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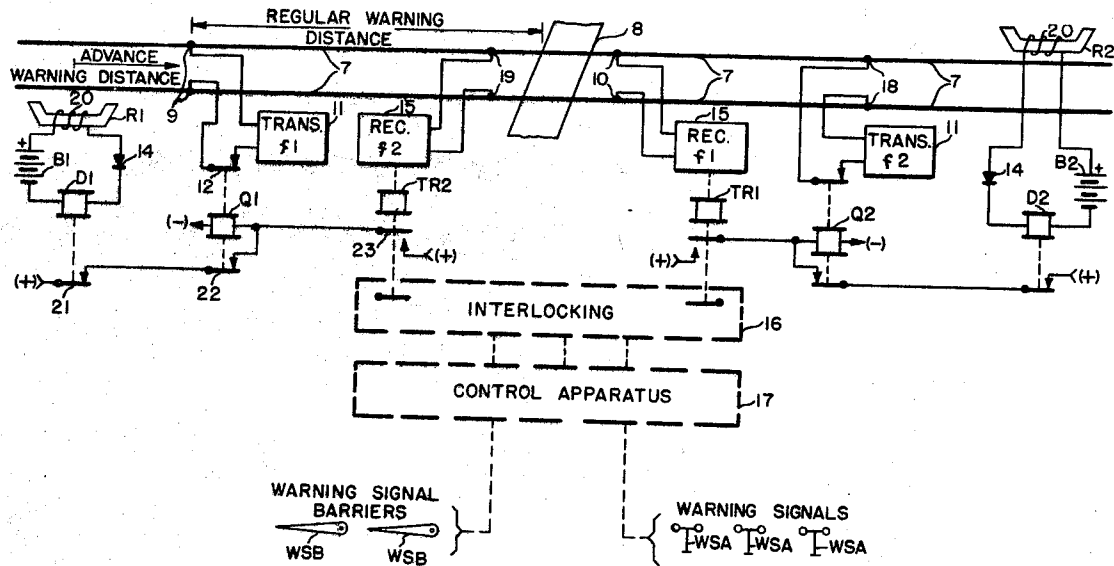
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[54] SIGNALS AT HIGHWAY CROSSINGS FOR HIGH
SPEED TRAINS
13 Claims, 4 Drawing Figs.

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246/63
[51] Int. Cl. B61I 1/02,
B61I 29/32
[50] Field of Search 246/125, 63

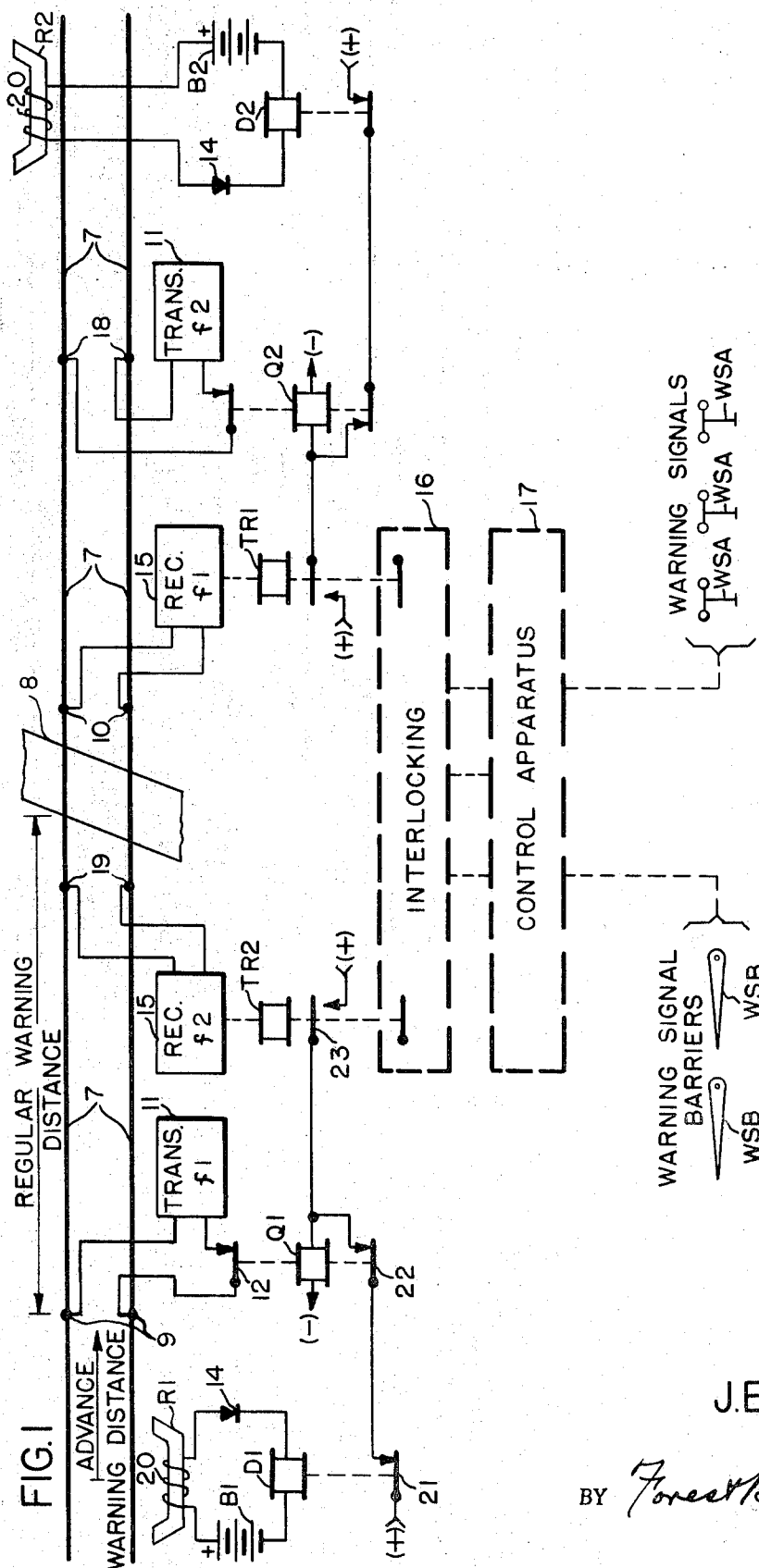
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ABSTRACT: The system differentiates between high speed trains and regular trains by having inductive means partly on the car and partly on the wayside for the high speed trains, while the regular speed trains cooperate with detector track circuit apparatus on the wayside for initiating the warning signals at the highway crossing. The inductive means on the wayside is located considerably in advance of the detector track circuit apparatus, but acts through such apparatus for initiating the warning signals. The warning signals given at the crossing continue their operation until the train has passed the highway. In one form of the invention, the car-carried equipment includes a radio transmitter which is initiated when the train passes the wayside inductive means. The transmission of such radio signal initiates the warning at the highway crossing and also causes the transmission of a return radio signal. If such return radio signal is promptly received, the train can continue in the usual fashion; but, if such return signal is not received within a predetermined length of time, the apparatus then causes an automatic application of the train brakes. This form also withholds the return radio signal for stopping the train if a vehicle is stalled on the railroad track at the crossing.



REGULAR SPEED TRAIN — NO INERT INDUCTORS

HIGH SPEED TRAIN — ONE INERT
INDUCTOR ON RIGHT
SIDE ONLY OF LEADING CAR



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INDUCTOR ON RIGHT
SIDE ONLY OF LEADING CAR

WARNING SIGNAL
BARRIERS WSB

WARNING SIGNALS
WSA WSA WSA

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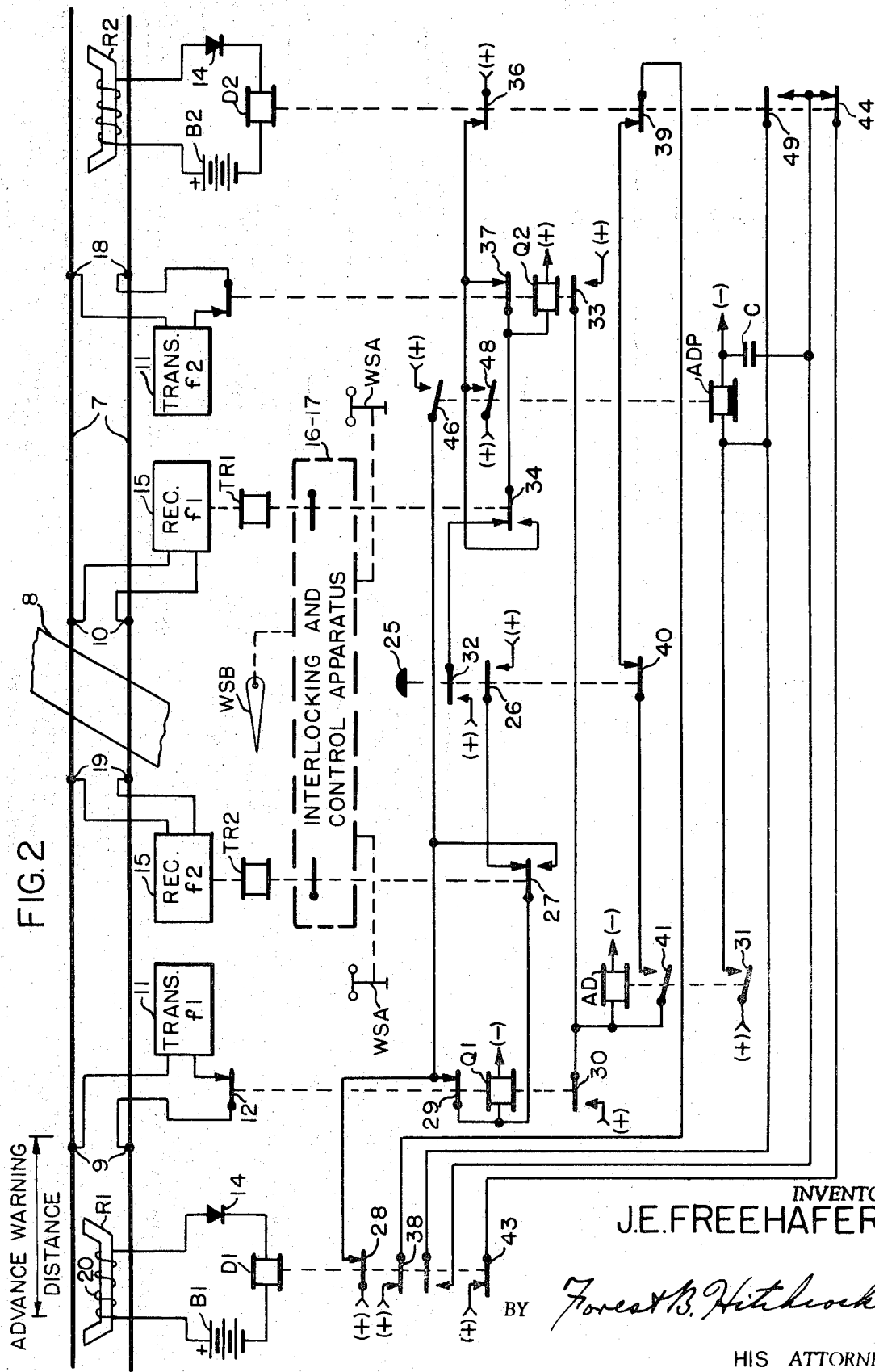
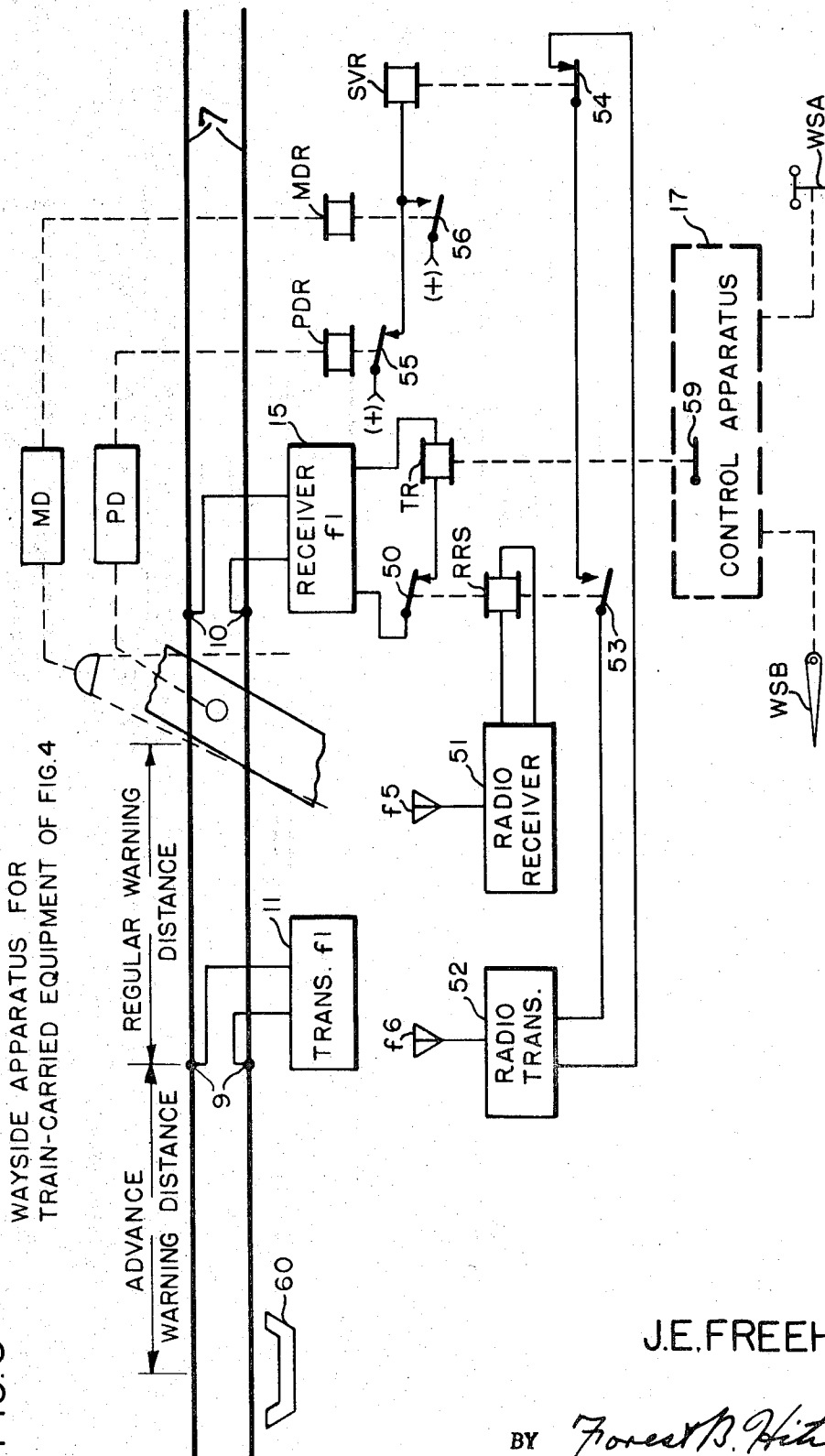


FIG. 3

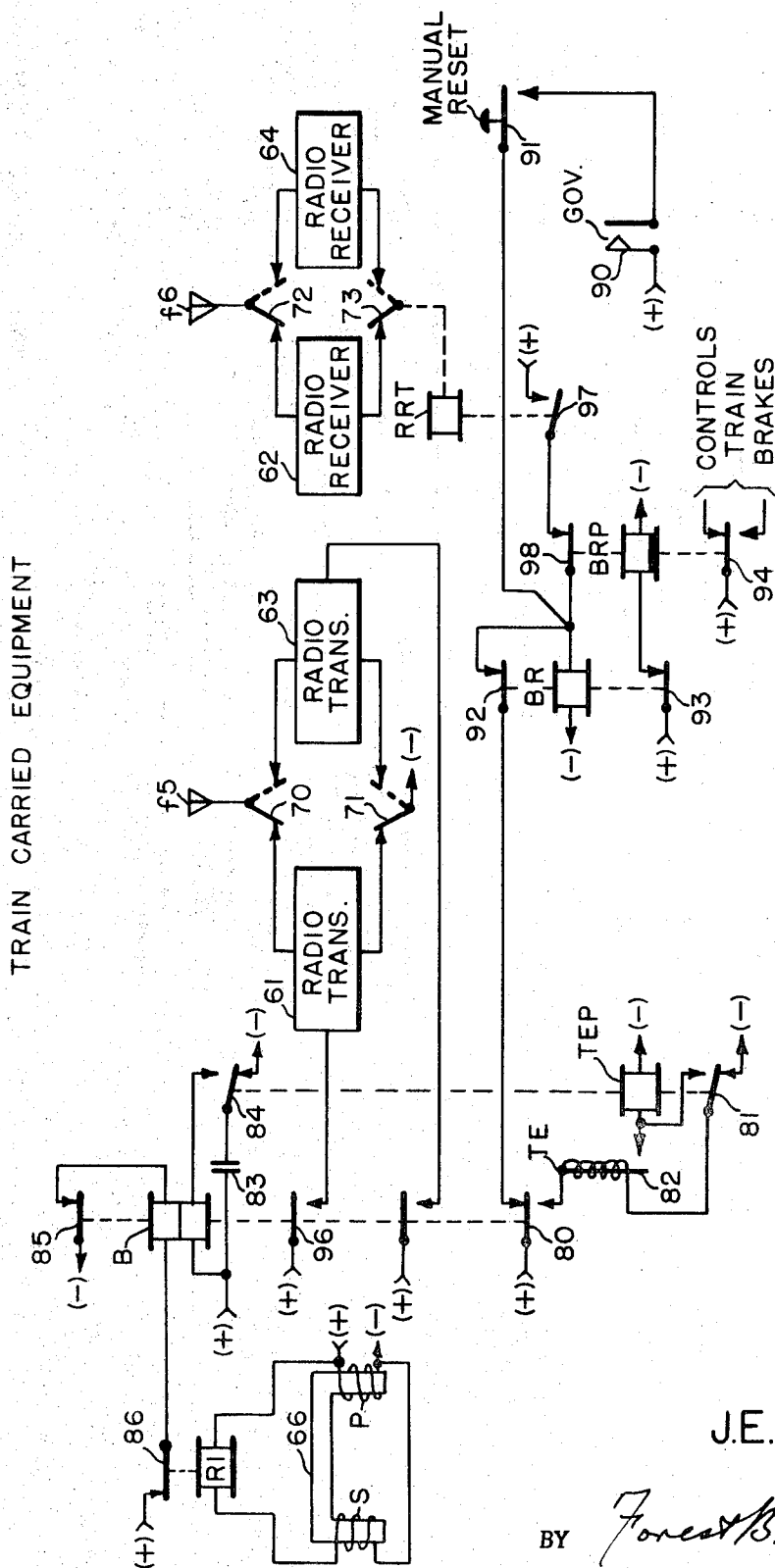


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FIG. 4



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SIGNALS AT HIGHWAY CROSSINGS FOR HIGH SPEED TRAINS

BACKGROUND OF THE INVENTION

This invention relates to highway-crossing warning systems; but more particularly pertains to such a system which distinguishes between high speed trains and regular speed trains so as to advance the point at which the warning is initiated by high speed trains.

Various systems have been proposed for relating the speed of a train to the response of wayside apparatus to give a warning at the highway crossing at a substantially uniform time in advance of the train arriving at the crossing regardless of the speed of the train. Most of these systems are useful for giving a substantially uniform warning time regardless of the speed of the regular trains; but, when very high speed trains are used, the distance in advance of the crossing required for the initial warning becomes much greater than the distance for regular speed trains. However, the use of track circuits is very expensive when they are extended for greater than normal distances for the relatively few high speed trains passing over the trackway.

The present invention proposes to provide apparatus where no track circuits are employed beyond the detection zone for the regular speed trains; and yet, the approach of a high speed train actually initiates the warning from a point appropriately located in advance of the detector zone. Also, such apparatus is effective until the train actually passes the highway in the usual way.

The present invention proposes to provide a means for indicating the passage of a train which operates in a safe and proven manner. Such means uses magnetic inductors and receivers the same as employed in intermittent inductive train control systems which have been found to be very reliable over a period of years.

In addition, the present invention provides a way of including the apparatus for the approach indication mainly in train-carried equipment which also includes a check upon the complete communication between the train and the wayside equipment. Also, the train carried equipment includes means for effecting stoppage of a train both upon failure of communication and also upon the presence of a stalled nonmoving vehicle on the crossing track. The communication in this form of the invention is via radio channels.

SUMMARY OF THE INVENTION

Warning signal means is provided at the highway crossing for warning vehicles of an approaching train. The usual track circuit apparatus is employed for detecting the presence and approach of a regular speed train for causing operation of the warning system. However, inductive means is located on the wayside at a distance beyond the track circuit apparatus for the detecting of only the passage and approach of a high speed train. Such detection of the high speed train is effective to act on the regular track circuit apparatus the same as if it were shunted by a regular train to effect the initiation of the warning signal.

Further, a system is provided having warning signal means at a highway crossing for warning vehicles of an approaching train when rendered active. Means is also provided at a wayside location for identifying the passage of a vehicle at that point and initiating control means on the train for indicating the passage of that point. The control means when initiated transmits a signal to the highway crossing for rendering the warning signal active. However, if the transmitted signal is promptly received, a return transmission means is rendered active to transmit a return signal to the train. The apparatus on the train acts to apply the brakes and remove the power from the train if a return signal fails to be received a predetermined time following the initial reception of the signal from the wayside identifying the passage of the train.

In addition, there is means at the highway crossing for detecting the presence of a stalled vehicle on the crossing and

thereby preventing the transmission of the return signal for removing the power and applying the brakes in the presence of a dangerous condition.

For a better understanding of the present invention, together with other and further objects thereof, reference should be made to the following description, taken in connection with the accompanying drawings, while its scope will be pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic illustration of one organization for effecting the initiation of the warning signals at the highway crossing in accordance with high speed trains as compared to low speed trains for both directions of traffic;

FIG. 2 is a diagrammatic illustration of a different organization for distinguishing the high speed trains from the regular speed trains;

FIG. 3 is a diagrammatic illustration of a wayside apparatus responsive to a radio control signal from a train passing an identified point for initiating the crossing signal; and

FIG. 4 diagrammatically illustrates a train carried equipment which cooperates with the apparatus of FIG. 3 for producing such radio control signal upon the passage of the identified point; and also, which requires the reception of a return radio signal in order for the train to proceed.

DESCRIPTION OF PREFERRED EMBODIMENTS

The first form of the invention constitutes apparatus responsive to traffic in either direction for initiating the highway crossing for high speed trains before they reach the track circuit detecting apparatus provided for the regular speed trains.

The locomotives for the high speed trains each have an inductor on their right hand side; but, the regular speed trains do not have any inductors. This means that a regular speed train is detected by the detector track circuit apparatus for initiating the highway-crossing warning signals to give the usual approach warning of at least 20 seconds before the train reaches the crossing. However, the approach of a high speed train actuates the wayside receiver on the right side of the track, and its control reaches ahead from its advanced position to deenergize the detector track circuit apparatus the same as if the train were actually shunting the rails. This condition is maintained until the train actually passes over the highway crossing at which time a reset control is established. The leaving inductor location is on the opposite side of the track so that the train proceeds without further actuating a wayside receiver.

It is assumed that such locomotive with its inductor on the right-hand side of the locomotive is turned around on a turntable at the end of its route, so that its inductor will actuate the receiver on the opposite side of the track for the opposite direction of travel.

As an alternative, a locomotive may have two inductors, one on each side. These inductors would have choke windings. These choke windings would be controlled by an automatic reversing switch which would render effective the inductor on the right-hand side of the locomotive for the particular direction which it is then traveling; and which would render the other inductor on the other side ineffective. An inductor is ineffective when its choke winding is short circuited; but, when its choke winding is open circuited, it is then effective to actuate a wayside receiver.

The second form of the invention provides for distinguishing the high speed trains from the regular speed trains by providing an inductor on each car of the high speed train. These inductors are located in the center of each car so as to pass over each wayside receiver regardless of its direction. The wayside receivers are located between the two rails of the track to cooperate with the inductors.

Regular speed trains would be detected by the detector track circuit apparatus in the usual way; but each high speed train would act on the wayside receiver to each of the cars of

that train. The activation of a receiver would cause its control to reach ahead to act upon the detector track circuit the same as if the train were passing over it and shunting its rails. The repeated response of a receiver for each car of the train is rendered ineffective to interrupt the initial control established. Also, the initial control established is maintained until the train reaches the crossing. The operation of the leaving wayside receiver is not effective on the apparatus, although the warning signals are restored to their normal ineffective conditions after the rear of the train has passed over the highway crossing.

Thus, each high speed train is detected in the same way to give an advance warning regardless of its direction of travel. This organization avoids the necessity of a turntable and also avoids the use of an automatic reversing switch and choke coils on the car-carried inductors, above described in connection with the first form.

Third form of the invention proposes that the regular speed trains give warning signals by the usual detector track circuit apparatus; but the high speed trains cause warning signals to be initiated from the train at an advanced point which is designated by an inductor on the wayside. Such inductor activates a receiver on the locomotive of the train which in turn transmits a radio signal to the wayside crossing equipment. If such radio signal is properly received at the highway crossing, a return radio signal is transmitted. Such return radio signal is received on the locomotive and forestalls automatic removal of power and application of the brakes. In other words, a limited time is given after the locomotive equipment receives its initial control and transmits its control radio signal within which the return signal must be received in order to keep the train going.

However, the locomotive equipment continues to transmit its radio control signal until a different and longer time runs out. This different time is sufficient for the high speed train to actually occupy the detector track circuit. When such time has elapsed, the locomotive apparatus is reset in readiness for the next highway crossing. In this way, once the highway warning signals are rendered active they remain active until the train has passed the crossing.

In addition, suitable detector means is provided adjacent the highway crossing to detect the presence of stalled vehicles with such detection causing the failure of transmission of the return radio signal. This causes an immediate automatic brake application to the train and power removal from the locomotive.

These several forms of the invention have the common feature of reaching ahead from an advance location to control the regular warning devices at a highway crossing to stop the highway traffic without employing track circuits between such advanced location and the usual detector track circuits in approach to the highway crossing. The detailed operation of these several forms will now be given.

FIRST FORM

With regard to FIG. 1 of the accompanying drawings, a stretch of track with rails 7 is shown having the roadway of a highway 8 crossing such rails. The rails 7 are divided into detector sections by suitable overlay track circuits of the high frequency type using for example, frequencies in the range 1,000 to 5,000 cycles per second suitably modulated by frequencies in the order of 80 to 240 cycles per second. For example, a section is established by the connection of transmitter 11 for frequency f_1 across the rails at 9 and extends to the receiver 15 for frequency f_1 which is connected across the rails at 10. Another section is established by connecting the transmitter 11 for frequency f_2 across the rails at 18 with a receiver 15 for frequency f_2 connected across the rails at 19. It is noted that these two detector sections overlap the highway crossing 8 to provide the effect of an island track circuit.

These overlay track circuits can be applied to the track rails regardless of whether direct current track circuits, coded track circuits, or other high frequency track circuits are otherwise applied to the rails for regular signaling purposes. These overlaid track circuits do not shunt the rails because the connections are made through capacitors of sufficient size to carry the transmitted high frequencies; and, in some instances, the receivers are coupled to the rails through the use of coupling loops. Such overlay track circuits are well-known in the art and have been described for example in the Handbook 76 entitled "Shunt Overlay Track Circuits," published in 1962 by the General Signal Corporation.

The two track circuit sections transmit different frequencies suitably designated as f_1 and f_2 so that each circuit acts wholly independently of the other.

The transmitters 11 are constructed to produce their distinctive modulated frequency; and the receivers 15 are constructed to respond to their distinctive modulated frequency and effect the energization of their respective track relays but to allow such track relays to release when their associated frequency ceases.

It is noted that the warning signals at the crossing are required to be set into operation at least 20 seconds in advance of the arrival of the fastest train which may pass over the crossing.

If the highest speed of the regular trains happens to be 60 m.p.h., the warning would have to be initiated when the train is 1,760 feet away from the crossing. If the speeds of the regular trains have a higher or lower maximum the distance of course would be adjusted accordingly. Assuming that the highest speed of the regular trains is 60 m.p.h., then the actual warning time is established by providing a track circuit of suitable length. For example, the detector circuit from the connection 10 to the connection 9 is sufficiently long to include the highway and thus its length would be in the order of 1,800 feet.

The track relays TR1 and TR2 are interlocked by suitable apparatus indicated by the dotted rectangle 16, which interlocking in turn provides for operation of the control apparatus 17. This control apparatus in turn renders the warning signals WSA active or inactive dependent upon whether or not a train is approaching. The suitable control apparatus 17 also effects operation of the gates or barriers WSB in accordance with the usual control principles for automatic barriers.

One such interlocking and control apparatus is shown in the prior patent to Luft U.S. Pat. No. 3,035,167 dated May 15, 1962. This patent illustrates the control of both warning signals and automatic barriers in connection with the overlapping of high frequency track circuits as shown herein. It should also be understood that other forms of track circuits may be employed such as the usual direct current track circuits. In which case, an island-type track circuit can be used adjacent the highway 8. On the other hand a high frequency track circuit can be used as the island circuit such as shown in Crain U.S. Pat. No. 3,025,393 dated Mar. 13, 1962.

Although warning signals and automatic barriers are designated separately in the drawings, it is to be understood that the term warning signals is also intended to be inclusive of automatic barriers since such barriers are of the frangible type and are indicative of the desired stopped condition of a vehicle rather than forcing an actual stopping of the vehicle.

In addition to the detector track circuit apparatus above described as being associated with the highway crossing for giving warning signals to approaching highway vehicles, suitable apparatus is also provided to initiate an advance warning for high speed trains. For example, if the high speed trains are expected to run at a maximum of 120 m.p.h., the advance warning distance from the connection 9 to the wayside receiver R1 would be in the order of 1,760 feet.

The wayside receiver R1 of FIG. 1 has a winding 20 on it which is energized from the battery B1 through the detector relay D1 and rectifier unit 14. The energy in this circuit flows continually and magnetizes the laminated iron core structure

of receiver R1. This circuitry also energizes the detector relay D1 which supplies stick energy to the relay Q1 from (+), through circuit including front contact 21 of relay D1, front contact 22 of relay Q1, windings of relay Q1, to (-).

Let us assume that a high speed train is approaching. It is carrying an inductor (not shown) on the right-hand side of its lead locomotive. This inductor is an appropriate stacking of iron laminations suitably mounted on the train to cooperate with the wayside receivers.

When the inductor approaches the receiver R1, the EMF induced in winding 20 tends to slightly aid the battery B1; but as the inductor moves over and away from the receiver R1, a substantial EMF is produced in the winding 20 which first opposes the battery B1 and then aids it before returning to normal. The essential point is that the opposing EMF reduces the current in relay D1 below its release value and it quickly drops away. The presence of the rectifier unit 14 in the circuit for relay D1 prevents its over energization in the reverse direction should the opposing EMF produced by the winding 20 exceed the voltage of the battery B1 when the locomotive inductor passes over the receiver very rapidly at the high speeds.

The momentary deenergization of the relay D1 upon the passage of the inductor (not shown) causes the quick release of contact 21 which in turn causes relay Q1 to immediately open front contact 22 and front contact 12. Open front contact 22 maintains relay Q1 deenergized although front contact 21 again closes almost immediately.

The opening of front contact 12 disconnects the transmitter 11 so that its frequency f_1 is no longer transmitted. The failure to receive frequency f_1 by the receiver 15 at the connection 10 causes the relay TR1 to release. This initiates the warning signals at the highway through the interlocking and control apparatus 16 and 17. This assures that the warning signals remain active during the approach of the train.

When the train occupies the track section between the connections 9 and 19, the rails 7 are shunted which prevents the transmission of frequency f_1 the same as the opening of contact 12 of the relay Q1. The passage of the train past the connection 19 causes the receiver 15 for frequency f_2 to release the track relay TR2 and close its back contact 23. This completes a pickup circuit for relay Q1, which causes front contact 22 to reset the relay Q1. The warning signals are maintained because the train still shunts the track rails 7 preventing the frequency f_1 from picking up the track relay TR1.

When the train passes wholly beyond the highway crossing 8 and the connection 10, the frequency f_1 is again received by the receiver 15 to energize the track relay TR1. This picking up of relay TR1 causes the signals at the crossing to be rendered inactive and restored to normal at rest conditions. However, since the track rails 7 are still shunted, the frequency f_2 is kept from the receiver 15 for the connection 19 and the relay TR2 remains deenergized, but this does not affect the warning signals because of the stored conditions in the interlocking apparatus 16. When the train passes wholly out of the detector track section area, past the connection 18, the track relays TR1 and TR2 are both energized and the interlocking apparatus is fully restored to normal for the next train.

The interlocking apparatus 16 includes directional relay means, mechanically interlocked relays or the like, so as to determine that the traffic is from left to right to maintain the warning signals operative only until the train has wholly past the crossing. Such interlocking apparatus is also effective to prevent the leaving train from affecting the warning apparatus although the track relay TR2 is released as above described.

A similar operation for a train traveling from right to left would take place. Such train would initially control the apparatus when the train passes receiver R2, but subsequent operating conditions would of course be in reverse sequence. This also assumes that the locomotive has been turned around, or a selection between two car-carried inductors is made as previously pointed out.

SECOND FORM

With reference to FIG. 2, the same detector track circuit apparatus is employed along the rails 7 for the highway crossing 8 as shown in FIG. 1 and described in connection therewith. The interlocking and control apparatus 17-16 is also the same as described in connection with FIG. 1.

The receivers R1 and R2 of this FIG. are connected to their detector relays D1 and D2 respectively, and are operated the same as disclosed in connection with FIG. 1; but, the receivers R1 and R2 are located between the track rails 7 instead of on opposite sides of the track way as shown in FIG. 1. This is so that the inductors in the middle of the cars of a train will cooperate with the wayside receivers regardless of the direction of movement. Also, this form is particularly adaptable to rapid transit cars or a multiple unit train where each car of such train is self-propelled and may be operated alone or in a train of cars. For this reason, each car has its own inductor located so as to cooperate with the receivers located between the rails. Such midposition is particularly useful where the cars may operate in either direction without being turned around on a turntable.

This form of the invention may have repeated detections of the inductors on a high speed train but this does not cause any adverse effects as the train passes the wayside receiver in approach to the crossing. Also, as the train is leaving the crossing, the multiple actuations of the wayside receiver on such leaving side of the crossing are rendered ineffective because of the storage of the fact that the train entered at the other end of the stretch of track.

When the apparatus is being installed, it is assumed that the detector track circuit apparatus is installed first, and that the track relays TR1 and TR2 will be normally energized. It is also assumed that the wayside receivers R1 and R2 with their respective batteries will normally provide for the energized condition of their detector relays D1 and D2. However, the relays Q1, Q2, AD, and ADP, may not readily be caused to assume their normal conditions. For this reason, a so-called normalizing button 25 is provided to be momentarily actuated upon installation of the apparatus, and upon any repair work or other conditions requiring the same. For example, the actuation of this self-restoring button 25 closes back contact 26 connecting (+) through back contact 26, front contact 27 of track relay TR2, winding of relay Q1, to (-). Relay Q1 then sticks up through front contact 28 of relay D1. Also, the actuation of button 25 completes a similar pickup circuit for relay Q2 from (+), through back contact 26 of button 25, front contact 34 of relay TR1, winding of relay Q2, to (-). Relay Q2 then sticks up through front contact 36 of relay D2.

Since either the relay Q1 or Q2, or both, may have been initially deenergized, or may have become deenergized due to the momentary release of either one or the other or both of the relays D1 and D2, the relay AD is picked up by reason of either back contact 30 or back contact 33, or both. If this had occurred, then the energized condition of relay AD would have closed front contact 31 to energize the slow release relay ADP through an obvious circuit. Since this relay ADP is constructed to be slow released, it is also slightly slow to pick up. Since both relay Q1 and Q2 are picked up by the actuation of button 25, the relay AD would be held stuck up through its stick circuit; but the actuation of the button 25 also opens contact 40 which opens such stick circuit so that relay AD is released. This in turn deenergizes the relay ADP. Upon the release of button 25 all of the relays in FIG. 2 can be in the normal positions illustrated.

Since both of the detector relays D1 and D2 are picked up, a circuit is closed for charging the capacitor C from (+) through front contact 43 of relay D1, front contact 44 of relay D2, capacitor C, to (-).

Let us now assume that a train is proceeding from the west or left-hand end of the stretch of track and its inductor passes over the receiver R1. This will cause a momentary deenergiza-

tion of the relay D1, as previously described, which is sufficient to allow the relay Q1 to open its contacts and deenergize its stick circuit. The closure of back contact 30 of relay Q1 will cause relay AD to pick up which in turn closes contact 31 and energizes relay ADP to cause it to close its front contacts in due course. As a consequence of the momentary release of relay D1, back contact 38 of relay D1 is momentarily closed and briefly connects charged capacitor C across relay ADP. Since relay ADP is slightly slow to pick up, this charge does not actually cause its operation to a picked up condition, but very shortly its picked up condition is actually accomplished by its energization through front contact 31 as previously described. This picked-up condition of relay ADP is maintained until the train proceeds further over the track as later described.

However, in the meantime this high speed train may have several cars and the inductor on each of them will each cause the detector relay D1 to be momentarily released; but, no action takes place with regard to the rest of the apparatus because the relay Q1 has no way of picking up between repeated operations of the relay D1. Thus, the relay Q1 remains deenergized and opens front contact 12 causing the stopping of the transmission of the frequency f_1 over the detector track circuit apparatus the same as if the rails 7 were shunted. This causes the release of the track relay TR1. Such release of the relay TR1 initiates the interlocking and control apparatus to cause the warning signals at the highway crossing to become active immediately following the activation of receiver R1.

As the train proceeds from the receiver R1 toward the east, the steady deenergization of relay Q1 maintains the warning signals and the rest of the apparatus in condition for the entry of the train into the detector track circuit apparatus. When the train passes the connection 9, its wheels shunt the rails and thus makes it no longer necessary to maintain the relay Q1 deenergized although it actually does stay in that condition.

When the train passes the connection 19, its wheels shunt the track rails 7 and prevents the frequency f_2 from being received by the associated receiver 15 for maintaining the track relay TR2 energized. Thus, the track relay TR2 is released. Since the relay ADP is picked up closing front contact 46, the closing of back contact 27 of relay TR2 completes a pickup circuit for the relay Q1 through an obvious circuit. The closure of front contact 29 sticks relay Q1. But the opening of its back contact 30 does not release the relay AD because of its stick circuit previously pointed out is now closed. This maintains relay ADP steadily energized through front contact 31 so that it remains picked up.

Incidentally, under these conditions a circuit is closed for charging the capacitor C from (+) through front contact 43 of relay D1, front contact 44 of relay D2, capacitor C, to (-). This circuit is closed when relay ADP initially picks up, but it is steadily closed when relay D1 is steadily picked up following the passage of the last car of the train past the receiver R1. When relay ADP is picked up, it causes front contact 48 to maintain relay Q2 picked up as later described.

When the train entirely passes the connection 10, the frequency f_1 is received by the receiver 15 associated therewith and causes the track relay TR1 to pick up. This removes the warning signals from the crossing because the interlocking apparatus prevents the deenergized condition of TR2 from being effective since it was deenergized later than the deenergization of relay TR1. The train then proceeds through the track circuit toward the connection 18.

When the train entirely passes this connection 18, the frequency f_2 can then flow through the rails to be received by the receiver 15 at the connection 19 and energizes the track relay TR2. In brief, when the train entirely leaves the detector track circuit apparatus both relays TR2 and TR1 are picked up; but, under these circumstances, the relay AD is picked up maintaining the relay ADP picked up. Also, capacitor C is fully charged.

When the first car of the train with an inductor passes over the receiver R2, the relay D2 is momentarily released but the

opening of front contact 36 cannot release Q2 because of the closed front contact 48 of relay ADP. However, the opening of front contact 39 of relay D2 causes the relay AD to release because of its open stick circuit. Although contact 31 opens promptly, the relay ADP remains picked up because the capacitor C is discharged through it by the back contact 49 of relay D2. In other words, a momentary release of the relay D2 causes the relay ADP to remain picked up.

Assuming that a second car of the train also has an inductor which passes over the receiver R2, the relay D2 would again be momentarily released. Since the preceding picked-up condition of D2 closed front contact 44, the capacitor C would be recharged, so that the momentary closure of back contact 49 would again cause capacitor C to discharge through ADP. In brief, the capacitor C is charged during the periods that relay D2 is picked up and is discharged through the relay ADP during the periods that D2 is dropped away. The relay ADP remains picked up between its successive energizations due to its slow release characteristics. However, when the high speed train has wholly passed the receiver R2, the relay D2 remains picked up which causes front contact 36 to maintain the relay Q2 picked up although the relay ADP releases because of open-back contact 49. The relay ADP would release in any event although the back contact 49 did not open because the capacitor C would shortly become discharged. The relay ADP would release after an interval of time according to its slow release characteristics.

In connection with the regular speed train, which has no inductors, it is detected only by the detector track circuit apparatus as previously described. The operation of the high speed trains in the opposite direction is of course analogous to the description already given but in the reverse sequence. It is understood that the interlocking and control apparatus responds to the sequence of operations to appropriately control the highway warning signals.

THIRD FORM (FIGS. 3 AND 4)

With reference to FIG. 3, a stretch of track having rails 7 is shown intersecting the highway crossing 8 the same as in prior FIGS. 1 and 2. However, the detector track circuit apparatus here shown relates only to the control of the warning signals at the crossing for railroad traffic in a single direction. Suitable track circuit detection is provided in approach to the highway crossing in the form of what is known as an overlay track circuit with transmitter 11 connected across the rails at 9 and with a receiver 15 connected across the rails at 10. This overlay track circuit is the same as described in connection with FIG. 1. Therefore, the connection 9 is spaced from the connection 10 to provide the usual length track circuit for a standard warning time of 20 seconds for trains of usual speed such as 60 m.p.h. The connection 9 at the left is therefore approximately 1,800 feet from the connection 10 to the right of the crossing assuming that the 1,760 feet is reached for the regular warning distance at the left of the crossing, and that the roadway is approximately 40 feet wide.

The transmitter 11 transmits a modulated frequency f_1 through the connection 9 over the track rails 7 to the connection 10 and through receiver 15 for energizing the track relay TR. The circuitry from the receiver 15 for energizing the track relay TR includes back contact 50 of the relay RRS which is controlled by the radio receiver 51 in response to the radio frequency f_5 from the approaching high speed train. When a radio signal is received from the high speed train, front contact 53 of relay RRS is picked up which closes a circuit for the radio transmitter 52 including front contact 54 of relay SVR.

Also, associated with the highway crossing 8 is a presence sonic detector PD which provides for the energization of the relay PDR whenever a vehicle is on the crossing within its range of detection. Another sonic detector MD preferably of the motion-detecting type, such as the detector which operates on the Doppler principle, is located to detect any movement by vehicles which are passing over the crossing and

in turn are also detected by the presence detector PD. When vehicle movement is detected by the motion detector MD, it then energizes the relay MDR. Both of these detectors are required because the usual movements of traffic would be detected by the presence detector PD and at least cause the relay PDR to be intermittently picked up and released. In a similar way, the moving traffic would be detected by the motion detector MD and cause intermittent operation of relay MDR. Since the purpose of this organization is to detect a stalled vehicle, the detection of a vehicle that is not moving results in the deenergization of the relay MDR and the energization of the relay PDR. This effects the dropping away of the relay SVR which prevents the transmission of a return radio signal in response to the receipt of a control radio signal by the radio receiver 51.

Under normal conditions, the vehicles are in motion so that motion and presence are detected substantially simultaneously. This closes the front contact 56 of relay MDR and maintains SVR energized while the relay PDR is picked up opening back contact 55. The detection of a normal vehicle passing over the crossing cannot release the relay SVR. Thus, the return radio signal of frequency f_6 is transmitted by radio transmitter 52 and the train continues to operate in the usual way.

The wayside inductor 60 is of the inert type formed of laminated magnetic material such as iron, and it is located at an appropriate distance from the regular detector track circuit apparatus so as to provide the appropriate warning distance for the additional speed at which the high speed trains run. For example, if the regular speed trains run at 60 m.p.h. and such speed is doubled to 120 m.p.h., then the warning distance from the crossing would be in the order of 3,520 feet. Since the detector track circuit apparatus provides a warning distance of 1,760 feet then the inductor will be a further 1,760 feet from the first connection 9 to provide the advance warning distance as illustrated in FIG. 3.

TRAIN-CARRIED EQUIPMENT OF FIG. 4

Each high speed train has train carried equipment which will respond to the wayside inductor at the appropriate advance warning distance; whereas, each regular speed train has no train-carried receiver and associated equipment. A regular speed train is not detected until it reaches the detector track circuit apparatus of FIG. 3.

The train-carried equipment for each high speed train includes two radio transmitters 61 and 63 and also includes two radio receivers 62 and 64. The radio transmitter 61 and the radio receiver 62 are rendered active when the contacts 70, 71, 72, and 73 are in their left-hand positions; but the radio transmitter 63 and the radio receiver 64 are rendered active when the contacts 70, 71, 72, and 73 are in their right-hand positions. These two sets of receivers and transmitters are provided as alternates so that upon the failure of one set, the other set can be immediately switched into activity. The contacts 70, 71, 72, and 73 are manually actuated simultaneously by suitable means.

The train-carried equipment also includes a receiver 66 constructed of iron laminations in the usual way. This receiver 66 is located on the locomotive in a manner to cooperate with the wayside inductor 60 of FIG. 3. This receiver 66 is connected to a suitable direct current source to energize the primary winding P directly, and to energize the secondary winding S and relay R1 in series. During the installation of the system, power will be applied (as indicated) through suitable terminals and a master control switch (not shown). The application of this power will cause energy to be supplied to effect the pickup of relay TEP, shortly to be described, which will then discharge the capacitor 83 through front contact 84 and cause the relay B to be picked up. Relay B is then stuck up through front contacts 85 and 86. More specifically, when energy is first placed on the heel of contact 80, the back contact 80 energizes the thermal relay TE through back contact

81 of relay TEP. After a suitable time measured by the thermal relay TE, the contact 82 closes and energizes the relay TEP through an obvious circuit. When the contacts of relay TEP pick up, front contact 81 connects the thermal winding through the relay TEP which reduces the current in such thermal relay to a value where its contact 82 restores to a normal condition. When the relay TEP is deenergized as shown, the capacitor 83 is energized through back contact 84 of relay TEP. Thus, when the relay TEP picks up, the capacitor 83 is discharged through the lower winding of relay B which causes its contacts to be picked up. The closure of front contact 85 with the closed condition of front contact 86 causes the relay B to be energized through a stick circuit which will be readily apparent. The opening of back contact 80 of relay B removes the energy from relay TEP so that it releases and again closes back contact 84 to supply energy to the capacitor 83.

Before the train can proceed, the train brakes must be removed. With the train standing still, the governor contacts 90 are closed so that the actuation of the manual reset button closes contacts 91 to supply energy to the relay BR. Such relay BR picks up and closes front contact 92 to complete stick circuit through contact 80 of relay B. The closure of front contact 93 of relay BR immediately completes an obvious circuit for picking up relay BRP. The operation of contact 94 is in a released condition and causes the brakes to be removed when the contact is in a picked-up position.

OPERATION OF FIG. 3 AND 4

Let us assume that the train carried equipment on a locomotive as shown in FIG. 4 has its receiver 66 located so that it passes directly over the inductor 60. This movement of the receiver 66 over the inductor 60 induces a current in the secondary winding of the receiver 66 which is in opposition to the current normally flowing in that circuit so as to reduce the current therein below a holding value for the relay R1. The release of relay R1 in turn is repeated by the relay B because of open contact 86 in its stick circuit. The release of relay B is repeated into the relay BR because of open contact 80. Relay BR opens contact 93 and initiates a relatively short timing period during which a return radio signal can be received to forestall the application of the brakes and removal of passer. Also, the closure of back contact 80 starts a timing operation of larger duration as will shortly be described.

The closure of back contact 96 of relay B renders the radio transmitter 61 active for sending a radio control signal of frequency f_5 to the radio receiver 51 of FIG. 3. This receiver 51 then immediately actuates the relay RRS to open back contact 50 and release the normally energized track relay TR. Thus, contact 59 causes the warning signal apparatus at the crossing to be set into operation. The closure of front contact 53 (assuming no vehicle is stalled on the crossing) closes a circuit through front contact 53 and front contact 54 to activate the radio transmitter 52 to transmit a return signal of frequency f_6 to the radio receiver 62 of FIG. 4. This signal acts through contact 73 to energize the relay RRT which picks up contact 97 and completes a holding circuit through contact 98 of relay BRP to energize the relay BR. So long as the control radio signal is transmitted, the return radio signal will be received and the relay BR and its repeater relay BRP will be maintained energized. The continued receipt of the radio control signal by radio receiver 51 continues the warning signal apparatus in operation advising vehicles that a high speed train is approaching.

When the train reaches the detector track circuit apparatus, it shunts the rails 7 which causes the continued operation of the warning signals irrespective of the continued receipt of the radio control signal. Thus, the thermal time element relay TE is provided with a time of operation sufficient for the train to travel at its high speed from the inductor 60 to and past the first track connection 9 (from the left) as shown in FIG. 3. When the thermal relay TE has operated after its predetermined time has elapsed, it picks up the relay TEP and

discharges the capacitor 83 through the relay B. This picks up the relay B so that it sticks up through front contact 86 of relay R1.

The opening of back contact 96 deenergizes the radio transmitter 61 causing the radio control signal of frequency f_5 to cease. This then releases the relay RRS at the wayside apparatus of FIG. 3 causing the return radio signal of frequency f_6 to cease. The resulting release of the contact 97 of relay RRT is ineffective to release the relay BR because the relay BR has its stick circuit closed through front contact 80. The continued closure of contact 93 of relay BR causes the relay BRP to be maintained energized which in turn prevents any operation of the train brakes. The train thus continues through the track circuit and past the second connection 10. When the train has fully passed the crossing and the connection 10, the frequency f_1 will be received by the receiver 15 and result in the energization of the track relay TR for removing the warning signals from the highway.

On the other hand, if when the train passed the inductor 60, a stalled vehicle was located on the highway crossing, the return radio signal would not be transmitted because of the open condition of contact 54 of relay SVR. This would then allow the relay BR to remain deenergized sufficiently long for the relay BRP to release and apply the brakes and remove the power from the train. Any subsequent transmission of the return radio signal for any reason what so ever such as the removal of the stalled vehicle, would not reenergize the relay BR because the relay BRP is released. In other words, the train must stop. After the train has stopped as indicated by its contacts 90 of the governor, the trainman can reset the apparatus by picking up the relay BR. Assuming that the time of thermal relay TE has elapsed and that relay TEP has picked up and had in turn picked up the relay B, then the relay BR would be stuck up through front contact A.

It is desired to point out that the time of release of relay BRP is just slightly longer than the time required to effect the rapid return of the radio signal. If such signal is not returned immediately, the brakes of the train are therefore applied.

In connection with the operation of the thermal relay TE its time can be delayed if desired almost until the train reaches the highway crossing so that the removal of the return radio signal could during such time apply the brakes to the train. But this is thought to be unnecessary, since the critical time for detecting the stalled vehicle is immediately following the initiation of the highway-warning signals and the lowering of the gate barriers. After such barriers have been lowered, no further vehicles are supposed to enter the crossing area and any vehicle that was in the crossing area before the gate was lowered should then shortly remove itself from the crossing area. Thus, the time element measured by the thermal relay TE is essentially the time required for the high speed train to reach the track circuit apparatus and be detected by it.

Should the train have its brakes applied because of failure in the train-carried radio transmitting and receiving equipment, the operator can manually actuate the contacts 70, 71, 72, and 73 and determine whether or not such shift to the auxiliary radio equipment is effective to remove the difficulty. Following this he may actuate the manual reset button and restore the train-carried equipment to normal in the event the substitute of the auxiliary radio equipment is effective.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein, without departing from the invention, and it's, therefore, aimed in the appending claims to cover all such changes and modifications as fall within the direct spirit and scope of the invention.

I claim:

1. A railroad highway-crossing protection system for activating a signal means at the crossing for warning vehicles of an approaching train, approach apparatus including track circuit means for detecting the presence of a train in approach of said crossing and causing the operation of said signal means at

said crossing wherein the improvement comprises: coupling means including; inductive means on the wayside, located at a distance beyond each end of the track circuit and only on certain trains, said wayside inductive means responsive to the train carried inductive means for detecting the passage of only those certain trains regardless of speed, and means responsive to said coupling means for acting upon said track circuit means the same as if any train were present to affect the operation of said signal means.

2. A system as specified in claim 1 wherein said means responsive to said coupling means remains responsive thereto until reset for acting upon said track circuit and reset means responsive to the rear end of the train passing said crossing for resetting said means.

3. A protective system for vehicles at a grade crossing between a railroad track and a highway, a warning signal means at the crossing for warning vehicles of an approaching train, a track circuit means for detecting the presence of a train in approach of said crossing and causing the operation of said warning signal means at said crossing, wherein the improvement comprises: inductive approach means located at a substantial distance beyond the range of said track circuit for detecting the approach of certain trains, inductive actuating means carried only on the certain trains and operative for actuating said approach means, and electrical means responsive to said approach means in response to the passage of a train carrying said operative actuating means for acting upon said track circuit the same as if any train were present on it, whereby the warning signal means at the crossing is initiated by said certain trains and by those trains not equipped with said inductive actuating means at two different distances in approach to the crossing.

4. A protective system as specified in claim 3 wherein said track circuit means is of the overlay relatively high frequency type.

5. A protective system as specified in claim 3 wherein said approach means is an inductive receiver distinctively responsive to a high speed train.

6. A protective system for vehicles at a grade crossing between a railroad track and a highway comprising, a warning signal means at the crossing for warning vehicles of an approaching train, a wayside inductor located at a suitable approach distance from the crossing, means on the train responsive to the passage of the train past said inductor, radio-transmitting means on the train initiated by said means responsive to the passage of a wayside inductor and acting to transmit a radio signal, means at the wayside responsive to said radio signal for initiating operation of said warning signal means, wayside located radio-transmitting means associated with said warning signal means when it is initiated to transmit a return radio signal to said train-carried apparatus, and means on the train for stopping the movement of said train if said return signal is delayed longer than a predetermined time.

7. A protective system for vehicles at a grade crossing between a railroad track and a highway comprising, a warning signal means at the crossing for warning vehicles of an approaching train when rendered active, a wayside location identifier located at a suitable approach distance from the grade crossing, control means on a train including means responsive to said location identifier for indicating the passage of the train past said location identifier and, means for transmitting a radio signal to said grade crossing for rendering said warning signal means active, return transmission means rendered active by the reception of said radio signal at said highway crossing to transmit a return radio signal to said train, and means on the train for applying its brakes if a return radio signal fails to be received a predetermined time following the receipt of the initial signal from the wayside location identifier.

8. A system as defined in claim 7 wherein said control means on the train is restored to normal a predetermined time following the reception of a control from said wayside-identifying means.

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9. A system as specified in the preceding claim 8 wherein said restoration of said control means after said predetermined time causes the warning signal means to be rendered inactive unless said train has approached to within a predetermined distance of said grade crossing within said predetermined time.

10. A system as specified in claim 8 wherein there is approach track circuit means adjacent said grade crossing and a predetermined distance in advance of the crossing for detecting the presence of a train and rendering said warning signal means active, whereby said warning signal means is continuously rendered active from the time of a train passing said wayside location identifier until it passes said grade crossing if said train occupies said approach track circuit means before said control means is restored.

11. A system as defined in claim 7 wherein there is means at the crossing for detecting the presence of a stalled vehicle, said means being effective to prevent the operation of said return transmission means to transmit a return radio signal to the train when a vehicle is stalled on the tracks, whereby said train is automatically caused to immediately apply the brakes and remove power upon the presence of a dangerous condition.

12. A railroad highway crossing protection system for activating warning signal means at the crossing for warning vehicles of an approaching train, comprising: approach apparatus means at a preselected distance on each side of the crossing for at least momentarily detecting the presence of a train as it passes, control means responsive to said approach apparatus means for initiating the operation of the warning signal means when said train engages said approach apparatus means in a direction approaching the crossing, means at the crossing responsive to the last car for restoring said control means when the train passes the crossing, and storage means for registering the passage of said train by said approach apparatus, including a capacitor repeatedly charged by the repeated operation of the approach means by the train leaving the crossing to thereby maintain the control means in a restored condition.

13. A system as defined in claim 12 wherein said storage means includes a capacitor repeatedly charged by the repeated operation of said approach means by said leaving train to thereby maintain said control means in its restored condition.

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