claimed is:

1. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a series of time element relays, means including circuit connections for normally maintaining said relays in an energized condition, means actuated by the passage of a vehicle through one of said sections for interrupting the circuit connections for said relays to thereby deenergize said relays, and additional time element means controlled in accordance with the number of said relays which drop away and rendered effective upon the entrance of a vehicle into the other of said sections for actuating said protective device at the expiration of a predetermined interval after said entrance.

2. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a series of time element relays, a first normally complete circuit for energizing a first one of said relays, a second normally energized circuit controlled by said first one of said relays for normally energizing a second one of said relays, means actuated by the entrance of a vehicle into one of said sections for interrupting said first circuit to initiate a successive dropping away of said relays, and additional time element means controlled in accordance with the number of said relays which drop away and rendered effective upon the entrance of a vehicle into the other of said sections for actuating said protective device at the expiration of a predetermined interval after said entrance into said other section.

3. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a series of time element relays, means for normally energizing said relays including means whereby the dropping away of each relay interrupts the circuit for and de-energizes the next succeeding relay in the series, means responsive to the entrance of a vehicle into one of said sections for interrupting the circuit for and de-energizing the first relay in said series to thereby initiate a successive dropping away of said relays, means responsive to the entrance of said vehicle into the other of said sections for completing secondary energizing cir-

cuits for any of said relays which have not dropped away during the passage of said vehicle through said one section, and means controlled in accordance with the number of said relays which drop away for actuating said protective device.

4. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a series of time element relays, means for normally energizing said relays including means whereby the dropping away of each relay interrupts the circuit for and de-energizes the next succeeding relay in the series, means responsive to the entrance of a vehicle into one of said sections for interrupting the circuit for and de-energizing the first relay in said series to thereby initiate a successive dropping away of said relays, means responsive to the entrance of said vehicle into the other of said sections for completing secondary energizing circuits for any of said relays which have not dropped away during the passage of said vehicle through said one section, and means also rendered effective by the entrance of said vehicle into said other section and controlled in accordance with the number of said relays which drop away for actuating said protective device.

5. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a series of time element relays, means for normally energizing said relays including means whereby the dropping away of each relay interrupts the circuit for and de-energizes the next succeeding relay in the series, means responsive to the entrance of a vehicle into one of said sections for interrupting the circuit for and de-energizing the first relay in said series to thereby initiate a successive dropping away of said relays, means responsive to the entrance of said vehicle into the other of said sections for completing secondary energizing circuits for any of said relays which have not dropped away during the passage of said vehicle through said one section, a second series of time element relays corresponding to the relays of said first series, means forming a normally complete energizing circuit for each relay of said second series disposed to be interrupted by the dropping away of the corresponding relay of the first series, and means controlled by the number of relays of said second series which drop away for controlling said protective device.

6. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a series of time element relays, means for normally energizing said relays including means whereby the dropping away of each relay interrupts the circuit for and de-energizes the next succeeding relay in the series, means responsive to the entrance of a vehicle into one of said sections for interrupting the circuit for and deenergizing the first relay in said series to thereby initiate a successive dropping away of said relays, means responsive to the entrance of said vehicle into the other of said sections for completing secondary energizing circuits for any of said relays which have not dropped away during the passage of said vehicle through said one section, a second series of time element relays corresponding to the relays of said first series, means forming a normally complete energizing circuit for each relay of said second series disposed to be interrupted by the dropping away of the corresponding relay of the first series, and means also rendered effective by the entrance of a vehicle into the other of said sections and controlled in accordance with the number of relays of said second series which drop away for actuating said protective device.

7. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining a timing section and protective section in advance of said point, a series of time element relays, means including circuit connections for normally maintaining said relays in an energized condition, means actuated by the passage of a vehicle through said timing section for causing a successive interruption of the circuit connections for said relays to thereby de-energize said relays, means actuated by the entrance of a vehicle into said protective section and disposed upon actuation to actuate said protective device, and means controlled by said relays for delaying the actuation of the protective device after said entrance for a predetermined period determined by the number of said relays which drop away.

8. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining a timing section and a protective section in advance of said point, a series of time element relays, a first normally complete circuit for energizing a first one of said relays, a second normally energized circuit controlled by said first one of said relays for normally energizing a second one of said relays, means actuated by the entrance of a vehicle into said timing section for interrupting said first circuit to initiate a successive dropping away of said relays, means actuated by the entrance of a vehicle into said protective section and disposed upon actuation to actuate said protective device, and means controlled by said relays for delaying the actuation of the protective device after said entrance into said protective section for a period determined by the number of said relays which drop away.

9. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a series of time element relays, means for normally energizing said relays including means whereby the dropping away of each relay interrupts the circuit for and de-energizes the next succeeding relay in the series, means responsive to the entrance of a vehicle into one of said sections for interrupting the circuit for and de-energizing the first relay in said series to thereby initiate a successive dropping away of said relays, means responsive to the entrance of said vehicle into the other of said sections for completing secondary energizing circuits for any of said relays which have not dropped away during the passage of said vehicle through said one section, a second series of time element relays corresponding to the relays of said first series, circuit connections for each relay of said second series disposed to be interrupted by the entrance of said vehicle into said other section providing the corresponding relay of said first series has dropped away, and means controlled by the number of relays of said second

series which drop away for controlling said protective device.

10. In a system for protecting a predetermined point along a traveled way, a protective device associated with said point, means defining first and second protective sections along said way in advance of said point, a time element relay, means including circuit connections for normally retaining said relay in energized condition, means actuated by the entrance of a vehicle into one of said sections for interrupting said circuit connections to thereby de-energize said relay, additional means responsive to the entrance of said vehicle into the other of said sections for normally operating said protective device upon said last-mentioned entrance, means controlled by a dropping away of said relay for delaying said actuation of said protective device for a predetermined interval after said last-mentioned entrance, and means actuated by the actuation of said protective device for restoring said relay to an energized condition.

JAMES MOORE EVANS.
EDMUND J. PHILLIPS.